Colorado Department of Transportation

Standard Specifications
for
Road and Bridge Construction

COLORADO
Department of Transportation

2023

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For
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PREFACE

Use these standard specifications on contract work awarded by the Colorado Department of Transportation (CDOT). They may be supplemented or modified to suit specific contracts.

These specifications are expressed in United States Standard Measure (English units). The international System of Units (SI, Modernized Metric) is used only where standardized testing requires metric units. For clarity, aggregate sieve sizes appear in both SI and English Units. The dimensions, measurements, and requirements stated in English units are the specification requirements. All Contractor submittals shall be prepared in English Units. Pay item quantities will be measured in English units.

Unless otherwise identified, forms referred to (Form 605) are CDOT forms. Forms from other organizations or agencies are clearly identified (FHWA Form 1273). When used in this manner, it shall be capitalized as shown.

Use of these specifications by any other organization or individual will be at the user's risk. Organizations or individuals citing these specifications by reference in their contract work will be responsible for furnishing prospective bidders' copies of the specifications along with any addenda that may affect their contract.

Addenda to these specifications may be issued by the Department to suit its needs. Addenda may be accessed on the CDOT website.

Wherever the term "manhole" or "maintenance hole" are used, they should be considered interchangeable.

TABLE OF CONTENTS

DIVISION 100 GENERAL PROVISIONS

DIVISION 200 EARTHWORK

DIVISION 300 BASES

TABLE OF CONTENTS

DIVISION 400 PAVEMENTS

DIVISION 500 STRUCTURES

DIVISION 600 MISCELLANEOUS CONSTRUCTION

TABLE OF CONTENTS

DIVISION 600 MISCELLANEOUS CONSTRUCTION (continued)

DIVISION 700 MATERIAL DETAILS

TABLE OF CONTENTS

TABLE OF CONTENTS

REFERENCE TABLES

TABLE OF CONTENTS

REFERENCE TABLES

TABLE OF CONTENTS

REFERENCE TABLES

TABLE OF CONTENTS

REFERENCE TABLES

TABLE OF CONTENTS

REFERENCE TABLES

TABLE OF CONTENTS

REFERENCE TABLES

TABLE OF CONTENTS

REFERENCE TABLES

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DIVISION 100
GENERAL PROVISIONS

SECTION 101
DEFINITIONS AND TERMS

Titles used in these specifications having a masculine gender, such as “workmen” and the pronouns “he” or “his”, are for the sake of brevity and are intended to refer to persons of either gender. The titles or headings of the sections and subsections are intended for convenience of reference and shall not have any bearing on their interpretation.

When the Contract indicates that work is to be “accepted, acceptable, subject to approval, approved, authorized, condemned, considered necessary, contemplated, deemed necessary, designated, determined, directed, disapproved, established, given, indicated, deemed insufficient, subject to interpretation, interpreted, ordered, permitted, rejected, required, reserved, satisfactory, specified, sufficient, suitable, suspended, unacceptable, or unsatisfactory,” it shall be understood that these expressions are followed by the words “By the Engineer,” or “To the Engineer.”

When the Contract indicates that something “shall” be done, the action is required and is not discretionary.

Wherever the following abbreviations or terms are used in these specifications, plans, or other contract documents, the intent and meaning shall be interpreted as follows:

101.01 Abbreviations.

	ABBREVIATIONS
AAN	American Association of Nurserymen
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AGC	Associated General Contractors of America
AI	Asphalt Institute
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
ANSI	American National Standards Institute, Inc.
ARTBA	American Road and Transportation Builders Association
ASA	American Society of Agronomy
ASCE	American Society of Civil Engineers
ASLA	American Society of Landscape Architects
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATSSA	American Traffic Safety Services Association
AWG	American Wire Gauge
AWPA	American Wood Protection Association
AWS	American Welding Society
AWWA	American Water Works Association

ABBREVIATIONS

BLM	Bureau of Land Management
CCA	Colorado Contractors Association
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
CP	Colorado Procedure
CP-L	Colorado Procedure – Laboratory
CRS	Colorado Revised Statutes, 1973, as amended
CRSI	Concrete Reinforcing Steel Institute
DBE	Disadvantaged Business Enterprise
EIA	Electronic Industries Association
EPA	Environmental Protection Agency
EEO	Equal Employment Opportunity
FHWA	Federal Highway Administration
FSS	Federal Specifications and Standards
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
IMSA	International Municipal Signal Association
IPCEA	Insulated Power Cable Engineers Association
ISEA	International Safety Equipment Association
ITE	Institute of Transportation Engineers
MASH	Manual for Assessing Safety Hardware
MIL	Military Specifications
MS4	Municipal Separate Storm Sewer System
MUTCD	Manual on Uniform Control Devices
NAPT	National Association for Proficiency Testing
NCHRP	National Cooperative Highway Research Program
NEC	National Electrical Code
NEMA	National Electrical Manufacturers' Association
NIST	National Institute of Standards and Technology
NSF	National Sanitation Foundation
NSPS	National Society of Professional Land Surveyors
NTPEP	National Transportation Product Evaluation Program
OSHA	Occupational Health and Safety Administration
PCI	Prestressed Concrete Institute
RCSC	Research Council of Structural Connections
ROW	Right of Way
SWMP	Stormwater Management Plan
SAE	Society of Automotive Engineers
TMECC	Test Method for the Examination of Composting and Compost
USDA, NRCS	US Dept of Agriculture, Natural Resources Conservation Service
UL	Underwriters Laboratories, Inc.

101.02 Definitions, alphabetically.

Advertisement. A public announcement, inviting proposals for work to be performed or materials to be furnished.

Affected Area. As related to mined land reclamation, the total disturbed surface of a pit or quarry such as sand, gravel, topsoil, or borrow, that is being mined or will be mined. The area includes, but is not limited to, the excavation area, plant, and stockpile areas, parking and storage areas, and the haul roads.

Award. The acceptance by the Department of a proposal.

Basis of Payment. The terms under which "work" is paid, as a designated "Pay Item" per the quantity measured and the "Pay Unit."

Bidder. An individual, firm, corporation, or other legal entity submitting a proposal for the advertised work. A contractor intending to contract with the Department for performance of prescribed work.

Bridge. A structure, including supports, erected over a depression or an obstruction, such as water, highway, or railroad, and having a track or passageway for carrying traffic or other moving loads and having a length measured along the center of roadway of more than 20 feet between undercopings of abutments or extreme ends of openings for multiple boxes.

Length. The length of a bridge structure is the over-all length measured along the line of survey stationing back-to-back of backwalls of abutments, if present, otherwise, end-to-end of the bridge floor, but in no case less than the total clear opening of the structure.

Roadway Width. The clear width measured at right angles to the longitudinal centerline of the bridge between the bottom of curbs or guard timbers or in the case of multiple height of curbs, between the bottoms of the lower risers.

Calendar Day. Each and every day shown on the calendar, beginning and ending at midnight. When day is used, it shall mean calendar day unless otherwise defined.

CDOT Resident Engineer. The Resident Engineer is directly responsible for the overall administration of assigned construction projects. Unless the CDOT Project Engineer is a Professional Engineer, the Resident Engineer is CDOT's full time engineer in responsible charge of the project. The Resident Engineer will delegate authority to Project Engineers consistent with their experience and abilities. Only a CDOT Resident Engineer can approve and sign vouchers for interim and final Contractor pay estimates. Only a CDOT Resident Engineer can authorize and sign changes to the Contract if the Project Engineer is a Consultant Employee.

Certificate of Compliance. A certification, including a signature by a person having legal authority to act for the manufacturer, stating that the product or assembly to be incorporated into the project was fabricated per and meets the applicable specifications.

Certified Invoice. Any invoice or billing endorsed by the Contractor, certifying that material, specialty work, subcontract work, rental, lease, and services were acquired for the project and that the invoiced or billed amount represents the actual costs.

Certified Test Report. A test report from the manufacturer or an independent testing laboratory, including a signature by a person having legal authority to act for the manufacturer or the independent testing laboratory stating that the test results show that the product or

assembly to be incorporated into the project has been sampled and tested and the samples have passed all specified tests.

Conformity. Compliance with reasonable and customary manufacturing and construction tolerances where working tolerances are not specified. Where working tolerances are specified, conformity means compliance with such working tolerances.

Construction Material: Includes an article, material, or supply — other than an item of primarily iron or steel — that is or consists primarily of non-ferrous metals; plastic and polymer-based products (including polyvinyl chloride [PVC], composite building materials, and polymers used in fiber optic cables); glass; lumber; or drywall.

Construction Drawings . A complete set of plans, reviewed shop drawings, working drawings, and other submittals kept available on the project site at all times by the Contractor.

Construction Requirements. Specifications covering performance of work required for proper completion and acceptance.

Contract. The written agreement between the State of Colorado through the Department of Transportation and the Contractor, setting forth the obligations of the parties for the performance of the work and the basis of payment.

The Contract includes the invitation for bids, proposal, contract bonds, standard specifications, supplemental specifications, special provisions, general and detailed plans, Notice to Proceed, Contract Modification Orders, and authorized extensions of time, all of which constitute one instrument.

Contract Item (Pay Item). A specifically described unit of work for which a price is provided in the Contract.

Contract Modification Order. A written order issued to the Contractor by the Department covering contingencies, extra work, increases or decreases in contract quantities, and additions or alterations to the plans or specifications, within the scope of the Contract, and establishing the basis of payment and time adjustments for the work affected by the changes. The Contract Modification Order is the only method authorized for changing the Contract. Contract Modification Orders must be approved as established in subsection 105.14.

Contract Payment Bond. The security executed by the Contractor and Surety or Sureties and furnished to the Department to guarantee payment of all legal debts of the Contractor pertaining to the Construction of the project.

Contract Performance Bond. The security executed by the Contractor and Surety or Sureties and furnished to the Department to guarantee completion of the work per the Contract.

Contract Time. The number of workdays or calendar days allowed for completion of the Contract, including authorized time extensions. Where a calendar date of completion is specified, the Contract shall be completed on or before that date.

Contractor. The individual, firm, or corporation contracting with the State of Colorado through the Department of Transportation for performance of prescribed work.

Contractor's Engineer. A professional engineer registered in the State of Colorado who is an employee of either the Contractor, a consulting engineer under contract to the Contractor, or a manufacturer or supplier of materials supplied to the project.

Control Measures for Stormwater Pollution Prevention. Control measures prevent or reduce the pollutants in stormwater discharges from the construction site.

County. The county where the work is to be done.

Culvert. Any structure not classified as a bridge that provides an opening under the roadway.

Day. See "calendar day" and "working day".

Department. State Department of Transportation. A department within the executive branch of the State of Colorado.

Domestic Content Procurement Preference: A phrase meaning that all iron and steel used in the project is produced in the United States; the manufactured products used in the project are produced in the United States; or the construction materials used in the project are produced in the United States.

Engineer. The Chief Engineer of the Department acting directly or through an authorized representative, responsible for engineering and administrative supervision of the project.

Equipment. All machinery, tools, and apparatus together with supplies for upkeep and maintenance, necessary for the proper construction and acceptable completion of the work.

Extra Work. Work not provided for in the Contract as awarded but found by the Engineer to be essential to the satisfactory completion of the Contract within its intended scope.

Falsework. Falsework is temporary construction used to support structural elements of concrete, steel, masonry, or other materials during their construction or erection until they become self-supporting. Falsework may also be used to provide temporary support to elements of a structure during demolition or reconstruction.

Finished Grade. Final grade of the site after excavating or filling for pavement or topsoil that conforms to the approved final grading plan. The finished grade is also the grade at the top of a paved or finished surface.

Force Account Work. Work paid for on the basis of actual costs plus approved additives. See subsection 109.04.

Formwork. Formwork is the temporary structure or mold used to retain plastic or fluid concrete in its designated shape until it hardens.

Highway. A general term denoting a public way for purposes of vehicular travel, including the entire area within the right of way.

Holidays. Holidays recognized by the State of Colorado are:

New Year's Day
Dr. Martin Luther King, Jr.'s Birthday (observed)
President's Day
Cesar Chavez Day
Memorial Day
Juneteenth
Independence Day
Labor Day
Cabrini Day
Veterans' Day
Thanksgiving Day
Christmas Day

When New Year's Day, Cesar Chavez Day, Juneteenth, Independence Day, or Christmas Day falls on a Sunday, the following Monday shall be considered a holiday. When one of these days falls on a Saturday, the preceding Friday shall be considered a holiday.

Infrastructure: Includes, at a minimum, the structures, facilities, and equipment for, in the United States, roads, highways, and bridges; public transportation; dams, ports, harbors, and other maritime facilities; intercity passenger and freight railroads; freight and intermodal facilities; airports; water systems, including drinking water and wastewater systems; electrical transmission facilities and systems; utilities; broadband infrastructure; and buildings and real property. Infrastructure includes facilities that generate, transport, and distribute energy.

Inspector. The Engineer's authorized representative assigned to make detailed inspections of contract performance.

Invitation for Bids. All documents, whether attached or incorporated by reference, utilized for soliciting proposals. The advertisement will indicate with reasonable accuracy the quantity and location of the work to be done or the character and quantity of the material to be furnished and the time and place of the opening of proposals.

Laboratory. The testing laboratory of the Department, or any other testing laboratory designated by the Engineer.

Materials. All components required for use in the construction of the project.

Method of Measurement. The manner in which a "Pay Item" is measured to conform with the "Pay Unit."

Notice to Proceed. Written notice to the Contractor to proceed with the contract work including, when applicable, the date of beginning of contract time.

Ordinary High-Water Mark. The term "ordinary high-water mark" means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas. This is typically the 2-year storm event elevation.

Original Contract Amount. The sum of the total dollar amounts bid for all the construction pay item quantities. In subsection 626.02 this figure is modified for use in calculating partial payments for mobilization.

Pavement Structure. The combination of one or more of the following courses placed on a subgrade to support and distribute the traffic load to the roadbed.

(1) Subbase. The layer or layers of specified or selected material placed on a subgrade to support a base course, surface course, or both. Subgrade that has been treated with lime, fly ash, cement kiln dust, or combinations thereof for stabilization will be considered subbase.

(2) Base Course. The layer or layers of specified or selected material placed on a subbase or a subgrade to support a surface course.

(3) Surface Course. One or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion, and the disintegrating effects of climate. The top layer is sometimes called "wearing course."

Planned Force Account . Items of work, included on the plans, which will be paid for per subsection 109.04.

Plans. The drawings, or reproductions, provided by the Department, showing the location, character, dimensions, and details of the work.

Pre-construction Conference. A meeting of CDOT project personnel, Contractor project personnel, and other stakeholders held before the beginning of construction, discussing pertinent topics for the successful completion of the work.

Profile Grade. The trace of a vertical plane usually intersecting the top surface of the proposed wearing surface and usually along the longitudinal centerline of the roadbed. Profile grade means either elevation or gradient of such trace per to the context.

Project. The specific section of the highway where construction is being performed, as described in the Contract.

Project Engineer. The Chief Engineer's duly authorized representative who may be a CDOT employee or an employee of a consulting engineer (consultant) under contract to CDOT as defined below:

(a) CDOT Project Engineer. The CDOT employee, assigned by the Resident Engineer, who is the Chief Engineer's duly authorized representative. The CDOT Project Engineer is in direct charge of the work and is responsible for the administration and satisfactory completion of the project under contract.

(b) Consultant Project Engineer. The consultant employee under the responsible charge of the consultant's Professional Engineer who is in direct charge of the work and is responsible for the administration and satisfactory completion of the project. The Consultant Project Engineer's duties are delegated by the CDOT Resident Engineer per the scope of work in the consultant's contract with CDOT. The Consultant Project Engineer is not authorized to sign or approve Contract Modification Orders.

Project Special Provisions. See definition for special provision.

Project Termini. Limits of the Project as shown on the plans.

Proposal. The offer of a bidder, on the prescribed form, to perform the work at the prices quoted. Also called bid.

Proposal Form. A bidder submits their bid on these Department furnished documents. Also called bid proposal.

Proposal Guaranty. The security furnished with a proposal to guarantee that the bidder will enter into the Contract if the proposal is accepted.

Record Set. A reproduction of a drawing or set of drawings, design calculations, or other record of engineering work required to be performed by the Contractor's engineer and Professional Land Surveyor, which is electronically sealed by the Contractor's engineer and Professional Land Surveyor using Adobe Sign software and per the Bylaws and Rules of the State Board of Licensure for Architects, Professional Engineers, and Professional Land Surveyors Rules and Regulations, 4 CCR 730-1.

Region Transportation Director. The Department's representative, responsible for construction, maintenance and safety activities, within the geographical jurisdiction established by the Department. The Region Transportation Director is responsible for acting on written appeals made by the Contractor relating to contract claims for additional compensation or extension of contract time.

Right of Way. A general term denoting land, property, or interest, usually in a strip, acquired for or devoted to a highway.

Road. A general term denoting a public way for purposes of vehicular travel, including the entire area within the right of way.

Roadbed. The graded portion of a highway within top and side slopes, prepared as a foundation for the pavement structure and shoulders.

Roadside. A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

Roadside Development. Those items necessary for the preservation of landscape materials and features. The rehabilitation and protection against erosion of all areas disturbed by construction through seeding, sodding, mulching and the placing of other ground covers. Suitable planting and other improvements as may increase the effectiveness and enhance the appearance of the highway.

Roadway. The portion of a highway within limits of construction.

Roadway Prism. The portion of the roadway defined as the prism of embankment situated beneath the shoulders and pavement structure and inside the lines projected downward and outward on a one-to-one slope from the outside edges of the roadway shoulders to their intersection with the base of the embankment.

Safety Critical Work . Elements of the work that, if performed improperly, could encroach upon and endanger traffic that is following all traffic regulations. Safety critical work may include work elements performed under one or more of the following situations:

- Work that is constructed on, over, or near a traffic route and could become unstable over time if installed improperly.
- Work that requires the use of lifting devices in the vicinity of traffic.
- Elements of work considered safety critical for the project will be as identified in *Section 107 – Performance of Safety Critical Work*.
- "Traffic", as used above, is defined as the vehicles, railroad, pedestrians, aircraft, and watercraft moving along a route. The route may be permanent or temporary, such as a detour.

SafetyEdge$_{SM}$ for Pavement. A pavement edge drop-off treatment which allows drivers who leave the road to return safely.

Salvable Material. Material that can be saved or salvaged. Unless otherwise specified in the Contract, all salvable material shall become the property of the Contractor.

Shop Drawings. A general term that includes drawings, diagrams, illustrations, samples, schedules, calculations, and other data that provide details of the construction of the work and details to be used by the Engineer for inspection. Shop drawings shall be prepared by the Contractor, subcontractors, manufacturers, suppliers, or distributors. Shop Drawings are submitted to the Engineer for formal review and return to the Contractor per subsection 105.02(c). Shop drawings include data that illustrates material, equipment, and items that are incorporated in and become part of the permanent work per the Contract.

Shoring. Shoring is temporary construction that is used to support the earth adjacent to excavation or embankment.

Shoulder. The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

Sidewalk. That portion of the roadway constructed for pedestrian use.

Special Provisions. Additions and revisions to the standard and supplemental specifications covering conditions specific to an individual project or group of projects. Special provisions fall within one of the two following categories and take precedence as specified in subsection 105.09.

(a) Project Special Provisions. Additions and revisions to the Standard and Supplemental Specifications, specific to the project.

(b) Standard Special Provisions. Additions and revisions to the Standard and Supplemental Specifications, specific to a selected group of projects or that are intended for temporary use.

Specifications. A general term applied to all directions, provisions and requirements pertaining to performance of the work.

(a) Standard Specifications: The Department's printed book (including errata) titled *Standard Specifications for Road and Bridge Construction*. The book is divided into three parts namely:

1. General Provisions (Division 100)
2. Construction Details (Divisions 200 thru 600)
3. Material Details (Division 700)

(b) Supplemental Specifications: Additions and revisions to the Standard Specifications that are adopted subsequent to the issuance of the printed book.

The outline for "Work" items in the Construction Details contains the following:

1. Description
2. Materials
3. Construction Requirements
4. Method of Measurement
5. Basis of Payment

Specified Completion Date. The date that the contract work is specified to be completed.

Standard Special Provisions. See definition for Special Provisions.

State. The State of Colorado acting through its authorized representative.

State Waters. State Waters means any and all surface and subsurface waters that are contained in or flow in or through this state, but does not include waters in sewage systems, waters in treatment works of disposal systems, waters in potable water distribution systems, and all water withdrawn for use until use and treatment have been completed.

Examples of State waters include, but are not limited to, perennial streams, intermittent or ephemeral gulches and arroyos, ponds, lakes, reservoirs, irrigation canals or ditches, wetlands, stormwater conveyances (when they discharge to a surface water), and groundwater.

Note that for the purposes of these specifications "surface waters" means all State waters, except groundwater.

Stormwater Management Plan (SWMP). The Stormwater Management Plan comprises those contract documents containing the requirements necessary to accomplish all the following:

- Protect and identify sensitive environments (state waters, wetlands, habitat, and existing vegetation).
- Minimize the amount of disturbed soil.
- Control and minimize erosion and sedimentation during and after project construction.
- Minimize runoff from offsite areas from flowing across the site.
- Slow down the runoff.
- Reduce pollutants in stormwater runoff.

Street. A general term denoting a public way for purposes of vehicular travel, including the entire area within the right of way.

Structures. Bridges, culverts, catch basins, drop inlets, retaining walls, cribbing, manholes, endwalls, buildings, storm drains, service pipes, underdrains, foundation drains, fences, guardrail, signs, end sections, traffic signals, light standards, and other features that may be encountered in the work and not otherwise classified.

Subcontractor . An individual, firm, corporation, or other legal entity to whom the Contractor sublets part of the Contract. A subcontractor shall include an individual, firm, or corporation who meets one or both of the following criteria:

(a) Establishes a fabricating process or facility exclusively for the use of the Project, whether on or off the site of work per 29 CFR 5.2(l)(1) and 29 CFR 5.2(l)(2).

(b) Performs work that is incorporated within the Project limits.

Subgrade. The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed. Subgrade that has been treated with lime, fly ash, cement kiln dust, or combinations thereof for stabilization will be considered subbase.

Substructure. All of the structure below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames, together with the backwalls, wingwalls, and wing protection railings.

Superintendent. The Contractor's authorized employee in responsible charge of the work.

Superstructure. The entire structure except the substructure, as defined.

Supplier. An individual, firm, or corporation who meets one or both of the following criteria:
(a) Fabricates or processes a material not on the site of work per 29 CFR 5.2(l)(3).
(b) Delivers material directly to the project.

In both cases, the material shall be intended for permanent incorporation into the worksite.

Supplemental Specifications. See definition for Specifications.

Surety. The corporation, partnership, or individual, other than the Contractor, executing a bond furnished by the Contractor.

Traffic Control Plan (TCP). The parts of the contract documents for each project that contain the requirements for the maintenance of traffic during construction of the project.

Traveled Way. The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

Value Engineering Change Proposal (VECP). A change to contract requirements proposed by the Contractor that will accomplish the project's functional requirements at less cost or improve value or service at no increase or at a minor increase in cost.

Wheel Path. Wheel paths are the two sections of each through-traffic lane that bear the wheel loading. The center of each wheel path is located 3 feet from the center of the lane; each wheel path is 2 feet wide.

Work. The furnishing of all labor, materials, equipment, and incidentals necessary to successfully complete the project according to all duties and obligations imposed by the Contract.

Working Day. Any day, exclusive of Saturdays, Sundays, and holidays, that weather and other conditions not under the control of the Contractor will permit construction operations to proceed with the normal working force engaged in performing those items controlling the completion of the work.

Working Drawings. A general term that includes drawings, diagrams, illustrations, samples, schedules, calculations, and other data that illustrate the construction of the work, material, equipment, methods, and items that are necessary to construct the work per the plans and specifications. Working drawings shall be prepared by the Contractor, subcontractors, manufacturers, suppliers, or distributors. Working drawings are submitted to the Engineer for information only and are not formally reviewed and returned to the Contractor.

Workplace Violence. Workplace violence is conduct in the workplace against employees, employers, or outsiders committed by a person who either has an employment related connection with CDOT or is a contractor working on a CDOT project. This conduct includes:

(1) Physical acts against persons or their property, or against CDOT or Contractor property that are perceived to be harmful or threatening.

(2) Veiled or direct verbal threats, profanity, or vicious statements or gestures that are meant to harm or create a threatening or intimidating work environment.

(3) Written threats, profanity, vicious cartoons or notes that are meant to create a threatening or intimidating environment.

(4) Any other acts that are perceived to be threatening or intended to injure or convey hostility.

SECTION 102
BIDDING REQUIREMENTS
AND CONDITIONS

102.01 Prequalification of Bidders. The bidder shall follow the prequalification and bidding procedures contained in the Rules Governing Construction Bidding for CDOT Public Works Projects, 2 CCR 601-10, ("Rules"), on file with the Colorado Secretary of State. Copies are available upon request in the Contracts and Market Analysis Branch of the Department.

Only prequalified bidders will be allowed to bid on any project. At least 10 days before opening of proposals, the bidder must file an experience questionnaire and a confidential financial statement on standard forms furnished by the Department.

102.02 Contents of Proposal Forms. The Department will publish bidding opportunities to prospective bidders on the CDOT Business Center website. The forms on this website will state the location and description of the contemplated construction and will show the estimate of the various quantities and types of work to be performed or materials to be furnished and will have a schedule of items inviting unit bid prices. The proposal form will state the time that the project must be completed, the amount of the proposal guaranty, and the date, time, and place of the opening of proposals.

All bidders on projects shall submit electronic bids only. Innovative delivery method projects such as Design-Build, CMGC and Best Value, are not subject to this electronic bidding requirement.

The plans, specifications, and other documents designated in the proposal form, will be considered a part of the proposal.

The prospective bidder shall pay the Department the sum stated in the Invitation for Bids for each paper set of plans.

102.03 Interpretation of Quantities in Proposal Form. Except as otherwise provided in this subsection and the method of measurement for individual items, the quantities appearing in the proposal form are estimates prepared for the comparison of proposals. Payment to the Contractor will be made per the following procedures:

(a) Measurement required. When the Contract requires measurement of work performed or material furnished, payment will be made for actual quantities measured and accepted.

(b) Measurement Not Required. When the Contract does not require quantities of work performed or materials furnished to be measured, payment will be made for the quantities appearing in the Contract.

The estimated quantities of work to be performed and materials to be furnished may be increased, decreased or omitted.

102.04 Interpretation of Plans and Specifications Any changes to proposal forms, plans, or specifications before the opening of proposals will be issued by the Department through posting of the changes on the Department's Schedule Bid Openings web page, Business Management System (B2GNow), and the Electronic Bid System. Certain individuals are named in the project specifications who have authority to provide information, clarification or interpretation to bidders before opening of proposals. Information obtained from persons other than those named individuals is invalid and shall not be used for bidding purposes.

102.05 Examination of Plans, Specifications, Special Provisions, and Site of Work. The bidder is expected to examine the site of the proposed work, the proposal, plans, specifications, supplemental specifications, special provisions, and contract forms, before submitting a proposal. The submission of a proposal will be considered conclusive evidence that the bidder has made this examination and is aware of the conditions to be encountered in performing the work according to the Contract.

Boring logs, utility mapping, and other records of subsurface investigations, if they exist, are available for inspection by bidders. These logs and records are made available so that all bidders have access to identical subsurface information that is available to the Department. These items are not intended as a substitute for personal investigation, interpretation, and judgment of the bidders.

The Department does not warrant the adequacy of boring logs, utility mapping, and other records of subsurface investigations, and such information is not considered to be a part of the Contract. When a log of test borings is included in the subsurface investigation record, the data shown in the individual log of each test boring applies only to that particular boring and is not intended to be conclusive as to the character of any material between or around test borings. When utility mapping is included, the information shown will be identified as Quality Level A/B/C/D per the most recent version of the ASCE Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data (CI/ASCE 38-02). Utility location depictions are only valid at the time of collection, and it is the Contractor's sole responsibility to verify all utility locations before beginning the work. If bidders use this information in preparing a proposal, it is used at their own risk, and bidders are responsible for all conclusions, deductions, and inferences drawn from such information.

Bidders may conduct subsurface investigations at the project site at bidder's expense; the Department will afford them this opportunity before public opening of proposals.

If a bidder discovers an apparent error or omission in the proposal form, estimated quantities, plan, or specifications, the bidder shall immediately notify the Engineer to enable the Department to make any necessary revisions. The Department may consider it to be detrimental to the Department for a bidder to submit an obviously unbalanced unit bid price. See subsection 102.07.

102.06 Preparation of Proposal. The bidder shall submit the proposal (bid) upon the forms furnished by the Department per the "Rules" referenced in subsection 102.01.

102.07 Irregular Proposals. Proposals (bids) will be considered irregular and may be rejected for any of the following reasons:

(1) If the proposal is on a form other than that prescribed by the Department, or if the form is altered or any part thereof is detached, or if the form does not contain original signatures.

(2) If there are unauthorized additions, conditional or alternative proposals, or irregularities of any kind that may tend to make the proposal incomplete, indefinite, or ambiguous.

(3) If the bidder fails to acknowledge in the proposal the receipt of all revisions current on the date of opening of proposals.

(4) If the proposal does not contain a unit price for each pay item listed except in the case of authorized alternative pay items, the mathematical products of the respective unit prices and the estimated quantities, and the total amount of the bid obtained by adding such mathematical products.

(5) If the Department determines that any of the unit bid prices are materially unbalanced to the potential detriment of the Department. There are two types of unbalanced bids: (1) mathematically unbalanced and, (2) materially unbalanced. The mathematically unbalanced bid is a bid containing lump sum or unit pay items that do not reflect reasonable actual costs plus a reasonable proportionate share of the bidder's anticipated profit, overhead costs, and other indirect costs, but not necessarily to the detriment of the Department. These costs should all relate to the performance of the items in question. The materially unbalanced bid is a mathematically unbalanced bid that the Department determines leaves reasonable doubt that award will result in the lowest ultimate cost to the Department, or that award is in the public interest.

(6) If the Contractor submitting the bid is affiliated with another bidder that has submitted a bid on the same public project.

(7) If the bidder has been sent a notice of intent to revoke prequalification under Chapter Two of the "Rules."

(8) If the bidder has been asked in writing to show why it should not be found in default on a Department contract.

(9) If the bidder has been sent a notice of intent to debar or of suspension under Chapter Three of the "Rules."

The Department reserves the right to reject any or all bids, to waive technicalities or to advertise for new bids, if in the judgment of the Department its best interests will be promoted thereby.

102.08 Combination or Conditional Proposals. If proposal forms are issued for projects in combination and separately, the bidder may submit proposals either on the combination or on separate units of the combination. The Department reserves the right to make awards on combination or separate proposals to the advantage of the Department. Combination proposals will be considered, only when specified.

102.09 Anti-Collusion Affidavit. Every proposal (bid) submitted to the Department shall contain a statement certifying that the bidder has not participated in any collusion or taken any action in restraint of free competitive bidding. This statement shall be in the form of an affidavit provided by the Department and signed by the bidder.

The original of the signed anti-collusion affidavit, Form 606, shall be submitted with the proposal. The proposal will be rejected if it does not contain the completed Form 606.

102.10 Material Guaranty. The successful bidder may be required to furnish a complete statement of the origin, composition, and manufacture of materials used in the construction of the work together with samples, which will be tested for conformance with Contract provisions.

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SECTION 103

AWARD AND EXECUTION OF CONTRACT

103.01 Consideration of Proposals. After the proposals (bids) are opened and read, they will be evaluated, and the Contract awarded or rejected per the "Rules" referenced in subsection 102.01.

The low responsible bidder shall submit a completed CONTRACTORS PERFORMANCE CAPABILITY STATEMENT, Form 605, and a completed ASSIGNMENT OF ANTITRUST CLAIMS, Form 621, to the Award Officer before 4:30 P.M. on the fifth calendar day after the bid opening.

To be eligible for contracting with CDOT, the apparent low responsible bidder shall have an account in the B2GNow software system.

Failure to submit the Forms 605 and 621 and to have an account in the B2GNow software system may result in the denial of award to the apparent low responsible bidder and forfeiture of the proposal guaranty.

103.02 Award of Contract. If the Contract is awarded, the award will be made within 30 calendar days after the opening of proposals to the lowest bidder whose proposal complies with all the requirements prescribed. The successful bidder will be notified in writing of the acceptance of the proposal and the award of the Contract.

103.03 Requirement of Contract Bonds. At the time of the execution of the Contract, the successful bidder shall furnish a Contract Payment Bond and a Contract Performance Bond. Each bond shall be in a penal sum equal to the nearest integral one hundred dollars in excess of the sum of the original bid items plus all force account items specified in the project special provisions to be included in the payment and performance bonds. The Contract Payment Bond and the Contract Performance Bond shall remain in full force and effect for the term of the Contract. The bonds and the security shall be acceptable to the Department.

103.04 Execution and Approval of Contract. The Contract shall be signed and returned by the successful bidder together with the contract bonds, within 15 days after the date of award. If the signed Contract and bonds are returned by the successful bidder within 15 days after award and, if the Contract is not executed by the Department within 30 days from date of award, the bidder shall have the right to withdraw the proposal without penalty. The Contract will not be considered effective until it has been fully executed by all of the parties to the Contract.

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SECTION 104

SCOPE OF WORK

104.01 Intent of Contract. The Contractor shall complete the work described and furnish all labor, materials, equipment, tools, transportation, and supplies required to complete the work per the Contract. Alterations of plans or the nature of the work will not involve or require work beyond the termini of the original project, until a Contract Modification Order has been executed.

104.02 Differing Site Conditions, Suspensions of Work, and Significant Changes in the Character of Work.

(a) Differing Site Conditions. During the progress of work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the Contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before the site is disturbed and before the affected work is performed.

Upon written notification, the Engineer will investigate the conditions, and if the Engineer determines that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the Contract, an adjustment, excluding anticipated profits, will be made and the Contract modified in writing accordingly. The Engineer will notify the Contractor of the determination whether or not an adjustment of the Contract is warranted. No Contract adjustment that results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice.

(b) Suspensions of Work Ordered by the Engineer. If the performance of all or any portion of the work is suspended or delayed by the Engineer in writing for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation, contract time, or both are due as a result of such suspension or delay, the Contractor shall submit to the Engineer in writing a request for adjustment within seven calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

Upon receipt, the Engineer will evaluate the Contractor's request. If the Engineer agrees that the cost, time required, or both for the performance of the Contract has increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the Contractor, its suppliers, or subcontractors at any approved tier, and not caused by weather, the Engineer will make an adjustment (excluding profit) and modify the Contract in writing accordingly. The Engineer will notify the Contractor of the determination whether or not an adjustment of the Contract is warranted. No Contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time prescribed.

No Contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided for or excluded under any other term or condition of this Contract.

(c) Significant Changes in the Character of Work. The Engineer reserves the right to make, in writing, at any time during the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the project. Such changes in quantities and alterations shall not invalidate the Contract nor release the surety, and the Contractor agrees to perform the work as altered.

If the alterations or changes in quantities significantly change the character of the work under the Contract, whether such alterations or changes are in themselves significant changes to the character of the work, or by affecting other work cause such other work to become significantly different in character, an adjustment, excluding loss of anticipated profit, will be made to the Contract. The basis for the adjustment shall be agreed upon before the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

If the alterations or changes in quantities do not significantly change the character of the work to be performed under the Contract, the altered work will be paid for as provided elsewhere in the Contract. The term "significant change" shall be construed to apply only to the following circumstances:

(1) When the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction, or

(2) When a major item of work is increased in excess of 125 percent or decreased below 75 percent of the original contract quantity. Any allowance for an increase in quantity shall apply only to that portion in excess of 125 percent of original contract item quantity, or in case of a decrease below 75 percent, to the actual amount of work performed. A major item is defined to be any item having an original contract value in excess of 10 percent of the original contract amount.

104.03 Extra Work. The Contractor shall perform unforeseen work, for which there is no price included in the Contract, whenever the extra work is necessary or desirable for contract completion. This work shall be performed per the Contract and as directed and will be paid for as provided under subsection 109.04.

104.04 Maintaining Traffic. Unless otherwise provided, the Contractor shall keep the road open to all traffic per the Traffic Control Plan during the progress of the work. The Contractor shall schedule construction operations so that only one side of the existing roadbed is denied to traffic at any time. The Contractor shall also provide and maintain in a safe condition temporary approaches or crossings and intersections with trails, roads, streets, businesses, parking lots, residences, garages, and farms. The road and the intersections of the access points shall be maintained in a manner that will safely and adequately accommodate traffic.

The Contractor shall not store materials or equipment nor park vehicles on the highway except in designated areas. The Contractor shall not have materials or equipment in the traffic lanes open to traffic at any time unless directed.

Portions of the roadway that are not included in the contract work will be maintained by the Department. Snow removal will be the responsibility of the Department. The Contractor shall be responsible for maintaining all work that is included in the Contract, and maintaining approaches, crossings, intersections, and other features as may be necessary to accommodate traffic without direct compensation, except as provided in the Contract or described in (a) and (b) below.

(a) *Approved Detours.* The cost of constructing detours and temporary bridges, and the removal of temporary bridges and obliteration of the detour road will be paid for at the appropriate unit bid prices for the items of work involved.

Maintenance requirements, as approved, will be paid for by the appropriate bid item; however, if a bid item does not exist, then payment will be made as provided in subsection 104.03.

(b) *Maintaining Traffic During Suspension of Work.* During any suspension ordered by the Engineer per subsection 105.01, the Contractor shall open to traffic the portions of the project as directed. Before allowing traffic on the project, the Contractor shall prepare the roadbed so that it will safely and adequately accommodate traffic. During the suspension period, the maintenance of the roadway will be the responsibility of the Department. However, when the suspension is the result of a failure by the Contractor, all costs for maintenance of traffic during the suspension period shall be borne by the Contractor. When the suspension is lifted, the Contractor shall renew any work or replace materials lost or damaged on the project and shall remove, as directed, work or materials used during the suspension. The Contractor shall complete the project as though the prosecution of the work had been continuous and without interference. All additional work caused during the suspensions, for reasons beyond the Contractor's control, will be paid for as provided in subsection 104.02 when contract unit prices exist, or as extra work as provided in subsection 104.03 when no unit price exists.

(c) *Maintaining Traffic During Free Time.* During the free time period, if provided for in the Contract, the Contractor shall be responsible for maintaining traffic control items as long as construction operations interfere with traffic. When construction operations that interfere with traffic cease, the Contractor shall notify the Engineer, in writing, and shall adhere to the same procedures as in paragraph (b) above. The Contractor shall notify the Engineer, in writing, when construction operations that interfere with traffic will resume and shall resume responsibility for maintaining traffic.

(d) *Maintenance Directed by the Engineer.* If the Engineer directs special maintenance for the benefit of the traveling public, that is not included in the Contract, the Contractor will be paid per subsection 104.02 when contract unit prices exist, or as extra work, per subsection 104.03, when no contract unit prices exist. The Engineer will determine the work to be classed as special maintenance.

104.05 Rights in and Use of Materials Found on the Work. The Engineer may authorize the Contractor's use of materials found in the excavation for completing pay items other than excavation. Payment will be made for both the excavation of such materials at the corresponding contract unit price, and for the pay item that the excavated material is used. The Contractor shall replace the removed material with acceptable material at no additional cost to the Department. The Department will not charge the Contractor royalty or additional cost of select material for the removed material. The Contractor shall not excavate or remove any material from within the roadway that is not within the grading limits, as indicated by the slope and grade lines, without written authorization from the Engineer.

Unless otherwise provided, the material from structures designated for removal shall be the Contractor's property and may be used temporarily by the Contractor in the erection of the new structure.

104.06 Final Cleaning Up. Before final acceptance, the highway, material pits, and all ground occupied by the Contractor in connection with the project shall be cleaned of all rubbish, excess materials, temporary structures, and equipment; and all parts of the work shall be left in an acceptable condition. The cost of final cleanup will not be paid for separately but shall be included in the work.

104.07 Value Engineering Change Proposals by the Contractor. The Contractor is encouraged to develop and offer proposals for improved construction techniques, alternative materials, and other innovations. Proposals must provide a project comparable to CDOT's original design either at lower cost, improved quality, or both. Proposals that lower the quality of the intended project will be rejected. Bid prices shall not be based on the anticipated approval of a Value Engineering Change Proposal (VECP). Proposals shall be submitted only by the successful bidder after contract award. If a VECP is rejected, the work shall be completed per the Contract at contract bid prices. Any delay to the project due to a VECP submittal and review shall be considered within the Contractor's control and will be nonexcusable with the exception of those delays that are approved as part of the VECP.

Proposals shall be categorized as VECP (Category A) or VECP (Category B).

VECPs (Category A) will be all proposals that involve the design and construction of a structure including but not limited to a bridge, retaining wall, concrete box culvert, or building. A VECP (Category A) will also include any proposal that would result in a change of original bid items that totals over $250,000. Alternatives investigated and not selected in the project Structural Selection Reports may be presented in a VECP if significant benefits can be demonstrated to the Engineer. In addition, design criteria and constraints listed in the Structural Selection Report cannot be modified or relaxed as part of a VECP unless significant and previously unknown benefits can be proven to the Engineer. Experimental or demonstration-type design concepts, products, structures, or elements that have not been pre-approved by CDOT, in writing, for general use will be considered a VECP (Category A). Category A proposals will also result in a realized and shared cost savings to CDOT. Cost savings generated to the Contract as a result of VECP offered by the Contractor and accepted by CDOT shall be shared between the Contractor and CDOT.

All other VECPs that do not meet the previous requirements will be classified as a VECP (Category B).

Net cost savings on VECPs that are less than $25,000 can be kept by the Contractor. Net cost savings greater than $25,000 shall be split equally between the Contractor and CDOT as defined in the Basis of Payment section of this specification.

Both VECP (Category A) and VECP (Category B) will produce savings to CDOT or provide improved project quality without impairing essential functions and characteristics of the facility. Essential functions include but are not limited to service life, requirements for planned future development, prior commitments to governmental agencies or the public, corridor requirements, economy of operation, ease of maintenance, desired appearance, safety, and impacts to the traveling public or to the environment during and after construction.

The Contractor may submit either a full VECP or a preliminary Conceptual VECP, followed by a full proposal. These proposals are subject to rejection at any time if they do not meet the criteria outlined in this subsection.

(a) Submittal of Conceptual Proposal. For a VECP (Category A) that requires a significant amount of design or other development resources, the Contractor may submit an abbreviated Conceptual Proposal for preliminary evaluation. The Engineer will evaluate the information provided. The Contractor will then be advised in writing if any conditions or parameters of the Conceptual Proposal are found to be grounds for rejection. Preliminary review of a conceptual proposal reduces the Contractor's risk of subsequent rejection but does not commit CDOT to eventual approval of the full VECP. The following information shall be submitted for each Conceptual Proposal:

1. Statement that the proposal is submitted as a Conceptual VECP.
2. General description of the difference between the existing Contract and the proposed change, and the advantages and disadvantages of each, including effects on service life, requirements for planned future development, prior commitments to governmental agencies or the public, corridor requirements, economy of operation, ease of maintenance, desired appearance, safety, and impacts to the traveling public or to the environment during and after construction. The Contractor shall request in writing the necessary information from the Engineer.
3. One set of conceptual plans and a description of proposed changes to the Contract specifications.
4. Estimate of the anticipated cost savings or increase.
5. Statement specifying the following:
    A. When a response to the conceptual proposal from the CDOT is required to avoid delays to the existing contract prosecution.
    B. The amount of time necessary to develop the full Proposal.
    C. The date that a Contract Modification Order must be executed to obtain maximum benefit from the Proposal.
    D. The Proposal's impact on time for completing the Contract.

(b) Submittal of Full Value Engineering Change Proposal. The following materials and information shall be submitted for both Category A and Category B VECPs:

1. A statement that the proposal is submitted as a VECP:
2. A description of the difference between the existing Contract and the proposed change, and the advantages and disadvantages of each, including effects on service life, requirements for planned future development, prior commitments to governmental agencies or the public, corridor requirements, economy of operation, ease and cost of maintenance, desired appearance, safety, and impacts to the traveling public or to the environment during and after construction. The Contractor shall request in writing the necessary information from the Engineer.
3. A complete set of plans and specifications showing the proposed revisions relative to the original Contract. This portion of the submittal shall include design notes and construction details. The Contractor's Engineer shall electronically seal the proposed plans and specifications.

4. A cost comparison, summarizing all of the items that the proposed VECP replaces, reduces, eliminates, adds, or otherwise changes from the original Contract work, including all impacts to traffic control, detours and all other changes. The cost comparison shall not include cost savings resulting from purportedly decreased inspection or testing requirements, or CDOT overhead. All costs and proposed unit prices shall be documented by the Contractor.
5. A statement specifying the date that a Contract Modification Order must be executed to obtain the maximum cost reduction during the remainder of the Contract and the date when a response from CDOT is required to avoid delays to the prosecution of the Contract.
6. A statement detailing the effect the Proposal will have on the time for completing the Contract.
7. A description of any previous use or testing of the proposed changes and the conditions and results. If the Proposal was previously submitted on another CDOT project, the proposal shall indicate the date, Contract number, and the action taken by CDOT.
8. An estimate of any effects the VECP will have on other costs to CDOT.
9. A statement of life cycle costs, when appropriate. Life cycle costs will not be considered as part of cost savings but shall be calculated for additional support of the Proposal. A discount rate of four percent shall be used for life cycle calculations.

(c) Evaluation. VECP will be evaluated by CDOT per the CDOT *Construction Manual*.

Additional information needed to evaluate Proposals shall be provided in a timely manner. Untimely submittal of additional information will result in rejection of the Proposal. Where design changes are proposed, the additional information shall include results of field investigations and surveys, design and computations, and changed plan sheets required to develop the design changes.

1. The Engineer will determine if a Proposal qualifies for consideration and evaluation. The Engineer may reject any Proposal that requires excessive time or costs for review, evaluation, or investigation. The Engineer may reject proposals that are not consistent with CDOT's design criteria for the project.
2. VECPs, whether or not approved by CDOT, apply only to the ongoing Contracts referenced in the Proposal and become the property of CDOT. Proposals shall contain no restrictions imposed by the Contractor on their use or disclosure. CDOT has the right to use, duplicate and disclose in whole or in part any data necessary for the utilization of the Proposal. CDOT retains the right to utilize any accepted.

   Proposal or part thereof on other projects without obligation to the Contractor. This provision is subject to rights provided by law with respect to patented materials or processes.
3. If CDOT is already considering revisions to the Contract or has approved changes in the Contract that are subsequently proposed in a VECP, the Engineer will reject the Proposal and may proceed to implement these changes without obligation to the Contractor.
4. The Contractor shall have no claim against CDOT for additional costs or delays resulting from the rejection or untimely acceptance of a VECP. These costs include but are not limited to development costs, loss of anticipated profits, increased material or labor costs, or untimely response.

5. Proposals will be rejected if equivalent options are already provided in the Contract.
6. Proposals that only reduce or eliminate contract pay items will be rejected.
7. The cost savings and other benefits generated by the Proposal must be sufficient to warrant review and processing, as determined by the Engineer.
8. A proposal changing the type or thickness of the pavement structure will be rejected.
9. No VECP proposal can be used to alter incentive and disincentive rates and maximums on Cost plus Time bid (A+B) projects.
10. Right of way cannot be bought as part of a VECP to eliminate phasing on a project.
11. A VECP changing the design of a structure may be considered by CDOT, if the design meets the following conditions:
    A. The design shall not involve detouring of traffic onto local roads or streets to an extent greater than the original plans, unless previously approved by the affected local agencies.
    B. The design has the same roadway typical section as the original plans.
    C. The design meets or exceeds the benefits of the construction-handling or traffic phasing scheme shown in the original plans.
    D. The design meets or exceeds all environmental commitments and permit requirements of the original Contract.
    E. The design shall not increase environmental impacts beyond those of the original Contract.
    F. The design meets or exceeds the vertical and horizontal clearances and hydraulic requirements shown on the original plans.
    G. The design has the same or greater flexibility as the original design to accommodate future widening.
    H. The design shall not change the location of the centerline of the substructure elements, without demonstrating substantial benefits over the original plans.
    I. The design shall not change the grade or elevation of the final riding surface, without demonstrating substantial benefits over the original plans.
    J. The design shall match corridor future development plans and architectural, aesthetic and pavement requirements, if applicable.
    K. The design shall not adversely impact CDOT's Bridge Inspection, maintenance, or other long-term costs or operations.
    L. The design shall meet all CDOT design standards and policies.
    M. The design shall include all additional costs and coordination necessary to relocate utilities.
    N. Major structure designs provided by the Contractor shall include an independent plan review and design check by a Professional Engineer licensed in the State of Colorado and employed by a firm other than the engineer-of-record. This design review will be performed at the Contractor's expense and shall be included in the Contractor's engineering costs.

O. The Contractor shall provide CDOT with all design calculations, independent design check calculations, a rating package for each bridge prepared per the current CDOT Bridge Rating Manual, and a record set of quantity calculations for each structure.

If a structure design VECP meets these and all other requirements, CDOT may, at its sole option, accept or reject the proposal.

12. The Engineer will reject all or any portion of the design or construction work performed under an approved VECP if unsatisfactory results are obtained. The Engineer will direct the removal of such rejected work and require construction to proceed under the original Contract requirements without reimbursement for work performed under the proposal, or for its removal.

(d) Basis of Payment. If the VECP is accepted, a Contract Modification Order will authorize the changes and payment. Reimbursement will be made as follows:

1. The changes will be incorporated into the Contract by changes in quantities of unit bid items, new agreed unit price items, lump sum or any combination, as appropriate, under the Contract. Unless there is a differing site condition as described in subsection 104.02, the Contractor shall not receive additional compensation for quantity overruns, design errors, supplemental surveys, geotechnical investigations, additional items, or other increases in cost that were not foreseen in the accepted VECP unless otherwise approved by the Engineer.

2. For all VECPs, the incentive payment shall be calculated as follows:

   (gross cost of deleted work) - (gross cost of added work) = (gross savings)

   (gross savings) - (Contractor's engineering costs) - (CDOT's engineering costs) = (net savings)

   Any net savings less than $25,000 can be kept by the Contractor.

   If the net savings are greater than $25,000 then the amount over $25,000 will be shared equally with CDOT and calculated as follows:

   (net savings) - $25,000 = shared savings

   Contractor's total incentive = (shared savings) /2 + $25,000

   The Contractor's engineering costs will be reimbursable only for outside consultant costs that are verified by certified billings. CDOT's engineering costs shall be actual consultant costs billed to CDOT and extraordinary in-house personnel labor costs. These labor costs will be calculated at the fixed amount of $50 per hour per employee. Project personnel assigned to the field office or who work on the project on a regular basis shall not be included in CDOT''s portion of the cost.

3. At the completion of the VECP design work, the Contractor shall furnish CDOT any additional documentation such as surveys, geotechnical reports, documentation, or calculations and shop drawings required to complete the work.

   At the completion of the project, the Contractor shall furnish CDOT with Professional Engineer electronically sealed Record sets, and As-Constructed plans showing the VECP work.

(e) Contractor Appeal Process. Appeals can be made only on VECPs (Category A). The Prime Contractor submitting the VECP may file a one-time appeal to the Region Transportation Director (RTD) on the denial of any VECP (Category A). The Contractor must have a valid reason for the appeal and the decision of the Region Transportation Director will be final.

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SECTION 105

CONTROL OF WORK

105.01 Authority of the Engineer. The Engineer will decide all questions regarding the quality and acceptability of materials furnished, work performed, and the rate of progress of the work; all interpretation of the plans and specifications; and the acceptable fulfillment of the Contract.

The Engineer will, in writing, suspend the work, wholly or in part:

(1) For failure of the Contractor to correct conditions unsafe for the workers or the general public.
(2) For failure to carry out Contract provisions.
(3) For failure to carry out orders.
(4) For periods of unsuitable weather.
(5) For conditions unsuitable for the completion of the work.
(6) For any other condition or reason determined to be in the public interest.

105.02 Plans, Shop Drawings, Working Drawings, Other submittals, and Construction Drawings.

(a) Plans. The Contract plans will show lines, grades, typical cross sections of the roadway, location and design of all structures, and summary of items appearing on the proposal. Only general features will be shown for steel and prestressed concrete bridges.

(b) Shop drawings, Working Drawings, and Other Submittals - General. All work shall be performed per the plans, reviewed shop drawings, working drawings, or other submittals. Specific requirements for the required shop drawings, working drawings, and other submittals for this project are contained in the specifications.

The Contractor shall be responsible for the accuracy of all dimensions and quantities shown on the shop drawings, working drawings, and other submittals. The Contractor shall correlate all information in the Contract, in the submittals, and in all revisions at the project site to ensure that there are no conflicts and that the work can be constructed as shown. The Contractor shall be responsible for all information that pertains to the fabrication processes and methods of construction.

Shop drawings, working drawings, and other submittals shall be delivered to the Engineer. The Contractor shall notify the Engineer, in writing, at the time of submittal of shop drawings, working drawings, and other submittals, of any information submitted that deviates from the requirements of the plans and specifications. In addition, specific notation of the deviations or changes from the plans and specifications shall be placed on the shop drawing, working drawing, or other submittal.

The first sheet or page of each set of shop drawings, working drawings, and other submittals shall be stamped “Approved for Construction” and signed and electronically sealed by the Contractor. Submittals shall be made in complete packages, which will allow the Engineer to properly review them for general compliance with the Contract and to effectively evaluate the proposed methods of construction. The allowed time for review shall not begin until such submittals are complete.

The format of the shop drawings, working drawings, and other submittals shall be as follows:

1. Electronic shop drawings and working drawings are preferred.
2. All manually drafted shop drawings and working drawings shall be 34 inches long by 22 inches wide overall. There shall be a 2-inch margin on the left side of the sheet and a 1/2-inch margin on the other three sides. A blank space, 6 inches long by 3 inches wide, shall be left available near the lower right-hand corner of shop drawings, for the Engineer's review stamp. Computer drafted 11-inch by 17-inch drawings may be submitted.
3. There shall be a title block in the lower right-hand corner of each sheet. The title block shall show the project number, structure number, the location of the structure, the contents of the sheet, designer/engineer, sheet number, and revision number.
4. Design notes, calculations, lists, reports, descriptions, catalog cuts, and other non-drawing submittals shall be submitted on 8 1/2-inch by 11-inch sheets.
5. Unless otherwise specified, seven sets of shop drawings, and other submittals shall be submitted to the Engineer. One additional set of shop drawings shall be submitted for each railroad company.
6. Unless otherwise specified, two sets of working drawings shall be submitted to the Engineer.
7. The shop drawings, working drawings, other submittals and all revisions shall be signed and electronically sealed for the Contractor, by a professional engineer registered in the state of Colorado when required by the specifications. Submittals without the required signature and seal will not be accepted and will be returned to the Contractor without action.

   Table 105-1 summarizes the minimum required submittals is included at the end of subsection 105.02. Table 105-1 lists submittals in one location for information. The table clarifies the type of submittal and whether the Contractor's Engineer must sign and electronically seal the submittal. Table 105-1 may not be all inclusive. The Contractor shall provide all submittals required by the Contract, including those not listed in the table.

(c) Shop Drawings. The Contractor shall provide shop drawings to adequately control the work. The Contractor shall submit shop drawings to the Engineer for formal review.

The Engineer will review the shop drawings to evaluate that general conformance with the design concept and that general compliance with the information given in the plans and specifications has been achieved. The review does not extend to accuracy of dimensions, means, methods, techniques, sequences, schemes, procedures of construction, or to safety precautions. The review by the Engineer is not a complete check. Review of the shop drawings does not relieve the Contractor of the responsibility for the correctness of the shop drawings. All work done before the Engineer's review of shop drawings shall be at the Contractor's sole risk.

The Engineer may request additional details and require the Contractor to make changes in the shop drawings that are necessary to conform to the provisions and intent of the plans and specifications without additional cost to the Department.

After review, the Engineer will return two sets of shop drawings, for use by the Contractor and the Fabricator or Supplier. Returned shop drawings will be stamped with the Engineer's review stamp to indicate one of the following:

STATUS OF RETURNED SHOP DRAWINGS AND MEANINGS

Reviewed, no exception taken	Shop drawings have been reviewed and do not require additional review.
Reviewed, revise as noted	Shop drawings have been reviewed and the Contractor shall incorporate the comments noted in the shop drawings into the work. The shop drawings do not require additional review.
Resubmit, revise as noted	Shop drawings require correction or redrawing and shall be resubmitted for review. If shop drawings are returned for correction or redrawing, corrections shall be made, and the shop drawings shall be resubmitted by the Contractor in the same manner as the first submittal. Specific notation shall be made on the shop drawings to indicate the revisions.

The time required for the Engineer's review of each submittal will not exceed four weeks after a complete submittal of shop drawings is received by the Engineer. It is the intent of these specifications that no more than two submittals of shop drawings shall be required for any one particular item. If additional submittals are required by actions of the Contractor, resulting delays shall be the responsibility of the Contractor. If additional submittals are required by the Engineer's actions or if shop drawing review is delayed by the Engineer, the Contractor may request an extension of time as provided in subsection 108.08.

All revisions made to the shop drawings after the Engineer's initial review process will require resubmittal.

(d) Working Drawings. The Contractor shall supplement the plans with working drawings to detail the construction or to provide the Engineer with information on the proposed methods of construction.

Unless otherwise specified, the Contractor shall submit two sets of working drawings to the Engineer for information only. These drawings will not be formally reviewed by the Engineer. The Contractor shall submit working drawings to the Engineer10 days before the start of work. Working drawings will not be returned to the Contractor.

(e) Other Submittals. Other submittals shall be prepared and submitted by the Contractor as defined for working drawings. Unless otherwise specified, two copies shall be submitted to the Engineer for information only. The plans or specifications will indicate which submittals require formal review by the Engineer.

One record set of all design work performed by the Contractor's Engineer shall be submitted to the Project Engineer.

(f) Construction Drawings. The Contractor shall keep one set of plans, reviewed shop drawings, working drawings, and other submittals available on the project site at all times. This set shall be defined as the "construction drawings." The Contractor shall note on these construction drawings all changes and deviations from the work shown on the plans, shop drawings, working drawings, and other submittals. The construction drawings shall be kept current as the work progresses and notations shall be made within seven days of the change or deviation. The first sheet or page of each set of construction drawings shall be stamped "As Constructed" and signed by the Contractor.

Upon completion of the work and before final payment, the construction drawings shall be submitted to the Engineer.

The Contractor shall provide pile and caisson tip elevations and provide all refusal and restrike information, driving records and PDA information to the Engineer before proceeding with further construction for permanent archiving.

(g) Furnishing the shop drawings, working drawings, construction drawings, and other submittals will not be measured and paid for separately, but shall be included in the work.

(h) Failure of the Contractor to comply with the requirements for shop drawings, working drawings, other submittals, and construction drawings may be considered unsatisfactory contract progress. Monthly progress payments may be withheld until the requirements are met.

(i) Except as specifically noted, all time required for review of shop drawings, working drawings, and other submittals shall be included in the work and shall not be the basis for any claim for a time extension or monetary adjustment except as provided.

Table 105-1
CONTRACTOR SUBMITTALS
(Including Contractor Qualifications)

Section No.	Description	Type	Contractor P.E. Seal Required?	Specialty Unit Review	Review Time (working days)
202	Bridge Removal Plan	Other	Yes	Staff Bridge	10
206	Shoring	Working Drawing	Yes*	Staff Bridge‡	10
502	Piling Equipment Testing	Other	No	No	10
502	Welding	Qualifications	No	No	10
503	Assembly and Placement of Reinforcing Steel	Shop Drawing	Yes	Staff Bridge	30
503	Drilled Shafts	Qualifications	No	No	30
504	Soil Nail Wall	Qualifications	No	No	15
504	Soil Nail Wall (Contractor Alternative & Sacrificial)	Shop Drawing	Yes*†	Geotechnical	10

Table 105-1 (continued)
CONTRACTOR SUBMITTALS
(Including Contractor Qualifications)

Section No.	Description	Type	Contractor P.E. Seal Required?	Specialty Unit Review	Review Time (working days)
504	Hybrid Wall (Contractor Alternative)	Shop Drawing	Yes*	Staff Bridge	10
504	MSE Wall	Qualifications	No	No	10
504	MSE Walls (Contractor Alternative)	Shop Drawing	Yes	Staff Bridge/ Geotechnical	15
504	MSE Walls (Default Design)	Shop Drawing	No	Staff Bridge	15
504	Geomembrane and Joints	Working Drawing	No	No	10
508	Timber Structures	Shop Drawing	No	Staff Bridge	20
509	Steel Structures	Shop Drawing	Yes*	Staff Bridge	20
509 and 618	Erection Plan	Other	Yes	Staff Bridge	5
509	Fracture Critical Plan	Other	No	Staff Bridge	15
512	Bearing Devices Type II	Shop Drawing	No	Staff Bridge	15
512	Bearing Devices Type III	Shop Drawing	Yes	Staff Bridge	15
514	Pedestrian and Bikeway Railing	Working Drawing	No	No	10
518	Elastomeric Expansion Devices	Working Drawing	No	No	10
518	Expansion Devices: 0-4"	Shop Drawing	Yes	Staff Bridge	15
518	Expansion Devices: 0-6", 9", 12"…	Shop Drawing	Yes	Staff Bridge	15
518	Modular Bridge Expansion Joint Design	Other	Yes	Staff Bridge	10
518	PPC End Dam	Qualifications	No	No	15
601 and 618	Precast Panel Deck Forms	Working Drawing	No	Staff Bridge‡	10
601	Permanent Steel Bridge Deck Forms	Shop Drawing	Yes	Staff Bridge	10
601	Falsework	Working Drawing	Yes	Staff Bridge‡	10
602	Reinforcing Steel	Working Drawing	No	No	10

Table 105-1 (continued)
CONTRACTOR SUBMITTALS
(Including Contractor Qualifications)

Section No.	Description	Type	Contractor P.E. Seal Required?	Specialty Unit Review	Review Time (working days)
603	Precast Culvert	Shop Drawing	Yes*	Staff Bridge	20
606	Bridge Railing	Working Drawing	No	Staff Bridge‡	10
607	Noise Barriers (Alternative)	Shop Drawing	Yes	Staff Bridge	15
607	Noise Barriers (Default Design)	Working Drawing	No	Staff Bridge‡	10
613	Light Standards (Low Mast)	Working Drawing	Yes	Traffic	10
613	Light Standards (High Mast)	Working Drawing	Yes	Traffic	10
614	Overhead Sign Structures	Shop Drawing	Yes*****	Staff Bridge/ Traffic	15
614	Variable Message Signs (Cabinet and tilting bracket)	Working Drawing	Yes	Traffic	10
614	Traffic Signal Pole (Mast Arm)	Shop Drawing	No	Staff Bridge/ Traffic	15
614	Traffic Signal Pedestal Pole	Working Drawing	Yes	Traffic	10
614	Traffic Signal Equipment	Working Drawing	No	Traffic	10
618	Prestressed Concrete (Pre-tensioned)	Shop Drawing	Yes*	Staff Bridge	20
618	Prestressed Concrete (Post-tensioned)	Shop Drawing	Yes*	Staff Bridge	10
618	Steel Diaphragms between Prestressed Girders	Working Drawing	No	Staff Bridge‡	10
618	PT Grouting	Qualifications	No	No	10
622	Buildings	Shop Drawing	Yes	Staff Bridge	Varies
628	Prefabricated Pedestrian Bridges	Shop Drawing	Yes*†	Staff Bridge	20
641	Shotcrete	Qualifications	No	No	10
641	Shotcrete	Shop Drawing	No	Geotechnical	10
715	Anchor Bolts	Working Drawing	No	Staff Bridge‡	10

Table 105-1 (continued)
CONTRACTOR SUBMITTALS
(Including Contractor Qualifications)

Section No.	Description	Type	Contractor P.E. Seal Required?	Specialty Unit Review	Review Time (working days)
Project Specials	As noted in project specials	Qualifications	No	Varies	Varies, 10 min.
Project Specials	As noted in project specials	Varies	Varies	Varies	Varies

Table 105-1 Notes: *An electronic PE seal is required where the Contractor has provided the design for the item or performed engineering to modify the details shown on the plans. The PE seal is not required where complete details are provided on the plans.

†Independent design check required for rating per Bridge Rating Manual.

‡Submittal only, no review required.

105.03 Conformity to the Contract. All work performed and all materials furnished shall conform to the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown in the Contract.

All hot mix asphalt (HMA) materials or work will be evaluated for conformity to the Contract per subsection 105.05 except HMA that is used for patching and temporary pavement.

For those items of work where working tolerances are not specified, the Contractor shall perform the work in a manner consistent with reasonable and customary manufacturing and construction practices.

When the Engineer finds that the materials furnished, the work performed, or the finished product does not conform with the Contract, but that reasonably acceptable work has been produced, the Engineer will determine the extent the work will be accepted and remain in place. If accepted the Engineer will (1) document the basis for acceptance by Contract Modification Order that will provide for an appropriate reduction in the Contract price for such work or materials not otherwise provided for in this subsection or (2) notify the Contractor in writing that the Contract unit price will be reduced per this subsection when P is 25 or less, or (3) in lieu of a price reduction, permit correction or replacement of the finished product provided the correction or replacement does not adversely affect the work.

When the Engineer finds the materials furnished, work performed, or the finished product are not in conformity with the Contract and has resulted in an inferior or unsatisfactory product, the work or materials shall be removed and replaced or otherwise corrected by and at the expense of the Contractor.

If asphalt cement testing demonstrates that asphalt cement was acid modified or alkaline modified, the supplier will be automatically decertified. In addition, all material placed containing the acid modified or alkaline modified asphalt cement shall be removed and replaced with specification material at no cost to the Department.

Materials will be sampled and tested by the Department per the sampling and testing schedules and procedures contained in the Department's Field Materials Manual. The approximate maximum quantity represented by each sample will be as set forth in the schedules. An additional number of samples in relation to the quantity of material

represented may be selected and tested at the Engineer's discretion. The quantity represented by five consecutive random samples will constitute a lot whenever production schedules and material continuity permit. The Engineer may establish a lot consisting of the quantity represented by any number of consecutive random samples from one to seven inclusive when it is necessary to represent short production runs, significant material changes, or other unusual characteristics of the work. Tests that are determined to have sampling or testing errors will not be used.

Materials or work will be evaluated for price reduction only when deviations from specifications occur on any of the several individual tests for the lot. The several individual test values will be averaged and the percent of price reduction for the lot will be determined by applicable formula.

The formula in (1) and (2) below will be used only when the lot is represented by three to seven tests inclusive.

(1) The formula, P = (Xn + aR – Tu)F, will be used if a maximum limit only is specified or when the average of the several test values is above the midpoint of the specification band or above the job-mix formula value.

(2) The formula, P = (TL + aR – Xn)F, will be used if a minimum limit only is specified or when the average of the several test values is below the midpoint of the specification band or below the job-mix formula value.

(3) When the lot is represented by fewer than three tests, the materials will be evaluated for price reduction by the following procedure: Lots represented by two tests will be divided into two separate lots represented by one test each, as determined by the Engineer. Each lot that deviates from the specifications will be price reduced by one of the following formulas. When a maximum limit only is specified or the test value is above the maximum specified limit, the formula P = 0.76(To – Tu)F will be used. When a minimum limit only is specified or the test value is below the minimum specified limit, the formula P = 0.76(TL – To)F will be used. When a lot is represented by one test only, the materials will be evaluated for price reduction as described in this paragraph.

Where:

P	is the percent of reduction in contract price,
Xn	is the average of the several test values from samples taken from the lot, with "n" indicating the number of values,
a	is a variable factor to be used in "n" changes according to the following: when n is 3, a = 0.45; n is 4, a = 0.38; n is 5, a = 0.33; n is 6, a = 0.30; and n is 7, a = 0.28.
R	is the difference between the highest and lowest values in the group of several test results from the lot,
Tu	is the upper or maximum tolerance limit permitted by the specifications,
TL	is the lower or minimum tolerance limit permitted by the specifications, and
To	is the test value of the test that deviates from the specifications,
F	is price reduction factor to be applied for each element as shown in the following table:

Table 105-2
PRICE REDUCTION FACTORS

Element	Factor "F"
100 percent size sieve	1
12.5 mm (1/2") sieve and larger	1
150 µm (No. 100) sieve to 9.5 mm (3/8") sieve inclusive (except 100 percent size sieve)	3
75 µm (No. 200) sieve	6
75µm (No. 200) sieve (cover coat material)	25
Liquid Limit	3
Plasticity Index	10
Asphalt penetration	1
Asphalt residue	3
Portland Cement Concrete Pavement Fine Aggregate Sand Equivalent	0.3
Hydrated Lime Gradation	0.3
Toughness, inch-pounds, minimum	0.8
Tenacity, inch-pounds, minimum	0.8
Elastic Recovery, 25 °C, percent minimum	1.25
Ductility, 4 °C (5cm/min) cm, minimum of RTFO Residue	1.25

If P is less than 3, or a negative quantity, the material will be accepted as being in conformity. In cases where one or more elements show a positive P value, such positive values will be added, and the resulting sum will be used to determine whether the material is in conformity. If the total P value is between 3 and 25, the Engineer may require correction or may accept the material at a reduced price. If P is greater than 25, the Engineer may: (1) require complete removal and replacement with specification material at no additional cost to the Department; (2) require corrective action to bring the material into conformity at no additional cost to the Department; or (3) where the finished product is found to be capable of performing the intended purpose and the value of the finished product is not affected, permit the Contractor to leave the material in place with an appropriate price reduction to be based on engineering evaluation but not to be less than that which would have occurred had a reduction been made where P = 25.

If the P for aggregate gradation for Items 206, 304, or the gradation of hydrated lime for item 403 is 3 or greater the reduction will apply to the contract price multiplied by the Multipliers (M) listed in the following table:

Table 105-3

MULTIPLIER FOR PRICE REDUCTIONS

FOR MISCELLANEOUS ITEMS

Item Number-Name	Element	Multiplier (M)
206- Structural Backfill	Gradation	0.60
304-Aggregate Base Course	Gradation	0.60
403-Hot Mix Asphalt*	Hydrated Lime Gradation	0.60

Table 105-3 Notes: * The P value for hydrated lime shall be applied to the price of the HMA item when asphalt cement is not paid for separately. Lime gradation P values will not be combined with Pay Factors for other elements.

Table 105-4

MULTIPLIER FOR HMA
PRICE REDUCTIONS

Where Asphalt Cement is not paid for separately:

Item Number-Name	Element	Multiplier (M)
403-Stone Matrix Asphalt	Gradation, Asphalt Cement Content, or Compaction	0.60
403-Hot Mix Asphalt*	Hydrated Lime Gradation	0.60

Table 105-4 Notes: * The P value for hydrated lime shall be applied to the price of the HMA item. Lime gradation P values will not be combined with Pay Factors for other elements.

The following equation shows how the Multiplier is used to determine the price reduction.

Price reduction = (P/100) • Multiplier • Price per Unit • Quantity.

If no multiplier is listed no adjustment to the computed P is required. This is equivalent to a multiplier of one.

Price reduction for those elements that are not included in the Table of Price Reduction Factors will be determined by the Engineer.

The Contractor will not have the option of accepting a price reduction in lieu of producing specification material. Continued production of non-specification material will not be permitted. Material that is obviously defective may be isolated and rejected without regard to sampling sequence or location within a lot.

(a) Retroreflectivity of High Build Acrylic Waterborne Paint and Modified Epoxy Pavement Marking. Retroreflectivity of High Build Acrylic Waterborne Paint and Modified Epoxy Pavement Marking shall be tested as follows:

1. The Contractor shall take retroreflectivity readings on all high build acrylic waterborne paint and modified epoxy pavement marking lines for each day of roadway striping work completed on the project. A test section is defined as each continuous line type (lane lines, centerlines, edge lines, channelizing lines, and others) 500 feet in length at a location that is selected by the Engineer using a Random Number Generator, which will be the representation of the work that has been completed in a single day. The Contractor shall use a Contractor-furnished retroreflectometer conforming to American Society for Testing and Materials (ASTM) E1710 or American Association of State Highway and Transportation Officials (AASHTO) TP111. The retroreflector meter shall be calibrated, tested and operated per manufacturer recommendations. The Contractor shall take 10 retroreflectivity readings within the test section for each stripe. These 10 readings shall be taken approximately 40 feet apart and shall be averaged to determine the retroreflectivity of that test section of striping. In cases where striping is less than 500 feet long, 10 readings shall be taken in 10 equal intervals.

2. The calibration for the retroreflector meter shall be witnessed and verified by the Engineer every day, before the readings being taken. The retroreflectivity readings shall be taken in the presence of the Engineer no sooner than 3 days and no later than 21 days after the marking is tack free. All scheduled readings within this timeline or beyond resulting in a reduced reading or failure will be at the risk of the Contractor. Initial minimum retroreflectivity reading (mcd/m2/lux) in the representative test section of pavement marking paint shall be according to table 105-5. The pay factor for High Build Acrylic Waterborne Paint and Modified Epoxy Pavement Marking that is allowed to remain in place at a reduced price, shall be according to the following table and shall be applied to the unit bid price for Item 627, High Build Acrylic Waterborne Paint and Modified Epoxy Pavement Marking, and applied to the work completed in the respective day.

Table 105-5

PRICE REDUCTIONS FOR RETROREFLECTIVITY

Retroreflectivity Reading (R) in the representative test section (mcd/m^2/lux**)**

Color	Modified Epoxy	High Build Acrylic Waterborne Paint	Pay Factor (%)
White	R $\geq$ 350	R $\geq$ 300	100
White	300 $\leq$ R < 350	250 $\leq$ R < 300	75
White	R < 300	R < 250	Remove and replace
Yellow	R $\geq$ 200	R $\geq$ 150	100
Yellow	150 $\leq$ R < 200	100 $\leq$ R < 150	75
Yellow	R < 150	R < 100	Remove and replace

3. Before taking retroreflectivity readings, the Contractor shall remove at the retroreflectivity reading locations any excess beads placed during marking application.

4. Retroreflectivity readings may be altered by chip seals, rumble strips, wet surfaces, ice treatment, snow conditions, or abnormal pavement conditions. If the Engineer determines that accurate reading cannot be taken within the specified timeline per the manufacturer's recommendations, through no fault of the Contractor, the Engineer may waive the requirements for testing and pay reduction.

5. Any and all work, including traffic control required for retroreflectivity readings, shall be included in the cost of the unit bid price for Item 627.

(b) Violation of Working Time Limitation.

If there is a violation of the working time limitations for traffic control as set forth in the special provisions, a written notice to stop work will be imposed on the Contractor at the start of the next working day. Work shall not resume until the Contractor assures the Engineer, in writing, that there will not be a reoccurrence of the working time violation. If more violations take place, the Engineer will notify the Contractor in writing that there will be a price reduction charge for each incident per this specification. This incident price reduction charge will be deducted from any money due the Contractor. This price reduction will not be considered a penalty but will be a price reduction for failure to perform traffic control in compliance with the Contract.

An incident is any violation up to 30 minutes in duration. Each 30 minutes or increment thereof will be considered as an incident. A price reduction will be assessed for each successive or cumulative 30-minute period in violation of the working time limitations, as determined by the Engineer. The price reduction for each incident will increase at a progressive rate starting with $150 for the second incident and increasing to $1,200 for the fifth and subsequent incidents per the following schedule. A 15-minute grace period will be allowed at the beginning of the second incident on the project before the price reduction is applied. This 15-minute grace period applies only to the second incident.

The number of incident charges will be accumulative throughout the duration of the Contract.

Table 105-6

VIOLATION OF THE WORKING TIME LIMITATIONS

PRICE REDUCTION SCHEDULE

Incident	Incident Rate	Total Price Reduction
First	Notice to Stop Work	----
Second	$150	$150
Third	$300	$450
Fourth	$600	$1,050
Fifth	$1,200	$2,250
Sixth	$1,200	$3,450
> Sixth	$1,200	$4,650

105.04 Conformity to the Contract of Superpave Performance Graded Binders. Asphalt binders will be price reduced according to the following if the requirements of subsection 702.01 are not met:

TABLE 105-7

PERFORMANCE GRADED BINDER LIMITS

Property	Specification	Compliance Limit for Price Reduction of 0%	Rejection Limit, Price Reduction = 25%
G*sin (delta) of RTFO Residue	2.20 Min	1.87 Min	< 1.53
Slope (m-value) of the Creep Curve at Low Grade Temperature + 10° C.	0.300 Min	0.295 Min	< 0.266
Stiffness of the PAV Residue at Low Grade Temperature + 10° C, (Mpa)	300 Max	311 Max	>355

The price reduction will be 25 percent at the rejection limit. Between the compliance limit and the rejection limit, the price reduction will be calculated as follows:

$$PR = 25 \bullet \left[\frac{CL - \text{test value}}{CL - RL} \right]$$

Where: PR = Price Reduction
CL = Compliance Limit
RL = Rejection Limit

(a) The price reductions will be cumulative if more than one PG binder property specified in the Table of Performance Graded Binder Limits is out of specification, resulting in P (total). When binder is included in the contract unit price for HMA, the price reduction will be calculated as follows:
Amount of Reduction = [P (total)] ● [(1/100) ● (Invoice Price for PG Binder)]

When the binder is paid for separately, the total price reduction will be calculated as follows:

Amount of Reduction = [P(total)] ● [(1/100) ● (Contract Unit Price for PG Binder)]

(b) Price reductions based on the "F" factors in the Table of Price Reduction Factors described in subsection 105.03 will be in addition to the PG binder price reductions. Other binder requirements listed in the Table of Performance Graded Binder Limits but not price reduced in subsections 105.03 or 105.04 may be tested but will not be considered for price reduction calculations. However, the Contractor will not be allowed to continue to produce mix with out of specification PG binder. If two consecutive samples fail to meet all requirements

listed in the Table of Performance Graded Binder Limits, the Contractor shall take corrective action before being allowed to continue production of hot mix asphalt. If proper corrective measures cannot be readily determined, the Engineer will suspend the use of such material until the Engineer can determine from laboratory tests that the Contractor can provide material that is in compliance with the Table of Performance Graded Binder Limits.

(c) The Contractor will not have the option of accepting a price reduction in lieu of producing specification material. Continued production of non-specification material will not be permitted. Material that is obviously defective may be isolated and rejected without regard to sampling sequence or location within a lot.

105.05 Conformity to the Contract of Hot Mix Asphalt. Conformity to the Contract of all Hot Mix Asphalt, Item 403, except Hot Mix Asphalt (Patching) and temporary pavement will be determined by tests and evaluations of elements that include asphalt content, gradation, in-place density, and joint density per the following:

All work performed and all materials furnished shall conform to the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown in the Contract.

When the Engineer finds the materials or work furnished, work performed, or the finished product are not in conformity with the Contract and has resulted in an inferior or unsatisfactory product, the work or material shall be removed and replaced or otherwise corrected at the expense of the Contractor.

Materials will be sampled randomly and tested by the Department per subsection 106.05 and with the applicable procedures contained in the Department's Field Materials Manual. The approximate maximum quantity represented by each sample will be as set forth in subsection 106.05. Additional samples may be selected and tested as set forth in subsection 106.05 at the Engineer's discretion.

A process will consist of either a single test value or a series of values resulting from related tests of an element of the Contractor's work and materials. An element is a material or workmanship property that can be tested and evaluated for quality level by the Department approved sampling, testing, and analytical procedures. All materials produced will be assigned to a process. A change in process is defined as a change that affects the element involved. For any element, with the exception of the joint density element, a process normally will include all produced materials associated with that element before a change in the job mix formula (Form 43). For joint density, a new process will be established for each new layer of pavement or for changes in joint construction. Density measurements taken within each compaction test section will be a separate process. The Engineer may separate a process in order to accommodate small quantities or unusual variations.

Evaluation of materials for pay factors (PF) will be done using only the Department's acceptance test results. Each process will have a PF computed per the requirements of this Section. Test results determined to have sampling or testing errors will not be used.

Except for in-place density measurements taken within a compaction test section, any test result for the asphalt content, in-place density or joint density element greater than the distance 2 x V (see Table 105-8) outside the tolerance limits will be designated as a separate process and the quantity it represents will be evaluated per subsection 105.05(a). An element pay factor less than zero shall be zero. The calculated PF will be used to determine

the Incentive/Disincentive Payment (I/DP) for the process per 105.05(e) Evaluation of Work.

In the case of in-place density or joint density, the Contractor will be allowed to core the exact location (or immediately adjacent location for joint density) of a test result more than 2 times V outside the tolerance limit. The core must be taken and furnished to the Engineer within eight hours after notification by the Engineer of the test result. The result of this core will be used in lieu of the previous test result. Cores not taken within eight hours after notification by the Engineer will not be used in lieu of the test result. All costs associated with coring shall be at the Contractor's expense.

(a) Representing Small Quantities. When it is necessary to represent a process by only one or two test results, PF will be the average of PFs resulting from the following:

If the test result is within the tolerance limits, then

PF = 1.00

If the test result is above the maximum specified limit, then

$PF = 1.00 - [0.25(T_O - T_U)/V]$

If the test result is below the minimum specified limit, then

$PF = 1.00 - [0.25(T_L - T_O)/V]$

Where: PF =pay factor.

V = V factor from Table 105-8.

T_O = the individual test result.

T_U = upper specification limit.

T_L = lower specification limit.

The calculated PF will be used to determine the I/DP for the process.

(b) Determining Quality Level. Each process with three or more test results will be evaluated for a quality level (QL) per Colorado Procedure (CP) 71.

(c) Gradation Element. Each specified sieve, with the exception of 100 percent passing sieves, will be evaluated for QL separately. The lowest calculated QL for a sieve will be designated as the QL for gradation element for the process.

(d) Joint Density Element. Joint Density will be tested according to subsection 401.17.

(e) Process Pay Factor. Using the calculated QL for the process, compute the PF as follows: The final number of random samples (Pn) in each process will determine the final pay factor. As test values are accumulated for each process, Pn will change accordingly. When the process has been completed, the number of random samples it contains will determine the computation of PF, based on Table 105-9 and formula (1) below. When Pn is from 3 to 9, or greater than 200, PF will be computed using the formulas designated in Table 105-9. Where Pn is equal to or greater than 10 and less than 201, PF will be computed by Formula (1):

$$PF = \frac{PF_1 + PF_2}{2} + \left[\frac{PF_2 + PF_3}{2} - \frac{PF_1 + PF_2}{2}\right] \bullet \frac{(Pn_2 - Pn_X)}{(Pn_2 - Pn_3)}$$

Formula (1)

Where, when referring to Table 105-9:

PF_1=PF determined at the next lowest Pn formula using process QL
PF_2=PF determined using the Pn formula shown for the process QL
PF_3=PF determined at the next highest Pn formula using process QL
Pn_2=the lowest Pn in the spread of values listed for the process Pn formula
Pn_3=the lowest Pn in the spread of values listed for the next highest Pn formula
Pn_x=the actual number of test values in the process

When evaluating the item of Furnish Hot Mix Asphalt, the PF for the element of In-Place Density shall be 1.0.

Regardless of QL, the maximum PF in relation to Pn is limited per Table 105-9.

As test results become available, they will be used to calculate QL and PF numbers for each process. The process I/DPs will then be calculated and accumulated for each element and for the item. The test results and the accumulated calculations will be made available to the Contractor upon request.

Numbers from the calculations will be carried to significant figures and rounded according to AASHTO Standard Recommended Practice R-11, Rounding Method.

(f) Evaluation of Work. When the PF of a process is 0.75 or greater, the finished quantity of work represented by the process will be accepted at the appropriate pay factor. If the PF is less than 0.75, the Engineer may:

(1) Require complete removal and replacement with specification material at the Contractor's expense; or

(2) Where the finished product is found to be capable of performing the intended purpose and the value of the finished product is not affected, permit the Contractor to leave the material in place. If the material is permitted to remain in place, the PF for the process will not be greater than 0.75. The Region Materials Engineer (RME) will be consulted before determining the material will be allowed to remain in place. The RME will also be consulted to assist in determining an appropriate pay factor.

When condition red, as described in subsection 106.05(g), exists for any element, resolution and correction will be per Section 106.05(g). Material that the Engineer determines is defective may be isolated and rejected without regard to sampling sequence or location within a process.

If removal and replacement is required because the joint density PF for a process is below 0.75, the Contractor shall remove and replace the full lane width adjacent to and including at least 6 inches beyond the visible joint line for the entire length of joint representing the process. If the lane removed is adjacent to another joint, that joint shall also be removed to a point 6 inches beyond the visible joint line. When a single joint density core is more than 2V outside the tolerance limits, the removal and replacement limits shall be identified by coring the failing joint at 25-foot intervals until two successive cores are found to be 1V or less below the minimum tolerance limit. If removal and replacement is required, the Contractor shall submit documentation identifying the process to be used to correct the area in question in writing. The process will be approved by the Engineer before commencing the corrective work.

Table 105-8
"W" AND "V" FACTORS FOR VARIOUS ELEMENTS

Hot Mix Asphalt

Element	V Factor	W Factor
2.36 mm (No. 8) mesh and larger sieves	2.8	N/A
600 µm (No. 30) mesh sieve	1.8	N/A
75 µm (No. 200) mesh sieve	0.8	N/A
Gradation	N/A	15
Asphalt Content	0.2	25
In-place Density	1.1	45
Joint Density	1.6	15

Table 105-9
FORMULAS FOR CALCULATING PF BASED ON Pn

Pn	When Pn as shown at left is 3 to 9, or greater than 200, use designated formula below to calculate Pay Factor, PF = ..., when Pn is 10 to 200, use formula (1) above:	Maximum PF
3	$0.31177 + 1.57878\ (QL/100) - 0.84862\ (QL/100)^2$	1.025
4	$0.27890 + 1.51471\ (QL/100) - 0.73553\ (QL/100)^2$	1.030
5	$0.25529 + 1.48268\ (QL/100) - 0.67759\ (QL/100)^2$	1.030
6	$0.19468 + 1.56729\ (QL/100) - 0.70239\ (QL/100)^2$	1.035
7	$0.16709 + 1.58245\ (QL/100) - 0.68705\ (QL/100)^2$	1.035
8	$0.16394 + 1.55070\ (QL/100) - 0.65270\ (QL/100)^2$	1.040
9	$0.11412 + 1.63532\ (QL/100) - 0.68786\ (QL/100)^2$	1.040
10 to 11	$0.15344 + 1.50104\ (QL/100) - 0.58896\ (QL/100)^2$	1.045
12 to 14	$0.07278 + 1.64285\ (QL/100) - 0.65033\ (QL/100)^2$	1.045
15 to 18	$0.07826 + 1.55649\ (QL/100) - 0.56616\ (QL/100)^2$	1.050
19 to 25	$0.09907 + 1.43088\ (QL/100) - 0.45550\ (QL/100)^2$	1.050
26 to 37	$0.07373 + 1.41851\ (QL/100) - 0.41777\ (QL/100)^2$	1.055
38 to 69	$0.10586 + 1.26473\ (QL/100) - 0.29660\ (QL/100)^2$	1.055
70 to 200	$0.21611 + 0.86111\ (QL/100)$	1.060
$\geq$ 201	$0.15221 + 0.92171\ (QL/100)$	1.060

(g) Process I/DP Computation.

I/DP = (PF - 1)(QR)(UP)(W/100)

Where: I/DP=Incentive or Disincentive Payment

PF = Pay Factor

QR = Quantity in Tons of HMA Represented by the Process

UP = Unit Bid Price of Asphalt Mix

W = Element factor from Table 105-8

When AC is paid for separately UP shall be:

$UP = [(Ton_{HMA})(UP_{HMA}) + (Ton_{AC})(UP_{AC})] / Ton_{HMA}$

Where: Ton_{HMA}=Tons of Asphalt Mix

UP_{HMA} = Unit Bid Price of Asphalt Mix

Ton_{AC} = Tons of Asphalt Cement

UP_{AC} = Unit Bid Price of Asphalt Cement

For the joint density element:

$UP = UP_{HMA}$

Where: UP_{HMA} is as defined above

When AC is paid for separately UP shall be:

$UP=[(BTon_{HMA})\ (BUP_{HMA})+(BTon_{AC})\ (BUP_{AC})] / (BTon_{HMA})$

Where: $BTon_{HMA}$=Bid Tons of Asphalt Mix

BUP_{HMA} = Unit Bid Price of Asphalt Mix

$BTon_{AC}$ = Bid Tons of Asphalt Cement

BUP_{AC} = Unit Bid Price of Asphalt Cement

(h) Element I/DP. The I/DP for an element shall be computed by accumulating the process I/DPs for that element.

(i) I/DP for a Mix Design. The I/DP for a mix design shall be computed by accumulating the process I/DPs for the asphalt content, in-place density, and gradation elements for that mix design. The accumulated quantities of materials for each element must be the same at the end of I/DP calculations for a mix design.

(j) Project I/DP. The I/DP for the project shall be computed by accumulating the mix design I/DPs and the joint density I/DPs. The accumulated quantities of materials for each element must be the same at the end of I/DP calculations for the project.

105.06 Conformity to the Contract of Portland Cement Concrete Pavement. Conformity to the Contract of all Portland Cement Concrete Pavement, Item 412, will be determined per the following:

When the Engineer finds that the materials furnished, the work performed, or the finished product does not conform to the Contract, or the Pay Factor (PF) for an element's process is less than 0.75 but that reasonably acceptable work has been produced, the Engineer will

determine the extent of the work that will be accepted and remain in place. The Engineer will use a Contract Modification Order to document the justification for allowing the work to remain in place and the price adjustment that will be applied.

When the Engineer finds the materials furnished, work performed, or the finished product is not in conformity with the Contract, or the PF for an element's process is less than 0.75 and has resulted in an inferior or unsatisfactory product, the work or material shall be removed and replaced or otherwise corrected by and at the expense of the Contractor. When the PF for any process is 0.75 or greater, the finished quantity of work represented by the process will be accepted at the calculated pay factor.

Materials will be sampled and tested by the Contractor and the Department per subsection 106.06 and with procedures contained in the Department's Field Materials Manual. The approximate quantity represented by each sample will be as set forth in subsection 106.06, Tables 106-2 and 106-3. Additional samples may be selected and tested at the Engineer's discretion.

(a) Incentive and Disincentive Payments (I/DP) will be made based on a statistical analysis that yields Pay Factors (PF) and Quality Levels (QL). The PF and QL will be made based on test results for the elements of compressive strength and pavement thickness (compressive strength criteria) or the elements of flexural strength and pavement thickness (flexural strength criteria). The Department will indicate in the plans whether compressive strength or flexural strength criteria will be used. If the acceptance criteria are not indicated, flexural strength criteria shall be used.

Incentive or Disincentive payment will not be made for thickness of concrete pavement furnished by the Contractor and placed by others.

When compressive strength criteria are indicated, then the QL will be calculated for the elements of compressive strength and pavement thickness on a process basis. When flexural strength criteria are indicated, then the QL will be calculated for the elements of flexural strength and pavement thickness on a process basis. A process will consist of the test results from a series of random samples. Test results determined to have sampling or testing errors will not be used. All materials produced will be assigned to a process. Changes in mix design, design pavement thickness, or a break of more than 120 working days between placements will create a new process. The following is provided to clarify changes in processes for each element:

1. Construction of mainline pavement, including the shoulders if placed with the mainline, is a single process for the compressive or flexural strength element, when the mix design does not change and there is not a break of more than 120 days between placements.
2. Construction of mainline pavement, including the shoulders if placed with the mainline, is a single process for the thickness element, when the planned thickness does not change and there is not a break of more than 120 days between placements.
3. Construction of ramps, acceleration and deceleration lanes and shoulders placed separately are considered separate processes.
4. Changes in paving equipment, changes in placement method, changes in hauling equipment, adjustments to mix designs that do not require a new mix design, changes in weather conditions, and changes in production rate shall not create a new process in the strength or thickness elements.

The Contractor and Engineer will determine element processes and what distinguishes them as processes during the Pre-pave meeting before concrete placement.

(b) When it is necessary to represent material by one or two tests, each individual test shall have a PF computed per the following:

If the value of the test is at or above the lower tolerance limit, then PF = 1.000. If the value of the test is below the lower tolerance limit, then:

$PF = 1.00 - [0.25(T_L - T_0)/V]$

where: PF = pay factor.

V = V factor from Tables 105-4 or 105-5.

T_0 = the individual test value.

T_L = lower tolerance limit.

(c) The following procedures will be used to compute Incentive and Disincentive Payments (I/DP), quality levels (QL), and pay factors (PF) for processes represented by three or more tests:

1. Quality Level (QL) will be calculated according to CP-71.
2. Compute the PF for the process. When the process has been completed, the number of tests (Pn) it includes shall determine the formula to be used to compute the final pay factor per the following:

   A. For pavement thickness:

   When $3 \le Pn \le 5$

   If $QL \ge 85$, then $PF = 1.00 + (QL - 85)0.001333$

   If $QL < 85$, then $PF = 1.00 + (QL - 85)0.005208$

   When $6 \le Pn \le 9$

   If $QL \ge 90$, then $PF = 1.00 + (QL - 90)0.002000$

   If $QL < 90$, then $PF = 1.00 + (QL - 90)0.005682$

   When $10 \le Pn \le 25$

   If $QL \ge 93$, then $PF = 1.00 + (QL - 93)0.002857$

   If $QL < 93$, then $PF = 1.00 + (QL - 93)0.006098$

   When $Pn \ge 26$

   If $QL \ge 95$, then $PF = 1.00 + (QL - 95)0.004000$

   If $QL < 95$, then $PF = 1.00 + (QL - 95)0.006757$

   B. For compressive strength and flexural strength:

   When $3 \le Pn \le 5$

   If $QL \ge 85$, then $PF = 1.00 + (QL - 85)0.002000$

   If $QL < 85$, then $PF = 1.00 + (QL - 85)0.005208$

When $6 \le Pn \le 9$

If $QL \ge 90$, then $PF = 1.00 + (QL - 90)0.003000$

If $QL < 90$, then $PF = 1.00 + (QL - 90)0.005682$

When $10 \le Pn \le 25$

If $QL \ge 93$, then $PF = 1.00 + (QL - 93)0.004286$

If $QL < 93$, then $PF = 1.00 + (QL - 93)0.006098$

When $Pn \ge 26$

If $QL \ge 95$, then $PF = 1.00 + (QL - 95)0.006000$

If $QL < 95$, then $PF = 1.00 + (QL - 95)0.006757$

3. Compute the I/DP for the process:

   I/DP = (PF-1)(QR)(UP)

   where: QR = Quantity Represented by the process.
   UP = Unit Price bid for the Item.

   The total I/DP for an element shall be computed by accumulating the individual I/DP for each process of that element.

(d) As acceptance test results become available, they will be used to calculate accumulated QL and Incentive and Disincentive Payments (I/DP) for each element and for the item. The Contractor's test results, and the accumulated calculations shall be made available to the Engineer upon request. The Engineer's test results, and the calculations will be made available to the Contractor as early as reasonably practical. Numbers from the calculations shall be carried to significant figures and rounded according to AASHTO Standard Recommended Practice R-11, Rounding Method.

I/DP will be made to the Contractor per subsection 412.24(a). During production, interim I/DP will be computed for information only. The Pn will change as production continues and test results accumulate. The Pn at the time and I/DP is computed shall determine the formula to be used.

(e) The Contractor shall not have the option of accepting a price reduction or disincentive in lieu of producing specification material. Continued production of non-specification material will not be permitted. Material that is obviously defective may be isolated and rejected without regard to sampling sequence or location within a process.

(f) When compressive strength is indicated, the Contractor may take cores at his own expense and per Colorado Procedure 65 to provide an alternative determination of strength to replace acceptance test results with a compressive strength less than 4,500 psi. The higher value of the 28-day compressive strength of acceptance cylinders or the corresponding core's compressive strength will be used for I/DP.

When flexural strength is indicated in the Contract, the Contractor shall, in the presence of the Engineer, develop a correlation curve during the first week of concrete placement per AASHTO T198 (ASTM C496) Splitting Tensile Strength of Cylindrical Concrete Specimens. At least three splitting tensile strength specimens and four flexural strength specimens will be tested at 3, 7, 14, and 28 days. The splitting tensile strength and flexural strength specimens for each age used to develop the correlation curve shall be cast from the same batch of concrete being placed on the project.

When flexural strength is indicated, the Contractor may take cores at his own expense and per Colorado Procedure 65 to provide an alternative determination of strength to replace PC/OA test results with a flexural strength less than 570 psi. The cores for the alternate flexural strength evaluation shall be obtained after 28 days, but before 45 days following placement. The higher value of the 28-day flexural strength of PC/OA beams or the corresponding core's flexural strength will be used for I/DP.

At any time during production, the Engineer may request a verification of the correlation curve developed during the first week of production. Verification of the curve shall be done by casting three splitting tensile specimens by the Department and testing them at the Region or Central Lab. The flexural strength of the correlated splitting tensile samples shall be compared to the Contractor PC flexural strength results cast from the same batch. For verification, both flexural strength specimens and splitting tensile specimens will be tested at 28 days. If the correlated flexural strength of the splitting tensile sample is not within 50 psi of the verification beam specimen's flexural strength, a new correlation curve shall be developed within 3 days for future low strength evaluations. The new correlation curve will be used for any future low flexural strength evaluations that result from concrete placed on or after the date the new correlation curve specimens are cast.

Table 105-10
"V" FACTORS AND INCENTIVE PAYMENTS
COMPRESSIVE STRENGTH CRITERIA

Element	V factor	Maximum Incentive Payment	Lower Tolerance Limit, T_L	Plan Value
Compressive Strength	400 psi	3.00 %	4500 psi	4500 psi
Pavement Thickness	0.4 inch	2.00 %	Plan Thickness -0.4 inch	Plan Thickness

Table 105-11
"V" FACTORS AND INCENTIVE PAYMENTS
FLEXURAL STRENGTH CRITERIA

Element	V factor	Maximum Incentive Payment	Lower Tolerance Limit, T_L	Plan Value
Flexural Strength	50 psi	3.00 %	570 psi	650 psi
Pavement Thickness	0.4 inch	2.00 %	Plan Thickness -0.4"	Plan Thickness

(g) Sand Equivalence. The sand equivalence (SE) as determined by CP 37 will be considered acceptable when the running average of three consecutive tests is greater than 80 percent and no individual test result is less than 75 percent. When the running average of three consecutive SE tests falls below 80 percent or an individual SE test result falls below 75 percent, paving operations shall be suspended. The Contractor shall submit a written plan to correct the low SE test results to the Engineer for approval. The Contractor shall not continue paving operations until the Engineer approves the plan in writing and three SE test results from random samples in the stockpile are above 80 percent.

(h) Pavement Surface Texture. The Contractor shall perform process control (PC) testing for the pavement surface texture depth per CP 77 Method B. All PC results for surface texture depth measurements shall be included in the Contractor's QC notebook. The start of PC testing for texturing depth shall be completed within 24 hours after the first 500 linear feet of textured pavement is placed for each lane. Paving shall not proceed until results are accepted by the Engineer.

Surface texture will be considered acceptable when the average texture depth (ATD) of the panel is greater than 0.05 inch. When the ATD is less than 0.05 inches, the Contractor shall determine the area represented by this test. The area shall be determined by taking additional tests at 15-foot intervals parallel to the centerline in each direction from the affected location until two consecutive tests are found to be within the specified limits. Any surface with unacceptable texturing exceeding 25 linear feet in any lane or shoulder greater than 8 feet wide shall be diamond ground full width of the lane. Upon the second unacceptable test result, the Contractor shall notify the Engineer, in writing, of the action taken to provide an acceptable surface texture.

The Department will perform surface texture acceptance testing per CP 77 Method B. The Department will determine the panel locations where acceptance test measurements are to be taken. One stratified random acceptance test per 2,500 linear feet or fraction thereof in each lane and shoulder wider than 8 feet shall be taken with a minimum of one test per day when the Contractor is paving.

When the Department locates areas of surface texture that do not meet the minimum ATD, the Contractor will be notified, and the Contractor shall identify the limits of the deficient texture depth. After the Engineer approves the limits, the Contractor shall correct the deficient surface texture by diamond grinding full lane width to provide an ATD greater than 0.05 inch at no additional cost to the project. The Contractor shall correct surface texture deficiencies before pavement smoothness testing and pavement thickness determinations.

105.07 Conformity to Roadway Smoothness Criteria. Roadway smoothness testing and corrective work shall be performed as described below. The pavement smoothness category shall be MRI Category II unless shown otherwise on the plans.

At least two weeks before the Pre-paving Conference the Contractor may request a change to the pavement smoothness category based on the CDOT's Design Bulletin guidelines for assigning pavement smoothness categories . The Contractor shall not assume a change will be granted and shall be prepared to build the pavement according to the assigned smoothness category. Once paving operations have been started, a change in pavement smoothness category will not be made.

(a) Smoothness Process Control Testing.

1. The Contractor shall perform Smoothness Process Control (SPC) testing. The test results shall be submitted to the Engineer within 48 hours of completion. SPC test results shall show the Mean Roughness Index (MRI) for each 0.10 mile.

   All traffic control costs associated with SPC testing will be paid for per Section 630.

   SPC testing shall be performed on the first 2,000 tons for the final layer of HMA or each day's paving within 24 hours after the concrete has achieved sufficient strength for PCCP. SPC testing on SMA will be tested after the sheen has been worn off. The Contractor may continue paving at his own risk. The Contractor shall not perform the SQC testing until after the concrete has attained a compressive strength of 1,000 psi if a lightweight profiler is used or 2,000 psi if a high-speed profiler is used.

   SPC testing shall be performed using the Contractor's inertial profiler, pursuant to the methods described in subsection 105.07(b). The Contractor's Inertial Profiler and Operator shall be certified according to CP 78. This link has a list of certified profilers and operators.

   Production shall be suspended if SPC testing indicates that corrective work is required per subsection 105.07(e). If the SPC data becomes available after production has started for the day, suspension will begin at the end of that production day for HMA. Production will remain suspended until the problem is identified and corrected. Each time production is suspended, corrective actions shall be proposed in writing by the Contractor. Production shall not resume until the proposed corrective actions have been accepted by the Engineer in writing.

   When production resumes, the Contractor shall profile the first 2,000 tons of HMA or each day's paving within 24 hours after the concrete has achieved sufficient strength for PCCP. The conditions described above for suspension of work will apply.

2. The finished transverse and longitudinal surface elevation of the pavement shall be measured using a 10-foot straightedge. Areas to be measured will be directed by the Engineer. The Contractor shall furnish an approved 10-foot straightedge, depth gauge, and operator to aid the Engineer in testing the pavement surface. Areas showing high spots of more than 3/16 inch in 10 feet shall be marked and diamond ground until the high spot does not exceed 3/16 inch in 10 feet.

(b) Initial Smoothness Acceptance Testing. The Contractor shall perform Smoothness Acceptance Testing (SA) that will be used for acceptance and calculation of incentive adjustments.

The Contractor shall submit a Method for Handling Traffic (MHT) to the Engineer for approval at least five days in advance of SA testing. The MHT shall detail the methods for traffic control that will allow for continuous non-stop profiling of each lane to be profiled at a minimum speed of 15 mph and for the placement of triggers. The Contractor shall provide the traffic control per the approved MHT. SA testing shall not be performed without traffic control using the approved MHT.

All traffic control costs associated with SA testing will be paid for per Section 630.

Pavement surfaces shall be tested and accepted for longitudinal smoothness as described.

1. Testing Procedure (General). The longitudinal surface smoothness of the final pavement surface shall be tested by the Contractor per CP 74 and using the Contractor's inertial profiler (profiler). The Contractor's Profiler and Operator shall be certified according to CP 78. This link has a list of certified profilers and operators.

   The profiler's instrumentation shall be verified per CP 74 before measurements. The Contractor shall lay out a distance calibration site. The distance calibration site shall be located no more than 10 miles from the project limits. The distance calibration site shall be 1056.0 feet long and shall be on a relatively flat, straight section of pavement as approved by the Engineer. The site shall have a speed limit equal to the project's highest speed limit that allows for the profiler to operate uninterrupted. The limits of the site shall be clearly marked, and the distance shall be measured to an accuracy of +/- 1 inch. The Contractor shall provide in writing the site location to the Engineer. The cost of the distance calibration site will not be measured and paid for separately but shall be included in the work.

   The entire length of each through lane, climbing lane and passing lane including bridge approaches, bridge decks and intersections from the beginning to the end of the project shall be profiled in their planned final configuration and direction. Shoulders with a width of 12 feet or greater, ramps, tapers, turn slots, acceleration lanes and deceleration lanes will be profiled, but will not be subject to incentive adjustments. Shoulders with a width of 12 feet or more, ramps, tapers, turn slots, acceleration lanes and deceleration lanes will be evaluated for MRI and shall require corrective work if a 0.10 mile or fraction thereof section exceeds an MRI greater than 100.0 in/mile. The profile of the entire length of a lane shall be taken at one time. However, a lane profile may be broken into sections to accommodate project phasing. At the Pre-paving Conference, the Contractor shall submit a plan for breaking the project profiling into phases for approval by the Engineer.

   Shoulders less than 12 feet in width and medians will not be profiled and will not be subject to incentive adjustments. Shoulders less than 12 feet in width and medians constructed as part of the project shall be measured per subsection 105.07(a).

   Pavement 25 feet outside of a traffic circle and traffic circles will not be profiled and will not be subject to incentive adjustments. Traffic circles shall be measured per subsection 105.07(a).

   A sufficient distance shall be deleted from the profile to allow the profiler to obtain the testing speed, plus a 300-foot distance to stop and start when required. The distance deleted from a profile shall be minimized by reducing testing speed as necessary. Incentive adjustments will not be made for this area. The final surface of these areas shall be tested per subsection 105.07(a).

The profile shall include transverse joints when pavement is placed on both sides of the joint. When pavement is placed on only one side of the joint, the profile shall start and stop at project paving limits.

The section of pavement 25 feet outside the paving limits to 5 feet inside the paving limits will be evaluated per subsection 105.07(a).

The profile of the area 25 feet each side of every railroad crossing, cattle guard, bus pad, manhole, gutter pan and intersection (where there is a planned breakpoint in the profile grade line in the direction of traffic) shall be deleted from the profile before the MRI is determined. Incentive adjustments will not be made for these areas. Areas deleted from the profile shall be tested per subsection 105.07(a).

The profile of the area 25 feet each side of the bridge deck shall be deleted from the profile before the MRI is determined. Incentive adjustments will not be made for this area. When both pavement and a bridge or bridge pavement are being constructed on the project, areas deleted from the profile shall be tested per subsection 105.07(a). Corrective work required in these areas will not be measured and paid for separately but shall be included in the work. For all other projects, the profile of the area 25 feet each side of the bridge deck shall be deleted from the profile before the MRI is determined. If the Engineer determines that corrective work is required in this area, payment will be made per subsection 109.04.

The Contractor shall notify the Engineer in writing and the Department by email at DOT_Profiles@state.co.us at least five working days in advance of his intention to perform SA testing. The Contractor shall profile the project within 14 days after the completion of paving operations. The Department will determine if Smoothness Verification Testing (SV) will be performed. If SV testing will be performed, it will be performed at the same time as the SA testing.

The Engineer will witness the SA profiling. Within 24 hours after each profile is collected, the Contractor shall submit the data electronically along with an SA data submittal form to the Department at DOT_Profiles@state.co.us, and to the Engineer.

2. Smoothness Testing Procedures. The Contractor shall mark the profiling limits and excluded areas. The Engineer will verify that the Contractor's marks are located properly. The Contractor shall use traffic cones with reflective tape or reflective tape on the pavement at the beginning and end of each lane for triggering the start and stop locations on the profiler and at any other location, where portions of the profile are being excluded. These locations shall be marked with temporary paint so that the final SA testing uses the same triggering locations.

   The ambient temperature shall be at least 34 °F for the profiler to operate.

   The Contractor shall clear the lanes to be tested of all debris before profiling.

   Each lane shall be profiled at least once. Profiling shall be at a constant speed (+/- 5 mph of the distance calibration speed) with a minimum speed of 15 mph and a maximum speed of 70 mph. Shoulders with a width of 12 feet or more, ramps, tapers, turn slots, acceleration lanes and deceleration lanes shall be profiled once. The profile shall be taken in the planned direction of travel. The left and right wheel paths shall be profiled simultaneously.

Triggers for the start of the profile, the end of the profile and the locations of each exclusion shall be collected during each run. The collected profiles shall be electronically submitted to the Department and Engineer to be analyzed using CP 74.

The Department will determine an MRI for each 0.1-mile section or fraction thereof of completed pavement. Sections will terminate at the beginning of an exclusion and a new section starts at the end of exclusion. The MRI consists of the left and right wheel path's profile passed through the International Roughness Index (IRI) filter. The IRI for the left and right wheel paths are averaged to determine MRI.

The Contractor's SA test results will be available within10 working days of the completion of SA testing. The Engineer will give the Contractor a report that will include the lane profiled, the MRI in 0.1-mile increments and a summary of areas requiring corrective work. The Engineer may determine that it is necessary for the Contractor to re-profile a lane.

Areas requiring corrective work will be determined according to subsection 105.07(e).

Sections less than 0.005 miles in length shall not be subject to corrective work as specified by Table 105-14. Sections less than 0.005 miles in length shall be evaluated per subsection 105.07(a).

(c) MRI Category IV. For MRI Category IV pavements, the following shall be used for acceptance:

An MRI for each 0.1-mile section shall be determined on the original pavement surface before beginning the work per subsection 105.07(b) without exclusions.

An MRI for each 0.1-mile section shall be determined on the pavement surface after the work is complete per subsection 105.07(b) without exclusions.

The original and final profile lengths shall have a difference in the length of each lane less than 0.2 percent. When the profile length difference exceeds 0.2 percent, the final testing shall be repeated.

When a 0.1-mile section has a final MRI greater than 92.0 in/mile and the final MRI is greater than the MRI before performing the work, that 0.1-mile section shall be corrected by a method approved in writing by the Engineer. Corrective work shall be such that the resulting final MRI is equal to or less than the initial MRI or 92.0 in/mile, whichever is greater. All costs associated with corrective work shall be at the Contractor's expense, including but not limited to traffic control, additional hot mix asphalt, grinding and milling.

When the Contractor fails to collect the profile of the original pavement surface before beginning the work, the final pavement surface will be evaluated for corrective work per the criteria for Category III pavement smoothness.

Incentive adjustments for smoothness will not be made for Category IV.

Pavements evaluated for Category IV that will be overlaid with a surface seal shall be evaluated for pavement smoothness before application of the surface seal (chip seal).

(d) Acceptance and Incentive Adjustments. Acceptance and incentive adjustments for pavement smoothness will be made on a square yard basis per the following:

Incentive adjustments will be based on the MRI for each 0.1-mile section or fraction thereof. Incentive adjustments for Pavement Smoothness will be made per Table 105-12 or 105-13. Incentive payments will not be made until all sections requiring corrective work have been corrected.

Final acceptance and incentive adjustments for pavement smoothness will be made on a square yard basis based on the MRI for each 0.1-mile section or fraction thereof from the Contractor's initial SA testing. Those sections requiring corrective work indicated by the initial SA testing will be re-evaluated. However, incentives will not be earned in these areas, regardless of the final smoothness.

Table 105-12
HMA PAVEMENT SMOOTHNESS (INCHES/MILE)
MEAN ROUGHNESS INDEX

Pavement Smoothness Category	Maximum Incentive Payment ($/sq yd)	Incentive Payment ($/sq yd)	No Incentive	Corrective Work Required (0.10-mile sections)
I	MRI ≤ 46.0 I = $1.28	MRI > 46.0 and < 73.0 I= 3.46-0.0474 MRI	MRI ≥ 73.0 and ≤ 88.0	MRI > 88.0
II	MRI ≤ 40.0 I = $1.28	MRI > 40.0 and < 67.0 I= 3.18 – 0.0474 MRI	MRI ≥ 67.0 and ≤ 82.0	MRI > 82.0
III	MRI ≤ 52.0 I = $1.28	MRI > 52.0 and < 80.0 I= 3.66 – 0.0457 MRI	MRI ≥ 80.0 and ≤ 97.0	MRI > 97.0

Table 105-13
PCCP SMOOTHNESS (INCHES/MILE)
MEAN ROUGHNESS INDEX

Pavement Smoothness Category	Maximum Incentive Payment ($/sq yd)	Incentive Payment ($/sq yd)	No Incentive	Corrective Work Required (0.10-mile sections)
I	MRI ≤ 46.0 I = $2.80	MRI > 46.0 and < 73.0 I = 7.57 – 0.1037 MRI	MRI ≥ 73.0 and ≤ 88.0	MRI > 88.0
II	MRI ≤ 40.0 I = $2.80	MRI > 40.0 and < 67.0 I = 6.948 – 0.1037 MRI	MRI ≥ 67.0 and ≤ 82.0	MRI > 82.0
III	MRI ≤ 52.0 I = $2.80	MRI > 52.0 and < 80.0 I= 8.00 – 0.100 MRI	MRI ≥ 80.0 and ≤ 97.0	MRI > 97.0

Table 105-14
CORRECTIVE WORK CRITERA (INCHES/MILE)
0.005 TO 0.10 MILE SECTIONS
MEAN ROUGHNESS INDEX

Pavement Smoothness Category	Corrective Work Required D = Section Length (miles)
I	MRI >134.32 – 463.16 D
II	MRI > 125.16 – 431.58 D
III	MRI > 148.05 – 510.53 D

(e) Corrective Work. The Department will analyze the SA testing for acceptance and indicate areas requiring corrective work per subsection 105.07(b). Corrective work shall be proposed in writing by the Contractor. Corrective work shall not be performed until approved in writing by the Engineer. The Contractor shall perform corrective work in the areas indicated by the SA testing.

The criteria for determining if a 0.1-mile section requires corrective work is specified in Table 105-12or 105-13. The criteria for determining if a section less than 0.10 miles in length and greater than 0.005 miles in length requires corrective work is specified in Table 105-14.

Corrective work shall consist of diamond grinding, an approved overlay, or removal and replacement. Corrective work shall conform to of one of the following conditions:

1. HMA Removal and Replacement. The pavement requiring corrective work shall be removed, full width of the lane and the full thickness of the layer per subsection 202.09.

The removal area shall begin and end with a transverse butt joint, which shall be constructed with a transverse saw cut perpendicular to centerline. Replacement material shall be placed in sufficient quantity, so the finished surface conforms to grade and smoothness requirements. Sections removed and replaced shall be at least 0.20 miles in length.

2. HMA Overlay. The overlay shall cover the full width of the pavement including shoulders. The area overlaid shall begin and end with a transverse butt joint, which shall be constructed with a transverse saw cut and asphalt removal. All material shall be approved hot bituminous mixtures that meet all contract requirements. The overlay shall be placed so that the finished surface conforms to grade and smoothness requirements. The overlay area shall be compacted to the specified density. The overlay thickness shall be equivalent to that of the final layer per the Contract. Sections overlaid shall be at least 0.20 miles in length.

3. Diamond Grinding. Grinding shall not reduce planned pavement thickness by more than 0.3 inches. Diamond grinding shall be the full width of a wheel path. The wheel path is from the stripe to the center of the lane. The grinding process shall produce a pavement surface that is true to grade and uniform in appearance. The grooves shall be evenly spaced. Any ridges on the outside edge next to the shoulder, auxiliary, ramps or adjacent lanes greater than 3/16-inch-high shall be feathered out to the satisfaction of the Engineer in a separate, feather pass operation.

   The pavement surface after grinding shall have no depressions or misalignment of slope in the longitudinal direction exceeding 1/8 inch in 12 feet when measured with a 12-foot straightedge placed parallel to the centerline. All areas of deviation shall be reground at no additional cost.

   The slurry and residue resulting from the grinding operation shall not be allowed to flow across lanes occupied by the traffic and shall be continuously removed during the grinding operation, leaving the pavement in a clean condition. The Contractor shall haul the grinding residue to an approved location at no additional cost.

   Cores shall be taken to verify that minimum pavement thicknesses have been maintained. A minimum of one core shall be taken every 100 cumulative feet or fraction thereof per lane of diamond grinding, as directed by the Engineer. Coring shall be at the Contractor's expense.

   For HMA pavements, the entire ground area of the final pavement surface shall be covered with a Tack Coat conforming to Section 407 (CSS-1h at 0.1 gallons per square yard of diluted emulsion; the emulsion shall be diluted with water at the rate of 50 percent water and 50 percent emulsion) when grinding is complete after final SA testing is complete.

   When any grinding on concrete pavement occurs where a core for determining pavement thickness has been previously taken, another core shall be taken after the grinding has been completed and shall replace the original core in the calculation of pavement thickness incentive and disincentive. Joint sealant that has been damaged by grinding on concrete pavement shall be repaired or replaced at the Contractor's expense per Standard Plan M-412-1 and subsection 412.18.

For PCCP, diamond ground surface texture will be considered acceptable when the average texture depth (ATD) of the panel is greater than 0.05 inch. The Contractor will perform surface texture testing per CP 77 Method B. Each area in a lane that required diamond grinding will be tested at least once. Areas in a lane with more than 500 continuous feet of grinding will be tested at a frequency of one test per 500 linear feet. Areas with deficient surface texture shall be diamond ground and retested.

(f) Final Smoothness Acceptance Testing. After the Contractor has completed the required corrective work, the Contractor shall retest the pavement per subsection 105.07(b). Final SA testing shall only be required on lanes with sections requiring corrective work. Final SA testing shall start and stop at the same locations as the Initial SA testing. If additional corrective work is required, the Contractor shall perform the corrective work and perform additional Final SA Testing. Time count will be charged pursuant to contract requirements during the time period required for all Final SA Testing. Delays associated with additional Final SA Testing will be considered nonexcusable and noncompensable.

The Contractor shall notify the Engineer and the Department by email at DOT_Profiles@state.co.us at least 5 working days in advance of his intention to perform final SA testing. The Department will determine if Smoothness Verification Testing (SV) will be performed. If SV testing will be performed, it will be performed at the same time as the SA testing.

The Initial SA and Final SA profile lengths shall have a difference in the length of each lane less than 0.2 percent. When the profile length difference exceeds 0.2 percent, the Final SA testing shall be repeated.

(g) Department Smoothness Verification Testing (SV). The Department may elect to perform smoothness verification testing using the Department's inertial profiler, with the methods described in subsection 105.07(b). The Engineer will notify the Contractor of the Department's intention to perform SV testing. The Contractor shall coordinate with the Department and his profiler to schedule SA and SV to occur at the same time.

The Department will randomly select scheduled Contractor Smoothness Acceptance Testing to verify. A minimum of 25 percent of each scheduled Contractor Smoothness Acceptance Testing by an individual profiler will be verified. The Engineer may also request verification for any Smoothness Acceptance Testing.

The Contractor's SA test results will be compared to the Department's SV test results. The Contractor's SA test results will be considered acceptable and will be used for incentive payment if the following criteria are met:

(1) The difference in MRI for a 1/10-mile section is less than 6.1 inches/mile for a minimum of 90 percent of the 1/10-mile sections for each lane.

(2) The difference in average MRI for each lane is less than 6.1 inches/mile.

(3) The difference in the length of each lane is less than 0.2 percent.

When the Contractor's SA test results are not considered acceptable, the Department's SV test results will be used for incentive payment and the Contractor's profiler certification will be suspended and evaluated pursuant to CP 78. The Contractor shall schedule with the Department within 10 working days to perform this evaluation or the profiler will be required to be re-certified per CP 78.

105.08 Document Management and Professional Engineer and Professional Land Surveyor Electronic Seals. Where the specifications require the Contractor to submit or return documents either in writing or the format is not specified, an electronic file is preferred. The Contractor shall submit the schedule native file, video recordings, photographs, image files, and other media formats in their native file formats. When the document format is not specified, the contractor shall submit electronic documents in PDF. When a submittal requires multiple copies, one electronic document shall satisfy the requirement.

Where a signature is needed, an electronic signature is acceptable. An original signature is a signature signed in ink. Where original signatures or original documents are required a scanned shall satisfy the requirement.

The Department and Contractor shall use Adobe Sign software to route and sign Contract Modification Orders and change orders for signature.

An electronic seal is when a Contractor's Engineer, a Professional Engineer or a Professional Land Surveyor affix their electronic signature and seal to plans or documents prepared under their responsible charge or control. Adobe Sign software shall be used for electronic seals on documents and electronic seals shall comply with the requirements of the Architects, Professional Engineers, and Professional Land Surveyors Rules and Regulations, 4 CCR 730-1.

The Contractor shall submit as-built plans using the template provided by the Project Engineer.

105.09 Coordination of Plans, Specifications, Supplemental Specifications, and Special Provisions. These specifications, the supplemental specifications, the plans, special provisions, and all supplementary documents are essential parts of the Contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work.

In case of discrepancy the order of precedence is as follows:

(a) Special Provisions

1. Project Special Provisions.
2. Standard Special Provisions.

(b) Plans

1. Detailed Plans
2. Standard Plans
3. Calculated dimensions will govern over scaled dimensions.

(c) Supplemental Specifications

(d) Standard Specifications

The Contractor shall not take advantage of any apparent error or omission in the Contract. If the Contractor discovers an error or omission, the Engineer shall immediately be notified. The Engineer will make corrections and interpretations as necessary to fulfill the intent of the Contract.

105.10 Cooperation by Contractor. The Contractor shall give the work the constant attention necessary to facilitate progress and shall cooperate with the Engineer, inspectors, and other contractors.

The Contractor shall have on the project, at all times that work is being performed, a competent superintendent capable of reading and understanding the contract documents and experienced in the type of work being performed. The superintendent will receive instructions from the Engineer and shall be authorized to act for the Contractor on the project and to execute orders or directions of the Engineer without delay. The superintendent shall promptly supply, irrespective of the amount of work sublet, materials, equipment, tools, labor, and incidentals to complete the Contract.

PROJECT FIRST PROGRAM. Project First is required on all projects with an Engineer's Estimate of over one million dollars and is optional and highly recommended for all other projects. The Project First Program shall not take precedent over any other Contract requirement and shall only apply to contracts with the Department.

The Project First Program is structured to draw on the strengths of the Contractor and the Department to identify and achieve mutual goals. Project First is a scalable program that supports effective and efficient contract performance and is performed with reciprocal cooperation. The goal is a project completed within budget, on schedule, and per the Contract. The Department Engineer and the Superintendent are the lead representatives to address the issues promptly and at the appropriate level. Executives from both organizations are encouraged to be active supporters and to visit with the Project Teams. The Project First Program includes the Project Team, consisting of the Department and the Contractor, developing tools to identify and manage project risks and facilitate communication. The tools are developed and updated for the project's duration in formal Workshops and project meetings.

Project First Workshops.

(a) Workshop Facilitation. All costs related to Project First are incidental to the project except for the actual costs for the use of a workshop third-party facilitator. The cost for a workshop facilitator shall be agreed upon before engagement. The Project Team shall equally share the facilitation costs. Either the Department or the Contractor may contract directly with the third party.

(b) Initial Workshop. The Project Team shall conduct an initial workshop before the Preconstruction Conference. The Engineer and the Superintendent shall jointly agree on the individuals to invite to the initial workshop. They shall invite the members from their respective teams. The Region Transportation Director or the Program Engineer, the Resident Engineer, the Engineer, and other project personnel shall attend the initial workshop. The Contractor owner, executive or a representative, the Superintendent, project supervision personnel, and key subcontractors shall attend the initial workshop. The Engineer and the Superintendent shall jointly determine if other stakeholders shall attend. At the initial workshop, the parties each will discuss their planned approach to the project and develop the Project First Tools.

(c) *Follow-up and Closeout Workshops*. Project Team shall conduct follow-up workshops at least once every two months, unless the Engineer and the Superintendent jointly determine the frequency of these meetings can be reduced, and one final closeout workshop. When there are open items on the Project Risk Assessment Tool, workshops shall continue during no-work periods. Workshops are not required during landscape establishment periods. The Project Team shall conduct the closeout workshop before Final Acceptance.

The Resident Engineer, the Engineer, the Superintendent, and project supervision personnel shall attend the follow-up and Closeout Workshops. The Region Transportation Director or Program Engineer, the Contractor owner, executive, or representatives are not required to attend the follow-up and closeout workshops. The subcontractors or stakeholders with open risk items and incomplete work, shall attend the follow-up and closeout workshops. The Engineer and the Superintendent shall jointly determine if other stakeholders shall attend.

In the follow-up workshops the parties will update Risk Assessment Tool risks, including adding any new risks and closing completed risks. The parties shall resolve all remaining risks and document lessons learned before or by the closeout workshop. The Project Team should also celebrate the project successes.

Project First Tools.

(a) *Project Risk Assessment Tool*. The Project Team shall develop and update a Project Risk Assessment Tool. This Tool shall support risk identification, analysis, response strategy, monitoring, and control. All parties shall use the Project Risk Assessment Tool to document and manage the project risks. A risk for the purpose of Project First is an unexpected known event or potential future event that may positively or negatively affect the project costs, schedule, scope, or relationship. The Project Team may modify the Project Risk Assessment Tool to suit the project.

(b) *Project First Escalation Ladder*. Use the Escalation Ladder to escalate major or repeated performance concerns to the next person in the supervisory chain. The Escalation Ladder is a list that includes the name, title, and contact information of the individuals in the supervisory chain for the Contractor's project organization and for the Department's project organization. The Contractor and the Department shall keep the Escalation Ladder up to date. The Project Team shall use the Escalation Ladder when the following types of concerns occur:

- Bad Faith: When an individual is knowingly or willingly dishonest, not fulfilling legal or contractual obligations, misleads others, enters into an agreement without the intention or means to fulfill it, or violates basic standards of honesty in dealing with others.
- Administration Performance: When an individual is not responsive in administrative performance such as resolving requests for information, developing partial payments, submitting required documentation, delays in progressing issues, and in negotiations. When an individual is unable to or is not competent in performing construction administration duties.

- Defiance: When an individual disregards Contract requirements or the direction of the Engineer.
- Professionalism: When an individual acts in an unprofessional manner, including disrespectful, vulgar, or aggressive behavior.

Although these concerns may contribute to the issues described in subsection 105.22, they are different. Subsection 105.22 is the Contract escalation process for issues related to items in subsections 104.02, 104.03, 106.05, 106.06, 108.08(a), and 108.08(d) for merit and quantum.

(c) Project First Charter. The establishment of a Project First charter is optional. A Charter shall not change the legal relationship of the parties to the Contract nor act as a waiver of, nor supersede the terms of the Contract. If a Charter is developed, the Project Team shall develop the Charter jointly.

105.11 Cooperation with Utilities. The Department will notify all utility companies, pipe line owners, or other parties affected, and have all necessary adjustments of the public or private utility fixtures, pipe lines, and other appurtenances within or adjacent to the limits of construction made as soon as practicable.

Water lines, gas lines, wire lines, service connections, meter and valve boxes, light standards, cableways, signals, and all other utility facilities within the limits of the proposed construction are to be relocated or adjusted at the owner's expense unless otherwise provided in the Contract. The Contractor shall cooperate with the utility owners in their removal and relocation operations, so that progress is expedited, duplication of work is minimized and service interruptions are avoided.

Per C.R.S. 9-1.5-103 et seq. (Excavation Requirements – Plans and Specifications), the Department will certify in the project plans and specifications which Quality Level (A-D) the depicted existing known utilities are, pursuant to the most recent version of the ASCE Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data (CI/ASCE 38-02). The Contractor shall not be relieved of its responsibility to comply with the requirements set forth and shall not rely solely on the Department's plans and specifications when completing its work with respect to existing buried utilities. The Contract will indicate those utility items that are to be relocated or adjusted by the utility owner or those to be relocated or adjusted by the Contractor. The Contractor shall consider in the bid proposal all of the permanent and temporary utility facilities in their present or relocated positions as shown in the Contract and as revealed by site investigation. Utility delays due to changes that are the responsibility of the Contractor will be considered nonexcusable delays. Utility delays beyond the Contractor's control and not due to the fault or negligence of the Contractor shall be documented by the Contractor and tied to the project's critical path schedule, so as to demonstrate a timeline of events leading up to the utility owner's failure to perform and subsequent delay to the project. Delays will be determined to be compensable or noncompensable per subsection 108.08. The Contractor and the Engineer shall meet with the utility owners as often as necessary to coordinate and schedule relocations or adjustments. Additional compensation will not be allowed for foreseeable coordination, inconvenience, or damage sustained due to interference from the utility facilities or the removal or relocation operations as indicated in the Contract.

If utility facilities or appurtenances are found that are neither identified in the Contract, nor revealed by site investigation, the Engineer will determine whether adjustment or relocation of the utility is necessary. The Engineer will make arrangements with either the utility owner

or the Contractor to accomplish necessary adjustments or relocations when not otherwise provided for in the Contract. Extra work will be considered for payment per subsection 104.03. Consideration for delays shall be per subsection 108.08(d).

Where the Contractor's operations are adjacent to properties of railroad, telegraph, telephone, power, or other utility companies, that damage might result in considerable expense, loss, or inconvenience, work shall not commence until arrangements for the protection of the utilities have been made.

If water or utility services are interrupted, the Contractor shall promptly notify the owner and shall cooperate in the restoration of service. Repair work shall be continuous until the service is restored. Work shall not be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority.

105.12 Cooperation Between Contractors. The Department reserves the right to contract for and perform other or additional work on or near the work covered by the Contract.

When separate contracts are let within the limits of any one project, each Contractor shall conduct the work without interfering or hindering the progress or completion of the work being performed by other Contractors. Contractors working on the same project shall cooperate with each other as directed.

Each Contractor involved shall assume all liability, financial or otherwise, in connection with the Contract and shall protect and save harmless the Department from any and all damages or claims that may arise because of inconvenience, delay, or loss because of the presence and operations of Contractors working within the limits of the same or adjacent project.

105.13 Construction Stakes, Lines and Grades. Construction work shall not be performed until adequate lines and grades have been established by the Department or by the Contractor.

(a) Contractor Surveying. When the bid schedule contains pay item 625, Construction Surveying, the Department will provide control points and benchmarks as described in the Contract. The Contractor shall furnish and set construction stakes establishing lines and grades per the provisions of Section 625. The Engineer may order extra surveying, which will be paid for at a negotiated rate not to exceed $150 per hour.

(b) Department Surveying. When the bid schedule does not contain pay item 625, Construction Surveying, the Engineer will furnish one set of construction stakes and marks establishing lines and grades as described below for proper completion of the work.

Roadway staking will include stakes for; fence, centerline, slopes, grades (bluetops), curb and gutter, sidewalk, and median barrier. Grade stakes for finished subgrade will not be set until the grade established by the slope stakes is constructed to within 0.3 foot of the finished subgrade elevation.

Minor structures and retaining wall staking will be limited to stakes establishing line and grade by using offset line and grade stakes.

Major structures staking and references will be limited to centerlines (or work lines or control lines) as shown on the plans, appropriate offset lines and grades; and elevations set for footings, piers, pier caps, abutments, bottom of deck grades and finish deck screed grades.

It will be the responsibility of the Contractor to use these references and marks and establish any additional control and layout necessary for the proper completion of the work in its final location. The Contractor shall be responsible for the accuracy of all the vertical and horizontal control it transfers and establishes. The Contractor shall, when required, provide access to abutments, piers or other locations, and shall furnish working platforms that meet applicable safety requirements so the Engineer's duties can be performed.

The Contractor shall preserve all stakes and marks. If any stakes or marks are destroyed, disturbed or removed by the Contractor, subcontractors, or suppliers, the cost of replacing them will be charged against the Contractor and will be deducted from the payment for the work at a negotiated rate not to exceed $150 per hour.

It is the responsibility of the Contractor to perform all required layout work, which shall include, but will not be limited to the following:

1. Piling locations and cut off elevation.
2. Girder seats on piers and abutments.
3. Bolt locations and patterns.
4. Construction sign locations.
5. Guardrail.

The Engineer reserves the right to inspect all staking and work in place to ensure conformance with the Contract. A minimum of two workdays will be required as advance notice to the Engineer to provide project control staking.

105.14 Authority and Duties of the Project Engineer. The Project Engineer has immediate charge of the administration and engineering details of each construction project. The Project Engineer has the authority to exercise all duties and responsibilities of the Engineer contained in the Contract, except those specifically retained by the Chief Engineer. The CDOT Project Engineer and the CDOT Resident Engineer are the only representatives of the Chief Engineer authorized to sign Contract Modification Orders. The Project Engineer is responsible for initial decisions relating to Contractor disputes pursuant to subsection 105.22.

105.15 Duties of the Inspector. Inspectors employed by the Department are authorized to inspect all work done, and materials furnished. This inspection may extend to all or any part of the work and to the preparation, fabrication or manufacture of the materials to be used. The inspector is not authorized to alter or waive the provisions of the Contract. The inspector is not authorized to issue instructions contrary to the provisions of the Contract or to act as foreman for the Contractor.

105.16 Inspection and Testing of Work. All materials and each part or detail of the work shall be subject to inspection by the Engineer. The Engineer shall be allowed access to all parts of the work and shall be furnished with information and assistance by the Contractor as required to make a complete and detailed inspection.

Before final acceptance of the work, the Contractor shall remove or uncover such portions of the finished work, as directed. After examination, by the Engineer, the Contractor shall restore the work to the standard required by the Contract. If the work thus exposed or examined proves acceptable, the uncovering, removing, or restoring the work will be paid for as extra work. If the work exposed or examined proves unacceptable, the uncovering, removing, or restoring the work shall be at the Contractor's expense.

Any work done or materials used without inspection by an authorized Department representative may be ordered uncovered, removed, or restored at the Contractor's expense.

When any unit of government or political subdivision, utility, or railroad corporation is to pay a portion of the cost of the work covered by a highway Contract, its respective representatives shall have the right to inspect the work. This inspection shall not make any unit of government or political subdivision, utility, or railroad corporation a party to the Contract, and shall not interfere with the rights of either party.

All inspections and all tests conducted by the Department are for the convenience and benefit of the Department. These inspections and tests do not constitute acceptance of the materials or work tested or inspected, and the Department may reject or accept any work or materials at any time before the inspection pursuant to subsection 105.21(b) whether or not previous inspections or tests were conducted by the Engineer or authorized representative.

105.17 Removal of Unacceptable Work and Unauthorized Work. Unacceptable work is work that does not conform to the requirements of the Contract.

Unacceptable work, resulting from any cause, found to exist before the final acceptance of the work, shall be removed and replaced in an acceptable manner at the Contractor's expense. The fact that the Engineer or an inspector may have overlooked the unacceptable work shall not constitute an acceptance of any part of the work.

Unauthorized work is work that was done without adequate lines and grades having been established by the Engineer or by the Contractor, work done contrary to the instructions of the Engineer, work done beyond the lines shown on the plans, or extra work done without the Engineer's authorization. Unauthorized work will not be paid for under the provisions of the Contract and may be ordered removed or replaced at the Contractor's expense.

If the Contractor fails to comply with any order of the Engineer made under the provisions of this subsection, the Engineer will have authority to cause unacceptable work to be remedied or removed and replaced, and unauthorized work to be removed. The Engineer will deduct the costs from any monies due or to become due the Contractor.

105.18 Load Restrictions. The Contractor shall comply with all legal load restrictions in the hauling of equipment or materials on public roads beyond the limits of the project. A special permit will not relieve the Contractor of liability for damage resulting from the moving of equipment or material.

The operation of equipment or hauling loads that cause damage to structures, the roadway or any other construction will not be permitted. Hauling of materials over the base course or surface course under construction shall be limited by the Contractor to methods and equipment that will prevent damage to the pavement structure. Loads will not be permitted on a concrete pavement or structure before the expiration of the curing period. The Contractor shall be responsible for the repair of all damage and related expense resulting from hauling equipment and construction operations.

If a vehicle's gross weight exceeds the legal limit, and the material transported by the vehicle is delivered to the project, the material and the scale ticket (certificate of correct weight) will not be accepted.

If a scale ticket from an overweight vehicle is inadvertently accepted and the material incorporated into the project, the Engineer will adjust the price for the overweight load as follows:

(1) The pay item quantity represented by the amount of material in excess of the legal weight will not be paid for.

(2) A price reduction will be assessed for the overweight portion of the load based on the following schedule.

Overweight (Pounds)	Price Reduction (Dollars)
0 - 3000	20
3001 - 4000	40
4001 - 5000	82
5001 - 6,000	130
6001 - 7000	226
7001 - 8000	376
8001 - 9000	582
9,001 - 10,000	842
Over 10,000	$870 plus $164 for each 1,000 lbs. over 10,000 lbs.

105.19 Maintenance During Construction. The Contractor shall maintain all work that is included in the Contract during construction and until final written acceptance, except as otherwise specified in subsection 107.17. This maintenance shall constitute continuous and effective work prosecuted with adequate equipment and forces, so the roadway or structures are kept in satisfactory condition at all times.

If the Contract involves the placement of material on or utilization of, a previously constructed subgrade, pavement structure or structure, the Contractor shall maintain the previously constructed work during all construction operations. All cost of maintaining the contract work during construction and before final written acceptance will not be paid for separately, but shall be included in the work, except as otherwise specified in subsection 107.17.

105.20 Failure to Maintain Roadway or Structure. If the Contractor fails to comply with the provisions of subsection 105.19, the Engineer will immediately notify the Contractor of such noncompliance. Except in the case of traffic signal maintenance, the Contractor shall respond and remedy unsatisfactory maintenance within 24 hours after receipt of such notice. If the Contractor fails to remedy unsatisfactory maintenance in the allotted time, the Engineer may immediately proceed to maintain the project, and the entire cost of this maintenance will be deducted from the monies due or to become due to the Contractor on the Contract.

In the case of traffic signal maintenance, the Contractor shall respond and remedy unsatisfactory maintenance within one hour of receipt of notice on urban highways, and within four hours of receipt of notice on rural highways.

Traffic signal maintenance shall include all approved traffic control items and work that are required to maintain traffic through the affected area while the traffic signal is being repaired

or replaced. If the Department performs traffic signal maintenance, the Department shall be held harmless for all subsequent occurrences of maintenance to the signals that the Department maintained.

If damage occurs to an existing structure through improper maintenance per 105.19, the Contractor shall submit a repair procedure to the Engineer to repair the defect(s).

The repair categories and requirements are defined as follows:

a) "In-kind" repairs. In-kind repairs are repairs where the As-Built or Advertised plans are utilized to replace or repair damaged components with identical dimensions and materials used plans and where no plan modifications are made. In-kind repair procedures shall be reviewed and accepted by the Engineer before any repair. The use of approved repair grouts or doweled reinforcing with epoxy adhesive is permitted in in-kind repairs. Doweled reinforcing shall meet or exceed the strength requirements of the original design.

b) "*Modified repairs*". Modified repairs are those which deviate in dimensions and/or materials from the As-Built or Advertised plans or where plans are not available. Modified repair procedure submittals shall include calculations, independent design calculations, shop drawings, and/or working drawings per 105.02, and any other applicable section of the specifications for the needed repair. The Contractor's Engineer shall electronically seal Modified repair submittals.

Damage to new structures or modified structures, shall be repaired per the contract documents.

The Engineer of Record shall be notified and review all corresponding submittals before any repairs.

105.21 Acceptance.

(a) Partial Acceptance. If, during the prosecution of the project, the Contractor satisfactorily completes a unit or portion of the project, such as a structure, an interchange, or a section of road or pavement that can be used advantageously for traffic, the Engineer may make final inspection of that unit. If the Engineer finds that the unit has been satisfactorily completed in compliance with the Contract, the Contractor may be relieved of further responsibility for that unit except as otherwise provided in subsection 107.16. Partial acceptance shall not void or alter any of the terms of the Contract.

(b) Final Acceptance. Upon notice from the Contractor of presumptive completion of the entire project, the Engineer will make an inspection. If the work provided for by the Contract has been satisfactorily completed, that inspection shall constitute the final inspection and the Engineer will notify the Contractor in writing of final acceptance indicating the date the project was inspected and accepted.

If the inspection discloses any unsatisfactory work, the Engineer will give the Contractor a written list of the work needing correction. Upon correction of the work, another inspection will be made. If the work has been satisfactorily completed, the Engineer will notify the Contractor in writing of the date of final inspection and acceptance. Final acceptance under this subsection does not waive any legal rights contained in subsection 107.21.

If not included in the Partial or Final Acceptance letter, no later than 3 working days after the acceptance letter is provided to the Contractor, the Engineer will provide in writing a detailed list of all remaining documentation required by the Contract. Upon reviewing and accepting the remaining documentation, and with no other outstanding issue(s), the Engineer will release retainage as follows:

1. 65% of the current retainage shall be released.
2. If the release of retainage is less than $10,000, no retainage will be released.
3. Retainage will be released only to the extent that the remaining retainage shall not be less than $20,000.

105.22 Dispute Resolution. Subsections 105.22, 105.23, and 105.24 detail the process through which the parties (CDOT and the Contractor) agree to resolve any issue that may result in a dispute. The intent of the process is to resolve issues early, efficiently, and as close to the project level as possible. Figure 105-1 outlines the process. Specified time frames may be extended by mutual agreement of the Engineer and the Contractor. In these subsections, when a time frame ends on a Saturday, Sunday or holiday, the time frame shall be extended to the next scheduled workday.

An issue is a disagreement concerning contract price, time, interpretation of the Contract, or all three between the parties at the project level regarding or relating to the Contract. Issues include, but are not limited to, a disagreement resulting from a delay, a change order, another written order, or an oral order from the Project Engineer, including any direction, instruction, interpretation, or determination by the Project Engineer, interpretations of the Contract provisions, plans, or specifications or the existence of alleged differing site conditions.

The Contractor shall bring all issue(s) to the Project Engineer’s attention, in writing, within 30 days of the Contractor being aware of the issue(s). Written notice must take the form of a stand-alone, non-chain e-mail or letter, addressed and delivered to the Project Engineer. If a Contractor provides written notice outside of the 30-day deadline, it shall be presumed that CDOT suffered prejudice. Where the Contractor failed to provide the required notice, the failure to provide notice may be treated as a separate and threshold dispute to be resolved before other related disputes(s) are submitted, addressed, or resolved.

A dispute is an issue which the Contractor and CDOT have not been able to resolve and for which the Contractor submits a written formal notice of dispute per subsection 105.22(b).

A claim is a dispute not resolved at the Resident Engineer level or resolved after a DRB recommendation.

The term "merit" refers to the right of a party to recover on a claim or dispute, irrespective of quantum, based on the substance, elements, and grounds of that claim or dispute. The term "quantum" refers to the quantity or amount of compensation or time deserved when a claim or dispute is found to have merit.

Disputes from subcontractors, material suppliers, or any other entity not party to the Contract shall be submitted through the Contractor. Review of a pass-through dispute does not create privity of Contract between CDOT and the subcontractor.

An audit may be performed by the Department for any dispute or claim. All audits will be completed within 90 days of the request for an audit, provided the Contractor allows the auditors reasonable and timely access to the contractor’s books and records.

If CDOT does not respond within the specified timelines, the Contractor may advance the dispute to the next level.

When the Project Engineer is a Consultant Project Engineer, actions, decisions, and determinations specified as made by the Project Engineer shall be made by the Resident Engineer.

The dispute resolution process set forth in this subsection shall be exhausted in its entirety before initiation of litigation. Failure to comply with the requirements set forth in this subsection, including notice requirements, shall bar either party from any further administrative, equitable, or legal remedies. Subject to the rebuttable presumption of prejudice to CDOT set forth above, if a deadline is missed that does not prejudice either party, further relief shall be allowed.

All written notices of dispute shall be submitted within 30 days of date of the Project Engineer's Final Acceptance letter; see subsection 105.21(b).

When a project has a landscape maintenance period, the Project Engineer will grant partial acceptance per subsection 105.21(a). This partial acceptance will be project acceptance of all the construction work performed before this partial acceptance.

All disputes and claims related to the work in which this partial acceptance is granted shall be submitted within 30 days of the Project Engineer's partial acceptance.

Should the Contractor's dispute use the Total Cost approach for calculating damages, damages will be determined by subtracting the contract amount from the total cost of performance. Should the Contractor's dispute use the Modified Total Cost approach for calculating damages, if the Contractor's bid was unrealistic in part, or some of its costs were unreasonable or some of its damages were caused by its own errors, those costs and damages will be deducted from the total cost of performance to arrive at the Modified Total Cost. The Total Cost or Modified Total Cost basis for calculating damages shall not be available for any disputes or claims seeking damages where the Contractor could have kept separate cost records at the time the dispute arose as described in subsection 105.22(a).

(a) Document Retention. The Contractor shall keep full and complete records of the costs and additional time incurred for each dispute for a period of at least three years after the date of final payment or until dispute is resolved, whichever is more. The Contractor, subcontractors, and lower tier subcontractors shall provide adequate facilities, acceptable to the Engineer, for an audit during normal business hours. The Contractor shall permit the Engineer or Department auditor to examine and copy those records and all other records required by the Engineer to determine the facts or contentions involved in the dispute. The Contractor shall identify and segregate any documents or information that the Contractor considers particularly sensitive, such as confidential or proprietary information.

Throughout the dispute, the Contractor and the Project Engineer shall keep complete daily records of extra costs and time incurred, per the following procedures:

1. Daily records shall identify each operation affected, the specific locations where work is affected, and the potential effect to the project's schedule. Such records shall also reflect all labor, material, and equipment applicable to the affected operations.

2. On the first workday of each week following the date of the written notice of dispute, the Contractor shall provide the Project Engineer with the daily records for the preceding week. If the Contractor's records indicate costs greater than those kept by the Department, the Project Engineer will meet with the Contractor and present his records to the Contractor at the meeting. The Contractor shall notify the Engineer in writing within three workdays of any inaccuracies noted in, or disagreements with, the Department's records.

(b) Initial Dispute Resolution Process. To initiate the dispute resolution process, the Contractor shall provide a written notice of dispute to the Project Engineer upon the failure of the Parties to resolve the issue through negotiation. Disputes will not be considered unless the Contractor has first complied with specified issue resolution processes such as those specified in subsections 104.02, 106.05, 108.08(a), and 108.08(d).

The Contractor shall supplement the written notice of dispute within 15 days with a written Request for Equitable Adjustment (REA) providing the following:

(1) The date of the dispute.

(2) The nature of the circumstances that caused the dispute.

(3) A detailed explanation of the dispute citing specific provisions of the Contract and any basis, legal or factual, that support the dispute.

(4) If any, the estimated quantum, calculated per methods set forth in subsection 105.24(b)12., with supporting documentation.

(5) An analysis of the progress schedule showing the schedule change or disruption if the Contractor is asserting a schedule change or disruption. This analysis shall meet the requirements of subsection 108.08(d).

The Contractor shall submit as much information on the quantum and impacts to the Contract time as is reasonably available with the REA and then supplement the REA as additional information becomes available. If the dispute escalates to the DRB process, neither party shall provide or present to the DRB any issue or any information that was not contained in the REA and fully submitted in writing to the Project Engineer and Resident Engineer during the subsection 105.22 process.

(c) Project Engineer Review. Within 15 days after receipt of the REA, the Project Engineer will meet with the Contractor to discuss the merits of the dispute. Within seven days after this meeting, the Project Engineer will issue a written decision on the merits of the dispute.

The Project Engineer will either deny the merits of the dispute or notify the Contractor that the dispute has merit. This determination will include a summary of the relevant facts, Contract provisions supporting the determination, and an evaluation of all scheduling issues that may be involved.

If the dispute is determined to have merit, the Contractor and the Project Engineer will determine the adjustment in payment, schedule, or both within 30 days. When a satisfactory adjustment is determined, it shall be implemented per subsections 106.05, 108.08, 109.04, 109.05 or 109.10 and the dispute is resolved.

If the Contractor accepts the Project Engineer's denial of the merits of the dispute, the dispute is resolved, and no further action will be taken. If the Contractor does not respond in seven days, it will be assumed he has accepted the denial. If the Contractor rejects the Project Engineer's denial of the merits of the dispute or a satisfactory adjustment of payment or schedule cannot be agreed upon within 30 days, the Contractor may further pursue resolution of the dispute by providing written notice to the Resident Engineer within seven days, according to subsection 105.22(d).

(d) Resident Engineer Review. Within seven days after receipt of the Contractor's written notice to the Resident Engineer of unsatisfactory resolution of the dispute, the Project Engineer and Resident Engineer will meet with the Contractor to discuss the dispute.

Meetings shall continue weekly for a period of up to 30 days and shall include a Contractor's representative with decision authority above the project level.

If these meetings result in resolution of the dispute, the resolution will be implemented per subsections 108.08, 109.04, 109.05, or 109.10 and the dispute is resolved.

If these meetings do not result in a resolution or the participants mutually agree that they have reached an impasse, the dispute shall be presented to the Dispute Review Board per subsection 105.23.

105.23 Dispute Review Board. A Dispute Review Board (DRB) is an independent third party that will provide specialized expertise in technical areas and administration of construction contracts. The DRB will assist in and facilitate the timely and equitable resolution of disputes between CDOT and the Contractor in an effort to avoid animosity and construction delays, and to resolve disputes as close to the project level as possible. The DRB shall be established and operate as provided and shall serve as an independent and impartial board. A DRB member shall not be called as witness for future litigation.

There are two types of DRBs: the "On Demand DRB" and the "Standing DRB". The DRB shall be an "On Demand DRB" unless a "Standing DRB" is specified in the Contract. An On Demand DRB shall be established only when the Project Engineer initiates a DRB review per subsection 105.23(a). A Standing DRB, when specified in the Contract, shall be established at the beginning of the project.

(a) Initiation of Dispute Review Board Review. When a dispute has not been resolved per subsection 105.22, the Project Engineer will initiate the DRB review process within five days after the period described in subsection 105.22(d).

(b) Formation of Dispute Review Board. DRBs will be established per the following procedures:

1. CDOT, in conjunction with the Colorado Contractors Association (CCA), will maintain a statewide list of pre-approved DRB candidates experienced in construction processes and the interpretation of contract documents and the resolution of construction disputes. Only individuals who have completed training (currently titled DRB Administration and Practice Training) through the Dispute Resolution Board Foundation or otherwise approved by CDOT can be a DRB member. DRB nominees shall be selected from the list of pre-approved candidates. When a DRB is formed, the parties shall execute the agreement set forth in subsection 105.23(l).
2. If the dispute has a value of $250,000 or less, the On Demand DRB shall have one member. The Contractor and CDOT shall select the DRB member and execute the Three-Party Agreement within 30 days of initiating the DRB process. If the parties do not agree on the DRB member, each shall select five candidates. Each party shall numerically rank their list using a scale of one to five with one being their first choice and five being their last choice. If common candidates are listed, but the parties cannot agree, that common candidate with the lowest combined numerical ranking shall be selected. If there is no common candidate, the lists shall be combined, and each party shall eliminate three candidates from the list. Each party shall then numerically rank the remaining candidates, with Number 1 being the first choice. The candidate with the lowest combined numerical ranking shall be the DRB member. The CDOT Project Engineer will be responsible for having all parties execute the agreement.

3. If the dispute has a value over $250,000, the On Demand DRB shall have three members. The Contractor and CDOT shall each select a member and those two members shall select a third. Once the third member is approved, the three members will nominate one of them to be the Chair and execute the Three-Party Agreement within 45 days of initiating the DRB process.
4. The Standing DRB shall always have three members. The Contractor and CDOT shall each select a member and those two members shall select a third member. Once the third member is approved the three members will nominate one of them to be the Chair. The Contractor and CDOT shall submit their proposed Standing DRB members within five days of execution of the Contract. The third member shall be approved before the Pre-construction Conference. The third member shall be selected within 15 days of execution of the Contract. Before construction starting, the parties shall execute the Three-Party Agreement. The CDOT Project Engineer will be responsible for having all parties execute the agreement. The Project Engineer will invite the Standing DRB members to the Pre-construction and any Project First conferences.
5. DRB members shall not have been involved in the administration of the project under consideration. CDOT and the Contractor shall inform its selected DRB member who the major firms/people are on the project and request its selected DRB member to review the CDOT disclosure requirements and Canon of Ethics and then submit a disclosure statement which shall also be submitted to the other party. DRB candidates shall complete the DRB Disclosure Requirements and DRB Nominee Disclosure Form and disclose to the parties the following relationships:

   (1) Prior employment with either party

   (2) Prior or current financial interests or ties to either party

   (3) Prior or current professional relationships with either party

   (4) Anything else that might bring into question the impartiality or independence of the DRB member.

   (5) Before agreeing to serve on a DRB, members shall notify all parties of any other CDOT DRB's they are serving or that they will be participating in another DRB.

   If either party objects to the selection of the chair or other DRB members based on the disclosures, or based on information not disclosed, which might bring into question the impartiality, independence, or performance of the potential member, that potential member shall not be placed on the Board.
6. There shall be no ex parte communications with the DRB at any time.
7. The service of a Board member may be terminated only by written agreement of both parties.

(c) If a Board member resigns, is unable to serve, or is terminated, a new Board member shall be selected within four weeks in the same manner as the Board member who was removed was originally selected.

(d) Additional Responsibilities of the Standing Disputes Review Board

1. General. No later than 10 days after the Three-Party Agreement has been signed by the Chief Engineer, the DRB will coordinate with the parties on the date and location of the initial DRB meeting.

(1) Obtain copies of the Contract documents and Contractor's schedules for each of the Board members.

(2) Agree on the location of future meetings, which shall be reasonably close to the project site.

(3) Establish an address and telephone number for each Board member for the purposes of Board business.

2. Regular meetings. Regular meetings of the Board shall be held approximately every 120 to 180 days throughout the life of the Contract, except that this schedule may be modified to suit developments on the job as the work progresses. Regular meetings shall be attended by representatives of the Contractor and the Department.

3. The Board shall establish an agenda for each meeting which will cover all items that the Board considers necessary to keep it abreast of the project such as construction status, schedule, potential problems and solutions, status of past claims and disputes, and potential claims and disputes. Copies of each agenda shall be submitted to the Contractor and the Department at least seven days before the meeting date. Oral or written presentations or both shall be made by the Contractor and the Department as necessary to give the Board all the data the Board requires to perform its functions. The Board will prepare minutes of each meeting, circulate them to all participants for comments and approval, and issue revised minutes before the next meeting. As a part of each regular meeting, a field inspection trip of all active segments of the work at the project site may be made by the Board, the Contractor, and the Department.

4. Advisory Opinions

(1) Advisory opinions are typically used soon after the parties find they have a potential dispute and have conducted preliminary negotiations but before expenditure of additional resources and hardening their positions. Advisory opinions provide quick insight into the DRB's likely assessment of the dispute. This process is quick and may be entirely oral and does not prejudice the opportunity for a DRB hearing.

(2) Both parties must agree to seek an advisory opinion and so notify the chairperson. The procedure for requesting and issuing advisory opinions should be discussed with the DRB at the first meeting with the parties.

(3) The DRB shall issue a one-page written opinion within 5 days of the hearing.

(4) The opinion is only advisory and does not require an acceptance or rejection by either party. If the dispute is not resolved and a hearing is held, the oral presentations and advisory opinion are completely disregarded and the DRB hearing procedure is followed.

(5) Advisory opinions should be limited to merit issues only.

(e) Arranging a Dispute Review Board Hearing. When the Project Engineer initiates the DRB review process, the Project Engineer will:

1. Contact the Contractor and the DRB to coordinate an acceptable hearing date and time. The hearing shall be held at the Resident Engineer's office unless an alternative location is agreed to by both parties. Unless otherwise agreed to by both parties an On Demand DRB hearing will be held within 30 days after the Three-Party Agreement is signed by the CDOT Chief Engineer. Unless otherwise agreed to by both parties, a Standing DRB hearing will be held within 30 days after the DRB has been requested per subsection 105.23(a).

2. Ensure DRB members have copies of all documents previously prepared by the Contractor and CDOT pertaining to the dispute, the DRB request, the Contract documents, and the special provisions at least two weeks before the hearing.

(f) Pre-Hearing Submittal. All Pre-hearing Submittals shall include only arguments, supporting documentation, quantum, and other information as previously submitted in writing and as previously disputed in the formal dispute process covered in subsection 105.22(b), (c), and (d). All Pre-hearing Submittals planned to be used at the hearing, shall be submitted to the other party 35 days before the hearing for review for compliance with this requirement. If either party contends there are new arguments, supporting documents, new quantum, or any new information in a pre-hearing Submittal, and the other party objects to this information being presented to the DRB, the objecting party shall submit its objections in writing to the other party within 10 days. The parties shall meet within five days to reconcile the objection before the submittal is submitted to the DRB. If the parties cannot reconcile the objection, but the new argument, supporting documentation, new quantum, or new information does not change either party's position on merit or quantum, the information shall be allowed in the Pre-hearing submittal and presented to the DRB. If the parties cannot reconcile the objections within the five days allowed, each party shall submit a one-page brief on their objections, but not the actual information objected to, to the DRB for a decision on the use of the documents. The DRB shall not approve any information simply because it is relevant to the dispute or referenced during the dispute. Neither party shall attempt to present anything to the DRB which they did not present to the other party during the dispute process. The dispute process shall be delayed while this determination is being made and a new hearing date set, if necessary. Pre-hearing Submittals to the DRB are as follows:

1. Joint Statement: At least 20 days before the hearing the Joint Statement(s) shall be submitted to the DRB. The parties shall make every attempt to agree upon a Joint Statement of the dispute. If the parties cannot agree on the Joint Statement, each party's independent statement shall be submitted to the DRB. The Joint Statement shall summarize, in a few sentences, the nature of the dispute(s) and the scope of the desired decision.

2. Position Paper: At least 15 days before the hearing, CDOT and the Contractor shall submit by email to the DRB Chairperson their party's Position Paper. The DRB Chairperson shall simultaneously distribute by email the Position Papers to all parties and other DRB members, if any. The Position Paper shall contain the following:

   (1) The basis and justification for the party's position, with reference to specific contract language and the supporting documents of each element of the disputes.

   (2) A list of proposed attendees for the hearing. In the event of any objection by a party, the DRB shall make a final determination as to who attends the hearing.

   (3) When the scope of the hearing includes quantum, full cost details will be calculated per methods set forth in subsection 105.24(b)12. The Scope of the hearing will not include quantum if CDOT has requested an audit that has not been completed.

3. Supporting Documents: At least 15 days before the hearing, each party shall submit a copy of all its supporting documents to the DRB and the other party. Supporting documents include any presentations, visuals, or handouts planned to be used at the hearing. To minimize duplication and repetitiveness, the parties are encouraged to identify a common set of documents that will be referred to by both parties and submit them in a separate package to the DRB at least 20 days before the hearing. Common documents are communications between parties, speed memos, change orders, schedules, request for equitable adjustment, and correspondence, and any document used in the subsection 105.22 process. CDOT shall submit the common set of documents to the Board and Contractor.
4. If relevant to the dispute and requested by the Board, the Engineer shall provide to the DRB either website links, electronic PDFs, or hard copies of pertinent contract documents such as plans, specifications, and M and S Standards.

(g) Pre-Hearing Phone Conference. A pre-hearing phone conference with all Board members and the parties shall be conducted as soon as a hearing date is established, but no later than 10 days before the hearing. The DRB Chairperson shall explain the specifics of how the hearing will be conducted including how the two parties will present their information. (Ex. Each party makes a full presentation of their positions or presentations will be made on a "point by point" basis with each party making a presentation only on the individual dispute issue before moving onto the next issue.)

If the pre-hearing position papers and documents have been received by the DRB before the conference call, the Chairperson shall discuss the estimated hours of review and activities for the disputes (such as time spent evaluating and preparing recommendation on specific issues presented to the DRB). If the pre-hearing position papers and documents have not been received by the Board before the conference call, another conference call will be scheduled during the initial conference call to discuss the estimated hours of review. The Engineer shall coordinate the conference call.

(h) Dispute Review Board Hearing. The DRB shall preside over a hearing. The chairperson shall control the hearing and conduct it as follows:

1. An employee of CDOT presents a brief description of the project and the status of construction on the project.
2. The party that requested the DRB presents the dispute in detail as supported by previously submitted information and documentation in the pre-hearing position paper. No new information or disputes will be heard or addressed by the DRB. Rebuttals of the other party's arguments shall not be presented at this time.
3. The other party presents its position in detail as supported by previously submitted information and documentation.
4. The party that requested the DRB presents their rebuttals followed by the other party's rebuttals.
5. Upon completion of their presentations and rebuttals, both parties and the DRB will be provided the opportunity to exchange questions and answers. Questions from the parties shall be directed to the Chairperson. Attendees may respond only when board members request a response.
6. Employees of each party are responsible for leading presentations at the DRB hearing.

7. Attorneys shall not participate in the hearing unless the DRB specifically addresses an issue to them or unless agreed to by both parties. Should the parties disagree on attorney participation, the DRB shall decide on what, if any, participation will be permitted. Attorneys representing the parties are permitted to attend the hearing, provided their presence has been noted in the pre-hearing submittal.
8. Either party may use experts only if the expert has previously presented to the other party before the DRB process. A party intending to offer an outside expert's analysis at the hearing shall disclose such intention in the pre-hearing position paper. The expert's name and a general statement of the area of the dispute that will be covered by his presentation shall be included in the disclosure. The other party may present an outside expert to address or respond to those issues that may be raised by the disclosing party's outside expert.
9. If both parties approve, the DRB may retain an outside expert. The DRB chairperson shall include the cost of the outside expert in the DRB's regular invoice. CDOT and the Contractor shall equally bear the cost of the services of the outside expert employed by the DRB.
10. If either party attempts to present an argument, documentation, quantum, or new information which the other party feels was not in the Pre-hearing submittals, the chairperson shall require the party to demonstrate where in the Pre-hearing submittal the information in question resides.
11. If either party fails to timely deliver a position paper, the DRB may reschedule the hearing one time. On the final date and time established for the hearing, the DRB shall proceed with the hearing using the information that has been submitted.
12. If a party fails to appear at the hearing, the DRB shall proceed as if all parties were in attendance.

(i) Dispute Review Board Recommendation. The DRB shall issue a Recommendation per the following procedures:

1. The DRB shall not make a recommendation on the dispute at the meeting. Before the closure of the hearing, the DRB members and the Contractor and CDOT together will discuss the time needed for analysis and review of the dispute and the issuance of the DRB's recommendation. The maximum time shall be 30 days unless otherwise agreed to by both parties.
2. After the meeting has been closed, the DRB shall prepare a written Recommendation signed by each member of the DRB. In the case of a three member DRB where one member dissents, that member shall prepare a written dissent and sign it. The DRB's recommendation shall include the following:
   A. A summary of the issues and factual evidence presented by the Contractor and CDOT concerning the dispute.
   B. Recommendations concerning the validity of the dispute.
   C. Recommendations concerning the value of the dispute as to cost impacts if the dispute is determined to be valid.
   D. The contractual and factual bases supporting the recommendation(s) made including an explanation as to why each and every position was accepted or rejected.
   E. Detailed and supportable calculations which support any recommendation(s).

3. The chairperson shall transmit the signed Recommendation and any supporting documents to both parties.

(j) Clarification and Reconsideration of Recommendation. Either party may request in writing clarification or reconsideration of a decision within 10 days following receipt of the Recommendation. Within 10 days after receiving the request, the DRB shall provide written clarification or reconsideration to both parties.

Requests for clarification or reconsideration shall be submitted in writing simultaneously to the DRB and to the other party.

The Board shall not accept requests for reconsideration that amount to a renewal of a prior argument or additional argument based on facts available at the time of the hearing. The Board shall not consider any documents orarguments which have not been made a part of the pre-hearing submittal other than clarification and data supporting previously submitted documentation.

Only one request for clarification or reconsideration per dispute from each party will be allowed.

(k) Acceptance or Rejection of Recommendation. CDOT and the Contractor shall submit their written acceptance or rejection of the Recommendation, in whole or in part, concurrently to the other party and to the DRB within 14 days after receipt of the Recommendation or following receipt of responses to requests for clarification or reconsideration.

If the parties accept the Recommendation or a discreet part thereof, it will be implemented per subsections 108.08, 109.04, 109.05, or 109.10 and the dispute is resolved.

If either party rejects the Recommendation in whole or in part, it shall give written explanation to the other party and the DRB within 14 days after receiving the Recommendation. When the Recommendation is rejected in whole or in part by either party, the other party may either abandon the dispute or pursue a formal claim per subsection 105.24.

If either party fails to submit its written acceptance or rejection of the Dispute Board's recommendation, according to these specifications, such failure shall constitute that party's acceptance of the Board's recommendation.

(l) Admissibility of Recommendation. Recommendations of a DRB issued per subsection 105.23 are admissible in subsequent proceedings but shall be prefaced with the following paragraph:

This Recommendation may be taken under consideration with the understanding that:

1. The DRB Recommendation was a proceeding based on presentations by the parties.
2. No fact or expert witnesses presented sworn testimony or were subject to cross-examination.
3. The parties to the DRB were not provided with the right to any discovery, such as production of documents or depositions.
4. There is no record of the DRB hearing other than the Recommendation.

(m) Cost and Payments.

1. General Administrative Costs. The Contractor and the Department shall equally share the entire cost of the following to support the Board's operation:

   (1) Copies of Contract and other relevant documentation
   (2) Meeting space and facilities
   (3) Secretarial services
   (4) Telephone
   (5) Mail
   (6) Reproduction
   (7) Filing

2. The Department and the Contractor shall bear the costs and expenses of the DRB equally. Each DRB board member shall be compensated at an agreed rate of $1,200 per day if time spent on-site per meeting is greater than four hours. Each DRB board member shall be compensated at an agreed rate of $800 per day if time spent on-site per meeting is less than or equal to four hours. The time spent traveling to and from each meeting shall be reimbursed at $50 per hour if the travel distance is more than 50 miles. The agreed daily and travel time rates shall be considered full compensation for on-site time, travel expenses, transportation, lodging, time for travel of more than 50 miles and incidentals for each day, or portion thereof that the DRB member is at an authorized DRB meeting. No additional compensation will be made for time spent by DRB members in review and research activities outside the official DRB meetings unless that time, (such as time spent evaluating and preparing recommendations on specific issues presented to the DRB), has been specifically agreed to in advance by the Department and Contractor. Time away from the project that has been specifically agreed to in advance by the parties will be compensated at an agreed rate of $125 per hour. The agreed amount of $125 per hour shall include all incidentals. Members serving on more than one DRB, regardless of the number of meetings per day, shall not be paid more than the all-inclusive rate per day or rate per hour for an individual project.

3. Payments to Board Members and General Administrative Costs. Each Board member shall submit an invoice to the Contractor for fees and applicable expenses incurred each month following a month in which the Board members participated in Board functions. Such invoices shall be in the format established by the Contractor and the Department. The Contractor shall submit to the Department copies of all invoices. No markups by the Contractor will be allowed on any DRB costs. The Department will split the cost by authorizing 50 percent payment on the next progress payment. The Contractor shall make all payments in full to Board members within seven calendar days after receiving payment from the Department for this work.

(n) Dispute Review Board Three Party Agreement.

DISPUTE REVIEW BOARD
THREE PARTY AGREEMENT
COLORADO PROJECT NUMBER

THIS THREE-PARTY AGREEMENT, made as of the date signed by the Chief Engineer below, by and between: the Colorado Department of Transportation, hereinafter called the "Department"; and

___,
hereinafter called the "Contractor"; and

__,

__,

__, and

__,
hereinafter called the "Dispute Review Board" or "Board".

WHEREAS, the Department is now engaged in the construction of the

[Project Name]

and

WHEREAS, the Contract provides for the establishment of a Board in accordance with subsections 105.22 and 105.23 of the specifications.

NOW, THEREFORE, it is hereby agreed:

ARTICLE I
DESCRIPTION OF WORK AND SERVICES

The Department and the Contractor shall form a Board in accordance with this agreement and the provisions of subsection 105.23.

ARTICLE II
COMMITMENT ON PART OF THE PARTIES HERETO

The parties hereto shall faithfully fulfill the requirements of subsection 105.23 and the requirements of this agreement.

ARTICLE III
COMPENSATION

The parties shall share equally in the cost of the Board, including general administrative costs (meeting space and facilities, secretarial services, telephone, mail, reproduction, filing) and the member's individual fees. Reimbursement of the Contractor's share of the Board expenses for any reason is prohibited.

The Contractor shall make all payments in full to Board members. The Contractor shall submit to the Department an itemized statement for all such payments, and the Department will split the cost by including 50 percent payment on the next progress payment. The Contractor and the Department will agree to accept invoiced costs prior to payment by the Contractor.

Board members shall keep all fee records pertaining to this agreement available for inspection by representatives of the Department and the Contractor for a period of three years after the termination of the Board members' services.

Payment to each Board member shall be at the fee rates established in subsection 105.23 and agreed to by each Board member, the Contractor, and the Department. In addition, reimbursement will be made for applicable expenses.

Each Board member shall submit an invoice to the Contractor for fees incurred each month following a month in which the members participated in Board functions. Such invoices shall be in the format established by the

Contractor and the Department.

Payments shall be made to each Board member within 60 days after the Contractor and Department have received all the applicable billing data and verified the data submitted by that member. The Contractor shall make payment to the Board member within seven calendar days of receipt of payment from the Department.

DISPUTE REVIEW BOARD
THREE PARTY AGREEMENT PAGE 2
COLORADO PROJECT NUMBER

ARTICLE IV
ASSIGNMENT

Board members shall not assign any of the work to be performed by them under this agreement. Board members shall disclose any conflicts of interest including but not limited to any dealings with either party in the previous five years other than serving as a Board member under other contracts.

ARTICLE V
COMMENCEMENT AND TERMINATION OF SERVICES

The commencement of the services of the Board shall be in accordance with subsection 105.23 of the specifications and shall continue until all assigned disputes under the Contract which may require the Board's services have been heard and a Recommendation has been issued by the Board as specified in subsection 105.23. If a Board member is unable to fulfill his responsibilities for reasons specified in subsection 105.23(b)7, he shall be replaced as provided therein, and the Board shall fulfill its responsibilities as though there had been no change.

ARTICLE VI
LEGAL RELATIONS

The parties hereto mutually agree that each Board member in performance of his duties on the Board is acting as an independent contractor and not as an employee of either the Department or the Contractor. Board members will guard their independence and avoid any communication about the substance of the dispute without both parties being present.

The Board members are absolved of any personal liability arising from the Recommendations of the Board. The parties agree that members of the dispute review board panel are acting as mediators for purposes of C.R.S. § 13-22-302(4) and, as such, the liability of any dispute review board member shall be limited to willful and wanton misconduct as provided for in C.R.S. § 13-22-305(6).

Board members shall not be called as witness for future litigation.

IN WITNESS HEREOF, the parties hereto have caused this agreement to be executed the day and year written below.

BOARD MEMBER:__.

BY:___.

BOARD MEMBER: __.

BY: __.

BOARD MEMBER:__.

BY:__.

CONTRACTOR:__.

BY:__.

TITLE: __

COLORADO DEPARTMENT OF TRANSPORTATION

BY:__. DATE:_____,

TITLE: CHIEF ENGINEER

105.24 Claims for Unresolved Disputes. The Contractor may file a claim only if the disputes resolution process described in subsections 105.22 and 105.23 has been exhausted without resolution of the dispute. Other methods of nonbinding dispute resolution, exclusive of litigation, can be used if agreed to by both parties.

This subsection applies to any unresolved dispute or set of disputes between CDOT and the Contractor with an aggregate value of more than $15,000. Unresolved disputes with an aggregate value of more than $15,000 from subcontractors, materials suppliers or any other entity not a party to the Contract shall be submitted through the Contractor per this subsection as a pass-through claim. Review of a pass-through claim does not create privity of Contract between CDOT and any other entity.

Subsections 105.22, 105.23 and 105.24 provide both contractual alternative dispute resolution processes and constitute remedy-granting provisions pursuant to Colorado Revised Statutes (CRS) which must be exhausted in their entirety.

Litigation proceedings must commence within 180-calendar days of the Chief Engineer's decision, absent written agreement otherwise by both parties.

The venue for all unresolved disputes with an aggregate value $15,000 or less shall be the County Court for the City and County of Denver.

Non-binding Forms of alternative dispute resolution such as Mediation are available upon mutual agreement of the parties for all claims submitted per this subsection.

The cost of the non-binding ADR process shall be shared equally by both parties with each party bearing its own preparation costs. The type of nonbinding ADR process shall be agreed upon by the parties and shall be conducted within the State of Colorado at a mutually acceptable location. Participation in a nonbinding ADR process does not in any way waive the requirement that litigation proceedings must commence within 180-calendar days of the Chief Engineer's decision, absent written agreement otherwise by both parties.

(a) Notice of Intent to File a Claim. Within 30 days after rejection of the Dispute Resolution Board's Recommendation issued per subsection 105.23, the Contractor shall provide the Region Transportation Director (RTD) with a written notice of intent to file a claim. The Contractor shall also send a copy of this notice to the Resident Engineer. For the purpose of this subsection, Region Transportation Director shall mean the Region Transportation Director or the Region Transportation Director's designated representative. CDOT will acknowledge in writing receipt of Notice of Intent within seven days.

(b) Claim Package Submission. Within 60 days after submitting the notice of intent to file a claim, the Contractor shall submit, to the RTD, five copies of a complete claim package representing the final position the Contractor wishes to have considered. All claims shall be in writing and in sufficient detail to enable the RTD to ascertain the basis and amount of claim. The claim package shall include all documents supporting the claim, regardless of whether such documents were provided previously to CDOT.

If requested by the Contractor, the 60-day period may be extended by the RTD in writing before final acceptance. At a minimum, the following information shall accompany each claim:

1. A claim certification containing the following language, as appropriate:

A. For a direct claim by the Contractor:

CONTRACTOR'S CLAIM CERTIFICATION

Under penalty of law for perjury or falsification, the undersigned,_____(name)
, (title)_____,_____of _____(company)_____, hereby certifies that the claim of $_____for extra compensation and ____Days additional time, made for work on this Contract is true to the best of my knowledge and belief and supported under the Contract between the parties.

This claim package contains all available documents that support the claims made and I understand that no additional information, other than for clarification and data supporting previously submitted documentation, may be presented by me.

Dated _____/s/___

Subscribed and sworn before me this _ day of_.

_

NOTARY PUBLIC

My Commission Expires: _____

B. For a pass-through claim:

PASS-THROUGH CLAIM CERTIFICATION

Under penalty of law for perjury or falsification, the undersigned,_____(name)
, (title)_____,_____, of _____(company)_____, hereby certifies that the claim of $_____ for extra compensation and_____ Days additional time, made for work on this Project is true to the best of my knowledge and belief and supported under the Contract between the parties.

This claim package contains all available documents that support the claims made and I understand that no additional information, other than for clarification and data supporting previously submitted documentation, may be presented by me.

Dated _____/s/___

Subscribed and sworn before me this _day of _____ .

_

NOTARY PUBLIC

My Commission Expires: _____

Dated _____/s_

The Contractor certifies that the claim being passed through to CDOT is passed through in good faith and is accurate and complete to the best of my knowledge and belief.

Dated _____/s/___

Subscribed and sworn before me this . day of _.

_

NOTARY PUBLIC

My Commission Expires: _____

2. A detailed factual statement of the claim for additional compensation, time, or both, providing all necessary dates, locations, and items of work affected by the claim. The Contractor's detailed factual statement shall expressly describe the basis of the claim and factual evidence supporting the claim. This requirement is not satisfied by simply incorporating into the claim package other documents that describe the basis of the claim and supporting factual evidence.

3. The date on which facts were discovered which gave rise to the claim.
4. The name, title, and activity of all known CDOT, Consultant, and other individuals who may be knowledgeable about facts giving rise to such claim.
5. The name, title, and activity of all known Contractor, subcontractor, supplier and other individuals who may be knowledgeable about facts giving rise to such claim.
6. The specific provisions of the Contract, which support the claim and a statement of the reasons why such provisions support the claim.
7. If the claim relates to a decision of the Project Engineer, which the Contract leaves to the Project Engineer's discretion, the Contractor shall set out in detail all facts supporting its position relating to the decision of the Project Engineer.
8. The identification of any documents and the substance of all oral communications that support the claim.
9. Copies of all known documents that support the claim.
10. The Dispute Review Board Recommendation.
11. If an extension of contract time is sought, the documents required by subsection 108.08(d).
12. If additional compensation is sought, the exact amount sought and a breakdown of that amount into the following categories:

    A. These categories represent the only costs that, if applicable, are recoverable by the Contractor. All other costs or categories of costs are not recoverable:

        (1) Actual wages and benefits, including FICA, paid for additional labor.

        (2) Costs for additional bond, insurance, and tax.

        (3) Increased costs for materials.

        (4) Equipment costs calculated per subsection 109.04(c) for Contractor owned equipment and based on certified invoice costs for rented equipment.

        (5) Costs of extended job site overhead (only applies if the dispute also includes a time extension).

        (6) Salaried employees assigned to the project (only applies if the dispute also includes a time extension or if the dispute required salaried employee(s) to be added to the Project).

        (7) Claims from subcontractors and suppliers at any level (the same level of detail as specified is required for all such claims).

        (8) An additional 16 percent will be added to the total of items (1) through (7) as compensation for items for which no specific allowance is provided, including profit and home office overhead.

        (9) Interest shall be paid per CRS 5-12-102 beginning from the date of the Notice of Intent to File Claim.

    B. In adjustment for the costs as allowed above, the Department will have no liability for the following items of damages or expense:

(1) Profit in excess of that provided in 12.A.(8) above.

(2) Loss of Profit.

(3) Additional cost of labor inefficiencies in excess of that provided in A. above.

(4) Home office overhead in excess of that provided in A. above.

(5) Consequential damages, including but not limited to loss of bonding capacity, loss of bidding opportunities, and insolvency.

(6) Indirect costs or expenses of any nature in excess of that provided in A. above.

(7) Attorney's fees, claim preparation fees, and expert fees.

(c) Region Transportation Director Decision. When the Contractor properly files a claim, the RTD will review the claim and render a written decision to the Contractor to either affirm or deny the claim, in whole or in part, per the following procedure.

The RTD may consolidate all related claims on a project and issue one decision, provided that consolidation does not extend the time period within which the RTD is to render a decision. Consolidation of unrelated claims will not be made.

The RTD will render a written decision to the Contractor within 90 days after the receipt of the claim package or receipt of the audit whichever is later. In rendering the decision, the RTD: (1) will review the information in the Contractor's claim; (2) will conduct a hearing if requested by either party; and (3) may consider any other information available in rendering a decision.

The RTD will assemble and maintain a claim record comprised of all information physically submitted by the Contractor in support of the claim and all other discoverable information considered by the RTD in reaching a decision. Once the RTD assembles the claim record, the submission and consideration of additional information, other than for clarification and data supporting previously submitted documentation, at any subsequent level of review by anyone, will not be permitted.

The RTD will provide a copy of the claim record and the written decision to the Contractor describing the information considered by the RTD in reaching a decision and the basis for that decision. If the RTD fails to render a written decision within the 60-day period, or within any extended time period as agreed to by both parties, the Contractor shall either: (1) accept this as a denial of the claim, or (2) appeal the claim to the Chief Engineer, as described in this subsection.

If the Contractor accepts the RTD decision, the provisions of the decision shall be implemented per subsections 108.08, 109.04, 109.05, or 109.10 and the claim is resolved.

If the Contractor disagrees with the RTD decision, the Contractor shall either: (1) accept the RTD decision as final, or (2) file a written appeal to the Chief Engineer within 30 days from the receipt of the RTD decision. The Contractor hereby agrees that if a written appeal is not properly filed, the RTD decision is final.

(d) Chief Engineer Decision. When a claim is appealed, the RTD will provide the claim record to the Chief Engineer. Within 15 days of the appeal either party may submit a written request for a hearing with the Chief Engineer or duly authorized Headquarters delegates. The Chief Engineer or a duly authorized Headquarters delegate will review the claim and render a decision to affirm, overrule, or modify the RTD decision per the following.

The Chief Engineer will render a written decision within 60 days after receiving the written appeal. The Chief Engineer will not consider any information that was not previously made a part of the claim record, other than clarification and data supporting previously submitted documentation.

The Contractor shall have 30 days to accept or reject the Chief Engineer's decision. The Contractor shall notify the Chief Engineer of its acceptance or rejection in writing.

If the Contractor accepts the Chief Engineer's decision, the provisions of the decision will be implemented per subsections 108.08, 109.04, 109.05, or 109.10 and the claim is resolved.

If the Contractor disagrees with the Chief Engineer's decision, the Contractor shall either (1) pursue an alternative dispute resolution process per this specification or (2) initiate litigation per subsection 105.24(f).

If the Chief Engineer does not issue a decision as required, the Contractor may immediately initiate litigation per subsection 105.24(f).

For the convenience of the parties to the Contract it is mutually agreed by the parties that any merit binding or De Novo litigation shall be brought within 180-calendar days from the date of the Chief Engineer's decision. The parties understand and agree that the Contractor's failure to bring suit within the time period provided, shall be a complete bar to any such claims or causes of action.

(e) De Novo Litigation. If the Contractor disagrees with the Chief Engineer's decision, the Contractor may initiate de novo litigation to finally resolve the claim that the Contractor submitted to CDOT. Such litigation shall be strictly limited to those claims that were previously submitted and decided in the contractual dispute and claims processes outlined. This does not preclude the joining in one litigation of multiple claims from the same project provided that each claim has gone through the dispute and claim process specified in subsections 105.22 through 105.24. The parties may agree, in writing, at any time, to pursue some other form of alternative dispute resolution.

Any offer made by the Contractor or the Department at any stage of the claims process, as set forth in this subsection, shall be deemed an offer of settlement pursuant to Colorado Rule of Evidence 408 and therefore inadmissible in any litigation.

If the Contractor selected litigation, then de novo litigation shall proceed per the Colorado Rules of Civil Procedure and the proper venue is the Colorado State District Court in and for the City and County of Denver.

Figure 105-1 provides a summary of the disputes and claims process described in subsections 105.22, 105.23, and 105.24.

Figure 105-1 DISPUTES AND CLAIMS FLOW CHART
(Note: If an audit is to be performed, durations in this flow chart are extended accordingly)

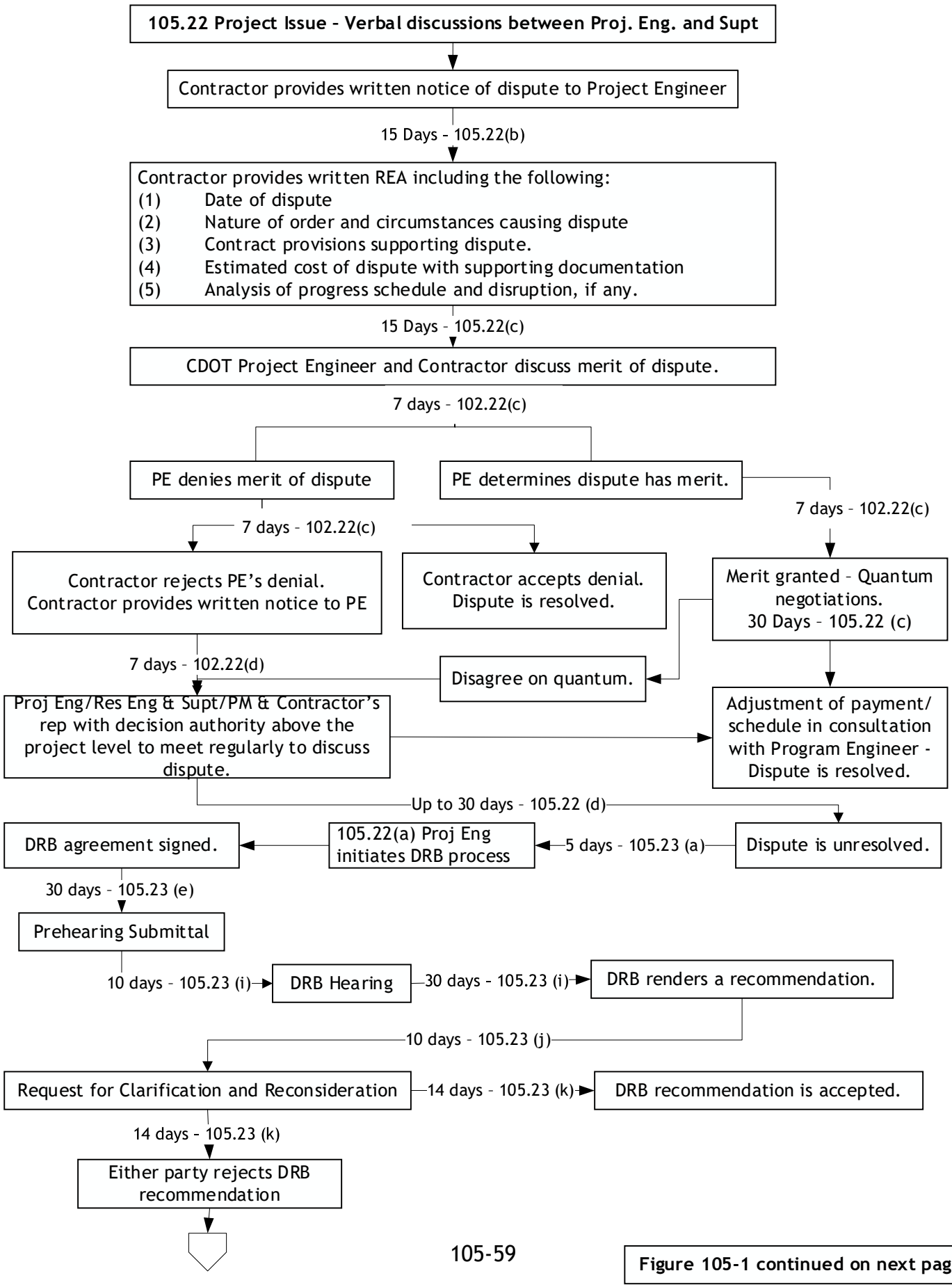
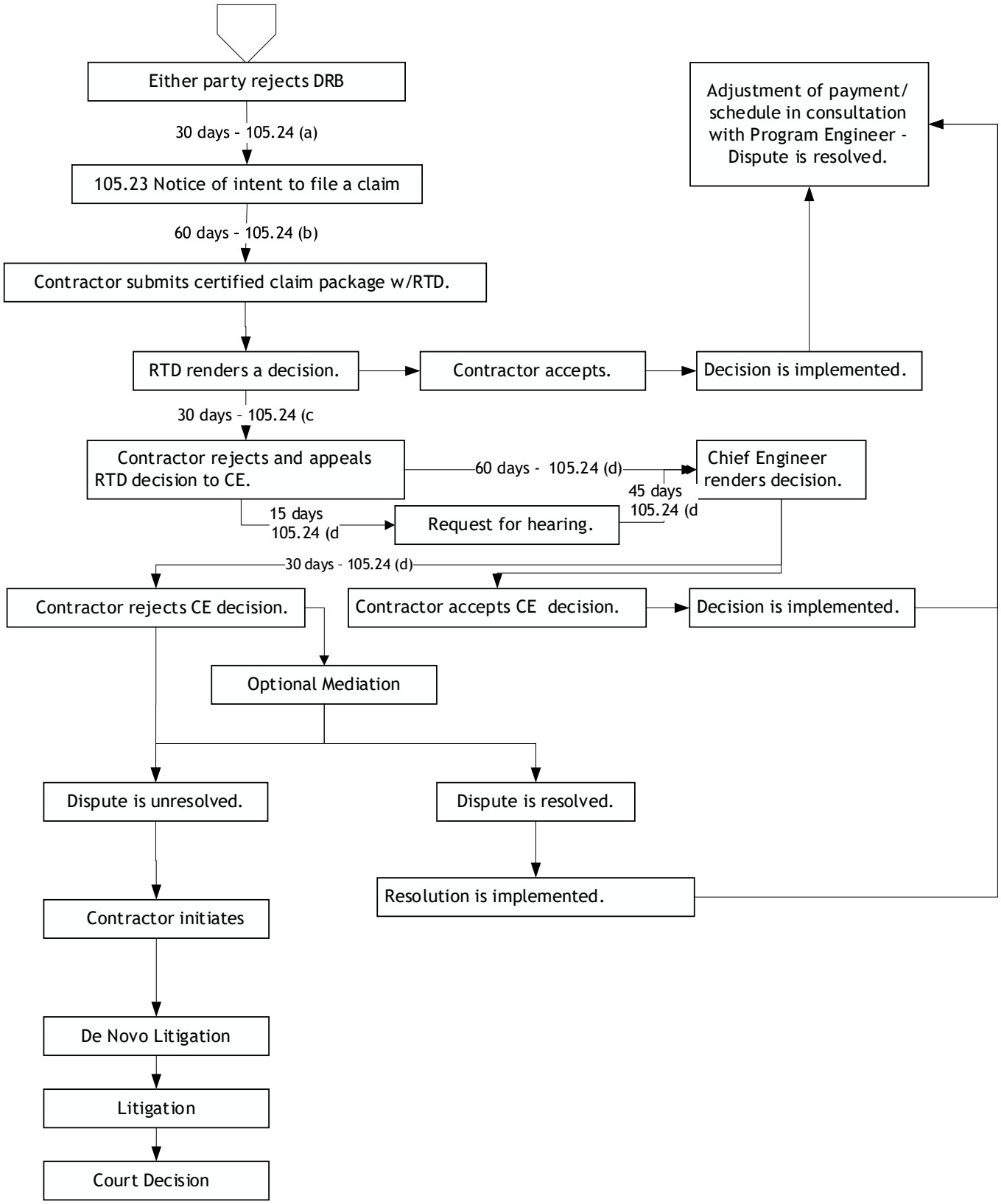


Figure 105-1 continued on next page

Figure 105 - 1 continued



SECTION 106

CONTROL OF MATERIALS

106.01 Source of Supply and Quality Requirements. All materials used shall meet all quality requirements of the Contract. The Contractor shall comply with the requirements of the special notice to contractors contained in the Department's Field Materials Manual, including notifying the Engineer of the proposed sources of materials at least two weeks before delivery.

When alternative materials are permitted for an item in the Contract, the Contractor shall state at the Pre-construction Conference the material that will be furnished for that item.

Reference in the Contract to a particular product or to the product of a specific manufacturer, followed by the phrase "or approved equal", is intended only to establish a standard of quality, durability, and design, and shall not be construed as limiting competition. Products of other manufacturers will be acceptable provided such products are equal to that specified.

All suppliers who provide one or more of the following elements in which the cost exceeds $10,000 shall create an account in the B2GNow software system.

(a) Fabrication of material

(b) Processing of materials

(c) Delivery service cost of the material delivered to the project.

If the supplier does not have an account created, approval of the Form 1425 may be withheld.

The Contractor shall submit a completed Form 1425 for each direct supplier that meets the $10,000 criteria outlined above via the B2GNow software system. The Form 1425 shall be submitted to the Engineer before beginning work on the project, incorporating materials into the project or at such time that the $10,000 amount is known to be exceeded.

If an individual, firm, or corporation is responsible for the installation of supplies, a Form 205 shall be required for the subcontractor. The supplier shall notify the Contractor if an individual spends more than 20percent of their workweek performing actual construction work such as installation, repair or warranty work, on the site of work as that would require the submission of a Form 205 and certified payrolls. During the performance of the project, the Contractor shall submit an updated Form 1425 if information changes.

Each subcontractor or supplier at any tier meeting the $10,000 requirement above shall submit a Form 1425 to the Contractor, who will then submit it to the Department. The Contractor shall submit the subcontractor's Form(s) 1425 with Form 205 (if any) to the Engineer before the subcontractor/supplier beginning any work on the project, incorporating materials into the project, or at such time the $10,000 amount is known to be exceeded.

Failure to comply with the requirements of this subsection shall be grounds for withholding of progress payments.

106.02 Material Sources. Where practicable, borrow pits, gravel pits, and quarry sites shall be located so that they will not be visible from the highway.

(a) *Available Source*. When the Contract shows a location that may be used by the Contractor as a source of sand, gravel, or borrow material, the location will be known as an available source. The Department will have an agreement with the property owner that allows removal of material under certain conditions and for a stated price.

Conditions of this agreement that concern use of this material on the project and pit construction and reclamation requirements for the available source will be included in the Contract.

The Contract will indicate whether the Department has or has not obtained the necessary County or City Zoning Clearance and the required permit from Colorado Department of Natural Resources needed to explore and remove materials from the available source. If the Department did not obtain the necessary clearances or permits, the Contractor shall obtain them. Any delays to the project or additional expenses that are incurred while these clearances or permits are being obtained shall be the responsibility of the Contractor. The Contractor shall ensure that the requirements of the permits do not conflict with the pit construction and reclamation requirements shown in the Contract for the available source.

The Department will investigate and obtain samples from the various available sources. These samples are not intended to indicate the full extent and composition of an entire deposit. These samples will be tested by the Department and may be combined with various materials such as mineral fillers and additives for further testing, especially for testing aggregate sources to obtain a satisfactory design mix. The Contract will show the location of the test holes where samples were obtained, test results, and amounts and kinds of any added materials utilized in the testing to obtain a satisfactory product. If the Contractor uses an available source, all material shall meet contract specifications. The Department will not be responsible for the material as produced by the Contractor.

All costs of producing specification material shall be borne by the Contractor.

(b) *Contractor Source*. Sources of sand, gravel, or borrow other than available sources will be known as contractor sources. The contractor source will be tested by the Department and approved by the Engineer before incorporation of the material into the project. If the submitted materials do not meet the contract specifications it will become the Contractor's responsibility to re-sample and test the material. The Contractor shall supply the Department with passing test results from an AASHTO accredited laboratory electronically sealed by a Professional Engineer. If requested by the Engineer, the Department will then re-sample and re-test the material for compliance to the contract specifications. The Contractor shall produce material that meets contract specifications throughout construction of the project.

The cost of sampling, testing, and corrective action by the Contractor will not be paid for separately but shall be included in the work.

The Contractor shall obtain all permits and agreements necessary to explore and remove material from a contractor source. The Contractor shall also be responsible for any costs or delays associated with obtaining these permits and agreements.

For each source of imported embankment or topsoil the Contractor shall provide the following certification. The Contractor shall assure and certify that unacceptable levels of hazardous waste and substances; including but not limited to those defined in the Code of Federal Regulations (CFR), 40 CFR Part 261 Subparts C and D, and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Section 101(14) as amended; are not incorporated into the project as a result of

importing embankment or topsoil materials. For each contractor source outside of the project limits, the Contractor shall submit such certification to the Engineer, signed by either a Certified Industrial Hygienist (CIH), Certified Hazardous Materials Manager (CHMM), Certified Safety Professional (CSP), or Registered Environmental Manager (REM) or electronically sealed by a registered Professional Engineer (PE).

If contractor source material for embankment or topsoil, originating outside of the project limits, is placed on the project and is at any time found to be contaminated with unacceptable levels of hazardous waste or substances, the Contractor shall remove the contaminated material from the Department's right of way, dispose of it per applicable laws and regulations, and make necessary restoration.
The cost of complying with these requirements, including sampling, testing, and corrective action by the Contractor, shall be included in the work.

106.03 Samples, Tests, Cited Specifications. All materials or the finished product where the materials are used, will be inspected and tested by the Engineer, or by others if specified in the Contract. The Engineer will furnish copies of test results that indicate out of specification material, to the Contractor, promptly as the test results become available. Acceptance will be based on the applicable requirements of Section 105. Any work where untested and uninspected materials are used shall be performed at the Contractor's risk and may be considered as unacceptable and unauthorized work.

Unless otherwise designated, when AASHTO, ASTM, or other specifications, standards, or policies are cited, the reference shall be to the latest edition as revised or updated by approved supplements or interim editions published and issued before the date of advertisement for bids.

Sampling and testing will be done per the Department's minimum sampling, testing, and inspection schedule; the special notice to contractors; and the Colorado procedures; all contained in the Department's Field Materials Manual.

Where the method of test is not cited, the applicable procedure shall be per the Standard AASHTO Method that was current on the date of advertisement for bids.

Samples will be taken by the Department except that the Contractor shall take samples of Portland Cement Concrete per CP 61; asphalt cement, per AASHTO T 40; hot mix asphalt per CP 41; and a composite of aggregates for hot asphalt mixtures per CP 30. The Engineer will determine the sampling locations, and the samples shall be taken in the presence of the Engineer. The Contractor may retain a split of each sample.

All materials being used are subject to inspection and testing at any time before or during incorporation into the work. Tests will be made by and at the expense of the Department.

106.04 Qualification of Testing Personnel and Laboratories. Personnel performing tests used in mix design or the acceptance, rejection, or price adjustment decision, and the laboratories where those tests are performed, shall be qualified per Colorado Procedure 10.

106.05 Sampling and Testing of Hot Mix Asphalt. All HMA, Item 403, except HMA (Patching) and temporary pavement shall be tested per the following program of process control testing and acceptance testing:

(a) *Process Control Testing*. The Contractor shall be responsible for process control testing on all elements listed in Table 106-1. Process control testing shall be performed at the expense of the Contractor. The Contractor shall develop a process control plan (PCP) per the following:

1. Process Control Plan. For each element listed in Table 106-1, the PCP must provide adequate details to ensure that the Contractor will perform process control. The Contractor shall submit the PCP to the Engineer at the Pre-construction Conference. The Contractor shall not start any work on the project until the Engineer has approved the PCP in writing.

   A. Frequency of Tests or Measurements. The PCP shall indicate a random sampling frequency, which shall not be less than that shown in Table 106-1. The process control tests shall be independent of acceptance tests.

   B. Worksheets, Forms, and Charts. The Contractor shall submit examples of worksheets, test result forms, and test results charts per CP 12 as part of the PCP.

   C. Test Result Chart. Each process control test result, the appropriate tonnage and the tolerance limits shall be plotted. For in place density tests, only results after final compaction shall be shown. The chart shall be posted daily at a location convenient for viewing by the Engineer.

   D. Quality Level Chart. The Quality Level (QL) for each element used to calculate incentive or disincentive in Table 106-1 and each required sieve size shall be plotted. The QL will be calculated per the procedure in CP 71 for Determining Quality Level (QL). The QL will be calculated on tests 1 through 3, then tests 1 through 4, then tests 1 through 5, then thereafter the last five consecutive test results. The tonnage of material represented by the last test result shall correspond to the QL. For in place density tests, only results after final compaction shall be shown. The chart shall be posted daily at a location convenient for viewing by the Engineer.

2. Elements Not Conforming to Process Control. The QL of each discrete group of five test results, beginning with the first group of five test results, shall be a standard for evaluating material not conforming to process control. When the group QL is below 65, the process shall be considered as not conforming to the PCP. In this case, the Contractor shall take immediate action to bring the process back into control. Except where the cause of the problem is readily apparent and corrected without delay, production shall be suspended until the source of the problem is determined and corrected. A written explanation of actions taken to correct control problems shall accompany the test data and be submitted to the Engineer on the day the actions are taken.

3. Point of Sampling. The material for process control testing shall be sampled by the Contractor using approved procedures. Acceptable procedures are Colorado Procedures, AASHTO and ASTM. The order of precedence is Colorado Procedures, AASHTO procedures and then ASTM procedures. The location where material samples will be taken shall be indicated in the PCP.

4. Testing Standards. The PCP shall indicate which testing standards will be followed. Acceptable standards are Colorado Procedures, AASHTO and ASTM. The order of precedence is Colorado Procedures, AASHTO procedures and then ASTM procedures.

5. Testing Supervisor Qualifications. The person responsible for the process control sampling and testing shall be identified in the PCP and be qualified according to the requirements of CP 10
6. Technician Qualifications. Technicians taking samples and performing tests must be qualified according to the requirements of CP 10.
7. Testing Equipment. All of the testing equipment used to conduct process control testing shall conform to the standards specified in the test procedures and be in good working order. Nuclear testing devices used for process control testing of in-place density do not have to be calibrated on the Department's calibration blocks.
8. Reporting and Record Keeping. The Contractor shall report the results of the process control tests to the Engineer in writing at least once per day. The Contractor shall assemble a process control (PC) notebook and update it daily. This notebook shall contain all worksheets, test results forms, test results charts and quality level charts for each of the elements listed in Table 106-1. The Contractor shall submit the PC notebook to the Engineer for review once a month on the date agreed to at the Pre-Paving Conference. The PC notebook will be returned to the Contractor within one working day after submittal. The Engineer will notify the Contractor in writing of any deficiencies in the PC notebook, including the failure to submit the notebook on time or an absence of the required reports. Upon the second failure to submit the complete PC notebook on time or with an absence of the required reports, the Engineer will notify the Contractor, and the pay estimate will be withheld until the Contractor submits, in writing, a report detailing the cause for the failure to submit the complete PC notebook on time or the cause for the absence of required reports. The report shall include how the Contractor plans to resolve the failures. Additional failures to submit the PC notebook on time or absent the required reports will result in a delay of the pay estimate until the Contractor has identified and resolved the failure along with revising and resubmitting his PCP to address these issues. Once the Engineer has reviewed and approved the revised PCP the estimate may be paid. Upon submittal of the PC notebook for the semi-final estimate, the PC notebook shall become the property of the Department. The Contractor shall make provisions such that the Engineer can inspect process control work in progress, including PC notebook, sampling, testing, plants, and the Contractor's testing facilities at any time.

(b) Acceptance Testing. Acceptance testing is the responsibility of the Department and shall not be addressed in the PCP. The Department will determine the locations where samples or measurements are to be taken. The maximum quantity of material represented by each test result and the minimum number of test results will be per Table 106-1. The location or time of sampling will be based on a stratified random procedure as described in CP 75. Acceptance sampling and testing procedures will be per the Schedule for Minimum Materials Sampling, Testing and Inspection in the Department's Field Materials Manual. Samples for project acceptance testing shall be taken by the Contractor per the designated method. The samples shall be taken in the presence of the Engineer. Where appropriate, the Contractor shall reduce each sample to the size designated by the Engineer. The Contractor may retain a split of each sample which cannot be included as part of the PCP.

If the Contractor elects to question the Hot Mix Asphalt (HMA) acceptance test results, the steps outlined in CP 17 shall be followed. The results from the CP 17 resolution process shall be binding on both the Department and the Contractor. Requests for CP 17

process for all elements except density shall be submitted in writing to the Engineer within 5 workdays from the date the Contractor receives acceptance test data from the Engineer. The specific element questioned shall be identified in writing. All requests for the CP 17 process for the density element shall be submitted in writing to the Engineer within 24 hours of receiving test data from the Engineer.

The Contractor shall choose either the CDOT Materials and Geotechnical Branch or a consultant laboratory not associated with the project to perform the third-party testing. The Contractor shall document his choice in writing at the Pre-Paving Conference. If a consultant laboratory is chosen, the CDOT Materials and Geotechnical Branch will determine the consultant that will be used from a pre-established list and ensure there is no conflict of interest.

If third party testing is required, the responsibility for the testing expenses shall be assigned per CP 17. The costs for testing are shown in CP 17, Table 17-2.

All materials being used are subject to inspection and testing at any time prior to, during, or after incorporation into work. Acceptance tests will be made by and at the expense of the Department, except when otherwise provided.

(c) Check Testing Program (CTP). Prior to, or in conjunction with, placing the first 500 tons of asphalt pavement, under the direction of the Engineer, a CTP will be conducted between acceptance testing and process control testing programs. The CTP will consist of testing for asphalt content, theoretical maximum specific gravity, HMA 4.75 mm (#4) sieve, HMA 2.36 mm (#8) sieve, HMA 0.075 mm (#200) sieve, in-place density, and joint density per CP 13. If the Contractor intends to test to determine air voids and VMA, check testing for these tests is recommended. The CTP will be continued until the acceptance and process control tests are within the acceptable limits shown in Table 13-1 of CP 13. For joint density, the initial check test will be a comparison of the seven cores tested by CDOT and the seven cores tested by the Contractor. These are the cores from the compaction test section used for nuclear gauge calibration and test section payment.

During production, a split sample check will be conducted at the frequency shown in Table 106-1. Except for joint density, the split samples will be from an acceptance sample obtained per subsection 106.05(b). The acceptance test result will be compared to the process control test result obtained by the Contractor using the acceptable limits shown in Table 13-1 of CP 13. For joint density, the comparison sample for testing by the Contractor will be obtained by taking a second core adjacent to the joint density acceptance core. The acceptance test result will be compared to the process control test result obtained by the Contractor using the acceptable limits as shown in Table 13-1 of CP 13 and following the check testing procedure given in CP 13.

If production has been suspended and then resumed, the Engineer may order a CTP between process control and acceptance testing persons to assure the test results are within the acceptable limits shown in Table 13-1 of CP 13. Check test results shall not be included in process control testing. The Region Materials Engineer shall be called upon to resolve differences if a CTP shows unresolved differences beyond the values shown in Table 13-1 of CP 13.

(d) Stability Verification Testing. After the mix design has been approved and production commences, the Department will perform a minimum of three stability verification tests to verify that the field produced HMA conforms to the approved mix design:

The test frequency shall be one per day unless otherwise directed by the Engineer.

The test results will be evaluated, and the Contractor shall make adjustments if required per the following:

1. The minimum value for stability will be the minimum specified in Table 403-1 of the specifications. There will be no tolerance limit.
2. Quality Level. Calculate a QL for stability.

   If the QL for stability is less than 65, then production shall be halted, and the Contractor shall submit a written proposal for a mix design revision to the Engineer. The Engineer shall give written approval to the proposed mix design revision before production continues.

   After a new or revised mix design is approved, three additional stability tests will be performed on asphalt produced with the new or revised mix design. The test frequency shall be one per day unless altered by the Engineer.

   If the stability QL is less than 65, then production shall be halted until a new mix design has been completed and approved using plant produced material or the Contractor shall submit a written proposal for a mix design revision to the Engineer. The Engineer shall give written approval to the proposed mix design revision before production continues.
3. New or Revised Mix Design. Whenever a new or revised mix design is used and production resumes, three additional stability field verification tests shall be performed, and the test results evaluated per the above requirements. The test frequency shall be one per day unless altered by the Engineer.
4. Field Verification Process Complete. When the field verification process described above is complete and production continues, the sample frequency will revert back to 1 per 10,000 tons.

(e) Mix Verification Testing. After the mix design has been approved and production commences, the Department will perform a minimum of three volumetric verification tests for each of the following elements to verify that the field produced Hot Mix Asphalt (HMA) conforms to the approved mix design:
(1) Air Voids.
(2) Voids in Mineral Aggregate (VMA).
(3) Asphalt Content (AC).

The test frequency shall be one per day unless altered by the Engineer.

The test results will be evaluated, and the Contractor shall make adjustments if required per the following:

1. Target Values. The target value for VMA will be the average of the first three volumetric field test results on project produced hot mix asphalt or the target value specified in Table 403-1 and Table 403-2 of the specifications, whichever is higher. The target value for VMA will be set no lower than 0.5 percent below the VMA target on Form 43 prior to production. The target values for the test element of air voids and AC shall be the mix design air voids and mix design AC as shown on Form 43.
2. Tolerance Limits. The tolerance limits for each test element shall be:

   AC ± 0.3 percent

   Air Voids ± 1.2 percent

   VMA ± 1.2 percent

3. Quality Levels. Calculate an individual QL for each of the elements using the volumetric field verification test results. If the QL for VMA or AC is less than 65 or if the QL for air voids is less than 70, the production shall be halted, and the Contractor shall submit a written proposal for a mix design revision to the Engineer. Production shall only commence upon receipt of written approval from the Engineer of the proposed mix design revision.

   After a new or revised mix design is approved, three additional volumetric field verification tests will be performed on asphalt produced with the new or revised mix design. The test frequency shall be one per day unless altered by the Engineer.

   If the QL for VMA or AC is less than 65 or the QL for the test element of air voids is less than 70, then production shall be halted until a new mix design has been completed per CP 52 or CP 54, a new Form 43 issued, and the Contractor demonstrates that he is capable of producing a mixture meeting the verification requirements per A or B below:

   A. The Contractor shall produce test material at a site other than a CDOT project. The Contractor shall notify the Engineer a minimum of 48 hours' notice prior to the requested test. The location and time of the test are subject to the approval of the Engineer, prior to placement. Three samples will be tested for volumetric properties. If the QL for VMA or AC is equal or greater than 65 and the QL for the element of air voids is equal or greater than 70, full production may resume; or

   B. The Contractor may construct a 500-ton test strip on the project. Three samples in the last 200 tons will be tested for volumetric properties. After construction of the test section, production shall be halted until the testing is complete and element QLs are calculated. If the QL for VMA or AC is equal to or greater than 65 or the QL for the element of air voids is equal to or greater than 70, full production may resume. If the QL for VMA or AC is less than 65 or the QL for the element of air voids is less than 70, the material shall be removed and replaced at no cost to the Department. The time count will continue, and any delay to the project will be considered to have been caused by the Contractor and will not be compensable.

      The costs associated with mix designs shall be solely at the Contractor's expense.

      If the Contractor fails to verify the new mix design per A or B, then production shall be halted until a new mix design has been completed per CP 52 or CP 54, a new Form 43 issued, and the Contractor demonstrates they are capable of producing a mixture meeting the verification requirements per A or B.

4. New or Revised Mix Design. Whenever a new or revised mix design is used and production resumes, three additional volumetric field verification tests shall be performed, and the test results evaluated per the above requirements. The test frequency shall be one per day unless altered by the Engineer.

5. Field Verification Process Complete. When the field verification process described above is complete and production continues, the sample frequency will revert back to a minimum of 1/10,000 tons. The Engineer has the discretion to conduct additional verification tests at any time.

(f) Testing Schedule. Process control and project acceptance testing frequency shall be per Table 106-1.

(g) Reference Conditions. Three reference conditions can exist determined by the Moving Quality Level (MQL). The MQL will be calculated per the procedure in CP 71 for Determining Quality Level (QL). The MQL will be calculated using only acceptance tests. The MQL will be calculated on tests 1 through 3, then tests 1 through 4, then tests 1 through 5, then thereafter on the last five consecutive test results. The MQL will not be used to determine pay factors. The three reference conditions and actions that will be taken are described as follows:

1. Condition green will exist for an element when an MQL of 90 or greater is reached, or maintained, and the past five consecutive test results are within the specification limits.
2. Condition yellow will exist for all elements at the beginning of production or when a new process is established because of changes in materials or the job-mix formula, following an extended suspension of work, or when the MQL is less than 90 and equal to or greater than 65. Once an element is at condition green, if the MQL falls below 90 or a test result falls outside the specification limits, the condition will revert to yellow or red as appropriate.
3. Condition red will exist for any element when the MQL is less than 65. The Contractor shall be notified immediately in writing and the process control sampling and testing frequency increased to a minimum rate of 1 per 250 tons for that element. The process control sampling and testing frequency shall remain at 1 per 250 tons until the process control QL reaches or exceeds 78. If the QL for the next five process control tests is below 65, production will be suspended.

   If gradation is the element with MQL less than 65, the Department will test one randomly selected sample in the first 1250 tons produced in condition red. If this test result is outside the tolerance limits, production will be suspended. (This test result will not be included as an acceptance test.)

   After condition red exists, a new MQL will be started. Acceptance testing will stay at the frequency shown in Table 106-1. After three acceptance tests, if the MQL is less than 65, production will be suspended.

   Production will remain suspended until the source of the problem is identified and corrected. Each time production is suspended, corrective actions shall be proposed in writing by the Contractor and approved in writing by the Engineer before production may resume.

   Upon resuming production, the process control sampling and testing frequency for the elements causing the condition red shall remain at 1 per 250 tons. If the QL for the next five process control tests is below 65, production will be suspended again. If gradation is the element with MQL less than 65, the Department will test one randomly selected sample in the first 1,250 tons produced in condition red. If this test result is outside the tolerance limits, production will be suspended.

Table 106-1
SCHEDULE FOR MINIMUM
SAMPLING AND TESTING FOR HMA

Element	Process Control	Acceptance*, #	Check (CTP)
Asphalt Content	1/500 tons	1/1000 tons	1/10,000 tons
Gradation	1/Day	1/2000 tons	1/20,000 tons
Theoretical Maximum Specific Gravity	1/1000 tons, minimum 1/Day	1/1000 tons, minimum 1/Day	1/10,000 tons
In-place Density	1/500 tons	1/500 tons	1/5000 tons
Joint Density	1 core/2500 linear feet of joint	1 core/5000 linear feet of joint	1 core/50,000 linear feet of joint
Aggregate Percent Moisture ^	1/2000 tons, minimum 1/Day	1/2000 tons	Not applicable
Percent Lime ^,+	1/Day	Not applicable	Not applicable

Table 106-1 Notes: * The minimum number of acceptance tests will be: 5 asphalt content, 3 gradation, 10 in-place density and 5 joint density tests, for all projects.

When unscheduled job mix formula changes are made (Form 43) acceptance of the elements, except for in-place density, will be based on the actual number of samples that have been selected up to that time, even if the number is below the minimum listed in the schedule. At the Engineer's discretion, additional random in-place density tests may be taken in order to meet scheduled minimums, provided the applicable pavement layer is available for testing under safe conditions. Beginning with the new job mix formula, the quantity it will represent shall be estimated. A revised schedule of acceptance tests will be based on that estimate.

^ Not to be used for incentive or disincentive pay. Test according to CP-33 and report results from Form 106 or Form 565 on Form 6.

+ Verified per Contractor's PC Plan

106.06 Sampling and Testing of Portland Cement Concrete Paving. All Portland Cement Concrete Pavement, Item 412, shall be tested per the following process control and acceptance testing procedures:

(a) Process Control Testing. The Contractor shall be responsible for process control testing of all elements listed in Table 106-2 or 106-3. Process control testing shall be performed at the expense of the Contractor. The Contractor shall develop a process control plan (PCP) per the following:

1. Process Control Plan. For each element listed in Tables 106-2 or 106-3, the PCP must provide adequate details to ensure that the Contractor will perform process control. The Contractor shall submit the PCP to the Engineer at the Pre-construction Conference. The Contractor shall not start any work on the project until the Engineer has approved the PCP in writing.

A. Frequency of Tests or Measurements. The PCP shall indicate a random sampling frequency, which shall be equal to or more frequent than that shown in Table 106-2 or 106-3. The process control tests shall be independent of acceptance tests.

B. Test Result Chart. Each process control test result, the appropriate area, volume, and the tolerance limits shall be plotted. The chart shall be posted daily at a location convenient for viewing by the Engineer.

C. Quality Level Chart. The QL for each element in Table 106-2 or 106-3 shall be plotted. The QL shall be calculated per the procedure in CP 71 for Determining Quality Level. The QL shall be calculated on tests 1 through 3, then tests 1 through 4, then tests 1 through 5, then thereafter the last five consecutive test results. The area of material represented by the last test result shall correspond to the QL.

D. F-test and t-test Charts. If flexural strength criteria is indicated, then the results of F-test and t-test analysis between the Department's verification tests of flexural strength and the Contractor's process control tests of flexural strength shall be shown on charts. The F-test and t-test shall be calculated per standard statistical procedures using all verification tests and process control tests completed to date. Only results from cast beams shall be used in the F & t analysis, flexural strengths from splitting tensile correlations shall not be included in the F & t analysis. When a verification test is completed, the F- test and t-test calculations shall be redone. The area of material represented by the last test result shall correspond to the F-test and t-test. A warning value of 5 percent and an alert value of 1 percent shall be shown on each chart. The chart shall be submitted to the Engineer electronically daily, as results become available.

2. Point of Sampling. The material for process control testing shall be sampled by the Contractor using CP 61. The location where material samples will be taken shall be indicated in the PCP.

3. Testing Standards. The PCP shall indicate which testing standards will be followed. Acceptable standards are Colorado Procedures, AASHTO and ASTM. The order of precedence is Colorado Procedures, AASHTO procedures and then ASTM procedures.

   The compressive strength test for process control will be the average strength of two test cylinders cast in plastic molds from a single sample of concrete, cured under standard laboratory conditions, and tested three to seven days after molding.

4. Testing Supervisor Qualifications. The person in charge of and responsible for the process control testing shall be identified in the PCP. This person shall be present on the project and possess one or more of the following qualifications:

   A. Registration as a Professional Engineer in the State of Colorado.

   B. Registration as an Engineer in Training in the State of Colorado with two years of paving experience.

   C. A Bachelor of Science in Civil Engineering or Civil Engineering Technology with three years of paving experience.

   D. National Institute for Certification in Engineering (NICET) certification at level III or higher in the subfields of Transportation Engineering Technology, Highway Materials, or Construction Materials Testing Engineering Technology, Concrete and four years of paving experience.

5. Technician Qualifications. Technicians performing tests shall meet the requirements of Colorado Procedure 10.

6. Testing Equipment. All of the testing equipment used to conduct process control testing shall conform to the standards specified in the test procedures and be in good working order. If flexural strength criteria is indicated, then the Contractor shall provide the following equipment and supplies, which will not be paid for separately but shall be included in the work:

   A. A separate, temperature-controlled facility of at least 300 square feet usable space. This facility shall be used exclusively for the molding, storage and testing of concrete test specimens as required. This facility shall be provided in addition to other facilities required in Section 620. The storage facility shall have sufficient water storage capacity for curing all required test specimens. The storage facility shall provide separate storage tanks for each type of required testing. Each storage tank shall have a continuously recording thermometer and sufficient blank charts for the project. Temperatures of each storage tank shall be recorded for the duration of the project.

   B. A machine for testing flexural, compressive and splitting tensile strength of concrete specimens. The machine shall have an opening size capable of housing the flexural strength apparatus, splitting tensile apparatus and compression heads. The machine shall have a square or rectangular bottom platen at least 2 inches thick. The machine shall have a minimum capacity of 300,000 lbs. The machine shall have a digital monitor capable of displaying load rate and total load. The following or an approved equal may be used:

      (1) Forney model number FHS-300 with a Co-Pilot digital monitor.

      (2) Humboldt model number HCM-3000 with an iD Digital Indicator.

      (3) Gilson model number MC-400 with Pro Controller.

      (4) Test Mark Industries CM-3000 with i720 Digital Indicator.

      Both the Contractor and the Engineer will use this machine for testing concrete specimens. The machine shall meet the requirements of AASHTO T 97 and T 22. After the machine has been certified and accepted by the Engineer it shall not be moved until all portland cement concrete paving and flexural strength acceptance tests have been completed. A weekly check of the planeness of all bearing surfaces on the flexural strength apparatus shall be made and recorded in the Contractor's PC notebook for each week that flexural strength testing occurs.

      Swapping flexural strength apparatus, splitting tensile strength apparatus and compressive strength head will not require recertification of the test machine.

   C. Beam molds for molding all test specimens required. Beam molds shall have a cross section of approximately 6 inches by 6 inches. All beam molds shall be checked by the Contractor before being placed in service and monthly. The checks of each beam mold shall be recorded in the Contractor's PC notebook. This shall include all testing described in subsection 106.06.

   D. The Contractor shall supply an MIT Scan T2 or MIT Scan T3 and the associated test plates when pavement thick acceptance is based on magnetic pulse induction (MPI).

7. Reporting and Record Keeping. The Contractor shall report the results of the tests to the Engineer electronically at least once per day.

   The Contractor shall assemble a process control (PC) notebook and update it daily. This notebook shall contain all worksheets, test results forms, test results charts and quality level charts for each of the elements listed in Table 106-2 or 106-3. The Contractor shall submit examples of worksheets, test result forms and test results charts per CP 12B as part of the Contractor's Process Control Plan (PCP). The Contractor shall submit the PC notebook electronically to the Engineer for review once a month on the date agreed to at the Pre-construction Conference.

   A list of recognized deficiencies will be returned to the Contractor within two workdays after submittal. Deficiencies may include, but are not limited to, the failure to submit the notebook on time or an absence of the required reports. For any month that deficiencies are identified, the PC notebook will be submitted for review two weeks after the PC notebook is returned. Upon the second recognized deficiency the Engineer will notify the Contractor, and the pay estimate shall be withheld until the Contractor submits, in writing, a report detailing the cause for the recognized deficiency. The report shall include how the Contractor plans to resolve the deficiencies. Additional recognized deficiencies will result in a delay of the pay estimate until the Contractor has identified and resolved the deficiency along with revising and resubmitting his PCP to address these issues. Once the Engineer has reviewed and approved the revised PCP the estimate may be paid. Upon submittal of the PC notebook for the semi-final estimate, the PC notebook shall become the property of the Department. The Contractor shall make provisions such that the Engineer can inspect process control work in progress, including PC notebook, sampling, testing, plants, and the Contractor's testing facilities at any time.

8. Optimized Gradation. The Contractor shall perform process control testing of the combined aggregate gradation (CAG) when an Optimized Gradation (OG) is used for Class P Concrete. The combined aggregate gradation testing frequency shall be three per day. Test one shall be sampled and tested after full production begins but before production reaches 100 cubic yards. Test two shall be sampled and tested after four hours of continuous production or production reaches 1,000 cubic yards, whichever comes first. Test three shall be sampled and tested after seven hours of continuous production or production reaches 1750 cubic yards, whichever comes first. The frequency shall be a minimum of one per day if production is less than 750 cubic yards.

   The Department will perform one gradation test each day that may be a split of one of the three daily PC samples. This data will not be used to determine acceptability of the material but as information only.

   The Contractor's gradation test data will be used to evaluate the gradation optimization.

   When the Contractor's gradation test results fail to meet their optimization range, the Contractor shall immediately make corrections to bring the aggregate gradation optimization range and notify the Engineer. If two or more consecutive test results for any single day or two successive days are found to fall outside the optimization range, the Contractor shall immediately suspend production and provide a written corrective plan to the Engineer for approval before resuming production.

Upon being allowed to resume production, the Contractor shall follow the daily sampling frequency. If the next two consecutive gradation tests indicate that they meet the optimization range, the Contractor may continue production. If the first two aggregate samples do not meet the optimization range, production shall be suspended.

Before resuming production, the Contractor shall sample the individual aggregate stockpiles at two or more locations to determine the range of variability within each stockpile, make appropriate adjustments to the percentages for each aggregate component, and discharge and sample the combined aggregates. The combined aggregate gradation shall be tested to determine if the optimization range is met. Production can resume if the CF and WF plot within the workability box. Production will continue to be suspended for additional evaluation of stockpiles and aggregate feed rates until gradation sampling and testing indicate the optimization range is met.

All gradation test information during production shall be provided to the Engineer daily. The Contractor shall immediately report all gradation test data to the Engineer for evaluation during periods when production is suspended or upon resuming production. The Contractor will be notified in writing in all cases when production may resume or shall remain suspended.

9. Concrete Test Reports. The Contractor shall distribute electronically to the concrete supplier all compressive-strength process control (PC) data for the concrete supplied to the project. The Contractor shall distribute the PC compressive strength data within two business days of the 7-day and 28-day compressive strength testing. The data shall include the compressive strength and batch ticket number at a minimum.

(b) Acceptance Testing. Acceptance testing frequencies shall be per the Schedule (Owner Acceptance) in the Department's Field Materials Manual. Except for flexural strength, acceptance tests will be conducted by and at the expense of the Department. Acceptance sampling and testing procedures will be per the Department's Field Materials Manual with the following exceptions and inclusions:

A split sample from an acceptance test shall not be used for a process control test. The Engineer will designate the location where samples are to be taken. Samples shall be taken by the Contractor per CP 61. The Engineer will be present during the sampling and take possession of all acceptance samples. Samples transported in different containers will be combined and mixed before molding specimens. All materials are subject to inspection and testing at all times.

Pavement thickness acceptance will be determined by cores or magnetic pulse induction (MPI).

Acceptance tests for thickness using MPI shall be the Contractor's process control tests. MPI testing shall be per AASHTO T359.

When compressive strength testing is specified, the Engineer will distribute electronically to the concrete supplier all compressive-strength Owner Acceptance (OA) data for the concrete supplied to the project. The Engineer will distribute the OA compressive strength data within two business days of the 7-day and 28-day compressive strength testing. The data will include the compressive strength and batch ticket number at a minimum. The Contractor shall not have a valid dispute or claim as a result of any action or inaction by the Department related to the distribution of test results.

The compressive strength test for acceptance will be the average compressive strength of three test cylinders cast in plastic molds from a single sample of concrete and cured under standard laboratory conditions before testing. If the compressive strength of any one specimen differs from the average by more than 10 percent, that specimen will be deleted, and the average strength will be determined using the remaining two specimens. If the compressive strength of more than one specimen differs from the average by more than 10 percent, the average strength will be determined using all three specimens. Each set of three cylinders will be tested at 28 days after molding.

Acceptance tests for flexural strength shall be the Contractor's process control tests. The flexural strength tests shall be the average flexural strength of four test beams. The test beams shall be prepared according to AASHTO T23. The flexural strength of each specimen shall be measured according to AASHTO T97 with the following additional requirements: If the flexural strength of only one specimen differs from the average by more than 10 percent, that specimen shall be deleted, and the average strength shall be determined using the remaining three specimens. If the flexural strength of more than one specimen differs from the average by more than 10 percent, the test value shall be the average of all four specimens. Each set of four beams shall be tested at 28 days after molding.

(c) Verification Testing. Verification testing will be used only when flexural strength criteria is indicated and is the responsibility of the Department. The Department will determine the locations where samples or measurements are to be taken. The location of sampling shall be based on a stratified random procedure.

Verification sampling and testing procedures will be per Sections 105, 106, 412, the Schedule for Minimum Materials Sampling, Testing and Inspection in the Department's Field Materials Manual, and CP 13. Samples for verification testing shall be taken by the Contractor per CP 61 in the presence of the Engineer.

An analysis of test results will be performed after all test results are known using the t-test and F-test statistical methods with an alpha value set at 0.05. If either the above t-test and F-test analysis shows a significant difference, then the following items shall be checked: comparison of beam fracture locations and types, computations and flexural testing machine outputs, curing tank temperature charts, slump and air contents, plant batch tickets for major changes, review of sampling, molding, testing procedures, along with IAT check tests and any other investigations that may clarify the significant differences. If after a review of the data no reasons can be determined for the significant difference, the Department's test data shall be used for determining Quality Levels and Incentive or Disincentive according to the methods in this Section.

(d) Check Testing. The Contractor and the Engineer shall conduct a check testing program (CTP) before the placement of any concrete pavement. The check testing program will include a conference directed by the Region Materials Engineer, the Contractor's testers, and the Department's testers concerning methods, procedures and equipment for compressive or flexural strength testing. Check testing shall be completed before any portland cement concrete pavement (PCCP) is placed. A set of three cylinders or four beams will be molded by both the Contractor and the Department's project testers from a split sample. The specimens will be sampled, molded and cured for seven days and tested for compressive or flexural strength according to the procedures of Section 106. The Department's Independent Assurance Tester will also mold, cure and test a set of three cylinders or four beams, but the Independent Assurance Test results will not be entered in

the check testing analysis. If the results of the check tests do not meet the following criteria, then the check testing will be repeated until the following criteria are met:

(1) The average of the Contractor's test results, and the average of the Department's test results shall be within 10 percent of the average of all test results.

(2) Each specimen test result shall be within 15 percent of the average of all test results.

When compressive strength criteria is indicated, a check test must also be conducted on the sand equivalent test. A set of 5 sand equivalents will be run by both the Contractor's and the Department's project tester, from a split sample. The average of the absolute differences between tests taken by the process control personnel and the acceptance testing personnel will be compared to the acceptable limits shown in Table 13-1 of CP 13. The CTP will be continued until the acceptance and process control test results are within the permissible ranges shown in Table 13-1 of CP 13.

During production, split samples of randomly selected acceptance tests will be compared to the permissible ranges shown in Table 13-1 of CP 13. The minimum frequency will be as shown in Table 106-3.

If production has been suspended and then resumed, the Engineer may order a CTP between tests taken by process control and acceptance testing persons to assure the test results are within the permissible ranges shown in Table 13-1 of CP 13. Check test results shall not be included in process control testing. The Region Materials Engineer shall be called upon to resolve differences if a CTP shows unresolved differences beyond the ranges shown in Table 13-1 of CP 13.

(e) Independent Assurance Testing. The sample for the IAT will be a split sample of the Contractor's process control test. The Department's representative performing verification tests shall also use a split sample of the Contractor's process control test and participate in the IAT. The IAT for flexural strength will be the average flexural strength of four test beams prepared according to the requirements of Section 106 and cured for seven days in the field before being transferred to the IAT lab. IAT specimens will be tested at 28 days.

(f) Testing Schedule. All samples used to determine Incentive or Disincentive payment by quality level formulas per Section 105, will be selected by a stratified random process.

Table 106-2
TESTING SCHEDULE - ITEM 412
PORTLAND CEMENT CONCRETE
PAVEMENT, FLEXURAL STRENGTH CRITERIA

Element	Minimum Testing Frequency Contractor's Process Control
Aggregate Gradation and Sand Equivalent	For the first five days, minimum of 1/day, then 1/10,000 sq. yds. After 5 days, 1/40,000 sq. yds.
Slump	First three loads each day, then as needed for control.
Water Cement Ratio	First three loads each day, then 1/500 cu. yds.
Air Content and Yield	Minimum of 1/day, then 1/2500 sq. yds.
Flexural Strength	Minimum of 1/day, then 1/2500 sq. yds.
Compressive Strength	1/10,000 sq. yds.
Pavement Thickness	Per subsection 412.21.
Pull Test Joints	Minimum of six transverse and six longitudinal joint locations for the first 2500 linear feet, then three transverse and three longitudinal joints thereafter
Load Transfer Dowel Bar Placement	Per subsection 412.13(b)2
Average Texture Depth	1 per 528 linear feet in each lane and shoulder wider than 8 feet.

Table 106-3
TESTING SCHEDULE - ITEM 412
PORTLAND CEMENT CONCRETE
PAVEMENT, COMPRESSIVE STRENGTH CRITERIA

Element	Minimum Testing Frequency Contractor's Process Control
Aggregate Gradation	Minimum of 1/day, then 1/10,000 sq. yds.
Slump	First three loads each day, then as needed for control
Compressive Strength, Air Content, Yield, and Sand Equivalent	Minimum of 1/day, then 1/2500 sq. yds.
Pavement Thickness	Per subsection 412.21
Pull Test Joints	Minimum of six transverse and six longitudinal joint locations for the first 2500 linear feet, then three transverse and three longitudinal joints thereafter
Load Transfer Dowel Bar Placement	Per subsection 412.13(b)2
Average Texture Depth	1 per 528 linear feet in each lane and shoulder wider than 8 feet
Water Cement Ratio	First three loads each day, then 1/500 cu. yds.

106.07 Material Inspection at Plant. If the Engineer inspects the materials at the source, the following conditions shall be met:

(1) The Engineer shall have the cooperation and assistance of the Contractor and the materials producer.
(2) The Engineer shall have full entry to all parts of the plant necessary for the manufacture or production of the materials being furnished.
(3) Adequate safety measures shall be provided and maintained.

The Department reserves the right to retest all materials that have been previously tested or inspected. The retesting may be before or after incorporation of the materials into the work. Those materials inspected and tested after delivery on the project or after incorporation into the work, that do not meet the requirements of the Contract will be rejected or accepted with an adjustment in price per the requirements of subsection 105.03.

106.08 Storage of Materials. Materials shall be stored to assure the preservation of their quality and fitness for the work. Stored materials, even though conditionally approved before storage, will be subject to inspection and testing before incorporation into the work.

Stored materials shall be located to facilitate prompt inspection. With prior approval, portions of the right of way may be used for storage of materials and equipment, and for the Contractor's plant. Any additional space required shall be provided at the Contractor's expense. Stored materials will be paid for per subsection 109.07. Private property shall not be used for storage purposes without written permission of the owner or lessee. If requested, copies of such written permission shall be furnished to the Engineer. All storage sites shall be restored to their original condition at the Contractor's expense.

106.09 Handling Materials. All materials shall be handled so their quality and fitness for the work is preserved. Aggregates shall be transported to the work in vehicles constructed to prevent loss or segregation of materials.

106.10 Department Furnished Materials. Material furnished by the Department will be made available to the Contractor at the points specified in the Contract.

The cost of handling and placing materials after they are made available to the Contractor shall be included in the contract price for the item.

The Contractor will be held responsible for all material received until it is incorporated into the work and accepted.

Demurrage charges resulting from the Contractor's failure to accept the material at the designated time and point of delivery will be deducted from monies due the Contractor.

106.11 Buy America Requirements.

(a) *Steel and Iron.* All manufacturing processes, including the application of a coating, for all steel and iron products permanently incorporated in the work shall have occurred in the United States of America. All manufacturing processes include the processes that change the raw ore or scrap metal into a finished steel or iron product. This requirement will not prevent a minimal use of foreign steel or iron, provided the total cost, including delivery to the project, of all such steel and iron products does not exceed one-tenth of one percent of the total contract cost or $2,500, whichever is greater. When there is foreign steel or iron permanently incorporated into the project, the Contractor shall provide documentation of the project delivered cost of that foreign steel or iron.

The Contractor shall maintain on file Buy America certifications that every process from either the original smelting or melting operation, including the application of a coating, performed on steel or iron products either has or has not been carried out in the United States of America. These Buy America certifications apply to every steel and iron product that requires pre- inspection, pretesting, certified test results, or a certificate of compliance. Shipping invoices, bar lists, and mill test reports shall accompany the Buy America certifications. The Contractor shall obtain a Buy America certification from each supplier, distributor, fabricator, and manufacturer that has handled each steel or iron product. These Buy America certifications shall create a chain of custody trail for every supplier, distributor, fabricator, and manufacturer that handled the steel or iron product and shall include certified mill test reports with heat numbers from either the original smelting or melting operation. Upon request, the Contractor shall allow the State, FHWA, and their representatives access to the Buy America certifications including supporting documentation. When the Contractor does not provide the Buy America certifications at the Engineer's request, the Engineer will reject the steel or iron product.

Before the permanent incorporation into the project and before payment for steel or iron products, the Contractor shall provide an assurance document. The assurance document shall certify in writing that the steel or iron products comply with Buy America requirements; the Buy America certifications and supporting documentation are on file; and when requested, the Contractor has submitted the required documentation to CDOT. The Contractor shall also maintain an assurance document that summarizes the date and quantity of all steel and iron material delivered to the project. This assurance document shall include the pay item, quantity of material delivered to the project, mill test reports with heat numbers, and the quantity of material installed by the monthly progress payment cutoff date. The assurance document shall reconcile the pay item quantities and certified mill test reports, for the material delivered to the project to the Buy America certifications and supporting documentation. The assurance documentation shall include the cost of all foreign steel or iron delivered and permanently incorporated into the project. The Contractor shall also submit a summary for each month that no steel or iron products are incorporated into or delivered to the project. The Contractor shall submit the assurance documentation to the Engineer by the monthly progress payment cutoff date. The assurance documentation does not relieve the Contractor of providing the necessary Buy America certifications and supporting documentation for steel or iron products.

(b) *Manufactured Products*. Regulations require the use of domestic steel and iron in Federally funded construction projects. Buy America applies to construction components which are "predominantly steel or iron products," defined by CDOT as products which are manufactured with at least 90% steel or iron content by weight when delivered to the job site for installation. FHWA provides waivers for manufactured products and products that are not predominantly steel or iron. The FHWA's 1983 final Buy America regulations waive the application of Buy America to manufactured products that do not include steel and iron components. However, Buy America applies to the steel wire mesh or steel reinforcing components of manufactured products (precast reinforced concrete elements).

(c) *Glass Beads for Pavement Marking*. All post-consumer and industrial glass beads for pavement marking shall have been manufactured from North American glass waste streams in the United States of America. The bead manufacturer shall submit a COC in accordance with subsection 106.12 confirming that North American glass waste streams were used in the manufacture of the glass beads.

(d) *Construction Materials*. All manufacturing processes for eligible construction materials permanently incorporated into the work shall have been manufactured in the United States of America. All manufacturing processes for construction materials consist of at least the final manufacturing process and the immediately preceding manufacturing stage for the construction material. Buy America requirements shall apply to the following eligible construction materials:

1. Non-ferrous metals.
2. Plastic and polymer-based products (including, but not limited to polyvinylchloride [PVC]).
3. Glass.
4. Lumber; or 5. Drywall

Note 1: Raw materials such as cement and cementitious materials; aggregates such as stone, sand, or gravel; or aggregate binding agents or additives are excluded from Buy America requirements.

Items that consist of two or more of the listed materials that have been combined together through a manufacturing process, and items that include at least one of the listed materials combined with a material that is not listed through a manufacturing process, should be treated as manufactured products, rather than as construction materials.

Before the permanent incorporation into the project for all eligible construction materials, the Contractor shall obtain a certification from each supplier. This certification must identify where the construction material was manufactured and attest specifically to Buy America compliance.

The Contractor shall maintain and submit on a monthly basis, CDOT Form #1600, Contractor's Certificate of Compliance summarizing the Item Description, CDOT Bid Item #, Manufacturer Name Identifier, Date and Quantity Received, Date and Quantity Installed, and Bid Item Unit of all eligible construction materials.

The COC does not relieve the Contractor of providing the necessary Buy America supplier certifications prior to permanent incorporation into the project. Upon request, the Contractor shall allow the State, FHWA, and their representatives access to the Buy America certifications. The lack of these certifications will be justification for rejection of the construction material.

(e) *Waivers.* The Federal Highway Administration is responsible for processing and approving all waivers, including waivers requested by recipients and on behalf of subrecipients. More information on Buy America waivers can be found in Section 5.2 of the Field Materials Manual Special Notice to Contractors.

If a Contractor desires to pursue a waiver they shall notify the CDOT Project Engineer in writing who will then submit it to the CDOT Materials & Geotechnical Services Unit, Pavement Design and Documentation Services Program. The Pavement Design and Documentation Services Program will review it and forward it to the FHWA Division Office for consideration.

A Contractor's decision to pursue any waivers on the project shall not waive or otherwise nullify any provisions of the Contract. In addition, the time to obtain a waiver shall be considered a non-excusable, non-compensable delay and Liquidated Damages (per Subsection 108.09) will be enforced should the Contract Time (original or as-amended) expire due to the approval or non-approval of a waiver.

The Contractor will not be entitled to an extension of contract time due to the approval or non-approval of a waiver and no such claim will be considered.

106.12 Certificates of Compliance. The Contract will designate products and assemblies that can be incorporated in the work, if accompanied by Certificates of Compliance. The Certificate of Compliance shall be a legible copy or an original document from the manufacturer, and shall include, under penalty of perjury, the original or electronic signature (including corporate title) of a person having legal authority to act for the manufacturer. It shall state that the product or assembly to be incorporated into the project has been sampled and passed all specified tests in conformity to the plans and specifications for the project.

The Contractor's original signature and certification shall be added to the manufacturer's document, as directed below.

Each certificate shall include:

(1) Manufacturer's name.

(2) Address of manufacturing facility.

(3) Laboratory name and address.

(4) Name of product or assembly.

(5) Complete description of the material.

(6) Model, catalog, stock number (if applicable).

(7) Lot, heat, or batch number identifying the material delivered (if applicable).

(8) Date(s) of the laboratory testing.

(9) Listing of all applicable specifications required by the Department for this particular product or assembly. Certificates shall reference the actual tests conducted on samples taken from the same lot, heat, or batch, and shall include a statement that the product or assembly to be incorporated into the project was fabricated per and meets the applicable specifications.

The Contractor shall certify and sign the manufacturer's original Certificate of Compliance as directed below. The quantity certified by the Contractor shall be that which has been delivered to the project at that time and is represented by that COC. For products with multiple delivery dates, multiple Certificates of Compliance will be required. One legible copy of the fully signed Certificate of Compliance shall be furnished to the Engineer before installation of material. The original shall be provided to the Engineer before payment for the represented item will be made. Both the legible copy and the fully signed Certificate of Compliance shall include the Contractor's certification and signature. Each product or assembly delivered to the project must contain the lot, heat, or batch number identical to that on the accompanying Certificate of Compliance.

The following certification, signed by a person having legal authority to act for the Contractor:

> I hereby certify under penalty of perjury that the material listed in this Certificate of Compliance represents _____ (quantity and units) of pay item _____ (pay item number and Description) that will be installed on project number _____.
>
> _____ _____ Contractor and Date

Failure to comply with the above requirements may result in delays to the project or rejection of the materials. Products or assemblies furnished on the basis of Certificates of Compliance may be sampled and tested by the Department, and if determined not to meet the applicable specifications will be rejected or accepted according to subsection 105.03.

106.13 Certified Test Report. The Contract will designate products and assemblies that can be incorporated in the work if accompanied by Certified Test Reports. The Certified Test Report shall be a legible copy or an original document from the manufacturer, and shall include, under penalty of perjury, the original or electronic signature (including corporate title) of a person having legal authority to act for the manufacturer or the independent testing laboratory. It shall state that the test results show that the product or assembly to be incorporated into the project has been sampled and passed all specified tests in conformity to the plans and specifications for this project. Each report shall include:

Each certificate shall include:

(1) Manufacturer's name.

(2) Address of manufacturing facility.

(3) Laboratory name and address.

(4) Name of product or assembly.

(5) Complete description of the material.

(6) Model, catalog, stock number (if applicable).

(7) Lot, heat, or batch number identifying the material delivered (if applicable).

(8) Date(s) of the laboratory testing.

(9) All test results are required to verify that the material furnished conforms to all applicable Department specifications. Test results shall be from tests conducted on samples taken from the same lot, heat, or batch.

The Contractor shall certify and sign the manufacturer's original Certified Test Report as directed below. The quantity certified by the Contractor shall be that which has been delivered to the project at that time and is represented by that Certified Test Report. For products with multiple delivery dates, multiple Certified Test Reports will be required. One legible copy of the fully signed Certified Test Report shall be furnished to the Engineer before installation of material. The original shall be provided to the Engineer before payment for the represented item will be made. Both the legible copy and the fully signed Certified Test Report shall include the Contractor's certification and signature. Each product or assembly delivered to the project must contain the lot, heat, or batch number identical to that on the accompanying Certified Test Report.

The following certification, signed by a person having legal authority to act for the Contractor:

> I hereby certify under penalty of perjury that the material listed in this Certified Test Report represents _____ (quantity and units) of pay item _____ (pay item number and Description) that will be installed on project number _____.
>
> _____ _____ Contractor, Date

Failure to comply may result in delays to the project or rejection of the materials. Products or assemblies furnished on the basis of Certified Test Reports may be sampled and tested by the Department, and if determined not to meet the applicable specifications will be rejected or accepted according to subsection 105.03.

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SECTION 107

LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

107.01 Laws to be Observed. The Contractor shall keep fully informed and comply with all Federal, State and local laws, ordinances, and regulations and all orders and decrees of bodies or tribunals having any jurisdiction or authority, which may affect those engaged or employed on the work or affect the conduct of the work. The Contractor shall protect and indemnify the Department and its representatives against any claim or liability arising from or based on the violation of any such law, ordinance, regulation, order or decree, whether by the Contractor, the subcontractors, suppliers of materials or services, or their employees.

Failure to comply with all contractual obligations may lead to the suspension, debarment, or both of the Contractor as stipulated in the "Rules".

107.02 Permits, Licenses, and Taxes. The Contractor shall procure all permits and licenses, pay all charges, fees, and applicable taxes, and give all notices necessary and incidental to the due and lawful prosecution of the Contract.

Before beginning work, the Contractor shall furnish the Engineer a written list of all permits required for the proper completion of the Contract. The list shall clearly identify the type of permit or permits that must be obtained before work on any particular phase or phases of work can be started. Copies of the fully executed permits shall be furnished to the Engineer upon request.

107.03 Patented Devices, Materials, and Processes. If the Contractor employs any design, device, material, or process covered by letters of patent or copyright, the Contractor shall provide for their use by suitable legal agreement with the patentee or owner. The Contractor and the Surety shall indemnify and save harmless the Department, any affected third party, or political subdivision from any and all claims for infringement resulting from the use of any patented design, device, material or process, or any trademark or copyright, and shall indemnify the Department for any costs, expenses, and damages that they may be obliged to pay by reason of any infringement, during the prosecution or after the completion of the Contract.

107.04 Restoration of Surfaces Opened by Permit. An individual, firm, or corporation may be issued a permit to construct or reconstruct a utility service. The Contractor shall allow permit holders to perform permitted work. The Contractor shall make necessary repairs resulting from this work, as directed. The repairs will be paid for as extra work per subsection 109.04.

The repairs will be subject to the same requirements as the original work performed.

107.05 Federal Aid Provisions. When the United States Government participates in the cost of a project, the Federal laws and the rules and regulations made pursuant to such laws must be observed by the Contractor, and the work shall be subject to the inspection of the appropriate Federal agency.

Such inspection shall not make the United States Government a party to the Contract and shall not interfere with the rights of the parties to the Contract.

107.06 Safety, Health, and Sanitation and Performance of Safety Critical Work.

(a) Project Safety Management Plan. Before the start of construction, the Contractor's Project Safety Manager shall prepare a written Project Safety Management Plan (Plan), which shall be specific to the project. The Plan shall include:

(1) Designation of a Project Safety Manager and an alternate, including names and contact information, and competent persons for each construction activity as described below.

(2) A list of all significant or high-risk construction activities and safety considerations as described below, and a hazard assessment for each.

(3) Direction as to whether engineering, administrative, personal protection measures, training, or a combination thereof, shall be implemented to address the hazards identified in (2) above.

(4) Provisions for field safety meetings. The Contractor shall conduct field safety meetings (also known as Toolbox or Tailgate meetings) at the frequency specified in the Plan, which shall be at least once per week. The Contractor shall encourage participation by all persons working at the project site. Participants at these meetings shall discuss specific construction activities for that work period, results from safety inspections, required personal protective equipment, and all other necessary safety precautions.

(5) Provisions for project safety meetings. In the event of a safety stand-down, the Contractor shall conduct a project safety meeting to discuss the circumstances leading to the stand-down, and the measures that shall be taken to prevent a recurrence. The Contractor shall notify the Engineer of the time, date, and location of these meetings, shall require participation by all persons (including Department personnel and consultants) working at the project site, and shall track attendance through sign-up lists.

(6) At the Contractor's option, portions of the Plan may be prepared by the subcontractors that will be performing that subcontracted work. The Contractor shall remain responsible for the overall project Plan, and for incorporating portions prepared by subcontractors. Portions of the Plan prepared by subcontractors shall be as stringent as the Contractor's overall Plan.

(7) Procedures for assuring compliance by subcontractors, suppliers, and authorized visitors to the project. In addition, the Plan shall specify the measures that will be taken to discourage unauthorized personnel from entering the site.

(8) Procedures to be followed in cases where workers are suspected of drug or alcohol impairment.

(9) Provisions for project safety inspections. The Project Safety Manager shall conduct regular project safety inspections at the frequency specified in the Plan, at least once per month. The Contractor shall notify the Engineer in advance of these inspections. Documentation of the inspections shall include the date of the inspection, the participants, the findings, and the corrective measures taken to address the findings. Within one week after these inspections, the Contractor shall provide a copy of the documentation to the Engineer and shall maintain a copy on the project site.

(10) Procedures to be followed to correct violations of the Plan by any personnel.

(11) The notification, investigation, and implementation procedures that the Contractor shall follow in the case of a safety stand down. The procedures shall include immediately

reporting the reason for safety standdown and reporting the results of the investigation and implementation procedures.

(12) The safety plan should address issues including, but not limited to the following:

Protocols for requiring symptomatic individuals to stay away from the project site.

Protocols for identifying and protecting vulnerable individuals.

Protocols on reporting of potential and confirmed infections to project and CDOT staff.

Cleaning and sanitizing of devices and materials brought to the site for installation.

Cleaning and sanitizing practices for equipment, workspaces, and sanitation facilities both for everyday situations and for a situation where a worker is found to have been infected by the pandemic virus. Provisions and protocols for washing hands or other means of hand sanitizing.

The planned use of shift work to minimize interpersonal contact between crews.

Task specific protocols that ensure people minimize contact and maximize social distancing while performing particular jobs. For example, rules for laborers to follow when forced to work in close quarters like tying steel on a structure, or installing pipe in a trench, or other similar operations.

Protocols to ensure materials testers, inspectors and other project staff can perform their work while maintaining proper social distancing from contractor staff. This includes the exchange of necessary documents like load tickets, COC's, payroll information etc.

Meeting arrangements, including techniques for remote meetings, and maintaining 6 feet minimum spacing if face-to-face meetings are unavoidable, and when trying to verbally communicate around loud machinery and operations. Protocol and plan for enforcement on who may access Field office and Material testing trailers to ensure social distancing is maintained. Protocols to ensure staff maintain social distancing while taking breaks from work activities, including the use of temporary lodging on remote jobs.

Supplemental PPE to be used during the pandemic.

(13) The Contractor's certification shall be as follows:

By authorized signature below, (Contractor name),hereinafter referred to as "the Contractor," hereby certifies that this Project Safety Management Plan (Plan) complies with and meets applicable Federal, State, and local laws, rules, regulations and guidelines governing safety, health and sanitation, including but not limited to the Occupational Safety and Health Act, 29 CFR 1910, 29 CFR 1926, 23 CFR 634, Mine Safety and Health Administration (MSHA), Title 30 CFR, the "Colorado Work Zone Best Practices Safety Guide", CFR 49,

national consensus standards, and the Drug-Free Workplace Act (Public Law 100-690 Title V, subtitle D, 41 USC 701 et seq.), and subsection 107.06 of the Standard Specifications. All operations and work practices of the Contractor shall comply with this Plan. The Contractor requires that all subcontractors, suppliers, Department personnel, and consultants comply with this Plan.

_____

(Signature of Contractor's Project Safety Manager or alternate)

_____

Title

_____

Date

Before the start of construction, the Contractor shall submit the Plan to the Engineer for the project records, and shall provide updates to the Plan as necessary, and as work conditions or personnel change. The Contractor shall review the Plan for sufficiency and accuracy at least once per twelve months of contract time. The Engineer will review the Plan for general compliance with subsection 107.06 and notify the Contractor in writing that the Plan has been received and addresses items 1 thru 13 above. An up-to-date copy of the Plan shall be on the project site in the Contractor's possession at all times.

(b) Contractor Responsibilities. The Contractor shall ensure compliance with applicable Federal, State, and local laws, rules, regulations, and guidelines governing safety, health and sanitation, including but not limited to the Plan, the Occupational Safety and Health Act, 29 CFR 1910, 29 CFR 1926, 23 CFR 634, Mine Safety and Health Administration (MSHA), Title 30 CFR, the "Colorado Work Zone Best Practices Safety Guide", CFR 49, national consensus standards, and the Drug-Free Workplace Act (Public Law 100-690 Title V, subtitle D, 41 USC 701 et seq.). The Contractor shall provide all safeguards, safety devices, and protective equipment, and shall take all other actions necessary to protect the life, safety, and health of persons working at or visiting the project site, and of the public and property in connection with the performance of the work covered by the Contract. In the case of conflicting requirements, the more stringent of the requirements shall apply. The Contractor shall require that all operations and work practices by Contractor, subcontractor, supplier, and Department personnel and consultants comply with the provisions of the Plan. The Contractor shall respond in writing to all safety issues raised by the Engineer.

All work vehicles and mobile equipment shall be equipped with one or more functioning warning lights mounted as high as practicable, which shall be capable of displaying in all directions one or more flashing, oscillating, or rotating lights for warning roadway traffic. The lights shall be amber in color. The warning lights shall be activated when the work vehicle or mobile equipment is operating within the roadway, the right of way, or both. All supplemental lights shall be Society of Automotive Engineers (SAE) Class 1 certified.

(c) Project Safety Manager. Before the start of construction, the Contractor shall designate a Project Safety Manager and an alternate, who shall be responsible for the coordination of safety activities, and preparation, certification, and implementation of the Plan.

(d) Competent Persons. Before the start of construction, the Contractor shall designate at least one competent person for each of the construction activities being completed. A competent person is an individual who, by way of training, experience, or combination thereof, is knowledgeable of applicable standards, is capable of identifying existing and predictable workplace hazards relating to a specific construction activity, is designated by the employer, and has authority to take prompt, appropriate actions. Construction activities and safety considerations that must be addressed by the Plan and by designation of a competent person shall include, but are not limited to (if applicable to the project):

(1) Rotomilling and paving operations.
(2) Concrete paving.
(3) Concrete placement.
(4) Lead abatement.
(5) Hearing protection.
(6) Respiratory protection.
(7) Rigging.
(8) Assured grounding.
(9) Scaffolding.
(10) Fall protection.
(11) Use of cranes.
(12) Trenching and excavating.
(13) Steel erection.
(14) Underground construction (including caissons and cofferdams).
(15) Demolition.
(16) Blasting and the use of explosives.
(17) Stairways and ladders.
(18) Asbestos.
(19) Confined space.

The appropriate competent persons shall be present on the project site at all times during the specific construction activities that require those competent persons.

(e) Project Safety and Health Requirements. All personnel on the project site shall wear the following personal protective equipment (PPE) at all times when in the highway right of way, except when in their vehicles:

(1) Head protection and high visibility apparel, reflectorized for night use conforming to American National Standards Institute, Inc. (ANSI)/ International Safety Equipment Association (ISEA) 107 – 2004, and appropriate, sturdy footwear, all of which shall comply with the latest appropriate national consensus standards.

(2) All other PPE that is stipulated by the Plan. All PPE shall comply with the latest appropriate national consensus standards.

(f) Safety Stand-Down. The Engineer may immediately suspend all or part of any work in the case of an accident (including property damage), or catastrophe (one or more persons hospitalized in a single incident), or other situation presenting an imminent danger to life or health, such as a near miss, violation of the Plan, or presence of a hazardous situation. In the case of a worksite fatality directly related to the Contractor's or any subcontractor's

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work operations, the safety stand-down shall be mandatory. In the case of a traffic fatality unrelated to a work-zone incident in the opinion of the Engineer, the safety stand-down will not be mandatory. During any mandatory safety stand-down due to a fatality, all work on the project shall cease, except that work deemed immediately necessary by the Engineer to make the project safe. The Contractor will be allowed to resume operations only after providing written documentation, certified by the Project Safety Manager or alternate, regarding the corrective actions taken to prevent recurrence.

(g) Regulatory Enforcement Actions. The Contractor shall provide written notifications of all Regulatory agency actions relating to safety to the Engineer.

(h) Failure to Comply. Failure to comply with the requirements of subsection 107.06 shall be grounds for withholding of progress payments, project suspension, or both.

(i) Costs. All costs associated with the preparation and implementation of the Plan and compliance with all safety, health, and sanitation provisions and requirements will not be measured and paid for separately but shall be included in the work.

Performance of Safety Critical Work. Consider the following work elements safety critical work.

(1) Overhead girder erection, location and structure number as shown on the plans.

(2) Overhead structure(s) construction or repair, location and structure number as shown on the plans.

(3) Removal of bridge, location and structure number as shown on the plans.

(4) Removal of portion of bridge(s), location and structure number as shown on the plans.

(5) Temporary work: falsework, shoring that exceeds 5 feet in height, cofferdams, and temporary bridges.

(6) Work requiring the use of cranes or other heavy lifting equipment to set girders, sound walls, make overhead repairs; also, when construction materials are being lifted that may fall onto active traffic lanes.

(7) Blasting.

(8) Excavation and embankment adjacent to the roadway, especially if it requires shoring. The Engineer will specify the depth or proximity of the earthwork considered safety critical work.

(9) Tunneling.

(10) Work operations such as pile driving and jack hammering which may create vibration and cause debris to fall onto traffic.

(11) Rockfall mitigation.

(12) Work within 50 feet of active railroad track centerline.

(13)Caissons and/or directional boring in high density utility corridor. This includes open holes for new drilled shafts within two existing shaft diameters of existing drilled shafts and structures.

(14) Work over or adjacent to river, stream, or other protected water way.

(15) Urban work near and/or where pedestrian or bicycle pathways must be maintained during construction.

The Contractor shall submit, for review, an initial, detailed construction plan that addresses safe construction methods for each of the safety critical elements applicable. The Engineer will submit bridge removal and girder erection plans to Engineer of Record and the corresponding CDOT Bridge Unit Leader for a concurrent review. The Engineer's review will be for general conformance with the plans, specifications, best management practices regarding safety of the operation and industry standards. When the specifications already require an erection plan, a bridge removal plan, or a removal of portion of bridge plan, it shall be included as a part of this plan. Submit the detailed construction plan two weeks prior to the safety critical element conference described below.

The Contractor shall stamp and sign the construction plan "Approved for Construction". The Engineer will review the construction plan for acceptance. CDOT review of this information shall not relieve the Contractor of liability. Certifications that are expired are invalid and not in compliance with this specification.
The Construction Plan shall include the following:

(1) Safety Critical Element for which the plan is being prepared and submitted.

(2) Contractor or subcontractor responsible for the plan preparation and the work.

(3) Schedule, procedures, equipment, and sequence of operations, that comply with the working hour limitations.

(4) Temporary work required: falsework, bracing, shoring, etc.

(5) Underground, above grade, and overhead utilities identification and protective steps taken.

(6) Communication plan as necessary with stakeholders, media, and the public.

(7) Additional actions that will be taken to ensure that the work will be performed safely.

(8) Names and qualifications of workers who will be in responsible charge of the work:
A. Years of experience performing similar work
B. Training taken in performing similar work.
C. Certifications earned in performing similar work.

(9) Names and qualifications of workers operating cranes or other lifting equipment
A. Years of experience performing similar work
B. Training taken in performing similar work.
C. Certifications earned in performing similar work.

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(10)The construction plan shall address how the Contractor will handle contingencies such as:

A. Unplanned events (storms, traffic accidents, work accidents, etc.)
B. Structural elements that don't fit or line up.
C. Work that cannot be completed in time for the roadway to be reopened to traffic.
D. Replacement of workers who don't perform the work safely.
E. Unexpected absence of critical management team
F. Equipment failure
G. Other potential difficulties inherent in the type of work being performed.

(11)Name and qualifications of Contractor's person designated to determine and notify the Engineer in writing when it is safe to open a route to traffic after it has been closed for safety critical work.

(12)Erection plan or bridge removal plan when submitted as required elsewhere by the specifications. Submit plan requirements that overlap with above requirements only once.

The Contractor shall hold a Safety Critical Element Conference two weeks prior to beginning construction on each safety critical element. The Engineer, the Contractor, the safety critical element subcontractors, and the Contractor's Engineer shall attend the conference.

Required pre-erection conferences or bridge removal conferences may be included as a part of this conference. Communications staff (Contractor or CDOT) shall also attend in order to address any public/media needs.

After the safety critical element conference, and prior to beginning work on the safety critical element, the Contractor shall submit a final construction plan to the Engineer for record purposes only except for bridge removal and girder erection plans. Submit safety critical construction plans related to bridge removal and girder erection per the corresponding standard specification, 202-Removal of Bridge, 509-Structural Steel or 618-Prestressed Concrete as appropriate. The Contractor's Engineer shall seal temporary works, such as falsework, shoring etc., related to construction plans for the safety critical elements, (3) Removal of Bridge, (4) Removal of Portion of Bridge and (5) Temporary Work. The Contractor shall stamp and sign the final construction plan "Approved for Construction", if the elements Removal of Portion of Bridge and Temporary Works are safety critical work elements for this project.

The Contractor shall perform safety critical work only when the Engineer, or an authorized representative, is on the project site. The Contractor's Engineer shall be onsite to inspect and provide written approval of safety critical work for which they provided signed and sealed construction details. Unless otherwise directed or approved, the Contractor's Engineer need not be onsite during the actual performance of safety critical work but shall be present to conduct inspection for written approval of the safety critical work.

When ordered by the Engineer, the Contractor shall immediately stop safety critical work that is being performed in an unsafe manner or which will result in an unsafe situation for the traveling public. Prior to stopping work, the Contractor shall make the situation safe for work stoppage. The Contractor shall submit an acceptable plan to correct the unsafe process before the Engineer will authorize resumption of the work.

When ordered by the Engineer, the Contractor shall remove workers from the project that are performing the safety critical work in a manner that creates an unsafe situation for the public per subsection 108.06.

If an unplanned event occurs or the safety critical operation deviate from the submitted plan, the Contractor shall immediately cease operations on the safety critical element. Perform all necessary work to ensure worksite safety and provide proper protection of the work and the traveling public. If the Contractor intends to modify the submitted plan, he shall submit a revised plan to the Engineer prior to resuming operations.

All costs associated with the preparation and implementation of each safety critical element construction plan will not be measured and paid for separately but shall be included in the work.

The Contractor shall not be relieved from ultimate liability for unsafe or negligent acts or receive a waiver of the Colorado Governmental Immunity Act on behalf of the Department.

107.07 Public Convenience and Safety. The Contractor shall conduct the work to minimize obstruction to traffic. The safety and convenience of the general public and the residents along the highway and the protection of persons and property shall be provided for by the Contractor as specified under subsection 104.04.

107.08 Railroad-Highway Provisions. If the Contract requires materials to be hauled across railroad tracks, the Department will make arrangements with the railroad company for any new crossings required or for the use of any existing crossings. The Contractor shall make arrangements for the use of crossings not provided in the Contract.

Work performed by the Contractor on the railroad right of way shall be performed to avoid interference with the movement of trains or traffic on the railroad tracks. The Contractor shall use care and precaution in order to avoid accidents, damage, or unnecessary delay or interference with the railroad company's trains or property.

107.09 Construction Over and Adjacent to Navigable Waters. Work on navigable waters shall be conducted to avoid interference with free navigation of the waterways and so the existing navigable depths will not be impaired except as allowed by permit issued by the U.S. Coast Guard or the U.S. Army Corps of Engineers, as applicable.

107.10 Barricades and Signs. The Contractor shall provide, erect, and maintain barricades, suitable and sufficient lights, pavement markings, signs, and other traffic control devices, and shall protect the work and safety of the public per the Contract. Highways closed to traffic shall be protected by barricades, and obstructions shall be illuminated during hours of darkness. Signs shall be provided to control and direct traffic.

The Contractor shall erect signs at locations where operations may interfere with the use of the road by traffic, and at all intermediate points where the new work crosses or coincides with an existing road, bike path, or sidewalk. Signs shall be constructed, erected, and maintained per the Contract.

Barricades, warning signs, lights, temporary signals, and other protective devices shall conform with the latest revision of the "Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways" published by the FHWA and adopted by the Department, the latest revision of the Colorado Supplement thereto, and the required traffic control plan.

107.11 Use of Explosives. When explosives are utilized in the prosecution of the work, the Contractor shall not endanger life, property, or new work. The Contractor shall be responsible for all damage resulting from the use of explosives.

The Contractor's explosives shall be stored in a secure manner in compliance with laws and ordinances, and storage places shall be clearly marked. When electric blasting caps are used, stored or moved in the vicinity of the work, warning signs prohibiting the use of radio transmitters and mobile telephones shall be posted on all roads within 350 feet of the blasting operation.

The Contractor shall notify property owners and public utility companies having structures in the proximity of the work of the intention to use explosives. Notice shall be given sufficiently in advance to enable them to protect their property.

In advance of doing any blasting work involving the use of electric blasting caps within 200 feet of any railroad's track or structures, the Contractor shall notify the proper authority of the railroad company as to the location, date, time and approximate duration of such blasting operations.

At the conclusion of each day of blasting, all spent surface blasting components shall be removed. At the conclusion of blasting and excavation work, the Contractor shall properly dispose of all spent blasting components. At the completion of final grading, the Contractor shall inspect the project and remove all exposed blasting components.

107.12 Protection and Restoration of Property and Landscape. The Contractor shall preserve private and public property and protect it from damage. Land monuments and property marks shall not be disturbed or moved until their location has been witnessed or referenced per Section 629 and their removal approved.

The Contractor shall be responsible for the damage or injury to property resulting from:

1. The Contractor's neglect, misconduct, or omission in the manner or method of execution or non-execution of the work, or
2. The Contractor's defective work or the use of unacceptable materials.

The Contractor's responsibility shall not be released until the work has been completed in compliance with the Contract. The Contractor shall restore damaged or injured property, at the Contractor's expense, to a condition similar or equal to that existing before the damage or injury occurred, by repairing, rebuilding, or restoring the property.

Existing trees, shrubs, bushes or grass, outside the designated work areas but inside project limits that are damaged due to the Contractor's operations shall be replaced in kind at the Contractor's expense.

107.13 Forest Protection. The Contractor shall comply with all regulations of the State Department of Natural Resources, the National Forest Supervisor, or other authority having jurisdiction, governing the protection of forests, and shall observe all sanitary laws and regulations with respect to the performance of work within or adjacent to state or National Forests. The Contractor shall keep the areas in an orderly condition, dispose of all refuse, obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks, and other structures per the regulations and instructions issued by the Forest Supervisor.

The Contractor shall take all reasonable precaution to prevent forest fires and shall make every possible effort to notify a forest official at the earliest possible moment of the location and extent of any fire seen by them. The Contractor, subcontractors, and their employees shall prevent and suppress forest fires and provide assistance in this effort as directed by forest officials.

107.14 Interruption of Irrigation Water Flow. The Contractor shall arrange the work to avoid interference with the flow of irrigation water. If it is impractical to install the structure during the time the ditches are not flowing, the Contractor shall make arrangements with the ditch owners regarding temporary interruption of flow or temporary diversion of water. This will require construction of new ditches with appurtenant structures before old ditches or canals are altered. The Contractor shall provide any temporary ditches, canals or structures necessary for the uninterrupted flow of irrigation water. Temporary construction and removal shall be at the expense of the Contractor.

107.15 Responsibility for Damage Claims, Insurance Types and Coverage Limits. The Contractor shall indemnify and save harmless the Department, its officers, and employees, from suits, actions, or claims of any type or character brought because of any and all injuries or damage received or sustained by any person, persons, or property on account of the operations of the Contractor; or failure to comply with the provisions of the Contract; or on account of or in consequence of neglect of the Contractor in safeguarding the work; or through use of unacceptable materials in constructing the work; or because of any act or omission, neglect, or misconduct of the Contractor; or because of any claims or amounts recovered from any infringements of patent, trademark, or copyright, unless the design, device, material or process involved is specifically required by the Contract; or from any claims or amounts arising or recovered under the Worker's Compensation Act, or other law, ordinance, order, or decree. The Department may retain as much of any moneys due the Contractor under any Contract as may be determined by the Department to be in the public interest.

(a) The Contractor shall obtain, and maintain at all times during the term of this Contract, insurance in the following kinds and amounts:

1. Workers' Compensation Insurance as required by state statute, and Employer's Liability Insurance covering all of Contractor's employees acting within the course and scope of their employment.
2. Commercial General Liability Insurance written on ISO Occurrence Form CG 00 01 10/93 or equivalent, covering premises operations, fire damage, independent Contractors, products and completed operations, blanket contractual liability, personal injury, and advertising liability with minimum limits as follows:

   (1) $1,000,000 each occurrence.
   (2) $2,000,000 general aggregate.
   (3) $2,000,000 products and completed operations aggregate: and
   (4) $50,000 any one fire.
   (5) Completed Operations coverage shall be provided for a minimum period of one year following final acceptance of work.

   If any aggregate limit is reduced below $1,000,000 because of claims made or paid, the Contractor shall immediately obtain additional insurance to restore the full aggregate limit and furnish to CDOT a certificate or other document satisfactory to CDOT showing compliance with this provision.

3. Automobile Liability Insurance covering any auto (including owned, hired, and non-owned autos) with a minimum limit as follows: $1,000,000 each accident combined single limit.

4. Professional liability insurance with minimum limits of liability of not less than $1,000,000 Each Claim and $1,000,000 Annual Aggregate for both the Contractor or any subcontractors when:

   (1) Contract items 625, 629, or both are included in the Contract.

   (2) The Contractor's Engineer, shall electronically seal plans, specifications and submittals, including but not limited to:

      A. Shop drawings and working drawings as described in subsection 105.02.

      B. Mix Designs.

      C. Contractor performed design work as required by the plans and specifications.

      D. Change Orders.

      E. Approved Value Engineering Change Proposals.

   (3) The Contractor and any included subcontractor shall renew and maintain Professional Liability Insurance as outlined above for a minimum of one year following final acceptance of work.

5. Umbrella or Excess Liability Insurance with minimum limits of $1,000,000. This policy shall become primary (drop down) in the event the primary Liability Policy limits are impaired or exhausted. The Policy shall be written on an Occurrence Form and shall be following form of the primary. The following form Excess Liability shall include CDOT as an additional insured.

(b) CDOT shall be named as additional insured on the Commercial General Liability and Automobile Liability Insurance policies. Completed operations additional insured coverage shall be on endorsements CG 2010 11/85, CG 2037, or equivalent. Coverage required of the Contract will be primary over any insurance or self-insurance program carried by the State of Colorado.

(c) Each insurance policy shall include provisions preventing cancellation or non-renewal without at least 30 days' prior notice to Contractor. The Contractor shall forward to the Engineer any such notice received within seven days of the Contractor's receipt of such notice.

(d) The Contractor shall require all insurance policies in any way related to the Contract and secured and maintained by the Contractor to include clauses stating that each carrier will waive all rights of recovery, under subrogation or otherwise, against CDOT, its agencies, institutions, organizations, officers, agents, employees and volunteers.

(e) All policies evidencing the insurance coverages required hereunder shall be issued by insurance companies satisfactory to CDOT.

(f) The Contractor shall provide certificates showing insurance coverage required by this contract to CDOT before execution of the contract. No later than 15 days before the expiration date of any such coverage, the Contractor shall deliver CDOT certificates of insurance evidencing renewals thereof. At any time during the term of this Contract, CDOT may request in writing, and the Contractor shall thereupon within 10 days supply to CDOT, evidence satisfactory to CDOT of compliance with the provisions of this section.

(g) Notwithstanding subsection 107.15(a), if the Contractor is a "public entity" within the meaning of the Colorado Governmental Immunity Act CRS 24-10-101, et seq., as amended ("Act"), the Contractor shall at all times during the term of this Contract maintain only such liability insurance, by commercial policy or self-insurance, as is necessary to meet its liabilities under the Act. Upon request by CDOT, the Contractor shall show proof of such insurance satisfactory to CDOT. Public entity Contractors are not required to name CDOT as an Additional Insured.

(h) When the Contractor requires a subcontractor to obtain insurance coverage, the types and minimum limits of this coverage may be different than those required, as stated above, for the Contractor, except for the Commercial General Liability Additional Insured endorsement and those that qualify as needing Professional Liability Insurance.

107.16 Opening Sections of Project to Traffic. Opening certain sections of the work for traffic use shall not constitute acceptance of the work or provide a waiver of any provision of the Contract.

The Contract will designate the sections to be opened and specify the method of compensation for signing and traffic control. The Contractor shall maintain the roadway in a condition equal to or better than the condition of the roadway when it was initially opened to traffic. Where applicable, the Contract may specify the time or date that certain portions of the work shall be completed to provide for the accommodation of traffic.

The Engineer may order certain portions of the work opened for traffic, other than specified in the Contract. If the Engineer has not ordered the roadway opened because of unnecessary delay by the Contractor, and if no damage occurs other than that can be attributed to traffic, the Contractor will be relieved of all responsibility for maintenance of traffic control devices and damage due to traffic. Any expense resulting from opening such sections shall be borne by the Department or the Contractor will be compensated for the added expense per subsection 109.04. If the opening causes changed working conditions or delays the completion of other items of work on the project, compensation for the added expense and recommendations for additional time will be set forth by a Contract Modification Order.

If the Contractor is dilatory in completing the work, the Engineer may order all or a portion of the project to be opened to traffic. In such event, the Contractor will not be relieved of the liability and responsibility during the period the work is so opened before final acceptance. The Contractor shall conduct the remainder of the construction operations to cause the least obstruction to or interference with traffic. Damage attributed to traffic shall be paid for at the Contractor's expense.

Damages not attributable to traffic that might occur on sections opened to traffic shall be repaired at the Contractor's expense. The removal of slides that are not caused by the Contractor's operations shall be done by the Contractor on a basis agreed to before the slide removal.

107.17 Contractor's Responsibility for Work. The Contractor shall be responsible for and protect the contract work against injury or damage from all causes whether arising from the execution or nonexecution of the work, including but not limited to action of the elements, traffic, fire, theft, vandalism, or third party negligence, until final written acceptance of the project by the Engineer. The Contractor shall rebuild, repair, restore, or replace all contract work that is injured or damaged before final written acceptance at no cost to the Department.

The Engineer may, in writing, relieve the Contractor of expenses for damage to certain portions

of the contract work caused by traffic or the action of the elements. The following conditions must be met before the Engineer will consider any relief:

(1) All work on the portion of contract work being considered must be complete under terms of the Contract except for seeding, mulching, landscape items, final clean-up, and bridge painting or structural coating.

(2) Traffic shall be in its final configuration and location.

Portions of contract work that may be considered are described below:

(1) A minimum of 0.5 mile of roadway, or a minimum of 0.5 mile of one direction of a divided highway.

(2) A complete bridge. This includes all approach roadway safety features that protect traffic from such items as: bridge railing and median barrier ends, piers, and abutments.

(3) A complete intersection traffic signal system.

(4) A complete highway lighting system.

Loss, injury, or damage to the contract work due to unforeseeable causes beyond the control of the Contractor, including but not limited to acts of God, such as earthquake, flood, tornado, high winds, or other cataclysmic phenomenon of nature, or acts of the public enemy or of governmental authorities, shall be restored by the Contractor under the provisions of subsection 104.02 or 104.03, as applicable.

During periods that work is suspended, the Contractor shall be responsible for the work under the Contract and shall prevent damage to the project, provide for drainage, and shall erect necessary temporary structures, signs, or other facilities required to maintain the project. During the suspension period, the Contractor shall maintain in a growing condition all newly established plantings, seedings, and soddings furnished under the Contract, and shall protect new tree growth and other vegetative growth against injury.

107.18 Unused.

107.19 Furnishing Right of Way. The Department will be responsible for the securing of all necessary rights of way in advance of construction. Any exceptions will be indicated in the Contract.

107.20 Personal Liability of Public Employees. The Engineer or authorized representatives are acting solely as agents and representatives of the Department when carrying out and exercising the power or authority granted to them under the Contract. There shall not be any liability on them either personally or as employees of the Department.

107.21 No Waiver of Legal Rights. Upon completion of the Contract, the Department will make final inspection and notify the Contractor of acceptance. Final acceptance shall not preclude the Department from correcting any measurement, estimate, or certificate made before or after completion of the Contract, nor from recovering from the Contractor or surety or both, overpayments sustained because the Contractor failed to fulfill the obligations under the Contract. A waiver on the part of the Department of any breach of any part of the Contract shall not be held to be a waiver of any other or subsequent breach.

The Contractor without prejudice to the terms of the Contract, shall be liable to the Department, for latent defects, fraud, or such gross mistakes as may amount to fraud, or as regards the Department’s rights under any warranty or guaranty.

107.22 Third Party Beneficiary. It is specifically agreed between the parties executing this Contract that it is not intended by any of the provisions of any part of the Contract to create

in the public or any member thereof a third party beneficiary hereunder, or to authorize any one not a party to this Contract to maintain a suit for personal injuries or property damage.

pursuant to the terms or provisions of this Contract. The duties, obligations and responsibilities of the parties to this Contract with respect to third parties shall remain as imposed by law.

107.23 Archaeological and Paleontological Discoveries. When the Contractor's operations, including materials pits and quarries, encounter plant or animal fossils, remains of prehistoric or historic structures, prehistoric or historic artifacts (bottle dumps, charcoal from subsurface hearths, old pottery, potsherds, stone tools, arrowheads, etc.), the Contractor's affected operations shall immediately cease. The Contractor shall immediately notify the Engineer, or other appropriate agency for contractor source pits or quarries, of the discovery of these materials. When ordered to proceed, the Contractor shall conduct affected operations as directed. Additional work, except that in contractor source materials pits or quarries under subsection 106.02(b), will be paid for by the Department as provided in subsection 104.02 when contract unit prices exist, or as extra work as provided in subsection 104.03 when no unit prices exist. Delays to the Contractor, not associated with work in contractor sources, because of the materials encountered may be cause for extension of contract time per subsection 108.08. If fossils, prehistoric or historic structures, or prehistoric or historic artifacts are encountered in a contractor source materials pit or quarry, all costs and time delays shall be the responsibility of the Contractor.

107.24 Air Quality Control. The Contractor shall comply with the "Colorado Air Quality Control Act," Title 25, Article 7, CRS and regulations promulgated thereunder.

107.25 Water Quality Control. The project work shall be performed using practices that minimize water pollution during construction. All the practices listed in (b) below shall be followed to minimize the pollution of any State waters, including wetlands.

(a) Definitions.

1. Areas of Disturbance (AD). Locations where any activity has altered the existing soil cover or topography, including vegetative and non-vegetative activities during construction.
2. Construction Site Boundary/Limits of Construction (LOC). The project area defined by the Stormwater Construction Permit.
3. Discharge of Pollutants. One or more pollutants leaving the LOC or entering State waters or other conveyances.
4. Limits of Disturbed Area (LDA). Proposed limits of ground disturbance as shown on the Plans.
5. Pollutant. Dredged spoil, dirt, slurry, solid waste, incinerator residue, sewage, sewage sludge, garbage, trash, chemical waste, biological nutrient, biological material, radioactive material, heat, wrecked or discarded equipment, rock, sand, or any industrial, municipal, or agricultural waste, as defined in the Colorado Code of Regulations (CCR) [5 CCR 1002-61, 2(76)]
6. Pollution. Man-made, man-induced, or natural alteration of the physical, chemical, biological, and radiological integrity of water. [25-8-103 (16), CRS]
7. State waters. Defined in section 101.
8. Owner. The party that has overall control of the activities and that has funded the

implementation of the construction plans and specifications. This is the party with ownership of, a long-term lease of, or easements on the property where the construction activity is occurring (CDOT).

9. Operator. The party that has operational control over day-to-day activities at a project site that are necessary to ensure compliance with the permit. This party is authorized to direct individuals at a site to carry out activities required by the permit (the general contractor).

(b) Construction Requirements.

1. The Contractor shall comply with the "Colorado Water Quality Control Act" (Title 25, article 8, CRS), the "Protection of Fishing Streams" (Title 33, Article 5, CRS), the "Clean Water Act" (33 USC 1344), regulations promulgated, certifications or permits issued, and to the requirements listed below. In the event of conflicts between these requirements and water quality control laws, rules, or regulations of other Federal, or State agencies, the more restrictive laws, rules, or regulations shall apply.
2. If the Contractor determines construction of the project will result in a change to the permitted activities or LDA, the Contractor shall detail the changes in a written report to the Engineer. Within five days after receipt of the report, the Engineer, after coordination with Region Planning and Environmental Manager (RPEM), will approve or reject in writing the request for change, or detail a course of action including revision of existing permits or obtaining new permits.
3. If construction activities result in noncompliance of any permit requirement, the project will be suspended and the permitting agency notified, if required. The project will remain suspended until the Engineer receives written approval by the permitting agency.

   The Contractor is legally required to obtain all permits associated with specific activities within, or off the right of way, such as borrow pits, concrete or asphalt plant sites, waste disposal sites, or other facilities. It is the Contractor's responsibility to obtain these permits. The Contractor shall consult with the Engineer and contact the Colorado Department of Public Health and Environment (CDPHE) or other appropriate federal, state, or local agency to determine the need for any permit.
4. The Contractor shall conduct the work in a manner that prevents pollution of any adjacent State waters. Erosion control work shall be performed per Section 208, this subsection, and all other applicable parts of the Contract.
5. Before the Environmental Pre-construction Conference, the SWMP Administrator, identified in subsection 208.03(c), shall identify and describe all potential pollutant sources, including materials and activities, and evaluate them for the potential to contribute pollutants to stormwater discharges associated with construction activities. The list of potential pollutants shall be continuously updated during construction. At a minimum, each of the following shall be evaluated for the potential for contributing pollutants to stormwater discharges and identified in the SWMP, if found to have such potential:

   (1) All exposed and stored soils.

   (2) Vehicle tracking of sediments.

   (3) Management of contaminated soils.

   (4) Vehicle and equipment maintenance and fueling.

   (5) Outdoor storage activities (building materials, fertilizers, chemicals, etc.).

   (6) Significant dust or particle generating processes.

(7) Routine maintenance involving fertilizers, pesticides, detergents, fuels, solvents, oils, etc.

(8) On-site waste management practices (waste piles, dumpsters, etc.).

(9) Dedicated asphalt and concrete batch plants.

(10) Concrete truck and equipment washing, including the concrete truck chute and associated fixtures and equipment.

(11) Concrete placement and finishing tool cleaning.

(12) Non-industrial waste sources that may be significant, such as worker trash and portable toilets.

(13) Loading and unloading operations.

(14) Other areas or procedures where spills could occur.

The SWMP Administrator shall record the location of potential pollutants on the site map. Descriptions of the potential pollutants shall be added to the SWMP.

At or before the Environmental Pre-construction Conference the Contractor shall submit a Spill Response Plan for any petroleum products, chemicals, solvents, or other hazardous materials in use, or in storage, at the work site. See subsection 208.06(c) for Spill Response Plan requirements. Work shall not be started until the plan has been submitted to and approved by the Engineer.

On-site above ground bulk storage containers with a cumulative storage shell capacity greater than 1,320 U.S. gallons, or storage containers having a "reasonable expectation of an oil discharge" to State waters, are subject to the Spill Prevention, Control and Countermeasure Plan (SPCC) Rule. Oil of any type and in any form is covered, including, but not limited to petroleum; fuel oil; sludge; oil refuse; oil mixed with wastes other than dredged spoil. EPA Region 8 is responsible for administering and enforcing the SPCC plan requirements in Colorado. Before start of work, the Contractor shall submit an SPCC Form that has been approved by the EPA for the project.

6. The Contractor shall obtain a Construction Dewatering (CDW) permit from CDPHE anytime uncontaminated groundwater, including groundwater that is commingled with stormwater or surface water, is encountered during construction activities and the groundwater or commingled water needs to be discharged to State waters. If contaminated groundwater is encountered, a Remediation permit may be needed from CDPHE per Section 250.

7. Water from dewatering operations shall not be directly discharged into any State waters, unless allowed by a permit. Water from dewatering shall not be discharged into a ditch unless:

(1) Written permission is obtained from the owner of the ditch.
(2) It is covered in the approved CDW or Remediation Permit that allows the discharge.
(3) A copy of this approval is submitted to the Engineer. A copy of the Permit shall be submitted to the Engineer before dewatering operations commencing.

Construction Dewatering may be discharged to the ground on projects where CDPHE's Low Risk Guidance Document for Discharges of Uncontaminated Groundwater to Land are met. The conditions of this guidance are:

(1) The source of the discharge is solely uncontaminated groundwater or uncontaminated groundwater combined with stormwater and does not contain pollutants in

concentrations that exceed water quality standards for groundwater referenced above.

(2) Discharges from vaults or similar structures shall not be contaminated. Potential sources of contamination include process materials used, stored, or conveyed in the structures or introduced surface water runoff from outside environments that may contain oil, grease, and corrosives.

(3) The groundwater discharge does not leave the project boundary limits where construction is occurring.

(4) Land application is conducted at a rate and location that does not allow for any runoff into State waters or other drainage conveyance systems, including but not limited to streets, curb and gutter, inlets, borrow ditches, open channels, etc.

(5) Land application is conducted at a rate that does not allow for any ponding of the groundwater on the surface, unless the ponding is a result of implementing control measures that are designed to reduce velocity flow. If the control measures used result in ponding, the land application shall be done in an area with a constructed containment, such as an excavation or berm area with no outfall. The constructed containment shall prevent the discharge of the ponding water offsite as runoff.

(6) A visible sheen is not evident in the discharge.

(7) Control measures are implemented to prevent any sediment deposited during land application from being transported by stormwater runoff to surface waters or other conveyances.

(8) All control measures used shall be selected, installed, implemented, and maintained according to good engineering, hydrologic, and pollution control practices. The selected control measures shall provide control for all potential pollutant sources associated with the discharge of uncontaminated groundwater to land. The discharge shall be routed in such a way that it will not cause erosion to land surface. Energy dissipation devices designed to protect downstream areas from erosion by reducing the velocity of flow (such as hose attachments, sediment and erosion controls) shall be used when necessary to prevent erosion.

All dewatering operations shall be recorded in the SWMP as follows:

(1) The source is identified in the SWMP and updated by the SWMP Administrator.

(2) The SWMP describes and locates the practices implemented at the site to control stormwater pollution from the dewatering of groundwater or stormwater.

(3) The SWMP describes and locates the practices to be used that will ensure that no groundwater from construction dewatering is discharged from the LOC as surface runoff or to surface waters or storm sewers.

(4) Groundwater and groundwater combined with stormwater do not contain pollutants in concentrations exceeding the State groundwater standards in Regulations 5 CCR 1002-41 and 42.

If surface waters are diverted around a construction area and no pollutants are introduced during the diversion, a CDW Permit is not required. If the diverted water enters the construction area and contacts pollutant sources (e.g., disturbed soil, concrete washout, etc.), the Contractor shall obtain a CDW permit for the discharge of this water to State waters or to the ground.

8. At least 15 days before commencing dredging or fill operations in a watercourse, the Contractor shall provide written notification to owners or operators of domestic or public water supply intakes or diversion facilities, if these facilities are within 20 miles downstream from the dredging or fill operations. Notification shall also be given to

Owners or operators of other intakes or diversions that are located within five miles downstream from the site of the project. Identities of downstream owners and operators can be obtained from Colorado Division of Water Resources, Office of the State Engineer.

9. Temporary fill into wetlands or streams will not be allowed, except as specified in the Contract and permits. If such work is allowed, upon completion of the work all temporary fills shall be removed in their entirety and disposed of in an upland location outside of flood plains unless otherwise specified in the Contract.
10. Construction operations in waters of the United States as defined in 33 CFR Part 328.3, including wetlands, shall be restricted to areas and activities authorized by the U.S. Army Corps of Engineers as shown in the Contract. Fording waters will be allowed only as authorized by the U.S. Army Corps of Engineers 404 Permit.
11. Wetland areas outside of the permitted limits of disturbance shall not be used for storage, parking, waste disposal, access, borrow material, or any other construction support activity.
12. Pollutant byproducts of highway construction, such as concrete, asphalt, solids, sludges, pollutants removed in the course of treatment of wastewater, excavation or excess fill material, and material from sediment traps shall be handled, stockpiled, and disposed of in a manner that prevents entry into State waters, including wetlands. Removal of concrete waste and washout water from mixer trucks, concrete finishing tools, concrete saw, and all concrete material removed in the course of construction operations or cleaning shall be performed in a manner that prevents waste material from entering State waters and shall not leave the site as surface runoff. A minimum of 10 days before the start of the construction activity, the Contractor shall submit in writing a Method Statement for Containing Pollutant Byproducts to the Engineer for approval.

    The use of chemicals such as soil stabilizers, dust palliatives, herbicides, growth inhibitors, fertilizers, deicing salts, etc., shall be per the manufacturer's recommended application rates, frequency, and instructions.
13. All materials stored on-site shall be stored in a neat, orderly manner, in their original containers, with the original manufacturer's label. Materials shall not be stored in a location where they may be carried into State waters at any time.
14. Spill prevention and containment measures conforming to subsection 208.06 shall be used at storage, and equipment fueling and servicing areas to prevent the pollution of any State waters, including wetlands. All spills shall be cleaned up immediately after discovery or contained until appropriate cleanup methods can be employed. Manufacturer's recommended methods for spill cleanup shall be followed, along with proper disposal methods. When required by the Colorado Water Quality Control Act, Regulation 5 CCR 1002-61, spills shall be reported to the Engineer and CDPHE in writing.
15. The Contractor shall prevent construction activities from causing grass or brush fires.
16. The construction activities shall not impair Indian tribal rights, including, but not limited to, water rights, and treaty fishing and hunting rights.
17. Before start of work, the Contractor shall certify in writing to the Engineer that construction equipment has been cleaned before initial site arrival. Vehicles and equipment shall be free of soil and debris capable of transporting noxious weed seeds or invasive species onto the site. Additional equipment required for construction shall also be certified before being brought onto the project site.

18. Vehicles that have been certified by the Contractor as having been cleaned before arrival on site may be cleaned on site at an approved area where wash water can be properly contained. Vehicles leaving and reentering the project site shall be recertified.
19. At the end of each day, the Contractor shall collect all trash and dispose of it in appropriate containers.
20. Construction waste that is considered a pollutant or contaminant shall be collected and disposed of in appropriate containers. This material may be stockpiled on the project when it is contained or protected by an appropriate control measure.
21. If the project area is covered by a CDPS-SCP, permittees are authorized to discharge stormwater associated with construction activity and specified non-stormwater associated with construction activity to State waters.

    A. Allowable Stormwater Discharges:

        (1) Stormwater discharges associated with construction activity.

        (2) Stormwater discharges associated with producing earthen materials, such as soils, sand, and gravel dedicated to providing material to a single contiguous site, or within 1/4 mile of a construction site (i.e., borrow or fill areas).

        (3) Stormwater discharges associated with dedicated asphalt, concrete batch plants and masonry mixing stations. (Coverage under the CDPS-SCP is not required if alternative coverage has been obtained.)

        (4) Discharges resulting from emergency firefighting activities.

    B. Allowable Non-Stormwater Discharges if identified in the SWMP with appropriate control measures:

        (1) Discharges from uncontaminated springs that do not originate from an area of land disturbance.

        (2) Discharges to the ground of concrete washout water associated with the washing of concrete tools and concrete mixer chutes. Discharges of concrete washout water shall not leave the site as surface runoff or reach receiving waters.
        (3) Discharges of landscape irrigation return flow.

        Discharges authorized by the CDPS-SCP shall not cause, have the reasonable potential to cause, or measurably contribute to an exceedance of any applicable water quality standard, including narrative standards for water quality.

        All construction site wastes shall be properly managed to prevent potential pollution of State waters. The CDPS-SCP does not authorize on-site waste disposal.

(c) Stormwater Construction Permit. A Colorado Discharge Permit System Stormwater Construction Permit (CDPS-SCP) will be obtained from CDPHE by CDOT. The Contractor and CDOT will be co-permittees. The Contractor shall coordinate with CDOT to become

the Operator permittee of the respective permit upon award of the Contract. The Contractor shall provide a copy of permit certification as the Operator to the Engineer before or at the Pre-construction Conference. No work shall begin until the CDPS-SCP permit with Owner and Operator has been approved by CDPHE. A copy of the permit shall be placed in the project SWMP.

The Contractor is legally required to obtain all other permits associated with specific activities within or outside of the right of way, such as borrow pits, concrete or asphalt plant sites, waste disposal sites, or other facilities. Staging areas within a quarter mile, but not within CDOT right of way shall be considered a common plan of development and permits for these facilities require permitting in the Contractor's name as Owner and Operator. These permits include local agency, federal, or other stormwater permits. The Contractor shall consult with the Engineer and contact the CDPHE or other appropriate federal, state, or local agency to determine the need for any permit.

When a Utility Company has obtained a CDPS-SCP within a CDOT project area, before the Contractor being on-site, the Contractor shall coordinate with the Engineer and the Utility Company to transfer or reassign the permit area within the project's Limits of Construction to the Contractor and CDOT before work commencing. The Contractor shall not commence construction until CDPHE issues a new CDPS-SCP identifying the Contractor as the Operator, and the permit is put in the SWMP.

To initiate acceptance of the stormwater construction work (including seeding and planting required for erosion control), the Contractor shall request in writing a Stormwater Completion Walkthrough. The Engineer will set up the walkthrough. It will include the Engineer or designated representative, Superintendent or designated representative, Stormwater Management Plan (SWMP) Administrator, Region Water Pollution Control Manager (RWPCM), Landscape Architect, and a Regional Maintenance representative. Unsatisfactory and incomplete stormwater and sediment/erosion control work will be identified in this walkthrough and will be summarized by the Engineer in a punch list.

The completed action items associated with the corrective work will be shown as completed on the punch list. Upon completion of all items shown, the Contractor shall notify the Engineer. Upon written agreement that the punch list is completed from the Engineer, the Contractor shall submit the appropriate form to the CDPHE such that CDOT Maintenance becomes the Operator permittee of the CDPS-SCP.

Until the transfer of the permit has been approved by the CDPHE, the Contractor shall continue to adhere to all permit requirements. Requirements shall include erosion control inspections, control measure installation, control measure maintenance, control measure repair including seeded areas, and temporary control measure removal. All documentation shall be submitted to the Engineer and placed in the SWMP.

All costs associated with the Contractor applying for, holding, and transferring the CDPS-SCP permit between parties will not be measured and paid for separately, but shall be included in the work per subsection 107.02.

(d) Measurement and Payment.

1. All the work listed in (b) above, including but not limited to dewatering, erosion control for dewatering, and disposal of water resulting from dewatering operations, including all costs for CDPHE concurrences and permits, will not be measured and paid for separately, but shall be included in the work.
2. The Contractor shall be liable for any penalty (including monetary fines) applied to the Department caused by the Contractor's noncompliance with any water quality permit or

certification. Monetary fines shall be deducted from any money due to the Contractor. If the monetary fine is in excess of all the money due to the Contractor, then the Contractor shall pay to the Department the amount of such excess.

3. The Contractor will not receive additional compensation, or time extensions, for any disruption of work or loss of time caused by any actions brought against the Contractor for failure to comply with good Engineering, hydrologic and pollution control practices.
4. If a spill occurs as a direct result of the Contractor's actions or negligence, the cleanup of such spill shall be performed by the Contractor at the Contractor's expense.
5. Areas exposed to erosion by fire resulting from the Contractor's operations shall be stabilized per Section 208 by the Contractor and at the Contractor's expense.

SECTION 108

PROSECUTION AND PROGRESS

108.01 Subletting of Contract. The Contractor shall not sublet, sell, transfer, assign, or dispose of the Contract or Contracts, or any portion thereof without written permission of the Engineer. Before beginning any work by the subcontractor, the Contractor shall request permission from the Engineer by submitting a completed Sublet Permit Application, CDOT Form. 205, via the B2GNow software system. The subcontracted work shall not begin until the Contractor has received the Engineer's written permission. The Contractor shall make all project-related written subcontracts, agreements, and purchase orders available to the Engineer for viewing, upon request, and at a location convenient to the Engineer.

The Contractor will be permitted to sublet a portion of the Contract. However, the Contractor's organization shall perform work amounting to 30 percent or more of the total original contract amount. Any items designated in the Contract as "specialty items" may be performed by subcontract. The cost of "specialty items" so performed by subcontract may be deducted from the total original contract amount before computing the amount of work required to be performed by the Contractor's own organization. The original contract amount includes the cost of material and manufactured products that are to be purchased or produced by the Contractor and the actual agreement amounts between the Contractor and a subcontractor. The proportional value of a subcontracted partial contract item will be verified by the Engineer. When a firm both sells material to a prime contractor and performs the work of incorporating the materials into the project, these two phases shall be considered in combination and as constituting a single subcontract.

The calculation of the percentage of subcontracted work shall be based on subcontract unit prices.

Subcontracts or transfer of Contract shall not release the Contractor of liability under the Contract and Bond.

Failure to comply with all contractual obligations may lead to the suspension, debarment, or both of the subcontractor, and if necessary, the Contractor as stipulated in the "Rules".

All firms that the contractor will be subletting a portion of the contract shall have an account created in the B2GNow software system. If the firm does not have an account created approval of the form 205 may be withheld.

108.02 Notice to Proceed. The Contractor shall not commence work before the issuance of a Notice to Proceed. The "Notice to Proceed" will stipulate the date that contract time commences. When the Contractor proceeds with work before that date, contract time will commence on the date work actually begins. The Contractor shall commence work under the Contract on or before the 15th day following Contract execution or the 30th day following the date of award, whichever comes later, or per the selected start date allowed in the special provisions.

108.03 Project Schedule.

(a) Definitions.

Activity (Task). A portion of the project that requires time or resources to complete. An activity has a description, start date, finish date, duration, and one or more logic ties. A critical activity is an activity on the critical path.

Activity ID. A unique, alphanumeric, identification code assigned to an activity that remains constant throughout the project.

Baseline Schedule. The original, approved project schedule before the project begins with no progress.

Calendar. Defined work periods and no work periods that determine when project activities can occur. Multiple calendars may be used.

Constraint. A restriction imposed in a schedule, which fixes a value that would otherwise be calculated within the schedule. Examples of values that can be fixed by a constraint include start date, end date, and completion date.

Critical Path Method (CPM) Scheduling. CPM Scheduling is a logic-based planning technique using activity durations and relationships between activities to calculate a schedule determining the minimum total project duration and the interdependencies of all activities.

Critical Path. The longest logical path through the CPM network driven by calendars, constraints, and activity logic. It consists of activities that determine the shortest time for project completion and the sequence of activities such that a delay to any of the activities on the critical path will prolong contractual project milestones, such as project completion.

Data Date. The starting point from which to schedule all remaining work. It can also be considered the cut-off date wherein all work before this date has actual starts, actual finishes, or both.

Duration. The estimated amount of time needed to complete an activity.

Free Float (Free Slack). The amount of time an activity can be delayed without delaying the Early Start or Early Finish of its successor activity or activities.

Gantt Chart. A time-scaled graphical display of the project's schedule.

Lag. A time-value assigned to a relationship.

Logic. Relationships between activities defining the sequence of work (See also predecessor activity and successor activity).

Milestone. An activity, with zero duration used to represent an event.

Near Critical Activity. An activity with a total float of five days or fewer, or as defined by the Engineer.

Open-Ended Activity. An activity that does not have a predecessor activity and a successor activity, or only has a start-to-start as a predecessor or finish-to-finish as a successor.

Planned Completion Date. The date that the schedule shows work is planned to be completed.

Predecessor Activity. An activity that is defined by schedule logic to precede another activity.

Relationship. The interdependence between activities.

Successor Activity. An activity that is defined by schedule logic to follow another activity.

Time-Scaled Logic Diagram. Gantt chart that illustrates logic links depicting both schedule logic and the time that activities are performed.

Total Float (Total Slack). The amount of time between the earliest date an activity can start and the latest date when an activity must start, or the earliest date an activity can finish and latest date when an activity can finish before the activity causes a delay to the time specified in the *Commencement and Completion of Work* special provision.

(b) Project Schedule - General

The Contractor shall use either Microsoft Project or Primavera Scheduling software to develop and manage a CPM Project Schedule to plan, schedule, and report the progress of the work. Before, or at the Pre-construction Conference, the Contractor shall notify the Engineer in writing, the scheduling software the Contractor shall use to manage the project. The Contractor's selection and use of particular scheduling software cannot be changed after the first schedule submittal. If the Contractor selects Primavera, the Contractor shall calculate the schedule using the Retained Logic scheduling option.

The Contractor shall submit schedules for approval by the Engineer. The Contractor's schedule shall be an accurate plan to complete the work so that the Department can use the schedule to evaluate progress, schedule CDOT resources, inform the project stakeholders, and evaluate the effect of changes to the schedule. A schedule review meeting shall be held to discuss each schedule submittal.

The Contractor shall submit a monthly update as either a Project Schedule Update or Revised Schedule as determined by the Engineer. When the project has a maintenance or landscape establishment period, the Engineer may waive the monthly update requirement during that period. The Contractor shall submit a final update that shows all work through the final acceptance date.

The Engineer will not issue a monthly progress payment if the Engineer has not received an update. The Engineer may not make monthly progress payments for the months following the update submission until the Engineer either approves or approves-as-noted the Project Schedule Update or Revised Schedule.

The Contractor shall use activity descriptions that ensure the work is easily identifiable. Activity description shall start with an action verb when practicable to clearly communicate what is being performed. The Contractor shall show the no-workdays in the schedule calendars. The contract completion date shall be included as an activity.

The Contractor shall use durations for individual construction activities that do not exceed 15 days of work unless approved by the Engineer. The Contractor may group a series of activities with an aggregate duration of five workdays or less into a single activity. Non-construction activities may have durations exceeding 15 days of work, as approved by the Engineer.

The Contractor may include summary bars in the schedule as long as the detailed activities to complete the work are displayed.

The Contractor shall not use the following unless approved by the Engineer:

(1) Negative lags.

(2) Lags in excess of 10 workdays.

(3) Start-to-finish relationships.

(4) Open-ended activities.

(5) Constraints.

The Project Schedule shall show all activities required by all parties to complete the work. The Contractor, its subcontractors, suppliers, and engineers, at any tier, shall perform the work according to the approved Project Schedule.

Float within the Baseline Schedule or any other Project Schedule is not for the exclusive use or benefit of either party but is a project resource available to both parties as needed until it is depleted.

The Engineer's review of the schedule will not exceed 10 days. The Engineer will provide the Contractor with one of the following responses within 10 days after receipt of the Project Schedule:

(1) Approved, no exceptions taken.

(2) Approved-as-Noted; or

(3) Revise and Resubmit within 10 days.

Approval of the Project Schedule shall not relieve the Contractor of any contract requirement including the requirement to complete all work within the Contract Time. Contractual requirements shall not change by submission or approval of a schedule, unless specifically amended by a Change Order.

(c) Schedule Submittals. The Contractor shall include a time-scaled logic diagram with all schedule submittals that:

1. Is plotted on a horizontal timescale per the project calendar.
2. Uses color to clearly identify the critical path.
3. Is based on early start and early finish dates of activities.
4. For Project Schedule Updates and Revised Schedules, shows actual completion dates up to but not including the data date.
5. Clearly shows the sequence and relationships of all activities necessary to complete the contract work.
6. Includes an activity block for each activity with the following information:

TABLE 108-1

DETAILS OF AN ACTIVITY BLOCK

Activity ID	Activity Description	Original Duration
Total Float	Early start date	Early finish date
Late start date *	Late finish date *	Actual Start date ^
Actual Finish date ^	Calendar used on the activity	Activity Responsibility#
Remaining Duration ^	Duration Percent Complete ^	Gantt chart

Table 108-1 Notes: * Required with the Preliminary and Baseline Schedule.

^ Required with the Project Schedule Update and Revised Schedule.

Specify subcontractors, vendors, and all stakeholders.

The Contractor shall include the following with all schedule submittals:

A. A Job Progress Narrative Report that includes the following:

(1) Baseline, Preliminary, and Revised Schedules:

(i) A narrative of the critical and near critical work activities. This narrative shall include real or perceived risks and assumptions, including production

rates. Particular emphasis shall be made on activities that are the Contractor's and Department's responsibilities, third party activities, or long lead procurement items.

(ii) A narrative, including attachments if appropriate, of all of the project's calendars. This narrative shall explain work and non-work periods as well as special weather dependent calendars. A list of the calendars used in the schedule, a description of each calendar's work and non-workdays, a list of the activities using each calendar, and an explanation of how the calendar applies to that work.

(iii) A narrative of planned work on night shifts or planned work that will require approval from the Department or other agencies.

(iv) A list of all added and deleted activities along with a brief explanation for the change.

(v) All logic and duration changes to any activity along with an explanation for changes to any critical and near critical activities.

(vi) A description of site mobilization (such as dates of expected material shipments, planned dates for equipment arrivals, office setup, material laboratory arrival and setup, and anticipated portable crusher or batch plant setup).

(vii) A list of the fabrication and delivery of key and long-lead procurement activities.

(2) Project Schedule Update:

(i) A description of the work performed since the previous month's schedule update.

(ii) A description of changes to any items in the baseline, preliminary, and revised schedules.

(iii) A description of problems encountered or anticipated since the previous month's schedule submission.

(iv) A description of unusual labor, shift, equipment, or material conditions or restrictions encountered or anticipated.

(v) The status of all pending items that could affect the schedule.

(vi) Explanations for milestones forecasted to occur late.

(vii) Scheduled completion date status and any change from the previous month's submission.

(viii) An explanation for a scheduled completion date forecasted to occur before or after the contract completion date or contract time.

(ix) Schedule Delays:

(a) A description of current and anticipated delays including identification of the delayed activity or activities by Activity ID(s) and description(s).

(b) Effect of the delay on other activities, milestones, and completion dates.

(c) Identification of the actions needed to avoid a potential or mitigate an actual delay.

(d) A description of the critical path impact and effect on the scheduled completion date in the previous month's schedule update.

(x) An explanation of any critical and near critical work that is not progressing

as planned.

(xi) A list of all added and deleted activities along with a brief explanation for the change.

(xii) Any logic and duration changes to a critical or near critical activity along with an explanation for the change.

(xiii) For working day contracts, a list of planned non-working days with actual work.

B. A Predecessor Activity and Successor Activity report that defines all schedule logic and clearly indicates all logical relationships and constraints.

C. An Early Start report listing all activities, sorted by actual start/early start date.

D. A Float report listing all activities sorted in ascending order of available float.

E. A Critical Path report listing all activities not yet complete with the percent complete, sorted by float and then by early start.

F. A listing of all non-workdays.

For all required schedule submittals, the Contractor shall submit two USB flash drives or other media as directed by the Engineer with electronic copies of the schedule submittals. Electronic copies of the CPM schedules shall be submitted both in the native file format and in Portable Document Format (PDF).

Each schedule submittal shall be appropriately labeled as a Preliminary Schedule, Baseline Schedule, Project Schedule Update, or Revised Schedule. The title bar shall include the CDOT project number, subaccount, project name, Contractor name, and schedule data date. If an originally submitted schedule is revised during review, the title bar shall also include a revision number (REV1, REV2, etc.) revision date, and submission date.

(d) Preliminary Schedule. Within 14 days of Award of the Contract, the Contractor may submit a Preliminary Schedule showing all planned activities from the Notice to Proceed through the first 60 days of the project. If the Contractor elects not to submit a Preliminary Schedule, then the Contractor shall submit a complete Baseline Schedule within 14 days of award of the Contract, which will be subject to all requirements of a Baseline submittal. The Preliminary Schedule shall not show any progress and it will be approved by the Engineer before work can commence. The Preliminary Schedule shall be used as the basis for the Baseline Schedule.

(e) Baseline Schedule. If the Contractor elects to submit a Preliminary Schedule, within 45 days of the award of Contract, the Contractor shall submit a Baseline Schedule that includes all work activities completed within Contract Time. The Contractor shall not show progress in the Baseline Schedule. Further partial payments will not be made beyond 60 days after the start of Contract Time unless the Baseline Schedule is approved. When approved, the Baseline Schedule shall become the Project Schedule. The Contractor shall use all information known by the Contractor at the time of bid submittal to develop the Baseline Schedule. If the Contractor elects to submit a Baseline Schedule in lieu of a Preliminary Schedule, the Baseline Schedule shall be approved before work can commence.

(f) Project Schedule Update. The Contractor shall submit a monthly update of the Project Schedule updated through the cut-off date for the monthly progress pay estimate, and a projection for completing all remaining activities. A schedule update may show a

completion date that is different than the Contract completion date. Approval of this schedule shall not relieve the Contractor of its obligation to complete the work within the Contract Time. When approved, the Project Schedule Update will become the Project Schedule.

(g) Weekly Planning Schedule. The Contractor shall submit, in writing, a Weekly Planning Schedule that shows the Contractor's and all Subcontractor's planned activities for a minimum of two weeks immediately following the date of submittal and actual days worked versus planned for the week before the date of submittal. This schedule shall include the description, duration and sequence of work activities and anticipated lane closures for the upcoming two weeks. The Weekly Planning Schedule shall be based on the Project Schedule and may be a time-scaled logic diagram or other standard format as approved by the Engineer. Schedule Submittal requirements for reports do not apply to the Weekly Planning Schedule.

(h) Revised Schedule. A Revised Schedule is required in the event of any major change to the work. Examples of major changes are:

(1) Significant changes in logic or methods of construction or changes to the critical path.

(2) Addition, deletion, or revision of activities required by Contract Modification Order.

(3) Approval of a Contractor submitted Value Engineering Change Proposal.

(4) Delays in milestones or project completion.

(5) Phasing revisions.

(6) When the Engineer determines that the schedule has a fatal flaw; or

(7) When the work cannot be constructed as scheduled.

The Contractor shall provide a Revised Schedule within 10 days of the Engineer's written notification and shall include the diagrams and reports as described in subsections 108.03(b) and 108.03(c). Once approved, the Revised Schedule becomes the Project Schedule.

(i) Payment. All costs relating to the requirements of this subsection will not be paid for separately but shall be included in the work.

108.04 Payment Schedule. The Contractor shall prepare a payment schedule that shall show the dollar amount of work the Contractor expects to complete, including Force Accounts, retainage and expected incentive payments, by the progress estimate date each month for the duration of construction. The payment schedule shall be signed by the Contractor's authorized agent. The payment schedule shall show the dollar amount of work the Contractor expects to complete for every month on the Contract from commencement of work to Project Acceptance. The fiscal year (July 1 to June 30) totals shall also be shown on the payment schedule. The payment schedule may be prepared using standard spreadsheet software such as MS Excel and submitted in electronic format.

(a) Initial Payment Schedule. The Contractor shall submit the certified initial payment schedule within 15 days of the award of the Contract.

(b) Payment Schedule Updates. Once each month the Contractor shall submit an update to the Engineer. The update shall be in the same format as the initial payment schedule and shall be submitted to the Engineer by the first day of each month. In each update, estimated monthly dollar amounts shall be revised to show the dollar amount for actual work accomplished that includes actual progress payments made to the Contractor to date and

work accomplished but not paid. Each update shall show corrected dollar amounts of work to be completed each month through the Specified Completion Date as shown on the Contractor's Project Schedule Update.

If the update has any State Fiscal Year (July 1 to June 30) payment in excess of the encumbrance amount, the Department may, in its sole discretion, approve the update. If the Department does not approve the update the Contractor shall either revise the payment schedule or proceed at his own risk. The risk is either not being paid in a timely manner, or not being paid at all for any amounts over the encumbrance amount. If the Contractor proceeds at his own risk, then payment for the at-risk work will be dependent upon ratification of this work by the State Controller's Office.

If the update exceeds the encumbrance amount because of additional compensable work, and the Department does not approve this update, any delay to critical path work related to this additional compensable work will be considered excusable and compensable per subsection 108.08(c), if the Contractor does not proceed at his own risk.

If the update exceeds the encumbrance amount because of the Contractor's accelerated schedule, and the Department does not approve the update, the delay for not performing the work associated with the Contractor's accelerated schedule in the scheduled Fiscal Year will be noncompensable per subsection 108.08(c), if the Contractor does not proceed at his own risk.

(c) *Failure to Submit Payment Schedule*. If the Contractor fails to submit the initial payment schedule, the Contract will not be executed. If a payment schedule update is not submitted by the required date, the Engineer will withhold progress payments until such time as the Contractor has submitted a current payment schedule.

108.05 Limitation of Operations. The Contractor shall conduct the work in a manner and sequence to assure the least interference with traffic. The Contractor shall not open up work to the prejudice or detriment of work already started. The Engineer may require the Contractor to finish a section of work before starting any additional sections if the opening of a section is essential to public convenience.

108.06 Character of Workers; Methods and Equipment. The Contractor shall employ resources for completing work to full completion in the manner and time required by the Contract.

All workers shall have skill and experience to perform the work assigned to them.

Any person employed by the Contractor or by any subcontractor who does not perform the work in a proper and skillful manner shall, at the written request of the Engineer, be removed by the Contractor or subcontractor and shall not be employed on the project without the approval of the Engineer.

Should the Contractor fail to remove this person or persons or fail to furnish skilled and experienced personnel for the proper prosecution of the work, the Engineer may suspend the work by written notice until compliance is achieved.

All equipment used on the project shall be of size and mechanical condition to meet requirements of the work and to produce a satisfactory quality of work. Equipment used shall not cause injury to the roadway, adjacent property, or other highways.

When the methods and equipment to be used are not prescribed in the Contract, the Contractor shall use any methods or equipment that will accomplish the contract work in

conformity with the contract requirements.

When the methods and equipment to be used are specified in the Contract, other methods and equipment shall not be used in the performance of the work unless the Contractor receives written authorization from the Engineer.

If the Contractor desires to use a method or equipment other than specified in the Contract, the Contractor may request approval from the Engineer. The request shall include a full description of the methods and equipment proposed to be used and the Contractor's explanation for the proposed change. The Contractor will be fully responsible for producing work in conformity with contract requirements. If the substituted methods or equipment do not produce results conforming to contract requirements, the Contractor shall complete the remaining construction with the originally specified methods and equipment. Deficient work shall be removed, repaired, or replaced to conform with the specified quality by and at the Contractor's expense. No increase will be made in the basis of payment for the construction items involved nor in contract time when a change in methods or equipment is authorized.

108.07 Workplace Violence. If a representative or employee of the Contractor, or a subcontractor, commits an act of workplace violence on the project, they shall be sanctioned as provided by the Contractor's employment policies and, where appropriate, shall be reported to law enforcement authorities. At the request of either the Contractor or the Engineer, the Engineer and the Contractor shall meet to discuss appropriate actions to be taken against the representative or employee. Appropriate action may include removing the representative or employee from the project. If removal is warranted and the Contractor fails to remove the representative or employee, the Engineer may suspend the work by written notice until compliance is achieved.

108.08 Determination and Extension of Contract Time. The contract time is stated in the Commencement and Completion of Work special provision. The contract time will be used to determine the contract completion date.

The Contractor shall not perform construction operations on Saturdays, Sundays, or holidays unless previously arranged and approved. The Contractor shall not perform work on any day of a three-day holiday weekend when the holiday is New Year's Day, Memorial Day, Independence Day, Labor Day, or Christmas Day. The Contractor shall not perform work on any day of a four-day holiday weekend when the holiday is Thanksgiving Day. Construction operations shall stop at 12 P.M. the day before the start of the holiday weekend and shall commence the day after the three or four days have passed. When the holiday is New Year's Day, Independence Day, or Christmas Day and falls on a Tuesday, Wednesday, or Thursday, construction operations shall stop at 12 P.M. the day before the holiday and shall commence the next Working Day. The Contractor shall only make emergency repairs and provide proper protection of the work and traveling public on these days.

(a) Time Count Contract. When the contract time is on a working day or calendar day basis, the Engineer will furnish the Contractor a weekly statement showing the number of days assessed for the preceding week and the number of days remaining for completion of the Contract. If the Contractor is in disagreement with the current weekly statement, the Contractor shall submit a request for review of the current weekly statement. Such request shall be made within 30 calendar days of the receipt of the statement and shall detail the reasons the statement is believed to be incorrect.

When final acceptance has been made by the Engineer as prescribed in subsection 105.21, the daily time charges will cease on working day and calendar day projects.

1. *Working Day Contract*. When the work is on a working day basis, one whole day of contract time will be assessed for each working day that the work can be effectively prosecuted during six hours or more of the day. One-half day will be assessed for each working day that the work can be effectively prosecuted for at least two hours but less than six hours of the day. Contract time will not be assessed when the work can be effectively prosecuted for less than two hours. Saturdays, Sundays, and holidays will be assessed as workdays when the Contractor utilizes such days for prosecuting the work.
2. *Calendar Day Contract*. When the work is on a calendar day basis, one calendar day of contract time will be assessed for each calendar day from the date that Contract time starts including Saturdays, Sundays, and holidays. Less than full time charges may be made on those days when conditions, which are beyond the control of and unknown to the Contractor, make it impossible to prosecute the work on items controlling the completion of the work with full, normal efficiency. Less than full time charges may be allowed for inclement weather only when the Engineer directs the Contractor not to work for the safety of the traveling public. When less than full time charges are to be assessed, the following procedures will be followed: One whole day of contract time will be assessed for each calendar day that the work is prosecuted during six hours or more of the Contractor's daily working schedule; one-half day will be assessed for each calendar day that the work is prosecuted for at least two hours but less than six hours of the day; contract time will not be assessed when the work is prosecuted for less than two hours.

(b) Completion Date Contract. When the Contract specifies a completion date, all work under the Contract shall be completed on or before that date. No extension of the completion date will be allowed for inclement weather, foreseeable causes, or conditions under the control of the Contractor.

If all work under the Contract is not completed on or before the specified completion date, contract time will be assessed for each additional calendar day per subsection 108.08(a)2.

(c) Delay. Any event, action or factor that extends the performance period of the Contract.

1. Excusable Delay: A delay that was beyond the Contractor's control and was not due to the Contractor's fault or negligence. The Department may grant a contract time extension for an excusable delay.
   A. Compensable Delay: A delay that the Department, not the Contractor, is responsible for entitling the Contractor to a time extension and monetary compensation. Monetary compensation for compensable delays will be made per subsection 109.10.
   B. Noncompensable Delay: An excusable delay that neither the Contractor nor the Department is responsible for that may entitle the Contractor to a contract time extension but no additional monetary compensation. Contract time allowed for the performance of the work may be extended for delays due to force majeure (acts of God, acts of the public enemy, terrorist acts, fires, floods, area wide strikes, embargoes, or unusually severe weather).
2. Nonexcusable Delay: A delay that was reasonably foreseeable or within the control of the Contractor that the Department will not grant monetary compensation or a contract time extension.

3. Concurrent Delay. Independent delays to critical activities occurring at the same time.

   A. The Department will not grant a time extension or additional compensation for the period of time that a nonexcusable delay is concurrent with an excusable delay.

   B. The Department may grant time but no compensation for the period of time that a noncompensable delay is concurrent with a compensable delay.

   Delays in delivery of materials or fabrication scheduling resulting from late ordering, financial considerations, or other causes that could have been foreseen or prevented will be considered nonexcusable delays. However, delays caused by fuel shortage or delay in delivery of materials to the Contractor due to some unusual market condition caused by industry-wide strike, national disaster, area-wide shortage, or other reasons beyond the control of the Contractor that prevent procurement of materials or fuel within the allowable contract time limits will be considered excusable delays.

(d) Extension of Contract Time. The Contractor shall orally notify the Engineer as soon as the Contractor recognizes a potential project delay. The Contractor or Engineer shall document the discussion in writing. This discussion and documentation are not considered an official notice of a delay.

The Contractor shall provide a written notice of delay within seven days of determining the need for additional contract time. The notice of delay shall describe the nature and specific cause of the delay. Failure to submit the written notice of delay within seven days constitutes a waiver of entitlement to additional time or compensation.

The Contractor shall submit the time extension request and supporting analysis within 30 days of the written delay notice. The request shall include a schedule analysis with all information needed to support the time extension request pursuant to one of the following methods including an explanation for selecting that method:

(1) Time Impact Analysis (TIA) for all forward-looking analyses of time impacts following the guideline AACE® International Recommended Practice No. 52R-06 Prospective Time Impact Analysis – As Applied in Construction.

(2) Forensic Schedule Analysis for all time impacts absorbed into the schedule following the AACE® International Recommended Practice 29R-03 Forensic Schedule Analysis.

(3) Other acceptable method of schedule analysis, as approved by the Engineer.

The analyses shall show a delay to the critical path in order to obtain a contract time extension. The Contractor shall demonstrate that efforts were made to avoid the delay by resequencing the work or by using other reasonable alternatives. Failure to submit the documentation to support the time extension request within 30 days of the Contractor's written notice of delay constitutes a waiver of entitlement to additional time or compensation. The Engineer's review of the time extension request will not exceed 15 days.

The schedule included in the request shall be per subsection 108.03(c). The Engineer will base a determination of an allowable contract time extension on the current "Approved, no exceptions taken" or "Approved-as-Noted" Project Schedule that shall have a data date within 30 days before the alleged delay, the supporting documentation and schedule analysis submitted by the Contractor, and any additional relevant information available.

The Contractor's assertion that insufficient contract time was specified is not a valid reason for an extension of contract time. Adding activities to or changing logic on a Project Schedule Update shall not constitute supporting documentation of a delay request justification. The Contractor shall submit a justification for determination of a contract time extension separately from the Project Schedule Update. Approval of a Project Schedule Update or Revised Schedule will not constitute approval of a contract time extension. When the Engineer grants a contract time extension, the revised Contract Completion date will be in effect as though it were the original contract date. The Contractor's failure to have an "Approved" or "Approved-as-Noted" current project schedule in place will preclude the Department from approving a Contractor's time extension request.

108.09 Failure to Complete Work on Time. A daily charge will be made against the Contractor for each calendar day, including free time, that any work remains uncompleted after the elapse of contract time. This daily charge will be deducted from any money due the Contractor. This deduction will not be considered a penalty, but as liquidated damages.

The schedule of liquidated damages set forth below is an amount, agreed to by the Contractor and the Department, as reasonably representing additional construction engineering costs incurred by the Department if the Contractor fails to complete performance within the contract time.

Table 108-2
LIQUIDATED DAMAGES

Original Contract Amount ($); from more than, to, and including	Liquidated Damages per Calendar Day ($)
0 -1,000,000	1,400
1,000,000 – 2,000,000	2,500
2,000,000 – 6,000,000	4,500
6,000,000 – 9,000,000	8,000
9,000,000 – 20,000,000	8,800
Above 20,000,000	12,500

Due account shall be taken of any adjustment of the contract time for completion of the work granted under the provisions of subsection 108.08.

Permitting the Contractor to continue and finish the work or any part thereof after elapse of contract time will not operate as a waiver on the part of the Department of any of its rights under the Contract.

Deductions assessed as liquidated damages under this subsection shall not relieve the Contractor from liability for any damages or costs resulting from delays to other contractors on the project or other projects caused by a failure of the assessed Contractor to complete the work according to contract times.

108.10 Default of Contract.

(a) The Engineer may send a written notice of intent to find the Contractor in default to the Contractor and the Surety by certified mail for any of the reasons listed below.

The notice will describe the conditions causing the impending default, advise them of the actions required for remedy, and state that if the conditions have not been corrected within 10 days of receipt of the notice, CDOT will find the Contractor in default.

The Department may send a written notice of intent under this part (a) if the Contractor:

(1) Fails to begin the Contract work within the time specified to begin work, or

(2) Fails to perform the Contract work with sufficient resources to assure its timely completion, or

(3) Discontinues the Contract work, or

(4) Fails to resume discontinued Contract work, or

(5) Becomes insolvent, is declared bankrupt, commits an act of bankruptcy or insolvency, allows a final judgment to remain unsatisfied for a period of 10 calendar days, makes an assignment for the benefit of creditors, or

(6) Fails to comply with the Contract regarding minimum wage payments, Disadvantage Business Enterprise (DBE) requirements, or Equal Employment Opportunity (EEO) requirements, or

(7) Is a party to fraud.

If the Contractor fails to correct the conditions identified in the notice of intent to find the Contractor in default within 10 calendar days of receipt, the Department may serve the Contractor with an immediate notice of default and take prosecution of the work from the Contractor. Copies of the default notice will also be sent, by certified mail, to the Contractor and the Surety.

(b) The Engineer may send a written notice of intent to find the Contractor in default to the Contractor and the Surety by certified mail for the reason listed below. The notice will include a suspension of work, which will require the Contractor to cease work on the Contract Items that are unacceptable. The notice will describe the conditions causing the impending default, advise the Contractor of the actions required for remedy and state that if the conditions have not been corrected within 10 days of receipt of the notice, CDOT will find the Contractor in default.

The Department may send a written notice of intent under this part (b) if the Contractor fails to perform the work to Contract requirements or neglects or refuses to correct or remove and replace rejected materials or unacceptable work.

The Contractor shall not resume work on the unacceptable Contract Items until the following conditions have been met:

(1) The Contractor shall submit a written proposal to the Engineer outlining the procedures that will be followed by the Contractor to correct the unacceptable conditions, and

(2) The Engineer and the Contractor shall meet to discuss the written proposal; and

(3) The Engineer will issue written permission for the Contractor to commence work.

If the Contractor fails to meet these three conditions within 10 calendar days of receipt of the notice of intent to find the Contractor in default, or if at any time after the Contractor resumes work, the work does not meet Contract requirements or the Contractor again neglects or refuses to correct or remove and replace rejected materials or unacceptable work, the Department may serve the Contractor with an immediate notice of default and take prosecution of the work from the Contractor. Copies of the default notice will also be sent, by certified mail, to the Contractor and the Surety.

(c) In the case of default under either subsection 108.10(a) or 108.10(b):

(1) The Department will revoke the Contractor's Prequalification. If the Department chooses to rebid the remaining Contract work on this project, the Contractor will not be allowed to submit a bid for this work.

(2) The Department may appropriate or use materials at the project site and contract with others to complete the remaining Contract work.

(3) The Department will determine the methods used for completion of the Contract.

(4) Resulting costs and charges incurred by the Department will be deducted from payments owed the Contractor. If such costs exceed the payment owed the Contractor, the Contractor and Surety shall reimburse the Department for these costs. These costs and charges may include but are not limited to cost of Contract completion, including designing, advertising, bidding and awarding the remaining work and liquidated damages or disincentives.

(d) If the notice of default is determined to be in error, the rights and obligations of the parties shall be the same as if the Contract had been terminated per subsection 108.10. Damages for improper notice of default may be awarded accordingly.

108.11 Termination of Contract.

(a) Termination Notice. The Department may terminate work under the Contract in whole or in part if the Engineer determines that termination is in the Department's best interest. Contract termination will be initiated by the Engineer's written Contract Termination Notice to the Contractor. The notice will specify the effective date.

(b) Canceled Commitments. The Contractor, after receiving the Contract Termination Notice, shall cancel any outstanding commitments for procurement of materials, supplies, equipment, and miscellaneous items. In addition, the Contractor shall use reasonable effort to cancel or divert any outstanding subcontract commitments to the extent they relate to any work terminated. With respect to such canceled commitments the Contractor shall:

(1) Settle all outstanding liabilities and all claims arising out of these canceled commitments. Such settlements will be approved by the Engineer and shall be final; and

(2) Assign to the Department all of the rights, title and interest of the Contractor under the terminated orders and subcontracts, as directed. The Department will then have the right to settle or pay any or all claims arising out of the termination of these commitments.

(c) Termination Claim. The Contractor shall submit the termination claim to the Engineer within 90 days after the termination notice effective date. During the 90-day period, the Contractor may make a written request for a time extension in preparing the claim. Any time extension must be approved by the Engineer. If the Contractor fails to submit the termination claim within the time allowed, the Engineer may determine the amount due the Contractor by reason of the termination.

(d) Payment. Subject to subsection 108.11(c) above, the Contractor and Engineer may agree upon the whole or any part of the amount to be paid to the Contractor because of the termination. The amount may include reasonable cancellation charges incurred by the Contractor. The amount may also include any reasonable loss upon outstanding commitments for subcontracts that the Contractor is unable to cancel, provided the Contractor has made reasonable effort to divert the commitments to other activities.

The amount agreed upon shall be embodied in a Contract Modification Order and the Contractor shall be paid that amount.
Payments claimed and agreed to pursuant to termination shall be based on the Contract unit prices. Payment for partially completed lump sum items may be made in the proportion that the partially completed work is to the total lump sum item. Where work performed is of a nature that it is impossible to separate the costs of uncompleted work from completed units, the Contractor will be paid the actual cost incurred for the necessary preparatory work and other work accomplished.

The Department may from time to time, under terms and conditions it may prescribe, make partial payments against costs incurred by the Contractor in connection with the contract termination. The total of such payments shall not exceed the amount, as determined by the Engineer, the Contractor will be entitled to hereunder.

(e) Disposition of Work and Inventory. The Contractor shall transfer title and deliver to the Department, as directed, such items which, if the Contract had been completed, would have been furnished to the Department including:

(1) Completed and partially completed work; and

(2) Materials or equipment produced or in process or acquired in connection with the performance of the work terminated by the notice.

Other than the above, any termination inventory resulting from the contract termination may, with written approval of the Engineer, be sold or acquired by the Contractor under the conditions prescribed by and at prices approved by the Engineer. The proceeds of any such disposition shall be applied to reduce any payments to the Contractor under the Contract or shall otherwise be credited to the cost of work covered by the Contract or paid in a manner as directed. Until final disposition, the Contractor shall protect and preserve all the material related to the Contract that is in the Contractor's possession and that the Department has or may acquire an interest.

(f) Cost Records. The Contractor agrees to make cost records available to the extent necessary to determine the validity and amount of each item claimed.

(g) Contractual Responsibilities. Termination of a Contract or portion thereof shall not relieve the Contractor of contractual responsibilities for the work completed, nor shall it relieve the Surety of its obligation for and concerning any just claim arising out of the work performed.

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SECTION 109

MEASUREMENT AND PAYMENT

109.01 Measurement of Quantities. All work completed under the Contract will be measured by the Engineer according to United States standard measure (English units).

A station when used as a definition or term of measurement will be 100 linear feet.

The method of measurement and computations to be used in determination of quantities of material furnished and of work performed under the Contract will be those methods generally recognized as conforming to good engineering practice.

Unless otherwise specified, longitudinal measurements for area computations will be made horizontally, and deductions will not be made for individual structures having an area of 9 square feet or less. Unless otherwise specified, transverse measurements for area computations will be the neat dimensions shown on the plans or as ordered in writing by the Engineer.

Structures will be measured according to neat lines shown on the plans or as altered to fit field conditions.

Items that are measured by linear foot, such as pipe culverts, guardrail, underdrains, etc., will be measured parallel to the base or foundation that the structures are placed, unless otherwise shown on the plans.

In computing volumes of excavation and embankment, the average end area method or the method incorporated into the Department's computer earthwork program will be used.

The term "gauge," when used in connection with the measurement of plates, will mean the U.S. Standard gauge.

When the term "gauge" refers to the measurement of wire, it will mean the wire gauge specified in ASTM A510.

The term "ton" will mean the short ton consisting of 2,000 pounds avoirdupois.

Materials measured or proportioned by weight shall be weighed on accurate scales. Scales shall be accurate within the allowable tolerances as prescribed by State law. The scales shall be tested for accuracy by the Colorado Department of Agriculture or an approved Colorado Department of Agriculture vendor at least once each year, each time the scales are relocated, and as often as the Engineer may deem necessary. Scales shall be furnished by the Contractor, or the Contractor may utilize commercial scales.

Scales shall be operated according to the Colorado Department of Agriculture's regulations. Weighers, scales, scale tickets, scale house, and verification of the scales' accuracy will not be measured and paid for separately but shall be included in the work.

The Contractor may use either certified hopper scales or certified platform scales.

When platform scales are used to weigh vehicles carrying material paid for by weight, a certified weigher shall weigh each vehicle. Hopper scales used to directly measure material paid for by weight shall be operated by certified weighers and provide an accurate net weight.

The operator of each vehicle carrying material measured and paid for by weight shall obtain a scale ticket (certificate of correct weight) from the certified weigher and deliver the ticket to the Engineer at the point of delivery of the material.

The scale ticket shall include the following information:

(1) Project Number.

(2) Date.

(3) Ticket Number.

(4) Haul Unit Number.

(5) CDOT Form 43 Number (HMA and SMA Only)

(6) Plant Location

(7) Gross Weight.

(8) Tare Weight.

(9) Net Weight.

(10)Material Type.

(11)Certified Weigher's Name.

Vehicles used to haul material being paid for by weight shall bear a plainly legible identification mark. Each of these vehicles shall be weighed empty daily at times directed by the Engineer. The Contractor shall furnish to the Engineer, in writing, a vehicle identification sheet that lists the following for each delivery vehicle to be used on the project:

(1) Identification mark.

(2) Vehicle length.

(3) Tare weight.

(4) Number of axles.

(5) The distance between extreme axles.

(6) Information related to legal weight, including the Permit Number and permitted weight of each vehicle that the State has issued an overweight permit.

This information shall be furnished before time of delivery of the material and at any subsequent time the Contractor changes vehicles, combination vehicles, axle length relationships, or overweight permitting of vehicles.

Weighers using hopper scales solely for batching materials not measured and paid for by weight need not be certified.

The Engineer will randomly verify the accuracy of the certified weigher on every project where the weights are manually entered on the scale ticket. This verification will consist of at least one comparison check on the project. Additional verification checks may be required as determined by the Engineer. The Engineer will randomly select a loaded truck after the truck has been issued a scale ticket by the certified weigher. The loaded truck will then be reweighed, in the presence of the Engineer, on the same scale and the weight compared with the weight on the scale ticket. Reweighed loads shall be within the tolerance of 200 pounds plus or minus.

The Engineer will also verify the accuracy of computerized scales. Computerized scales are scales that automatically print weights on the scale ticket. This verification will consist of at least one comparison check when the project requires more than 2,500 tons of material to be weighed. This comparison check shall be made by reweighing a loaded vehicle. The Contractor shall either provide a second certified scale or select a second certified scale in the vicinity to be used for the comparison check. Comparison checks shall be performed using the following procedures:

- Hopper Scale. A loaded truck will be randomly selected by the Engineer. The loaded truck shall be weighed on a certified platform scale to record the gross weight. The truck shall be unloaded and weighed again on the same scale to record the tare weight. The tare weight shall be subtracted from the gross weight and compared against the net weight recorded on the scale ticket.
- Platform Scales. The Engineer will randomly select a loaded truck. The loaded truck shall be reweighed on a second certified scale and the gross weight shall be compared against the gross weight on the first scale ticket.

  Should a comparison check reveal a weight difference of more than one percent, a second comparison check shall be performed immediately. If the weight differences of both comparison checks exceed the one percent limit, the Contractor shall immediately stop weighing and the scale shall be recertified and resealed at the Contractor's expense. The necessary adjustments as indicated by the recertification will be made to all scale tickets issued since the last certification or on the entire project, whichever occurred later, unless the Contractor demonstrates to the satisfaction of the Engineer that the defect in the scale was present for a lesser period of time.

  If it is necessary to recertify a scale, and more than 2,500 tons of material remain to be weighed, another scale comparison check shall be made.

  All comparison checks shall be made at the Contractor's expense.

Materials to be measured by volume in the hauling vehicle shall be hauled in approved vehicles and measured at the point of delivery. Vehicles for this purpose may be of any size or type, provided the body is shaped so the actual contents may be readily and accurately determined. All vehicles shall be loaded to their water level capacity and all loads shall be leveled when the vehicles arrive at the point of delivery.

Water used in the work will be measured by the M Gallon or 1,000 U.S. Gallons. The weight of inherent moisture in the material will not be deducted. Water added for the Contractor's convenience will not be paid for.

Water may be measured by either volume or weight. Water meters shall be accurate within a range of plus or minus 3 percent. When water is metered, the Contractor shall use an approved metering device and shall furnish the Engineer a certificate showing the meter has been accurately calibrated within the time allowed in the following schedule:

2 inch	4 years
4 inch to 6 inch	2 years
8 inch to 10 inch	1 year

Water meters shall be calibrated when the Engineer determines there is reason to believe the meters are not accurate within the allowable tolerance. If water meter accuracy is found acceptable, the cost involved in checking the water meter shall be at the Department's expense. If the water meter accuracy is found unsatisfactory, the cost involved in checking the water meter shall be at the Contractor's expense.

For those materials specified to be measured by the cubic yard, an acceptable method of computing volumes of excavation is to determine a weight to volume factor and convert weight to volumes by means of the factor. Colorado Procedure 80 as described in the Department's Field Materials Manual shall determine the weight to volume factor. The number of tests used to determine the material weight to volume factor will be determined by the Engineer. The locations where the tests are taken shall be at those locations specified in the "Method of Measurement" for the particular bid item; i.e., Unclassified Excavation - in its original position: Embankment Material - in its final compacted position, etc.

Asphalt materials will be measured by the gallon or ton. Volumes will be measured at 60 °F or will be corrected to the volume at 60 °F using ASTM D1250 for asphalts or ASTM D633 for tars. Net certified scale weight or weight based on certified volumes in the case of rail shipments will be used as a basis of measurement, subject to correction when asphalt material has been lost from the car or the distributor, wasted, or otherwise not incorporated in the work. When asphalt materials are shipped by truck or transport, net certified weight or volume subject to correction for loss or foaming will be used for computing quantities.

Cement will be measured by the ton.

Timber will be measured by the number of thousand feet board measure or MFBM actually incorporated in the structure. Measurement will be based on nominal commercial widths and thicknesses.

The term "lump sum" when used as an item of payment will mean complete payment for the work described in the Contract.

When a complete structure or structural unit (in effect, "lump sum" work) is specified as the unit of measurement, the unit will include all necessary fittings and accessories.

Rental of equipment will be measured in hours of actual working time and necessary traveling time of the equipment within the limits of the project. If special equipment has been ordered by the Engineer in connection with force account work, travel time and transportation to the project will be measured. If equipment has been ordered held on the job on a standby basis by the Engineer, and is not otherwise utilized by the Contractor, standby rental rates for the equipment will be paid at the rates specified in subsection 109.04.

When standard manufactured items are specified such as fence, wire, plates, rolled shapes, and pipe conduit, and these items are identified by gauge, unit weight, and section dimensions, the identification will be considered to be nominal weight or dimensions. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted.

109.02 Scope of Payment. The Contractor shall receive and accept compensation provided for in the Contract as full payment for furnishing all materials and for performing all work under the Contract in a complete and acceptable manner and for all risk, loss, damage, or

expense of whatever character arising out of the nature of the work or the prosecution thereof, subject to the provisions of subsection 107.21.

Work or materials that have pay items and that are to be paid for separately will be included in the appropriate pay item in the Summary of Approximate Quantities on the plans. Work or materials that are essential to the project but do not have pay items, will not be measured and paid for separately but shall be included in the project.

Payment for any pay item listed in the Summary of Approximate Quantities on the plans, having additional items shown within parentheses, shall be full compensation for all work necessary to complete the item as designated.

109.03 Compensation for Altered Quantities. When the accepted quantities of work vary from the quantities in the Contract the Contractor shall accept as payment in full, payment at the original contract unit prices for the accepted quantities of work done. Allowance will not be made except as provided in subsections 104.02 and 108.11, for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting either directly from such alterations or indirectly from unbalanced allocation of overhead expense among the contract items or from any other cause.

If any such alteration directly causes the loss of any work or materials already furnished by the Contractor under the terms of the original Contract, reimbursement for such work or of salvaging such materials will be at actual cost. Any such materials may, at the option of the Department, be purchased at the actual cost to the Contractor, as evidenced by certified invoices.

109.04 Compensation for Changes and Force Account Work. Differing site conditions, changes, and extra work performed under Section 104 will be paid for as stipulated in the order authorizing the work. Compensation will be at unit prices or lump sum, or the Department may require the Contractor to do the work on a force account basis to be compensated in the following manner:

(a) Labor. For all labor and foremen in direct charge of the specific operations, the Contractor will receive the actual rate of wage normally paid for each and every hour that the labor and foremen are actually engaged in the work, as documented by certified payrolls.

The Contractor will receive the actual costs paid to, or on behalf of, workers by reason of subsistence and travel allowances, health and welfare benefits, pension fund benefits, or other benefits, when the amounts are required by a collective bargaining agreement or other employment contract or generally applicable to the classes of labor employed on the work.

An amount equal to 67 percent of the actual wages and fringe benefits paid directly to the employees will also be paid to the Contractor. This 67 percent will not be applied to subsistence, travel allowance, or to fringe benefits paid to a third party or a trustee.

(b) Materials. For materials accepted by the Engineer and incorporated in the work, the Contractor shall receive the actual cost of such materials, including transportation charges paid (exclusive of equipment rentals as set forth), to which 15 percent will be added.

(c) Owned or Leased Equipment. For the use of any machinery or equipment, approved by the Engineer, which is owned or leased directly by the Contractor or subcontractors, or by entities that are divisions, affiliates, subsidiaries or in any other way related to the Contractor or subcontractors or their parent companies, the Contractor will be paid in the

manner specified. Rental rates will be from the current edition of the Rental Rate Blue Book of Rental Rates for Construction Equipment and will be used as follows:

1. Determination of the rental rate to be used will be as follows:

   Hourly rate: RR = (ADJ BB/176)(RF)+EOC
   Standby rate: SR = (ADJ BB/176)(RF)(0.5)

   Where:

RR	=	Hourly rental rate
SR	=	Standby rate
ADJ BB	=	Blue Book Monthly Rate adjusted for year of manufacture
RF	=	Regional Factor of 1.06
EOC	=	Estimated Hourly Operating Costs from Blue Book

2. The number of hours to be paid for will be the number of hours that the equipment is actually used on a specific force account activity.
3. Overtime shall be compensated at the same rate indicated in subsection 109.04(c)1. above.
4. The EOC will be used for each hour that the equipment is in operation on the force account work. Such costs do not apply to idle time regardless of the cause.
5. Idle time for equipment will not be paid for, except where the equipment has been held on the Project site on a standby basis at the direction of the Engineer. Such payment will be made at the standby rate established in subsection 109.04(c)1 above. The Engineer must approve the payment of standby rates for equipment before the costs are incurred. Payment for standby time will not be made on any day the equipment operates for eight or more hours. For equipment accumulating less than eight hours operating time on any normal workday standby payment will be limited to only that number of hours that, when added to the operating time for that day, equals eight hours. Additionally, payment for standby time will not be made in any consecutive 30-day period that the equipment operates for 176 or more hours. For equipment accumulating less than 176 hours operating time in any consecutive 30-day period, standby payment will be limited to only that number of hours that, when added to the operating time for that consecutive 30-day period, equals 176 hours. Standby payment will not be made in any case on days not normally a workday.
6. The rates established above include the cost of fuel, oil, lubrication, supplies, incidental tools valued at less than $500, necessary attachments, repairs, overhaul and maintenance of any kind, depreciation, storage, overhead, profit, insurance, all costs (including labor and equipment) of moving equipment onto and away from the site, and all incidentals, except as allowed in subsection 109.04(c)8.
7. The rental rate for small tools shall be $2 per hour. Small tools are defined as any tool that would be valued between $500 and $2,000 if purchased new.
8. Transportation charges for each piece of equipment to and from the site of the work will be paid provided:

   (1) The equipment is obtained from the nearest source,
   (2) Charges are restricted to those units of equipment not already available or required on the Project, and

(3) The equipment is used solely for the force account work.

9. Fast use expendable parts not included in the Rental Rate Blue Book will be paid at certified invoice cost plus 10percent. Such parts not totally expended on the force account work will be prorated based on actual use.

10. Payable time periods will not include:

(1) Time elapsed while equipment is broken down.

(2) Time spent in repairing equipment; or

(3) Time elapsed after the equipment is no longer needed.

If a piece of equipment that is not in the Blue Book is needed, rates shall be agreed to in writing before the equipment is used.

(d) Rental Equipment. Use of rental equipment not owned or leased by the Contractor or subcontractors will be paid for by certified invoice cost. The EOC will also be paid if not included in the rental rate. The use of and rates for rental equipment shall be approved by the Engineer before use. Proration of rental rates to an hourly rate for equipment not used solely for the force account shall be based on 176 hours per month, 40 hours per week or 8 hours per day as applicable. The cost of moving the rental equipment onto and away from the job will also be paid when the equipment is used solely for the force account work. An amount equal to 10 percent of the total due to the Contractor for rental equipment cost will be added to compensate the Contractor for related overhead costs.

(e) Administrative Compensation. Administrative compensation will be paid to the Contractor for work performed on a force account basis by a subcontractor, utility, railroad, waste disposal company, or specialty firm. The compensation will be a percentage of the value of the force account work performed per the following:

To $1,000	10%
Over $1,000 to $10,000	$100 plus 5% of excess over $1,000
Over $10,000	$550 plus 3% of excess over $10,000

The percentages will be calculated after certified invoices are furnished by the Contractor. Compensation for administrative loading expenses will be applied to each individual billing for each force account, not to exceed one administrative loading per billing nor one billing per force account per month.

(f) Records. The Contractor's representative and the Engineer shall, on a daily basis, agree in writing on the quantities of labor, equipment and materials used for work completed on a force account basis.

(g) Statements. Payment will not be made for work performed on a force account basis until the Contractor has furnished the Engineer with triplicate itemized statements of the cost of the force account work, detailed as follows:

(1) Labor classification, hours, rate, and extension for each labor class or pay rate within a class.

(2) Equipment type, hours, rate and extension for each unit of equipment.

(3) Quantities of materials, prices, extensions and transportation charges.

(4) Administrative compensation when applicable.

Statements shall be accompanied and supported by certified invoices for all materials and rental equipment including transportation charges. If materials used on the force

account work are not specifically purchased for the work, but are taken from the Contractor's stock, the Contractor shall furnish a written statement certifying that the materials were taken from stock, that the quantity claimed was actually used, and that the price and transportation claimed represent the actual cost to the Contractor.

(h) Alternative Method of Documenting Force Account Work. The following method of documenting the amount of force account work done may be used in lieu of the method described in subsections 109.04(f) and (g) above, when agreed to by both the Engineer and the Contractor.

The Engineer will keep a daily record of the labor, equipment and material used on approved force account work. The Contractor's representative shall review and initial the record each day to ensure that the record is accurate and complete, and that the costs were actually incurred.

The Contractor shall furnish certified copies of invoices for the cost of all materials used including transportation charges. If materials used on force account work are not specifically purchased for the work, but are taken from the Contractor's stock, the Contractor shall furnish a written statement certifying that the quantity claimed was actually used, and that the price and transportation charges claimed represent the actual cost to the Contractor.

The Engineer will calculate the cost of the force account work each month and include payment on the monthly progress estimate.

(i) The additional percentages stated in (a) through (h) above constitute full compensation for all items of expense not specifically designated, including general superintendence, use of incidental tools, field and office overhead and profit. The total payment made as provided above shall constitute full compensation for such work.

109.05 Eliminated Items. Should any items contained in the Contract be found unnecessary for the proper completion of the work, the Engineer will notify the Contractor in writing, to eliminate the item. Such action will not invalidate the Contract. The Contractor, by Contract Modification Order, will be reimbursed for actual work done and all costs incurred, including mobilization of materials and equipment before the elimination of the items.

109.06 Partial Payments. Partial payments will be made once each month as the work progresses, when the Contractor is performing satisfactorily under the Contract. Payments will be based upon progress estimates prepared by the Engineer, of the value of work performed, materials placed per the Contract, and the value of the materials on hand per subsection 109.07. The amount of the progress estimate paid to the Contractor will be subject to the following:

(a) Standard Amount Retained. The Department will make a deduction from the progress estimate in the amount considered necessary to protect the interests of the State, pursuant to Section 24-91-103, CRS. The amount to be retained will be 3 percent of the value of the completed work, exclusive of mobilization and payments for materials on hand, to a maximum of 1 1/2 percent of the original contract amount. No further amount will be retained if the Contractor makes satisfactory progress in the contract work. The amount retained will be in effect until such time as final payment is made, with the following exception that requires the Contractor's written request and consent of the Surety: Upon completion and acceptance of the project, after the project quantities are finalized, and the Contractor has submitted the necessary forms, the Engineer may make reduction in the amount retained.

The Contractor shall request release of retainage on work that has been partially accepted per subsection 105.21(a). The Contractor shall provide a certified invoice to the Engineer stating the percentage of the original contract amount constituted by the partially accepted work. The calculated percentage will be multiplied by the maximum retainage amount allowed to determine the retainage to be released.

(b) *Securities in Lieu of Standard Amount Retained*. When the original contract amount exceeds $150,000, the Contractor may withdraw all or any portion of the standard amount retained if acceptable securities are assigned to the Department, and deposited as set forth in Section 24-91-105, CRS and the implementing regulations. The securities shall at all times have a market value at least equal in value to the sums withdrawn. If at any time the Department determines that the market value of the securities has fallen below the sums withdrawn, the Contractor, shall deposit additional acceptable securities in an amount sufficient to reestablish a total deposit of securities equal in value to the sums withdrawn. This security substitution shall not apply if a part of the contract price is paid from federal, or other sources, and the federal or other source has requirements that are inconsistent with this subsection.

(c) *Subcontractor and Supplier Claims*. In addition to a standard amount retained, the Department will withhold funds for all claims against the Contractor filed by subcontractors and suppliers, pursuant to Sections 38-26-107 and 24-91-103, CRS.

(d) *No Payment*. A partial payment will not be made when the total value of the work done since the last estimate amounts to less than $500.

(e) *Prompt Payment*. The Contractor shall pay subcontractors and suppliers for all work that has been satisfactorily completed within seven calendar days after receiving payment for that work from the Department. For the purpose of this section only, work shall be considered satisfactorily complete when the Department has made payment for the work. The Contractor shall include in all subcontracts a provision that this requirement for prompt payment to subcontractors and suppliers must be included in all subcontracts at every tier. The Contractor shall ensure that all subcontractors and suppliers at every tier are promptly paid. If the Contractor or its subcontractors fail to comply with this provision, the Engineer will not authorize further progress payment for work performed directly by the Contractor or the noncompliant subcontractor until the required payments have been made. The Engineer will continue to authorize progress payments for work performed by compliant subcontractors.

(f) *Retainage by the Contractor*. The Contractor may withhold retainage of each progress estimate on work performed by subcontractors. If during the prosecution of the project, a subcontractor satisfactorily completes all work described on CDOT Form 205, as amended by changes directed by the Engineer, the following procedure will apply:

1. The subcontractor may make a written request to the Contractor for the release of the subcontractor's retainage.
2. Within 10 workdays of the request, the Contractor shall determine if all work described on Form 205 has been satisfactorily completed and shall inform the subcontractor in writing of the Contractor's determination.
3. If the Contractor determines that the subcontractor has not achieved satisfactory completion of all work described on Form 205, the Contractor shall provide the subcontractor with written notice, stating specifically why the subcontract work is not

satisfactorily completed and what has to be done to achieve completion. A copy of this written notice shall be provided to the Engineer.

4. If the Contractor determines that the subcontractor has achieved satisfactory completion of all work described on Form 205, the Contractor shall release the subcontractor's retainage within seven calendar days.
5. In determining whether satisfactory completion has been achieved, the Contractor may require the subcontractor to provide documentation such as certifications and releases, showing that all laborers, lower-tiered subcontractors, suppliers of material and equipment, and others involved in the subcontractor's work have been paid in full. The Contractor may also require any documentation from the subcontractor that is required by the subcontract or by the Contract between the Contractor and the Department or by law such as affidavits of wages paid, material acceptance certifications and releases from applicable governmental agencies to the extent that they relate to the subcontractor's work.
6. Within 14 calendar days after receiving the Contractor's request, the Engineer will make inspection of all work described on Form 205. The Engineer will measure and furnish the final quantities to the Contractor of the items completed by the subcontractor. Agreement on these final quantities by the Contractor will not constitute the acceptance of the work described on Form 205 by the Engineer.
7. If the subcontractor performs only a portion of an item of work, the Contractor shall release retainage per the procedures stated above and when the subcontractor has completed all of the work included in the subcontract, however, final measurement of quantities will not be made until the item of work and all of the work on the associated Form 205 has been completed.
8. If additional quantities of a particular item of work are required at a later date after final measurement has been made, the Contractor shall perform this work per Contract requirements and at unit bid prices.
   For this subsection only, satisfactory completion of all work described on CDOT Form 205 is when all tasks called for in the subcontract as amended by changes directed by the Engineer have been accomplished and documented as required by the Department.
   The requirements stated above do not apply to retainage withheld by the Department from monies earned by the Contractor. The Department will continue to process the release of that retainage based upon the completion date of the project as defined in the Commencement and Completion of Work special provision.
9. If during the prosecution of the project a portion of the work is partially accepted per subsection 105.21(a), the Contractor shall release all subcontractors' retainage on the portion of the partially accepted work performed by subcontractors. Before the Department releasing the Contractor's retainage on work that has been partially accepted per subsection 105.21(a), the Contractor shall submit to the Engineer a certified statement for each subcontractor that has participated in the partially accepted work. The statement shall certify that the subcontractor has been paid in full for its portion of the partially accepted work including release of the subcontractor's retainage. The statement shall include the signature of a legally responsible official for the Contractor, and the signature of a legally responsible official for the subcontractor.
10. The Contractor shall be solely responsible for all additional costs involved in paying retainage to the subcontractors before total project completion.

(g) *Good Cause Exception.* If the Contractor has "good cause" to delay or withhold a subcontractor's progress payment, the Contractor shall notify the subcontractor in writing within seven calendar days after receiving payment from the Department. The notification shall specify the amount being withheld and provide adequate justification for withholding the payment. The notice shall also clearly state what conditions the subcontractor must meet to receive payment. "Good cause" shall include but not be limited to the failure of the subcontractor to make timely submission of required paperwork.

(h) *Monthly Reporting.* For CDOT projects, by the 15th of each month, the Contractor shall record all payments to subcontractors by completing an audit in the B2GNow System. If the Contractor has good cause for delay as described in subsection 109.06(g), the Contractor shall include the justification in its monthly audit. Once the prime enters a payment to a subcontractor or supplier, the subcontractor or supplier will receive a notice to confirm payment. The subcontractor or supplier shall have fifteen days from the notice to confirm payment or report an issue. If a subcontractor or supplier is also a payer, the subcontractor or supplier shall also report all prompt payment to its subcontractors. If the subcontractor or supplier does not report a prompt payment issue within fifteen days from the Contractor's monthly reporting, the subcontractor waives CDOT's assistance in resolving the prompt payment issue and the monthly audit will be closed. This provision should not be construed to limit the subcontractor's contractual remedies.

(i) *Fuel Cost Adjustments.* Contract cost adjustments will be made to reflect increases or decreases in the monthly average prices of gasoline, diesel and other fuels from the average price for the month preceding the month that bids were received for the Contract. These cost adjustments are not changes to the Contract unit prices bid. When bidding, the Contractor shall specify on the Form 85 whether the cost adjustment will apply to the Contract. After bids are submitted, the Contractor will not be given any other opportunity to accept or reject this adjustment. If the Contractor fails to indicate a choice on the Form 85, the cost adjustment will not apply to the Contract. If the fuel cost adjustment is accepted by the Contractor, the adjustment will be made per the following criteria:

1. Cost adjustments will be based on the fuel price index established by the Department and calculated as shown in subsection 109.06(i)2.D below. The index will be the monthly average of the rates posted by the Oil Price Information Service (OPIS) for Denver No. 2 Diesel. The rate used will be the *OPIS Average* taken from the OPIS Standard Rack table for *Ultra-Low Sulfur w/Lubricity Gross Prices* (ULS column), expressed in dollars per gallon and rounded to two decimal places.
2. Cost adjustments will be made on a monthly basis subject to the following conditions:
   A. Adjustment will be based on the pay quantities on the monthly partial pay estimate for each of the pay items listed in the table below that fuel factors have been established. Adjustment will be made only when the pay item is measured by the pay unit specified in the table:

Table 109-1

FUEL COST ADJUSTMENT FACTORS

Item	Pay Unit	Fuel Factor (FF)
202-Removal of Asphalt Mat (Planing)	Square Yard	0.006 Gal/SY/Inch depth
203-Excavation (muck, unclassified) Embankment, Borrow	Cubic Yard	0.29 Gal/CY
203-Rock Excavation	Cubic Yard	0.39 Gal/CY
206-Structure Excavation and Backfill [applies only to quantities paid for by separate bid item; no adjustment will be made for pay items that include structure excavation and backfill, such as RCP(CIP)]	Cubic Yard	0.29 Gal/CY
304-Aggregate Base Course (Class___)	Cubic Yard	0.85 Gal/CY
304-Aggregate Base Course (Class___)	Ton	0.47 Gal./Ton
307-Processing Lime Treated Subgrade	Square Yard	0.12 Gal/SY
310-Full Depth Reclamation	Square Yard	0.06 Gal/SY
403-Hot Mix Asphalt (HMA) (Grading __) *	Ton	2.47 Gal/Ton
403-Stone Matrix Asphalt (Grading __)	Ton	2.47 Gal/Ton
405-Heating and Scarifying Treatment	Square Yard	0.44 Gal/SY
405-Heating and Repaving Treatment	Square Yard	0.44 Gal/SY
405-Heating and Remixing Treatment	Square Yard	0.44 Gal/SY
406-Cold Bituminous Pavement (Recycle)	Square Yard	0.01 Gal/SY/Inch depth
412- Concrete Pavement (___Inch)	Square Yard	0.03 Gal/SY/Inch thickness
412-Place Concrete Pavement**	Square Yard	0.03 Gal/SY/Inch thickness

Table 109-1 Notes: *Hot Mix Asphalt (Patching) is not subject to fuel cost adjustment.

**Use the thickness shown on the plans.

B. A fuel cost adjustment will be made only when the current fuel price index varies by more than 5 percent from the price index at the time of bid, and only for that portion of the variance in excess of 5 percent. Fuel cost adjustments may be either positive or negative dollar amounts.

C. Fuel cost adjustments will not be made for any partial estimate falling wholly after the expiration of contract time.

D. Adjustment formula:

EP greater than BP:

FA = (EP – 1.05 BP)(Q)(FF)

EP less than BP:

FA = (EP – 0.95 BP)(Q)(FF)

Where:

BP	= Average fuel price index for the calendar month before the calendar month that bids are opened
EP	= Average fuel price index for the calendar month before the calendar month that the partial estimate pay period ends
FA	= Adjustment for fuel costs in dollars
FF	= Fuel usage factor for the pay item
Q	= Pay quantity for the pay item on the monthly partial pay estimate

Note: When the pay item is based on area, and the rate of fuel use varies with thickness, Q should be determined by multiplying the area by the thickness. For example: for 1000 square yards of 8-inch concrete pavement Q should be 8000.

Example: Bids are opened on July 16. The BP will be the average of the daily postings for June 1 through June 30. For an estimate cut-off date selected by the Contractor at the Pre-construction Conference of the 20th of the month, a February estimate will include HMA quantities (Q) measured from the 21st of January through the 20th of February, the FF will be 2.47 Gal/Ton, and the EP index used to calculate FA will be the average of the daily postings for January 1 through January 31 as established by CDOT.

E. Fuel cost adjustment will not be made for the quantity of any item that is left in place at no pay.

F. Fuel cost adjustments will not be made to items of work added to the Contract by Change Order after the award of the Contract.

The fuel cost adjustment will be the sum of the individual adjustments for each of the pay items shown. No adjustment will be made for fuel costs on items other than those shown. The factors shown are aggregate adjustments for all types of fuels used, including but not limited to gasoline, diesel, propane, and burner fuel. No additional adjustments will be made for any other type of fuel.

Fuel cost adjustments resulting in an increased payment to the Contractor will be paid for under the planned force account item: Fuel Cost Adjustment. Fuel cost adjustments resulting in a decreased payment to the Contractor will be deducted from monies owed the Contractor.

(j) Asphalt Cement Cost Adjustments. Contract cost adjustments will be made to reflect increases or decreases in the monthly average price of asphalt cement from the average price for the month preceding the month that bids were received for the Contract. These cost adjustments are not a change to the contract unit prices bid. When bidding, the

Contractor shall specify on the Form 85 whether the cost adjustment will apply to the Contract. After bids are submitted, the Contractor will not be given the opportunity to accept or reject this adjustment. If the Contractor fails to indicate a choice on the Form 85, the cost adjustment will not apply to the Contract. If the asphalt cement cost adjustment is accepted by the Contractor, the adjustment will be made per the following criteria:

Abbreviations and Terms

1. Estimate Price for asphalt (EP) – Average Asphalt Cement price index for the calendar month before the calendar month that the partial estimate pay period ends.

   a. On the first Monday of each month, the Department determines the EP using price values from the most recent **Poten and Partners Asphalt Weekly** and the **Argus Americas Asphalt Report**. The Department averages values for the following, eliminating the single highest and single lowest values, before averaging.

      The high reported selling price (per ton) of typical non-modified paving grades of asphalt from the **Poten and Partners Asphalt Weekly Monitor**.

      Colorado
      Colorado Springs Area

      Montana
      Eastern markets
      Western markets

      Nebraska
      Western markets

      New Mexico
      Northern
      Southern

      Utah
      Salt Lake City area

      Wyoming
      Northern markets
      Southern markets

      The high reported selling price (per ton) of typical non-modified paving grades of asphalt from the **Argus Americas Asphalt Report**.

      Denver
      Kansas City
      Omaha

      Salt Lake City
      Wyoming

      This average value is then averaged with values obtained in the same manner for the previous three weekly reports to establish the EP.

   b. The EP remains in effect until the first Monday of the following month and is used for regular partial estimates closed before the first Monday of the following month.

2. Base Price for asphalt (BP) – Average Asphalt Cement price index for the calendar month before the calendar month that bids are opened.

3. Asphalt cost adjustment (ACCA) – Asphalt Cement Cost Adjustment.
4. Cost adjustments will be made on a monthly basis subject to the following conditions:

   A. Adjustment will be based on the pay quantities on the monthly partial pay estimate for the following two pay items when measured by the ton and asphalt cement is included in the pay items:

Item No.	Item	Pay Unit
411	Asphalt Cement (__)*	Ton

*Asphalt Cement used with Hot Mix Asphalt (Patching) is not subject to asphalt cement cost adjustment.

   B. A cost adjustment will be made only when the EP asphalt cement price index varies by more than 10 percent from the BP asphalt cement price index, and only for that portion of the variance in excess of 10 percent. Cost adjustments may be either positive or negative dollar amounts.

   C. The maximum allowable monthly and final price adjustment to the Contractor or rebate to The Department is limited to a (EP/BP) ratio of 1.6 and 0.4, respectively.

   D. Asphalt cement cost adjustments will not be made for any partial estimate falling wholly after the expiration of contract time.

   E. Adjustment formula:

      EP greater than BP:

      ACCA = (EP – 1.10 BP) (PA) (Q)

      EP less than BP:

      ACCA = (EP – 0.90 BP) (PA) (Q)

Where:

BP = Average Asphalt Cement price index for the calendar month before the calendar month that bids are opened

EP = Average Asphalt Cement price index for the calendar month before the calendar month that the partial estimate pay period ends

ACCA = Asphalt Cement Cost Adjustment

PA = Percent of the paving mixture that is asphalt cement. Asphalt Cement content will be determined by the weighted average of all asphalt cement content percentages obtained from the field acceptance tests for that item (Use decimal in formula: 0.053). If Reclaimed Asphalt Pavement (RAP), Reclaimed Asphalt Shingles (RAS), or both is used, the percent of Virgin Asphalt Cement added to the mix will be determined by subtracting the percent of asphalt cement in the RAP, RAS, or both from the percent of asphalt cement in the mix as calculated from Revision of Section 401, Reclaimed Asphalt Pavement and Revision of Section 401 Reclaimed Asphalt Shingles.

Q = Pay quantity for all 403 items shown above on the monthly partial pay estimate in Tons.

Example: Bids are opened on July 16. The BP will be the average of the weekly postings for June 1 through June 30. For an estimate cut-off date selected by the Contractor at the Pre-construction Conference of the 20th of the month, a February estimate will include HMA quantities measured from the 21st of January through the 20th of February, and the EP index used to calculate ACCA will be the average of the weekly prices for January 1 through January 31 as established by CDOT.

F. Cost adjustment will not be made for the quantity of any item that is left in place at no pay or for material removed and replaced at the Contractor's expense.

G. Cost adjustments will not be made to items of work added to the Contract by Change Order after the award of the Contract.

H. The asphalt cement cost adjustment will be the sum of the individual adjustments for each of the pay items shown above. No adjustment will be made for asphalt cement costs on items other than those shown above.

I. Asphalt cement cost adjustments resulting in an increased payment to the Contractor will be paid for under the planned force account item: Asphalt Cement Cost Adjustment. Asphalt cement cost adjustments resulting in a decreased payment to the Contractor will be deducted from monies owed the Contractor.

109.07 Payment for Material on Hand (Stockpiled Material). Payments may be made to the Contractor for materials to be incorporated into the work as evidenced by invoices or cost analyses of material produced on the project subject to the following:

1. The material has been fabricated or processed and is ready for installation into the project and conforms to the requirements of the Contract. The Contractor shall provide the Engineer with a monthly accounting of all materials stockpiled on the project that stockpiled payment is being requested and certification of compliance that the materials conform to the requirements of the Contract. This monthly accounting shall include the specific location of materials, the amounts of materials stockpiled, the amounts of

materials incorporated into the work, and the net amounts of materials that stockpile material payment is being requested.

Payment for stockpiled structural steel (unfabricated milled plate) may be made subject to the following additional conditions:

A. The plan quantity of structural steel shall exceed one million pounds.

B. The structural steel shall have been delivered to the Contractor's fabrication plant.

C. The material conforms to the requirements of the Contract.

D. Payment shall not exceed 60 percent of the certified invoice cost of the structural steel.

2. The material is stored on the project, on State owned property, or at an acceptable secured location within the State of Colorado. In the latter case, the Contractor shall provide a document signed by the owner and lessee of the property establishing that the Department has a vested interest in, and the right of access to and possession of the material. The material shall be clearly identified for the CDOT project.

   If the material is structural steel (either completely fabricated or unfabricated milled plate), it is stored on the project, stored on State owned property, or identified and stored separately from all other lots of similar material in acceptable storage places. In the latter case, the Contractor shall provide a document signed by the owner and lessee of the property establishing that the Department has vested interest in, and the right of access to and possession of the structural steel. When the structural steel is stockpiled outside the State of Colorado, the Contractor shall reimburse the Department for all costs incurred to verify the quantity of the material, conformance to contract requirements, and proper storage.

3. The Contractor provides the Engineer with a written cost analysis that confirms that the balance of funds in the corresponding items is sufficient to complete the installation. Partial payments will not exceed 85 percent of the contract unit price for the item or 100 percent of the certified invoice cost of the stockpiled material, whichever is less.

4. The Contractor shall provide the Engineer with a certified invoice.

   Payment for stockpiled materials will not relieve the Contractor of responsibility for loss or damage to the material.

   Payment for living plant materials, perishable materials, or materials that will not become an integral part of the finished project will not be made under this subsection.

109.08 Reserved .

109.09 Acceptance and Final Payment. When the project has been accepted as provided in subsection 105.21, the Engineer will prepare the final estimate of the quantities of the various classes of work performed. After approval of the final estimate by the Contractor, payment of the entire sum found to be due after deducting all previous payments and all amounts to be retained or deducted under the provisions of the Contract will be made.

All prior estimates and payments, except for those made per subsection 109.06(f)6. will be subject to correction in the final estimate and payment.

109.10 Compensation for Compensable Delays. If the Engineer determines that a delay is compensable per either subsection 105.22, 105.23, 105.24, or 108.08, monetary compensation will be determined per this subsection.

(a) These categories represent the only costs that are recoverable by the Contractor. All other costs or categories of costs are not recoverable:

1. Actual wages and benefits, including FICA, paid for additional labor not otherwise included in (5) below.
2. Costs for additional bond, insurance and tax.
3. Increased costs for materials.
4. Equipment costs calculated per subsection 109.04(c) for Contractor owned equipment and based on invoice costs for rented equipment.
5. Costs of extended job site overhead.
6. Costs of salaried employees not otherwise included in (1) or (5) above incurred as a direct result of the delay.
7. Claims from subcontractors and suppliers at any level (the same level of detail as specified is required for all such claims).
8. An additional 16 percent will be added to the total of items (1) through (7) as compensation for items that no specific allowance is provided, including profit and home office overhead.

(b) In adjustment for costs as allowed above, the Department will have no liability for the following items of damages or expense:

1. Profit in excess of that provided in (a) above.
2. Loss of profit.
3. Additional cost of labor inefficiencies in excess of that provided in (a) above.
4. Home office overhead in excess of that provided in (a) above.
5. Consequential damages, including but not limited to loss of bonding capacity, loss of bidding opportunities, and insolvency.
6. Indirect costs or expenses of any nature in excess of that provided in (a) above.
7. Attorney fees, claim preparation fees, and expert fees.

All costs claimed must be documented and accompanied by a claim certification form obtained from the Department.

DIVISION 200
EARTHWORK

SECTION 201

CLEARING AND GRUBBING

DESCRIPTION

201.01. This work consists of clearing, grubbing, removing, and disposing of vegetation and debris within the limits of the right of way, easement areas, borrow pits, and other areas shown in the Contract or required by the work. Vegetation and objects designated to remain shall be preserved free from injury or defacement.

CONSTRUCTION REQUIREMENTS

201.02. The Engineer will designate all trees, shrubs, plants, and other objects to remain. Every object that is designated to remain and is damaged shall be repaired or replaced as directed at the Contractor's expense.

Clearing and grubbing shall extend to the toe of fill or the top of cut slopes, unless otherwise designated.

All surface objects, trees, stumps, roots, and other protruding obstructions not designated to remain shall be cleared and grubbed. In areas to be rounded at the tops of backslopes, stumps shall be removed to at least 2 feet below the surface of the final slope line.

Except in areas to be excavated, all holes resulting from the removal of obstructions shall be backfilled with suitable material and compacted per subsection 203.06.

Burning of perishable material will not be permitted without the written approval of the Engineer. If permitted, perishable material shall be burned under the constant care of the Contractor, at times and in a manner that will not endanger the surrounding vegetation, adjacent property, or objects designated to remain. Burning shall be done per applicable laws and ordinances.

No material or debris shall be disposed of within the project limits without the written permission of the Engineer. Material or debris that is disposed of within the project limits shall be buried to a depth of at least 2 feet and the surface shall be reshaped to match the adjacent ground line. The Contractor shall make all arrangements to obtain written permission from property owners for disposal locations outside the limits and view of the project. Copies of this written agreement shall be furnished to the Engineer before the disposal area is used.

All cleared merchantable timber shall be removed from the project and shall become the property of the Contractor.
Branches on trees or shrubs shall be removed as directed. Branches of trees extending over the roadbed shall be trimmed to give a clear height of 20 feet above the roadbed surface. All trimming shall be done per good tree surgery practices.

The Contractor shall clear and grub the areas within the excavation or embankment grading limits and shall include the removal from the ground of brush, roots, sod, grass, residue of agricultural crops, sawdust, and other vegetable matter. See subsection 208.04(e) for disturbed

area limits.

METHOD OF MEASUREMENT

201.03. Measurement will be by one of the following methods:

Area Basis. The work to be paid for will be the number of acres acceptably cleared and grubbed, including scalping, within the limits shown on the plans or staked by the Engineer.

Lump Sum Basis. When the Contract contains a clearing and grubbing lump sum item, no measurement will be made.

BASIS OF PAYMENT

201.04. The accepted quantities of clearing and grubbing will be paid for at the contract unit prices as follows:

Area Basis. The quantities will be paid for at the contract unit price bid per acre for each pay item that appears in the bid schedule.

Lump Sum Basis. When the bid schedule contains a lump sum item, the lump sum price so bid will be paid and shall be full compensation for clearing and grubbing the entire project.

Clearing and grubbing beyond the limits designated under this item will be paid for as Extra Work per subsection 104.03.

Payment will be made under:

Pay Item	Pay Unit
Clearing	Acre, Lump Sum
Grubbing	Acre, Lump Sum
Clearing and Grubbing	Acre, Lump Sum

Exclusions. When the bid schedule does not contain an estimated quantity or a lump sum item for clearing and grubbing, the work will not be paid for separately, but shall be included in the work.

SECTION 202

REMOVAL OF STRUCTURES AND OBSTRUCTIONS

DESCRIPTION

202.01. This work consists of the removal and disposal of trees, slope and ditch protection, abandoned utility services, curb, gutter, pipes, sidewalk, structures, bridges or parts of bridges, railroad appurtenances, traffic control devices, impact attenuators, guardrail, fences, foundations, detours, pavements, pavement markings, and all other obstructions that are not designated or permitted to remain. It shall also include salvaging, stockpiling and loading salvable materials, sandblasting, plugging structures, cleaning culverts, and sawing and cutting to facilitate controlled breaking and removal of concrete and asphalt to a neat line. Except in areas to be excavated, the resulting trenches, holes, and pits shall be backfilled. This work also consists of plugging and abandoning water wells as designated in the Contract.
Materials removed and not designated in the Contract to be salvaged or incorporated into the work shall become the property of the Contractor.

This work consists of removal of the existing bridge(s) at the locations shown in the plans. Bridge removal shall consist of the complete removal of all superstructure and substructure elements including caissons and piling to a depth of at least two (2) feet below finished grade unless otherwise shown on the plans. Time limitations for the work shall be as shown in the contract and/or plans.

CONSTRUCTION REQUIREMENTS

202.02 General. The Contractor shall raze, remove, and dispose of all structures and obstructions that are identified on the project, except utilities, structures and obstructions removed under other contractual agreements, and salvable material designated to remain the property of the Department.

Basements and other cavities left by structure removal shall be filled to the level of the surrounding ground with suitable material and, if within the construction limits, shall be compacted per subsection 203.06.

Bridges, culverts, and other drainage structures shall not be removed until satisfactory arrangements have been made to accommodate traffic and drainage.

Blasting or other operations used to remove existing structures or obstructions, which may damage new construction, shall be completed before placing the new work.

Where portions of structures are to be removed, the portions designated to remain shall be prepared to fit the new construction and shall be protected from damage. All damage to structures designated to remain in place shall be repaired at the Contractor's expense. Method of repair shall be approved by the Engineer.

Sawing of concrete shall be done to a true line, with a vertical face, unless otherwise specified. The minimum depth of a saw cut in concrete shall be 2 inches or to the depth of the reinforcing steel, whichever occurs first.

Removed concrete and asphalt material may be used to construct embankments per subsection 203.07.

Where culverts or sewers are to be left in place and plugged, the ends of concrete or masonry culverts shall be filled with suitable material. The ends of corrugated metal pipe culverts shall be crushed. Culvert and sewer ends are to be sufficiently filled or crushed to prevent future settlement of embankments. Plugging of culverts shall include removal of headwalls and other appurtenances where necessary to accommodate the work.

Procedures for abandoning water wells shall conform to the Revised and Amended Rules and Regulations of the State of Colorado, Division of Water Resources, Board of Examiners of Water Well Construction and Pump Installation Contractors, (Board). The State Engineer who acts for the Board is located at 818 Centennial Bldg., 1313 Sherman St., Denver, CO 80203 (Phone 303-866-3587).

The Contractor shall properly plug and abandon the designated wells and file an abandonment report for each. An abandonment report shall be prepared using Form GWS-9 obtained from the Board at the above address. The report shall describe the well location and how it was plugged. This report shall be submitted to the Board, with a copy given to the Project Engineer, within 60 days after performing the work.

Existing guardrail shall not be removed unless the need for the guardrail has been eliminated or the hazard has been protected or delineated. The duration and manner of protection or delineation shall be submitted in writing for approval by the Engineer.
Perform the removal of the existing bridges per the requirements in this specification and Standard Specification 107.06. The Construction Plan requirements shown in Revision of Section 107-Performance of Safety Critical Work shall be included in the Bridge Removal Plan.

When removal operations are located over or in proximity to a railroad or any live water way, additional coordination including potential incident emergency/risk management notifications with the railroad or other agency (United States Army Corps of Engineers (USACE), US Fish and Wildlife Service, US Forest Service, etc.) shall be required.

The Contractor shall submit a Bridge Removal Plan to the Engineer for review and acceptance at least 2 weeks prior to the Pre-removal Conference. This Plan shall detail procedures, sequences, and all features required to perform the removal in a safe and controlled manner. The Bridge Removal Plan shall be prepared by the Contractor's Engineer and contain the Seal of a Professional Engineer registered in the State of Colorado. The Contractor's Engineer shall stamp and sign the Bridge Removal Plan "Approved for Construction". Submit the Bridge Removal Plan to the Engineer of Record, the corresponding CDOT Region Bridge Unit Leader and the Engineer for review and concurrence with general specification compliance, but it will not be approved. Submit comments from the referenced reviewers of the Bridge Removal Plan in writing to the Contractor within seven calendar days from receipt of the plan and prior to the Pre-removal Conference. Acceptance of the Bridge Removal Plan will be contingent upon the Contractor adequately addressing all written comments to the satisfaction of the Engineer.

The Bridge Removal Plan shall provide complete details of the bridge removal process, including:

(1) The removal sequence corresponding to the construction phasing shown on the plans, including calculations and analysis of the Contractor's removal equipment as related to loading capacity and any crane bearing during the removal operations. Sequence of operation shall include a detailed schedule that complies with the working hour limitations.

(2) Equipment descriptions including size, number, type, capacity, backup/standby need, and location of equipment during removal operations.

(3) Roles, responsibilities, and positioning of all CDOT project management, construction supervision, and critical workers during removal activities. Include instructions for communicating and managing a 'safe-all stop' scenario in this section, if unexpected hazards are discovered during the activity.

(4) Shoring that exceeds 5 feet in height, all falsework and bracing. Shoring design shall follow the AASHTO Guide Design Specifications for Bridge Temporary Works, or other design standard as approved by the Engineer.

(5) Shoring construction, including verification and proof testing shall be per Section 206. Shoring will not be measured and paid for separately but shall be included in the cost of item 202 – Removal of Bridge, unless otherwise provided on the plans or as directed by the Engineer.

(6) Details, locations, and types of protective coverings to be used. The protective covering shall prevent materials, equipment, and debris from falling onto the property below. When removal operations are located over or in proximity to a live waterway, railroad, or pedestrian/bicycle path, additional width of protective covering sufficient to protect these facilities shall be required. Include detailed methods of protection of the existing roadway facilities, including measures to assure that people, property, utilities, and improvements will not be endangered. Consider a catastrophic, unplanned failure of the structure during demolition as worst-case scenario.

(7) Detailed methods for protection of live waterways including minimization of turbidity and sedimentation, and protection of existing wetlands.

(8) Detailed methods for mitigation of fugitive dust resulting from the demolition.

(9) Details for dismantling, removing, loading, and hauling steel elements.

(10) Locations of railroad tracks, roadways, utilities (overhead and underground), structures or facilities located within the area of the bridge removal operations.

(11) Detailed methods of fire suppression.

(12) Methods of Handling Traffic, including bicycles and pedestrians, in a safe and controlled manner.

(13) Details for managing project communications, media, and on-looking public during demolition as needed.

(14) Contingency planning for unexpected weather.

(15) Details for emergency and post-incident management in a catastrophic failure or other serious incident or worker injury.

The Contractor's Engineer shall be responsible for the stability of the existing "in service" structure for any deviation from the bridge removal limits shown on the construction phasing plans. The Contractor is also responsible for the protection of any portion of the structure to remain in place for later phases, including protection from the Contractor's construction activities.

Use the more stringent criteria of the design guidelines, when a temporary works or demolition guideline is provided by a railroad or local agency.

Hold a Pre-removal Conference at least seven days prior to the beginning of removal of the bridge. The Engineer, Staff Bridge, the Contractor, the subcontractor performing the removal(s), the Contractor's Engineer, the Traffic Control Supervisor (TCS), and CDOT/Project Communications Staff shall attend the Pre-removal Conference. Finalize the Bridge Removal Plan at this Conference. Record meeting minutes and the attendance list.

The Contractor's Engineer shall seal items (1) and (4) listed above in the final Bridge Removal Plan. Demonstrate with adequate calculations that the loads and impact of the Contractor's demolition equipment do not impose detrimental effects on the stability of the structure remaining after the end of each phase of removal. Review these calculations before traffic is allowed to resume in its normal configuration.

The final Bridge Removal Plan shall be stamped "Approved for Construction" and sealed by the Contractor's Engineer. The Contractor shall address all written comments from the Engineer and submit a final Bridge Removal Plan to the Engineer. The Contractor shall not begin the removal operations without the Engineer's written acceptance of the final Bridge Removal Plan.

Submittal of the final Bridge Removal Plan to the Engineer, and field inspection performed by the Engineer, will in no way relieve the Contractor and the Contractor's Engineer of full responsibility for the removal plan and procedures.

Work within Railroad right-of-way shall be per Section 107. For bridge removal over railroads, including overhead wires, tunnels and underground facilities, approval of the bridge removal plans will be contingent upon the drawings being satisfactory to the railroad company involved.

The Contractor's Engineer shall be onsite during safety critical removal operations considered to have a high degree of safety risk. At or before the Pre-removal Conference, the Contractor and the Engineer shall agree if the Bridge removal operations are of high safety risk. Document said agreement in writing. The Contractor's Engineer shall inspect and provide written approval of each phase of the removal operations corresponding to the construction phasing shown on the plans prior to allowing vehicles or pedestrians on, below, or adjacent to the structure. The Contractor's Engineer shall certify in writing that the falsework, bracing, and shoring conform to the details of the final Bridge Removal Plan. Submit a copy of the certification to the Engineer. If any part of the adjacent structure designated to remain in place is damaged during removal operations, the Contractor's Engineer shall perform a full and complete engineering evaluation of the structure and submit a written report to the Engineer. This evaluation, as well as any additional costs to stabilize the structure due to or resulting from the Contractor's actions or inactions, shall be borne solely by the Contractor. Do not permit further work involving the bridge until the report and any subsequent remedial stability measures are complete and satisfactory to the Engineer and Staff Bridge.

The Contractor shall have all necessary workers, materials, and equipment at the site prior to closing any lanes to traffic to accommodate bridge removal operations. Pursue work promptly and without interruption until reopening the roadway to traffic.

Removal of hazardous material shall be per Section 250.

The Contractor shall take all necessary steps to avoid contaminating state waters, per subsection 107.25.

If an unplanned event occurs or the bridge removal operation deviate from the submitted Bridge Removal Plan, the bridge removal operations shall immediately cease. Perform all necessary work to ensure worksite safety. The Contractor shall submit to the Engineer the procedure or operation proposed by the Contractor's Engineer to correct or remedy the occurrence of this unplanned event or to revise the final Bridge Removal Plan. The Contractor's Engineer shall submit a written report to the Engineer within 24 hours of the event summarizing the details of the event and the procedure for correction. The Engineer shall review the information submitted regarding the unplanned event and provide written acceptance of the corrective action or remedy procedure prior to resuming operations.

Before removal of the protective covering, the Contractor shall clean the protective covering of all debris and fine material.

The Engineer may suspend bridge removal for the following reasons:

(1) Final Bridge Removal Plan has not been submitted, or written acceptance has not been provided by the Engineer to begin the removal.

(2) The Contractor is not proceeding per the final Bridge Removal Plan, procedures, or sequence.

(3) The Contractor's Engineer is not onsite to conduct inspection for the written approval of the work.

(4) Safety precautions are deemed to be inadequate.

(5) Existing neighboring facilities are damaged because of bridge removal.

Suspension of bridge removal operations shall in no way relieve the Contractor of their responsibility under the terms of the Contract. A suspension ordered as a direct result of (1) through (5) above, shall be considered a non-excusable delay. Bridge removal operations shall not resume until modifications have been made to correct the conditions that resulted in the suspension, as approved in writing by the Engineer.

The Contractor shall notify all emergency response agencies of the proposed removal work and any detours a minimum of three days in advance of the work. This shall include the Colorado State Patrol, local Police Department, local Fire Department, all local ambulance services, and the Sheriff's Department, as appropriate.

All required traffic control devices, nighttime flagging stations, barricades and VMS signs shall be in place, with detours in operation, prior to the beginning of removal operations each day. Night work shall conform to the requirements of the MUTCD, Parts 1, 5, and 6.

Prior to reopening the roadway to public traffic, remove all debris, protective pads, materials, and devices and sweep the roadways clean. The Contractor shall install any restriping necessary to achieve full compliance pavement markings prior to reopening. All costs related to pavement marking replacement shall be included in the work.

Do not use explosives for removal work without the written approval of the Engineer.

Removal shall include the superstructure, the substructure, which includes the piers, abutments and wingwalls, the bridge rail, and any approach slabs and sleeper slabs.

During removal of the substructure, take it down to at least 2 feet below the natural existing or future ground surface at the lowest point of interface with the abutment, unless otherwise approved by the Engineer. Holes resulting from substructure removal shall be backfilled with Structure Backfill (Class 2) to the adjacent existing grades.

All other materials removed from the existing structure shall become the property of the Contractor and shall be properly disposed of offsite at the Contractor's expense, unless otherwise stated on the plans.

The Contractor shall not damage the existing structures, facilities, and surrounding roadways during the removal operations. Repair damage that occurs immediately, at the Contractor's expense.

202.03 Salvable Material. All salvable material designated in the Contract to remain the property of the Department shall be removed without damage, in sections or pieces that may be readily transported and shall be stockpiled by the Contractor at specified locations within the project limits. The Contractor shall safeguard salvable materials and shall be responsible for the expense of repairing or replacing damaged or missing material until it is incorporated into the work or is loaded onto Department equipment by the Contractor.

Protect and remove all brass bridge plaques prior to demolition of the bridge. Deliver plaques to the Region Environmental group or Staff Bridge.

202.04 Signs and Traffic. Removal of signs shall include removal of posts, footings, pedestals, sign panels, and brackets. Concrete adhering to salvable signposts shall be removed.

Removal of sign panel shall include removal of the panel and its attachment hardware from the existing installation and adjusting the spacing of the remaining panels.

The removal of traffic signal items shall include poles, mast arms, signal heads, span wires, footings, all attachment hardware, and other incidental materials. Removal of signal pole or pedestal pole shall include pole, span wire, cable, signal heads, overhead sign support wire, footings, and pedestrian push buttons. Removal of traffic signal controller and cabinet shall include removal of the footing and all auxiliary equipment contained within the cabinet.

202.05 Pavement Markings. Pavement markings shall be removed from the pavement to the maximum extent possible, by methods that do not materially alter or damage the surface or texture of the pavement, to the satisfaction of the Engineer. The proposed method of pavement marking removal shall be designated by the Contractor at the Pre-construction Conference and approved by the Engineer. Operations that do not produce the desired result, damage the pavement, or may constitute a hazard to the traveling public will not be permitted. Materials deposited on the pavement because of removal of pavement markings shall be promptly removed so as not to interfere with traffic or roadway drainage.

Pavement markings, designated to be removed, shall be removed before any change is made in traffic patterns. Temporary marking tape sections longer than one foot shall be removed before placement of the final pavement course. All tape shall be removed on sections where tape conflicts with revised traffic lanes before opening of new lanes to traffic.

Removal of Temporary Pavement Marking on Final Alignment. Temporary pavement marking paint on the approved final alignment shall be removed completely from the roadway surface at locations of permanent pavement markings as shown on the plans. The removal location shall be clean, dry and free of laitance, oil, dirt, grease, paint, and other foreign contaminants before application of final pavement marking.

The Contractor shall not remove more pavement marking paint than what can be replaced with permanent pavement marking during the same working day or working period. If a storm or other event prevents the Contractor from completing the placement of permanent marking, the Contractor shall halt the removal operation and place raised flexible pavement markers where temporary pavement markings have been removed but the permanent markings have not been placed. Raised flexible pavement markers shall be installed with one marker at 40-foot centers. Raised flexible pavement markers shall remain in place while the pavement is drying before the permanent marking application. Permanent marking application shall resume when the pavement is dry and has had no moisture for a minimum of 24 hours.

Removal of Temporary Pavement Marking on Transitions. Removal of pavement marking paint on temporary transitional alignments shall be performed by grinding or water blasting. The removal shall result in 100 percent removal of the paint and a wide swath of ground pavement surrounding the former location of the temporary paint. The width of the swath shall be as follows; the center of the swath shall be the location of the paint line:

Table 202-1

REMOVAL OF TEMPORARY PAVEMENT MARKING - SWATH SIZE

Width of Pavement Marking to be Removed	Width of Swath
less than 8 inches	12 inches
more than 8 inches	15 inches

202.06 Detours. The Contractor shall completely remove the detour and dispose of the materials per the Contract.

202.07 Pavements, Sidewalks, Curbs. All concrete pavement, sidewalks, structures, curbs, gutters, designated for removal, shall be disposed of per subsection 201.02. Concrete pavement to be broken and left in place shall be broken so the largest fragment does not exceed 1 square yard in surface.

202.08 Portions of Structures. Unless otherwise directed, remove the substructures of removed structures to 2 feet below the natural stream bottom and remove those parts outside of the stream down 2 feet below natural ground or finished surface. Remove such portions of existing structures, which lie wholly or in part within the limits of a new structure, as necessary to accommodate the construction of the proposed structure.

Reinforcing steel projecting from the structure, designated to remain, shall be cleaned and aligned to the new construction.
Required dowels shall be securely grouted with approved grout. When concrete is removed, all exposed reinforcing steel designated to remain in place shall be cleaned by sandblasting to sound steel free of oil, dirt, concrete fragments or laitance, loose rust scale, and other coatings that would destroy or inhibit the bond with the new concrete.

Adequate measures shall be taken by the Contractor to protect the steel from contamination or corrosion. Reinforcing steel, contaminated because of the Contractor's failure to provide adequate protection, shall be re-sandblasted at the Contractor's expense with no allowance for contract time extension.

A protective device shall be placed between the sandblasting operations and the traveling public.

202.09 Removal of Asphalt Mat (Planing). The Contractor shall not commence planing operations until the hot mix asphalt, (HMA) Mix Design (CDOT Form 43) has been approved and signed.

Before beginning planing operations, the Contractor shall submit a planing plan for approval by the Engineer. This plan shall include as a minimum:

The number and types of planers to be used.

The width and location of each planing pass.

The number and types of brooms to be used, and their locations with respect to the planers. The Contractor shall have at least one back up broom on the project at all times in case one of the operating brooms breaks down.

Each planer shall conform to the following:

The planer shall have sufficient power, traction, and stability to maintain an accurate depth of cut. The propulsion and guidance system of the planer shall be maintained in such condition that the planer may be operated to straight and true lines.

Operation with broken or missing teeth will not be allowed. Worn teeth shall be replaced if the planer does not produce a uniform surface.

The planer shall be capable of picking up the removed asphalt in a single operation.

A self-loading conveyer shall be an integral part of the planer. Windrows will not be allowed.

All planed areas shall be broomed with a pickup broom, unless otherwise specified, before being opened to traffic. A sufficient number of brooms shall be used immediately after planing to remove all planed material remaining on the roadway.

If the Contractor fails to adequately clean the roadway, work shall cease until the Engineer has approved the Contractor's revised written proposal to adequately clean the roadway.

At the completion of each day's work, vertical edges caused by planing that are greater than 1 inch in height shall be: Longitudinal - tapered to not less than a 3:1 slope, Transverse - tapered to not less than a 50:1 slope.

The roadway shall be left in a safe and usable condition at the end of each workday. All required pavement markings, removed by the planing, shall be restored before the roadway is opened to traffic.

All planing shall be completed parallel to the travel lanes unless otherwise directed by the Engineer.

All planing shall be completed full width before resurfacing commences.

202.10 Clean Culvert. Culverts designated in the Contract to be cleaned shall be cleaned by removing all sedimentation and debris from within the culvert and all appurtenant structures.

METHOD OF MEASUREMENT

202.11. When the Contract provides payment for removal of obstructions on a lump sum basis, this payment will include all stipulated structures and obstructions encountered within the right of way per this section. When the Contract provides payment for the removal of specific items on a unit basis, measurement will be by the unit.

Removal of pavement marking will be measured in square feet, completed and accepted. Sandblasting of pavement that is to be covered with pavement marking material will be measured as the same area as measured for the pavement marking where the sandblasting is required.

Removal of asphalt mat (planing) will be measured by the area in square yards, completed to the required depth, and accepted.

Sandblasting reinforcing steel will be measured by the square yard of deck surface. Multiple layers of reinforcing steel within a common area of the deck exposed and requiring sandblasting will not be measured separately.

Clean culvert will be measured by the number of culverts acceptably cleaned as designated on the plans, irrespective of the kind or size involved.

Abandon well will be measured by the actual number plugged, abandoned, and the abandonment report submitted.

Removal of temporary pavement marking on transitions will be measured by the actual square feet of the swath that is removed for the required width. Removal of pavement marking for the permanent alignment will be measured as the actual in square feet of pavement marking that is removed.

BASIS OF PAYMENT

202.12 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule. Payment shall be full compensation for sawing, removing, disposal, excavation and subsequent backfill, and salvage of materials removed, their custody, preservation, storage, and disposal as provided.

Payment will be made under:

Pay Item	Pay Unit
Removal of Bridge	Each
Removal of Structures and Obstructions	Lump Sum
Removal of Asphalt Mat (Planing)	Square Yard
Removal of Pavement Marking	Square Foot
Removal of Pavement Marking (12 Inch)	Square Foot
Removal of Pavement Marking (15 Inch)	Square Foot
Plug	Each
Clean Culvert	Each
Abandon Well	Each
Sandblasting	Square Foot
Sandblasting (Reinforcing Steel)	Square Yard

When the Contract does not include pay items for removal of structures and obstructions, the removal will not be paid for separately but shall be included in the work.

Payment for abandon well will be full compensation for all labor and materials required to complete the work, including preparing and submitting the abandonment report.

Temporary raised flexible pavement markers used per subsection 202.05(a) will not be measured and paid for separately but shall be included in the work.

Payment for Removal of Bridge will be full compensation for all labor and materials required to complete the work, including, preparation and implementation of the Bridge Removal Plan, Engineering work, inspection, equipment, debris handling and disposal, salvaging, handling and storage of salvable materials, handling and disposal of all hazardous materials and disposal of non-salvable materials.

Lighting required for nighttime operations will not be measured and paid for separately but shall be included in the work.

DIAMOND GRINDING
CONCRETE PAVEMENT

DESCRIPTION

202.13 Diamond Grinding Concrete Pavement. This work consists of rehabilitating existing concrete pavement by diamond grinding to restore smoothness and texture at the locations indicated on the plans such that the surface area has a minimum average macrotexture depth of 0.05 inches when tested per Colorado Procedure 77B. The maximum grinding depth shall be 0.25 inches unless approved by the Engineer.

MATERIALS

202.14. A hardness of approximately 7 is anticipated for the existing concrete pavement based on the Mohs hardness scale. For bidding purposes, the Contractor shall be responsible for verifying the hardness of the existing concrete pavement.

CONSTRUCTION REQUIREMENTS

202.15. Before beginning work on the project, the Contractor shall submit to the Engineer for approval a detailed plan for accomplishing the grinding. The plan shall include a sequence for grinding that produces the desired surface ride qualities with a minimum macrotexture depth throughout the project. Grinding shall be performed in the longitudinal direction. The entire surface width of the driving and passing lane pavement shall be ground until the pavement surfaces on both sides of all transverse joints and random cracks are in the same plane and meet the smoothness requirements specified. Grinding shall begin and end at lines normal to the pavement centerline.

The Contractor shall grind driving and passing lane pavement surfaces within designated limits as shown on the plans. The finished grinding shall maintain the existing cross slope of the roadway in the driving and passing lanes. A feather pass shall be ground at the edge of traveled way as indicated on the plans or as directed by the Engineer. No adverse drainage conditions shall be caused by the grinding operations. The sequence of work shall not allow for ponding of water in the travel lanes due to a weather event. Shoulders that require grinding will be designated on the plans.

Approach slabs and bridge decks shall not be ground and textured. Grinding depth shall transition to 0 inches before the approach slab interface.

One stratified random acceptance test for texture per 2,500 linear feet or fraction thereof in each lane and shoulder shall be taken with a minimum of one test per day.

Smoothness for this project will be measured by the Department per subsection 105.08. The MRI after grinding for each 0.10-mile section or fraction thereof shall have an MRI of 95 in/mile or less. Sections with an MRI greater than 95 in/mile shall be corrected by further diamond grinding.

At various locations within the driving and passing lanes, miscellaneous tie bars may be exposed due to wearing of the pavement surface. Removal of these tie bars will be incidental to the grinding and texturing work.

All grinding shall be parallel to the longitudinal joints. Adjacent passes shall be overlapped by a maximum of 2 inches.

Grinding shall be performed using diamond blades mounted on a self-propelled machine designed for grinding and texturing concrete pavement. The equipment shall weigh a minimum 35,000 pounds including the grinding head and be of a size that will grind a strip at least 3 feet wide in a single pass. The effective wheelbase of the machine shall be at least 12 feet. Grinding equipment that causes raveling, aggregate fractures or disturbance to the joints shall not be permitted. The equipment shall be maintained to ensure it is in proper working order, including the roundness of the match and depth of control wheels. Any wheels found to be out of round shall be immediately replaced. The Engineer may approve smaller equipment for areas that the above equipment cannot reach.

The grinding process shall produce a pavement surface that is true to grade and uniform in appearance. Grooves shall be evenly spaced. Ridges on the outside edge next to the shoulder, auxiliary, or ramp lanes greater than 3/16 inch shall be feathered out to the satisfaction of the Engineer in a separate, feather pass operation. No adverse drainage conditions shall be caused by the grinding operations.

The pavement surface after grinding shall have no depressions or misalignment of slope in the longitudinal direction exceeding 1/8 inch in 10 feet when measured with a 10-foot straightedge placed parallel to the centerline. The grinding coverage shall be at least 95 percent of the pavement surface area. All areas of deviation shall be reground at no additional cost.

When the texture depth is below the lower specified limit, the Contractor shall determine the area represented by this test. The area shall be determined by taking additional tests at 15-foot intervals parallel to the centerline in each direction from the affected location until two consecutive tests are found to be within the specified limits. Any surface with unacceptable texturing exceeding 25 linear feet in any lane or shoulder shall be reground (full width). After the Engineer approves the limits, the Contractor shall correct the deficient surface texture by grinding full width at no additional cost to the project. The corrected surface texture will be retested for acceptance. Correcting surface texture deficiencies shall occur before pavement smoothness testing. Upon the second unacceptable test result, the Contractor shall notify the Engineer, in writing, the action taken to provide an acceptable surface macrotexture. Upon the project's third unacceptable test result from the Department, the Engineer will notify the Contractor, in writing, and the pay estimate will be withheld until diamond grinding is taken to provide an acceptable surface macrotexture.

The slurry and residue, including joint sealant, resulting from the grinding operation shall not be allowed to flow across lanes occupied by traffic and shall be continuously removed during the grinding operation, leaving the pavement in a clean condition.

The Contractor shall haul the grinding residue to an approved suitable location at no additional cost. The Contractor shall obtain approval of the disposal method from the Engineer before beginning the grinding operation.

METHOD OF MEASUREMENT

202.16. Diamond Grinding Concrete Pavement will be measured by the square yard of acceptable finished surface regardless of the number of passes required. The quantity of grinding and texturing will be determined by measuring the finished area ground within the limits indicated on the plans or as directed by the Engineer.

BASIS OF PAYMENT

202.17. Diamond Grinding Concrete Pavement will be paid for at the contract unit bid price per square yard. Payment will be considered full compensation for all labor, materials, supplies, tools, water, equipment, and incidentals necessary for completing the work as specified. Payment will be made under:

Pay Item	Pay Unit
Diamond Grinding Concrete Pavement	Square Yard

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SECTION 203

EXCAVATION AND EMBANKMENT

DESCRIPTION

203.01 General. This work consists of excavation, hauling, disposal, placement, and compaction of all material encountered within the limits of the work, including construction of dikes and excavation for ditches and channels, necessary for the construction of the roadway per the Contract.

MATERIALS

203.02 Excavation Definitions. All excavation will be defined as, "unclassified excavation", "stripping", "removal of unsuitable material", "rock excavation", "borrow", or "potholing" as described below:

(a) Unclassified Excavation. Unclassified excavation shall consist of the excavation of all materials of whatever character required for the work, obtained within the right of way, including surface boulders and excavation for ditches and channels that is not removed under some other item.

(b) Stripping. Stripping shall consist of removing overburden or other specified material from borrow pits, and the replacement of overburden or other specified material over the disturbed area of the site or pit after the underlying material has been removed.

(c) Removal of Unsuitable Material. Removal of unsuitable material shall consist of the removal of soils or mixtures of soil and organic matter identified in the Contract or as directed by the Engineer that would be detrimental to the roadway or embankment if left in place in its existing condition.

(d) Rock Excavation. Rock excavation shall consist of removal of igneous, metamorphic, and sedimentary rock that cannot be excavated without blasting or with the use of rippers, including all boulders or other detached stones having a volume of 1/2 cubic yard or more. Unless specified in the Contract, rock excavation is material that meets one of the following field test criteria to be conducted by the Contractor:

1. Ripping Test: Material that cannot be broken down by one pass with a single tooth ripper mounted on a crawler type tractor in low gear with a minimum net flywheel power rating of 235 horsepower; or material that cannot be broken down with a 48,000-pound tracked excavator using a bucket with rock teeth.

2. Seismic Test: Material that has a seismic velocity of 6,000 feet per second or greater. The Contractor shall submit the qualifications of the individual performing or interpreting the seismic testing to the Engineer a minimum of 14 days before testing. The ripping test will be used to resolve differences if seismic velocities fall below 6,000 feet per second.

3. Handling Test: Any boulder or detached stone having a volume of ½-cubic yard or more that cannot be readily broken down with the excavation equipment described above in 1.

(e) Borrow. Borrow shall consist of approved material obtained from outside the right of way required for the construction of the project.

(f) Potholing. Potholing shall consist of exposing and verifying the location of existing utilities at locations as directed.

203.03 Embankment Material. Embankment material shall consist of approved material acquired from excavations or borrow pits and hauled and placed in embankments. Approval of embankment material is contingent on the material meeting the Atterberg Limit and gradation requirements specified in the Contract. Approval of the embankment material in the upper 2 feet of embankment below the subgrade elevation is contingent on the material meeting one of the following as specified in the Contract:

(1) The specified resistance value when tested by the Hveem Stabilometer or the equivalent resilient modulus.

(2) The specified Atterberg Limit and gradation requirements.

(3) The specified resistance value when tested by the Hveem Stabilometer or equivalent resilient modulus, and the specified Atterberg Limit and gradation requirements.

Embankment material shall be classified into one of the material groups listed below and placed and compacted per the appropriate methods specified in subsection 203.07. If any material does not meet the criteria for one of the following classifications, it shall be processed on site to meet the requirements for one of the material groups listed below or disposed of at the Contractor's expense.

1. Soil Embankment: Soil embankment shall have all particle sizes less than 6 inches. The material shall be classified per AASHTO M 145 and placed and compacted per subsection 203.07(a).

2. Rock Embankment: Rock embankment shall meet all of the following requirements:

   A. A minimum of 50 percent of the material shall be retained on the 4.75 mm (No. 4) sieve.

   B. More than 30 percent of the material shall be retained on the 19.0 mm (3/4-inch) sieve.

   C. The material shall meet the classification of an AASHTO A-1 soil type.

   D. All particle sizes shall be less than 6 inches.

   E. Particles retained on the 4.75mm (No. 4) sieve shall not be composed of non-durable bedrock types.

   Rock embankment may be placed without moisture density control as described in subsection 203.07(b).

3. Rock Fill: Rock fill shall meet all of the following requirements:

   A. A minimum of 50 percent of the material shall be retained on a 100 mm (4-inch) sieve.

   B. The maximum dimension of any particle shall not exceed 36 inches.

   C. The material shall be well-graded as determined on visual inspection.

   D. The material shall contain less than 20 percent by volume of material passing the 75 µm (No. 200) sieve based on visual inspection.

E. Particles retained on the 4.75 mm (No. 4) sieve shall not be composed of non-durable bedrock types.

Rock fill can be placed without moisture density control as described in subsection 203.07(b).

Non-durable bedrock shall be identified and classified using Colorado Procedure - Laboratory (CP-L) 3104. Any material classified as Soil-like Non-durable (S-N) as defined in the procedure shall be pulverized, broken down and processed to 6-inch maximum particle sizes before incorporation into embankment fill. These materials shall be placed and compacted as "soil embankment" per subsection 203.07(a). Non-durable bedrock particles in excess of 6 inches shall not be placed into embankment fill.

If recycled concrete or asphalt are to be incorporated into embankment fill, the maximum dimension permitted for concrete is 24 inches and the maximum dimension permitted for asphalt is 12 inches. Embankment material imported onto the project will be tested for water soluble sulfates using CP-L 2103 Method B. The average of three consecutive tests shall show that the sulfate content is not greater than that corresponding to the sulfate exposure level specified in the Contract. No single test shall have a sulfate content more than 20 percent greater than that corresponding to the sulfate exposure level specified in the Contract. When there is a single failing test, the remaining sample shall be split into four equal portions. The CDOT Region Lab shall receive one portion, the Contractor shall receive one portion, and the remaining two portions shall go to the CDOT Central Lab. The CDOT Region Lab, the CDOT Central Lab, and the Contractor's Lab shall retest the sample. If the results from the three labs are within 10 percent of each other, the results will be averaged. The averaged result will be used for determining Contract compliance. If the results from the labs are not within 10 percent of each other, the remaining split sample shall be sent to an independent laboratory for testing using CP-L 2103. The independent laboratory shall be mutually agreed upon by the Department and the Contractor. The independent lab's test result will be used for determining Contract compliance.

If the water-soluble sulfate content is less than that corresponding to the sulfate exposure level specified in the Contract, CDOT will bear all costs associated with the independent lab test. If the soluble sulfate content is greater than that corresponding to the sulfate exposure level specified in the Contract, all costs associated with independent lab testing shall be at the Contractor's expense. Embankment represented by failing tests shall be removed from the project and replaced at the Contractor's expense.

Imported material used for backfilling pipes (storm sewer, cross culverts, side drains, etc.) shall be tested for compatibility with the selected pipe material. When non-reinforced concrete pipe or reinforced concrete pipe is used, the imported material shall be tested for sulfate and pH. When corrugated steel pipe, bituminous-coated corrugated steel pipe or pre-coated corrugated steel pipe is used, the imported material shall be tested for sulfates, chlorides, pH and resistivity. When aramid fiber bonded corrugated steel pipe or corrugated aluminum pipe is used, the imported material shall be tested for pH and resistivity. When plastic pipe is selected, the imported material does not need to be tested for sulfates, chlorides, pH or resistivity.

Sulfates, chlorides, pH and resistivity shall be determined by the following procedures:

(1) Water soluble sulfates using CP-L 2103 Method B
(2) Chlorides using CPL 2104
(3) Resistivity using ASTM G57
(4) pH using ASTM G51

The average of three consecutive tests shall show the imported material's sulfate, chloride, pH and resistivity is not greater than the limits corresponding to the Pipe Class in Table 203-1 or 203-2 for the pipe class specified in the Contract. No single test shall have a result more than 20 percent greater than that corresponding to the limit in Table 203-1 or Table 203-2 for sulfates, chlorides and resistivity. No single test shall have a result more than 5 percent outside the limit in Table 203-1 for pH. The remaining sample material from a single failing test shall be split into three equal portions. CDOT shall receive one portion, the Contractor shall receive one portion and the remaining portion shall be retained by the Project. CDOT and the Contractor's Lab shall retest the failed sample; if the results from those tests are within 10 percent of each other, the results will be averaged. The averaged result will be used for Contract compliance. If the results from the Labs are not within 10 percent of each other, the remaining sample portion shall be sent to an independent laboratory for testing using the testing requirements specified above. The independent laboratory shall be mutually agreed upon by the Department and the Contractor. The Independent Lab's test result will be used for Contract compliance.

If the imported material's sulfates, chlorides, and resistivity are less than the limits and the pH is within the limits in Table 203-1 or 203-2, CDOT will bear all costs associated with the independent lab test. If the imported material's sulfates, chlorides, and resistivity is greater than the limits and the pH is outside the limits in Table 203-1 or 203-2, all costs associated with independent lab testing shall be at the Contractor's expense.

Embankment represented by failing tests shall be removed from the project and replaced at the Contractor's expense.

Table 203-1
SULFATE, CHLORIDE AND pH OF IMPORTED MATERIAL

Pipe Class	Soil Sulfate (SO4) % max.	Soil Chloride (Cl) % max.	Soil pH
0, 7	0.05	0.05	6.0-8.5
1, 7	0.1	0.1	6.0-8.5
2, 8	0.2	0.2	6.0-8.5
3, 9	0.5	0.5	6.0-8.5
4, 9	1	1	5.0-9.0
5, 10	2	2	5.0-9.0
6, 10	>2.00	>2.00	<5 or >9

Table 203-2

RESISTIVITY AND pH OF IMPORTED MATERIAL

SOIL SIDE Resistivity R (Ohm – cm)	**SOIL SIDE** pH
≥ 1500	5.0-9.0
≥ 250	3.0-12.0

CONSTRUCTION REQUIREMENTS

203.04 General. The excavations and embankments shall be finished to smooth and uniform surfaces conforming to the typical sections specified. Variation from the subgrade plan elevations specified shall not be more than 0.08 foot. Where asphalt or concrete surfacing materials are to be placed directly on the subgrade, the subgrade plane shall not vary more than 0.04 foot. Materials shall not be wasted without written permission of the Engineer. Excavation operations shall be conducted so material outside of the slope limits will not be disturbed. Before beginning grading operations, all necessary clearing and grubbing in that area shall have been performed per Section 201.

The Contractor shall notify the Engineer at least five workdays before beginning excavation. The Contractor shall not excavate beyond the dimensions and elevations shown in the Contract.

Archaeological and paleontological materials encountered during the work shall be handled per subsection 107.23.

All excavation activities in areas where asbestos is encountered or expected to be encountered shall conform to the Colorado Department of Public Health and Environment's Asbestos-Contaminated Soil Guidance Document or the State of Colorado's Asbestos Contaminated Soil Statewide Management Plan (ACS), whichever is more recent at the time of advertisement and per subsection 250.07(d) and the Air Quality Control Commission Regulation No. 8 Part B or Section 5.5 of the solid Waste Regulation 6 CCR 1007-2, as applicable.

203.05 Excavation. Excavation shall be one or more of the following:

(a) Rock. Unless otherwise specified, rock shall be excavated to a minimum depth of 0.5 foot and a maximum depth of 1 foot below subgrade, within the limits of the roadbed. Rock removed in excess of 1 foot below subgrade will not be paid for. Backfilling of the depth in excess of 1 foot below subgrade shall be at the Contractor's expense. Approved embankment material shall be used to bring the rock-excavated areas to subgrade elevations within the tolerances specified in subsection 203.04.

Undrained pockets shall not be left in the rock surface and depressions shall be drained at the Contractor's expense.

When required for rock excavation, controlled blasting shall be conducted per the Contract.

(b) Unclassified. Excess or unsuitable excavated material, including rock and boulders, that cannot be used in embankments may be placed on the side slopes of the nearest fill if approved.

Unless otherwise specified by the Engineer, intercepting ditches shall be made above the top of cut slopes and carried to outlets near the ends of the cuts. In order to blend the intersection of cut slopes with the slope of the adjacent natural ground surfaces in a uniform manner, the tops of all cut slopes, except those in solid rock, shall be flattened and rounded per typical sections and details specified. Earth overburden lying above solid rock cuts shall be treated in the same manner as earth cuts.

The Department reserves the right to change cut slopes during the progress of excavation.

(c) *Unsuitable Material*. Unsuitable materials encountered in the subgrade, roadway, or embankment foundation that are determined to be detrimental to the roadway or embankment shall be removed to the depth and extents directed by the Engineer. The excavated area shall be backfilled to the finished graded section with approved material. Materials that contain organics or that cannot be dried or moisture conditioned, then compacted to the required density shall be disposed of and shall not be reused as embankment fill. Materials that do not contain organics and that can be dried or moisture conditioned and compacted to the required density may be reused as embankment fill as approved by the Engineer.

(d) *Borrow*. If the Contractor places more borrow than is specified or approved and causes a waste of roadway excavation, the quantity of waste will be deducted from the borrow volume. All borrow areas shall be bladed and shaped to permit accurate measurements after excavation is completed. The finished borrow areas shall be graded to a smooth and uniform surface and shall be finished so water will not collect or stand, unless otherwise specified.

(e) *Stripping*. Overburden shall be removed to the depth required for the production of acceptable material, and at least 5 feet beyond area being excavated.

(f) *Potholing*. All necessary potholing as determined by the Contractor and agreed to by the Engineer shall be completed under this item with appropriate equipment as approved.

The Contractor shall acquire necessary permits, locate utilities, excavate all materials of whatever character required to expose the utilities, survey the location of the utilities, and backfill the excavation to existing grade lines with the excavated or other approved materials. Backfilling shall be accomplished per subsection 206.03.

The Contractor shall use extreme caution during this work. All damage to existing utility lines or adjacent facilities shall be repaired promptly at the Contractor's expense.

203.06 General Embankment Construction Requirements. When Contractor Process Control is required, the Contractor's Process Control Representative shall be certified with Western Alliance for Quality Transportation Construction (WAQTC) Embankment and Base Testing and CDOT's Excavation, Embankment, and Soil Inspection certification course.

Embankment construction shall include preparation of the areas where embankments are to be placed, construction of dikes, and placing and compacting approved material within roadway areas including holes, pits, and other depressions within the roadway area. Only approved materials shall be used in the construction of embankments and fills.

All sod, vegetable and other organic matter, stumps, and roots shall be removed from the surface where the embankment is to be placed per Section 201. Unless a thickness is otherwise specified in the Contract, the upper 4 inches of the ground surface will be considered topsoil and shall be removed per Section 207 before placement of embankment fill.

The cleared surface shall be completely broken up by plowing or scarifying to a minimum depth of 6 inches or as specified in the Contract, the moisture content increased or reduced as necessary, and compacted to the specified embankment density for the material type present.

When embankment is placed on a slope that is steeper than 4H:1V, as measured in the steepest direction, the existing slope shall be benched as the embankment is placed in layers. A 2-foot-deep key shall be excavated at the base of the existing slope and backfilled with approved and compacted material. The embankment shall be placed in layers from that key. Each horizontal cut shall begin at the intersection of the original ground and the vertical sides of the previous bench. Excavated material from benching may be placed and compacted with the embankment material at the Contractor's expense.

During the course of construction, embankment side slopes shall be built a minimum of 12 inches wider than the final grade indicated in the Contract to allow for compaction equipment to compact the full width of the embankment. Once the specified level of compaction is achieved, the side slopes shall be trimmed back to final grade. Excess material placement and removal to satisfy this requirement shall be at the Contractor's expense.

If embankment can be placed on only one side of structures such as retaining walls, abutments, wing walls, piers, or culvert headwalls, compaction shall be accomplished without initiating movement or deformation of the structure and without placing excessive pressure against the structure. When noted in the Contract, the fill adjacent to the abutment of a bridge shall not be placed higher than the bottom of the backwall until the superstructure is in place. When embankment is placed on both sides of a concrete wall or box type structure, the embankment shall be brought up equally on both sides of the structure.

Where embankment is to be placed and compacted and end dumping is used, the slopes of the original ground or embankment shall be deeply plowed or scarified before starting end dumping.

Embankment fill other than A-1 soil types shall not be placed within standing water, unless otherwise noted in the Contract. During the construction of the embankment, the top surface shall be maintained so that it is well drained at all times.

Frozen materials shall not be used in construction of embankments. Frozen material will be identified by the visual observation of ice crystals within the foundation or embankment material, or by measuring the temperature of the ground surface.

203.07 Embankment Placement and Compaction Requirements. Materials incorporated into embankment fill shall be placed and compacted according to the following requirements:

(a) Soil Embankment. All soil embankment shall be placed in horizontal layers not to exceed 8 inches in loose lift thickness. Each layer shall be compacted before the placement of subsequent layers. Spreading equipment shall be used to obtain uniform thickness before compaction. As the compaction progresses, continuous mixing, leveling, and manipulating shall be done to assure uniform moisture and density. Additional work involved in drying soil embankment to the required moisture content shall be included in the contract price paid for excavating or furnishing the material with no additional compensation.

Soil embankment that is classified as A-1 material may be used to bridge across standing water or swampy ground within the embankment foundation and may be placed in lift thicknesses greater than 8 inches when used for this purpose if approved by the Engineer.

Soil embankment with less than or equal to 30 percent retained on the 3/4-inch sieve shall be tested for compaction using CP 80. Materials classified as AASHTO A-1, A-2-4, A-2-5, and A-3 soils shall be compacted at plus or minus 2 percent of Optimum Moisture Content (OMC) and to at least 95 percent of maximum dry density determined per AASHTO T 180 as modified by CP 23. All other soil types shall be compacted to 95 percent of the maximum dry density determined per AASHTO T 99 as modified by CP 23. Soils with 35 percent fines or less shall be compacted at plus or minus 2 percent of OMC. Soils with greater than 35 percent fines shall be compacted at a moisture content equal to or above OMC to achieve stability of the compacted lift. Stability is defined as the absence of rutting or pumping as observed and documented by the Contractor's Process Control Representative and as approved by the Engineer. If the soils cannot be compacted and prove to be unstable at a moisture content equal to or above OMC, then the required moisture content for compaction may be reduced below OMC if approved by the Engineer.

Before placing any soil embankment with greater than 30 percent retained on the 3/4-inch sieve, the Contractor shall construct a test strip to the dimensions specified in the Contract or as directed by the Engineer. The test strip may be incorporated into the final embankment. The Contractor shall determine the moisture conditioning necessary to achieve compaction and shall determine the equipment and number of passes necessary to achieve adequate compaction. The Contractor shall use compression-type or vibratory rollers on granular materials and sheepsfoot rollers on cohesive soils. Adequate compaction shall be demonstrated by the absence of rutting, pumping, or deflection following a proof roll of the test strip using any piece of construction equipment that exerts a minimum 18-kip per axle load. The proof roll will be observed and accepted by the Engineer. Once the test strip passes a proof roll, the Contractor may resume embankment construction using the same moisture conditioning and compaction methods that were used to construct the test strip.

Placement, moisture conditioning, and compaction of every lift of soil embankment with greater than 30 percent retained on the 3/4-inch sieve shall be observed by the Contractor's Process Control Representative and accepted by the Engineer. Adequate compaction of each lift shall be demonstrated as the absence of rutting, pumping, or deflection as construction equipment is routed over a lift following the compactive efforts that were used and accepted for the respective test strip. The Engineer may request a proof roll at any time to document the condition of a lift.

Significant changes in the material being hauled for soil embankment with greater than 30 percent retained on the 3/4-inch sieve will require construction of a new test strip, and demonstration of adequate compaction methods using a proof roll.

Non-durable bedrock shall be watered to promote slaking and break down and pulverized or processed to a maximum particle size of 6 inches. These materials shall be placed and compacted as soil embankment; except they shall be compacted with a heavy tamping foot roller weighing at least 30 tons. Each tamping foot shall protrude from the drum a minimum of 4 inches. Each embankment layer shall receive a minimum of four passes with the tamping foot roller.

The roller shall be operated at a uniform speed not exceeding 3 miles per hour. No additional compensation will be made for additional roller passes to achieve specified density requirements.

Non-durable Bedrock shall not be used to bridge over standing water or swampy ground within an embankment foundation. Non-durable bedrock shall also not be placed within 2 feet of the final subgrade elevation.

(b) Rock Embankment and Rock Fill.

Rock embankment shall be placed in horizontal layers not to exceed 8 inches in loose lift thickness. The lift thickness can be increased when bridging over standing water or swampy ground in the embankment foundation as directed by the Engineer. Each layer shall be compacted before the placement of subsequent layers. Spreading equipment shall be used to obtain uniform thickness before compaction.

Rock fill shall be placed in horizontal layers not to exceed a loose lift thickness equivalent to the average particle size up to a maximum permitted lift thickness of 18 inches. Particles with a maximum dimension of 36 inches are permitted; however, rocks larger than the lift thickness shall be separated enough to allow compaction equipment to operate in between. Material shall be placed to fill in voids between larger stones with finer particle sizes and to avoid nesting. Spreading equipment shall be used to obtain uniform thickness before compaction. If the use of leveling equipment is not practical, the Engineer may permit rock fill material to be cast or end dumped. In such cases sufficient hand or machine work will be required to construct a compact, stable fill and to finish the slopes to a neat and smooth appearance. Rock fill shall not be placed within 2 feet of the final subgrade elevation. When a rock fill is placed over any structure, the structure shall be covered with a minimum of 2 feet of compacted soil embankment or rock embankment material before the rock fill is placed.

The Contractor shall determine the moisture conditioning necessary to achieve compaction for rock embankment or rock fill. Vibratory or compression-type rollers shall be used to compact these materials. At a minimum, compression-type rollers weighing 20 tons shall complete four passes over the entire width of a lift at a speed not to exceed 3 miles per hour. Vibratory rollers shall exert a minimum dynamic force of 30,000 pounds of impact per vibration and achieve a minimum 1,000 vibrations per minute. Vibratory rollers shall complete a minimum of four passes over the entire width of a lift at a speed not to exceed 1.5 miles per hour.

Before placing rock embankment or rock fill, the Contractor shall construct a test strip to the dimensions specified in the Contract, or as directed by the Engineer. The test strip may be incorporated into the final embankment. Adequate compaction of the rock embankment or rock fill test strip shall be demonstrated by the absence of rutting, pumping, or deflection following a proof roll of the test strip using any piece of construction equipment that exerts a minimum 18-kip per axle load. The proof roll will be observed and accepted by the Engineer. Once the test strip passes a proof roll, the Contractor can resume rock embankment or rock fill construction with the same moisture conditioning and compaction methods as the test strip was constructed. Placement, moisture conditioning, and compaction of every lift of rock embankment and rock fill shall be observed by the Contractor’s Process Control Representative and accepted by the Engineer. Adequate compaction of each lift shall be demonstrated as the absence of rutting, pumping, or

deflection as construction equipment is routed over a lift following the compactive efforts that were used and accepted for the respective test strip. The Engineer may request a proof roll at any time to document the condition of a lift.

Significant changes in the characteristics of material being hauled for rock embankment or rock fill will require construction of a new test strip, and demonstration of adequate compaction methods using a proof roll.

If the Contractor wishes to deviate from the minimum equipment and compactive efforts specified above for rock embankment or rock fill, the Contractor must first demonstrate the adequacy of the proposed methods with a test strip and passing proof roll. In addition, proof rolls are required for every lift placed for the first 2,000 cubic yards of rock embankment or rock fill placed. The proof rolls used to demonstrate adequate compaction of the first 2,000 cubic yards placed will not be measured and paid for separately but shall be performed at the Contractor's expense.

(c) *Use of Recycled Concrete and Asphalt*. Recycled concrete and asphalt may be incorporated into embankment material, and shall be processed, placed, and compacted per subsection 203.07(a) or (b), depending on the overall classification of the embankment material once the recycled material is incorporated. Rebar shall not extend more than one inch beyond the edges of recycled concrete particles. Recycled concrete or asphalt shall not be placed in the upper 2 feet of the final subgrade elevation or within 2 feet of the final finished side slopes unless otherwise noted in the Contract.

203.08 Proof Rolling. Proof rolling with pneumatic tire equipment shall be performed using a minimum axle load of 18 kips per axle. A weigh ticket from an approved scale shall be furnished by the Contractor to substantiate this weight.

The subgrade shall be proof rolled after the required compaction has been obtained and the subgrade has been shaped to the required cross section.

The proof roller shall be operated in a systematic manner so that a record may be readily kept of the area tested and the working time required for the testing. Areas that are observed to have soft spots in the subgrade, where deflection is not uniform or is excessive as determined by the Engineer, shall be ripped, scarified, dried or wetted as necessary, and re-compacted to the requirements for density and moisture at the Contractor's expense. After re-compaction, these areas shall be proof rolled again and all failures again corrected at the Contractor's expense.

Upon approval of the proof rolling, the subbase, base course, or initial pavement course shall be placed within 48 hours. If the Contractor fails to place the subbase, base course, or initial pavement course within 48 hours or the condition of the subgrade changes due to weather or other conditions, proof rolling, and correction shall be performed again at the Contractor's expense.

203.09 Blading. Blading shall consist of furnishing motor graders of the specified horsepower rating, with operators, for shaping roadway, shoulders, or other areas as designated by the Engineer.

When scarifying is specified, the motor grader shall be equipped with an independently operated "V" type scarifier and attachments.

203.10 Dozing. Dozing shall consist of furnishing crawler-type tractors of the specified horsepower rating, complete with operators and bulldozer blades. Rippers, if specified, will not be measured and paid for separately, but shall be included in the work.

METHOD OF MEASUREMENT

203.11. Items paid for by volume be the quantities designated in the Contract. Exceptions will be made when field changes are ordered or when it is determined that there are discrepancies in the Contract in an amount of at least plus or minus two percent of the plan quantity.

(a) Excavation. The original cross-sections will be used for determination of volumes of excavated material removed, unless changes have been directed. These measurements will include authorized excavation of rock, shale, or other unsuitable material. All accepted stripping will be measured in stockpiled locations by cross-sectioning.

When the excavation conforms to the staked lines and grades, the original cross-sections and the staked sections shall be used for the determination of volumes excavated. Volumes will be computed from the cross-sections by the average end area or other acceptable method.

When topsoil or wetland topsoil is included as a separate pay item and is specified, the measured volume of excavation will be reduced by the volume of topsoil or wetland topsoil removed from the area shown as excavation in the Contract.

Measurements will include over-breakage in rock excavation from the back slopes to an amount not to exceed, in any half station of 50 feet, 10 percent of the actual quantity required for that half station.

(b) Embankment. If provided in the Contract, embankment material will be measured in its final compacted position in the roadway. Measurement will be made upward from the original ground line without any allowance for subsidence due to compaction of the base under the embankment. The original cross-sections will be used for determination of volumes of embankment material placed, unless changes have been directed.

The measured volume of embankment material will be increased by the volume of topsoil or wetland topsoil removed from the area below the original ground line and under the embankment.

(c) Rock Fill. Rock fill will be measured as the volume in cubic yards in its final position, unless otherwise specified, and shall be limited to the elevations specified.

(d) Blading and Dozing. The quantity measured for blading and dozing will be the number of hours that each motor grader or bulldozer is actually used as ordered. A minimum of four hours for any half shift or part thereof will be paid for unless the equipment is inoperative due to breakdown or other causes determined to be the Contractor's responsibility. Time involved in moving onto or off the project will not be measured and paid for.

Time will be paid for moving motor graders or bulldozers from one location on the project to another, if directed; but time will not be allowed for moves that are made for the convenience of the Contractor.

Payment for a minimum of four hours will not be allowed in cases where the motor grader, bulldozer, or operator is assigned to work on other pay items connected with the project.

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(e) Potholing. Potholing will be measured by the total number of hours that excavation and backfilling equipment is actually used as directed. All other related work, including removal of existing pavement, backfilling, shoring, and labor will not be measured and paid for separately, but shall be included in the work.

(f) Proof Rolling. Proof rolling will be measured by the actual number of hours that the pneumatic equipment is used as a proof roller.

The time to be measured under this item will be the number of hours that each piece of equipment is actually used as ordered.

Proof rolling will be measured and paid for only once for each test strip required during construction; for final verification of subgrade before placement of subbase, base coarse, or pavement; or for each incident where the Engineer directs it through the course of construction. Additional proof rolling that is required due to failure of embankment fill; due to the Contractor's failure to place subbase, base course, or initial pavement course within 48 hours of the initial proof roll; or due to the condition of the subgrade changing due to weather; or additional proof rolls deemed necessary due to the Contractor's choice to deviate from minimum equipment and compaction efforts specified, shall be at the Contractor's expense.

BASIS OF PAYMENT

203.12 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Unit
Rock Excavation	Cubic Yard
Rock Fill	Cubic Yard
Unclassified Excavation	Cubic Yard
Unclassified Excavation (Complete in Place)	Cubic Yard
Unsuitable Materials	Cubic Yard
Borrow	Cubic Yard
Borrow (Complete in Place)	Cubic Yard
Embankment Material (Complete in Place)	Cubic Yard
Stripping	Cubic Yard
Blading	Hour
Dozing	Hour
Potholing	Hour
Proof Rolling	Hour

Water will not be measured and paid for separately but shall be included in the work.

Compaction will not be measured and paid for separately but shall be included in the work.

Payment for replacement of unsuitable material shall be as follows: If excavated material can be re-used as embankment fill by moisture conditioning and compaction, replacement shall be included in the cost for Unsuitable Material. If the material cannot be re-used as embankment fill, payment for replacement of unsuitable material shall be for the volume that is placed in the excavated area at the respective unit price for the material that is approved by the Engineer and used.

Payment for Unclassified Excavation (Complete in Place), Embankment Material (Complete in Place), or Borrow (Complete in Place) shall be full compensation for all work necessary to complete the item including construction of embankments, reworking of existing materials to satisfy benching requirements, unclassified excavation, borrow, compaction, compaction of bases of cuts and fills, all work in available materials pits, and disposal of excess excavated material.

Reducing the size of the claystone particles, removing the oversized particles, and disposal of the oversized particles will not be measured and paid for separately but shall be included in the work.

Ripping tests or seismic tests used to evaluate whether a material meets the criteria for Rock Excavation will not be measured and paid for separately but shall be included in the work.

Pavement replacement if required due to potholing, shall be accomplished, measured, and paid for per appropriate sections of the specifications.

Pneumatic tire equipment and load required to achieve the desired weight of proof rolling equipment will not be measured and paid for separately but shall be included in the work.

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SECTION 206

EXCAVATION AND BACKFILL FOR STRUCTURES

DESCRIPTION

206.01. This work consists of the excavation and backfill, or disposal of all material required for the construction of structures.

The excavation and disposal of excavated material for ditches and channels shall be accomplished per Section 203.

All excavation and backfill for structures below the designed slope or subgrade line provided in the Contract shall be included under this item.

Unless otherwise specified, structure excavation shall include all pumping, bailing, draining, and incidentals required for proper execution of the work.

MATERIALS

206.02 General. All structure backfill, bed course material, and filter material will be accepted in place.

(a) Structure Backfill.

1. Structure Backfill (Class 1), (Class 2), and (Class 3). Class 1, Class 2, and Class 3 structure backfill shall be composed of non-organic mineral aggregates and soil from excavations, borrow pits, or other sources. Material shall conform to the requirements of subsection 703.08. Class of material shall be as specified in the Contract or as designated.

   Structure Backfill (Class 1) with mechanical reinforcement shall be used to backfill bridge abutments, unless otherwise shown on the Plans.

   Imported material used as structure backfill for pipes (storm sewer, cross culverts, side drains, etc.) shall meet the requirements of the Class specified and the requirements of subsection 206.02(a)3.

   The Contractor may substitute Structure Backfill (Flow-Fill) conforming to subsection 206.02(a)2 for Structure Backfill (Class 1) or Structure Backfill (Class 2) to backfill culverts and sewer pipes.

   The Contractor may also substitute Structure Backfill (Class 3) as backfill for culverts and sewer pipes.

2. Structure Backfill (Flow-Fill). Flow-Fill shall be a self-leveling low strength concrete material composed of cement, fly ash, aggregates, water, chemical admixtures or cellular foam for air-entrainment. Flow-fill shall have a slump of 7 to 10 inches, when tested per ASTM C143 or a minimum flow consistency of 6 inches when tested per ASTM D6103. Flow-Fill shall have a minimum compressive strength of 50 psi at 28 days when tested per ASTM D4832. Flash fill is a rapid setting Flow-Fill that may be used when approved by the Engineer and will be tested, accepted, and paid for as Flow-Fill.

Flow-Fill placed in areas that require future excavation, such as utility backfill shall have a Removability Modulus (RM) of 1.5 or less.

Removability Modulus, RM, is calculated as follows:

$$RM = \frac{W^{1.5} \times 104 \times C^{0.5}}{10^6}$$

where: W = unit weight (pcf)

C = 28-day compressive strength (psi)

Materials for Structure Backfill (Flow-Fill) shall meet the requirements specified in the following subsections:

Fine Aggregate*, ▸ 703.01

Coarse Aggregate#, ▸ 703.02

Portland Cement 701.01

Fly Ash ◂ , ▸ 701.02

Water 712.01

Air-Entraining Admixture 711.02

Chemical Admixtures 711.03

*Fine aggregate not meeting the requirements of subsection 703.01 may be used if testing indicates acceptable results for strength and air content.

#Coarse aggregate not meeting the requirements of subsection 703.02 may be used if testing indicates acceptable results for strength and air content.

◂ Fly ash not meeting the requirements of subsection 701.02 may be used if testing indicates acceptable results for strength and air content.

▸ For industrial by-product aggregates (foundry sand, bottom ash, etc.) and fly ash not meeting the requirements of subsection 701.02 the Contractor shall submit a report from the supplier documenting the results of testing per the Toxicity Characteristic Leaching Procedure (TCLP) described in 40 CFR 261. The report shall include the results of TCLP testing for heavy metals and other contaminants. Materials shall not exceed the TCLP limits of 40 CFR 261.24 for heavy metals.

Cellular foam shall conform to ASTM C869 and ASTM C796.

Recycled broken glass (glass cullet) is acceptable as part or all of the aggregate. Aggregate including glass must conform to the required gradations. All containers used to produce the cullet shall be empty before processing. Chemical, pharmaceutical, insecticide, pesticide, or other glass containers containing or having contained toxic or hazardous substances shall not be allowed and shall be grounds for rejecting the glass cullet. The maximum debris level in the cullet shall be 10 percent. Debris is defined as

any deleterious material that impacts the performance of the Structure Backfill (Flow-Fill) including all non-glass constituents.

The Contractor may use aggregate that does not meet the above specifications if the aggregate conforms to the following gradation:

Sieve Size	Percent Passing
25.0 mm (1 inch)	100
75 µm (No. 200)	0-10

[1]The amount of material passing the 75 µm (No. 200) screen may exceed 10 percent if testing indicates acceptable results for strength and air content.

The Contractor shall submit a Structure Backfill (Flow-Fill) mix design for approval before placement. The mix design shall include the following laboratory test data:

(1)ASTM C231, Air content.
(2)ASTM D6023, Unit Weight.
(3)ASTM C143, Slump or ASTM D6103 flow consistency.
(4)ASTM D4832 28-day Compressive Strength.
(5)Removability Modulus (RM).

The Contractor shall submit a Process Control (PC) Plan with the mix design to the Engineer. The PC Plan shall address the batching, mixing, testing, and placement of the Structure Backfill (Flow-Fill).

3. Imported Structure Backfill for Pipes. Imported Material used as structure backfill for pipes (storm sewer, cross culverts, side drains, etc.) shall be tested for compatibility with the selected pipe material.

When nonreinforced concrete pipe or reinforced concrete pipe is used, the imported material shall be tested for sulfate and pH.

When corrugated steel pipe, bituminous coated corrugated steel pipe or precoated corrugated steel pipe is used, the imported material shall be tested for sulfates, chlorides, pH and resistivity.

When aramid fiber bonded corrugated steel pipe or corrugated aluminum pipe is used, the imported material shall be tested for pH and resistivity.

When plastic pipe is selected, the imported material does not need to be tested for sulfates, chlorides, pH and resistivity.

Sulfates, chlorides, pH and resistivity shall be determined by the following procedures:

(1) Water soluble sulfates using CP-L 2103 Method B.

(2) Chlorides using CPL 2104.

(3) Resistivity using ASTM G57.

(4) pH using ASTM G51.

The average of three consecutive tests shall show the imported material's sulfate, chloride, pH and resistivity is not greater than the limits corresponding to the Pipe Class in Table 206-1 or 206-2 for the pipe class specified on the plans.

No single test shall have a result more than 20 percent greater than that corresponding to the limit in Table 206-1 or Table 206-2 for sulfates, chlorides and resistivity. No single test shall have a result more than 5 percent outside the limit in Table 206-1 for pH. The remaining sample material from a single failing test shall be split into three equal portions. CDOT shall receive one portion, the Contractor shall receive one portion, and the remaining portion shall be retained by the Project. CDOT and the Contractor's Lab shall retest the failed sample; if the results from those tests are within 10 percent of each other, the results will be averaged. The averaged result will be used for Contract compliance. If the results from the Labs are not within 10 percent of each other, the remaining sample portion will be sent to an independent laboratory for testing using the testing requirements specified above. The independent laboratory shall be mutually agreed upon by the Department and the Contractor. The Independent Lab's test result will be used for Contract compliance.

If the imported material's sulfates, chlorides, and resistivity are less than the limits and the pH is within the limits in Table 206-1 or 206-2, CDOT will bear all costs associated with the independent lab test. If the imported material's sulfates, chlorides, and resistivity is greater than the limits and the pH is outside the limits in Table 206-1 or 206-2, all costs associated with independent lab testing shall be at the Contractor's expense.

Structure backfill represented by failing tests shall be removed from the project and replaced at the Contractor's expense.

Table 206-1
SULFATE, CHLORIDE AND pH OF IMPORTED MATERIAL

Pipe Class	Soil Sulfate (SO4) % max.	Soil Chloride (Cl) % max.	Soil pH
0, 7	0.05	0.05	6.0-8.5
1, 7	0.1	0.1	6.0-8.5
2, 8	0.2	0.2	6.0-8.5
3, 9	0.5	0.5	6.0-8.5
4, 9	1	1	5.0-9.0
5, 10	2	2	5.0-9.0
6, 10	>2.00	>2.00	<5 or >9

Table 206-2
RESISTIVITY AND pH OF IMPORTED MATERIAL

SOIL SIDE Resistivity R (Ohm – cm)	**SOIL SIDE** pH
≥ 1500	5.0-9.0
≥ 250	3.0-12.0

(b) Bed Course Material. Material shall conform to the requirements of subsection 703.07. Upon approval, aggregate base course conforming to the requirements of subsection 703.03 may be used in lieu of bed course material.

(c) Filter Material. Class A, Class B, and Class C Filter Material shall conform to the requirements of subsection 703.09. Class of material shall be as specified or designated.

CONSTRUCTION REQUIREMENTS

206.03 Structure Excavation and Structure Backfill. Unsuitable foundation material shall be removed and wasted in a manner acceptable to the Engineer, and the excavated material will be paid for as structure excavation. Excavation and backfill for areas in excess of 3 feet below designed elevation will be paid for as provided in subsections 104.03 and 109.04. Unsuitable foundation material that is suitable for embankments and suitable surplus excavated material shall be used in the construction of embankments. Unsuitable material removed below designed elevation shall be replaced with approved material.

If asbestos containing material (ACM) is suspected or found, the ACM and the suspected ACM shall be managed per the Air Quality Control Commission Regulation No. 8 Part B or Section 5.5 of the solid Waste Regulation 6 CCR 1007-2, whichever applies. All work conducted on site shall be per the Colorado Department of Public Health and Environment's Asbestos-Contaminated Soil Guidance Document or the State of Colorado's Asbestos Contaminated Soil Statewide Management Plan (ACS), whichever is more recent at the time of advertisement, and per subsection 250.07(d).

Rock, hardpan, or other unyielding material encountered in trenches for culvert pipe or conduit shall be removed below the designed grade for a minimum depth of 12 inches. This extra depth excavation shall be backfilled with loose Structure Backfill (Class 1) or other approved material. The base of structure backfill shall be scarified to a depth of 6 inches and compacted with moisture and density control before placement of any structural element or structure backfill. The type of compaction shall be the same as that required for Structure Backfill (Class 2), as specified below.

Backfill shall consist of approved materials uniformly distributed in layers brought up equally on all sides of the structure. Each layer of backfill shall not exceed 6 inches and shall be compacted to the required density before successive layers are placed.

Structure Backfill (Class 1) shall be compacted to a density of at least 95 percent of maximum dry density determined per AASHTO T 180 as modified by CP 23. Backfill shall be compacted at plus or minus 2 percent of Optimum Moisture Content (OMC).

Structure Backfill (Class 2) shall be compacted to a density of at least 95 percent of maximum dry density. The maximum dry density and OMC for A-1, A-2-4. A-2-5 and A-3 materials will be determined per AASHTO T 180 as modified by CP 23. The maximum dry density and OMC for all other materials will be determined per AASHTO T 99 as modified by CP 23. Materials shall be compacted at plus or minus 2percent of Optimum Moisture Content (OMC). Materials having greater than 35 percent passing the 75 µm (No. 200) sieve shall be compacted at 0 to 3 percent above OMC.

Pipes, culverts, sewers, and other miscellaneous structures outside the roadway prism and not subjected to traffic loads shall be backfilled in layers as described above but shall be compacted to the density of the surrounding earth.

The excessive use of water during backfilling operations will not be permitted.

Compaction equipment or methods that produce horizontal or vertical earth pressures, which may cause excessive displacement or overturning, or may damage structures, shall not be used.

Backfill material shall not be deposited against newly constructed masonry or concrete structures, until the concrete has developed a compressive strength of 0.8f'c, except in cases where the structures support lateral earth pressure. Concrete compressive strength for structures supporting lateral earth pressure shall conform to subsection 601.12(o). Concrete compressive strength shall be determined by maturity meters.

Backfill at the inside of bridge wingwalls and abutments shall be placed before curbs or sidewalks are constructed over the backfill and before railings on the wingwalls are constructed.

Unless otherwise indicated in the Contract or directed, all sheeting and bracing used in making structure excavation shall be removed by the Contractor before backfilling.

Structure backfill placed at bridge piers in waterways and water channels, that does not support embankments, pavements, or slope protection, will not require compaction.

Structure Backfill (Flow-Fill) shall not be compacted.

The maximum layer thickness for Structure Backfill (Flow-Fill) shall be 3 feet unless otherwise approved by the Engineer. The Contractor shall not place Structure Backfill (Flow-Fill) in layers that are so thick that they cause damage to culverts, pipes, and other structures or that they cause formwork or soil failures during placement. Structure Backfill (Flow-Fill) shall have an indention diameter less than 3 inches and the indention shall be free of visible water when tested per

ASTM D6024 by the Contractor before placing additional layers of Structure Backfill (Flow-Fill). Testing Structure Backfill (Flow-Fill) per ASTM D6024 will be witnessed by the Engineer. Damage resulting from placing Structure Backfill (FlowFill) in layers that are too thick or from not allowing sufficient time between placements of layers shall be repaired at the Contractor’s expense.

The Contractor shall secure culverts, pipes and other structures to prevent floating and displacement of these items during the placement of the Structure Backfill (Flow-Fill).

When Flash Fill is used, it shall be batched with a volumetric mixing truck. Volumetric mixing trucks used to produce Flow-Fill and Flash Fill shall have a computer batching system, capable of producing the approved mix design and printing tickets. For Flash Fill, the batch weights of cement and fly ash per cubic yard shall be within 2 percent of the mix design batch weights and the batch weight of water per cubic yard shall be within 2 percent of the mix design batch weight.

Before the placement of structure backfill (Flow-Fill), the Contractor shall sample the structure backfill (Flow-Fill) per ASTM D5971. The Contractor shall test the structure backfill (Flow-Fill) unit weight per ASTM D6023. For Flash Fill, the measured unit weight shall be within 5.0 percent or 5.0 pounds per cubic foot, whichever is larger, of the approved mix design unit weight. The Contractor shall test the structure backfill (Flow-Fill) for slump per ASTM C143 or flow consistency according to ASTM D6103.

The Contractor shall sample and test the first three loads of Structure Backfill (Flow-Fill) for each placement and then randomly once every 50 cubic yards. Sampling and testing will be witnessed by the Engineer.

When Structure Backfill (Flow-Fill) is placed in areas that require future excavation, the unit weight of the placed Structure Backfill (Flow-Fill) shall not exceed the unit weight of the approved mix design by more than 2.0 pounds per cubic foot.

Structure Backfill (Flow-Fill) shall not be allowed to freeze during placement and until it has set sufficiently according to ASTM D6024. Frozen Structure Backfill (Flow-Fill) shall be removed and replaced at the Contractor's expense.

When the Contractor substitutes Structure Backfill (Flow-Fill) for Structure Backfill (Class 1) or (Class 2), the trench width may be reduced to provide a minimum 6-inch clearance between the outside diameter of the culvert and the trench wall.

206.04 Bed Course Material. Construction requirements for bed course material for sidewalks and curbing shall conform to the applicable requirements of Sections 608 and 609.

206.05 Filter Material. Construction requirements for filter material for subsurface drains shall conform to the applicable requirements of Section 605.

Filter material shall be placed behind bridge abutments, wingwalls, and retaining walls as provided in the Contract and per the following requirements:

When provided in the Contract, wall drain outlets shall be backed with sacked filter material conforming to the gradation requirements for coarse aggregate No. 3 or No. 4 set forth in Table 703-2.

Filter material shall be placed in horizontal layers along with and by the same methods specified for structure backfill.

METHOD OF MEASUREMENT

206.06. Structure excavation, structure backfill, and bed course material will not be measured but will be the quantities designated in the Contract. When field changes are ordered or when there are errors on the plans, quantities will be measured as follows:

(a) For bridges and irregular shaped structures, quantities will be computed to neat lines 18 inches outside and parallel to the outline of the revised foundation plan or as shown on the plans.

(b) For pipes, a profile will be made along the bottom of the center line extending 18 inches beyond the end of the structure, including end sections. Material excavated between this profile and a profile 1 foot above the top of the pipe will not be measured for payment but shall be included in the bid price for the pipe. In excavation sections the area above the profile 1 foot above the top of the pipe and below the limits of roadway excavation will be multiplied by the width shown on the plans to obtain the volume of structure excavation measured for payment. In embankment sections the area above the profile 1 foot above the top of the pipe and below the natural ground will be multiplied by the width shown on the plans to obtain the volume of structure excavation measured for payment.

(c) Backfill and filter material will be the calculated volume of material lying within the prism shown on the plans, from which shall be deducted the volume occupied by the structure.

(d) Bed course material will be the calculated volume of material lying within the prism shown on the plans.

BASIS OF PAYMENT

206.07 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.
Payment will be made under:

Pay Item	Pay Unit
Structure Excavation	Cubic Yard
Structure Backfill (Class)	Cubic Yard
Structure Backfill (Flow-fill)	Cubic Yard
Bed Course Material	Cubic Yard
Filter Material (Class)	Cubic Yard

Compaction, water, and all other work necessary to complete the above items will not be measured and paid for separately but shall be included in the work.

Structure backfill, including bed course material, for pipes and end sections will not be measured and paid for separately, but shall be included in the work. Where only end section work is required the structure excavation quantity and the structure backfill quantity will not be measured and paid for separately but shall be included in the work.

When the Contractor substitutes Structure Backfill (Flow Fill) for Structure Backfill (Class 1) or (Class 2), there will be no adjustment in the price or the quantity paid for structure excavation or structure backfill as a result of reducing the trench width.

SHORING

DESCRIPTION

206.08. This work consists of shoring specific areas designated in the Contract.

MATERIALS AND CONSTRUCTION REQUIREMENTS

206.09. The Contractor shall locate, size, design, and construct shoring that provides all necessary rigidity, and supports the loads imposed to facilitate construction as shown on the plans. Shoring used to facilitate construction is considered temporary and shall have a design life 1-1/2 times the expected construction service life, with a maximum design life of three years.

When the height of shoring exceeds 5 feet above the base of the excavation, the Contractor shall submit working drawings per subsection 105.02. The drawings shall be submitted to the Engineer for information only. The drawings shall be electronically sealed by the Contractor's Engineer. The Contractor shall design for internal and external stability of temporary shoring such as but not limited to bearing capacity, settlement, sliding, overturning, internal compound stability, and global stability. All proof and verification testing of the shoring elements shall be the responsibility of the Contractor and results shall be reported to the Engineer the day after the testing was performed.

All proof and verification testing of the shoring elements shall be the responsibility of the Contractor. For soil nail walls, a minimum of one proof test shall be performed per the Revision of Section 504 Soil Nail Wall, and test results shall be reported to the Engineer the day after the testing was performed.

The Contractor shall conduct additional proof and verification testing at the Engineer's request. Sufficient corrosion protection shall be provided in consideration of the temporary shoring design life and is the responsibility of the Contractor. Temporary shoring shall be designed for actual construction-related loads, such as phasing, stockpiles, and operation of large cranes or other large equipment near the area of the shoring. These drawings shall be signed by the Contractor and provided to the Engineer at least 10 days before start of work. Shoring construction shall conform with the shoring drawings provided to the Engineer. The Contractor shall conduct any necessary site-specific evaluation necessary to ensure shoring design, construction and performance.

The Contractor shall have performed and documented an independent review of their shoring design and drawings at designated areas before submittal. The Contractor's Engineer shall electronically seal the independent review shoring design and drawings.

The shoring plans shall detail the methods to control site drainage during the life of the shoring. The Contractor shall actively control drainage and surface runoff during the duration of construction to direct run off away from the shoring areas above and behind the shoring. A shoring site drainage quality control plan shall be included as part of the Contractor's Engineer's shoring plans and shall be part of the submittal to the Engineer. The plan shall include measures to prevent ponding water near the shoring area and maintenance of drainage to convey water away from and around the shoring excavation vicinity.

If the embankment, construction, traffic, or any other surcharge is in excess of what the original shoring was designed for and is to be placed adjacent to the shoring, the Contractor shall provide a signed letter from the Contractor's Engineer before the load placement stating that the shoring will support the additional load.

Shoring shall be designed and constructed per the requirements listed in this specification along with requirements in current AASHSTO and FHWA design manuals including, but not limited to:

(1) AASHTO Construction Handbook for Bridge Temporary Works including Division I.

(2) Section 5 of the AASHTO LRFD Bridge Design Specifications for allowable stress or load factor design; or

(3) AASHTO LRFD Bridge Design Specifications including current interims for load and resistance factor design.

If a shoring type is to be used that is not detailed in these three documents, the shoring type design method will need to be submitted to the Engineer. The Contractor's Engineer shall be on-site and perform construction inspection of the shoring during the first two days of active shoring construction, during any shoring element verification testing, and at the completion of shoring construction. Shoring drawings shall include the following information:

(1) The size and grade of all structural materials

(2) Design notes, including design assumptions, including loading, and construction details.

(3) Detailed plans for managing and maintaining shoring surface and subsurface drainage conditions for the project duration.

(4) Where applicable, restrictions on heavy equipment placement at specific locations adjacent to the shoring

(5) Areas determined by the Contractor's Engineer where dewatering of the shored excavation will be required, and a description of the requirements (i.e., head added by the pump, flow rate, minimum pump size, etc.) and methods to be used for dewatering.

(6) All other information determined by the Contractor's Engineer to be pertinent to the design and successful construction of the shoring.

Drawings for temporary shoring that requires structural designs shall include the following information:

(1) Individual site-specific geotechnical properties for each shoring location based on the plan, review of the Geotechnical Report per subsection 102.05, or from a geotechnical evaluation performed by the Contractor at their own expense.

(2) Global stability analysis showing that the shoring will be stable under the loads placed on it and construction conditions encountered during construction.

The Contractor's Engineer may assign an on-site representative, to perform construction field oversight, by submitting documentation of experience to the Engineer 10 days before starting shoring construction for review and the Engineer's acceptance. Before placing construction or traffic loads on or immediately adjacent to the supported earth, the Contractor's Engineer for the shoring shall certify in an electronically sealed letter that shoring materials and construction have been inspected and that all shoring, materials, and construction are in conformity with the shoring drawings. A copy of this certification shall be submitted to the Engineer.

METHOD OF MEASUREMENT

206.10 Shoring will not be measured but will be paid for as a single lump sum for each Area described on the plans. Incidental shoring work or shoring in locations other than those described on the plans will be as determined by the Contractor and will not be measured and paid for separately but shall be included in the work.

BASIS OF PAYMENT

206.11 The accepted quantities of shoring measured as provided above will be paid for at the contract unit price bid.
Payment will be made under:

Pay Item	Pay Unit
Shoring (Area ___)	Lump Sum

Payment for shoring will be full compensation for all labor, materials, and equipment required to design, construct, test, maintain, and dewatering.

Removal of the shoring shall include removal of all shoring elements. The removal area shall be specified in the plans.

Removal of shoring will not be measured and paid for separately but shall be included in the work.

The Department will pay for additional proof and verification testing, as requested by the Engineer, per subsection 109.04.

Other incidental shoring that is not included as a pay item will not be measured and paid for separately but shall be included in the work.

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SECTION 207

TOPSOIL

DESCRIPTION

207.01. This work consists of salvaging and stockpiling topsoil, and excavating suitable topsoil from stockpiles, contractor sources, available sources, or from the approved natural ground cover to place on designated areas. Placing of topsoil upon constructed cut and fill slopes after grading operations are completed is included.

MATERIALS

207.02. Topsoil shall consist of loose friable soil from the zone of major root development free of subsoil, refuse, stumps, woody roots, rocks, brush, noxious weed seed and reproductive plant parts from current state and county weed lists, heavy clay, hard clods, toxic substances, or other material that would be detrimental to its use on the project.
Wetland topsoil material shall consist of the moist, organic soil, including any existing wetland vegetation and seeds, to be excavated from areas as shown on the plans or as directed.

CONSTRUCTION REQUIREMENTS

207.03. Wetland topsoil material shall be excavated from the designated area to a maximum depth of 12 inches, or as otherwise designated, and placed within 24 hours in the specified area. The Contractor shall prepare the relocation site to elevations specified and approved by the Engineer before excavating the wetlands. If the Engineer determines that this is not possible, then the Contractor shall stockpile the material in an approved area, to remain undisturbed until the relocation site has been prepared. Storage time within the stockpile shall be as short as possible. Wetland topsoil material shall be placed over the prepared relocation areas to a depth of 12 inches, or as otherwise designated.
Topsoil within the limits of the roadway shall be salvaged before beginning hauling, excavating, or fill operations by excavating and stockpiling the material at designated locations in a manner that will facilitate measurement, minimize sediment damage, and not obstruct natural drainage. Topsoil shall be placed directly upon completed cut and fill slopes whenever conditions and the progress of construction will permit.

Topsoil shall be placed at locations and to the thickness provided in the Contract and shall be keyed and tracked to the underlying material without creating a compacted surface by the use of harrows, bulldozers, rollers, or other equipment suitable for the purpose.

Salvaged topsoil exceeding the quantity required under the Contract shall be disposed of at locations acceptable to the Engineer.

METHOD OF MEASUREMENT

207.04. Topsoil salvaged from the roadway and placed in stockpiles shall be measured in the stockpile in cubic yards by the method of average end areas and paid for as Stockpile Topsoil.
Topsoil salvaged from the roadway, taken from stockpiles or from approved pits, hauled and placed directly upon completed cut and fill slopes shall be measured at its source in cubic yards, as described in subsection 203.11, and paid for as Topsoil.

Topsoil generated from the roadway and placed in windrows will be measured at its source in cubic yards, as described in subsection 203.11, and paid for as Stockpile Topsoil. When it is subsequently placed upon the completed cut and fill slopes, the same quantity will be paid for as Topsoil, except that adjustment in quantity shall be made if the total windrowed quantity is not utilized.

Wetland topsoil material excavated from areas within the right of way and placed in stockpiles will be measured in the stockpile by the method of average end areas and paid for as Stockpile Wetland Topsoil.

Wetland topsoil material excavated from areas within the right of way or from stockpiles, hauled and placed directly on a relocated site will be measured at its source in cubic yards, as described in subsection 203.11, and paid for as Wetland Topsoil.

Topsoil secured from the Contractor's source will be measured in place by measuring random depths of topsoil and computing the volume by multiplying the area times the average depth.

BASIS OF PAYMENT

207.05. The accepted quantities measured as provided above will be paid for at the contract unit price per cubic yard for each of the pay items listed below that appear in the bid schedule.
Payment will be made under:

Pay Item	Pay Unit
Stockpile Topsoil	Cubic Yard
Topsoil	Cubic Yard
Stockpile Wetland Topsoil	Cubic Yard
Wetland Topsoil	Cubic Yard

SECTION 208

EROSION CONTROL

DESCRIPTION

208.01. This work consists of constructing, installing, maintaining, and removing when required, control measures during the life of the Contract to prevent or minimize erosion, sedimentation, and pollution of any State waters as defined in subsection 107.25, including wetlands.

Stormwater runoff from all disturbed areas and soil storage areas where permanent or interim stabilization is not implemented, must flow to at least one control measure to minimize sediment in the discharge. This shall be accomplished through filtering, settling, or straining. The control measure shall be selected, designed, installed, and adequately sized per good engineering, hydrologic, and pollution control practices. The control measures shall contain or filter flows in order to prevent the bypass of flows without treatment and shall be appropriate for stormwater runoff from disturbed areas and for the expected flow rate, duration, and flow conditions (i.e., sheet or concentrated flow).

The Contractor shall coordinate the construction of temporary control measures with the construction of permanent control measures to assure economical, effective, and continuous erosion and sediment control throughout the construction period.

When a provision of Section 208 or an order by the Engineer requires that an action be immediate or taken immediately, it shall be understood that the Contractor shall at once begin affecting completion of the action and pursue it to completion in a manner acceptable to the Engineer, and per the Colorado Discharge Permit System Stormwater Construction Permit (CDPS-SCP) requirements.

MATERIALS

208.02 Erosion control materials are subject to acceptance per subsection 106.01. Erosion control materials shall be subject to the following approval process:

Table 208-1

APPROVAL PROCESS FOR EROSION CONTROL MATERIALS

Material	Approval Process	Notes
Erosion Bales (Weed Free)	COC	The Contractor shall provide a transit certificate number, or a copy of the transit certificate as supplied from the producer.
Silt Fence	COC	
Silt Berm	APL	
Erosion Log (Type 1, Type 2, and Type 3)	COC	
Silt Dikes	COC	
Prefabricated Concrete Washout Structures (above ground)	APL	
Prefabricated Vehicle Tracking Pad	APL	
Aggregate Bag	COC	
Storm Drain Inlet Protection (Type I, II, and III)	APL	

Table 208-1 Notes: COC = Certificate of Compliance; APL= Approved Product List

The material for control measures shall conform to the following:

(a) *Erosion Bales*: Material for erosion bales shall consist of Certified Weed Free hay or straw. The hay or straw shall be certified under the Colorado Department of Agriculture Weed Free Forage Certification Program and inspected as regulated by the Weed Free Forage Act, Title 35, Article 27.5, CRS. Each certified weed free erosion bale shall be identified by blue and orange twine binding the bales.

The Contractor shall not place certified weed free erosion bales or remove their identifying twine until the Engineer has inspected them.

The Contractor may obtain a current list of Colorado Weed Free Forage Crop Producers who have completed certification by contacting the Colorado Department of Agriculture, Weed Free Forage Program, 305 Interlocken Pkwy, Broomfield, CO 80021, Contact: Weed Free Forage Coordinator at (303) 869-9038. Also available at www.colorado.gov/ag/csd.

Bales shall be approximately 5 cubic feet of material and weigh at least 35 pounds. Stakes shall be wood and shall be 2 inch by 2 inch nominal.

(b) Silt Fence. Silt fence posts shall be wood with a minimum length of 46 inches. Wood posts shall be 1.5-inch width by 1.5-inch thickness actual dimensions with 1/8-inch tolerance. Geotextile shall be attached to wood posts with three or more staples per post.

Silt fence geotextile shall conform to the following requirements:

Table 208-2

PHYSICAL REQUIREMENTS FOR SILT FENCE GEOTEXTILES

Property	**Wire Fence Supported Requirements**	**Self-Supported Requirements Geotextile Elongation <50%**	**Test Method**
Grab Strength, lbs.	90 minimum	124 minimum	ASTM D4632
Permittivity sec-1	0.05	0.05	ASTM D4491
Ultraviolet Stability	Minimum 70% Strength Retained	Minimum 70% Strength Retained	ASTM D4355

(c) Silt Fence (Reinforced). Silt fence posts shall be metal "studded tee" T-post with a minimum length of 66 inches. Metal posts shall be “studded tee” with .095-inch minimum wall thickness. Wire fabric reinforcement for the silt fence geotextile shall be a minimum of 14 gauge with a maximum mesh spacing of 6 inches. Geotextile shall be attached to welded wire fabric with ties or nylon cable ties at 12 inches on center at top, middle, and bottom wire. Welded wire fabric shall be attached to the post with a minimum three 12-gauge wire ties per post. Vinyl or rubber safety caps shall be installed on all T-post.

(d) Temporary Berms. Temporary berms shall be constructed out of embankment (subsoil) and not out of salvaged topsoil.

(e) Temporary Slope Drains. Temporary slope drains shall consist of fiber mats, plastic sheets, stone, concrete or asphalt gutters, half-round pipe, metal or plastic pipe, wood flume, flexible rubber, or other materials suitable to carry accumulated water down the slopes. Outlet protection riprap shall conform to Section 506. Erosion control geotextile shall be a minimum Class 2, conforming to subsection 712.08.

(f) Silt Berm. Silt berm shall consist of permeable multi-use material consisting of ultraviolet (UV) stabilized high-density polyethylene or other approved material effective in reducing water velocity. Designed and tested system shall be installed on a Turf Reinforcement Mat or Soil Retention Blanket per Section 216. The segment shall be secured to the ground with either metal or wood stakes. Minimum requirements for securing stakes shall be per the plans. Dimensions of individual segments shall meet the following criteria:

Table 208-3

SILT BERM DIMENSIONS

Width	6 - 11 inches
Height	6 - 10 inches
Weight	> 0.25 lbs./sq. ft.
Percent Open Area	20% – 50%

(g) Rock Check Dam. Rock Check dams shall be constructed of stone. Stone shall meet the requirements of Section 506.

(h) Sediment Trap. In constructing an excavated sediment trap, excavated soil may be used to construct the dam embankment, provided the soil meets the requirements of subsection 203.03. Outlet protection riprap shall be the size specified in the Contract and shall conform to Section 506. Erosion control geotextile shall be a minimum Class 1, conforming to subsection 712.08.

(i) Erosion Logs. Erosion logs shall be one of the following types unless otherwise shown on the plans:

1. Erosion Log (Type 1) shall consist of cylinder casings filled with curled aspen wood excelsior with a consistent width of fibers evenly distributed throughout the log. The casing shall be seamless, photodegradable tube netting. The curled aspen wood excelsior shall be fungus free, resin free, and free of growth or germination inhibiting substances.

2. Erosion Log (Type 2) shall consist of cylinder casings filled with Erosion Log (Type 2) Compost per subsection 212.02. The compost-wood chip blend may be pneumatically shot into a geotextile cylindrical casing or be pre-manufactured. The geotextile casing shall consist of high density polyethylene (HDPE) or polypropylene mesh (knitted, not extruded) with openings of 1/8 to 3/8 inch and contain the compost-wood chip material while not limiting water infiltration.

3. Erosion Log (Type 3) shall consist of cylinder casings filled with curled aspen wood excelsior with a consistent width of fibers evenly distributed throughout the log. The casing shall be seamless, 100 percent natural fiber cylinder netting (compostable) and shall have minimum dimensions as shown in Table 208-4, based on the diameter of the log shown on the plans. Netting shall be a woven cotton or cellulose base mesh that has an approval to compost certification with a maximum mesh size of 0.075 inches and index values as shown in Table 208-5. The curled aspen wood excelsior shall be fungus free, resin free, and free of growth or germination inhibiting substances.

   Natural compostable fiber netting shall not contain any synthetic material woven into the netting such as polypropylene, nylon, polyethylene, or polyester dyes. Oxo-degradable or oxo-biodegradable petrochemical-based fiber shall not be part of the netting material. Burlap netting material shall not be used for Erosion Log (Type 3).

   Erosion Log (Type 1, Type 2, and Type 3) shall have minimum dimensions as shown in Table 208-4, based on the specified diameter of the log.

Table 208-4

EROSION LOG DIMENSIONS

Diameter Type 1 and 3 (Inches)	Diameter Type 2 (Inches)	Min. Length (feet)	Max. Length (feet)	Min. Weight (lb/ft)	Stake Dimensions (Inches)
9	8	10	180	1.6	0.75 thickness by 0.75 width by 18 long
12	12	10	180	2.5	1.5 thickness by 1.25 width by 24 long
20	18	10	180	4	1.5 thickness by 1.25 width by 30 long

Table 208-4 Notes: Wood stake acceptable tolerance +/- 1/8 inch.

Table 208-5

Index Values for Natural Fiber Netting

Property	Requirement	Test Method
Fabric Tensile Strength	>70 lbs.	ASTM D3822
Biodegradable	100%	ASTM D5988
Mesh Pattern	Rib	

Stakes to secure erosion logs shall consist of pinewood or hardwood.

(j) Silt Dikes. Silt dikes shall be pre-manufactured flexible sediment barrier that will fully rebound when driven over by heavy equipment. Material shall consist of outer geotextile fabric covering closed cell urethane or polyethylene foam core. The geotextile fabric aprons shall extend beyond the foam core a minimum of 8 inches on both sides.

Table 208-6

GEOTEXTILE REQUIREMENTS

Property	Requirement	Test Method
Water Flow Rate	100 - 150 gallons per minute/square foot	ASTM D4491
Grab Breaking Load	200 lbs. minimum in each direction	ASTM D4632
Ultraviolet Degradation	70% of original unexposed grab breaking load after 500 hours	ASTM D4595

Each silt dike segment shall have the following dimensions:

Dimension Length

Vertical height after installation >5 inches

Geotextile sleeve section to interlock segments	>8 inches

Silt dike segments shall be anchored down using the minimum requirements shown in Table 208-7.

Table 208-7

SILT DIKE SEGMENT REQUIREMENTS

Surface	Nail	Washers
Soil Surface	Installed in 4-inch-deep trench with 6-inch nails no more than 4 feet O.C. (on center)	1-inch washers
Hard Surface	1-inch concrete nails no more than 4 feet O.C.	1-inch washers and solvent-free adhesive

(k) Concrete Washout Structure. The Contractor shall construct a washout structure that will contain washout from concrete placement, construction equipment cleaning operations, and residue from cutting, coring, grinding, grooving, and hydroconcrete demolition. Embankment required for the concrete washout structure may be excavated material, if this material meets the requirements of Section 203 for embankment. If the bottom of the excavated structure is within 5 feet of anticipated high ground water elevation or the soil does not have adequate buffering capacity to meet water quality standards, an impermeable synthetic liner shall be installed with the minimum properties shown in Table 208-8.

Table 208-8

IMPERMEABLE SYNTHETIC LINER REQUIREMENTS

Tested Property	Test Method	Units	Value
Thickness	ASTM D5199	mil	>30 +/- 1.5
Tear Strength	ASTM D1004	lbs.	>8
Low Temperature Impact	ASTM D1790	°F	Pass at -20

(l) Prefabricated Concrete Washout Structure. Prefabricated Concrete Washout Structures shall be one of the following types unless otherwise shown on the plans:

1. Prefabricated Concrete Washout Structure (Type 1). Type 1 portable bins shall be used only when specified in the Contract. It shall consist of a watertight multi-use container designed to contain liquid concrete washout wastewater, solid residual concrete waste from washout operations, and residue from saw cutting, coring, grinding, grooving, and hydro-concrete demolition. Minimum capacity including freeboard shall be 440 gallons. Prefabricated Concrete Washout Structure (Type 2). Type 2 portable bins shall be used only when specified in the Contract. It shall consist of a watertight one-time use container designed to contain liquid concrete washout wastewater, solid residual concrete waste from washout operations, and residue from saw cutting, coring, grinding, grooving, and hydro-concrete demolition. The structure shall have a system to secure to the ground. Minimum capacity including freeboard shall be 50 gallons.

(m)Vehicle Tracking Pad (VTP). Aggregate for the vehicle-tracking pad shall be crushed natural aggregate with at least two fractured faces that meets the following gradation requirements:

Table 208-9

AGGREGATE GRADATION

FOR VEHICLE TRACKING PAD

Sieve size	Percent by weight Passing Square Mesh Sieves
75 mm (3 inch)	100
50 mm (2 inch)	0-25
19.0 mm (3/4 inch)	0-15

Recycled crushed concrete or asphalt shall not be used for vehicle tracking pads.

Erosion control geotextile shall be a minimum Class 2, conforming to subsection 712.08.

Prefabricated or manufactured vehicle tracking pads shall only be used if specified in the Contract. Multi-use pads shall consist of industrial grade materials and shall be designed to minimize sediment leaving the project.

Minimum dimensions of the modular systems shall be:

Table 208-10

MINIMUM DIMENSIONS FOR VEHICLE TRACKING PAD

Width	12 feet
Length of pad	35 feet
Weight (min.) (lbs./sq. ft.)	8
Crush strength (min.) (psi)	400

To accommodate construction traffic turning radii between the tracking pad and a stabilized surface, additional flared sections of approved pads or aggregate per this specification shall be used at no additional cost to CDOT.

If pads weigh less than 8 pounds per square foot, an anchoring system approved by the manufacturer shall be used for pads placed on soil and hard surfaces.

A thin layer of stone, geotextile, or other stable surface may be required to stop rutting under the pad or area where the vehicles mount or dismount the manufactured trackout control device.

(n) Aggregate Bag. Aggregate bags shall consist of crushed stone or recycled rubber filled fabric with the following properties:

Table 208-11
AGGREGATE BAG PROPERTIES

Diameter (inches)	Weight (minimum) (lb/ft)
6-8	6
10	10
12	15

Rubber used in bags shall be clean, 95 percent free of metal and particulates.

Crushed stone contained in the aggregate bags shall conform to Table 703-1 for Coarse Aggregate No. 6.

The aggregate bag shall consist of a woven geotextile fabric with the following properties:

Table 208-12
GEOTEXTILE PROPERTIES FOR AGGREGATE BAG

Property	Requirement	Test Method
Grab Tensile Strength	90 lbs. min.	ASTM D4632
Trapezoid Tear Strength	25 lbs. min.	ASTM D4533
Mullen Burst	300 psi	ASTM D3786
Ultraviolet Resistance	70%	ASTM D4355

(o) Storm Drain Inlet Protection. Storm drain inlet protection shall consist of aggregate filled fabric with the following dimensions:

Table 208-13

AGGREGATE BAG DIMENSIONS FOR STORM DRAIN INLET PROTECTION

Storm Drain Inlet Protection Properties	*Protection Type I	#Protection Type II	^Protection Type III
Diameter	4 in.	4 in.	N/A
Minimum Section Length	7 ft.	5 ft.	5 ft.
Apron Insert	---	30 in. or sized to grate	30 in. or sized to grate

Table 208-13 Notes: *****Type I protection shall be used with Inlet Type R.

#Type II protection shall be used with Combination Inlet. Option A or B

^Type III protection shall be used with Vane Grate Inlet only. Option A or B Note: Options A and B are shown on Standard Plan M-208-1.

The Storm Drain Inlet Protection (Type I, II, and III) shall consist of a woven geotextile fabric with the following properties:

Table 208-14

WOVEN GEOTEXTILE FABRIC FOR STORM DRAIN INLET PROTECTION

Property	Test Method	Unit	Requirement
Grab tensile strength	ASTM D4632	lbs.	minimum 150x200
Mullen Burst Strength	ASTM D3786	lbs.	400
Trapezoid Tear Strength	ASTM D4533	lbs.	minimum 60x60
Percent Open Area	COE-22125-86	%	≥20
Water Flow Rate	ASTM D4491	gal./min./sq. ft.	≥100
Ultraviolet Resistance	ASTM D4355	%	≥70

Curb roll for Storm Drain Inlet Protection (Type I and II) shall have a weight greater than 4 pounds per linear foot of device. The device shall be capable of conforming to the shape of the curb. Aggregate contained in the storm drain inlet device shall consist of gravel or crushed stone conforming Table 703-1 for Coarse Aggregate No. 6.

CONSTRUCTION REQUIREMENTS

208.03 Project Review, Schedule, and Erosion Control Management. Before construction, an on-site Environmental Preconstruction conference shall be held. The conference shall be attended by:

(1) The Engineer.

(2) The Superintendent.

(3) The Contractor's Stormwater Management Plan (SWMP) Administrator. The SWMP Administrator is equivalent to the CDPS-SCP Qualified Stormwater Manager.

(4) Supervisors or Foremen of subcontractors working on the project.

(5) The Region Water Pollution Control Manager (RWPCM).

(6) CDOT personnel (e.g., CDOT Landscape Architect) who prepared or reviewed the Stormwater Management Plan (SWMP).

At this Conference, the attendees shall discuss the SWMP, CDPS-SCP, sensitive habitats on-site, wetlands, other vegetation to be protected, and the enforcement mechanisms for not meeting the requirements of this specification.

Before beginning construction, the Contractor shall evaluate the project site for stormwater draining into or through the site. When such drainage is identified, control measures shall be used if possible, to divert stormwater from running on-site and becoming contaminated with sediment or other pollutants. The diversion may be accomplished with a temporary pipe or other conveyance to prevent water contamination or contact with pollutants. Run-on water that cannot be diverted shall be treated as construction runoff and adequate control measures shall be employed.

The SWMP Administrator shall evaluate all non-stormwater coming onto the site, such as springs, seeps, and landscape irrigation return flow. If such flow is identified, control measures shall be used to protect off-site water from becoming contaminated with sediment or other pollutants.

The SWMP Administrator shall review existing inlets and culverts to determine if inlet protection is needed due to water flow patterns. Before beginning construction, inlets and culverts needing protection shall be protected and the location of the implemented control measure added to the SWMP Site Map.

Before construction, the Contractor shall implement appropriate control measures for protection of wetlands, sensitive habitat, and existing vegetation from ground disturbance and other pollutant sources, per the approved project schedule as described in subsection 208.03(b).

When additional control measures are required and approved by the Engineer, the Contractor shall implement the additional control measures and the SWMP Administrator shall record and describe them on the SWMP Site Map. The approved control measures will be measured and paid for per subsections 208.11 and 208.12.

(a) *Project Review*. The Contractor may submit modifications to the Contract's control measures in a written proposal to the Engineer. The written proposal shall include the following information:

1. Reasons for changing the control measures.
2. Diagrams showing details and locations of all proposed changes.
3. List of appropriate pay items indicating new and revised quantities.
4. Schedules for accomplishing all erosion and sediment control work.
5. Effects on permits or certifications caused by the proposed changes.

The Engineer will approve or reject the written proposal in writing within seven days after receipt of the submittal. The Engineer may require additional control measures before approving the proposed modifications. Additional modifications and additional control measures will be paid for at the Contract Unit Price for the specific items involved. If no items exist, they will be paid for as extra work per subsection 109.04.

(b) *Erosion and Sediment Control Activities*. The erosion and sediment control activities shall be included in the weekly meeting update. The project schedule shall specifically indicate the sequence of clearing and grubbing, earthwork operations, and construction of temporary and permanent erosion control features and stabilization. The project schedule shall include erosion and sediment control work for haul roads, borrow pits, storage and asphalt or concrete batch sites, and all areas within the project limits. If during construction the Contractor proposes changes that would affect the Contract's control measures, the Contractor shall propose revised control measures to the Engineer for approval in writing. If necessary, the SWMP Administrator shall update proposed sequencing of major activities in the SWMP. Revisions shall not be implemented until the proposed measures have been approved in writing by the Engineer.

(c) *Erosion Control Management* (ECM). Erosion Control Management for this project shall consist of SWMP Administration and Erosion Control Inspection. All ECM staff shall have working knowledge and experience in construction, and shall have successfully completed the Transportation Erosion Control Supervisory Certificate Training (TECS) as provided by the Department. The Superintendent cannot serve in an ECM role. The Erosion Control Inspector (ECI) and the SWMP Administrator may be the same person in projects with not more than 40 acres of disturbed area. The ECI and the SWMP Administrator are equivalent to the CDPS-SCP Qualified Stormwater Manager.

1. SWMP Administration. The SWMP Administrator shall maintain the SWMP. Record the name of the SWMP Administrator on the SWMP Section 3.B. The SWMP Administrator shall have full responsibility to maintain and update the SWMP and identify to the Superintendent critical action items needed to conform to the CDPS-SCP as follows:

   A. Complete the SWMP as described in subsection 208.03(d).
   B. Participate in the Environmental Pre-construction Conference.
   C. Attend weekly erosion and sediment control meetings.
   D. Attend all Headquarters and Region water quality control inspections. The Contractor and the Contractor's SWMP Administrator will be notified a minimum of five days in advance of each inspection by Headquarters or Region water quality staff.

E. Coordinate with the Superintendent to implement necessary actions to reduce anticipated or presently existing water quality or erosion problems resulting from construction activities.

F. Coordinate with the Superintendent to ensure that all labor, material, and equipment needed to install, maintain, and remove control measures are available as needed.

G. During construction, update the SWMP Site Map to reflect current field conditions and include, at a minimum, the following:

(1) Limits of Construction (LOC).

(2) Areas of disturbance (AD), including areas of borrow and fill.

(3) Limits of Disturbance (LDA).

(4) Areas used for storage of construction materials, equipment, soils, or wastes.

(5) Location of dedicated asphalt, concrete batch plants, and masonry mixing machines.

(6) Location of construction offices and staging areas.

(7) Location of work access routes during construction.

(8) Location of waste accumulation areas, including areas for liquid, concrete, masonry, and asphalt.

(9) Location of temporary, interim, and permanent stabilization.

(10) Location of outfalls.

(11) Flow arrows that depict stormwater flow directions on-site and runoff direction.

(12) Location of structural and non-structural control measures.

(13) Location of springs, streams, wetlands, and other State waters, including areas that require pre-existing vegetation be maintained within 50 horizontal feet of a receiving water, unless infeasible.

(14) Location of stream crossings located within the construction site boundary.

H. The SWMP shall reflect the field conditions and shall be amended to reflect control measures, including the following:

(1) A change in design, construction, operation, or maintenance of the site that would require the implementation of new or revised control measures; or

(2) Changes when the SWMP proves to be ineffective in achieving the general objectives of controlling pollutants in stormwater discharges associated with construction activity.

(3) Changes when control measures are no longer necessary and are removed.

I. Complete vegetative survey transects when required per CDOT Erosion Control and Stormwater Quality Guide.

J. Start a new site map before the current one becomes illegible. All site maps shall remain as part of the SWMP.

K. Document all inspection and maintenance activities. Keep the SWMP and documentation on the project site.

L. When adding or revising control measures in the SWMP, add a narrative explaining what, when, where, why, and how the control measure is being used, and add a detail to the SWMP.

(1) How to install and inspect the control measure.

(2) Where to install the control measure.

(3) When to maintain the control measure.

M. If using existing topography, vegetation, etc. as a control measure, label it as such on the SWMP Site Map; add a narrative as to when, where, why, and how the control measure is being used.

N. Indicate control measures in use or not in use by recording them on Standard Plans M-208-1, M-216-1, and M-6151 in the SWMP.

O. Record on the SWMP, the approved Method Statement for Containing Pollutant Byproducts.

P. Update the potential pollutants list in the SWMP and Spill Response Plan throughout construction.

Q. Do not use vegetative buffers as a sole control measure. Use them only as the final stage of a treatment train.

2. Erosion Control Inspector.

One ECI is required for every 40 acres of total disturbed area that is currently receiving temporary and interim stabilization measures as defined in subsection 208.04(e). An ECI shall not be responsible for more than 40 acres in the project. Accepted permanent stabilization methods as defined in subsection 208.04(e) will not be included in the 40 acres.

A. ECI duties shall be as follows:

(1) Coordinate with the SWMP Administrator on reporting the results of inspections and how to install and inspect the control measure.

(2) Review the construction site for compliance with the Stormwater Construction Permit.

(3) Inspect with the Superintendent and the Engineer (or their designated representatives) the stormwater management system at least every seven calendar days. Conduct post-storm event inspections within 24 hours after the end of any precipitation or snowmelt event that may cause surface erosion. If no construction activities will occur following a storm event, post-storm event

inspections shall be conducted before commencing construction activities, but no later than 72 hours following the storm event. Document delay in inspections in the inspection report. Form 1176 (Stormwater Field Inspection Report – Active Construction) shall be used for all seven-day inspections and inspections following storm events. The Contractor shall notify the ECI when a storm event occurs.

Inspections are not required at sites when construction activities are temporarily halted, when snow cover exists over the entire site for an extended period and melting conditions do not pose a risk of surface erosion. This exception shall be applicable only during the period where melting conditions do not exist, and applies to the routine seven-day, Headquarters and Region inspections, as well as the post-storm event inspections. Document the following information on Form 1176 for use of this exclusion: dates when snow cover occurred, date when construction activities ceased, and date melting conditions began.

B. The order of precedence for required inspections shall be as follows:

(1) Headquarters or Region water quality routine audits

(2) Post-storm event inspections

(3) Seven-day inspections

When one of the listed inspections is performed, the inspections listed below it need not be performed on that day if the required CDOT and Contractor personnel participated in the inspection.

A seven-day inspection is not required on the same day a Headquarters or Region water quality routine audit is conducted, as long as all of the inspection scope requirements for a seven-day and post-storm event inspection are met. A sheet shall be placed in the inspections area of the SWMP to refer to the date the inspection was performed.

C. Seven-day inspections and post-storm inspections shall include inspection of the following areas, if applicable, for evidence of, or the potential for, pollutants leaving the construction site boundaries, entering the stormwater drainage system, or discharging to State waters:

(1) Construction site perimeter
(2) Disturbed areas
(3) Designated haul routes
(4) Material and waste storage areas exposed to precipitation.
(5) Locations where stormwater has the potential to discharge offsite.
(6) Locations where vehicles exit the site.

D. Inspections shall include the following:

(1) Visually verify whether all implemented control measures are in effective operational condition and are working as designed in their specifications to minimize pollutant discharges.
(2) Determine if there are new potential sources of pollutants.
(3) Assess the adequacy of control measures at the site to identify areas requiring new or modified control measures to minimize pollutant discharges.

(4) Identify all areas of non-compliance with the permit requirements and, if necessary, implement corrective action per the CDPS-SCP.

Follow all other agency Stormwater requirements and inspections unless a waiver or other agreement has been made.

E. The Contractor shall report the following circumstances orally to CDOT, CDPHE, the Contractor's Superintendent, and the SWMP Administrator within 24 hours from the time the permittee becomes aware of the circumstances, and shall mail to the Division a written report containing the information requested within five working days after becoming aware of the following circumstances:

(1) Noncompliance that may endanger health or the environment, regardless of the cause of the incident.
(2) Unanticipated bypass that exceeds any effluent limitations per the CDPS-SCP.
(3) Upset conditions that causes an exceedance of any effluent limitation per the CDPS-SCP.
(4) Daily maximum violations for any of the pollutants limited by the permit. This includes any toxic pollutant or hazardous substance, or any pollutant specifically identified as the method to control any toxic pollutant or hazardous substance.

F. Document spills, leaks, or overflows that result in the discharge of pollutants on the Form 1176. The ECI shall record the time and date, weather conditions, reasons for spill, and how it was remediated.

(d) Documentation Available on the Project. The following Contract documents and references will be made available for reference at the CDOT field office during construction:

1. SWMP. The Engineer will provide an approved SWMP design at the Pre-construction Conference, which is and shall remain the property of CDOT. Before construction, CDOT will provide the documentation for items (1) through (4), and (18) as listed below, when available. The Contractor shall provide the contents required for items (5) through (17). The SWMP shall be stored in the CDOT field office or at another on-site location approved by the Division. The SWMP Administrator shall modify and update the SWMP as needed to reflect actual site conditions before the change or as soon as practicable, but in no case more than 72 hours after the change. The following Contract documents and reports shall be kept, maintained, and updated in the SWMP under the appropriate items by the SWMP Administrator:

A. SWMP Plan Sheets – Notes, tabulation, site description. The SWMP site description shall include, at a minimum, the following:

(1) The nature of the construction activity at the site.
(2) The proposed schedule for the sequence for major construction activities and the planned implementation of control measures for each phase. (clearing, grading, utilities, vertical, etc.)
(3) Estimates of the total acreage of the site, and the acreage expected to be disturbed by clearing, excavation, grading, or any other construction activities.
(4) A summary of any existing data used in the development of the construction site plans or SWMP that describe the soil or existing potential for soil erosion.
(5) A description of the percent of existing vegetative ground cover relative to the

entire site and the method for determining the percentage, per CDOT Erosion Control and Stormwater Quality Guide.

(6) A description of any allowable non-stormwater discharges at the site, including those being discharged under a division low risk discharge guidance policy.

(7) A description of areas receiving discharge from the site. Including a description of the immediate source receiving the discharge. If the stormwater discharge is to a municipal separate storm sewer system (MS4), the name of the entity owning the system, the location of the storm sewer discharge, and the ultimate receiving water(s).

(8) A description of all stream crossings located within the construction site boundary.

B. SWMP Site Maps and Project Plan Title Sheet.

C. Specifications – Standard and project special provisions related to stormwater and erosion control.

D. Standard Plans M-208-1, M-216-1 and M-615-1.

E. Control Measure Details not in Standard Plan M-208-1 – Non-standard details.

F. Weekly meeting sign-in sheet and weekly meeting notes.

G. Calendar of Inspections – Calendar of inspections marking when all inspections take place.

H. Contractor Stormwater Field Inspection Reports (Forms 1176, 1177, 1388).

I. All Water Quality Audit Reports and Form 105(s) relating to Water Quality.

J. Description of Inspection and Maintenance Methods – Description of inspection and maintenance methods implemented at the site to maintain all control measures identified in the SWMP and items not addressed in the design.

K. Spill Response Plan – Reports of reportable spills submitted to CDPHE.

L. List and Evaluation of Potential Pollutants – List of potential pollutants as described in subsection 107.25 and approved Method Statement for Containing Pollutant Byproducts.

M. Other Correspondence including agreements with other MS4s, approved deferral request, CDPHE audit documentation, Water Quality Permit Transfer to Maintenance Punch List, and other miscellaneous documentation such as documented use agreements for areas outside of the permitted area.

N. TECS Certifications of the SWMP Administrator and all ECIs, kept current through the life of the project.

O. Environmental Pre-construction Conference – Conference agenda with a certification of understanding of the terms and conditions of the CDPS-SCP and SWMP. All attendees shall sign the certification. A certification shall also be signed by all attendees of meetings held for new subcontractors beginning work on the project that could adversely affect water quality after the Environmental Pre-construction Conference has been held.

P. Project Environmental Permits – All project environmental permits and associated applications and certifications, including: CDPS-SCP, Senate Bill 40, USACE 404, temporary stream crossings, dewatering, biological opinions, and all other permits applicable to the project, including any separate CDPS-SCP obtained by the Contractor for staging area on private property, asphalt or concrete batch plant.

Q. Photographs Documenting Existing Vegetation – Project photographs shall include the following information with the record: project number, project code, name of the person who took the picture, date and time the picture was taken, and location and approximate station number or mile marker. The Contractor shall submit photographs documenting existing vegetation, before construction commencing, on paper with a maximum of four colored images per side of 8 1/2 inch by 11-inch sheet or a digital copy on CD-ROM/Flash Drive (JPG format) as directed by the Engineer.

R. Permanent Water Quality Plan Sheets – Plan sheets and specifications for permanent water quality structures and riprap.

The Engineer will incorporate the documents and reports available at the time of award. The Contractor shall provide and insert all other documents and reports as they become available during construction. The SWMP Administrator shall finalize the SWMP for CDOT Maintenance use upon completion of the project. The Engineer shall approve SWMP completeness. Corrections to the SWMP shall be made at the Contractor's expense.

2. Reference Materials. The following Reference materials shall be used:

(1) CDOT Erosion Control and Stormwater Quality Guide.

(2) CDOT Erosion Control and Stormwater Quality Field Guide.

(e) Weekly Meetings: The Engineer, the Superintendent, and the SWMP Administrator shall conduct a weekly meeting with supervisors involved in construction activities that could adversely affect water quality. The meeting shall follow an agenda prepared by the Engineer, or a designated representative, and have a sign-in sheet recording the names of all attendees. The SWMP Administrator shall take notes of water quality comments and action items at each weekly meeting and place the agenda and sign-in sheet in the SWMP. At this meeting the following shall be discussed and recorded in tab 6 of the SWMP:

(1) Recalcitrant, chronic, and severe inspection findings.
(2) Unresolved issues from previous inspections.
(3) Requirements of the SWMP.
(4) Problems that may have arisen in implementing the site specific SWMP or maintaining control measures.
(5) Control measures that are to be installed, removed, modified, or maintained, and associated SWMP modifications.
(6) Planned activities that will affect stormwater in order to proactively phase control measures.

All subcontractors not in attendance at the Environmental Pre-construction Conference shall be briefed on the project by the Engineer, Superintendent, and the SWMP Administrator before start of work. The SWMP Administrator shall record the names of these subcontractors as an addendum to the list of attendees and add it to the SWMP.

208.04 Control Measures for Stormwater. The SWMP Administrator shall modify the SWMP to clearly describe and locate all control measures implemented at the site to control potential sediment discharges.

Vehicle tracking pads shall be used at all vehicle and equipment exit points from the site to prevent sediment exiting the limits of construction (LOC) of the project site. Access shall be provided only at locations approved by the Engineer. The SWMP Administrator shall record vehicle tracking pad locations on the SWMP Site Map.

New inlets and culverts shall be protected during their construction. Appropriate protection of each culvert and inlet shall be installed immediately. When riprap is called for at the outlet of a culvert, it shall be installed within 24 hours of completion of each pipe. The Contractor shall remove sediment, millings, debris, and other pollutants from within the newly constructed drainage system per the CDPS-SCP, before use, at the Contractor's expense. All removed sediment shall be disposed of outside the project limits per all applicable regulations.

Concrete products wasted on the ground during construction including, but not limited to, excess concrete removed from forms, spills, slop, and all other unused concrete are potential pollutants that shall be removed from the site or contained at a preapproved containment area that has been identified in the SWMP. The concrete shall be picked up and recycled per 6 CCR 1007-2 (CDPHE Regulations Pertaining to Solid Waste Sites and Facilities) at regular intervals, as needed, or as directed by the Engineer. The uses of recycled concrete from permitted recycling facilities shall be per Section 203.

(a) Unforeseen Conditions. The Contractor shall design and implement erosion and sediment control measures for correcting conditions unforeseen during the design of the project, or for emergency situations, that develop during construction. The Department's Erosion Control and Stormwater Quality Guide shall be used as a reference document for the purpose of designing erosion and sediment control measures. Measures and methods proposed by the Contractor shall be reviewed and approved in writing by the Engineer before installation.

(b) Other Agencies. If CDPHE, US Army Corps of Engineers (USACE), the Environmental Protection Agency (EPA), or a Local Agency reviews the project site and requires additional measures to prevent and control erosion, sediment, or pollutants, the Contractor shall cease and desist activities resulting in pollutant discharge and immediately implement these measures. If the work may negatively affect another MS4, the Contractor shall cease and desist activities resulting in the discharge and shall implement appropriate measures to protect the neighboring MS4, including installing additional measures. Implementation of these additional measures will be paid for at contract unit prices.

(c) Work Outside the Right of Way. Disturbed areas, including staging areas, that are outside CDOT ROW and outside easements acquired by CDOT for construction, are the responsibility of the Contractor. These areas shall be subject to a separate CDPS-SCP and all other necessary permits, as they are considered a common plan of development if within a 1/4 mile of the construction site. The Contractor shall acquire these permits and submit copies to the Engineer before any disturbance. These permits shall be acquired, and all erosion and sediment control work performed at the Contractor's expense. These areas are subject to inspections by CDOT or any other agency, as agreed upon in writing. A documented use agreement between the permittee and the owner or operator of any control measures located outside of the permitted area that are utilized by the permittee's construction site for compliance with the CDPS-SCP, but not under the direct control of the permittee shall be placed in the project's SWMP.

(d) Construction Implementation. The Contractor shall incorporate control measures into the project as outlined in the accepted schedule.

(e) Stabilization. Once earthwork has started, the Contractor shall maintain erosion control measures until permanent stabilization of the area has been completed and accepted. Clearing, grubbing and slope stabilization measures shall be performed regularly to ensure final stabilization. Failure to properly maintain erosion control and stabilization methods, either through improper phasing or sequencing will require the Contractor to repair or replace sections of earthwork at the Contractor's expense. The Contractor shall schedule and implement the following stabilization measures during the course of the project:

1. Temporary Stabilization. At the end of each day, the Contractor shall stabilize disturbed areas by surface roughening, vertical tracking, or a combination thereof. Disturbed areas are locations where actions have been taken to alter the existing vegetation or underlying soil of a site, such as clearing, grading, roadbed preparation, soil compaction, and movement and stockpiling of sediment and materials. Designated topsoil distributed on the surface or in stockpiles shall not receive temporary stabilization. Other stabilization measures may be implemented, as approved. The maximum area of temporary stabilization (excluding areas of designated topsoil) shall not exceed 20 acres.

2. Interim Stabilization. As soon as it is known with reasonable certainty that work will be temporarily halted for 14 days or more, sediment and material stockpiles and disturbed areas shall be stabilized using one or more of the following methods:

   A. Application of 1.5 tons per acre of mechanically crimped certified weed free hay or straw in combination with an approved organic mulch tackifier.

   B. Placement of bonded fiber matrix per Section 213.

   C. Placement of mulching (hydraulic) wood cellulose fiber mulch with tackifier, per Section 213.

   D. Application of spray-on mulch blanket per Section 213. Magnesium Chloride, Potassium Chloride, and Sodium Chloride or other salt products shall not be used as a stabilization method.

   E. Topsoil stockpiles shall receive interim stabilization unless specified per Section 207 as a different material than the other disturbed areas on-site.

3. Summer and Winter Stabilization. Summer and winter stabilization is defined as stabilization during months when seeding is not permitted. As soon as the Contractor knows shutdown is to occur, interim stabilization shall be applied to the disturbed area. Protection of the interim stabilization method is required. Reapplication of interim stabilization may be required as directed.

4. Permanent Stabilization. Permanent stabilization is defined as the covering of disturbed areas with topsoil, seeding, mulching with tackifier, soil retention coverings, and such non-erodible methods as riprap, road shouldering, etc., or a combination as required by the Contract. Other permanent stabilization techniques may be proposed by the Contractor, in writing, and shall be used if approved in writing by the Engineer. Permanent stabilization requirements shown on the plans shall be completed within four working days of the placement of the topsoil per Section 207.

5. Final Stabilization. Final stabilization is achieved when all ground-disturbing activities at the site have been completed, and uniform vegetative cover has been established with an individual plant density of at least 70 percent of predisturbance levels, or equivalent permanent physical erosion reduction methods have been employed.

(f) Maintenance. Erosion and sediment control practices and other protective measures identified in the SWMP as control measures for stormwater pollution prevention shall be maintained in effective operating condition until the CDPS-SCP has been transferred to CDOT. Control measures shall be continuously maintained per good engineering, hydrologic, and pollution control practices, including removal of collected sediment when silt depth is 50 percent or more of the effective height of the erosion control device. When possible, the Contractor shall use equipment with an operator rather than labor alone to remove the sediment.

Maintenance of erosion and sediment control devices shall include replacement of such devices upon the end of their useful service life as recommended by the Contractor and approved by the Engineer. Maintenance of rock check dams and vehicle tracking pads shall be limited to removal and disposal of sediment or addition of aggregate. Damages resulting from failure to maintain control measures shall be repaired at the Contactor’s expense.

Complete site assessment shall be performed as part of comprehensive inspection and maintenance procedures to assess the adequacy of control measures at the site and the necessity of changes to those control measures to ensure continued effective performance. Where site assessment results in the determination that new or replacement control measures are necessary, the control measures shall be installed to ensure continuous effectiveness. When identified, control measures shall be maintained, added, modified or replaced as soon as possible, immediately in most cases.

Approved new or replaced control measures will be measured and paid for per subsections 208.11 and 208.12. Devices damaged due to the Contractor's negligence shall be replaced at the Contractor’s expense.

From the time seeding and mulching work begins until project acceptance the Contractor shall maintain all seeded areas. Damage to seeded areas or to mulch materials shall be immediately restored. Damage to seeded areas or to mulch materials due to Contractor negligence shall be immediately restored at the Contractor’s expense. Restoration of other damaged areas will be measured and paid for under the appropriate bid item.

Temporary control measures may be removed upon completion of the project, as determined by the Water Quality Partial Acceptance walk-through. If removed, the area where these control measures were constructed shall be returned to a condition similar to what existed before its disturbance. Removed control measures shall become the property of the Contractor.

If the Contractor fails to complete construction within the approved contract time, the Contractor shall continue erosion and sediment control operations at its expense until acceptance of the work.

Sediment removed during maintenance of control measures and material from street sweeping may be used in or on embankment, provided it meets the requirements of Section 203 and is distributed evenly across the embankment.

Whenever sediment collects on the paved surface, the surface shall be cleaned. Street washing will not be allowed. Storm drain inlet protection shall be in place before shoveling, sweeping, or vacuuming. Sweeping shall be completed with a pickup broom or equipment capable of collecting sediment. Sweeping with a kick broom will not be allowed.

Material from pavement saw cutting operations shall be cleaned from the roadway surface during operations using a vacuum. A control measure, such as a berm, shall be placed to contain slurry from joint flushing operations until the residue can be removed from the soil surface. Aggregate bags, erosion logs or other permeable control measures shall not be used. Residue shall not flow into driving lanes. It shall be removed and disposed of per subsection 107.25(b). Material containment and removal will not be paid for separately but shall be included in the work.

208.05 Construction of Control Measures. Control measures shall be constructed per Standard Plans M-208-1 and M-216-1, and with the following:

(a) Seeding, Mulching, Sodding, Soil Retention Blanket. Seeding, mulching, sodding, and soil retention blanket installation shall be performed per Sections 212, 213, and 216.

(b) Erosion Bales. The bales shall be anchored securely to the ground with wood stakes.

(c) Silt Fence. Silt fence shall be installed in locations specified in the Contract.

(d) Temporary Berms. Berms shall be constructed to the dimensions shown in the Contract, and sufficiently compacted to prevent erosion or failure. If the berm erodes or fails, it shall be immediately repaired or replaced at the Contractor's expense.

(e) Temporary Diversion. Diversions shall be constructed to the dimensions shown in the Contract and graded to drain to a designated outlet. The berm shall be sufficiently compacted to prevent erosion or failure. If the diversion erodes or fails, it shall be immediately repaired or replaced at the Contractor's expense.

(f) Temporary Slope Drains. Temporary slope drains shall be installed before installation of permanent facilities or growth of adequate ground cover on the slopes. Temporary slope drains shall be securely anchored to the slope. The inlets and outlets of temporary slope drains shall be protected to prevent erosion.

(g) Silt Berm. Before installation of silt berms, the Contractor shall prepare the surface of the areas where the berms are to be installed such that are they free of materials greater than 2 inches in diameter and are suitably smooth for the installation of the silt berms, as approved. Silt berms shall be secured with spikes. The Contractor shall install the silt berm in a manner that will prevent water from going around or under the silt berm. Silt berms shall be installed on top of soil retention blanket or turf reinforcement blanket.

(h) Rock Check Dam. Rock shall be installed at locations shown on the plans. Rock check dams shall conform to the dimensions shown on the plans.

(i) Rip rap Outlet Protection. Geotextile used shall be protected from cutting or tearing. Overlaps between two pieces of geotextile shall be 1-foot minimum. Riprap size shall be as shown on the plans.

(j) Storm Drain Inlet Protection. Before installation, the Contractor shall sweep the surface of the area where the storm drain inlet protection devices are to be installed such that the pavement is free of sediment and debris. The ends of the inlet protection Type 1 and Type 2 shall extend a minimum of 1 foot past each end of the inlet.

The Contractor shall remove all accumulated sediment and debris from the surface surrounding all storm drain inlet protection devices after each rain event or as directed. The Contractor shall remove accumulated sediment from each Type II and III containment area when it is more than one third full of sediment, or as directed.

The Contractor shall protect storm drain facilities adjacent to locations where pavement cutting operations involving wheel cutting, saw cutting, sand blasting, or abrasive water jet blasting are to take place.

(k) Sediment Trap. Sediment traps shall be installed to collect sediment-laden water and to minimize the potential of pollutants leaving the project site. Locations shall be as shown on the plans or as directed.

Sediment traps shall be constructed before disturbance of upslope areas and shall be placed in locations where runoff from disturbed areas can be diverted into the trap.

The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and roots.

Fill material for the embankment shall be free of roots or other vegetation, organic material, large stones, and other objectionable material.

Sediment shall be removed from the trap when it has accumulated to one half of the wet storage depth of the trap and shall be disposed of per subsection 208.04(f).

(l) Erosion Logs. Erosion logs shall be embedded 2 inches into the soil. Stakes shall be embedded so that the top of the stake does not extend past the top erosion log more than 2 inches, at the discretion of the Engineer, a shallower stake depth may be permitted if adverse site conditions are encountered, such as rock or frozen ground.

The Contractor shall maintain the erosion logs during construction to prevent sediment from passing over or under the logs.

(m) Silt Dikes. Before installation of silt dikes, the Contractor shall prepare the surface of the areas where the silt dikes are to be installed such that they are free of materials greater than 2 inches in diameter and are suitably smooth for the installation of the silt dikes, as approved by the Engineer.

(n) Concrete Washout Structure. The concrete washout structure shall meet or exceed the dimensions shown on the plans. Work on this structure shall not begin until the Engineer provides written acceptance of location.

Implement control measures designed for concrete washout waste. If the bottom of the excavated structure is within 5 feet of anticipated high ground water elevation or the soil does not have adequate buffering capacity to meet water quality standards, an impermeable synthetic liner shall be installed with the minimum properties shown in Table 208-8 or use a prefabricated washout.

Meet the following requirements:

1. The structure shall contain all washout water.
2. Stormwater shall not carry wastes from washout and disposal locations.
3. The site shall be located a minimum of 50 horizontal feet away from State waters and shall meet all requirements for containment and disposal as defined in subsection 107.25.
4. The site shall be signed as “Concrete Washout.”
5. The site shall be accessible to appropriate vehicles.
6. Freeboard capacity shall be included in the structure design to reasonably ensure the structure will not overtop during or because of a precipitation event.
7. The Contractor shall prevent tracking of washout material out of the washout structure.
8. Do not add solvents, flocculants, and acid to wash water.
9. Surround the structure on three sides by a compacted berm.
10. The structure shall be fenced with orange plastic construction fencing to provide a barrier to construction equipment and to aid in identification of the concrete washout area.
11. Concrete waste, liquid and solid, shall not exceed 2/3 the storage capacity of the washout structure.

(o) Prefabricated concrete washout structures (Type 1 and Type 2). Structures and sites shall meet the following requirements:

1. Structure shall contain all washout water. If bins are determined to be leaking, the Contractor shall replace the bin onsite and clean up the spilled material.
2. Structure shall be located a minimum of 50 horizontal feet away from State waters and shall be confined so that no potential pollutants will enter State waters and other sensitive areas as defined in the Contract. Locations shall be as approved by the Engineer. Sign the prefabricated structure as “Concrete Washout”. Sign can be on portable bin.
3. The site shall be accessible to appropriate vehicles.
4. Washout bins shall be covered with a tarp tied down to the structure or staked to the ground when a storm event is anticipated.
5. Do not add solvents, flocculants, and acid to wash water.
6. Concrete waste, liquid and solid, shall not exceed ⅔ the storage capacity of the washout structure.
7. Do not move prefabricated structures when they contain liquid, unless otherwise approved.
8. The concrete washout structure shall be installed and ready for use before concrete placement operations.
9. Check and maintain washout areas as required. Do not allow on-site permanent disposal of concrete washout waste.

10. All liquid and solid wastes, including contaminated sediment and soils generated from concrete washout shall be hauled away from the site and disposed of properly at the Contractor's expense.

11. Delivery to the site shall not occur until written acceptance is provided by the Engineer for both the product and the concrete waste disposal facility.

(p) Vehicle Tracking Pad (VTP). Vehicle tracking pads shall be constructed to the minimum dimensions shown in the Contract, unless otherwise directed by the Engineer. Construction of approved vehicle tracking pads shall be completed before any disturbance of the area.

The Contractor shall maintain each vehicle tracking pad during the entire time that it is in use for the project. The vehicle tracking pad shall be removed at the completion of the project unless otherwise directed by the Engineer. Additional aggregate may be required for maintenance and will be paid for under Pay Item, Maintenance Aggregate (Vehicle Tracking Pad).

(q) Detention Pond. Permanent detention ponds shown on the plans may be used as temporary control measures if the following conditions are met:

1. The pond is designated as a construction control measure in the SWMP.

2. The pond outfall and outlet are designed and implemented for use as a control measure during construction per good engineering, hydrologic, and pollution control practices. The stormwater discharges from the outfall shall not cause degradation or pollution of State waters and shall have control measures as appropriate.

3. All silt shall be removed, and the pond returned to the design grade and contour, before project acceptance.

(r) Aggregate Bag. Aggregate bags shall be placed on a stable surface, consisting of hardscape or compacted gravel. If approved by the Engineer, the aggregate bag may be placed on compacted dirt areas, where bags conform to the surface and can effectively minimize sediment transport. Aggregate bags shall not be placed in concentrated flow areas. Aggregate bags shall be placed to conform to the surface without gaps to ensure that discharge water does not cause erosion.

(s) Surface roughening. Surface roughening creates horizontal grooves along the contour of the slope. Roughening may be accomplished by furrowing, scarifying, ripping, or disking the soil surface to create a 2 to 4-inch minimum variation in soil surface.

(t) Vertical Tracking. Vertical tracking involves driving a tracked vehicle up and down the soil surface and creating horizontal grooves and ridges along the contour of the slope. Sandy soils or soils that are primarily rock need not be tracked.

208.06 Materials Handling and Spill Prevention. The SWMP Administrator shall clearly describe and record on the SWMP, all practices implemented at the site to minimize impacts from procedures or significant material that could contribute pollutants to runoff. Areas or procedures where potential spills can occur shall have a Spill Response Plan in place as specified in subsections 107.25(b) or 208.06(c). Construction equipment, fuels, lubricants, and other petroleum distillates shall not be stored or stockpiled within 50 horizontal feet of any State waters or more if the Contractor determines necessary. Equipment fueling and servicing shall occur only within approved designated areas.

(a) Bulk Storage Structures. Bulk storage structures for petroleum products and other chemicals shall have impervious secondary containment or equivalent adequate protection to contain all spills and prevent any spilled material from entering State waters. Secondary containment shall be capable of containing the combined volume of all the storage containers plus at least 10 percent freeboard. For secondary containment that is used and may result in accumulation of stormwater within the containment, a plan shall be implemented to properly manage and dispose of all accumulated stormwater deemed to be contaminated (has an unusual odor or sheen).

(b) Lubricant Leaks. The Contractor shall inspect equipment, vehicles, and repair areas daily to ensure petroleum, oils, and lubricants (POL) are not leaking onto the soil or pavement. Absorbent material or containers approved by the Engineer shall be used to prevent leaking POL from reaching the soil or pavement. The Contractor shall have onsite approved absorbent material or containers of sufficient capacity to contain any POL leak that can reasonably be foreseen. The Contractor shall inform all Spill Response Coordinators per the Spill Response Plan if unforeseen leakage is encountered. All materials resulting from POL leakage control and cleanup shall become the property of the Contractor and shall be removed from the site. Control, cleanup, and removal of by-products resulting from POL leaks shall be performed at the Contractor's expense.

(c) Spill Response Plan. A Spill Response Plan shall be developed and implemented to establish operating procedures for handling potential pollutants and preventing spills.

1. The Response Plan shall contain the following information:
2. Identification and contact information of each Spill Response Coordinator.
3. Locations of areas on the project site where equipment fueling and servicing operations are permitted.
4. Location of clean-up kits.
5. Quantities of chemicals and locations stored on-site.
6. Label system for chemicals and Safety Data Sheets (SDS) for products.
7. Clean-up procedures to be implemented in the event of a spill that does not enter State waters or ground water.
8. Procedures for spills of any size that enter surface waters or ground water or have the potential to do so. CDOT’s Erosion Control and Stormwater Quality Guide contains spill notification contacts and phone numbers required in the Spill Response Plan.
9. A summary of the employee training provided.

Information in items (1) through (8) shall be updated in the SWMP when they change.

208.07 Stockpile Management. Material stockpiles shall be located 50 horizontal feet away from State waters and shall be confined so that no potential pollutants will enter State waters and other sensitive areas as defined in the Contract. Locations shall be approved by the Engineer.

Erodible stockpiles (including topsoil) shall be contained with acceptable control measures at the toe (or within 20 feet of the toe) throughout construction. Control measures shall be approved by the Engineer. The SWMP Administrator shall describe, detail, and record the sediment control devices on the SWMP.

208.08 Limits of Disturbance. The Contractor shall limit construction activities to those areas within the limits of disturbance shown on the plans and cross-sections. Construction activities, in addition to the Contract work, shall include the on-site parking of vehicles or equipment, on-site staging, on-site batch plants, haul roads or work access, and all other activities that would disturb existing soil conditions. Staging areas within the LDA shall be as approved by the Engineer. Construction activities beyond the limits of disturbance due to Contractor negligence shall be restored to the original condition by the Contractor at the Contractor's expense. The SWMP Administrator shall tabulate additional disturbances not identified in the CDPS-SCP application and indicate changes to locations and quantities on the SWMP. The Contractor shall report the changes and additional disturbances to the Engineer, Water Quality Control Division of CDPHE, and all other involved agencies.

The Contractor shall pursue stabilization of all disturbances to completion.

208.09 Regulatory Mechanism for Water Quality The Department will identify and document findings not in compliance with the Water Quality Specifications, as specified in subsection 208.09(a)7, during Headquarters and Region water quality control inspections or observation by the Engineer. The Engineer will immediately notify the Contractor of these findings by issuing Form 105, which will be tracked in ESCAN/CARL software. Failure by the Contractor to clarify a finding location with the Engineer shall not interrupt the timelines noted in subsection 208.09(b).

Timelines noted in subsection 208.09(b) do not indemnify the Contractor from failing to comply with CDPS-SCP timelines for corrective actions. The CDPS-SCP (Part I.D.8) states corrective actions "…must be addressed as soon as possible, immediately in most cases, to minimize the discharge of pollutants."

(a) Definitions.

1. Compliance Assistance. A low-risk event as determined by the Region Water Pollution Control Manager (RWPCM). Compliance assistance events are not considered Findings and not subject to the Regulatory Mechanism noted in subsection 208.09(b).
2. Deferment. A request from the Contractor to the Engineer to delay implementation of corrective actions for Regular Findings pertaining to Water Quality Specifications. Deferments may only be granted due to extraordinary circumstances. However, it is at the Department's discretion to approve or reject these requests.

3. Finding. An incident discovered through inspection by the Department or by Engineer observation, which is noncompliant with the Water Quality Specifications. A Finding will be classified as one of the following:

   A. Regular Finding. A situation upon inspection that is in noncompliance with the Water Quality Specifications.

   B. Severe Finding. A discharge outside the project's Limits of Construction (LOC), subsection 107.25(a), to State waters or to a live inlet where the pollutant cannot be reclaimed.

   C. Chronic Finding. A Chronic Finding is assessed when the same Regular Finding at the same location is documented twice in the last three Headquarters or Region water quality control inspections. Engineer observed findings outside these inspections will not apply.

4. Inspection Form 105. The Form 105 issued by the Engineer documenting findings from Headquarters or Region led water quality inspection per subsection 208.03(c).

5. Location. The place where the finding was observed; can be a document (Stormwater Management Plan [SWMP]) or physical location. A physical location must be described with enough detail to guide an independent party to the spot of the finding. Physical locations must be supported with at least one photograph.

6. Recalcitrance. Contractor has shown willful negligence or misrepresentation or unwillingness to adhere to the Water Quality Specifications.

7. Water Quality Specifications. Subsection 107.25, Sections 208, 213 and 216, and Standard Plans M-208-1 and M-216-1.

(b) Liquidated Damages and Stop Work Orders. The Contractor will be subject to Liquidated Damages for incidents of failure to comply with the Water Quality Specifications and implement corrective actions to resolve noncompliance in the time frame established in subsection 208.09(b and c). Liquidated damages will not be considered a penalty but will be assessed to recover costs associated with environmental damages, and engineering and administrative expenses incurred by the Department for the Contractor's failure to comply with the Water Quality Specifications. Liquidated damages will accumulate for each finding, for each cumulative day that the finding remains uncorrected. Liquidated damages associated with incidents pertaining to this subsection do not indemnify the Contractor of other Liquidated Damages associated with this project.

In addition to Liquidated Damages, the Contractor will be subject to a project-wide Stop Work Order for recalcitrance and the Engineer may, in writing, issue a Stop Work Order for Chronic and Severe Findings per subsection 105.01.

Findings are closed when the corrective action is complete, reported to ESCAN and accepted by the Department. The Department will notify the Contractor through ESCAN when the corrective action is accepted or denied. Liquidated damages will be assessed by the type of finding as follows and will continue until the corrective action is approved by the Department.

1. Regular Finding. The time required to repair a Regular Finding shall begin at 11:59 PM on the date the Inspection Form 105 is issued. The Contractor shall have no more than a seven-day grace period to correct the Regular Finding before Liquidated Damages are assessed. The grace period extends until 11:59 PM on the seventh day after the Inspection Form 105 was issued.

   The Engineer will issue a Form 105 notifying the Contractor that Liquidated Damages are accruing at $1,500 per day for each full or partial calendar day a Regular Finding remains uncorrected after the seven-day grace period. At 11:59 PM on the 14th day after the Form 105 was issued, each uncorrected, undeferred Regular Finding will be assessed as recalcitrant and the Engineer will issue a project-wide stop work order. The Contractor shall fix each recalcitrant finding and submit a plan to avoid future instances of each recalcitrance to the Department for approval. The recalcitrance plan shall be in writing, signed by the Superintendent and shall include:

   A. Each Recalcitrant Finding.

   B. Why the corrective action for each Recalcitrant Finding was not implemented within 14 days.

   C. How the Contractor will avoid future recalcitrance.

   The Department will discuss the recalcitrance plan and may meet with the Superintendent to recommend modifications, if needed. The Engineer will issue a Form 105 accepting or rejecting the recalcitrance plan within 24 hours of the Contractor submitting a plan or resubmitting a modified plan.

   The Contractor will neither be reimbursed for costs incurred to fix each Recalcitrant Finding pertaining to a control measure in the SWMP plan nor costs to prepare the recalcitrance plan. The Contractor shall propose additional control measures, if needed, according to subsection 208.04(a). The project-wide Stop Work Order and Liquidated Damages will be assessed until approval of the corrective action for each Recalcitrant Finding and approval of the Contractor's recalcitrance plan by the Department is given. After written approval by the Engineer, the project-wide Stop Work Order will be lifted, and accrual of Liquidated Damages will cease.

2. Severe Finding. In response to a Severe Finding, the Engineer will issue Inspection Form 105 and immediately assess Liquidated Damages of $3,500 per Severe Finding. Severe Findings shall not be eligible for the seven-day grace period (subsection 208.09(b)1). Liquidated damages will accrue at $3,500 per Severe Finding per calendar day beginning at 11:59 PM of day the Inspection Form 105 is issued.

   A. If the Severe Finding is a discharge to State waters, the Contractor shall prevent any further discharge and shall reclaim discharge that has not yet entered State waters. The Contractor shall report the discharge to CDPHE per CDPS-SCP requirements.

   B. If the Severe Finding is a discharge outside the LOC that does not enter State waters, the Contractor shall fully reclaim the discharge before it enters State waters and implement relevant CDPS-SCP noncompliance notification procedures.

The Engineer may require the Contractor to submit a plan for permanent stabilization of disturbed areas outside the LOC per 208.04(e)4 for approval. Permanent stabilization plans pertaining to Severe Findings and subsequent stabilization activities are not subject to 208.09(b).

The Contractor shall not be reimbursed for activities undertaken to reclaim the discharge, stabilize areas outside the LOC and implement relevant CDPS-SCP noncompliance notification procedures.

3. Chronic Finding. In response to a Chronic Finding, the Engineer will issue Inspection Form 105 and immediately assess Liquidated Damages of $1,500 per Chronic Finding. Chronic Findings shall not be eligible for the seven-day grace period (subsection 208.09(b)). Liquidated damages will accrue at $1,500 per Chronic Finding per day beginning at 11:59 PM of day the Inspection Form 105 is issued.

   When the Chronic Finding is comprised of two Severe Findings, the Department will assess Liquidated Damages per this specification.

(c) Deferment. If the Contractor seeks deferment, the Superintendent shall submit a deferment request to the Engineer by 11:59 PM of the day after the issuance of Inspection Form 105. Chronic and Severe Findings are not eligible for deferment. The deferment request shall be in writing, signed by the Superintendent and shall include:

1. Regular Findings to be deferred.
2. The reasons why the Findings cannot be corrected in seven days.
3. An action plan containing:

   A. Methodology to protect water quality until each deferred Finding is corrected and accepted.

   B. Milestones to measure progress toward completion.

   C. Additional control measures to be implemented until each deferred Finding is corrected and accepted.

   D. Corrective completion dates for each Finding

The Department will discuss the deferment request and may meet with the Superintendent to recommend modifications to the action plan. The Engineer will issue a Form 105 accepting or rejecting the deferment request by 11:59 PM of the third day after the Inspection Form 105 documenting the Regular Finding is issued. The Department will not accept a deferment for operational error, lack of resources, improperly installed control measures, inadequate control measures, lack of preventative maintenance, careless or improper operation, or other non-proactive reason.

Preparation of deferment documentation and additional materials, including additional control measures, required to complete the action plan shall be at the Contractor's expense. Time frames noted in subsection 208.09(b)1 will not be stopped during the deferment review period, therefore, Liquidated Damages will be assessed beginning 11:59 PM on calendar day seven if the deferment request is rejected and, furthermore, a rejected deferment plan (subsection 208.09(c)) shall not absolve the Contractor from recalcitrance.

The Engineer will assess Liquidated Damages of $1,500 per calendar day, and partial day, for each uncorrected Deferred Finding. These Liquidated Damages will start on the date the uncorrected work was deferred to be completed (subsection 208.09(c)(3)). In addition, Liquidated Damages of $1,500 per calendar day will be assessed retroactively to 11:59 PM of the day the finding was originally noted on the Inspection Form 105.

(d) Conflict Resolution. Subsections 105.22, 105.23, and 105.24 detail the process through which the parties (CDOT and the Contractor) agree to resolve any issue that may result in a dispute.

(e) Exemptions. The Engineer will exempt from subsection 208.09(b) situations of Compliance Assistance, Documented Upset Conditions, Documented Reportable Spills and Documented Winter Exemptions. Release from subsection 208.09(b) does not exempt the Contractor from compliance with CDPS-SCP, Part I.D.8.

1. Documented Upset Condition. The Contractor shall report, both verbally and in writing, the Upset Condition to CDPHE per CDPS-SCP Part II.A.6 and subsection 208.03(c) and provide written documentation to the Engineer. The Engineer will issue a Form 105 and recognize the exemption to the Regulatory Mechanism. The Contractor shall also update the SWMP with the Form 105 and the documented Upset Condition.

2. Documented Reportable Spills. The Contractor shall report, both verbally and in writing, the Reportable Spill to CDPHE per subsection 107.25(b) and provide written documentation to the Engineer. The Engineer will issue a Form 105 and recognize the exemption to the Regulatory Mechanism. The Contractor shall also update the SWMP with the Form 105 and the documented Reportable Spill.

3. Winter Exemptions. The Contractor is unable to address findings noted on the Headquarters or Region led water quality control inspection due to:

   A. Snow covers the entire site for an extended period,

   B. No construction activity, and

   C. Melting conditions posing a risk of surface erosion do not exist.

   The Contractor shall request a Winter Exemption to the Department. If approved, the Engineer will issue a Form 105 and recognize the exemption to subsection 208.09(b). The Contractor shall also update the SWMP with the Form 105 and the documented Winter Exemption. Liquidated Damages, if assessed, will only accrue up to the point where the Winter Exemptions are approved.

4. Compliance assistance during Headquarters or Region led water quality control inspections. The RWPCM will record compliance assistance in ESCAN/CARL software.

208.10 Items to Be Completed Before Requesting Partial Acceptance of Water Quality Work.

(a) Reclamation of Washout Areas. After concrete operations are complete, washout areas shall be reclaimed per subsection 208.05(n) at the Contractor's expense.

(b) Survey. When Permanent Water Quality (PWQ) control measures are required on the project and once built, the Contractor shall survey the control measures to confirm that the PWQ control measures conform to the configuration, grade, and volume shown on the plans. The survey shall conform to Section 625. The results of the survey shall be submitted per CDOT's Survey Manual (MicroStation to GIS and TMOSS Codes), or GIS with attribute tables, showing both designed and final elevations and configurations. The Contractor's Surveyor shall submit electronically sealed control measure drawings.

PWQ control measures that do not meet the Contract requirements will be identified in writing by the Engineer and shall be repaired or replaced at the Contractor's expense. Correction surveys shall be performed at the Contractor's expense to confirm the locations, dimensions, and volume certification (for water quality capture volume structures only) of each PWQ control measure. The Engineer, CDOT Hydraulics Engineer for the region, Headquarters Permanent Water Quality Manager, and Headquarters Maintenance staff will perform a walkthrough of the PWQ control measures to confirm conformance to material requirements, locations, and dimensions. Before the walkthrough, the Contractor shall provide the corrected survey to the Engineer, Regional, and Headquarters Permanent Water Quality Managers.

(c) Locations of Temporary Control Measures. The Engineer will identify locations where modification, cleaning, or removal of temporary control measures are required and will provide these in writing to the Contractor. Upon completion of work required, the SWMP Administrator shall modify the SWMP to provide an accurate depiction of control measures to remain on the project site.

Complete and approve all punch list and walkthrough items by the Engineer and Maintenance.

METHOD OF MEASUREMENT

208.11. Erosion Control Management will be measured as the actual number of days of ECM work performed, regardless of the number of personnel required for SWMP Administration and Erosion Control Inspection, including erosion control inspections, documentation, meeting participation, SWMP Administration, and the preparation of the SWMP. If the combined hours of SWMP Administration and Erosion Control Inspection is four hours or less in a day, the work will be measured as a half day. If the combined hours of SWMP Administration and Erosion Control Inspection is more than four hours in a day, the work will be measured as one day. Pay the total combined hours of ECM work exceeding eight hours in a day as one day.

Erosion bales and rock check dams will be measured by the actual number installed and accepted.

Silt fence, silt berms, erosion logs, aggregate bags, silt dikes, temporary berms, temporary diversions, and temporary slope drains, will be measured by the actual number of linear feet that are installed and accepted. Measured length will not include required overlap.

Concrete washout structure will be measured by the actual number of structures that are installed and accepted.

Prefabricated concrete washout structures will be measured by the actual number of structures delivered to the site. It shall not include structures moved on-site.

Storm drain inlet protection will be measured by linear foot or actual number of devices that are installed and accepted.

Sediment trap quantities will be measured by the actual number installed and accepted.

Removal of trash that is not generated by construction activities will be measured by the actual number of hours that Contractor workers actively remove trash from the project. Each week the Contractor shall submit to the Engineer a list of workers and the hours spent collecting such trash.

Removal of accumulated sediment from traps, basins, areas adjacent to silt fences and erosion bales, and other clean out excavation of accumulated sediment, and the disposal of such sediment, will be measured by the number of hours that equipment, labor, or both are used for sediment removal.

Vehicle tracking pads will be measured by the actual number constructed and accepted.

Additional aggregate required for maintaining vehicle-tracking pads will be measured as the actual number of cubic yards installed and accepted.

Prefabricated vehicle-tracking pads will be measured by the actual number of pads delivered to the site and set up to the minimum dimensions. It shall not include pads moved on-site.

BASIS OF PAYMENT

208.12. Pay for ECM and control measures at the Contract unit price for each of the items listed below that appear in the bid schedule.

Pay under:

Pay Item	Pay Unit
Aggregate Bag	Linear foot
Concrete Washout Structure	Each
Erosion Bales (Weed Free)	Each
Erosion Control Management	Day
Erosion Log (Type 1) (____ Inch)	Linear foot
Erosion Log (Type 2) (____ Inch)	Linear foot
Erosion Log (Type 3) (____ Inch)	Linear foot
Prefabrctd. Concrete Washout Struc.(Type 1)	Each
Prefabrctd. Concrete Washout Struc.(Type 2)	Each
Prefabricated Veh.Tracking Pad	Each
Mtce. Aggregate (Veh. Tracking Pad)	Cubic Yard
Removal & Disposal of Sediment (Equip.)	Hour
Removal and Disposal of Sediment (Labor)	Hour
Removal of Trash	Hour
Rock Check Dam	Each
Sediment Basin	Each
Sediment Trap	Each
Silt Berm	Linear Foot
Silt Dike	Linear Foot
Silt Fence	Linear Foot
Silt Fence (Reinforced)	Linear Foot
Storm Drain Inlet Protection (Type__)	Linear Foot
Storm Drain Inlet Protection (Type__)	Each
Sweeping (Sediment Removal)	Hour
Temporary Berm	Linear Foot
Temporary Diversion	Linear Foot
Temporary Slope Drain	Linear Foot
Vehicle Tracking Pad	Each

Payment for Erosion Control Management (ECM) will be full compensation for all labor, materials and equipment necessary for the SWMP Administrator and Erosion Control Inspectors to perform all the work described in this specification. This includes assembling items (5) to (18) in subsection 208.03(d)1 and required updates to the SWMP.

The SWMP Administrator and ECI's commute times will not be measured and paid for separately but shall be included in the work.

Modifications to the SWMP due to construction errors or survey errors by the Contractor shall be made at the Contractor’s expense.

Surface roughening and vertical tracking (temporary stabilization) will not be measured and paid for separately but shall be included in the work. Payment for each control measure item will be full compensation for all work and materials required to furnish, install, maintain, and remove the control measure when directed.

Payment for Removal and Disposal of Sediment (Equipment) will be full compensation for use of the equipment, including the operator. Payment for Removal and Disposal of Sediment (Labor) will be full compensation for use of the labor.

Payment for concrete washout structure, whether constructed or prefabricated, will be full compensation for all work and materials required to install, maintain, and remove the item. Maintenance and relocation, as required, of these structures throughout the duration of the project will not be measured and paid for separately but shall be included in the work.

Silt berm spikes and wood spikes will not be measured and paid for separately but shall be included in the work. When required, soil retention blankets will be measured and paid for per Section 216.

Compost and wood stakes for Erosion Log (Type 2) will not be measured and paid for separately but shall be included in the work.

Spray-on mulch blankets required by the Contract, including those used in both interim and final stabilization, will be measured and paid for per Section 213.

Payment for storm drain inlet protection will be full compensation for all work, materials, and equipment required to complete the item, including surface preparation, maintenance throughout the project, and removal upon completion of the work. Aggregate will not be measured and paid for separately but shall be included in the work.

Sweeping, when used as a control measure as shown in the Contract, will be measured by the number of hours that a pickup broom or equipment capable of collecting sediment, authorized by the Engineer, is used to remove sediment from the roadway or other paved surfaces. Each week the Contractor shall submit to the Engineer a statement detailing the type of sweeping equipment used and the number of hours it was used to pick up sediment. The operator will not be measured and paid for separately but shall be included in the work.

Stakes, anchors, connections, geotextile, riprap, and tie downs used for temporary slope drains will not be measured and paid for separately but shall be included in the work.

Payment for vehicle tracking pad will be full compensation for all work, materials and equipment required to construct, maintain, and remove the entrance upon completion of the work. Aggregate and geotextile will not be measured and paid for separately but shall be included in the work. If additional aggregate for maintenance of vehicle tracking pads is required, it will be measured by the cubic yard per Section 304 and will be paid for under this Section as Maintenance Aggregate (Vehicle Tracking Pad).

Seeding, sod, mulching, soil retention blanket, and riprap will be measured and paid for per Sections 212, 213, 216, and 506.

All work and materials required to perform the permanent control measure survey and furnish the electronic files shall be included in the original unit price bid for surveying. Surveying will be measured and paid for per Section 625.

Payment will be made for control measures replaced as approved by the Engineer. Temporary erosion and sediment control measures required due to the Contractor’s negligence, carelessness, or failure to install permanent controls as a part of the work as scheduled or ordered by the Engineer or for the Contractor's convenience, shall be performed at the Contractor’s expense. If the Contractor fails to complete construction within the contract time, payment will not be made for Section 208 pay items for the period of time after expiration of the contract time. These items shall be provided at the Contractor's expense.

SECTION 209

WATERING AND DUST PALLIATIVES

DESCRIPTION

209.01. This work consists of applying water to soils or aggregates for moisture and density control, landscaping, prewetting an excavation area, and dust palliatives. It also includes applying magnesium chloride dust palliative for the control of dust and the stabilization of soil and aggregate surfaced roads.

MATERIALS

209.02 Water applied for moisture and density control, as dust palliative, and for prewetting shall be free from injurious matter. Water for landscaping shall be free from oil, acids, alkalis, salts, or any substance injurious to plant life.

When the water source proposed for use by the Contractor is not of known quality and chemical content, submit samples of the water for approval before use.

Magnesium chloride dust palliative shall consist of a magnesium chloride base agent, water, and other enhancing or nondetrimental ions. The chemical analysis shall conform to the following:

Table 209-1

MAGNESIUM CHLORIDE DUST PALLIATIVE

CHEMICAL CONSTITUENTS PERCENT BY WEIGHT

Magnesium Chloride (MgCl2)	28 to 35
Enhancing or Non-detrimental Ions	0 to 5
Water	65 to 72

CONSTRUCTION REQUIREMENTS

209.03 Moisture and Density Control. Sprinkling equipment shall deliver uniform and controlled distribution of water without ponding or washing. Apply uniformly water for finishing operations by spraying across the full width of the course.

209.04 Prewetting. Prewetting material in excavation areas before its removal for placement in embankments will be allowed when approved. The Contractor shall furnish a prewetting layout for each area to be prewetted including nozzle size, spacing, number of lines, and other equipment to be used. The Contractor shall obtain the approval of the Engineer for each prewetting layout before each prewetting operation.

209.05 Dust Palliative. The Contractor shall furnish and apply a dust palliative on portions of the roadway and on haul roads at the locations and in the amounts as provided in the Contract.

Dust palliative shall consist of water. Apply water with acceptable sprinkling equipment at an appropriate rate as approved by the Engineer.

Apply Magnesium Chloride dust palliative as follows:

Scarify the top 2 inches of the existing road surface and wet with water to approximately four percent moisture content, or as directed.

Apply the magnesium chloride dust palliative in two applications of 0.25 gallon per square yard in each application.

Allow to soak for 30 minutes after each application.

Roll the surface with a pneumatic tire roller, as specified in the Contract.

Do not permit traffic on the treated surface until approved.

209.06 Landscaping. The Contractor shall furnish water for seeding, mulching, planting, transplanting, sodding, herbicide treatment, and any other landscaping work when called for on the plans or when designated.

METHOD OF MEASUREMENT

209.07 Water will be measured by the number of thousand gallons (M Gallon) used and accepted. Measurement of water may be made in the vehicle at point of delivery or by meter. When water is to be metered for measurement, the Contractor shall provide and use an approved metering device.

Magnesium Chloride dust palliative will be measured by the number of gallons applied and accepted.

BASIS OF PAYMENT

209.08 The accepted quantities of water measured as provided above will be paid for at the contract unit price per M Gallon. The accepted quantities of Magnesium Chloride dust palliative measured as provided above will be paid for at the contract unit price per Gallon. Pay under:

Pay Item	**Pay Unit**
Water	(M Gallon)
Water (Landscaping)	(M Gallon)
Dust Palliative (Magnesium Chloride)	Gallon

Water required for all items of work will not be measured and paid for separately but shall be included in the work, except that water for dust palliative, and water ordered for the benefit or safety of the public will be measured and paid for separately per the Contract.

If the area for landscape work is irrigated by a Department-owned system, the Contractor may use the water from this source. Water used from a Department source will not be measured and paid for.

SECTION 210

RESET STRUCTURES

DESCRIPTION

210.01 This work consists of removing, relaying, resetting, or adjusting structures and related materials. All designated items shall be carefully removed, and stored, reinstalled, or adjusted, in a manner that will avoid loss or damage.

CONSTRUCTION REQUIREMENTS

210.02 General. Relaid pipe and conduit and reset structures shall be cleaned of foreign material before reinstallation.

Except in areas to be excavated, all holes resulting from the removal of structures shall be neatly backfilled. Methods shall conform to those required in the specifications for the various types of construction involved.

Materials in good condition from removed structures may be re-used. Salvable material, as designated in the Contract, that is not re-used shall remain the property of the Department, and the Contractor shall be held responsible for safekeeping of all materials until receipted by the Department. Materials damaged, stolen, or lost before receipt by the Department shall be repaired or replaced, as determined by the Engineer, at no cost to the Department.

Unserviceable material, as determined by the Engineer, shall be replaced with new material of similar dimensions, and the material costs will be paid for per subsection 109.04(b), except as otherwise provided in this section. All new materials and replacement parts shall conform to the requirements of the Contract for the appropriate items.

210.03 Light Standard. Light standards shall be reset on new concrete foundation pads complete with conduit and wiring per the Department's Standard Plans at locations indicated in the Contract.

210.04 Fences and Gates. Where fences (except snow fence) are reset, the Contractor shall supply and install any new materials required to restore the fence to acceptable condition except for new posts. The Contractor shall supply new posts as needed for the reset fence per Section 607. Wire in the old fence shall be salvaged and used in the reset fence.

Where snow fences are reset, panels shall be removed from their existing location and reset at the new location.

Gates designated to be reset shall be removed and restored for service at the new locations.

Right-of-way fence shall be reset approximately six inches inside the boundary of the highway right of way shown on the plans. Anchorages, footings, or fence appurtenances shall not extend beyond the limits of the highway right of way without the written consent of the abutting property owner.

210.05 Guardrail. Where guardrail is reset, the Contractor shall supply and install any new materials needed to restore the guardrail to acceptable condition. New materials shall include additional posts, blocks, and hardware needed to complete the intermediate post installations as shown on the Department's Standard Plans. Posts with similar tops shall be installed in groups as directed. Installation of fiat-top posts alternately with other top shapes will not be permitted. Posts may be cut, rotated, or turned upside down to eliminate unacceptable tops. If the posts are cut, the Contractor shall treat the exposed surface with two coats of an approved preservative.

Adjust guardrail shall be the work necessary to adjust the height to the standard per Standard Plan M-606-1 and filling the resulting voids under the posts with a lean concrete mixture consisting of 1 part cement and 10 parts sand.

210.06 Mailbox. Mailboxes complete with supporting structures are to be removed and temporarily reset at points near their original location to be accessible for mail delivery service. Upon completion of surfacing operations, the boxes shall again be reset at the locations designated. A supporting structure may contain one or more mailboxes. New permanent mailbox support posts and mounting brackets shall be furnished and installed per the Department's Standard Plans.

210.07 Ground Sign. Signs and posts designated to be reset shall be removed, cleaned, and reset at designated locations, including all work necessary to provide the existing posts with break-away devices, where required.

210.08 Sign Structure Sign structures shall be sandblasted and repainted before reinstallation.

210.09 Traffic Signal Traffic signals designated to be reset shall be removed along with existing poles and electrical equipment. New concrete footings shall be installed along with any new electrical equipment necessary to restore the structure to service at the new location. Equipment and materials shall be cleaned before being reset.

210.10 Adjust Structure. Adjusting structures shall apply, but not be limited to, manhole rings and covers, inlet gratings and frames, water valve boxes, water meters, gate posts, and other structures and facilities. Construction operations shall consist of raising, lowering, moving, or removing masonry or concrete; adding brickwork, masonry, or concrete; and resetting grates, frames, or rings and covers to fit the new construction. Structures in the traveled roadway shall be adjusted to a tolerance of 1/4 inch to 1/2 inch below the surface of the roadway. Work on water services shall be subject to inspection and testing by the owners. Damage to any fire hydrant or any part of the water system by the Contractor shall be repaired at the Contractor's expense.

210.11 Flashing Beacon. Reset flashing beacon shall consist of providing a new concrete foundation or footing, adjustments of post and breakaway device as required, and providing all electrical equipment and materials necessary to restore the installation to service at the new location. The Contractor shall provide necessary connections from the nearest power source or from the source designated on the plans to the new location.

METHOD OF MEASUREMENT

210.12 The quantity to be measured where items are reset or adjusted on an “each” basis shall be the actual number of those items restored for service at new location, completed and accepted.

Concrete foundation pads will be measured and paid for as “Concrete Foundation Pad” per Section 613.

Concrete footings for ground signs and overhead sign structures, if required, will be measured and paid for per Section 614.

Steel post extensions, if required, will be measured and paid for as “Steel Signpost” per Section 614, of the type shown on the plans.

The quantity to be measured where items are reset or adjusted on a “linear foot” basis shall be the actual number of linear feet of the items completed and accepted, measured end to end, except guardrail and snow fence. Guardrail will be measured as the actual number of linear feet completed and accepted, as shown on the Department's Standard Plans. Snow fence shall be measured end to end of the anchor posts.

The quantity to be measured for “Relay Pipe” shall be the number of linear feet of re-laid pipe including end sections, measured end to end, in place, completed and accepted.

The quantity to be measured for “Reset Mailbox Structure” shall be the number of supporting structures, complete with mailboxes, restored at new locations and accepted. Moving the mailbox structures for temporary mail service during construction, and installing new support post, base, mounting brackets, and hardware will not be measured or paid for separately but shall be included in the work.

Resetting of structures, fences, and related materials shall include all work necessary to remove the items from their existing location to the new location, and shall include all mounting hardware, footings, and all other work necessary to complete the reset item, except for new fence posts. Fence posts required and approved will be measured and paid for per Section 607.

Resetting of traffic signals, poles, controllers, cabinets, preemption units, coordination and interconnection equipment, and related equipment and materials shall include all work necessary to remove the items from their existing location and reset them at the new location, and shall include all mounting hardware, footings, other electrical equipment and service, and all other materials and work necessary to complete the reset item in service at the new location.

BASIS OF PAYMENT

210.13 The accepted quantities, measured as provided above, will be paid for at the contract price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Reset	Each, Linear Foot, Square Yard, Lump Sum
Relay Pipe ( )	Linear Foot
Adjust	Each, Linear Foot
Modify	Each
Reset Mailbox Structure (Type)	Each

Adjust Guardrail Linear Foot

Structure excavation and structure backfill required for “Relay Pipe” will be measured and paid for per Section 206. Any void in the structure excavation prism created by the removal of pipe will be excluded from measurement and payment of structure excavation.

Except as otherwise provided in the Contract, collars and connecting devices will not be measured and paid for separately but shall be included in the work.

SECTION 212

SEEDING, FERTILIZER, SOIL CONDITIONER, AND SODDING

DESCRIPTION

212.01 This work consists of soil preparation, application of fertilizer, soil conditioners, or both, and furnishing and placing seed and sod. The work shall be per the Contract and accepted horticultural practices.

MATERIALS

212.02 Seed, Soil Conditioners, Fertilizers, and Sod.

(a) Seed. All seed shall be furnished in bags or containers clearly labeled to show the name and address of the supplier, the seed name, the lot number, net weight, origin, the percent of weed seed content, the guaranteed percentage of purity and germination, pounds of pure live seed (PLS) of each seed species, and the total pounds of PLS in the container. All seeds shall be free from noxious weed seeds per current state and local lists and as indicated in Section 213. The Contractor shall furnish to the Engineer a signed statement certifying that the seed is from a lot that has been tested by a recognized laboratory for seed testing within thirteen months before the date of seeding. The Engineer may obtain seed samples from the seed equipment, furnished bags, or containers to test seed for species identification, purity, and germination. Seed tested and found to be less than 10 percent of the labeled certified PLS and different than the specified species will not be accepted. Seed that has become wet, moldy, or damaged in transit or in storage will not be accepted.

Seed types and amount of PLS required per acre shall be provided per the Contract.

Seed and seed labels shall conform to all current State and Federal regulations and will be subject to the testing provisions of the Association of Official Seed Analysis. Computations for quantity of seed required on the project shall include the percent of purity and percent of germination.

The formula used for determining the quantity of PLS shall be:

Bulk Pounds of Seed Species • (Percent Purity • Percent Germination) = Pounds of PLS

(b) Soil Conditioners and Fertilizer.

1. Fertilizer: Fertilizer (plant nutrients) shall conform to the applicable State fertilizer laws. It shall be uniform in composition, dry, and free flowing, and shall be delivered to the site in the original, unopened containers, each bearing the manufacturer's guaranteed analysis. Fertilizer that becomes caked or damaged will not be accepted.

2. Soil Conditioner: Soil conditioner shall consist of compost, biological nutrient, biological culture or humic acid-based material.

   Humic acid-based material (Humate) shall include the following:

   A. A pH of 3 to 5.

   B. Maximum 20 percent inert ingredient.

   C. Minimum 80 percent organic matter with 40 percent minimum humic acid.

   Compost shall be weed-free, organic compost derived from a variety of feed stocks including agricultural, biosolids, forestry, food, leaf and yard trimmings, manure, tree wood with no substances toxic to plants. Material shall be aerobically composted in a facility permitted by the Colorado Department of Public Health and Environment (CDPHE) to produce or sell compost per House Bill (HB) 1181. The Contractor shall submit a copy of this permit to the Engineer for approval and the project records. The compost shall be tested per the U.S. Composting Council's Test Methods for Examining of Composting and Compost (TMECC) manual.

   The compost manufacturer shall be a participating member of in the U.S. Composting Council's Seal of Testing

   Assurance Program (STA). The Contractor shall provide a participation certificate and test data on a Compost Technical Data Sheet.

Compost shall have the following physical properties:

Table 212-1
COMPOST PHYSICAL PROPERTIES

Compost Parameters	Reported as	Requirement	Test Method
pH	pH units	6.0 – 8.5	TMECC 04.11-A
Soluble Salts (Electrical Conductivity)	dS m-1 or mmhos cm-1	Maximum 10 dS/m	TMECC 04.10-A
Moisture Content	%, wet weight basis	30 – 60%	TMECC 03.09-A
Organic Matter Content	%, dry weight basis	30 – 65%	TMECC 05.07-A
Particle Size (sieve sizes)	%, dry weight basis for each sieve fraction	Passing 1 inch – 100% 1/2 inch – 95%	TMECC 02.02-B
Man-made Inert Contamination	%, dry weight basis	< 1%	TMECC 03.08-A
Stability (Respirometry)	mg CO2-C per g TS per day mg CO2-C per g OM per day	8 or below	TMECC 05.08-B
Select Pathogens	(PASS/FAIL) Limits: Salmonella <3 MPN/4grams of TS, or Coliform Bacteria <1000 MPN/gram	Pass	TMECC 07.01-B Fecal Coliforms, or 07.02 Salmonella
Trace Metals	(PASS/FAIL) Limits (mg kg-1, dw basis): As 41, Cd 39, Cu 1500, Pb 300, Hg 17, Ni 420, Se 100, Zn 2800	Pass	TMECC 04.06
Maturity (Bioassay)			
Percent Emergence	%, (average)	> 80%	TMECC 05.05-A
Relative Seedling Vigor	%, (average)	> 80%	

Table 212-1 Notes: The Contractor shall provide a CTR per subsection 106.13 confirming the material has been tested per TMECC.

(c) Sod. Sod shall be nursery grown and 99 percent weed free. Species shall be as shown on the plans. Other sod types may be used only if approved in writing by the Engineer. The one percent allowable weeds shall not include any undesirable perennial or annual grasses, or plants defined as noxious by current State statute. Soil thickness of sod cuts shall not be less than 3/4 inch nor more than 1 inch. Sod shall be cut in uniform strips with minimum dimensions of 18 inches in width and 48 inches in length. The Contractor shall submit a sample of the sod proposed for use, which shall serve as a standard. Any sod furnished, whether in place or not, that is not up to the standard of the sample may be rejected. Sod that was cut more than 24 hours before installation shall not be used.

Each load of sod shall be accompanied by a certificate from the grower stating the type of sod and the date and time of cutting.

CONSTRUCTION REQUIREMENTS

212.03 Seeding Seasons. Seeding in areas that are not irrigated shall be restricted according to the following timetable and requirements.

Table 212-2

SEEDING SEASON TIMETABLE AND REQUIREMENTS

Areas other than the Western Slope

Zone	Spring Seeding	Fall Seeding
Below 6000 feet	Spring thaw to June 1	September 15 until consistent ground freeze
6000 to 7000 feet	Spring thaw to June 1	September 1 until consistent ground freeze
7000 to 8000 feet	Spring thaw to July 15	August 1 until consistent ground freeze
Above 8000 feet	Spring thaw to consistent ground freeze	

Western Slope

Zone	Spring Seeding	Fall Seeding
Below 6000 feet	Spring thaw to May 1	August 1 until consistent ground freeze
6000 to 7000 feet	Spring thaw to June 1	September 1 until consistent ground freeze

(1) “Spring thaw” shall be defined as the earliest date in a new calendar year that seed can be buried 1/2 inch into the surface soil (topsoil) thru normal drill seeding methods.

(2) “Consistent ground freeze” shall be defined as that time during the fall months that the surface soil (topsoil), due to freeze conditions, prevents burying the seed 1/2 inch thru normal drill seeding operations. Seed shall not be sown, drilled, or planted when the surface soil or topsoil is in a frozen or crusted state.

Seeding accomplished outside the time periods listed above will be allowed only when ordered by the Engineer or when the Contractor's request is approved in writing. When requested by the Contractor, the Contractor must agree to perform the following work at no cost to the Department: reseed, remulch, and repair areas that fail to produce species indicated in the Contract.

When seeding is ordered by the Engineer outside the time periods listed above, the cost of additional material will be paid for by the Department. The Contractor will not be responsible for failure of the seeded area to produce species indicated in the Contract due to reasons beyond the control of the Contractor.

The seeding, the soil conditioning, and the fertilizing application rate shall be as specified. The Engineer may establish test sections for adjusting the seeding and the fertilizing equipment to assure the specified rate. The Engineer may order equipment readjustment at any time.

Seed, soil conditioner and fertilizer shall not be applied during inclement weather including rain and high winds, or when soil is frozen or soil moisture is too high to evenly incorporate seed, soil conditioner or fertilizer.

212.04 Lawn Grass Seeding. Lawn grass seeding shall be accomplished in the seeding seasons described in subsection 212.03.

(a) Soil Preparation. Preparatory to seeding lawn grass, irregularities in the ground surface, except the saucers for trees and shrubs, shall be removed. Measures shall be taken to prevent the formation of low places and pockets where water will stand.

Immediately before seeding, the ground surface shall be tilled or hand worked into an even and loose seedbed to a depth of 4 inches, free of clods, sticks, stones, debris, concrete, and asphalt in excess of 2 inches in any dimension and brought to the desired line and grade.

(b) Fertilizing and Soil Conditioning. The first application of fertilizer, soil conditioner, or both shall be incorporated into the soil before seeding, and shall consist of a soil conditioner, commercial fertilizer, or both as designated in the Contract. Fertilizer called for on the plans shall be worked into the top 4 inches of soil at the rate specified in the contract. Biological nutrient, culture or humic acid-based material called for on the plans shall be applied in a uniform application onto the soil service. Organic amendments shall be applied uniformly over the soil surface and incorporated into the top 6 inches of soil.

The second application of fertilizer shall consist of a fertilizer having an available nutrient analysis of 20-10-5 applied at the rate of 100 lbs. per acre. It shall be uniformly broadcast over the seeded area three weeks after germination or emergence. The area shall then be thoroughly soaked with water to a depth of 1 inch.

Fertilizer shall not be applied when the application will damage the new lawn.

(c) Seeding. After the surface is raked and rolled, the seed shall be drilled or broadcast and raked into the top 1/4 inch of soil. Seeding shall be accomplished by mechanical landscape type drills. Broadcast type seeders or hydraulic seeding will be permitted only on small areas not accessible to drills. Seed shall not be drilled or broadcast during windy weather or when the ground is frozen or untillable. All loose exposed rock larger than 2 inches shall be removed from slopes that are to be seeded by drilling.

Hydraulic seeding equipment shall include a pump capable of being operated at 100 gallons per minute and at 100 pounds per square inch pressure, unless otherwise directed. The equipment shall have a nozzle adaptable to hydraulic seeding requirements. Storage tanks shall have a means of estimating the volume used or remaining in the tank.

212.05 Sodding.

(a) Soil Preparation. Preparatory to sodding, the ground shall be tilled or hand worked into an even and loose sod bed to a depth of 4 inches, and irregularities in the ground surface shall be removed. Sticks, stones, debris, clods, asphalt, concrete, and other material more than 2 inches in any dimension shall be removed. Any depressions or variances from a smooth grade shall be corrected. Areas to be sodded shall be smooth before any sodding is done.

(b) Sodding. The sod shall be laid by staggering joints with all edges touching. On slopes, the sod shall run approximately parallel to the slope contours. Where the sod abuts a drop inlet, the subgrade shall be adjusted so that the sod shall be 1 1/2 inch below the top of the inlet.

Within one hour after the sod is laid and fertilized it shall be watered. After watering the sod shall be permitted to dry to the point where it is still wet enough for effective rolling. It shall then be rolled in two directions with a lawn roller weighing at least 150 pounds.

(c) Fertilizing and Soil Conditioning. Before laying sod, the 4 inches of subsoil underlying the sod shall be treated by tilling in fertilizer, soil conditioner, or both. The rate of application shall be as designated in the Contract. Fertilizer called for on the plans shall be worked into the top 4 inches of soil at the rate specified in the contract. Biological nutrient, culture or humic acid-based material called for on the plans shall be applied uniformly onto the soil surface. Organic amendments shall be applied uniformly over the soil surface and incorporated into the top 6 inches of soil.

After laying, the sod shall be fertilized with a fertilizer having an available nutrient analysis of 20-10-5 at the rate of 200 pounds per acre. Fertilizer shall not be applied when the application will damage the sod.

212.06 Native Seeding. Areas that are unirrigated shall be seeded per subsection 212.03.

(a) Soil Preparation. Slopes flatter than 2:1, shall be tilled into an even and loose seed bed 4 inches deep. Slopes 2:1 or steeper shall be left in a roughened condition. Slopes shall be free of clods, sticks, stones, debris, concrete, and asphalt in excess of 4 inches in any dimension and brought to the desired line and grade.

(b) Fertilizing and Soil Conditioning. Before seeding, fertilizer, soil conditioner, or both shall be applied. The fertilizer and soil conditioner type and rate of application shall be as designated in the Contract. Fertilizer called for on the plans shall be worked into the top 4 inches of soil at the rate specified in the contract. Biological nutrient, culture or humic

acid-based material called for on the plans shall be applied in a uniform application onto the soil service. Organic amendments shall be applied uniformly over the soil surface and incorporated into the top 6 inches of soil. No measurable quantity of organic amendment shall be present on the surface after incorporation.

(c) Seeding. Seeding shall be accomplished within 24 hours of tilling or scarifying to make special seed bed preparation unnecessary. The seeding application rate shall be as designated in the Contract. All slopes flatter than 2:1 shall be seeded by mechanical power drawn drills followed by packer wheels or drag chains. Mechanical power drawn drills shall have depth bands set to maintain a planting depth of at least 1/4 inch and shall be set to space the rows not more than 7 inches apart. Seed that is extremely small shall be sowed from a separate hopper adjusted to the proper rate of application.

If strips greater than 7 inches between the rows have been left unplanted or other areas skipped, the Engineer will require additional seeding at the Contractor's expense.

When requested by the Contractor and approved by the Engineer, seeding may be accomplished by broadcast or hydraulic type seeders at twice the rate specified in the Contract at no additional cost to the project.

All seed sown by broadcast-type seeders shall be "raked in" or covered with soil to a depth of at least 1/4 inch. Broadcasting seed will be permitted only on small areas not accessible to machine methods.

Hydraulic seeding equipment and accessories shall conform to the equipment and accessories described in subsection 212.04(c).

Seeded areas damaged due to circumstances beyond the Contractor's control shall be repaired and reseeded as ordered. Payment for this corrective work, when ordered, shall be at the contract prices.

Multiple seeding operations shall be anticipated as portions of job are completed to take advantage of growing conditions and to comply with Section 208 and subsection 212.03.

METHOD OF MEASUREMENT

212.07 The quantities of lawn seeding and native seeding will not be measured but shall be the quantities designated in the Contract, except that measurements will be made for revisions requested by the Engineer, or for discrepancies of plus or minus five percent of the total quantity designated in the Contract. The quantity of lawn seeding shall include soil preparation, water, fertilizer, and seed, completed, and accepted. The quantity of native seeding shall include soil preparation, fertilizer, soil conditioner, and seed applied, completed, and accepted.

The quantity of sod to be measured will be the actual number of square feet, including soil preparation, water, fertilizer, and sod, completed, and accepted.

When soil conditioner is measured and paid for separately, it will be measured by the actual number of acres where soil conditioner is applied and will be paid for as Soil Conditioning.

The Contractor shall furnish the Engineer with seed certifications and analysis, fertilizer analysis, and bag weight tickers before placing any seed or fertilizer. Any seed or fertilizer placed by the Contractor without the Engineer’s approval will not be paid for.

Measurement for acres will be by slope distances.

BASIS OF PAYMENT

212.08 The accepted quantities of lawn seeding, native seeding, soil conditioning, and sod will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Seeding (Lawn)	Acre
Seeding (Native)	Acre
Sod	Square Foot
Soil Conditioning	Acre

Soil preparation, water, seed, fertilizer, and soil conditioner, incorporated into the seeding sodding or soil conditioning will not be paid for separately but shall be included in the work.

Adjusting or readjusting seeding or fertilizing equipment will not be paid for separately but shall be included in the work.

SECTION 213

MULCHING

DESCRIPTION

213.01 This work consists of mulching the seeded areas, furnishing and placing wood chip mulch in the planting beds and plant saucers, furnishing and applying hydromulch with tackifier on roadway ditches and slopes, furnishing and placing tackifier on mulch or soil on roadway ditches or slopes, and furnishing and installing metal landscape border for the separation of planting beds, per the Contract or as directed. Mulching may be accomplished by the crimping method using straw or hay, by the hydraulic method using wood cellulose fiber mulch, or by other approved methods with approved materials. When a specific mulching method is required, it will be designated in the Contract.

This work includes furnishing and applying spray-on mulch blanket or bonded fiber matrix on top of rock cuts and slopes after seeding or as temporary stabilization as shown on the plans or as directed by the Engineer.

MATERIALS

213.02 Materials shall conform to the following requirements.

(a) Mulching. Materials for mulching shall consist of Certified Weed Free field or marsh hay or straw of oats, barley, wheat, rye, or triticale certified under the Colorado Department of Agriculture Weed Free Forage Certification Program and inspected as regulated by the Weed Free Forage Act, Title 35, Article 27.5, CRS. Each certified weed free mulch bale shall be identified by one of the following:

(1) One of the ties binding the bale shall consist of blue and orange twine, or

(2) The bale shall have a regional Forage Certification Program tag indicating the Regional Forage Certification Program Number.

Mulch shall be inspected for and Regionally Certified as weed free based on the Regionally Designated Noxious Weed and Undesirable Plant List for Colorado, Wyoming, Montana, Nebraska, Utah, Idaho, Kansas, and South Dakota.

The Contractor shall not unload certified weed free mulch bales or remove their identifying twine, wire, or tags until the Engineer has inspected and accepted them.

The Contractor shall provide a transit certificate that has been filled out and signed by the grower and by the Department of Agriculture inspector.

The Contractor may obtain a current list of Colorado Weed Free Forage Crop Producers who have completed certification by contacting the Colorado Department of Agriculture, Division of Plant Industry.

Straw or hay in a stage of decomposition (discolored, brittle, rotten, or moldy) or old, dry mulch that breaks in the crimping process will not be accepted.

The type and application rate of mulch material shall be as designated in the Contract.

(b) Wood Cellulose Fiber Mulch. Wood cellulose fiber mulch shall consist of virgin wood fibers manufactured expressly from clean whole wood chips. The chips shall be processed in such a manner as to contain no growth or germination inhibiting factors. Fiber shall not be produced from recycled materials such as sawdust, paper, cardboard, or residue from pulp and paper plants. The wood cellulose fibers of the mulch must maintain uniform suspension in water under agitation. Upon application, the mulch material shall form a blotter like mat covering the ground. This mat shall have the characteristics of moisture absorption and percolation and shall cover and hold seed in contact with the soil. The Contractor shall obtain certifications from suppliers that laboratory and field testing of their product has been accomplished, and that it meets all of the foregoing requirements pertaining to wood cellulose fiber mulch.

The wood cellulose fiber mulch shall conform to the following requirements:

Table 213-1

WOOD CELLULOSE FIBER MULCH REQUIREMENTS

Property	Requirement
Percent moisture content	10.0% ± 3.0%
Percent Organic Matter* (Wood Cellulose Fiber)	99.3% ± 0.2%
Percent Ash Content*	0.7% ± 0.2%
pH	4.9 ± 0.5
Water Holding Capacity*	1200-1600 grams**

Table 213-1 Notes: *Oven Dried Basis
**Per 100 grams of fiber

The wood cellulose fiber mulch shall be packaged in units containing current labels, with the manufacturer's name, the net weight, and certification that the material meets the foregoing requirements for wood cellulose fiber mulch.

(c) Mulch Tackifier. Material for mulch tackifier shall consist of a free-flowing, noncorrosive powder produced either from the natural plant gum of Plantago Insularis (Desert Indianwheat) or pre-gelatinized 100 percent natural corn starch polymer. The powders shall possess the following properties:

Table 213-2

PROPERTIES OF PLANTAGO INSULARIS (DESERT INDIANWHEAT)

Property	Requirement
pH 1% solution	6.5 - 8.0

Table 213-3

PROPERTIES OF PRE-GELATINIZED

100 PERCENT NATURAL CORN STARCH POLYMER

Property	Requirement
Organic Nitrogen as protein	5.5-7%
Ash content	0-2%
Fiber	4-5%
pH 1% solution	6.5 – 8.0
Size	100% thru 850 microns (20 mesh)
Settleable solids	<2%

All fibers shall be colored green or yellow with a biodegradable dye.

The material used for mulch tackifier shall not contain any mineral filler, recycled cellulose fiber, clays, or other substances that may inhibit germination or growth of plants. Water shall conform to subsection 209.02.

(d) Wood Chip Mulch. Wood chip mulch shall consist of fresh, moist pole peelings material having approximate dimensions; Width: 1/4 to 1/2 inch; Length: 3 to 4 inches.

The Contractor shall submit a sample to the Engineer for approval at least 30 days before placing on the project.

(e) Metal Landscape Border. The metal landscape border shall consist of a strip of metal such as steel conforming to ASTM A1011 or approved equal.

(f) Spray-on Mulch Blanket. Spray on mulch blanket shall be one of the following, unless otherwise shown on the plans:

1. Spray-on Mulch Blanket (Type 1) shall be a hydraulically applied matrix conforming to the following:

Table 213-4

PROPERTIES OF MULCH BLANKET (TYPE 1)

Properties	Requirement	Test Method
Organic Fibers	71% Min.	ASTM D2974
Cross Linked Mulch Tackifiers	10% ± 2% Min.	
Reinforcing Fibers	2.5% Min.	
Biodegradability	100%	ASTM D5338
Ground Cover at Application Rate	90% Min.	ASTM D6567
Functional Longevity	12 Months Min.	
Cure Time	< 8 hours	
Application		
Application Rate	3000 lb/acre	

The organic fiber shall not contain lead paint, printing ink, varnish, petroleum products, seed germination inhibitors, or chlorine bleach. The organic fibers and reinforcing interlocking fibers cannot be produced from sawdust, cardboard, paper, or paper by-products.

2. Spray-on Mulch Blanket (Type 2) shall be a hydraulically applied matrix pre-packaged in 50-pound bags containing both a soil and fiber stabilizing compound and thermally processed wood fiber.

   The wood fiber mulch shall be manufactured through a thermo-mechanical defibrating process containing a specific range of fiber lengths averaging 0.25 inches or longer.

Mulch Blanket (Type 2) shall meet the following requirements:

Table 213-5
PROPERTIES OF MULCH BLANKET (TYPE 2)

Property	Requirement	Test Method
Fiber Retention On 28-Mesh Screen	≥ 40%	Tyler Ro-Tap Method
Moisture Content	12% ± 2%	Total Air Dry Weight Basis
Organic Matter	99.2% ± 0.2%	Oven Dry Weight Basis
Ash Content	0.8% ± 0.2%	Oven Dry Weight Basis
pH at 3% Consistency In Water	4.5-7.0 ± 0.5%	
Sterilized Weed-Free	Yes	
Non-Toxic To Plant or Animal Life	Yes	
Application		
Application rate	3,000 lb./acre	

The soil and fiber stabilizing compound shall be composed of linear anionic copolymers of acrylamide pre-packed within the bag having a minimum content of 1.0 percent. The compound shall conform to the following:

Table 213-6
SOIL AND FIBER STABILIZING COMPOUND PROPERTIES

Property	Requirement
Molecular Weight	≥ 12x106
Charge Density	> 25%
Non-Toxic To Plant or Animal Life	Yes

(g) Bonded Fiber Matrices (BFM). BFM shall consist of hydraulically-applied matrix with a minimum of 70 percent non-toxic thermally processed or refined long strand organic fibers and water soluble tackifier to provide erosion control and shall be designed to be functional for a minimum of 9 months. BFMs form an erosion-resistant blanket that promotes vegetation and prevents soil erosion. The BFM shall be 100 percent biodegradable. The binder in the BFM shall also be biodegradable. BFMs shall conform to the following requirements:

Table 213-7

BONDED FIBER MATRICES PROPERTIES

Property	Requirement	Test Method
Ground Cover (%)	95	ASTM D6567
Biodegradability (%)	100	ASTM D5338
functional Longevity (months)	9 months minimum	
Cure Time (hours)	24-48	
Cross-linked Tackifier	10% minimum	
Application		
Application Rate (lbs./Acre)	3000	

The fibers shall not contain lead paint, printing ink, varnish, petroleum products, seed germination inhibitors, or chlorine bleach. Fiber shall not be produced from sawdust, cardboard, paper, or paper by-products.

CONSTRUCTION REQUIREMENTS

213.03

(a) Hay or Straw Mulching. After seeding has been completed or when required for erosion control, hay or straw shall be uniformly applied, with no bare soil showing, at the rate designated in the Contract or as directed. It shall be crimped in with a crimper or other approved equipment. The Engineer may order hand-crimping on areas where mechanical methods cannot be used.

The seeded area shall be mulched and crimped within four hours after seeding. Areas not mulched and crimped within four hours after seeding or before precipitation or damaging winds on site shall be reseeded with the specified seed mix at the Contractor's expense, before mulching and crimping.

When tackifier is required in the Contract it shall be applied in the following order: (1) mulching, (2) mulch tackifier.

(b) Hydraulic Mulching. Wood cellulose fiber mulch and mulch tackifier shall be added to water to form a homogeneous slurry.

The operator shall spray apply the slurry mixture uniformly over the designated seeded area.

Hydraulic mulching shall not be done in the presence of free surface water.

Mixing procedure for the hydraulic mulch and tackifier mixture shall be as follows:

1. Fill tank with water approximately 1/4 full.
2. Continue filling while agitating with engine at full rpm.
3. Pour tackifier, at a moderate rate, directly into area of greatest turbulence.

4. With the recommended amount of tackifier in solution, add wood cellulose fiber mulch. Do not add fertilizer.

   Apply the hydromulch and tackifier mixture at the following rate:

Wood Cellulose Fiber	Mulch Tackifier
2,000 lb/acre	100 lb/acre

(c) Mulch Tackifier. Mixing procedure for mulch tackifier shall be as follows:

1. Fill tank with desired amount of water and run engine at full R.P.M.
2. Add wood cellulose fiber. Agitate until a homogenous, non-lumpy slurry is formed. Do not add fertilizer.
3. Slowly sift powdered tackifier into slurry and continue to agitate for at least five minutes.

   Mulch tackifier shall be sprayed over hay or straw using a nozzle that will disperse the spray into a mist that will uniformly cover the mulch.

   Application Rate: Apply this as an overspray at the following rate or as approved by the Engineer.

Mulch Tackifier Powder	Wood Cellulose Fiber	Water
200 lb/acre	300 lb/acre	2,000 gal acre

(d) General. Mulch shall be tacked simultaneously or immediately upon completion of mulching and crimping to avoid nonuniform coverage. Areas not properly mulched, or areas damaged due to the Contractor's negligence, shall be repaired and remulched as described above, at the Contractor's expense.

Mulch removed by circumstances beyond the Contractor's control shall be repaired and remulched as ordered. Payment for this ordered corrective work shall be at the contract prices.

The Engineer may order test sections be established for adjusting the mulching equipment to assure conformance with the specified application rate. The Engineer may order equipment readjustment at any time.

(e) Wood Chip Mulch. A 4-inch layer, unless otherwise shown in the plans, of wood chip mulch shall be uniformly applied to all planting beds as shown on the plans or as directed. Wood chip mulch shall be placed in all tree and shrub saucers in seeded areas. Wood chip mulch shall be capable of matting together to resist scattering by the wind.

(f) Metal Landscape Border. Metal landscape border shall be installed along the lines and at the grades shown on the plans by an approved method that will not damage the border. Ends of metal landscape border shall overlap the next adjacent section a minimum of 6 inches. Metal landscape border shall be anchored with wire tie-downs at intervals of approximately 2 feet. Wire tie-downs shall be 9-gauge wire at least 14 inches long. Metal landscape border shall be inserted into the ground by driving against the wire tiedowns; ground may be moistened to ease entrance into the ground. Driving on edge of metal landscape border will not be permitted except when the edge is properly shielded. Metal landscape border may be bent for sharp angles and overlapped at closure of perimeter.

(g) *Spray-On Mulch Blanket*. Spray-on mulch blanket installation shall strictly comply with the Manufacturer's mixing recommendations and installation instructions. No chemical additives with the exception of fertilizer, soil pH modifiers, extended-term dyes and bio nutrients will be permitted. The spray-on mulch blanket shall be mixed and applied as follows:

The hydromulching vessel shall be filled with water to at least 1/3 capacity (high enough to cover agitators) before adding any material. Continue to fill vessel with water and slowly add the fibers while agitators are in motion. Run agitators at 3/4 speed. Continue to mix tank a minimum of 10 minutes before application.

Apply spray-on mulch blanket in a uniform application using a minimum 22-degree arc type nozzle. Apply hydro slurry in two directions (from top of slope down and from toe of the slope up, as well as, be applied at a minimum of two layers).

Co-polymer shall not be used use in channels, swales, or other areas where concentrated flows are anticipated and should not be used on saturated soils that have groundwater seeps.

(h) *Bonded Fiber Matrices (BFM)*. Bonded fiber matrices shall strictly comply with the Manufacturer's mixing recommendations and installation instructions. No chemical additives with the exception of fertilizer, soil pH modifiers, extended-term dyes, and bio stimulant materials shall be permitted. BFMs shall be applied in a uniform application using a minimum 22-degree arc type nozzle. BFMs shall be applied in two directions (from top of slope down and from toe of the slope up, as well as, be applied at a minimum of two layers.

Biodegradable BFMs shall not be applied immediately before, during, or immediately after rainfall if the soil is saturated.

BFMs shall not be used use in channels, swales, or other areas where concentrated flows are anticipated and shall not be used on saturated soils that have groundwater seeps.

Foot traffic, mechanical traffic or grazing shall not be permitted on treated areas until vegetated. Treated areas damaged due to circumstances beyond the Contractor's control shall be repaired or re-applied as ordered. Payment for corrective work, when ordered, shall be at contract unit prices.

METHOD OF MEASUREMENT

213.04 The quantity of hay and straw mulch, wood chip mulch, wood fiber and, spray-on mulch blanket, bonded fiber matrix, and tackifier will not be measured but shall be the quantity designated in the Contract, except that measurements will be made for revisions requested by the Engineer, or for discrepancies of plus or minus five percent of the total quantity designated in the Contract. Measurement for acres will be by slope distances.

The quantity of mulch tackifier to be measured will be the actual number of pounds of dry tackifier powder used.

Metal landscape border will be measured by the linear foot of completed and accepted metal border. Measured length of metal landscape border will not include required overlap splices.

Spray-on mulch blanket and bonded fiber matrix will be measured by the acre or by the actual pounds of product applied, as shown on the plans. The area will be calculated on the basis of actual or computed slope measurements. The Contractor shall verify, before application, weight of spray on mulch blanket and bonded fiber matrix bags for certification of materials and application rate.

BASIS OF PAYMENT

213.05 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.
Payment will be made under:

Pay Item	Pay Unit
Mulching ( )	Acre
Mulching (Hydraulic)	Acre
Mulching (Weed Free Hay)	Acre
Mulching (Weed Free Straw)	Acre
Mulching (Wood Chip)	Cubic Foot
Mulch Tackifier	Pound
Metal Landscape Border	Linear Foot
Spray-on Mulch Blanket	Acre
Spray-on Mulch Blanket	Pound
Bonded Fiber Matrix	Acre
Bonded fiber Matrix	Pound

Water, wood fiber, mixing and application for mulch tackifier will not be measured and paid for separately but shall be included in the work.

Adjusting or readjusting mulching equipment will not be paid for separately but shall be included in the work.

Payment for spray–on mulch blanket and bonded fiber matrix will be full compensation for all work and materials necessary to complete the item.

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SECTION 214

PLANTING

DESCRIPTION

214.01 This work consists of furnishing all plants, labor, materials and equipment to install herbaceous and woody plant material, hereinafter referred to as "nursery stock". The work may also consist of obtaining live "unrooted cuttings" from approved donor plants and installing them on the site as shown on the plans.

All approvals and direction required from the Engineer in this specification will involve the Engineer working directly with Region or Headquarters Environmental Staff, as identified in the Contract.

MATERIALS

214.02 Nursery Stock and unrooted cuttings shall be of the minimum sizes and species as designated on the plans, in healthy condition with normal well-developed branch and root systems and shall conform to the requirements of the *American Standard for Nursery Stock* (ANSI Z60.1-2014). For specified deep rooted container stock the container class volume ranges shall be substituted with the requirements of this specification. See subsection 1.1.3.3 of the American Standard for Nursery Stock regarding unclassified containers.

All nursery stock and unrooted cuttings shall be free from plant diseases and insect pests. All shipments of plants shall comply with all nursery inspection and plant quarantine regulations of the State of origin and destination, and the Federal regulations governing Interstate movement of nursery stock. The Contractor shall submit proof of deposit that nursery stock, Contract species and Contract quantity have been secured 30 days post Environmental Pre-Construction Conference. For multi-year projects (two or more continuous years) the contractor shall submit a schedule for approval documenting when proof of deposits on nursery stock will be provided.

The minimum acceptable sizes of all nursery stock, with branches in normal position, shall conform to the measurements specified in the Landscape/Mitigation Plans.

Hardiness zones are defined in U.S. Department of Agriculture (USDA) 2012 Plant Hardiness Zone Map publications. Only Nursery Stock rated for USDA Hardiness Zones 2, 3, 4, and 5 will be accepted.

Other than approved unrooted cuttings or as otherwise approved by the Engineer, plants shall be nursery grown for at least one growing season, or plants that have established themselves in accordance with definitions set forth in the Colorado Nursery Act, Title 35, Article 26, CRS.

Field collected trees and shrubs shall have been root-pruned during their growing period in the nursery in accordance with standard nursery practice outlined in the American Standard for Nursery Stock.

No species substitutions are permitted without written approval. If nursery stock of acceptable quality and specified variety or size are not available, before any species substitutions will be approved the Contractor shall supply to the Engineer three written letters from nurseries verifying that a species or plant size is not available. Once three letters are provided, the Contractor Shall with Engineer's written approval:

(1) Substitute acceptable nursery stock that are larger than specified at no change in Contract price. For deep rooted nursery stock, the minimum depth requirement of the container must be maintained as stated in this specification.
(2) Substitute smaller plants than those specified on the Landscape/Mitigation Plans at the adjusted price or ratio stated in the written approval.
(3) Substitute of plants of different genus, species or variety shall be submitted to the Engineer for approval 30 days prior to installation at the adjusted price stated in the written request.

At the Environmental Pre-construction Conference, the Contractor shall name the nursery stock supplier for all items. Nursery stock will be rejected for not meeting the Contract at any of the four following times and locations:

(1) At the nursery stock supplier's location during inspection. The Engineer will notify the contractor when the nursery stock will be inspected.
(2) On the project site at the time of delivery, prior to planting.
(3) At the time of installation.
(4) At the partial or final acceptance walkthroughs on the project site.

Plant materials supplied by the Contractor shall be inspected by the Engineer at the growing site and tagged or otherwise approved for delivery. Inspection at nursery does not preclude right of rejection at construction site. Contractor shall remove rejected materials immediately from the site at Contractors expense. The Contractor shall ensure that all nursery materials meet the requirements of this Section prior to delivery.

Proposed materials shall be flagged at the nurseries by the Contractor prior to viewing by the Engineer. The Contractor shall schedule with the Engineer a time for viewing plant material at the nursery. Trips to nurseries shall be efficiently arranged to allow Engineer to maximize their viewing time. A minimum of two weeks shall be allowed for this viewing prior to time that plants are to be dug. When requested by the Engineer photographs of plant material or representative samples of plants shall be submitted. Viewing of plant materials by the Engineer at the nursery does not preclude their right to reject material at the site of planting.

The Contractor shall notify the Engineer at least three working days in advance of the anticipated delivery date of any plant material. The Contractor shall submit an invoice for each shipment of plants showing the quantities, kinds, and sizes of materials along with the certificate of inspection. Evidence of inadequate protection of plant material following digging, transit, storage or other handling will be cause for rejection. Upon arrival at the temporary storage location or work site, plants shall be inspected for proper handling (including but not limited to shipping procedures) in the presence of the Engineer for damage, including but not limited to dried out roots, broken branches, broken or loosened root balls, or torn bark. The Contractor shall replace the damaged material at their own expense.

Container grown nursery stock shall have a well-established root system reaching the sides and bottom of the container to provide a firm mass of growing medium, but shall not be root bound (i.e., have excessive root growth encircling the inside of the container). Bare root material will not be accepted as a substitution for nursery stock specified as container or balled and burlapped specified nursery stock.

Each species shall be identified by means of grower's label affixed to the plant. The grower's label shall include the data necessary to indicate conformance to specifications. For minimum plant requirements of height, width, minimum multi stems and root ball diameter as appropriate for the specified species type see the Plant Schedule on the Plans.

(a) Nursery stock. Contractor shall file copies of certificates after acceptance of material. Evidence of inadequate protection following digging, carelessness while in transit, or improper handling or storage, will be cause for rejection. When a plant has been rejected, the Contractor shall remove it from the area of the work and replace it with one of the required size and quality conforming to one of the following:

(1) Deep Rooted Containers shall be containers for growing native plants that are narrower in diameter and longer than standard nursery pots of equal volume. Containers must have physical "anti-spiraling" features such as vertical ribs on the inside walls or side slits in the sidewalls that will air-prune roots. Containers that have been treated with compounds such a copper to chemically prune the roots will not be accepted. Deep rooted container classifications shall have the following properties:

Deep Rooted Container Class Specification	Minimum Height (Inches)	Minimum Volume (Cubic Inches)
#10	8	10
#40	9	40
#60	13	60
#180	14	180
#300	29	300

(2) Standard Nursery Containers shall conform to the recommended specification in the *American Standard for Nursery* Stock (ANSI Z60.1-2014). For minimum plant requirements of height or width as appropriate for the specified species type see the Plant List on the drawings. Standard nursery container classifications shall have the following properties:

Standard Nursery Container Class	Acceptable Volume Range (Cubic Inches)
#1	152-251
#5	785-1242
#10	2080-2646
#20	4520-5152

(3) Balled and burlapped or large container shall conform to the recommended specifications in the *American Standard for Nursery Stock* (ANSI Z60.1-2014). Single stem deciduous tree caliper measurements shall be taken six inches above the ground for field grown

stock and from soil line for container grown stock. Multi-stem deciduous tree and evergreen tree height measurement shall be from ground level for field grown and from soil line for container grown stock.

(b) Unrooted Cuttings. Unless otherwise authorized, the Contractor shall notify the Engineer at least five working days in advance of the anticipated start of harvesting cuttings. All cuttings shall be harvested from approved parent material. Approval of parent material shall be in writing from the Engineer. This approval will include a detailed description of the approved locations. The Contractor shall select a site, and if outside of the construction boundary, provide written approval from the Owner, when applicable, for access and harvesting the required number of cuttings. The harvesting site shall be left clean and tidy, to the satisfaction of the Engineer and the Owner, when applicable. Unused material including trimmings shall be cut up to 2 feet in length and evenly distributed around the wetland mitigation site.

Unrooted cuttings shall be harvested and planted in early spring (March 1st to April 15th) while the plants are still dormant. However, the Engineer may authorize an alternative harvesting and planting timeframe based on project timing. Immediately upon harvesting, all cuttings shall be placed in water so that the cut ends are covered in water, and the cuttings shall be stored in a cool location. Plants shall be completely submerged in containers with water if not planted within 24 hours of harvesting. The containers shall be continuously shaded and protected from the wind. Cuttings shall be protected from drying at all times.
During transportation, the cuttings shall be kept completely submerged in containers with water in orderly fashion to prevent damage and to facilitate handling. Cuttings should be bundled using natural twine or flexible staking tape (and not with wire) in uniform groups of 25-100 to allow for easy tracking of quantities.

(1) Live Willow Stakes –Shall be unrooted cuttings approximately 3 feet long and between 1/2 and 1-inch in diameter. All side branches must be trimmed. Willow cuttings shall be cut from branches with smooth undamaged bark. Branches with thick, cracked bark shall not be used because they will not re-sprout effectively. Cuttings shall be cut about one foot from the ground using sharp loppers or pruning tools. Cuts shall be clean, without stripping the bark or splitting the wood. The base cuts shall be at a 45-degree angle to identify the root end of the cutting. The top shall be cut off with a square cut so that the top of the stake is easily distinguishable from the bottom. If willow stakes are to be planted in the second half of the growing season (June 15th to October 15th), then the cut top end shall be dipped into latex paint (covering approximately 1 inch at the top of the stake) to seal and reduce desiccation in hot/dry establishment conditions.

(2) Live Brush Mattress– Live willow unrooted cuttings to be used in brush mattress as a bioengineering application. The primary branch shall be approximately 6 – 15 feet long and between 1/2 and 2 inches in diameter at the base. Side branches are not trimmed unless a side branch is large enough to be used as a primary branch itself. Brush cuttings shall be cut at a height of between six to twelve inches above the ground. Cuts shall be clean, without stripping the bark or splitting the wood. Live brush cuttings should be composed primarily of willow cuttings but may include up to 20% cottonwood branch cuttings.

(3) Live Brush Fascines - Live willow unrooted cuttings to be used in fascines as a bioengineering application. Unrooted cuttings diameter shall vary and shall be a minimum 5 feet long and between 1/4 and 2 inches in diameter. Up to 30 percent of the bundle may be plant material that does not root easily or dead plant material. The remaining 70 percent of the bundle shall consist of younger wood between 1 to 4 years old (at a minimum 25 willow cuttings per fascines). Fascines bundles may be stored submersed in water for no longer than two weeks, if necessary.

(c) Wood Stakes. Wood stakes for deciduous tree support shall be 2 inches' x 2 inches square, or 2 1/2 inch diameter and 6 feet long free from bends. One end of all wood posts shall be pointed. Metal stakes for deciduous tree support shall be studded 6 feet long T-Post with a minimum weight of 1.25 lbs. per linear foot. Metal stakes for evergreen tree support shall be 24 inches long and consist of either minimum weight 1.25 lbs. per linear feet T-Post or #4 or larger rebar. Wood stakes shall be made of untreated wood guaranteed to last in the ground at least two growing seasons.

(d) Backfill. Backfill material consists of topsoil in accordance with the Contract requirements of 207 and additional compost material thoroughly mixed together and reasonably free of rocks and plant material. All other foreign material shall be removed. Do not use subsoil removed from planting pits as backfill unless accepted by CDOT Project Engineer. Compost shall be mixed into the backfill material at a rate of 25 percent by volume.

Live Willow Stake applications do not require additional compost in the backfill material, but holes must be backfilled with topsoil or native fine alluvium (sand or gravel).

Compost for planting pits shall be in accordance with section 212.

(e) Wood Mulch. Mulch shall consist of virgin moist wood product with shavings having approximate dimensions of: Width: 1/4 to 1/2 inch, Length 3 to 4 inches. Mulch shall be free of material injurious to plant growth. Sources of mulch should be free of weeds and invasive plant parts or seeds. Sawdust, dirt, garbage, or other debris mixed in the mulch is not acceptable. Contractor shall submit one pound of proposed mulch for approval.

(f) Flex Pipe Bark Protector. Bark Protector shall be made of flexible UV stabilized plastic that shall be able to push off and separate with tree growth, without harming the bark, stem, wood or any part of the tree.

(g) Wildlife Protection Fencing. When specified on plans fencing shall be made of 20-gage steel with black-vinyl coating, with a maximum opening of 1 inch.

(h) Deciduous Tree Wrapping Materials. Wrapping material shall be horticulturally standard waterproof corrugated cardboard material that allows stretching over time to prevent girdling of the tree.

(i) Tree Straps. Breathable nylon webbing 18 inches long and 1 ½ inches wide with metal grommets at each end.

CONSTRUCTION REQUIREMENTS

214.03 All nursery stock shall be protected from drying out or other injury with acceptable practices within the industry. Broken and damaged roots shall be pruned before planting.

(a) *Planting Seasons.* Nursery stock shall be planted in accordance with the Contract. Areas to be planted shall be brought to the lines and grades designated or approved. The Contractor shall place all plant material according to the approved Landscape/Mitigation Plans to the degree that unsuitable planting locations shall be avoided. Trees shall be planted outside of the clear zone, except when guardrail or vertical curb exists, this distance may be reduced to 20 feet. Shrubs shall not be planted closer than 6 feet from the edge of pavement. Locations of all nursery stock and unrooted cuttings shall be staked in the field prior to planting. Plants and planting locations shall be checked in the field by CDOT Region Biologist or CDOT Landscape Architect and shall be adjusted to the position as approved before planting begins. Planting holes shall not be constructed until written approval has been received from the Engineer.

(b) *Excavation.* Planting pits shall be circular in outline with vertical or sloped sides. The Contractor shall roughen sides of the pit to remove any compacting or glazing. When conditions detrimental to plant growth are encountered, such as over compacted topsoil, rubble fill, debris, or obstructions, notify the Engineer before planting. Use of a tree spade to dig plant pits is prohibited.

(c) *Planting.* Planting shall be done in accordance with good horticultural practices and only after topsoil has been placed. Plants of upright growth shall be set plumb, and plants of prostrate type shall be set normal to the ground surface. Plants with dry, broken, or crumbling roots will not be accepted for planting. When conditions detrimental to plant growth are encountered, such as over compacted topsoil, rubble fill, debris, or obstructions, notify the Engineer before planting. Use of a tree spade to dig plant pits is prohibited. Pits excavated with a backhoe shall be scarified as needed.

For automated irrigated areas planting pits shall be dug 2 to 4 inches shallower than the height of the rootball for trees, and 2 inches shallower for shrubs. In non-irrigated areas, planting pits shall be dug so that the top of the rootball is 2-4 inches depressed from surrounding final grades. The nursery stock shall be set in the center of the planting pit on undisturbed soil.

Trees shall be stabilized and then the top third of the wire basket, any twine and burlap shall be removed before the pit is backfilled. Shrubs shall be planted in the center of the pit. All of the plastic, metal and fabric, containers shall be removed. Peat containers shall be removed if directed by the Engineer. If the nursery stock is root-bound (roots circle the root ball) shallow scores with a sharp knife 1/4 to 1/2 inch deep shall be made along the edges and the bottom of the rootball.

Areas to be planted with ground cover shall be prepared by placing topsoil and a 1/2 inch layer of soil conditioner on the ground surface and rototilling to a depth of 6 inches. Ground cover shall be planted by excavating to a depth sufficient to accommodate the root structure of plant materials without crimping or bending roots. After planting, backfill shall be placed around the ground cover and compacted firmly around the roots. The planted areas shall be brought to a smooth and uniform grade, and then top dressed with a 2-inch-deep wood mulch.

(d) Backfilling. Backfill shall be thoroughly worked and watered-in to eliminate air pockets. For trees backfill 1/2 of the planting pit and saturate to remove air pockets. After settling finish backfilling and saturate again. After the soil has settled, nursery stock must be in the proper position and at the proper depth. Saucers shall be prepared around each plant to the dimensions shown on the planting details. For all nursery stock the excavated area shall be covered with a 4-inch-thick layer of wood mulch. After completion of all planting and before acceptance of the work, the Contractor shall water

nursery stock installed under this Contract, as needed to maintain a moist root zone optimum for plant growth. Nursery stock or prepared surfaces damaged during planting operations by the Contractor's operations shall be replaced at the Contractor's expense.

Surplus soil remaining after backfilling is completed shall be used for constructing water retention berms, or, if not needed for berms, shall be thinly distributed (wasted) in the vicinity, subject to approval of the Engineer.

(e) Wood Mulch. Mulch shall be placed to a minimum of 4-inch depth to cover nursery stock excavated areas, but not touching the trunk of trees.

(f) Pruning. All deciduous trees and shrubs shall be pruned in accordance with standard horticultural practice, preserving the natural character of the plant. Guidelines for pruning are indicated in the planting details. Pruning cuts shall be made with sharp clean tools.

All clippings shall become the property of the Contractor and be removed from the site.

(g) Guying. All deciduous trees 2-inch caliper and greater shall be staked as designated on the plans. Coniferous trees 4 feet or taller shall be staked as designated on the plans.

(h) Deciduous Wrapping Materials. Wrapping shall be applied from the base of the tree upward to the second scaffold branch and secured with arbor tape. Populus species shall be exempt from tree wrap. The Contractor shall submit the manufacturer's certification for the wrapping material requirements. Wrapping shall be done in the fall months prior to freeze and removed in the spring. Wrapping shall not remain on any trees throughout the summer months. Wrapping shall be removed by the Contractor.

All plant tags shall be removed from plants and all packing or other material used by the Contractor shall be removed from the site. Upon completion of work, the Contractor shall remove plant containers, bags and other debris and leave area in clean, acceptable condition.

(i) Unrooted Cuttings. Upon arrival at the construction site, cuttings shall be inspected for acceptability. Only healthy, undamaged material will be accepted. During installation activities, the cuttings shall be kept wet and out of the direct sun light. No cuttings shall be out of water for more than 10 minutes before planting. Water shall be applied to areas around the cuttings until the soil mass is saturated. Cuttings shall be watered thoroughly every day for a period of one month, unless natural soil saturation occurs within 12 inches of soil surface, as verified by the Engineer. Unrooted cuttings shall be used in the following:

1. *Live Willow Stakes.* Using a rock bar or other mechanical method such as a stinger backhoe attachment or trenching equipment, create a vertical hole or trench deep enough to reach a depth at which the water table will be present throughout the growing season, or deep enough to extend below the low summer flow, or groundwater elevation of the adjacent stream channel. Planting zones shall be surveyed and staked in the field for approval by the Engineer prior to planting. Insert 2/3 of the live cutting into the hole/trench, with the 45 degree cut end down, so that the end of the cutting maintains contact with the natural water table throughout the entire growing season;

planting depth must consider the natural fall of the water table that typically occurs in late summer. Planting depth shall be verified by Engineer. The placement of these cuttings shall be in areas shown on the plans and at the spacing specified. Minor adjustments in placement and spacing may be necessary based on field conditions.

The root end of cuttings shall be tamped into the pilot hole or placed in a trench to a minimum depth of 2 feet, or until the root-end of the cutting meets elevation at which groundwater will be present at the driest point of the growing season. Note that some water tables will vary greatly from April to October; the Contractor shall consult with the Engineer and Region environmental staff for proper depth.

The top of the cutting shall protrude a minimum of 4 inches, but no more than 1/3 of its length with at least two live buds showing above ground. Dead blow hammers or rubber mallets shall be used to tamp in the cuttings into holes, in such manner as to not cause the wood to split. Trench planting should not require any tamping.

Live cuttings require direct contact with soil. Soil shall be placed/backfilled in any spaces around the cuttings and tamped into place to remove any air pockets; if necessary, a soil-water slurry should be used to ensure good soil contact with cutting.

Water shall be applied to the planted cutting stakes areas until the soil mass is saturated. Cuttings shall be watered thoroughly every day for a period of one month, unless natural soil saturation occurs within 12 inches of soil surface, as determined by the Engineer, in consultation with the Region environmental representative.

2. Live Brush Mattress. Live unrooted cuttings shall be evenly distributed in the dimensions shown on the plans and laid flat against sloped stream bank to create a continuous mat of brush. The cut-end of the *branches* shall be buried in the toe of the slope. At a minimum, the ends shall be buried 6 inches at the toe of slope or otherwise secured with willow fascines, log and/or rock as specified in plans. The Contractor shall ensure that the lower willow tips are in contact with soil that is saturated during normal low flow stream conditions. The mattress will be secured to the stream embankment with a network of wood stakes and twine. Utilize minimum length 24-inch-long wood stakes and 0.25-inch diameter machine spun bristle coil twine (tensile strength: 140 pounds).

   The Contractor shall cover the mattress with a thin layer of clean topsoil and seed with wetland seed mix. Soil covering should cover 90 percent of the unrooted cuttings. Approximately 10 percent but no more than 20 percent of the cuttings should daylight above the soil covering once soil has settled into the voids of the mattress.

3. Live Brush Fascine. A fascine is a bundle of unrooted cuttings, fastened together with 0.25-inch diameter machine spun bristle coil twine (tensile strength: 140 lbs.) to keep the bundles tightly tied until placed in the ground and buried. Clean topsoil shall be worked over and around the bundles, no compaction is required. The length of the wattle bundle shall be placed parallel with the contour of the ground. Wood stakes shall be placed as shown on the plans centered along bundle. Utilize minimum length 24-inch wood stakes and 0.25-inch diameter machine spun bristle coil twine (tensile strength: 140 pounds). The Contractor shall puddle with water and allow soil to settle, then repeat backfill procedure until wattle bundle is covered to three-quarters

of bundle height. Unrooted cuttings installed above reliable ground water supply shall be watered thoroughly every day for a period of one month. Watering shall be continued after the first month at a minimum of once a week until the completion of the project.

(j) Watering.

1. Watering for nursery stock in irrigated areas (projects with 623 pay items). Irrigation system shall be operating and supplying the correct amount of water to the immediate area prior to any nursery stock being planted. Plants shall be thoroughly watered within 15 minutes of planting.
2. Watering in newly planted nursery stock and unrooted cuttings in non-irrigated areas. The Contractor shall furnish and supply the correct amount of water to the area receiving unrooted cuttings and nursery stock to keep the plants in a healthy and vigorous condition. All plantings shall be watered within four hours of placement. All plant material shown on the plans (excluding seeded areas) shall be watered to ensure successful establishment of the plant. Rate of flow shall allow the water to soak into the soil adjacent to the planting. At no time shall watering operations be applied at a rate or intensity that causes surface run off.

(k) Maintenance of landscape during construction. Maintenance of landscaping shall start immediately upon placement of first permanent landscaping and continue until the Notice of Substantial Landscape Completion has been received. The Contractor shall maintain the seeded areas, nursery stock and unrooted cuttings in a healthy and vigorous growing condition to ensure successful establishment. Maintenance shall consist of the following:

Work Item	Function	Notes
Weed control of areas having native seed	Areas shall be kept free of harmful insects, disease and weeds	Weed management strategies shall be discussed during the Site Pre-Vegetation Conference.
Hand watering trees	All plant material shown on the plans (excluding seeded areas) shall be watered to ensure successful establishment of the tree. Rate of flow must allow the water to soak into the soil adjacent to the planting. At no time shall watering operations be applied at a rate or intensity that causes surface run off.	Trees shall be watered two times a month at a rate of 10 gallons for each diameter inch of the tree for the months of May through October, and one time per month for the months of November through April.

Work Item	Function	Notes
Hand watering trees, shrubs, herbaceous plants and unrooted cuttings	All plant material shown on the plans (excluding seeded areas) shall be watered to ensure successful establishment of the plant. Rate of flow must allow the water to soak into the soil adjacent to the planting. At no time shall watering operations be applied at a rate or intensity that causes surface run off.	All plant material shown on the plans (excluding seeded areas) shall be watered to ensure successful establishment of the plant. Rate of flow must allow the water to soak into the soil adjacent to the planting. At no time shall watering operations be applied at a rate or intensity that causes surface run off.

214.04 Landscape Establishment. From the time of installation, during construction, and throughout the Landscape Establishment period the Contractor shall maintain all plant material and seeded areas in a healthy and vigorous growing condition and ensure the successful establishment of vegetation. This includes performing establishment, replacement work, and landscape maintenance work as described below.

The beginning of the Landscape Establishment period depends upon receipt of the written Notice of Substantial Landscape Completion from the Engineer. Substantial Landscape Completion occurs when all plant materials in the Contract have been planted and all work under Sections 212, 213, 214 and 623 has been performed, except for the Section 214 pay item, Landscape Maintenance. If the Notice of Substantial Landscape Completion is issued during the spring planting season, the Landscape Establishment period begins immediately and lasts for a period of 12 months. If the Notice of Substantial Landscape Completion is issued at any other time, the Landscape Establishment period begins at the start of the next spring planting season and lasts for a period of 12 months.

(a) Establishment and Replacement. After all planting on the project is complete, a plant inspection shall be held including the Contractor, Engineer and CDOT Landscape Architect to determine acceptability of plant material. During the inspection, an inventory of rejected material will be made, and corrective and necessary cleanup measures will be determined.

Dead, dying, or rejected material shall be removed each month during the Landscape Establishment period as directed. Plant replacement shall be performed during the spring planting seasons at the beginning and end of the Landscape Establishment Period. Plant replacement stock shall be planted per the Contract and is subject to all requirements specified for the original material. Plant replacement shall be at the Contractor's expense.

(b) Landscape Maintenance. During the Landscape Establishment period the Contractor shall perform landscape maintenance as described. The Contractor shall maintain all landscaped areas in the condition they were in when first installed and accepted.

Before the Notice of Substantial Landscape Completion, the Contractor shall submit a detailed maintenance plan, which includes a schedule showing the number of hours or days personnel will be present, the type of work to be performed, supervision,

equipment and supplies to be used, emergency program and responsible person to contact for emergency work, and inspection schedule. The detailed maintenance plan is subject to review and approval by the Engineer. The Engineer will not issue the Notice of Substantial Completion until the Engineer has received and approved the maintenance plan.

The proposed types, brand names, material safety data sheets, and rates of application of herbicides, pesticides, and fertilizers to be used shall be submitted for approval with the detailed maintenance plan. Herbicides, pesticides, and fertilizers shall meet all local, state, and federal regulations and shall be applied by a licensed applicator.

The Contractor shall perform start-up, watering, programming, operation, and fall winterization of the irrigation system. The Contractor shall do a spring start-up of the irrigation system before Final Acceptance and perform all irrigation system warranty work as specified in Section 623.

The Contractor shall keep a project diary documenting all landscape and irrigation maintenance activities including work locations and time spent. The Contractor shall provide copies of the diary to the Engineer upon request.

The Contractor shall restore and reseed eroded areas and areas of poor establishment per Sections 212 and 213. The Contractor shall maintain staking and guying until the end of the Landscape Establishment period. The Contractor shall remove all guying wire, straps, and stakes at the end of the Landscape Establishment period.

During the Landscape Establishment period, the Contractor shall water, cultivate, and prune the plants and repair, replace, or readjust guy material, stakes, and posts as required or directed by the Engineer. The Contractor shall reshape plant saucers, repair washouts and gullies, replace lost wood chip mulch, keep all planting sites free from weeds and do other work necessary to maintain the plants in a healthy and vigorous growing condition. This includes seasonal spraying or deep root watering with approved insecticides or fungicides as required.

(1) Watering in Irrigated Areas. Trees planted at all locations on the project shall be watered once per month at the rate of 30 gallons per tree for the months November through April until the Landscape Establishment period ends.

Shrubs planted at all locations on the project shall be watered once per month at the rate of 10 gallons per shrub for the months November through April until the Landscape Establishment period ends.

(2) Watering in Non-irrigated Areas. Trees planted shall be watered twice per month by the Contractor at the rate of 30 gallons per tree per watering for the months May through October, and once per month at the rate of 30 gallons per tree for the months November through April of the 12-month period following planting.

Shrubs planted in upland areas shall be watered twice per month by the Contractor at the rate of 10 gallons per shrub per watering for the months May through October and shall be watered once per month at the rate of 10 gallons per shrub for the months November through April of the 12-month period following planting.

The contract performance bond, required by subsection 103.03, shall guarantee replacement work during the Landscape Establishment period.

If all other work is completed on a project, no contract time will be charged during the plant establishment period.

METHOD OF MEASUREMENT

214.05 The quantity of nursery stock to be measured will be the number of plants, of the types and sizes designated in the Contract that are actually planted and accepted.

Live Willow Stakes will be measured by the number actually installed and accepted.

Live Brush Mattress will be measured by the actual number of linear feet installed and accepted.

Live Brush Fascines will be measured by the actual number of linear feet installed per the detail on the plans and accepted.

Landscape Maintenance will not be measured but will be paid for on a lump sum basis.

BASIS OF PAYMENT

214.06 The accepted quantities of nursery stock and unrooted cuttings will be paid for at the contract unit price for each of the items listed below:

Payment for the total cost of the item will be made at the completion of the installation of each item.

Cost of the performance bond shall be included in the cost of the plant items.
Payment will be made under:

Pay Item	**Pay Unit**
_____ Tree (____Inch Caliper)	Each
_____ Tree (____Foot)	Each
Deep Rooted Container #___ (Deep Rooted # ____ Container)	Each
Standard Nursery Container (#_____ Container)	Each
Live Willow Stakes	Each
Live Willow Fascine	Linear Feet
Live Brush Mattress	Linear Feet
Landscape Maintenance	Lump Sum

Additional slow-release organic fertilizer for nursery stock shall be used as specified in the plans will not be measured and paid for separately but shall be included in the work.

Compost required for backfill of nursery stock will not be paid for separately but shall be included in the work.

All water required for nursery stock and unrooted cuttings in projects without 623 pay items will be measured and paid for in accordance with Section 209 under Pay Item Water (Landscaping), up to the Notice of Substantial Completion.

Water required after the acceptance of the Notice of Substantial Completion will not be measured and paid for separately but shall be included in the work.

Standard waterproof tree wrap and flex pipe bark protector for nursery stock will not be measured and paid for separately but shall be included in the work.

Cleaning or repair of site conditions from equipment used by the Contractor for planting operations will not be measured and paid for separately by shall be included in the work. Wood mulch, stakes, guy wire, PVC protector, safety caps, wrapping, and all other materials required to install a tree will not be measured and paid for separately but shall be included in the work.

Wood stakes and other materials required to secure Live Brush Mattresses and Live Brush Fascines will not be measured and paid for separately but shall be included in the work.

Seeding will be measured and paid for per Section 212 and Topsoil will be measured and paid for per Section 207.

Maintenance of Landscaping during construction will not be measured and paid for separately but shall be included in the work.

For each month that landscape maintenance is performed and accepted during the Landscape Establishment period as specified in subsection 214.04, payment for landscape maintenance will be made in installments as follows:

- Ten percent of the lump sum amount will be paid for each of the eight growing season months, March through October.
- Five percent of the lump sum amount will be paid for each of the winter months, November through February.

Landscape maintenance performed during construction will not be measured and paid for separately but shall be included in the work.

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SECTION 215

TRANSPLANTING

DESCRIPTION

215.01 This work consists of transplanting trees, shrubs, plugs of wetland material including root mats from existing wetlands, and other plant material, referred to as "plants," of the designated species per this specification and accepted standard horticultural practice at the designated locations. Transplanting season is that period when plants are in a dormant condition and can be moved. Dormant means that deciduous material is without leaves and coniferous material is without new candle growth. Transplanting done in periods not considered dormant transplanting season shall require advance approval.

MATERIALS

215.02 Plants to be transplanted shall be those that are flagged on the project site within the right of way, or as directed. Plugs shall be dug from areas noted in the Contract or as directed by the Engineer. Removal shall be dispersed throughout the areas so as not to impact the existing wetland. Plugs shall be taken in early spring when plants are emerging. Plugs shall be a minimum of 4 inches in diameter and 6 inches to 8 inches deep with the root mat to remain intact. Plugs shall not be stockpiled but shall be transplanted directly to wetland mitigation sites as directed. Transplanting shall be accomplished the day they are dug. Plugs shall be kept moist and shall not be placed in holding beds.

CONSTRUCTION REQUIREMENTS

215.03 Plants shall be dug, properly pruned, and prepared for transplanting per standard practice. The root system shall be kept moist, and plants shall be protected from adverse conditions due to climate and transporting from the time they are dug to the actual planting. Before removal for transplanting, all coniferous trees shall be sprayed with an approved anti-desiccant.

The following table represents the minimum diameter of rootballs for collected plants.

Table 215-1

TYPE 6 COLLECTED PINON PINE

MIN. ROOTBALL DIAMETER

Caliper	Min. Ball Dia.
1 to 1 1/2 inch	15 inch
1 1/2 to 2 inch	17 inch
2 to 2 1/2 inch	20 inch
2 1/2 to 3 inch	24 inch
3 to 3 1/2 inch	26 inch
3 1/2 to 4 inch	28 inch
4 to 4 1/2 inch	30 inch
4 1/2 to 5 inch	32 inch

Table 215-2
TYPE 7 ALL COLLECTED PLANTS
OTHER THAN PINON PINE
MIN. ROOTBALL DIAMETER

Caliper	Min. Ball Dia.
1 to 1 1/2 inch	14 inch
1 1/2 to 2 inch	16 inch
2 to 2 1/2 inch	20 inch
2 1/2 to 3 inch	24 inch
3 to 3 1/2 inch	28 inch
3 1/2 to 4 inch	32 inch
4 to 4 1/2 inch	36 inch
4 1/2 to 5 inch	40 inch

For caliper sizes larger than those given under Type 7, the ratio of ball diameter to caliper shall be 8:1.

Planting pits for balled and burlapped trees shall be circular in outline with vertical sides. Pits shall be at least two times greater in diameter than the earth ball. Before a tree is placed in a plant pit, the pit shall be filled half full of water. Backfill shall be thoroughly worked and watered to eliminate air pockets. Unsuitable backfill soils shall be replaced.

Trees shall be machine transplanted with tree spades. The following table represents the minimum size of spade machine equipment to be used for transplanting plants based upon caliper size. The table also represents the minimum diameter of rootballs for machine transplanted plants.

Table 215-3
MINIMUM SPADE MACHINE SIZE
FOR MACHINE TRANSPLANTED PLANTS

Caliper (based on rootball width)	Min. Spade Machine Size
1 to 3 inch	44 inch
3 to 6 inch	65 inch
6 to 9 inch	80 inch
9 to 12 inch	> 90 inch

Each tree shall be transported to the new site using the same spade that it was dug, or several trees may be spade-dug and transported in a pod trailer manufactured specifically for this purpose. Trees shall not be removed from spade or transported in a haul truck. The Contractor shall give the Engineer one-week notice before transplanting trees. At the time of transplanting the Engineer will designate a Department landscape architect to be on the site to oversee all tree planting.

Planting pits for machine-dug trees shall have the same dimension as the machine ball being placed. Before a tree is placed in a planting pit, the pit shall be filled half full of water and allowed to drain. Once the tree is placed, voids in the pit shall be filled with clean suitable backfill and tamped. If unsuitable soil is encountered in the planting pits, the Contractor shall dispose of said material and backfill with suitable material as determined by the Engineer.

After the tree is planted (collected or machine transplanted), a basin shall be built to hold at least 30 gallons of water. For each inch of trunk diameter greater than 3 inches, the basin capacity shall be increased by 10 gallons. The depth of saucer shall not be below the top of the root system of the tree. The basin shall be filled with water three times and allowed to stand each time until empty before refilling. Saucers shall be covered with a 4-inch-thick layer of fresh moist wood chip mulch as shown on the plans. The size of mulch shall be approximately 1/4 to 1/2 inch wide and 3 to 4 inches long. A sample shall be submitted in advance to the Engineer for approval.

Transplanting shall be accomplished within one day. Trees shall not be placed in holding beds.

All transplanted trees shall be subject to a 180-day maintenance period during one or more growing seasons and shall be watered every seven calendar days. Each watering shall be 100 gallons per tree.

All transplanted trees shall be guyed per Standard Plan M 214-1. Guying material shall be removed at the end of the 180-day maintenance period. All trees damaged by the Contractor's operations shall be replaced and replanted at the Contractor's expense as approved. At the end of the 180-day maintenance period all dead trees shall be replaced and replanted with trees at the Contractor's expense. Further maintenance will not be required.

The Contractor shall not damage existing landscaped areas, including but not limited to turf, irrigation equipment, and other plants, during the transplanting operation. The Contractor may use suitable platform material over existing turf to prevent damage from heavy machinery.

Wetland plugs shall be a minimum of 4 inches in diameter and 6 to 8 inches in depth. Holes left in the existing wetlands from plug removal shall be filled with topsoil and tamped lightly. After tamping, the filled hole shall be at the same elevation as the existing surrounding wetlands.

Transplant plugs shall be placed in containers (one plug per container) after harvesting to facilitate handling and placing of material.

Plugs shall be spaced as directed in the Contract. Plugs shall be planted to match surrounding grade.

Water shall be applied to plugs until soil is saturated. Plugs shall be watered thoroughly every day for a period of one month.

METHOD OF MEASUREMENT

215.04 The quantity of transplanting to be measured will be the actual number of plants of the various types transplanted and accepted.
The quantity of transplanted trees to be measured will be the actual number of trees of the various calipers and types transplanted and accepted in their final location.

Caliper measurement shall conform to the USA Standard for Nursery Stock, sponsored by the American Association of Nurserymen, Inc. (AAN)

Only living plants in healthy condition at the end of the maintenance period will be accepted. If all other work is completed on the project, contract time will not be charged during the maintenance period.

The quantity of transplanted plugs to be measured will be the actual number of plugs transplanted and accepted in their final locations.

BASIS OF PAYMENT

215.05 The accepted quantities of transplanting measured as provided above will be paid for at the contract unit price each.
Payment will be made under:

Pay Item	Pay Unit
Transplant Tree	Each
Transplant Shrub	Each
Transplant Plug	Each

Water required will not be measured and paid for separately but shall be included in the work.

Hauling plants to their new location, removing unsuitable backfill, and providing clean suitable backfill for planting pit voids will not be measured and paid for separately but shall be included in the work.

SECTION 216

SOIL RETENTION COVERING

DESCRIPTION

216.01 This work consists of furnishing, preparing, applying, placing, and securing soil retention blankets and turf reinforcement mats for erosion control on roadway slopes or channels as designated in the Contract.

MATERIALS

216.02 Soil retention covering shall be either a soil retention blanket or a turf reinforcement mat as specified in the Contract. It shall be one of the products listed on CDOT's Approved Products List and shall conform to the following:

(a) Soil Retention Blanket. Soil retention blanket shall be composed of degradable natural fibers mechanically bound together between two slowly degrading synthetic or natural fiber nettings to form a continuous matrix and shall conform to the requirements of Tables 216-1 and 216-2. The blanket shall be of consistent thickness with the fiber evenly distributed over the entire area of the mat.

When specified, lightweight polypropylene netting shall be 1.5 pounds per 1,000 square feet; heavyweight netting shall be 2.9 pounds per 1,000 square feet.

When biodegradable blanket is specified, the thread shall be 100 percent biodegradable; polypropylene thread is not allowed.

When photodegradable netting is specified, the thread shall be polyester, biodegradable or photodegradable.

Blankets and nettings shall be non-toxic to vegetation and shall not inhibit germination of native seed mix as specified in the Contract. The materials shall not be toxic or injurious to humans. Class 1 blanket shall be an extended term blanket with a typical 24-month functional longevity. Class 2 blanket shall be a long-term blanket with a typical 36-month functional longevity. The class of blanket is defined by the physical and performance characteristics.

(b) Soil Retention Blanket (Straw-Coconut). Soil Retention Blanket (Straw-Coconut) shall be a machine-produced mat consisting of 70 percent certified weed free agricultural straw or Colorado native grass straw and 30 percent coconut fiber. The blanket shall be either biodegradable or photodegradable. Blankets shall be sewn together on a maximum 2-inch centers.

Netting shall be as follows:

When biodegradable netting is specified, the top and bottom netting shall be 100 percent biodegradable organic jute fiber. Netting shall be constructed using a weave unattached at intersections, which allows the strands of the net to move independently of each other.

When photodegradable netting is specified, the bottom side shall be lightweight polypropylene. The top side shall be heavyweight or lightweight polypropylene.

(c) Soil Retention Blanket (Excelsior). Soil Retention Blanket (Excelsior) shall consist of a machine-produced mat of 100 percent curled wood excelsior, 80 percent of which shall be 6 inches or longer in fiber length. It shall be either biodegradable or photodegradable. Blankets shall be sewn together at a maximum of 4-inch centers.

Netting shall be as follows:

When biodegradable netting is specified, the top and bottom netting shall be 100 percent biodegradable organic jute fiber. Netting shall be constructed using a weave unattached at intersections, which allows the strands of the net to move independently of each other.

When photodegradable netting is specified, the bottom side shall be lightweight polypropylene. The top side shall be heavyweight or lightweight polypropylene.

(d) Soil Retention Blanket (Coconut). Soil Retention Blanket (Coconut) shall be a machine-produced mat consisting of 100 percent coconut fiber. It shall be either biodegradable or photodegradable.

Netting shall be as follows:

When biodegradable netting is specified, the top and bottom netting shall be 100 percent biodegradable organic jute fiber. Netting shall be constructed using a weave that is unattached at the intersections, and which allows the strands of the net to move independently of each other.

When photodegradable netting is specified, the bottom and top side shall be heavyweight polypropylene.

Table 216-1
PHYSICAL REQUIREMENTS
FOR SOIL RETENTION BLANKET –
PHOTODEGRADABLE OR BIODEGRADABLE BLANKETS

Photo/Bio Degradable Class	Minimum Roll Width	Minimum Thickness ASTM D6525	Acceptable Matrix Fill Material	Min. Mass per Unit Area ASTM 6475	Size of Net Opening Photodegradable	Size of Net Opening Bio-degradable
1	6.5 ft	250 mils	Straw/ Coconut	8 oz/sy	Min. 0.50"x0.50" Max 0.75"x0.75"	Min. 0.50"x0.50" Max 0.50"x1.0"
1	6.5 ft	250 mils	Excelsior	8 oz/sy	Min. 0.50"x0.50" Max 1.0"x2.0"	NONE
2	6.5 ft	200 mils	Coconut	8 oz/sy	Min. 0.50"x0.50" Max 0.75"x0.75"	Min. 0.50"x0.50" Max 0.50"x1.0"

Table 216-2
PERFORMANCE REQUIREMENTS
FOR SOIL RETENTION BLANKET –
PHOTODEGRADABLE OR BIODEGRADABLE BLANKETS

Photo/Bio Degradable Class	Slope Application "C" Factor1 ASTM D6459	Minimum Tensile Strength MD2 ASTM D6818
1	< 0.10 at 3:1	8.33 lbs./in
2	< 0.10 at 3:1	10.42 lbs./in

Table 216-2 Notes:
"C" Factor is calculated as ratio of soil loss from soil retention blanket protected slope (tested at specified or greater gradient, 3H:1V) to ratio of soil loss from unprotected (control) plot in large-scale testing.
MD is for machine direction testing (along the length of the roll).

Blankets shall be tested for physical properties and have published data from an independent testing facility.

Large scale testing of Slope Erosion Protection ("C" factor) shall be performed by an independent testing facility.

(e) Turf Reinforcement Mat. Turf reinforcement mat (TRM) shall be a rolled mat consisting of UV stabilized, corrosion resistant, non-degradable synthetic fibers, filaments, or nets processed into a permanent three-dimensional matrix of the thickness specified in Tables 216-3 and 216-4. TRMs shall provide sufficient thickness, strength, and void space to permit soil filling and retention, and the development of vegetation within the matrix. The class of TRM is defined by the physical and performance characteristics as specified in the following tables.

Table 216-3
PHYSICAL REQUIREMENTS
FOR TURF REINFORCEMENT MAT

Product Class	Minimum Roll Width	Minimum Thickness ASTM D6525	Acceptable Matrix Fill Material2	Size of Net Opening2
1	6.5 ft	250 mils	Excelsior, Straw/Coconut, Coconut, or Polymer fibers	Minimum: 0.50"x0.50" Maximum: 0.75"x0.75"
2	6.5 ft	250 mils	100% UV Stabilized Synthetic or Coconut Fibers	Maximum 0.50"x 0.50"
3	6.5 ft	250 mils	100% UV Stabilized Synthetic Fibers	Maximum 0.50"x 0.50"

Table 216-3 Notes:

For TRMs containing degradable components, all property values shall be obtained on the non-degradable portion of the matting alone.

For TRMs with nets and fill material. Netted TRMs shall be sewn together on a maximum 2-inch centers.

Table 216-4
PERFORMANCE REQUIREMENTS
FOR TURF REINFORCEMENT MAT

Product Class	Tensile Strength MD ASTM D6818	Minimum UV Stability at 500 Hours ASTM D4355	Minimum Permissible Shear Stress* (Unvegetated) ASTM D6460
1	125 lb/ft	80%	1.8 lb/sf
2	150 lb/ft	80%	2.5 lb/sf
3	175 lb/ft	80%	3.1 lb/sf

Table 216-4 Notes: *Permissible shear stress is the minimum shear stress that a product must be able to sustain when placed on a channel un-vegetated without physical damage or excess soil loss. Failure is defined as 1/2 inch of soil loss during a 30-minute flow event in large scale testing.

TRMs shall be tested for physical properties and have published data from an independent testing facility.

Large scale testing of Permissible Shear Stress shall be performed by an independent testing facility.

(f) Staples. Staples shall be made of ductile steel wire, 0.165 inches in diameter, 8 inches long and have a 1-inch crown. "T" shaped staples will not be permitted.

A sample of the staples and a Certificate of Compliance (COC) including the manufacturer's product data showing that the product meets the Contract requirements shall be submitted for approval at the Environmental Pre-construction Conference. Installation of the blanket will not begin until approval has been received from the Engineer in writing.

(g) Earth Anchors. The mechanical earth anchor shall be composed of a load bearing face plate, a tendon rod or wire rope, and a locking head or percussion anchor. Each element of the anchor shall be composed of corrosion resistant materials. The anchor and wire rope shall have a breaking strength of 9,500 pounds utilizing standard tensile testing and ASTM A1007-07. The anchor shall have a minimum 1,000 pounds' ultimate holding strength in normal soil and a manufacturer's recommended 216.03 minimum driven depth of 3.5 feet.

A sample of the anchors and a Certificate of Compliance (COC) including the manufacturer's product data showing that the product meets the Contract requirements shall be submitted for approval at the Environmental Pre-construction Conference. Installation of the blanket will not begin until approval has been received from the Engineer in writing.

CONSTRUCTION REQUIREMENTS

216.03 The Contractor shall install soil retention coverings per Standard Plan M-216-1 and the following procedure:

(1) Prepare soil per subsection 212.06(a).

(2) Apply topsoil or soil conditioning as directed in the Contract to prepare seed bed.

(3) Place seed per the Contract.

(4) Unroll the covering parallel to the primary direction of flow.

(5) Ensure that the covering maintains direct contact with the soil surface over the entirety of the installation area.

(6) Do not stretch the material or allow it to bridge over surface inconsistencies.

(7) Staple the covering to the soil such that each staple is flush with the underlying soil.

(8) Ensure that staples or earth anchors are installed full depth to resist pull out. No bent over staples will be allowed. Install anchor trenches, seams, and terminal ends as shown on the plans.

The Contractor shall install TRMs using the following procedure:

1. Place 3 inches of topsoil or soil amended with soil conditioning.
2. Apply half of the specified seed at the broadcast rate and rake it into the soil.
3. Install TRM.
4. Place 1 inch of topsoil or soil amended with soil conditioning into the matrix to fill the product thickness.

5. Apply the remaining half of the specified seed at the broadcast rate and rake it into the soil.
6. Install soil retention blanket (Photodegradable or Biodegradable Class 1) over the seeded area and TRM.

   When applicable, the covering shall be unrolled with the heavyweight polypropylene netting on top and the lightweight polypropylene netting in contact with the soil.

216.04 Slope Application. Soil retention coverings shall be installed on slopes as follows:

The upslope end shall be buried in a trench 3 feet beyond the crest of the slope if possible. Trench depth shall be a minimum of 6 inches unless required by the manufacture to be deeper. Before backfilling begins, staples shall be placed across the width of the trench. The trench shall then be backfilled to grade with soil amended with soil conditioning or topsoil, compacted by foot tamping, and seeded. Fabric shall be brought back over trench and secured with staples or earth anchors at 1 foot on center.

There shall be an overlap wherever one roll of fabric ends and another begins, with the uphill covering placed on top of the downhill covering. Staples shall be installed in the overlap.

There shall be an overlap wherever two widths of covering are applied side by side. Staples shall be installed in the overlap.

Staple checks shall be installed on the slope length at a maximum of every 35 feet. Each staple check shall consist of two rows of staggered staples.

The down slope end shall be buried in a trench 3 feet beyond the toe of slope. Before backfilling begins, staples shall be placed across the width of the trench. The trench shall then be backfilled to grade with soil amended with soil conditioning or topsoil, compacted by foot tamping, and seeded. Fabric shall be brought back over the trench and secured with staples or earth anchors. If a slope runs into State waters or cannot be extended 3 feet beyond the toe of slope, the end of covering shall be secured using a staple check as described above.

Coverings shall be securely fastened to the soil by installing staples or earth anchors at the minimum rate shown on the Standard Plan M-216-1. Staple or earth anchor spacing shall be reduced where required due to soil type or steepness of slope.

216.05 Channel Application. Soil retention coverings shall be installed as follows on a channel application:

Coverings shall be anchored at the beginning and end of the channel across its entire width by burying the end in a trench. Trench depth shall be a minimum of 6 inches, unless a larger depth is specified by the manufacturer’s recommendations. Before backfilling begins, staples shall be placed across the width of the trench. The trench shall then be backfilled to grade with soil amended with soil conditioning or topsoil and compacted by foot tamping and seeded. Fabric shall be brought back over the trench and stapled.

Covering shall be unrolled in the direction of flow and placed in the bottom of the channel first. Seams shall not be placed down the center of the channel bottom or in areas of concentrated flows when placing rolls side by side.

There shall be an overlap wherever one roll of covering ends and another begins with the upstream covering placed on top of the downstream covering. Two rows of staggered staples shall be placed.

There shall be an overlap wherever two widths of covering are applied side by side. Staples shall be placed in the overlap.

The covering shall have a channel check slot every 30 feet along the gradient of the flowline. Check slots shall extend the entire width of the channel. The covering shall be buried in a trench. Before backfilling begins, staples shall be placed across the width of the trench. The trench shall then be backfilled to grade with soil amended with soil conditioning or topsoil, compacted by foot tamping, and seeded. Fabric shall be brought back over the trench and continued down the channel.

Coverings shall be securely fastened to the soil by installing staples at the minimum rate shown on the plans. Staple spacing shall be reduced where needed due to soil type or high flows.

216.06 Maintenance. The Contractor shall maintain the soil retention coverings until all work on the Contract has been completed and accepted. Maintenance shall consist of the repair of areas where damage is due to the Contractor's operations. Maintenance shall be performed at the Contractor's expense. Repair of those areas damaged by causes not attributable to the Contractor's operations shall be repaired by the Contractor and will be paid for at the contract unit price. Areas shall be repaired to reestablish the condition and grade of the soil and seeding before application of the covering.

METHOD OF MEASUREMENT

216.07 Soil retention coverings, including staples, complete in place and accepted, will be measured by the square yard of finished surface, excluding overlap, which is installed and accepted. Earth anchors will be measured by the actual number of earth anchors complete in place and accepted.

BASIS OF PAYMENT

216.08 The accepted quantities of soil retention coverings will be paid for at the contract unit price per square yard. The accepted quantities of earth anchors will be paid for at the contract unit price for each installed.

Payment will be made under:

Pay Item	Pay Unit
Soil Retention Blanket (_) (Photodegradable Class _)	Square Yard
Soil Retention Blanket (_) (Biodegradable Class _)	Square Yard
Turf Reinforcement Mat (Class _)	Square Yard
Earth Anchors	Each

Preparation of seedbed, fertilizing, and seeding will be measured and paid for per Section 212.

Placing and preparation of seedbed, fertilizing, and seeding of soil under the TRM layer will be measured and paid for per Section 212.

Topsoil or amended soil and seed placed on the TRM will be measured and paid for per Sections 207 and 212.

Staples will not be measured and paid for separately but shall be included in the work.

SECTION 217

HERBICIDE TREATMENT

DESCRIPTION

217.01 This work consists of furnishing and applying herbicides to prevent or control plant growth in areas shown on the plans or designated.

MATERIALS

217.02 Herbicides shall be designated in the contract.
All herbicide labels shall be currently registered with the Colorado Department of Agriculture and the U.S. Environmental Protection Agency. All herbicides shall be supplied to the project in labeled containers. The labels shall show the product name, chemical composition, expiration date, and directions for use.

CONSTRUCTION REQUIREMENTS

217.03 All herbicides shall be applied by commercial pesticide applicators licensed by the Colorado Department of Agriculture as qualified applicators. The Contractor shall furnish documentation of such licensing before herbicide application. Herbicide mixing and application shall be done per instructions on the registered product label. The Engineer shall be furnished such label information before mixing and application.
The Contractor shall notify the Engineer at least 24 hours before each herbicide application and shall indicate the time and location application will begin. Application will not be allowed on Saturdays, Sundays, or holidays unless otherwise approved by the Engineer.

Herbicides shall not be applied when weather conditions, including wind conditions, are unsuitable for such work. Herbicides shall not be applied when soil is extremely dry.

Herbicide application method shall be such that plant growth outside the designated treatment areas will not be damaged. All damage caused by improper herbicide application shall be repaired at the Contractor's expense.

Herbicides shall not be used on areas that are to be topsoil sources unless otherwise approved by the Engineer.

METHOD OF MEASUREMENT

217.04 The quantity of herbicide treatment to be measured will be the actual number of square yards treated per the foregoing requirements or the actual number of hours the Contractor spends applying the herbicide and accepted by the Engineer. Areas designated to receive herbicide treatment will be measured once for each designated application. Reapplication of herbicide required due to inappropriate timing of the original application will not be measured or paid for.

BASIS OF PAYMENT

217.05 The accepted quantities of herbicide treatment will be paid for at the contract unit price per square yard or per hour.

Payment will be made under:

Pay Item	Pay Unit
Herbicide Treatment	Square Yard
Herbicide Treatment	Hour

Water will not be measured and paid for separately but shall be included in the work.

SECTION 250

ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT

DESCRIPTION

250.01 This work consists of protection of the environment, persons, and property from contaminants that may be encountered on the Project. This includes monitoring the work for encounters with contaminants or suspected soil and groundwater contaminants; the management of solid, special, and hazardous waste; and management of visual emissions associated with hazardous waste, when encountered on the project.

250.02 The Contractor shall furnish all personnel, materials, equipment, laboratory services, and traffic control necessary to perform the contamination monitoring, testing, and site remediation when required. Traffic control shall be per the requirements of Section 630.

Monitoring equipment used to detect flammable gas, oxygen level, and toxic gas shall be capable of detection to meet the following standards:

Table 250-1
DETECTION STANDARDS FOR MONITORING GASES

Instrument Detection

Constituent	Threshold Limit	Increments
Flammable Gas	1% LEL	1%
Oxygen	19%	0.1%
Toxic Gas	1 PPM	1 PPM

Table 250-1 Notes: LEL = lower explosive limit

PPM = parts per million

CONSTRUCTION REQUIREMENTS

250.03 General. Prospective bidders, including subcontractors, are required to review the environmental documents available for this project. These documents are listed in subsection 102.05 as revised for this project.

This project may be in the vicinity of property associated with petroleum products, heavy metal-based paint, landfill, buried foundations, abandoned utility lines, industrial area or other sites that can yield hazardous substances or produce dangerous gases. These hazardous substances or gases can migrate within or into the construction area and could create hazardous conditions. The Contractor shall use appropriate methods to reduce, and control known landfill, industrial gases, and visible emissions from asbestos encounters and hazardous substances that exist or migrate into the construction area. The Contractor shall follow CDOT's Regulated *Asbestos-Contaminated Soil Management Standard Operating Procedure, dated October 18, 2016,* for proper handling of asbestos-contaminated soil, and follow all applicable Solid and Hazardous Waste Regulations for proper handling of soils encountered that contain any other substance mentioned above.

Encountering suspected contaminated material, including groundwater, old foundations, building materials, demolition debris, or utility lines that may contain asbestos or be contaminated by asbestos, is possible at some point during the construction of this project. When suspected contaminated material, including groundwater, is encountered, or brought to the surface, the procedures under subsection 250.03(d) and 250.05 shall be followed.

Transportation of waste materials on public highways, streets and roadways shall be done per Title 49, Code of Federal Regulations (CFR). All labeling, manifesting, transportation, etc., of waste materials generated on this project shall be coordinated with the Engineer. All hazardous waste manifests for waste materials generated on this project shall list the Colorado Department of Transportation as the generator of the waste materials except as otherwise noted. If the Contractor contaminates the site, the Contractor shall be listed as the generator on the hazardous waste manifests, permits, and other documents for such material. If the project is not on a State Highway or frontage road, then the appropriate local governmental entity having jurisdiction over the transportation system facility shall be listed as the hazardous waste generator.

If waste materials must be handled in a permitted treatment, storage and disposal (TSD) facility, the facility shall be designated in writing by the Engineer. If the waste materials are the result of the Contractor's actions, the Contractor shall designate the facility.

The hazardous waste transportation phase of the work involves insurance required by law and regulations. If the waste materials are determined to be hazardous, the Contractor must submit proof that the transportation company is covered by the appropriate type and amount of insurance required by laws and regulations governing the transportation of hazardous waste.

The Contractor alone bears the responsibility for determining that the work is accomplished in strict accordance with all applicable federal, state, and local laws, regulations, standards, and codes governing special waste, petroleum, and hazardous substance encounters and releases.

The Contract will list known or suspected areas of contamination. Health and Safety Officer, Monitoring Technician, and Health and Safety Plan shall be required when so stated in the Contract.

(a) Health and Safety Officer (HSO). The Contractor shall designate an HSO, not the Project Superintendent, who shall have at least two years of field experience in chemical related health and safety. The HSO shall be either a certified industrial hygienist (CIH), certified hazardous materials manager (CHMM), professional engineer (PE) licensed in the State of Colorado, certified safety professional (CSP), or registered environmental manager (REM) meeting the criteria set forth in 29 CFR 1926. When asbestos is present or is suspected to be present, the HSO shall have additional training and certification per the Air Quality Control Commission Regulation No. 8 Part B. The HSO shall meet the minimum training and medical surveillance requirements established by the Occupational Safety and Health Association. When regulated asbestos contaminated soil (RACS) is present or is suspected to be present on or near a project, the HSO shall have knowledge of RACS regulations. The HSO shall meet the minimum training and medical surveillance requirements established by the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) for a supervisory Site Safety Official per 29 CFR 1962.65. The Contractor shall furnish documentation to the Engineer, at the Pre-construction Conference, that the above requirements have been met. Certification as an Asbestos Building Inspector per subsection 250.03(b) is recommended.

The HSO shall be equipped with the following:

1. Communication equipment as required in subsection 250.03(d)2A and a vehicle.
2. Monitoring and detection equipment for flammable gas, oxygen sufficiency, toxic gas, radiological screening, and other hazards. This includes, as required, a combustible gas indicator, flame ionization or photo ionization detector, oxygen meter, radiation monitor with Geiger Mueller detector, and other foreseeable equipment.
3. Depth gauging equipment, sampling equipment, and sampling containers.
4. Personal protective equipment (levels C and D) when required.

The HSO shall recommend and supervise those actions that will minimize the risk of hazardous substance related injury to the workers, Department personnel, the general public, property, and the environment. Hazardous substance is defined in 29 CFR 1926.32. The HSO shall prepare written procedures for the monitoring of confined space entry and working in or near excavations, including but not limited to trenches and drill holes associated with this project. The HSO shall conduct or supervise all hazardous substance and solid waste related testing, sampling, monitoring, and handling for this project to ensure compliance with applicable statutes and regulations, and other applicable environmental requirements under subsections 107.01 and 107.02.

The HSO shall be available for consultation and assistance with contaminated materials related testing, sampling, and field monitoring as required by the Engineer.

The HSO shall prepare and submit a bound and indexed final site report to the Engineer at the end of the project. This site report shall include a detailed summary of all contaminated materials and contaminated water that were encountered and their final disposition.

During each week the HSO is utilized, the HSO shall prepare a daily diary that shall be submitted to the Contractor and the Engineer. This diary shall be submitted at the end of the week and shall become a part of the Department's records. The diary shall contain a chronological log of activities on the project including dates and times on site, equipment used and calibrations, field monitoring results, visual observations, conversations, directives both given and received, and disposition of suspected hazardous substances. The Engineer will review this submittal and approve the actual number of hours to be paid.

(b) Monitoring Technician (MT). The Contractor shall designate a monitoring technician to be responsible for monitoring of hazardous substances during work on the project. The MT shall have a minimum of two years of actual field experience in assessment and remediation of hazardous substances that may be encountered during highway construction projects. When asbestos is present or is suspected to be present on or near a project, the MT shall have additional 40 hours' experience in RACS project management and certification as an Asbestos Building Inspector per the Colorado Air Quality Control Commission Regulation No. 8 Part B. The MT shall be experienced in the operation of monitoring devices, identifying substances based upon experience and observation, and field sampling (for testing) of all media that may be found on the site. Completion of the 40-hour hazardous waste and 8-hour supervisory training required by OSHA and U.S. EPA rules and regulations that complies with the accreditation criteria under the provisions of the proposed 29 CFR 1910.121 is required before beginning work. The Contractor shall furnish documentation at the Pre-construction Conference that demonstrates these requirements have been met.

The MT shall be equipped with the following:

(1) Communication equipment as required in subsection 250.03(d)2A and a vehicle.

(2) Monitoring and detection equipment for flammable gas, oxygen sufficiency, toxic gas, radiological screening, and other hazards. This includes, as required, a combustible gas indicator, flame ionization or photo ionization detector, oxygen meter, radiation monitor with Geiger Mueller detector, and other foreseeable equipment.

(3) Depth gauging equipment, sampling equipment, and sampling containers.

(4) Personal protective equipment (levels C and D) when required.

The MT shall be present on site and perform monitoring as required by 250.03(d) when work is being performed in areas of suspected contamination and on a predetermined basis throughout other work on the project.

The MT shall monitor for compliance with regulations, the project Health and Safety Plan and the Materials Management Plan (if they exist for the project), the Contract, and the environmental documents for the project. The MT shall immediately notify the Contractor, the Engineer, and the HSO of any hazardous condition.

During each week the MT is utilized, the MT shall prepare a daily monitoring diary, which shall be submitted to the Contractor, HSO and the Engineer. This diary shall be submitted at the end of the week and shall become a part of the Department's records. The diary shall contain a chronological log of activities on the project including dates and times on site, equipment used and calibrations, field monitoring results, visual observations, conversations, directives both given and received, and disposition of suspected hazardous substances. The Engineer will review this submittal and approve the actual number of hours to be paid.

(c) Health and Safety Plan (HASP). The HSO shall prepare a written HASP for the project, formatted as shown in Appendix B, Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, DHHS (NIOSH) Publication No. 85-115, available from the Superintendent of Documents, U.S. Government Printing Office. The Contractor and the HSO shall review the environmental documents listed before preparation of the HASP.

The Contractor shall submit a signed (or electronically sealed when HSO is a Professional Engineer) electronic HASP to the Engineer for acceptance. The Engineer shall have seven calendar days to review and accept or reject the proposed HASP. Within five calendar days after acceptance, the HSO shall distribute the accepted HASP to each emergency response agency servicing the project area, the HASP designated emergency hospital, and the Engineer. Earth or demolition work shall not occur until after the HASP is accepted distributed. The HASP shall also be available to the Contractor's employees, their representatives, and officials of OSHA, EPA, Colorado Department of Public Health and Environment (CDPHE), local government health department, Federal Highway Administration (FHWA), and as determined by the Engineer. The Engineer will distribute the accepted HASP to appropriate Department personnel. The HSO shall revise and update the HASP as warranted by changes in the field conditions.

All on-site workers (Contractor's, Department's, Utilities', and others) shall be briefed by the HSO on the contents of the HASP and any revisions thereof. The HSO shall conduct briefings (group or individual) to inform new employees, subcontractors, utility

companies, and other on-site workers of the HASP contents before their entry on site. All personnel involved in excavation or other soil disturbing activities shall receive the required two-hour Asbestos Awareness training by a Certified Asbestos Inspector, when asbestos discoveries are anticipated, or discoveries are made. A signature log of all briefing attendees shall be kept and furnished to the Engineer. The. Contractor shall provide, as required, eyewash equipment and stations, emergency showers, hand and face washing facilities, and first aid equipment.

The Contractor shall provide, as required, decontamination facilities for personnel and equipment employed in the work. The exact procedure for decontamination and frequency shall be included in the accepted HASP. Decontamination facilities shall meet the criteria set forth in the Code of Federal Regulations (29 CFR and 40 CFR).

(d) Precautions and Procedures. The following minimum precautions and procedures shall be followed during the construction of the project:

1. General construction precautions:

   A. All monitoring and piezometer wells and test borings shall be established or abandoned by the Contractor as regulated by the State Engineer's Office. Copies of all required permits, notification, and abandonment documents shall be submitted to the Engineer before payment approval.

   B. Hazardous substance related activities shall have a work plan for each work phase, which shall be coordinated with the Engineer at least three workdays before commencement of each phase of the work.

   C. The Contractor shall properly handle all investigation-derived waste generated by this project. Documentation shall be submitted to the Engineer of all tests performed for Treatment, Storage, and Disposal (TSD) determination; classification of waste; hauling records; TSD acceptance; manifest (if required); per applicable laws and regulations.

   D. When the work may involve air emissions, the Contractor shall contact the Colorado Department of Public Health and Environment (CDPHE), Air Pollution Control Division to ascertain if an air pollution emission notice (APEN) or permit is required for this operation. The Contractor shall be responsible for filing the APEN and obtaining said permit, if required. The processing of air pollution permits, if required, in non-attainment areas or where public hearings are required, likely will take more than 90 days.

2. For construction on a known or potentially contaminated site, the following conditions shall apply, in addition to those listed in subsection 250.03(d)1:

   A. The HSO shall be on site or readily available by radio, telephone or pager at all times during the work. When on site, the HSO shall have an operational portable or mobile cellular telephone available for immediate use in areas where such service is available. When on site in cellular telephone non-service areas, the HSO shall have available, for immediate use, radio access to a site with telephone service. The HSO shall be notified at least 24 hours before the start of confined space entry, storage tank removal, drilling, excavation, trenching, or dewatering operations.

B. The HSO shall designate the onsite monitoring equipment for flammable gases, oxygen deficient or enriched atmosphere, and toxic gases, such as but not limited to, a flame ionization detector, photoionization detector, combustible gas indicator, and oxygen meter. This designated equipment shall be on site during all construction operations and be utilized during trenching, drilling, excavating, confined space entry, underground storage tank removal, and other appropriate construction operations. The exact equipment to fulfill this requirement shall be specified in the accepted HASP. The HSO shall conduct or supervise the monitoring. The monitoring equipment shall be calibrated as recommended by the manufacturer.

C. When drilling, trenching, or excavating in the presence of detectable concentrations of explosive gases, the soil shall be wetted, and the operating equipment shall be provided with spark proof exhausts.

D. The Contractor, through the HSO, is responsible for ensuring that 29 CFR 1926 is fully complied with during the construction of the project.

E. Affected excavation operations shall be discontinued and personnel shall be removed from the affected excavation sites where any of the following levels are detected:

(1) 20.0 percent or more LEL flammable gas, or 10.0 percent in an underground or confined space,

(2) Permissible Exposure Limit (PEL) of any toxic gas,

(3) 19.5 percent or less oxygen,

(4) 25.0 percent or more oxygen,

(5) Greater than 2 mrem/hr. (Beta particle and photon radioactivity),

(6) Greater than 15 pCi/L (Gross alpha particle activity), or

(7) Other action levels as determined by the HSO.

(8) Uncovering of suspect Asbestos Containing Material (ACM), including but not limited to, buried facility components, active or abandoned utility lines, buried foundations and demolition debris, or miscellaneous ACM dispersed in the soil. The Contractor shall follow the procedures outlined in the HASP and 29 CFR 1926 to address these conditions. Work shall resume in these areas when approved by the Engineer.

F. Personnel shall be issued and utilize appropriate health and safety equipment as determined by the HSO, who shall provide the Engineer with a written explanation of what personal protective equipment (PPE) shall be worn, when, and by which personnel. Except in emergency cases, the Engineer shall be advised by the HSO of changes in the degree of PPE before implementation.

G. Personnel shall avoid the area immediately downwind of any excavation unless the excavation is monitored and declared safe.

H. The operators of excavating, trenching, or drilling equipment shall wear appropriate PPE as required in the HASP.

I. Exhaust blowers shall be present at the location where required in the accepted HASP.

J. The Contractor shall accomplish the work with employees who have been trained and equipped as required by the HASP and applicable provisions of 29 CFR 1910 and 29 CFR 1926.

K. Fire extinguishers, electrical equipment and wiring shall conform to the applicable requirements of 29 CFR 1926 and 49 CFR.

L. Smoking shall not be permitted within 50 feet of any excavation.

3. For construction within 1,000 feet of a known or potentially contaminated site, the following conditions, in addition to those listed in subsection 250.03(d)1. shall apply:

A. The areas under construction shall be checked with a combustible gas indicator before excavation begins to determine if flammable or combustible gas is in the area.

B. Excavations, trenches, and drill holes shall be monitored by the HSO for flammable gas, toxic gas and oxygen deficiency or enrichment. This shall be carried out continuously unless the presence of flammable, combustible, or toxic gas or oxygen deficiency or enrichment in the area can be ruled out by the HSO. The recommendation to discontinue monitoring must be agreed to by the Engineer and the Contractor. Before implementation, this agreement shall be written, and shall contain specific conditions that will require re-evaluation of the area.

C. When flammable or toxic gas is found in the area, those precautions and procedures in subsection 250.03(d)2 shall apply.

4. The following procedures shall be followed if the level of contamination as documented in the environmental documents referenced in subsection 102.05 as revised for this project is exceeded, or if previously unidentified contaminated air, soil, or water, is encountered during the construction of the project:

A. Work in the immediate area of the release or discovery of contamination shall cease. The Engineer shall be immediately notified.

B. If no HSO is required by the Contract, the Contractor shall designate an HSO as directed, per subsection 250.03(a).

C. The Engineer may direct the HSO to evaluate the material for potential hazardous substance or other contamination or unsafe conditions. This evaluation may include, but is not limited to, on-site field monitoring, on-site testing, and on or off-site laboratory analysis. Removal of storage tanks and surrounding contaminated soils shall be per applicable laws, regulations and established procedures. If the contaminated material cannot be placed in the embankment or remediated on site, it must be removed to an appropriate TSD facility, as designated in writing by the Engineer. The HSO shall supervise the necessary testing required to make appropriate TSD determinations. Disposal of the unsuitable material shall be considered as remediation work as described in subsection 250.03(d)4. D and 250.03(d)4. E.

D. If this site is determined to be contaminated with petroleum products, hazardous substances, or other solid waste in excess of that indicated in the above listed site investigation documents, a thorough Site Investigation and Waste Management Plan shall be accomplished under the supervision of the HSO. The Site Investigation and Waste Management Plan shall be submitted to the Engineer for approval and shall determine the extent of contamination and propose at least three types of remedial action for the contaminated area as required by applicable statutes and regulations. The HSO shall be available to assist the Engineer in explaining this study to the regulatory agencies. When requested by the Engineer, the Contractor shall prepare a Remediation Plan based on the selected remedial method and shall submit this to the Engineer for approval. The time required for the Engineer's review of the Remediation Plan, including all necessary drawings, calculations, specifications, and other documentation will not exceed four weeks after a complete submittal is received. This work shall not be done unless authorized in writing by the Engineer.

E. If the site is determined to be contaminated with petroleum products; hazardous chemicals, materials, or wastes; or other solid wastes, and is required to be remediated, the HSO or other qualified individuals will supervise the Remediation Plan implementation as concurred to by the regulatory agencies, as directed. Hazardous Waste generated by remedial activities shall list the Colorado Department of Transportation as the hazardous waste generator on the required paperwork for projects on State Highways and their associated frontage roads. If this project is not on a State Highway or frontage road, then the appropriate local governmental entity having jurisdiction over the transportation system facility shall be listed as the hazardous waste generator. If the waste disturbed or produced was caused by Contractor negligence, the Contractor shall be listed as the hazardous waste generator. Remediation work shall be done only when authorized by the Engineer in writing.

250.04 Heavy Metal Based Paint Management. When the work includes the removal of paint or items covered with paint that may contain lead, chromium, or other heavy metals, the requirements of this subsection shall apply in addition to the requirements of subsection 250.03.

The requirements of the HASP shall be per OSHA Publication No. 3142, Working with Lead in the Construction Industry.

Paint Removal and Waste Disposal work shall be performed per 29 CFR 1926.62, State and local air quality regulations, the Steel Structures Painting Council (SSPC) Guide for Containing Debris Generated During Paint Removal Operations, the Industrial Lead Paint Removal Handbook (SSPC 91-18), and the references contained.

The following minimum precautions and procedures shall be followed unless modified in the approved HASP or its updates:

(a) The Contractor shall contact the CDPHE, Air Pollution Control Division to ascertain if an air pollution permit is required for the cleaning or demolition work. If an air pollution permit is required, the Contractor shall obtain the permit. The Contractor shall furnish the Engineer with a copy of the permit application and the permit issued before starting cleaning or demolition activities. A copy of the Air Pollution Emission Notice [APEN] shall be provided to the Engineer, if such notice is required under the Colorado Air Quality Control Commission's regulations. The processing of air pollution permits in non-attainment areas, or where public hearings are required, likely will take more than 90 days.

(b) The Contractor shall contain paint chips, corrosion residues, and spent abrasives, referred to as waste materials, resulting from the cleaning or demolition operations. The Contractor shall not deposit or release waste material into the water, air or onto the ground below or adjacent to the structure. The Contractor shall conduct cleaning operations to minimize the waste materials produced. Before beginning the work, the Contractor shall submit to the Engineer for acceptance, a detailed methods statement for capturing, testing, and disposing of the removed materials. The Engineer will have seven calendar days to review and accept or reject this methods statement.

(c) Abrasives utilized for blast cleaning shall be low-dusting and low waste. Unless approved otherwise, vacuum blasting or wheel blasting shall be used.

(d) The HSO shall sample and test the waste material for lead, chromium, and other paint associated heavy metals using the Toxicity Characteristic Leaching Procedure (TCLP) Test, Method 1311 of the EPA publication, Test Methods for Evaluating Solid Waste 846. Sample collection methodology and frequency shall be recommended by the HSO and accepted by the Engineer with an adequate number of samples taken to be representative of all waste material collected. If the waste material does not pass the TCLP test, it shall be disposed of in a permitted TSD facility as designated in writing by the Engineer. The waste materials handling decision shall be documented by a report (five copies) submitted to the Engineer. This documentation shall include a description of sample collection methodology, testing performed, test results, and comparison of test results with hazardous waste requirements. The waste material shall not be held at an unpermitted TSD facility site in excess of Resource Conservation and Recovery Act (RCRA) temporary storage time limits.

(e) When an item coated with paint is removed, all loose paint shall be removed and collected from the item within 24 hours of the time it is removed or placed onto the ground. All loose paint shall be removed and collected from a painted item before it is removed from the site. The Contractor shall contain loose paint until it is removed and collected. Loose paint is defined as that which can be removed by manual scraping methods. Over waterways, the Contractor shall capture all paint debris by the method specified in the methods statement. The paint debris shall be collected on a daily basis and shall be stored in a properly labeled, tightly sealed container, and placed in a secured location at the end of each working day.

(f) All painted steel components that are not designated to be salvaged shall be recycled. Contractor possession of the steel for future use shall be considered a form of recycling. Before transport of the components off-site, the Contractor shall obtain a letter from the recipients of the painted steel components stating that they have been fully informed of the contents of the paint and are capable of handling the paint. If the Contractor is to maintain future possession of the steel, the Contractor shall supply this letter. If there will be more than one recipient of the painted material, one letter shall be obtained from each recipient. The Contractor shall provide a copy of each letter to the Engineer. If the painted steel components will be recycled by melting, the letter from the recipient is not required. The Contractor shall submit a letter stating the destination of the painted steel components and that they will be melted.

(g) When the work consists of the removal of a bridge or components of a bridge coated with paint that has been assumed to contain lead, chromium, other heavy metals, or a combination thereof, the Contractor shall capture paint debris that is dislodged during removal operations. The Contractor may choose any method for dismantling the bridge, subject to the following required construction sequence limitations:

1. The concrete deck shall be removed before removal of the steel superstructure.
2. If the methods statement indicates that girders will be dropped to the ground during dismantling, all debris from the concrete deck removal operation shall be removed from the area below the bridge before any girders are dropped into this area.
3. Girders may be cut and dropped only if the span is located entirely over land.

250.05 Material Handling. This work consists of the additional handling of groundwater and soils to be excavated for construction of the project that are suspected or known to be contaminated. This work also includes stockpiling or containerization, analytical sampling and testing, and final disposition of contaminated groundwater and soils requiring special handling.

The Contractor shall maintain vertical trench walls for the work in the specified areas of known or potential contamination, as shown on the plans. Shoring may be necessary to meet this requirement. The Contractor shall confine the removal of contaminated groundwater and soils encountered as a result of the excavation activities in the specified areas to the vertical and horizontal limits of structure excavation specified in the Contract. The Contractor shall be responsible for any contaminated materials generated beyond the limits of excavation. This shall include any sampling, analysis, and disposal required, and the costs thereof. The Contractor shall be listed as the generator of any such material. The limits of excavation shall be determined as 18 inches outside of structures, including sewers, water lines, inlets, manholes, and other underground structures to be constructed, or as directed.

Specific areas of known or potential contamination have been identified in the project plans. There is the potential of encountering contaminated groundwater and soil, which has not been summarized in the plans or specifications, at unknown locations on the site. Suspected contaminated soil and groundwater shall be handled by one of three methods as follows:

(a) Materials Handling (Stockpile and Containerization). When recommended by the HSO and authorized by the Engineer, material shall be stockpiled or containerized for analysis and characterization for proper handling and, disposal, or both. Sampling and testing of materials shall be as described in the Contract. If analysis indicates that soil samples are designated as uncontaminated, as determined by the criteria shown in the Contract or as determined by the CDPHE, the associated soils will not require any special handling and will become the property of the Contractor and may be used on site, subject to other requirements of the Contract. Health and safety monitoring and strict fugitive dust control shall be conducted during the placement of these soils. If analysis indicates that groundwater samples are designated as uncontaminated, as determined by the criteria shown in the Contract or as determined by the CDPHE, the groundwater shall be handled per subsection 107.25.

Stockpiled and containerized materials shall be secured in compliance with the following provisions until they are determined to be uncontaminated:

1. The Contractor shall not store the material for more than 90 days.
2. The Contractor shall prevent any runoff from infiltrating the ground or running out of the containment area.
3. Soils and groundwater containing different contaminants shall be placed in separate containers or stockpiles.

4. The Contractor shall prevent the dispersion of materials or the dilution or mixing of containers and stockpiles.

5. The ground surface that the contaminated soils will be placed shall be covered with plastic sheeting, which will withstand the placement and removal of stockpiled materials without breaching.

6. The ground surface shall be graded to drain toward the edge of the soil piles and the berm or trench around them shall be covered by plastic sheeting.

7. Proper security shall be provided per 40 CFR.

(b) Solid Waste Disposal. Soils determined to be contaminated, but not hazardous, as established by criteria in the Contract or as determined by CDPHE or other regulatory agencies having jurisdiction, shall be handled and disposed of as recommended by the HSO and approved by the Engineer. The Contractor shall haul this material to a solid waste disposal facility.

(c) Contaminated Groundwater Disposal. Groundwater determined to be contaminated, but not hazardous, as established by criteria in the Contract or as determined by CDPHE or other regulatory agencies having jurisdiction, shall be handled and disposed of as recommended by the HSO and approved by the Engineer. The Contractor shall prepare a dewatering plan proposing at least three types of treatment and disposal options of contaminated groundwater as required by applicable statutes and regulations. One of the treatment options shall include permitting and onsite treatment before discharge or disposal. The dewatering plan shall be submitted to the Engineer for approval four weeks before dewatering activities begin.

(d) Hazardous Waste Disposal. Soils and groundwater that are designated or suspected to be hazardous shall be containerized immediately upon excavation or upon discovery. Hazardous material shall be labeled and transported to a permitted treatment, storage and disposal (TSD) facility or to a hazardous waste disposal facility approved by the Engineer.

(e) Additional Requirements. Stockpiled or containerized material characterized as uncontaminated, contaminated, or hazardous shall be stored and disposed of in a manner consistent with current established federal, state, and local regulations for waste materials.

Materials with contaminants not specifically regulated shall be disposed of by the Contractor as directed, in consultation with CDPHE. All areas where wastes are generated shall be reviewed by the HSO to identify potential contaminant sources that may result in a contaminated waste stream.

Contaminated groundwater and soils, which have been identified as solid waste or hazardous waste, requiring disposal according to federal, state, and local regulations, shall be transported per 49 CFR by the Contractor to an appropriately permitted treatment facility, landfill, incinerator, or asphalt plant or other facility approved to accept the waste. CDPHE and the landfill or other treatment or disposal facility shall be notified by the HSO of the material to be disposed of and the corresponding analytical test results before shipment. Potentially contaminated water collected from the lined trench of a stockpile shall be treated as required by Colorado Wastewater Discharge Permit System (CDPS) permits, 29 CFR and 40 CFR and reimbursed separately per Contract requirements.

250.06 Sample delivery. This work consists of the collection, containerization, and delivery of material samples for analysis to the testing facility designated in the Contract.

Environmental Protection Agency (EPA) protocol and standards shall be followed in the collection, containerization, and transport of samples to be analyzed, including the documentation of the proper chain of custody of all samples. The Contractor shall collect sufficient sample material to perform the required analysis and is responsible for ensuring that appropriate climate control has been provided for sample transport. Sample delivery shall be made within the maximum allowable holding time for each sample type, not to exceed 24 hours, excluding weekends. The time period required for sample collection and delivery to the testing facility will not be considered an excusable delay. The analysis to be completed and turnaround time shall be approved by the Engineer.

The Contractor shall provide the Engineer with a copy of documentation indicating that proper chain of custody requirements have been followed for all samples.

Quality control samples shall be provided by the Contractor per the quality control requirements of the testing facility designated in the Contract (quality control requirements are available from the Engineer). The Contractor shall prepare, label, and transport these samples to the testing facility in conjunction with the delivery of other samples authorized for analysis by the Engineer, at no additional cost.

The Engineer may request splits of samples, in advance of collection, which shall be provided at no additional cost by the Contractor.

250.07 Regulated Asbestos Contaminated Soils (RACS) Management. Environmental documents or plans listed in the special provisions shall include known or suspected locations that could involve encounters with RACS during excavation and other soil disturbing construction activities. Unexpected discoveries of RACS may occur during excavation and soil disturbing construction activities. RACS shall be properly managed or remediated, per subsection 250.07(a).

All asbestos related activities shall be performed by CDPHE certified asbestos professionals, contractors, or consultants.

Certifications are issued by the CDPHE, Indoor Air Quality Unit. A Colorado Certified Asbestos Building Inspector shall manage the assessment and disposal of RACS and other ACM. The Indoor Air Quality Unit within CDPHE is the only unit that certifies such professionals. The Contactor shall furnish a copy of the certification to the Engineer.

(a) Regulatory Compliance. RACS management is governed by 6 CCR 1007-2, Section 5.5, which includes and references regulatory compliance with Colorado Air Quality Control Commission *Regulation* No. 8 Part B-Asbestos. Colorado

Regulation No. 8 governs all asbestos activities, demolition, permitting, and certification of Certified Asbestos Professionals in the State of Colorado. The Contractor shall conform to all current regulations, policy directives, or both, issued by the CDPHE, and the Department.

(b) Asbestos Management and Visual Inspections. Asbestos management shall be performed by a CDPHE certified Asbestos Building Inspector. All inspections of the area of asbestos contaminated soil removal shall be performed by a CDPHE certified Asbestos Building Inspector to determine what, if any, controls must be instituted to allow future activity in the excavation area.

(c) *Permitting and Notification.* The CDPHE requires notification of any soil disturbing activity where asbestos is known, suspected, or discovered. A 24-hour notification to CDPHE is required before any soil disturbing activity of an unplanned asbestos discovery. A 10-workday notification to CDPHE is required before any soil disturbing activity in an area with known or potential RACS. Removal of asbestos-containing material on a facility component, that is located on or in soil that will be disturbed, with asbestos quantities above the following trigger levels shall be permitted and abated per the requirements of Colorado Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B):

1. 260 linear feet on pipes,
2. 160 square feet on other surfaces, or
3. The volume of a 55-gallon drum.

All permit applications shall be submitted to the CDPHE a minimum of 10 days before start of work for approval. The permit application and notification shall be submitted simultaneously. A CDPHE certified General Abatement Contractor shall obtain all required State and local permits and shall be responsible for all associated fees. Permit application, notification, and waiver request forms shall be submitted to:

> Colorado Department of Public Health and Environment Permit Coordinator/APCD - SS - B1 4300
> Cherry Creek Drive South Denver, CO 80246-1530 Phone: (303) 692-3100 Fax: (303) 782-0278

Application and waiver forms are available on the CDPHE website.

(d) *CDOT's Regulated Asbestos-Contaminated Soil Management Standard Operating Procedure, dated October 18, 2016.* Asbestos contaminated soil shall be managed per 6 CCR 1007-2, Part 1, Section 5.5, Management of RACS. Regulations apply only upon unexpected discovery of asbestos materials during excavation and soil disturbing activities on construction projects, or when asbestos encounters are expected during construction. The Contractor shall comply with procedures detailed in the CDPHE's *Management of Regulated Asbestos Contaminated Soil Regulation* and CDOT's CDPHE approved *Regulated Asbestos-Contaminated Soil Management Standard Operating Procedure*, dated October 18, 2016, including the following minimum requirements:

1. Immediate actions and implementation of interim controls to prevent visible emissions, exposure, and asbestos contamination in surrounding areas.
2. Soil Characterization.
3. Training required for all personnel involved in excavation and other soil disturbing activities, once asbestos is encountered during construction or on projects where asbestos encounters are expected. Asbestos Awareness Training shall be given by a qualified and certified Asbestos Building Inspector with a minimum of six months' experience inspecting asbestos contaminated soil.
4. Assessment for the presence and extent, within the proposed area of disturbance, of asbestos discoveries, whether expected or unexpected, by a CDPHE Certified Asbestos Building Inspector.
5. Investigation and sampling required for risk assessment and management. Investigation, if required, shall be conducted by a CDPHE Certified Asbestos Building Inspector.

6. Risk assessment and determinations for further management or abatement.

   A. Risk assessment and determinations shall be made by a CDPHE Certified Asbestos Building Inspector and coordinated with the Engineer.

   B. Soil remediation is not necessarily required, depending on the circumstances.

7. Submit CDPHE 24-hour Notification Form for unexpected RACS discovery included in Attachment 1 of the CDOT Regulated Asbestos-Contaminated Soil Management Standard Operating Procedure.

8. Submit CDPHE 10-day Notification Form for planned RACS management included in Attachment 1 of the CDOT Regulated Asbestos-Contaminated Soil Management Standard Operating Procedure.

(e) Risk Assessment and Determinations for Further Management or Remediation. Risk assessment and determinations for further management or remediation shall be closely coordinated with the Project Engineer and Project Manager of the Statewide Management Plan.

250.08 Methamphetamine Lab Sites. Demolition of former Methamphetamine (meth) labs is enforced by the Governing Authority, which varies from county to county. The Contractor shall demolish all buildings that are identified as former meth labs, as listed in public listings by the Governing Authority. The Contractor shall provide evidence of demolition to the Governing Authority, obtain receipt of such evidence by the Governing Authority, and shall submit these to Engineer immediately following demolition.

Septic tank removal at known meth lab sites shall undergo preliminary assessment by an Industrial Hygienist or Certified Industrial Hygienist to determine proper removal and disposal. Work shall proceed per the recommendations of the Hygienist.

METHOD OF MEASUREMENT

250.09 Environmental Health and Safety Management will not be measured but will be paid for on a lump sum basis. This will include all work, materials, and hourly time charges by the HSO and other personnel required to accomplish the following:

(1) Preparation, submittal and briefing of the initial HASP.

(2) Preparation and submittal of the Waste Management Plan.

   A. Preparation and Submittal of the Dewatering Plan.

   B. Preparation and Submittal of the Remediation Plan.

(3) Procedures and equipment specified in subsections 250.03 - 250.07.

(4) PPE (levels C and D) for Contractor's personnel for any contamination identified in the pre-construction investigations.

(5) Preparation and submittal of the final site report.

The quantity to be measured for Health and Safety Officer will be the total number of hours that the Health and Safety Officer is actually used, as authorized, for the following work:

(1) Field monitoring necessary to ensure the safety of workers on the site.

(2) Hours in excess of the items listed under Environmental Health and Safety Management.

(3) Hours that are necessary due to unforeseen site conditions.

(4) Hours of additional consultation or field work that is requested by the Engineer.

Equipment specified in subsection 250.03(a), preparation and submittal of the daily HSO diary, travel to and from the project site, and PPE (Levels C and D) required for use by the HSO will not be measured and paid for separately but shall be included in the hourly cost of the HSO.

The quantity to be measured for Monitoring Technician will be the total number of hours that Monitoring Technician is actually used as authorized. Equipment specified in subsection 250.03(b), supervision of the MT, preparation and submittal of the daily monitoring diary, travel to and from the project site, and PPE required for use by the MT (Levels C and D) will not be measured and paid for separately, but shall be included in the hourly cost of the MT.

Solid stockpiled materials will be measured by the cubic yard computed from cross sections by the average end area or other acceptable method. Disposal of solid waste and solid hazardous waste materials will be measured by the cubic yard in the disposal container.

Materials Sampling and Delivery will be measured by the actual number of samples collected, containerized, and transported to the testing facility indicated in the Contract.

Additional environmental health and safety management work required and authorized by the Engineer, but not included in the items listed above, will be considered extra work to be paid for per subsection 109.04, unless such work is caused by the Contractor's action.

BASIS OF PAYMENT

250.10 Partial payment for Environmental Health and Safety Management, as determined by the Engineer, will be made as the work progresses. The Contractor shall submit a schedule of environmental related Health and Safety Management work before the first partial payment is made. The schedule shall indicate the environmental related Health and Safety Management time for each work item that requires Contractor environmental related Health and Safety Management effort and the total time for the project.

The accepted quantity for Health and Safety Officer will be the number of hours actually used and approved for payment by the Engineer and will be paid for at the contract unit price.

The accepted quantity for Monitoring Technician will be the number of hours of onsite monitoring as approved by the Engineer and will be paid at the Contract unit price.

Environmental Health and Safety Management, Health and Safety Officer and Monitoring Technician bid items shall include vehicles, phone charges, supplies, printing, postage, office support, and all other miscellaneous costs associated with the work.

Payment for Groundwater Handling (Containerization and Analysis) will be made per subsection 109.04. Payment for Soil Handling (Stockpile) will be made at the contract unit price for all excavated material required to be stockpiled for analysis. The contract unit price will be full compensation for furnishing all materials, labor, equipment, and incidentals necessary to complete this work, and all handling of the material before disposal. This includes haul, stockpile, and security. Payment for this work will be in addition to any payment made under other bid items for excavation, embankment, or backfill on the project, or waste disposal of this material.

Payment for Solid Waste Disposal and Solid Hazardous Waste Disposal will be made at the appropriate contract unit price for the disposal of material determined to be either solid waste or solid hazardous waste. The contract unit prices will be full compensation for furnishing all materials, labor, equipment, tools, storage containers for transport, containerization of material for up to 60 days, and incidentals necessary to complete this work. This includes all handling of the material, loading for disposal, unloading for disposal, and borrow material required for replacement of excavated material disposed of offsite. It does not include stockpiling or containerization required for analysis that is included in the item Materials Handling (Stockpile and Containerization) paid for as described above. Payment for waste disposal fees and transport of hazardous waste will be made as shown below. Payment for this work will be in addition to any payment made under other bid items for excavation, embankment, backfill, or material handling (stockpile and containerization) on the project.

(1) Solid Waste. Transport costs to the disposal facility and disposal fees will be included in the contract unit price for this work.

(2) Solid Hazardous Waste. Transport costs, disposal fees, and treatment costs will be paid for by planned force account per subsection 109.04.

(3) Liquid Hazardous Waste. Transport costs, disposal fees, and treatment costs will be paid for by planned force account per subsection 109.04.

The cost of shoring required to limit the removal of contaminated materials to the specified limits shall be included in the contract unit prices for any excavation to be performed. Such shoring ordered by the Engineer in areas other than the specified areas of known or potential contamination, as shown on the plans, will be paid for per subsection 109.04.

Payment for Materials Sampling and Delivery will be made at the contract unit price for each material sample collected, containerized, and transported to the laboratory testing facility as designated in the Contract. The contract unit price will be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete this work including required sampling kits, containers, sample splits, and quality control samples.

The Contractor shall be responsible for damage caused by Contractor negligence to the environment, persons, or property. Expenditures associated with actions of the Contractor shall be borne by the Contractor at no cost to the project.

Contaminated groundwater containerized, treated, or disposed under the requirements of this specification will be paid for by planned force account per subsection 109.04.

The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Pay Item	Pay Unit
Environmental Health and Safety Management	Lump Sum
Health and Safety Officer	Hour
Monitoring Technician	Hour
Materials Sampling and Delivery	Each
Materials Handling (Stockpile)	Cubic Yard
Solid Waste Disposal	Cubic Yard

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DIVISION 300
BASES

SECTION 304

AGGREGATE BASE COURSE

DESCRIPTION

304.01 This work consists of furnishing and placing one or more courses of aggregate and additives, if required, on a prepared subgrade.

MATERIALS

304.02 Aggregate. The aggregates shall meet the requirements of subsection 703.03.

Acceptance will be based on random samples taken from each lift.

304.03 Commercial Mineral Fillers. Portland cement shall conform to subsection 701.01. Hydrated lime shall conform to subsection 712.03.

CONSTRUCTION REQUIREMENTS

304.04 Placing. If the required compacted depth of the aggregate base course exceeds 6 inches, it shall be constructed in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer shall not exceed 6 inches. When vibratory or other approved types of special compacting equipment are used, the compacted depth of a single layer may be increased to 8 inches upon request, provided that specified density is achieved, and written approval is given.

304.05 Mixing. The Contractor shall mix the aggregate by methods that ensure a thorough and homogenous mixture.

304.06 Shaping and Compaction. Compaction of each layer shall continue until a density of at least 95 percent of the maximum density has been achieved as determined per AASHTO T 180 as modified by CP 23. The moisture content shall be at plus or minus 2 percent of optimum moisture content. The surface of each layer shall be maintained during the compaction operations so that a uniform texture is produced, and the aggregates are firmly keyed. Moisture conditioning shall be performed uniformly during compaction.

Compaction of each reclaimed asphalt pavement aggregate layer shall continue until a wet density of at least 95 percent of the maximum wet density when determined per a one-point AASHTO T 180, Method D test has been achieved.

The surface of the base course will be tested with a 10-foot straightedge, or other approved device. The surface shall be tested before the application of any primer or pavement. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall not exceed 1/2 inch. All irregularities exceeding the specified tolerance shall be corrected to the satisfaction of the Engineer at no additional cost to the Department.

The above compaction and straightedge requirements shall not apply to shoulder gravel. Compaction of shoulder gravel shall be accomplished by wheel rolling, as directed.

METHOD OF MEASUREMENT

304.07 Aggregate base course will be measured by the ton, or by the cubic yard compacted in place.

BASIS OF PAYMENT

304.08 The accepted quantities of aggregate base course, of the class specified, will be paid for at the contract price bid per ton or per cubic yard, as shown in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Aggregate Base Course (Class ___)	Ton, Cubic Yard
Aggregate Base Course (RAP)	Ton, Cubic Yard

Water will not be measured and paid for separately but shall be included in the work.

Commercial mineral fillers, when used, will be measured and paid for per Section 307 or as provided in the Contract.

SECTION 306

RECONDITIONING

DESCRIPTION

306.01 This work consists of blading, shaping, wetting, and compacting the existing subgrade with moisture and density control.

CONSTRUCTION REQUIREMENTS

306.02 The top 6 inches of the existing subgrade shall be reconditioned by blading and rolling. Sufficient water shall be added to meet the density requirements as specified in the Contract. The reconditioned surface shall not vary above or below the lines and grades as staked by more than 0.08 foot. The surface shall be tested for smoothness and density before the application of any base course material. Where asphalt-surfacing materials are to be placed directly on the subgrade, the subgrade plane shall not vary more than 0.04 foot. All irregularities exceeding the specified tolerance shall be corrected to the satisfaction of the Engineer at no additional cost to the Department. The surface shall be satisfactorily maintained until base course has been placed.

METHOD OF MEASUREMENT

306.03 Reconditioning will be measured by the square yard of subgrade, including auxiliary lanes, and shall include blading, shaping, scarifying, compacting the subgrade, finishing, and maintenance of the finished surface.

BASIS OF PAYMENT

306.04 The accepted quantities of reconditioning will be paid for at the contract unit price for reconditioning.

Payment will be made under:

Pay Item	Pay Unit
Reconditioning	Square Yard

Water will not be measured and paid for separately but shall be included in the work.

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SECTION 307

LIME TREATED SUBGRADE

DESCRIPTION

307.01 This work consists of treating the earth subgrade by combining lime and water with the pulverized soil subgrade material to the specified depth and compaction requirements as shown on the plans.

MATERIALS

307.02 Lime. Lime for lime treated subgrade shall be applied in slurry form. Dry application of lime will not be allowed unless otherwise approved by the Engineer. Commercial lime slurry shall be a pumpable suspension of solids in water. Lime for lime treated subgrade shall conform to the requirements of ASTM C977 and rate of slaking test for moderate reactivity per ASTM C110 and shall be the product of a high-calcium limestone as defined by ASTM C51.

307.03 Water. Water used for mixing or curing shall be per subsection 712.01, with the additional requirement that the sulfate content shall be less than 500 ppm.

CONSTRUCTION REQUIREMENTS

307.04 General. The Contractor shall construct one or more compacted courses of treated material, to the depth specified in the Contract. The treated material shall be a uniform blend of soil, lime, and water, free from loose or segregated areas. It shall have uniform density and moisture content and be void of all vegetation and other organic or man-made material. The subgrade shall be well bound for its full depth and width with a smooth surface suitable for placing subsequent courses. The Contractor shall regulate the sequence of the work to accurately apply and uniformly blend the lime at the designated rate and rework the courses as necessary to meet the above requirements.

The Contractor shall submit a mix design to the Engineer for approval, before constructing the test section.

The Contractor shall mix hydrated or quicklime with water to produce lime slurry at the job site with equipment specifically manufactured for this purpose.

Excessive aeration of lime slurry will not be permitted.

The lime-treated subgrade shall not be mixed when it is raining, or when the subgrade material is frozen. The lime-treated subgrade shall not be mixed or compacted if the temperature of the lime or soil is below 35 °F.

307.05 Preparation of Subgrade. Before beginning any lime treatment, the subgrade shall be constructed and finished to smooth and uniform surfaces conforming to the grades and typical sections specified. Variation from the subgrade plane elevations specified shall not be more than plus or minus 0.1 foot. The subgrade shall also be proof rolled per subsection 307.07. Soft or otherwise unsuitable subgrade disclosed by proof rolling shall be over-excavated and replaced to a compacted stable state. The in-place density shall be at least 95 percent of AASHTO T 99 density within 0-3 percent of optimum moisture content.

307.06 Test Section. Before full-scale production, the Contractor shall construct a test section to demonstrate, to the satisfaction of the Engineer, subgrade stabilization using the materials, equipment, and methods to be used in full-scale production. The test section shall be at least 100 feet long, two spreading and mixing lanes wide, and the same depth as the course represented in the plans. The test section shall be constructed at a location approved by the Engineer.

The test section shall be tested per the same test requirements for the lime and soil design mix, and as determined by the Contractor.

If the test section is unsatisfactory, the Contractor shall adjust the materials, equipment, and methods or combinations thereof as necessary to conform to the specifications. Additional test sections shall be constructed as required to produce a satisfactory test section before full-scale production. Unsatisfactory test sections shall be removed and replaced at the Contractor's expense. Full production shall not begin until a satisfactory test section is completed and approved by the Engineer.

Before start of work, the Contractor shall determine the lime application rate, and the maximum dry density and optimum moisture content of the material after it has been treated with lime. All tests shall be performed in the presence of the Engineer. These test results will be used to determine the Contract requirements for lime application.

307.07 Proof Rolling. Both before and after the lime treatment, the Contractor shall perform proof rolling per subsection 203.08, except that final proof rolling will take place a minimum of seven days after lime treatment, unless otherwise approved by the Engineer.

307.08 Processing Materials. After the subgrade has been finished and approved as specified, the subgrade shall then be cut and pulverized by a cutting and pulverizing machine to the depth and width shown on the plans. Precautions shall be taken to avoid forming furrows of loosened material below the depth specified for the lime-stabilized soil mixture. The machine shall uniformly cut and pulverize the loosened material to a depth not greater than 10 percent over the thickness of the lime-treated layer as specified in the Contract and shall have cutters that plane the base of the cut and pulverize zone to a smooth surface over the entire width of the cut. The machine must give visible indication at all times that it is cutting to the proper depth.

(a) Lime Application. Lime shall be applied in the form of a slurry, on that area where the initial mixing operations can be completed during the same working day, and at the specified percentage of hydrated lime, by equipment capable of pumping and re-circulating the mixture while in transit. The slurry shall be applied through spray bars to assure a uniform flow and distribution.

(b) Initial Mixing. Initial mixing shall take place immediately after lime application. The lime, soil, and water shall be thoroughly mixed and blended by a self-propelled rotary type mixing machine, until a uniform mixture throughout the required depth and width is obtained and all clods and lumps are reduced to a maximum 2-inch diameter size. There shall be a minimum 6-inch overlap between passes to assure consistent mixing and breakdown.

The mixing machine shall make at least of two passes to uniformly mix the lime, water, and soil to the full depth of the pulverized layer. Non-uniformity of color reaction, when the treated material is tested with the standard phenolphthalein alcohol indicator, will be considered evidence of inadequate mixing. Streaks and pockets of lime will also be considered evidence of inadequate mixing and shall require additional mixing to correct.

The moisture content of the mixture immediately following the blending of water, lime, and soil shall not be less than optimum as determined by AASHTO T 99, plus necessary hydration moisture. Hydration moisture will be considered as one percentage point for each percent of lime being added. When proper mixing has been accomplished, the mixture shall be cured for at least 48 hours. Light rolling to seal the surface of the mixture shall be required. The mixture shall be maintained in a moist condition throughout the entire curing period.

(c) Final Mixing. After the required curing period, the mixture shall be uniformly mixed by a self-propelled rotary type mixing machine and maintained at approximate optimum moisture content as determined. If the lime stabilized soil mixture contains clods, they shall be reduced by approved pulverization so that the remainder of the material shall meet the gradation requirements of Table 307-1 when tested dry by laboratory sieves. If it is determined that additional lime needs to be added to the previously mixed subgrade, the total depth of the subgrade shall be mixed.

307.09 Compaction.

(a) Compaction of the lime and soil mixture shall begin immediately after final mixing. The material shall be aerated or sprinkled as necessary to maintain the mixture within the specified moisture content limits during and following compaction. The field density for the compacted mixture shall be at least 95 percent of the maximum density of laboratory specimens prepared from samples taken from the lime soil material in place after curing and before compacting. The specimens will be compacted and tested per AASHTO T 99, and the in-place field density will be determined per CP 80. Any mixture that has not been compacted shall not be left undisturbed for more than 30 minutes. The moisture content of the mixture at the start of compaction shall be at 2 plus or minus 1 percent above the optimum moisture content. The optimum moisture content will be determined per AASHTO T 99.

(b) The finished surface shall be smooth and uniform conforming to the typical sections specified. All irregularities, depressions, or weak spots, that develop, shall be corrected immediately by scarifying the areas affected, adding or removing material as required, and reshaping and re-compacting by sprinkling and rolling. The surface of the course shall be maintained in a smooth condition, free from undulations and ruts, until other work is placed or the work is accepted.

(c) In addition to the requirements specified for density, the full depth of the materials shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section is completed, the Engineer will conduct tests. If the material fails to meet the density and strength requirements per the lime and soil design mix, it shall be reworked to meet these requirements at the Contractor’s expense. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and shall conform with the typical section shown on the plans and to the established lines and grades. Variation from the subgrade plan elevations specified shall not exceed 0.04 foot. Should the material, due to any reason or cause, lose the required stability, density, or finish, before the next course is placed or the work is accepted, it shall be recompacted and refinished at the Contractor’s expense.

307.10 Finishing and Curing. When initial compaction of the top layer of the lime-stabilized soil mixture is nearing completion, the surface shall be shaped to the required lines, grades, and cross section, and compaction continued until uniform and adequate compaction is obtained. The treated material shall be maintained at a moisture content satisfactory for proper curing by one of the following:

(1) Sprinkling for a period of seven days.

(2) Sprinkling for a period less than seven days until emulsified asphalt prime coat (diluted 1 to 1) is applied per subsection 307.10, item (3) below.

(3) Applying a protective film of emulsified asphalt prime coat (diluted 1 to 1 with water) immediately after the lime-treated subgrade has been finished. One application shall be made consisting of 0.20-gallon diluted mixture per square yard.

The completed section shall be cured for a minimum of seven days before further courses are added or any traffic is permitted, unless otherwise directed by the engineer. Acceptable compressive strength test results shall be in a range from a minimum of 160 pounds per square inch to 500 pounds per square inch.

307.11 Construction Joints. Construction joints are not required after each day's work unless there is a time lapse of seven days or more between the processing of adjacent sections. If construction joints are required, they shall be formed by cutting back into the completed work to form a vertical face. Damage to completed work shall be avoided.

307.12 Thickness Acceptance. Lime treated subgrade will be accepted for minimum thickness on a lot basis. A lot will consist of 1,500 square yards. One core shall be taken at random by the Contractor's Process Control Inspector in each lot. When the measurement of the core from a lot is not deficient by more than 0.5 inch from the minimum plan thickness, full payment will be made. When such measurement is deficient by more than 0.5 inch and not more than 1.0 inch from the plan thickness, two additional cores shall be taken at random and used in determining the average thickness for that lot. The thickness of the core shall be determined by average caliper measurement of cores tested per ASTM C174. When the average measurement of the three cores is not deficient by more than 0.5 inch from the plan thickness, full payment will be made. If the average measurement of the three cores is deficient by more than 0.5 inch but less than 1.0 inch from the plan thickness, the entire lot may be left in place and a 10 percent price reduction to the contract unit price will be made. If the average measurement of the three cores is deficient more than 1.0 inch but less than 2.0 inches from the plan thickness, the entire lot may be left in place and a 50 percent price reduction to the contract unit price will be made. When the average thickness is deficient by more than 2.0 inches, the entire lot shall be replaced at the Contractor's expense.

Table 307-1
SCHEDULE FOR MINIMUM SAMPLING AND TESTING

Element and Procedure	Process Control	Acceptance	Remarks
pH ASTM C977 (App) (Design) *ASTM G51 (Field)*	1/5000 sq yd or fraction thereof	1/10,000 sq yd or fraction	pH will be determined after % lime has been established based on unconfined compressive strength
Atterburg Limits AASHTO T89, T90	1/5000 sq yd or fraction thereof	1/10,000 sq yd or fraction	Reduce by 1/2 original PI
Swell Potential ASTM D4546	1/5000 sq yd or fraction thereof	1/10,000 sq yd or fraction	1/2% or less with 200 psf surcharge pressure
Unconfined Compressive Strength ASTM D5102 (Procedure B)	1/5000 sq yd or fraction thereof 1/soil type	1/10,000 sq yd or fraction 1/soil type	Determined by design plan criteria. Do not immerse in water after moist-cure period. The tests shall be conducted on samples cured in a moist environment for 5 days @ 100 °F.
Thickness Acceptance ASTM C174	A lot is defined as 1 core per 1500 sq yd or fraction thereof	1/3000 sq yd or fraction	When measurement is <0.5", 2 additional cores shall be taken in that lot and the average of 3 cores will determine the thickness of that lot
Gradation AASHTO T11 and T27	1/5000 sq yd or fraction thereof	1/10,000 sq yd or fraction	1": 100% passing; #4: 60% passing. Dry sieving after final mixing
Determining Percent Relative Compaction Soil-Aggregate by Nuclear Method CP 80	1/5000 sq yd or fraction thereof	1/10,000 sq yds or fraction	Minimum 95% of maximum dry density per AASHTO T 99. Moisture content of mixture at the start of compaction shall be at 2 ± 1% above optimum moisture content.
Moisture Density Curve AASHTO T99	1/soil type	1/soil type	
Sulfate CP-L 2103	1/soil type	1/soil type	Water soluble sulfate content in soil shall be less than 0.2% by dry soil weight.

METHOD OF MEASUREMENT

307.13 Hydrated lime will be measured by the ton. If quicklime is used the pay quantity will be determined using the certified lime purity for each truckload as follows:

Pure quicklime (CaO) • 1.32 = Hydrated Lime ($Ca(OH)_2$)

Quicklime delivered • % purity • 1.32 = A

Quicklime delivered • % inert material = B

A + B = total hydrated lime produced = pay quantity

Processing lime-treated subgrade will be measured by the square yard for the area completed and accepted. Overlap mixing will not be measured and paid for separately but shall be included in the work.

BASIS OF PAYMENT

307.14 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule. Payment shall include all processing materials, lime application and mixing, compaction, and materials used in curing.

Payment will be made under:

Pay Item	**Pay Unit**
Hydrated Lime	Ton
Processing Lime Treated Subgrade (___ Inch)	Square Yard

Test sections and coring will not be measured and paid for separately but shall be included in the work.

All proof rolling will be measured and paid for per Section 203.

DIVISION 400
PAVEMENTS

SECTION 401
PLANT MIX PAVEMENTS-GENERAL

DESCRIPTION

401.01 These specifications include general requirements that are applicable to all types of hot mix asphalts irrespective of gradation of aggregate, kind and quantity of asphalt cement, or pavement use. Deviations from these general requirements will be indicated in the specific requirements for each type.

This work consists of one or more courses of asphalt mixture constructed on a prepared foundation per these specifications and the specific requirements of the type under contract, and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established.

MATERIALS

401.02 Composition of Mixtures. The asphalt plant mix shall be composed of a mixture of aggregate, filler or additives if required and approved, asphalt cement, and reclaimed material if permitted and used.

(a) Mix Design. The Contractor shall submit the following to the Engineer:

(1) A proposed hot mix asphalt mix design prepared per Colorado Procedure 52, including a proposed job-mix gradation for each mixture required by the Contract, which shall be wholly within the Master Range Table in subsection 703.04 before the tolerances shown in Section 401 are applied. The weight of lime shall be included in the total weight of the material passing the 75 μm (No. 200) sieve.

(2) The name of the refinery supplying the asphalt cement and the source of the anti-stripping additive.

(3) A sufficient quantity of each aggregate for the Department to perform the tests specified in Section 3.2.1 of CP 52.

The Contractor's proposed job-mix formula for each hot mix asphalt grading will be tested by the Department utilizing materials actually produced and stockpiled for use on the project.

The job-mix formula for each mixture shall establish a single percentage of aggregate passing each required sieve size, a single percentage of asphalt cement to be added to the aggregate, and a single temperature for the mixture at the discharge point of the plant.

When Laboratory tests indicate that a proposed job-mix formula complies with the specifications as revised for the project, a Form 43 shall be executed between the Engineer and the Contractor to establish the job-mix formula.

After the Form 43 is executed, and all materials are available on the project, the Contractor shall notify the Engineer a minimum of one working day in advance of beginning production of the hot mix asphalt. Any changes in the Form 43 will require the same notification unless otherwise approved by the Engineer.

(b) Mixtures Furnished to the Project. After the job-mix formula is established, all mixtures furnished for the project shall conform thereto within the ranges of tolerances listed in Table 401-1.

Table 401-1
***TOLERANCES FOR HOT MIX ASPHALT**

***Hot Mix Asphalt – Item 403, Gradations**	
#Passing the 9.5 mm (3/8 inch) and larger sieves	± 6%
#Passing the 4.75 mm (No. 4) and 2.36 mm (No. 8) sieves	± 5%
#Passing the 600 μm (No. 30) sieve	± 4%
#Passing the 75 μm (No. 200) sieve	± 2%
Asphalt Content	± 0.3%
Asphalt Recycling Agent	± 0.2%

Table 401-1 Notes: *****When 100% passing is designated, there shall be no tolerance. When 90 – 100% passing is designated, 90% shall be the minimum; no tolerance shall be used.

#These tolerances apply to the Contractor's Process Control Testing.

The job-mix formula for each mixture shall be in effect unless modified in writing on Form 43.

Should a change in sources of materials be made, a new job-mix formula shall be established before the new material is used. This new job-mix formula shall be in effect until modified by the Engineer. Requests made in writing by the Contractor for changes in the job-mix formula will be considered. The job-mix formula may be changed by the Engineer if the change will produce a mixture of equal or better quality and will:

1. Permit better utilization of available material, or
2. Result in a saving in cost to the Department through an adjustment in unit price.

Tests for cleanliness, abrasion loss, and percent of fractured faces will be made on representative samples of aggregate taken during production or from the stockpiles.

Hot mix asphalt (HMA) will be tested for moisture susceptibility by the Department per Table 401-2. If a sample fails to meet the criteria shown in Table 401-2, the Contractor shall take corrective action before being permitted to continue production. If proper corrective action cannot be readily determined, the Engineer will suspend the use of such material until Laboratory tests indicate that the corrective measures taken by the Contractor will provide material that is in compliance.

If one or more samples fail to meet the requirements of Table 401-2, material from the area represented by the failing sample will be evaluated as follows:

If the area represented by the failing sample contains 2,000 tons of the new pavement or less, then the result for the failing sample shall be considered a lot of one and will be evaluated according to the formulas and procedures in subsection 105.03.

If the area represented by the failing sample contains more than 2,000 tons of the new pavement, then the material from the area represented by the failing sample will be sampled and tested according to the following method:

Pavement samples for possible moisture susceptibility testing will be taken at a minimum frequency of once every 2,000 tons throughout the project. The Engineer will observe the sampling, take possession of the samples, and retain these samples for possible testing. Sample size shall be a minimum of 20 pounds. If a 10,000-ton sample fails, then the four 2,000-ton samples from the area represented by that failing 10,000-ton sample will be tested for moisture susceptibility. The 10,000-ton result and the four 2,000-ton results will be considered a lot of five and will be evaluated according to the formulas and procedures in subsection 105.03. If less than four retained samples are on hand because the 10,000-ton sample represents less than 8,000 tons of hot mix asphalt, the price adjustment will be based on the test results from the retained samples on hand plus the test result from the 10,000-ton sample.

For the above evaluation, the "F" factor used in calculating P factors shall be 2.5. The P value shall be applied to price of the HMA item. If asphalt cement is not paid for separately, the price reduction shall be multiplied by 0.60. Lottman P values will not be combined with Pay Factors for other elements determined per Process Control/Owner Acceptance (PC/OA) specifications.

Table 401-2

HMA MOISTURE SUSCEPTIBILITY

TEST FREQUENCY/CRITERIA

Grading	Test Procedure	Minimum Test Result	Sampling Frequency
All Gradings	CP L-5109 Method B	70	One per 10,000 tons or fraction (minimum)

401.03 Aggregates. Aggregates shall meet the applicable requirements of subsection 703.04.

401.04 Mineral Filler. Mineral filler shall meet the requirements of subsection 703.06.

401.05 Hydrated Lime. Hydrated lime shall meet the requirements of subsection 712.03.

401.06 Asphalt Cements. The type and grade of asphalt cement will be specified in the Contract.

The asphalt cement shall meet the applicable requirements of Section 702.

CONSTRUCTION REQUIREMENTS

401.07 Weather Limitations and Placement Temperatures. Hot mix asphalt shall be placed only on properly prepared unfrozen surfaces that are free of water, snow, and ice. The hot mix asphalt shall be placed only when both the air and surface temperatures equal or exceed the temperatures specified in Table 401-3 and the Engineer determines that the weather conditions permit the pavement to be properly placed and compacted.

Table 401-3
PLACEMENT TEMPERATURE LIMITATIONS IN °F

Compacted Layer Thickness in inches	Minimum Surface and Air Temperature °F Top Layer	Minimum Surface and Air Temperature °F Layers Below Top Layer
< 1 1/2	60	50
1 1/2 - < 3	50	40
3 or more	45	35

Table 401-3 Notes: Air temperature is taken in the shade. Surface is defined as the existing base on that the new pavement is to be placed.

If the temperature falls below the minimum air or surface temperatures, paving shall stop.

The Contractor shall schedule the work so that no planed or recycled surface is left without resurfacing for more than10 calendar days during the period specified in Table 401-4, below. The Contractor shall immediately place a temporary hot mix asphalt layer on any surface that has been planed or recycled and cannot be resurfaced per the above temperature requirements within10 calendar days after being planed or recycled. The minimum thickness of the temporary hot mix asphalt layer shall be 2 inches. The Contractor shall perform the process control required to assure adequate quality of the hot mix asphalt used in the temporary layer. All applicable pavement markings shall be applied to the temporary layer surface. The Contractor shall maintain the temporary layer for the entire period that it is open to traffic. Distress that affects the ride, safety, or serviceability of the temporary layer shall be immediately corrected to the satisfaction of the Engineer. The temporary hot mix asphalt layer shall be removed when work resumes.

Table 401-4
PERIODS REQUIRING OVERLAY OF TREATED SURFACES

Location by Elevation	Period That Planned or Recycled Surfaces Must be Overlaid within 10 Days
All areas below and including 7000 feet	October 1 to March 1
All areas above 7000 feet up to and including 8500 feet	September 5 to April 1
All areas above 8500 feet	August 20 to May 15

401.08 Asphalt Mixing Plant. The asphalt mixing plant shall be capable of producing a uniform material, have adequate capacity, and be maintained in good mechanical condition. Defective parts shall be replaced or repaired immediately if they adversely affect the proper functioning of the plant or plant units, or adversely affect the quality of the hot asphalt plant mix.

Dust, smoke, or other contaminants shall be controlled at the plant site to meet all air quality requirements per subsections 107.01 and 107.24.

Acceptable safety equipment shall be provided by the Contractor to accommodate sampling and testing.

Hot asphalt plant mix shall not be stored longer than nine hours, unless additional protective measures are used and approved.

When hot asphalt plant mix is obtained from a commercial plant, the Contractor shall make arrangements for approved laboratory facilities at the plant site for testing hot asphalt paving mixtures. The plant laboratory shall meet the requirements of subsection.

401.09 Hauling Equipment. Trucks used for hauling asphalt mixtures shall have tight, clean, smooth metal beds thinly coated with a minimum amount of paraffin oil, lime solution, or other approved release agent. Petroleum distillates such as kerosene or fuel oil will not be permitted. Each truck shall have a cover of canvas or other suitable material to protect the mixture from the weather.

401.10 Asphalt Pavers. Self-propelled asphalt pavers shall be provided and equipped with an activated screed assembly, heated, if necessary, capable of spreading and finishing the asphalt plant mix material in lane widths applicable to the typical section and thicknesses shown in the Contract. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of asphalt plant mix material in widths shown in the Contract.

The paver's receiving hopper shall have sufficient capacity for a uniform spreading operation and shall have an automatic distribution system that will place the mixture uniformly in front of the screed.

The screed or strike-off assembly shall produce the specified finished surface without tearing, shoving, or gouging the mixture.

The paver shall include an approved longitudinal paver wedge system to create a sloped SafetyEdge℠ as shown on the plans. The wedge system shall be attached to the screed and shall compact the HMA to a density at least as dense as the compaction imparted to the rest of the HMA layer by the paving screed. The system shall provide a sloped SafetyEdge℠ equal to 32 degrees plus or minus 5 degrees measured from the pavement surface cross slope extended. A single plate strike off shall not be used. The system shall be adjustable to accommodate varying paving thicknesses. The Engineer may allow the Contractor to use handwork for short sections or to saw cut the sloped SafetyEdge℠ after paving operations are completed in areas such as transitions at driveways, intersections, interchanges.

The Contractor shall submit the proposed paver wedge system for approval at the Pre-construction Conference. The Engineer may require proof that the system has been used on previous projects with acceptable results or may require a test section constructed before the beginning of work to demonstrate that it creates an acceptable wedge shape and compaction. Paving shall not begin until the system is approved in writing by the Engineer. The **SafetyEdge℠** may be constructed on each lift of HMA or on the full-specified plan depth on the final lift. The finished shape of the SafetyEdge℠ shall extend for the full depth of the asphalt pavement or for the top 5 inches whichever is less.

The paver shall be capable of operating at forward speeds consistent with uniform and continuous laying of the mixture. Stop and go operations of the paver shall be avoided.

The asphalt paver shall be equipped with a means of preventing the segregation of the coarse aggregate particles from the remainder of the asphalt plant mix when that mix is carried from the paver hopper back to the paver augers. The means and methods used shall be approved by the paver manufacturer and may consist of chain curtains, deflector plates, or other such devices and any combination of these.

The following specific requirements shall apply to the identified asphalt pavers:

(1) Blaw-Knox asphalt pavers shall be equipped with the Blaw-Knox Materials Management Kit (MMK).

(2) Cedarapids asphalt pavers shall be those that were manufactured in 1989 or later.

(3) Caterpillar asphalt pavers shall be equipped with deflector plates as identified in the December 2000 Service Magazine entitled “New Asphalt Deflector Kit {6630, 6631, 6640}”.

Before the start of using the paver for placing plant mix, the Contractor shall submit for approval a full description in writing of the means and methodologies that will be used to prevent asphalt paver segregation. Use of the paver shall not commence before receiving approval from the Engineer.

The Contractor shall supply a Certificate of Compliance that verifies that the approved means and methods used to prevent asphalt paver segregation have been implemented on all pavers used on the project.

Pavers shall be equipped with automatic screed controls with sensors capable of sensing grade from an outside reference line and maintaining the screed at the specified longitudinal grade and transverse slope. The sensor shall be constructed to operate from either or both sides of the paver and shall be capable of working with the following devices:

(1) Ski-type device at least 30 feet in length.

(2) Short ski or short shoe.

(3) At least 5,000 feet of control line and stakes.

The type or types of devices to be furnished shall be as provided in the Contract.

The controls shall be capable of maintaining the screed at the specified transverse slope within plus or minus 0.1 percent.

Manual operation will be permitted for constructing irregularly shaped and minor areas.

If the automatic controls fail or malfunction the equipment may be operated manually for the remainder of the normal working day, provided specified results are obtained.

If the Contractor fails to obtain and maintain the specified surface tolerances, the paving operations shall be suspended until satisfactory corrections, repairs, or equipment replacements are made.

Placement of hot mix asphalt on a waterproofed bridge deck shall be accomplished with equipment that will not damage the membrane or protective covering.

401.11 Tack Coat. When ordered by the Engineer or specified in the Contract, a tack coat shall be applied between pavement courses and paid for per Section 407.

401.12 Surface Conditioning. Irregularities in the existing pavement or base shall be brought to uniform grade and cross section.
Before placing tack coat and beginning overlay work, the surface to be tack coated shall be swept to remove accumulations of loose gravel and debris.

Asphalt plant mix shall be placed only on properly constructed surfaces that are free from substances that would adversely affect the pavement quality.

Contact surfaces of curbing, gutters, manholes, and other structures shall be painted with a uniform coating of asphalt cement before placing asphalt mixture against them.

401.13 Preparation of Asphalt Cement. The asphalt cement shall be heated to the specified temperature without local overheating and shall be continuously supplied to the mixer at a uniform temperature within the specified range.

401.14 Preparation of Aggregates. Heating and drying of the aggregates shall be accomplished without damaging the aggregate.

When hydrated lime is used it shall be added to the aggregate per one of the following methods:

(a) Lime Slurry Added to Aggregate. The hydrated lime shall be added to the aggregate in the form of a slurry and then thoroughly mixed in an approved pugmill. The slurry shall contain a minimum of 70 percent water by weight.

(b) Dry Lime Added to Wet Aggregate. The dry hydrated lime shall be added to the blended aggregate wetted a minimum of 2 percent above the surface saturated dry condition (SSD) as shown on the Form 43, and then thoroughly mixed in an approved pugmill. The Engineer will not require the Contractor to increase the moisture above 5 percent total, although the Contractor may elect to do so if the added water is necessary to meet the minimum Lottman specification (See Table 401-2).

The Contractor may request that the 2 percent above SSD requirement be waived, provided the requirements of CPL 5150 have been met. If the HMA fails to meet the minimum TSR requirements defined in Table 401-2 at any point during production, the Contractor shall immediately be required to add the minimum amount of moisture as defined above.

The lime-aggregate mixture may be fed directly into the hot plant after mixing or it may be stockpiled for not more than 90 days before introduction into the plant for mixing with the asphalt cement. The hydrated lime may be added to different sized aggregates and stockpiled, by adding 75 percent of the lime to the aggregate passing the 4.75 mm (No. 4) sieve and 25 percent to the aggregate retained on the 4.75 mm (No. 4) sieve.

In order to ensure the required lime and water quantities are introduced, lime and water feed for lime operation shall have control systems that change introduction rates in conjunction with changes in plant mix production. The control systems shall be documented in the Contractor's PC Plan.

When a test for aggregate percent moisture falls below the required minimum, the Contractor will receive a warning. When two consecutive tests for aggregate percent

moisture fall below the required minimum, a follow up test will immediately be performed. A failure on the follow up test will result in suspension of work. Production will remain suspended until the source of the problem is identified and corrected. Each time production is suspended, corrective actions shall be proposed in writing by the Contractor and approved in writing by the Engineer before production may resume.

401.15 Mixing. The dried aggregates and asphalt shall be combined in the mixer in the quantities required to meet the job-mix formula.

The materials shall be mixed until the aggregate is completely and uniformly coated, and the asphalt is uniformly distributed throughout the aggregate.

The minimum temperature of the mixture when discharged from the mixer and when delivered for use shall be as shown in Table 401-5:

Table 401-5

HMA MINIMUM DISCHARGE/DELIVERY TEMPERATURES

Asphalt Grade	Minimum Mix Discharge Temperature, °F*	Minimum Delivered Mix Temperature, °F#
PG 58-28	275	235
PG 64-22	290	235
PG 76-28	320	280
PG 64-28	320	280
PG 70-28	320	280
PG 58-34	300	280

Table 401-5 Notes: *The maximum mix discharge temperature shall not exceed the minimum discharge temperature by more than 30 °F.

Delivered mix temperature shall be measured behind the paver screed.

Hot mix asphalt mixture shall be produced at the lowest temperature within the specified temperature range that produces a workable mix and provides for uniform coating of aggregates (95 percent minimum per AASHTO T 195), and that allows the required compaction to be achieved.

Storing or holding of asphalt mixture will be permitted provided the characteristics of the mixture are not altered. If storing or holding of the mixture causes segregation, excessive heat loss, or adversely affects the quality of the finished product, corrective action shall be taken. Unsuitable mixture shall be disposed of at the Contractor's expense.

When placing hot asphalt mixture over bridge decks covered by waterproofing membrane, the minimum temperature of the mixture when rolling operations begin shall be 250 °F. The job-mix formula temperature may be increased up to 30 °F to obtain this temperature.

401.16 Spreading and Finishing. Asphalt pavers shall be used to distribute the mixture to the established grade and required thickness over the entire width or partial width as practicable.

The longitudinal joint in both a new pavement and an overlay pavement layer shall offset the joint in the layer immediately below by 6 inches. In every pavement layer, the longitudinal joints shall not be constructed in the wheel paths. The Contractor shall submit a longitudinal joint and pavement marking plan three days before the Pre-paving Conference. The plan shall show the location and configuration of the proposed longitudinal joints and pavement markings and shall detail the methods to be used to field establish a control line. The Contractor shall use a continuous string line to delineate every longitudinal joint during paving operations. All exposed string line shall be picked up and disposed of at the end of each day's paving. Paving shall not commence until the plan has been approved in writing by the Engineer. The joints in the top layer of pavement shall be located as follows unless otherwise approved in writing by the Engineer:

1. For 2-lane roadways, offset 6 to 12 inches from the center of pavement and from the outside edge of travel lanes.
2. For roadways of more than 2 lanes, offset 6 to 12 inches from lane lines and outside edge of travel lanes.

   Longitudinal joints shall not cross the centerline, lane line, or edge line unless approved by the Engineer.

Where paving operations are on the present traveled roadway, the Contractor shall arrange paving operations so there will be no exposed longitudinal joints between adjacent travel lanes at the end of a day's run. With the approval of the Engineer, the Contractor may leave an exposed longitudinal joint conforming to the following:

1. When the thickness of the pavement course being placed is 1.5 inches or less a vertical exposed longitudinal joint may be constructed.
2. When the thickness of the pavement course being placed is greater than 1.5 inches the joint shall be constructed according to one of the following:

   A. The entire joint shall be tapered 3:1 or flatter. A Taper steeper than 3:1 shall be considered vertical.

   B. The top portion of the longitudinal joint may be vertical. The vertical portion shall be a maximum of 1.5 vertical inches. The remainder of the joint, below the vertical portion, shall be tapered 3:1 or flatter.

   On areas where the use of mechanical spreading and finishing equipment is impracticable, the mixture shall be dumped, spread, raked, screeded, and luted by hand tools to the required compacted thickness and grades.

   Production of the mixture shall be maintained so pavers can be used in echelon to place the wearing course in adjacent lanes.

   The asphalt mixture shall be transported and placed on the roadway without segregation. All segregated areas behind the paver shall be removed immediately upon discovery. The segregated material shall be replaced with specification material before the initial rolling has taken place. If more than 50 square feet of segregated pavement is ordered removed and replaced in any continuous 500 linear feet of paver width laydown, operations shall be discontinued until the source of the segregation has been found and corrected.

   If at any time, the Engineer observes segregated areas of pavement, they will notify the Contractor immediately.

After rolling, segregated areas will be delineated by the Engineer and evaluated as follows:

1. The Engineer will delineate the segregated areas to be evaluated and inform the Contractor of the location and extent of these areas within two calendar days, excluding weekends and holidays, of placement.
2. In each segregated area or group of areas to be evaluated, the Contractor shall take five 10-inch cores at random locations designated by the Engineer. Per CP 75, the Contractor shall also take five 10-inch cores at random locations designated by the Engineer in non-segregated pavement adjacent to the segregated area. These cores shall be within 30 feet of the boundary of the segregated area and in the newly placed pavement. The coring shall be in the presence of the Engineer and the Engineer will take immediate possession of the cores. The Contractor may take additional cores at the Contractor's expense.
3. Gradation of the aggregate of the cores will be determined by CDOT per CP 46.
4. The core aggregate gradations from the segregated area will be compared to the core aggregate gradations of the corresponding non-segregated area.
5. Two key sieves of the core gradations from the segregated area will be compared to the core gradations from the corresponding non-segregated area to determine the difference. If differences for both key sieves exceed the allowable difference specified in the table below, the area is segregated.

Table 401-6
SEGREGATION DETERMINATION

Mix Grading	Key Sieves	Allowable Difference, %
SX	2.36 mm (#8), 4.75 mm (#4)	9
S	2.36 mm (#8), 4.75 mm (#4)	9

6. Segregated areas in the top lift shall be removed and replaced, full lane width, at the Contractor's expense. The Engineer may approve a method equivalent to removal and replacement that results in a non-segregated top lift. Segregated areas, in lifts below the top lift that are smaller than 50 square feet per 100 linear feet of lane width shall be corrected by the Contractor at the Contractor's expense in a manner acceptable to the Engineer. Segregated areas larger than 50 square feet per 100 linear feet of lane width in any lift shall be removed and replaced, full lane width, by the Contractor at the Contractor's expense.
   If the area is determined to be segregated, the coring shall be at the expense of the Contractor. If the area is determined to be non-segregated, the Engineer will reimburse the Contractor $2,000 for obtaining the10 cores.

   The Engineer will perform a systematic segregation check per CP 58 as early in the project as is feasible to determine if temperature segregation problems exist. Temperature segregation will be of concern on the project if, across the width of the mat, temperatures vary by 25 °F or more. Densities will not need to be taken in the systematic segregation check. The Engineer will discuss the temperature findings of the systematic segregation check with the Contractor.

The Engineer may evaluate the HMA for low density due to temperature segregation whenever industry best practices, as detailed on Form 1346, are not being followed or the Engineer suspects temperature segregation is occurring. The Engineer will first meet with the Contractor to discuss the paving practices that are triggering the temperature investigation. Areas across the mat, excluding the outside 1 foot of both edges of the mat, that are more than 25 °F cooler than other material across the width may be marked for density testing. Material for temperature comparison will be evaluated in 3-foot intervals behind the paver across the width of the mat. The material shall be marked and tested per CP 58. If four or more areas within a lot of 500 tons have densities of less than 93 percent of the material's maximum specific gravity for SMA mixes or less than 92 percent of the material's maximum specific gravity for all other HMA mixes, a 5 percent price disincentive will be applied to the 500-ton lot. The 500-ton count begins when the Engineer starts looking for cold areas, not when the first cold area is detected. This price disincentive will be in addition to those described in Sections 105 and 106. Only one area per delivered truck will be counted toward the number of low-density areas. Temperature segregation checks will be performed only in areas where continuous paving is possible.

401.17 Compaction. The hot mix asphalt shall be compacted by rolling. Both steel wheel and pneumatic tire rollers will be required. The number, weight, and type of rollers furnished shall be sufficient to obtain the required density while the mixture is in a workable condition. Compaction shall begin immediately after the mixture is placed and be continuous until the required density is obtained. When the mixture contains unmodified asphalt cement (PG 58-28 or PG 64-22) or modified (PG 58-34), and the surface temperature falls below 185 °F, further compaction effort shall not be applied unless approved, provided the Contractor can demonstrate that there is no damage to the finished mat. If the mixture contains modified asphalt cement (PG 76-28, PG 70-28 or PG 64-28) and the surface temperature falls below 230 °F, further compaction effort shall not be applied unless approved, provided the Contractor can demonstrate that there is no damage to the finished mat.

Warm Mix Asphalt compaction requirements shall conform to CP 59.

All roller marks shall be removed with the finish rolling. Use of vibratory rollers with the vibrator on will not be permitted during surface course final rolling and will not be permitted on any rolling on bridge decks covered with waterproofing membrane.

SMA shall be compacted to a density of 93 to 97 percent of the daily theoretical maximum specific gravity, determined according to CP 51. All other HMA shall be compacted to a density of 92 to 96 percent of the daily theoretical maximum specific gravity, determined according to CP 51. If more than one theoretical maximum specific gravity test is taken in a day, the average of the theoretical maximum specific gravity results will be used to determine the percent compaction. Field density determinations will be made per CP 44 or 81.

The longitudinal joints shall be compacted to a target density of 92 percent of the theoretical maximum specific gravity. The tolerance shall be plus or minus 4 percent. The theoretical maximum specific gravity used to determine the joint density will be the average of the daily theoretical maximum specific gravities for the material that was placed on either side of the joint. Density (percent relative compaction) will be determined per CP 44.

The Contractor shall obtain one 6-inch diameter core at a random location within each longitudinal joint sampling section for determination of the joint density. The Contractor shall mark and drill the cores at the location directed by the Engineer and in the presence of the Engineer. The Engineer will take possession of the cores for testing. The Contractor may take additional cores at his own expense. Coring locations shall be centered on the visible line where the joint between the two adjacent lifts abuts the surface. The center of all joint cores shall be within 1 inch of this visible joint line. Core holes shall be repaired by the Contractor using materials and methods approved by the Engineer. PC and OA joint coring shall be completed within five calendar days of joint construction.

Longitudinal joint coring applies to all pavement layers. When constructing joints in an echelon paving process, the joints shall be clearly marked to ensure consistent coring location. In small areas, such as intersections, where the Engineer prescribes paving and phasing methods, the Engineer may temporarily waive the requirement for joint density testing.

Incentive or disincentive payment determined for joint density per subsection 105.05 will apply to the HMA on each side of the joint. If a layer of pavement has joints constructed on both sides, incentive or disincentive payment for each of those joints will apply to one half of the pavement between the joints.

Along forms, curbs, headers, walls, and all other places not accessible to the rollers, the mixture shall be thoroughly compacted with mechanical tampers.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective, shall be immediately removed and replaced with fresh hot mixture, and compacted to conform to the surrounding area.

The Contractor shall construct a compaction pavement test section (CTS) for each job mix where 2,000 or more tons are required for the project. The CTS will be used to evaluate the number of rollers and the most effective combination of rollers and rolling patterns for achieving the specified densities. Factors to be considered include, but are not limited to, the following:

(1) Number, size, and type of rollers.

(2) Amplitude, frequency, size and speed of vibratory rollers.

(3) Size, speed, and tire pressure of rubber tire rollers.

(4) Temperature of mixture being compacted.

(5) Roller patterns.

The CTS shall be constructed according to the following procedures:

The CTS shall be constructed to provide the nominal layer thickness specified. The first 500 tons of hot mix asphalt on the project location shall constitute the CTS. The production and placement rates of the CTS shall closely approximate the anticipated production and placement rates for the remainder of the Contract.

Compaction of the CTS shall commence immediately after the hot mix asphalt has been spread and shall be continuous and uniform over the entire CTS. For the CTS, compaction shall continue until no discernible increase in density is obtained by additional compactive efforts. All compaction shall be completed before the surface temperature of the mixture drops below 185 °F.

Approved types of rollers shall be used to achieve the specified density. The Contractor shall determine what methods and procedures are to be used for the compaction operation. The compaction methods and procedures shall be used uniformly over the entire last 200 tons. The Contractor shall record the following information and a copy of this data shall be furnished to the Engineer.

(1) Type, size, amplitude, frequency, and speed of roller.

(2) Tire pressure for rubber tire rollers, and whether the pass for vibratory rollers is vibratory or static.

(3) Surface temperature of mixture behind the laydown machine and subsequent temperatures and densities after each roller pass.

(4) Sequence and distance from laydown machine for each roller, and number of passes of each roller to obtain specified density.

Two sets of random cores shall be taken within the last 200 tons of the CTS. Each set shall consist of seven random cores. The Engineer will determine the coring locations using a stratified random sampling process. The locations of these cores will be such that one set can serve as a duplicate of the other. One set of these cores shall be immediately submitted to the Engineer. This set will be used for determining acceptance of the CTS and determining density correction factors for nuclear density equipment. Densities of the random samples will be determined by cores according to CP 44. Density correction factors for nuclear density equipment will be determined according to CP 81. Coring shall be performed under CDOT observation. Coring will not be measured and paid for separately but shall be included in the work. For SMA, a CTS is not used. The Contractor shall follow the requirements for the demonstration control strip per the Revision of Section 403, Stone Matrix Asphalt Pavement.

The CTS meets requirements if the Quality Level of the random samples is greater than or equal to 75. The Quality Level will be determined according to CP 71. Once constructed and accepted, the CTS shall remain in place and become part of the hot mix asphalt on the project.

When the Quality level is less than 75 the Contractor shall construct an additional test section, utilizing different rollers, or roller positions, or roller patterns as required. A written proposal detailing the changes in methods and procedures that will be used to obtain density is to be submitted to the Engineer for review before constructing the additional test section.

If the Quality Level of a CTS is less than 75 and greater than or equal to 44, the Engineer may accept the material at a reduced price per Section 105.

If the Quality Level of a CTS is less than 44, the Engineer may:

(1) Require complete removal and replacement with specification material at the Contractor's expense.

(2) Where the finished product is found to be capable of performing the intended purpose and the value of the finished product is not affected, as determined by the Engineer, permit the Contractor to leave the material in place with a pay factor, but not more than 75 percent of the bid price.

Each CTS shall be 500 tons. If in-place densities of the CTS, as determined by nuclear density equipment before determining density of the cores, meet the CTS density requirements, the Contractor may begin production paving and continue to place hot mix asphalt pavement under the following conditions:

(1) The period during which the Contractor continues to pave without test results from cores shall not exceed one workday.

(2) Construction proceeds at the Contractor's risk. If correlation with the cores reveals that the densities do not meet the CTS requirements, the hot mix asphalt pavement placed subsequently will be subject to price reduction or removal and replacement.

After production paving work has begun, a new Roller Pattern shall be demonstrated when a change in the compaction process is implemented.

All additional costs associated with construction of the CTS shall be at the Contractor's expense. The hot mix asphalt placed in the CTS will be paid for per subsection 401.22, at the contract price for the hot mix asphalt.

401.18 Joints. Placing of the hot mix asphalt shall be continuous, and rollers shall not pass over the unprotected end of a freshly laid mixture. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. A coat of asphalt cement shall be applied to contact surfaces of all joints just before additional mixture is placed against the previously compacted material. Location and configuration of longitudinal joints shall be per subsection 401.16.

401.19 Pavement Samples. The Engineer may take samples of the compacted pavement at random locations on the project for testing. Where samples have been taken, new material shall be placed and compacted by the Contractor to conform with the surrounding area.

401.20 Surface Smoothness. The roadway surface smoothness shall be tested per subsection 105.07.

METHOD OF MEASUREMENT

401.21 Hot mix asphalt and asphalt cement will be measured by the ton. Batch weights will not be permitted as a method of measurement. The tonnage shall be the weight used in the accepted pavement. Deduction will not be made for the weight of asphalt cement in the mixture.

BASIS OF PAYMENT

401.22 All work performed and measured as described above will be paid for as provided in the respective sections for each type specified.

If there is no pay item for asphalt cement of the type specified it will not be measured and paid for separately but shall be included in the work.

Water used in the mixing plant, per subsection 401.14, to bring the lime-aggregate mixture to approved moisture content will not be measured and paid for separately but shall be included in the work.

Facilities for testing hot asphalt plant mix at the site of the commercial plant will not be paid for separately but shall be included in the work.

When asphalt cement is a separate pay item, the amount of asphalt cement contained in reclaimed asphalt pavement (RAP) material will not be measured or paid for but shall be included in the work.

Coring for in-place density, coring for longitudinal joint density, core hole repair, and associated expenses will not be paid for separately but shall be included in the work. Traffic control for this work will be paid for per the contract.

All costs of the temporary hot mix asphalt layer required according to subsection 401.07, maintenance and removal of the temporary pavement layer, temporary pavement marking, and traffic control will not be paid for separately but shall be included in the work.

All costs associated with the construction of the SafetyEdge℠ specified in subsection 401.10 will not be paid for separately but shall be included in the work.

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SECTION 403
HOT MIX ASPHALT

DESCRIPTION

403.01 This work consists of constructing one or more courses of hot mix asphalt (HMA) on a prepared base per these specifications, and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established.

The asphalt pavement shall be composed of a mixture of aggregate, filler if required, and asphalt cement.

Hot Mix Asphalt (Patching) consists of those quantities required for the replacement of unstable corrugated areas in the existing pavement, pipe trenches, areas removed for curb and gutter forms, areas between the curb and gutter or sidewalk and the existing paved parking lots, and areas designated on the plans. These quantities will be restricted to small areas that require hand placement methods and where conventional paving equipment cannot be utilized.

MATERIALS

403.02 The materials shall conform to the requirements of subsections 401.02 through 401.06.

CONSTRUCTION REQUIREMENTS

403.03 The construction requirements shall be as prescribed in subsections 401.07 through 401.20.

Areas to be patched shall be excavated and squared to a neat line, leaving the sides of the excavation vertical. Before placement of the patch, the exposed sides of the existing pavement shall be thoroughly coated with emulsified asphalt (slow-setting). Hot mix asphalt shall then be placed and compacted in succeeding layers not to exceed 3 inches in depth.

METHOD OF MEASUREMENT

403.04 Hot mix asphalt will be measured as prescribed in subsection 401.21.

BASIS OF PAYMENT

403.05 The accepted quantities of hot mix asphalt will be paid for per subsection 401.22, at the contract unit price per ton for the asphalt mixture.

Payment will be made under:

Pay Item	Pay Unit
Hot Mix Asphalt (Grading__)	Ton
Hot Mix Asphalt (Grading__) (Asphalt)	Ton
Hot Mix Asphalt (Patching) (Asphalt)	Ton

Aggregate, asphalt cement, asphalt recycling agent, additives, hydrated lime, and all other work necessary to complete each hot mix asphalt item will not be paid for separately but shall be included in the unit price bid.

Excavation, preparation, and tack coat of areas to be patched will not be measured and paid for separately but shall be included in the work.

SECTION 405
HEATING AND SCARIFYING TREATMENT

DESCRIPTION

405.01 This work consists of recycling the top portion of the existing asphalt pavement as shown in the Contract, by cleaning, heating, scarifying, redistributing, re-leveling, compacting, and rejuvenating the existing asphaltic material.

MATERIALS

405.02 Asphalt rejuvenating agent shall meet the requirements of subsection 702.02(f).

CONSTRUCTION REQUIREMENTS

405.03 Weather limitations shall be as provided in subsection 401.07. Before commencing heating and scarifying operations, the pavement shall be cleaned of all loose material. Power brooms shall be supplemented by hand brooming and use of other tools as required to bring the surface to a clean, suitable condition free of deleterious material.

Equipment used to heat and scarify the asphalt surface shall meet the following requirements:

(1) Capable of uniformly applying heat under totally insulated, enclosed hoods to produce radiant heat.

(2) Self-propelled and capable of scarifying to the depth specified.

(3) Capable of covering a minimum of 750 square yards per hour while heating the existing surface to the extent that it will be remixed by the scarifiers to a depth not less than specified.

The heating operation shall extend at least 4 inches beyond the width of scarifying on both sides. When a pass is made adjacent to a previously placed mat, the longitudinal seam shall extend at least 2 inches into the previously placed mat. The temperature of the scarified material shall be between 200 and 300 ºF when measured immediately behind the scarifier. The scarified material shall be distributed and leveled by a paving machine. The paving machine shall be capable of screeding the full width of the scarified material to produce a uniform cross section as shown in the Contract.

While the scarified material is still hot and before it is placed by the paving machine, an application of asphalt rejuvenating agent shall be applied as specified.

The asphalt surface shall be compacted immediately after it has been distributed and leveled, and while it is still workable. Two rollers shall be used to compact the scarified material. A steel wheel roller shall be used first to provide breakdown rolling, followed by a pneumatic tire roller with a minimum weight of 12 tons, to complete compaction to 92 to 96 percent of maximum theoretical density. When the mixture surface temperature falls below 165 ºF, no further compaction effort shall be done unless approved. A minimum of 24 hours shall elapse before an asphalt pavement overlay is applied to the scarified pavement.

The weight per cubic foot of the existing asphalt surface shall be determined per AASHTO T 166. Scarification depth will be acceptable when the moving average of a minimum of three consecutive random tests per hour indicates that the required amount per square foot, based on the weight per cubic foot of the existing asphalt surface, has been scarified. Testing shall be performed by the Contractor in lots of three per hour, or as often as necessary to maintain process control.

The longitudinal surface smoothness of the roadway before and after heating and scarifying shall be tested per subsection 105.07(f).

METHOD OF MEASUREMENT

405.04 Heating and scarifying treatment will be measured by the square yard of work completed and accepted.

BASIS OF PAYMENT

405.05 The accepted quantities of heating and scarifying treatment will be paid at the contract unit price per square yard for heating and scarifying treatment, and shall include cleaning, heating, scarifying, redistributing, re-leveling, and compacting the existing asphalt surfacing.

Payment will be made under:

Pay Item	Pay Unit
Heating and Scarifying Treatment	Square Yard

Asphalt rejuvenating agent will be measured and paid for per Section 411.

SECTION 406
COLD ASPHALT PAVEMENT (RECYCLE)

DESCRIPTION

406.01 This work consists of pulverizing the existing asphalt surfacing to the depth shown on the plans, mixing a recycling agent and water, if required, with the pulverized material, then spreading and compacting the mixed material.

MATERIALS

406.02 The recycling agent shall be either a high float emulsified asphalt (polymerized) or emulsified recycling agent meeting the requirements of subsection 702.02(e).

The pulverized material shall meet the following gradation requirements:

Table 406-1

COLD ASPHALT PAVEMENT (RECYCLE)

PULVERIZED MATERIAL GRADATION REQUIREMENTS

Sieve Size	Percent Passing
31.5 mm (1 1/4 inch)	100
25.0 mm (1 inch)	90-100

The sealing emulsion shall be high float emulsion (diluted), emulsified asphalt (SS), or approved equal.

CONSTRUCTION REQUIREMENTS

406.03 Weather Limitations. Daily recycling operations shall not begin until the atmospheric temperature is 55 ºF and rising. Recycling operations shall be discontinued when the temperature is 60 ºF and falling. Recycling operations shall not be performed when the weather is foggy or rainy, or when weather conditions are such that the proper mixing, spreading, compacting, and curing of the recycled material cannot be accomplished. Cold recycled pavement damaged by precipitation shall be reprocessed or repaired by methods approved by the Engineer, at the Contractor's expense.

The construction of cold recycled pavement will not be allowed from September 16 through May 14 unless otherwise approved. The Contractor's Progress Schedule shall show the methods to be used to comply with this requirement.

406.04 Milling. The existing asphalt surfacing shall be cold recycled in a manner that does not disturb the underlying material in the existing roadway.

Adjacent recycling passes shall overlap at the longitudinal joint a minimum of 4 inches.

The beginning of each day's recycling operation shall overlap the end of the preceding recycling operation a minimum of 100 feet unless otherwise directed.

Any fillet of fine, pulverized material that forms adjacent to a vertical face shall be removed before spreading the mixed material, except that such fillet adjacent to existing pavement that will be removed by a subsequent overlapping milling operation need not be removed. Vertical cuts in the roadway shall not be left overnight.

406.05 Mixing. When commencing recycling operations, the recycling agent shall be applied to the pulverized material at the initial design rate determined by the Materials Laboratory, based on samples obtained by the Department before construction. The exact application rate of the recycling agent will be determined and may be varied as required by existing pavement conditions. An allowable tolerance of plus or minus 0.2 percent of the initial design rate or directed rate of application shall be maintained at all times.

A representative of the recycling agent supplier shall be present on the project during recycling operations until an acceptable production sequence is established as determined by the Engineer.

The Contractor may add water to the pulverized material to facilitate uniform mixing with the recycling agent. Water may be added before or concurrently with the recycling agent, provided that this water does not adversely affect the recycling agent.

406.06 Spreading. Recycling and placing recycled material shall be at a rate sufficient to provide continuous operation of the paving machine. If paving operations result in being excessively behind or in excessive stopping of the paving machine, as determined by the Engineer, recycling operations shall be suspended. Recycling may resume when the Contractor can synchronize the rate of recycling with the capacity of the paving machine.

If segregation occurs behind the paver, the Contractor shall make changes in equipment, operations, or both to eliminate the segregation.

406.07 Compacting and Finishing. After the recycled material has been spread, traffic, including Contractor's equipment, shall not be allowed on the recycled material until it starts its initial break as determined by the Engineer. However, if precipitation is imminent, compaction may proceed to seal the surface from additional moisture.

Initial rolling shall be performed with one or more pneumatic tire rollers and be continued until no displacement is observed. Final rolling to eliminate pneumatic tire marks and achieve the required density shall be done by steel wheel rollers either in static or vibratory mode. The use of vibratory rollers shall be approved by the Engineer. If rollers are used in the vibratory mode, vibration shall be at low amplitudes to prevent transverse cracks.

The recycled material shall be compacted to a minimum of 100 percent of the density of a laboratory specimen compacted per CP 53. If the area tested fails to meet the required density, the area shall be reworked until it attains 100 percent compaction. The frequency of density testing for project acceptance will be one per 5,000 square yards. The Engineer will perform one CP 53 for calculation of the percent relative compaction with each field density taken.

Rollers shall not be started or stopped on uncompacted recycled material. Rolling shall be accomplished so that starting and stopping will be on previously compacted cold recycled pavement or existing pavement.

Any type of rolling resulting in cracking, movement, or other types of pavement distress shall be discontinued until the problem is resolved.

After the recycled material has been compacted, traffic, including the Contractor's equipment, shall not be permitted on the cold recycled pavement for at least two hours, unless otherwise approved.

Before placing the sealing emulsion or hot mix asphalt overlay, the cold recycled pavement shall be allowed to cure until the free moisture is reduced to 1 percent free moisture or less, by total weight of mix. Free moisture will be measured according to CP 57. After the free moisture content of the cold recycled pavement has reached the acceptable level, the hot mix asphalt overlay or sealing emulsion, if required, shall be placed. However, unless otherwise approved by the Engineer, the cold recycled pavement shall be covered with a minimum thickness of 2 inches of hot mix asphalt within10 calendar days after it is laid and compacted. The sealing emulsion, if required, shall be applied to the surface at an approximate rate of 0.025 to 0.10 gallons per square yard. The sealing emulsion shall be applied when the Engineer determines that it is necessary to prevent raveling (progressive separation of aggregate particles).

Damage caused by the Contractor to the cold recycled pavement shall be repaired at Contractor's expense, as directed, before placing any hot asphalt surfacing. Soft areas that are not caused by the Contractor or weather shall also be repaired before placing the hot mix asphalt.

406.08 Recycling Train. The Contractor shall furnish a self-propelled machine capable of pulverizing the existing asphalt surfacing to the depth shown on the plans, in one pass. The machine shall have a minimum rotor cutting width of 12 feet. The rotor cutting width selected for the project shall allow for the longitudinal joint to be offset from the longitudinal joint of the layer placed above by at least 6 inches. The longitudinal joint shall not fall in the wheel path. The machine shall have standard automatic depth controls and maintain a constant cutting depth. The machine shall also have screening and crushing capabilities to reduce or remove oversize particles before mixing with recycling agent. Oversize particles shall be reduced to size by crushing.

The machine shall perform continuous weight measurement of the pulverized material interlocked with the recycling agent metering device so the required recycling agent content will be maintained. Positive means shall be provided for calibrating the weight measurement device and the recycling agent metering device.

A positive displacement pump, capable of accurately metering the required quantity of recycling agent at rates as low as 4 gallons per minute, shall be used to apply the recycling agent. The interlock system shall allow addition of the recycling agent only when pulverized material is present in the mixing chamber. Each mixing machine shall be equipped with a meter capable of registering the rate of flow and the total amount of recycling agent introduced into the mixed material.

The recycling agent shall be applied through a separate mixing machine capable of mixing the pulverized material and the recycling agent to a homogeneous mixture and placing the mixture in a windrow. The mixture shall be placed in a windrow in a manner that prevents segregation.

406.09 Paver. The recycled material shall be placed with a self-propelled asphalt paver meeting the requirements of subsection 401.10, except that the screed shall not be heated. The mixed material shall be spread in one continuous pass, without segregation, to the lines and grades established on the plans.

When a pick-up machine is used to feed the windrow into the paver hopper, the pick-up machine shall be capable of picking up the entire windrow to the underlying materials.

406.10 Compactors. Rollers shall be steel wheel, pneumatic tire, vibratory or combination of these types. The number and weight of rollers shall be sufficient to obtain the required compaction while the recycled material is in a workable condition, except that each pneumatic tire roller shall be 30 tons' minimum weight.

406.11 Smoothness. The longitudinal surface smoothness of the roadway before and after cold recycling shall be tested by the Contractor per subsection 105.07.

METHOD OF MEASUREMENT

406.12 In-place cold recycled pavement will be measured by the square yard of paved surface actually recycled, complete in place and accepted.

Repair of cold recycled pavement will be measured by the square yard of paved surface repaired and accepted.

BASIS OF PAYMENT

406.13 The accepted quantity of in-place cold recycled pavement will be paid for at the contract unit price per square yard.

Payment will be made under:

Pay Item	Pay Unit
Cold Asphalt Pavement (Recycle)	Square Yard
Repair of Cold Asphalt Pavement (Recycle)	Square Yard

Asphalt materials will be measured and paid for per Section 411.

Water will not be measured and paid for separately but shall be included in the work.

Repair of cold recycled pavement damaged by the Contractor or by weather will not be measured and paid for separately but shall be included in the work.

Overlaps of preceding recycling operations will not be measured and paid for separately but shall be included in the work.

SECTION 407
PRIME COAT, TACK COAT, AND REJUVENATING AGENT

DESCRIPTION

407.01 This work consists of preparing and treating an existing surface with asphalt material, and blotter material if required, per these specifications and in conformity with the lines shown on the plans or established.

MATERIALS

407.02 Asphalt Material. The type and grade of asphalt material for prime and tack coating will be specified in the Contract.

The asphalt material for all coatings shall meet the applicable requirements of Section 702. The asphalt material for prime and tack coating may be conditionally accepted at the source. The rejuvenating agent shall be accepted before loading into the distributor.

407.03 Blotter Material. Blotter material for prime coating shall consist of aggregate base course conforming to the requirements specified for base course aggregate on the project.

Blotter material for rejuvenating agent shall consist of dry, gritty sand conforming to the fine aggregate gradation of Table 703-2, or as approved.

Blotter material may be accepted in the stockpile at the source or at the roadway before placement.

CONSTRUCTION REQUIREMENTS

407.04 Weather Limitations. Prime coat and tack coat shall not be applied under the following conditions:

(1) When the surface is wet.

(2) When weather conditions would prevent the proper construction of the prime or tack coat.

407.05 Equipment. The Contractor shall provide equipment for heating and uniformly applying asphalt material and blotter material.

The distributor and equipment shall be capable of uniformly distributing asphalt material at even temperature and uniform pressure on variable widths of surface up to 15 feet at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard. The allowable variation from any specified rate shall not exceed plus or minus 0.02 gallon per square yard. Distributor equipment shall include a tachometer, pressure gauges, accurate volume measuring devices or a calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically.

The distributor for rejuvenating agent shall also be equipped with the following:

(1) Heating facilities with controls to reach a temperature of 130 °F.

(2) Circulating system to maintain proper mixture of the rejuvenating agent.

407.06 Preparation of Surface. Preparation of the surface to be treated shall include all work necessary to provide a smooth, dry, uniform surface. The work shall include patching, brooming, shaping to required grade and section, compaction, and removal of unstable corrugated areas.

The edges of existing pavements that are to be adjacent to new pavement shall be cleaned to permit the adhesion of asphalt materials.

407.07 Application of Asphalt Material. Asphalt material shall be applied by a pressure distributor in a uniform and continuous spread. When traffic is maintained, not more than ½ of the width of the section shall be treated in one application, or sufficient width shall be left to adequately handle traffic. Care shall be taken so the application of asphalt material at the junctions of spreads is not in excess of the specified quantity. Excess asphalt material shall be removed or distributed as directed.

Skipped areas or deficiencies shall be corrected. Asphalt material shall not be placed on any surface where traffic will travel on the freshly applied material.

The rate of application, temperatures, and areas to be treated shall be approved before application of the coating.

407.08 Application of Blotter Material. If, after the application of the prime coat or rejuvenating agent the asphalt material fails to penetrate and the roadway must be used by traffic, blotter material shall be spread in the quantity required to absorb excess asphalt material.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

407.09 Asphalt material will be measured and paid for per Section 411.

Blotter material will not be measured and paid for separately but shall be included in the work.

Payment for patching will be made at the contract unit price for the various items used for patching.

SECTION 408
JOINT AND CRACK SEALANT

DESCRIPTION

408.01 This work consists of furnishing and placing an approved hot poured joint and crack sealant in properly prepared cracks in asphalt pavements. Cracks with a width greater than 1/8 inch and less than 1 inch are to be filled with this material.

MATERIALS

408.02 Materials for hot poured joint and crack sealant shall meet the requirements of subsection 702.04.

Using a mixture of different manufacturers' brands or different types of sealant is prohibited.

CONSTRUCTION REQUIREMENTS

408.03 Immediately before applying hot poured joint and crack sealant, the cracks shall be cleaned of loose and foreign matter to a depth approximately twice the crack width. Cleaning shall be performed using a hot compressed air lance. This lance shall be used to dry and warm the adjacent asphalt immediately before sealing. Direct flame dryers shall not be used.

These Cracks shall be filled with hot poured joint and crack sealant flush with the pavement surface. Immediately following the filling of the crack, excess sealant shall be leveled off at the wearing surface by squeegee, a shoe attached to the applicator wand, or other suitable means approved by the Engineer. The squeegeed material shall be centered on the cracks and shall not exceed 3 inches in width or 1/16 inch in depth.

The sealant material shall be heated and applied according to the manufacturer's recommendations. The equipment for heating the material shall be an indirect heating type double boiler using oil or other heat transfer medium and shall be capable of constant agitation. The heating equipment shall be capable of controlling the sealant material temperature within the manufacturer's recommended temperature range and shall be equipped with a calibrated thermometer capable of plus or minus 5 °F accuracy from 200 to 600 °F. This thermometer shall be located so the Engineer can safely check the temperature of the sealant material. Overheating of the sealant material will not be permitted.

The face of the crack shall be surface dry, and the air and pavement temperatures shall both be at least 40 °F and rising at the time of sealant application.

Sealant material picked up or pulled out after being placed shall be replaced at the Contractor's expense. The Contractor shall have blotter material available on the project in the event it is required to prevent tracking or pulling. If required, blotter material shall be approved by the Engineer and placed at the Contractor's expense.

METHOD OF MEASUREMENT

408.04 Hot poured joint and crack sealant will be measured by the ton of material used. The Engineer may require the weighing of equipment for determination of actual quantities of material used.

BASIS OF PAYMENT

408.05 The accepted quantities will be paid for at the contract unit price per ton.

Payment will be made under:

Pay Item	Pay Unit
Hot Poured Joint and Crack Sealant	Ton

All materials, equipment, and costs incidental to the preparation of the surface before application of the hot poured joint and crack sealant will not be paid for separately but shall be included in the work.

SECTION 409
CHIP SEAL

DESCRIPTION

409.01 This work consists of furnishing and applying asphalt emulsion and cover coat material on an existing surface, per these specifications and in conformity with the lines shown on the plans or established. When rejuvenating agent or emulsified asphalt is used as a fog seal, cover coat material will not be required.

MATERIALS

409.02 Asphalt Emulsion. Emulsified asphalt shall be polymerized or latex modified and shall be rapid set or medium set conforming to the requirements of subsection 702.02(b).

Rejuvenating agent shall conform to the requirements of subsection 702.02(f).

409.03 Cover Coat Material. Cover coat material shall meet the requirements of subsection 703.05 for the type specified. The material will be accepted at the spreader.

CONSTRUCTION REQUIREMENTS

409.04 Weather Limitations. Asphalt emulsion shall not be applied on a damp surface, when either the air or pavement surface temperature is below 70 °F, or when weather conditions would prevent the proper construction of the chip seal.

409.05 Equipment. The following equipment or its equivalent shall be used:

(1) Asphalt distributor and equipment shall be capable of uniformly distributing asphalt emulsion at even temperature and uniform pressure on variable widths of surface up to 15 feet at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard. The allowable variation from any specified rate shall not exceed plus or minus 0.02 gallon per square yard. The distributor's spreading capabilities shall be computer controlled or it shall be calibrated to conform to the distributor manufacturer's procedure before applying the emulsified asphalt. Distributor equipment shall include a tachometer, pressure gauges, accurate volume measuring devices or a calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump, and full circulation spray bars adjustable laterally and vertically. Distributors shall be equipped with an automatic heater capable of maintaining the asphalt emulsion at the manufacturer's recommended application temperature or at 140 °F, whichever is higher.

(2) A rotary power broom.

(3) A minimum of two pneumatic tire rollers that weigh at least 10 tons each.

(4) One self-propelled aggregate spreader of approved design supported by at least four wheels equipped with pneumatic tires on two axles. The aggregate spreader shall be capable of applying the larger cover coat material to the surface ahead of the smaller cover coat material and shall have positive controls, so the required quantity of material is deposited uniformly over the full width of the asphalt emulsion. Other types of aggregate spreaders may be used provided they accomplish equivalent results and are approved.

409.06 Preparation of Surface. The entire surface that is to receive a chip seal shall be cleaned of loose sand, dust, rock, mud, and all other debris that could prevent proper adhesion of the asphalt coating. The cleaning shall be accomplished by power broom, scraping, blading, or other approved measures. Chip sealing operations shall not be started until the surface is approved.

409.07 Applying Asphalt Emulsion. Asphalt emulsion shall be applied by a pressure distributor in a uniform, continuous spread and within the temperature range specified. The distributor's spreading capability shall be computer controlled or calibrated to conform to the distributor manufacturer's procedure before applying the emulsified asphalt. If streaking occurs, the distributor operation shall be stopped immediately until the cause is determined and corrected. Streaking is alternating, narrow, longitudinal areas of excessive and then insufficient quantities of asphalt emulsion. The quantity of asphalt emulsion per square yard may vary from the rate shown in the Contract, as directed. A strip of building paper, at least 3 feet in width and with a length equal to that of the spray bar of the distributor plus 1 foot shall be used at the beginning of each spread. If the distributor does not have a positive cut-off, the paper shall be used at the end of each spread. The paper shall be removed and disposed of in a satisfactory manner. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Skipped areas and deficiencies shall be corrected. Junctions of spreads shall be carefully made to assure a smooth riding surface.

The length of spread of asphalt emulsion shall not be in excess of the area that trucks loaded with cover coat material can immediately cover.

The spread of asphalt emulsion shall not be more than 6 inches wider than the width covered by the cover coat material from the spreading device. Under no circumstances shall operations proceed so asphalt emulsion will be allowed to chill, set up, dry, or otherwise impair retention of the cover coat.

The distributor shall be parked so that asphalt emulsion will not drip on the surface of the traveled way.

409.08 Application of Cover Coat Material. Immediately following the application of the asphalt emulsion, cover coat material shall be spread in quantities as designated. The spreading rate may vary from the rate shown in the Contract when approved. Spreading shall be accomplished so the tires of the trucks or aggregate spreader do not contact the uncovered and newly applied asphalt emulsion.

The cover coat material shall be moistened with a sufficient amount of water to reduce the dust coating of the aggregate before spreading. The cover coat material shall not contain free moisture as evidenced by drain down in the delivery truck bed.

Immediately after the cover coat material is spread, deficient areas shall be covered with additional material. Rolling shall begin immediately behind the spreader and shall continue until three complete coverages are obtained. Rolling shall be completed the same day the asphalt emulsion and cover coat materials are applied.

The completed roadway surface shall be lightly broomed the following morning to remove any excess material, without removing any embedded material. The Contractor shall conduct additional brooming if so directed.

A fog seal shall be applied to the surface of the completed chip seal at the rate of 0.11 plus or minus 0.04 gallon per square yard of diluted emulsion when directed. The fog seal shall have a 3:2 emulsion to water dilution rate. The application rate and the dilution rate may be changed by the Engineer.

METHOD OF MEASUREMENT

409.09 Chip seal will be measured by the number of tons, cubic yards, or square yards of the designated type of cover coat aggregate.

BASIS OF PAYMENT

409.10 The accepted quantities of chip seal will be paid for at the contract price per ton, cubic yard, or square yard for cover coat material.

Payment will be made under:

Pay Item	Pay Unit
Cover Coat Material (Type___)	Ton
Cover Coat Material (Type___) (Lightweight)	Cubic Yard
Cover Coat Material (Type __)	Square Yard

Asphalt emulsion, including the asphalt emulsion used for fog seal, will be measured and paid for per Section 411.

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SECTION 411
ASPHALT MATERIALS

DESCRIPTION

411.01 This work consists of furnishing asphalt materials of all types and the application of these materials per these specifications and details shown on the plans.

MATERIALS

411.02 All asphalt materials shall conform to the requirements of Section 702.

The type and grade of asphalt material will be specified in the Contract. The grade may be changed one step by the Engineer at no change in unit price except as provided for under subsection 104.02.

Emulsion used for seal coat will be identified as rapid setting or medium setting emulsion and conform to the requirements of subsection 702.02.

CONSTRUCTION REQUIREMENTS

411.03 Asphalt materials shall be fortified when required by the Contract with an additive of an approved type. Additive shall be uniformly blended with asphalt materials at the refinery, or through an approved in-line blender as specified in the Contract.

Asphaltic application methods that result in the discoloration of concrete structures, concrete curbs, and concrete gutters will not be permitted. Coatings shall be applied so as to cause the least inconvenience to traffic and to permit one-way traffic. Traffic will be permitted to travel on fresh asphalt material when it can be accomplished without pickup or tracking of the asphalt material.

Asphaltic materials used as fuel or lubricant shall be stored separately.

Emulsified asphalt for tack coat shall be diluted before use as shown in the Contract or as directed.

METHOD OF MEASUREMENT

411.04 Asphalt cement will be measured by the ton by one of the following methods as determined by the Engineer:

(1) The pay quantity of asphalt cement will be determined by multiplying the total accepted tons of paving mix by the weighted average of all asphalt content percentages obtained from the field acceptance tests for that item, or

(2) The pay quantity of asphalt cement will be determined from the invoices for the asphalt cement delivered to the job corrected by tank stabs.

Emulsified asphalt and liquid asphaltic materials will be measured by the gallon.

The pay quantity for emulsified asphalt shall be the number of gallons before dilution with water.

Concentrated asphalt rejuvenating agent will be measured by the gallon before any water is added.

Emulsified asphalt used for seal coat will be measured by the actual number of tons placed and accepted. The pay quantity of emulsified asphalt will be determined from the invoices of emulsified asphalt delivered to the project, corrected by any weight of remaining emulsion in the distributor truck or tanker at the conclusion of the project. The Engineer may elect to calculate the remaining weight in a distributor by use of the average specific gravity of materials delivered, or by tank stabs. The average specific gravity for this calculation will be as determined by Central Laboratory Testing. If tank stabs are to be utilized for this measurement, the Contractor's Process Control Plan shall include appropriate information for calculations on the distributor used on the project. This calculation will be limited to less than 4,000 gallons of material. All other material shall require weigh back for proper calculation of payment. The weight shall be determined by certified scales per Section 109. This will also be monitored and documented by daily distributor gauge readings and yield calculations. All proposed methods of weighing materials, calibrating distributor rates and monitoring the yields shall be included in the Process Control Plan per Section 409.

Diluted emulsified asphalt used for fog seal on chip seals will be measured by the actual number of tons of asphalt before dilution with water. Correction for the final diluted emulsion at the conclusion of a project will assume a 3:2 emulsion to water dilution rate, and the water subtracted from the weight of the remaining product unless otherwise approved.

BASIS OF PAYMENT

411.05 The accepted quantities, measured as provided above, will be paid for at the contract unit price per ton or gallon as the case may be, for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Asphalt Cement (___)	Ton
Emulsified Asphalt (___)	Gallon
Emulsified Asphalt (Rapid-Setting) (Polymerized)	Ton
Emulsified Asphalt (Medium-Setting) (Polymerized)	Ton
Liquid Asphaltic Material (___)	Gallon
Asphalt Rejuvenating Agent	Gallon
Recycling Agent	Gallon

High float emulsified asphalt (polymerized) or emulsified recycling agent used in Item 406, Cold Asphalt Pavement (Recycle) will be paid for by the gallon under the pay item Recycling Agent.

Water used to dilute emulsified asphalt or asphalt rejuvenating agent will not be paid for separately but shall be included in the work.

SECTION 412
PORTLAND CEMENT
CONCRETE PAVEMENT

DESCRIPTION

412.01 This work consists of constructing a pavement composed of Portland Cement Concrete on a prepared subgrade or base course per these specifications and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established.

MATERIALS

412.02 Materials shall meet the requirements of the following subsections:

Fine Aggregate	703.01
Coarse Aggregate	703.02
Portland Cement	701.01
Fly Ash	701.02
Water	712.01
Air-Entraining Admixtures	711.02
Joint Sealant with Backer Rod	705.01
Curing Materials	711.01
Reinforcing Steel	709.01
Chemical Admixtures	711.03
Dowel Bars and Tie Bars	709.03

CONSTRUCTION REQUIREMENTS

412.03 Classification. Concrete shall conform to the requirements for Class P concrete as specified in Section 601. Fast track concrete pavement is accelerated Class P concrete.

412.04 Proportioning. Proportioning shall conform to the requirements of subsection 601.05.

412.05 Batching. Batching shall conform to the requirements of subsection 601.06.

The Contractor shall provide a Process Control Plan (PCP) to minimize voids in the concrete pavement, such as clay balls, mud balls and other deleterious materials. It shall also identify the Contractor's method for ensuring that the provisions of the PCP are met. This PCP shall be submitted to the Engineer at the Pre-construction Conference. Paving operations shall not begin until the Engineer has approved the PCP. This PCP shall identify and address issues affecting the quality of aggregates incorporated into the concrete mix including but not limited to:

(1) Washing aggregates.

(2) Inspection at the pits, plants and aggregate storage areas.

(3) Base or floor of pits, plants and aggregate storage areas.

(4) Inspection of truck beds.

(5) Methods and frequency of aggregate testing.

(6) Training of operators, haulers and inspectors in regard to aggregate quality.

(7) Plant site selection and layout.

(8) Grizzlies and screens on conveyors.

(9) Stabilization of haul roads and construction accesses.

When the Engineer determines that any element of the approved PCP is not being implemented, the paving shall stop, the cause shall be identified and corrected by the Contractor before paving operations resume.

412.06 Mixing. Mixing shall conform to the requirements of subsection 601.07.

412.07 Equipment. Equipment and tools shall be capable of handling materials, performing the work, producing a product of specified quality, and shall be approved. The equipment shall be at the job site sufficiently ahead of the start of paving operations to be examined and approved.

(a) Hauling Equipment. Concrete may be hauled and placed with non-agitator equipment. Bodies of non-agitating equipment shall be smooth, mortar tight containers, and shall be capable of discharging the concrete at a controlled rate without segregation.

(b) Consolidating and Finishing Equipment. Concrete shall be spread, struck-off and finished by mechanical equipment, either from fixed forms or by slip form method, unless otherwise permitted.

The Contractor shall use an approved longitudinal paver wedge system to create a sloped SafetyEdge℠. The Contractor shall modify the paver screed to create a SafetyEdge℠ that meets the final cross-section shown on the plans. The system shall provide a sloped SafetyEdge℠ equal to 32 degrees plus or minus 5 degrees measured from the pavement surface cross slope extended. There may be areas where it is not possible to place the SafetyEdge℠ in conjunction with mainline paving but where the SafetyEdge℠ is required, such as transitions at driveways, intersections, interchanges, etc. In these areas the Engineer may allow the Contractor to use handwork for short sections or to saw cut the sloped SafetyEdge℠ after paving operations are completed.

The Contractor shall submit the proposed paver wedge system for approval at the Pre-construction Conference. The Engineer may require proof that the system has been used on previous projects with acceptable results or may require a test section constructed before the beginning of work to demonstrate that it creates an acceptable wedge shape. Paving shall not begin until the system is approved in writing by the Engineer. The finished shape of the SafetyEdge℠ shall extend for the full depth of the concrete pavement or for the top 5 inches whichever is less.

The full width and depth of concrete requiring a finishing machine shall be consolidated by a single pass of an approved internal vibrator. Internal vibrators shall be operated within a frequency range of 4,000 to 8,000 vibrations per minute (VPM). Vibrators shall not be operated in a manner to cause a separation of the mix materials, either a downward displacement of large aggregate particles or an accumulation or laitance on the surface of the concrete. Avoidance of separation of the mix may require reduction in the vibrator frequency when forward motion of the paver is reduced.

Paving machine operations shall stop if any vibrator fails to operate within specifications. Vibration shall be stopped whenever forward motion of the paver is stopped.

The use of surface vibrators shall be approved by the Engineer before use. Surface vibrators shall be operated within a frequency range of 3,500 to 6,000 VPM.

An electronic monitoring device displaying the operating frequency of each individual internal vibrator shall be required for mainline pavement exceeding 600 feet in length. The monitoring device shall have a readout display near the operator's controls visible to the paver operator and to the Engineer. It shall operate continuously while paving and shall display all vibrator frequencies with manual or automatic sequencing among all individual vibrators. If a vibrator monitor fails to function properly, a handheld device may be used until the monitor is repaired. The Contractor shall measure the vibrations of each vibrator at least once an hour. The vibrator monitor repair must be made within 48 hours.

The depth of penetration into the concrete pavement slab of internal vibrators shall be between the surface and mid slab and passing above any reinforcing steel. An operating position-locking device shall be provided so that no part of the vibrating unit can be lowered to the extent that it will come in contact with reinforcing steel or tie bars while paving.

Vibrators shall have a minimum eccentric diameter of 1 1/2 inches or as approved by the Engineer. Horizontal spacing of vibrators shall not exceed the manufacturer's recommendations and shall not exceed 18 inches from center to center. The longitudinal axis of the vibrator body shall be mounted approximately parallel to the direction of paving. Vibrators shall meet or exceed the following specifications at manufacturers design frequency of 10,000 VPM:

(1) Amplitude (peak to peak) 0.070 inch.

(2) Centrifuge force 1,200 pounds.

Within the frequency range, the Contractor shall adjust the frequency to provide optimum consolidation for the mix and placement conditions.

If any vibrator ceases to function properly, the paving operation shall be stopped immediately and not resumed until the faulty vibrator has been repaired or replaced. Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies by means of vibrators inserted in the concrete. Vibrators shall not come in contact with or cause displacement of the joint load transfer devices, subgrade, or side forms and shall not interfere with placement of reinforcing steel.

Any variation from the above method must have prior written approval from the Engineer. The Contractor's documentation shall include evidence that the proposed method of consolidation will provide equal or better consolidation than the method described above.

(c) Concrete Saw. When sawed joints are required, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at a rate that will control cracking. The Contractor shall provide at least one standby concrete saw in good working order at all times. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job during concrete placement.

Wastewater generated from concrete saw operations shall be contained and disposed of per subsection 107.25.

(d) Test Bridge. The Contractor shall furnish a movable bridge that conforms to subsection 601.15(g) for use by the Department.

412.08 Preparation of Subgrade. After the roadbed has been graded and compacted, the subgrade shall be trimmed to the correct elevation and slope. For slip form paving, the elevation and slope of the trimmer shall be automatically controlled from outside reference lines established for this purpose. The trimmed subgrade shall extend at least 2 feet beyond each edge of the proposed concrete pavement when forms are used and at least 1 foot outside the track width of finishing, curing, and tining equipment for slip form operations. Any work required beyond the planned roadbed necessary to support the Contractor's paving equipment or hauling vehicles, will not be paid for separately, but shall be included in the work.

The subbase or base course shall be brought to the specified cross section. High areas shall be trimmed to the proper elevation. Low areas in untreated bases may be filled and compacted to a condition similar to that of the surrounding grade or filled with concrete integral with the pavement. Low areas in treated bases shall be filled with concrete integral with the pavement. The finished grade shall be maintained in a smooth and compacted condition until the pavement is placed.

Untreated subgrade or base course shall be uniformly moist during concrete placement. If it becomes too dry, the untreated subgrade or base course shall be sprinkled without forming mud or pools of water.

412.09 Limitations of Placing Concrete. Limitations on the placing of concrete shall conform to subsections 601.12 (b) and (c), and 412.15.

412.10 Placing Concrete. The concrete shall be uniformly deposited on the grade in a manner that requires as little re-handling as possible. Concrete for areas that contain load transfer devices shall not be dumped directly from the hauling vehicles onto the grade. Concrete shall be placed by an approved placer spreader machine. Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them but shall not be dumped from the discharge bucket or hopper onto a joint assembly unless the discharge is well centered on the joint assembly. Necessary hand spreading shall be done with Shovels, not rakes. Workers shall not walk-in freshly mixed concrete with footwear coated with earth or foreign substances. All footprints in the fresh concrete shall be vibrated and finished flush with the adjacent surface.

Construction equipment other than standard paving equipment will not be allowed to handle plastic concrete in advance of the paver in the roadway without approval.

Where concrete is placed adjacent to a newly constructed lane of pavement with the concrete paving equipment operating on the newly constructed pavement, the concrete shall have attained a minimum compressive strength of 2,000 psi before commencing paving. Determination that the concrete has reached 2,000 psi shall not relieve the Contractor of the responsibility for protecting the pavement.

Any concrete or foreign material that falls on or is worked into the surface of a completed slab shall be removed immediately.

Following placement, the concrete shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the plans or established.

The Contractor shall provide a MIT-Scan-2, which is manufactured by MIT GmbH.

The Contractor shall ensure the MIT-Scan-2 is calibrated for the specific dowel bar size or load transfer device being placed and is operating within the manufacturer's tolerances. The Contractor shall also ensure that the operator of the MIT-Scan-2 is fully competent in the use of the device. The Contractor shall supply the serial number of the device to be used on the project.

412.11 Test Specimens. The Contractor shall furnish the concrete necessary for casting test cylinders and performing air and slump tests.

412.12 Finishing. The sequence of operations shall be strike-off and consolidation, floating, and final surface finish.

Water shall not be added to the surface of the concrete to assist in finishing operations. The surface shall be finished to a uniform texture, true to grade and cross section, and free from porous areas. When the finishing machine, either form, slip form, or hand finishing method, leaves a surface that is not acceptable, the operation shall stop, and corrective action shall be taken. Inability of the finishing machine to provide an acceptable surface finish, after corrective action, will be cause for requiring replacement of the finishing machine.

Wastewater generated from concrete finishing operations shall be contained and disposed of per subsection 107.25.

(a) Hand Finishing. Hand finishing shall be minimized wherever possible. The Engineer shall be notified beforehand finishing work and the proposed hand finished work shall be addressed in the Process Control Plan for concrete finishing. Unless otherwise specified, hand finishing methods will be permitted only under the following conditions. Hand finished concrete shall be struck off and screeded with a portable screed that is at least 2 feet longer than the maximum width of the slab to be struck off. It shall be sufficiently rigid to retain its shape. Concrete shall be thoroughly consolidated by hand vibrators. Hand finishing shall not be allowed after concrete has been in-place for more than 30 minutes or when initial set has begun unless otherwise approved by the Engineer. Finishing tools made of aluminum shall not be used.

The Contractor shall provide a Process Control Plan (PCP) to ensure that proper hand finishing is accomplished per current Industry standards for concrete pavement placement. It shall also identify the Contractor's method for ensuring that the provisions of the PCP are met. The PCP shall be submitted to the Engineer at the Pre-construction Conference. Paving operations shall not begin until the Engineer has approved the PCP. The PCP shall identify and address issues affecting the quality of finished concrete pavement including but not limited to:

(1) Timing of hand finishing operations

(2) Methodology to place and transport concrete

(3) Equipment and tools to be utilized

(4) Qualifications and training of finishers and supervisors

When the Engineer determines that any element of the approved PCP is not being implemented or that hand finished concrete is unacceptable, work shall be suspended. The Contractor shall supply a written plan to address improperly placed material and how to remedy future hand finishing failures and bring the work into compliance with the PCP. The Engineer will review the plan for acceptability before authorizing the resumption of operations.

(b) *Floating*. Hand floating will be permitted only as specified in subsection 412.12 (a). The Contractor shall not use floats made of aluminum.

(c) *Final Finish and Stationing*. The final surface of the pavement shall be uniformly textured with a broom, burlap drag, artificial turf or diamond ground in order to obtain the specified texture depth. The Contractor shall submit the proposed method of PCCP texturing at the Pre-construction Conference for approval by the Engineer. Surface imperfections resulting from the texturing operation shall be corrected by the Contractor at no additional cost.

Broom, burlap drag, or artificial turf texture shall be installed within 15 minutes after strike-off, or as pavement conditions allow.

Diamond grinding shall be performed using diamond blades mounted on a self-propelled machine designed for diamond grinding and texturing concrete pavement. The equipment shall have a positive means of vacuuming the grinding residue from the pavement surface, leaving the surface in a clean, near-dry condition. Diamond grinding shall not occur until the concrete has attained strength of at least 2,500 psi.

The diamond grinding process shall produce a pavement surface that is true to grade and uniform in appearance. The grooves shall be evenly spaced. Any ridges on the outside edge next to the shoulder, auxiliary, or ramp lanes greater than 3/16-inch high shall be feathered out to the satisfaction of the Engineer in a separate, feather pass operation.

The pavement surface after diamond grinding shall have no depressions or misalignment of slope in the longitudinal direction exceeding 1/8 inch in 12 feet when measured with a 12-foot straightedge placed parallel to the centerline. All areas of deviation shall be reground at no additional cost.

Stationing shall be stamped into the outside edge of the pavement, as shown on the plans.

412.13 Joints. Joints shall be constructed of the type, dimensions, and at locations required by the Contract. When a joint is saw cut more than 3 inches from the designated location, the pavement shall be removed and replaced to the nearest correct joints. When portions of concrete pavement are removed and replaced, the portion removed shall be the full width of the lane and length of the affected slabs. This corrective action shall be at the Contractor's expense.

Immediately after sawing, the sawed joints shall be flushed with water to remove any saw residue, and the saw residue shall be completely removed from the surface of the pavement. This residue shall be removed by approved methods.

All equipment other than saws shall be kept off the pavement until the sawing is complete.

After the proper curing period, the sawed joint shall be thoroughly cleaned and immediately sealed per subsection 412.18.

(a) Construction Joints Construction joints shall be slightly tooled while the concrete is plastic and later sawed to the dimensions specified in the Contract. The tooling shall not exceed the width of the sawed joint at any point.

In the event tie bars cannot or are not placed in plastic state concrete, then the tie bars shall be placed according to the following minimum requirements:

Holes with a diameter 1/4 inch greater than the bar diameter shall be drilled laterally into the hardened concrete slabs at one half the slab depth, 36 inches on center, 15 to 16 inches deep. Each hole shall be cleaned out with compressed air using a wand attachment that fits into the hole and is long enough to reach to the back of the hole. Each hole shall be brushed out with a stiff bristled cylindrical brush that is at least 1/4 inch larger than the diameter of the hole. Each hole shall be blown out with compressed air a second time using a wand attachment that fits into the hole and is long enough to reach to the back of the hole. Each hole shall be blown out until there is no longer any evidence of dust, debris or loose material in the hole.

An approved epoxy shall be used and installed according to the manufacturer's instructions. Epoxy shall be placed in the back of each hole with an applicator that will reach the end of the drilled hole. A sufficient amount of epoxy shall be placed in each hole to ensure that the bar will be completely covered with epoxy. Epoxy shall be placed on the bar before inserting the bar into the hole. The bar shall be inserted into the hole using a twisting motion to facilitate covering the bar and the inside surface of the hole with epoxy minimizing voids or air pockets.

When tie bars are placed in plastic state concrete or drilled and epoxied into a construction joint, and if required by the Engineer, the Contractor shall demonstrate by testing at least 15 of the tie bars that the bar pullout resistance is at least 11,250 pounds with slippage of 1/16 inch or less. If two or more tie bars do not meet the required pullout resistance, then another 15 tie bars shall be tested. If any of the second 15 do not meet the required pullout resistance, then all remaining tie bars shall be tested. The Contractor shall perform additional pullout tests and take corrective action when and as directed. All steps taken to test bars, and to correct, repair or replace failed tie bars and the surrounding failed area shall be at the Contractor's expense. Concrete strength shall have a compressive strength of at least 2,500 psi before testing. ASTM E488 shall be used for performing pullout testing.

1. Longitudinal Construction Joints. Keyways and epoxy-coated, deformed steel tie bars shall be placed as specified in the Contract. Tie bars shall be placed perpendicular to the longitudinal joint by an approved method.

   When adjacent lanes of pavement are constructed separately, tie bars may be bent at right angles against the edge of the first lane constructed and straightened into final position before the concrete of the adjacent lane is placed. In lieu of bent tie bars, approved two-piece connectors may be used. If the coating of epoxy coated tie bars is damaged, the bars shall be repainted with epoxy paint before placement of concrete.

2. Transverse Construction Joints. Transverse construction joints shall be constructed at a transverse contraction joint as specified in the Contract. Transverse construction joints shall be constructed when the concrete placement is interrupted for more than 30 minutes, or initial set is imminent. The concrete back to the preceding transverse joint

shall be removed and the bulkhead placed per the requirements for a standard transverse contraction joint. Transverse construction joints shall be placed at the end of each day's placement.

(b) Weakened Plane Joints. Weakened plane joints shall be spaced and skewed as specified in the Contract and formed by sawing. The time of sawing shall be determined by the Contractor to prevent random cracking and raveling from the sawing. The time will depend upon weather conditions, temperature, and other factors affecting the setting of concrete. If uncontrolled cracking occurs during or before joint sawing, the Contractor shall move the sawing operation ahead and, if necessary, add additional sawing units to eliminate uncontrolled cracking.

1. Longitudinal Weakened Plane Joints. Epoxy coated deformed steel tie bars shall be inserted into the plastic state concrete after the auger. In the event the tie bars are placed behind the machine paving mold, vibration will be required during placement. Other methods of bar placement may be acceptable if the Contractor can demonstrate satisfactory performance of the alternate method. Proposals of alternate methods or additional costs associated with other methods shall be at the Contractor's expense. Tie bars shall be placed according to a method approved by the Engineer. The Contractor shall use an MIT Scan-2 to evaluate the location of tie bars that cannot be visually inspected. Each longitudinal joint located within the dowel bar test locations described in subsection 412.13 (b) 2 that were not visually inspected shall be evaluated with the MIT Scan-2. The MIT Scan-2 shall be calibrated for the tie bar size placed. The tie bars shall be located within the middle third of the slab, and a minimum of 1/2 inch below the saw cut. Tie bars shall have a minimum embedment of 12 inches on each side of the joint. The weakened plane joint shall be made by sawing in hardened concrete per the plan details.

   Tie bars that are cut during sawing operations shall be replaced at the Contractor's expense. Tie bars that are located less than 2 inches above the bottom of the slab shall be replaced at the Contractor's expense. Tie bars that are not embedded a minimum of 12 inches on each side of the joint shall be replaced. When the spacing between two in-place tie bars exceeds 40 inches but less than 72 inches, a tie bar will be installed halfway between the two tie bars, unless this installation location is within 12 inches of a transverse weakened plane joint. When the spacing between two in-place tie bars exceeds 72 inches, tie bars will be installed at an even spacing not to exceed 36 inches but shall not be installed within 12 inches of a transverse weakened plane joint. The Contractor shall submit to the Engineer a method for replacing the tie bars. The Contractor shall not proceed to replace the tie bars until the method for replacement has been approved by the Engineer.

2. Transverse Weakened Plane Joints. When dowel bars are specified in the Contract, they shall be installed within the tolerances and of the size, grade, and spacing specified. Dowel bars shall be furnished in a rigid welded assembly or placed by a dowel bar insertion (DBI) machine. The center of the dowel assembly or the insertion location shall be marked on both sides of the pavement slab for reference in sawing the joint. When a DBI is used, the Contractor shall submit details and specifications of the proposed slip-form paver and DBI to the Engineer a minimum of 14 calendar days before the Concrete Pavement Pre-paving Conference. The Contractor shall detail his methodology for ensuring correct marking of dowel bar insertion points and correct sawing of the joints. The Contractor shall ensure that the slip-form paver is compatible with the DBI.

When a rigid assembly (dowel basket) is used, the rigid assembly shall be fabricated from number 1/0 wire or heavier with vertical support wires every 1 foot. The rigid assembly shall be securely fastened to the subbase and constructed to firmly hold all the dowel bars at T/2 depth, parallel to each other and to the pavement grade and alignment. Horizontal support wires or shipping braces shall be non- deformed bars or wires with a diameter less than or equal to 0.307 inches (gauge 0 wire). The number of horizontal support wires or shipping braces shall be limited to five per rigid assembly. Shipping braces shall not be cut.

The Contractor shall perform a pull test after baskets are staked. The minimum staking method will be determined using the pullout test. The pullout test shall be performed on all dowel baskets placed in a test section and one dowel basket per day thereafter when the minimum staking method is used. The test section for determining staking method shall be the first 10 joints with dowel baskets for each base type. Each dowel basket in the test section shall withstand a minimum of 25 pounds of force when pulled vertically at three equally spaced locations along the length of the dowel basket using a fish scale, or approved equivalent. If any basket moves more than 0.5 inches, a new staking method and test section will be required.

The use of the MIT Scan-2 will be used for joint acceptance. Joint acceptance or rejection will be based on the Joint Map generated by the MIT Scan software. Should the joint map show missing or misaligned bars the Contractor will have the choice of either performing additional testing using a method approved by the Engineer or perform corrective measures. Colorado Procedure 79 in the CDOT Field Materials Manual will be used to determine if dowel bars are misaligned or missing. Dowels in rigid assemblies will be inspected by the Engineer before concrete placement for misalignment and dowel bar depth. If misalignments and dowel bar depths exceeding the rejection tolerances are found, the rigid assembly shall be reset and re-inspected. The MIT Scan-2 shall be used for determining the depth of dowel bars placed by a DBI.

See Standard Plan M-412-1 for schematic describing the measurement of each tolerance.

Joint Rejection Criteria:

A. Any joint that does not have at least three acceptable dowel bars in each wheel path.
B. Rotational misalignment: Bars with misalignment greater than 1.5 inches.
C. Longitudinal (side) shift: Bars that are not embedded at least 6 inches on each side of the joint (saw-cut).
D. Depth: Bars within the top 3 inches of the pavement or at a depth less than the saw-cut depth. Bars within the bottom 3 inches of the pavement.

Corrective Measures: The following corrective measures will be allowed for the bars or joints that are rejected.

A. Rotational misalignment: Saw-cut the misaligned bars. Joints with less than three un-cut bars in each wheel path will require the addition of dowel bars using an approved dowel bar retrofit method.
B. Longitudinal (side) Shift and missing bars: Addition of dowel bars using an approved dowel bar retrofit method.
C. Depth: Inadequate cover above the bar—Saw-cut the bar and install a replacement bar using an approved dowel bar retrofit method.

Inadequate cover below the bar— Addition of dowel bars using an approved dowel bar retrofit method.

Retrofitted dowel bars shall not exceed the dowel bar rejection criteria.

In addition to the above procedures, the Contractor may propose removal and replacement of the affected slabs. The Contractor shall submit his method of repair to the Engineer for approval.

The Contractor shall demonstrate his ability to place dowel bars in conformance with the specifications by placement of a test section. The test section shall be a minimum of 300 feet in length. Upon completion of the test section, the Contractor shall shut down paving operations. During the shutdown period, the Contractor shall evaluate all joints in the test section using the MIT-Scan-2 and CP-79 and submit the results to the Engineer. Paving operations shall not be restarted until the Engineer approves the test section results. The test section will be found acceptable if 100 percent of the joints are found to be acceptable. All unacceptable joints must be addressed using the above corrective measures. The Contractor may continue paving at his own risk before the test section evaluation is complete.

If the Project has less than 500 linear feet of pavement, the test section will not be required. If a Project does not have sections of continuous pavement greater than 45 linear feet, the test section will not be required.

Upon completion of the test section(s) and for each week of production, the Contractor shall prepare an electronic report generated using MagnoProof software and submit it to the Engineer at the start of each working week during production, for the previous week's work. The reports shall show the joint map generated by the MIT-Scan-2 and the joint pass/fail rating according to CP-79.

When the test section is found to be unacceptable, the Contractor shall perform corrective actions and place a second test section. If the second test section is found to be unacceptable, the Contractor shall pave no more than 500 feet per day until an acceptable test section has been achieved.

Once a test section is successfully completed, Dowel Bar Placement testing frequency shall be a minimum of one location per 1,250 linear feet of each continuous lane including climbing lanes, passing lanes, acceleration and deceleration lanes and ramps. Sections greater than 45 linear feet and less than 1,250 linear feet require a minimum one of test location. Testing locations shall be determined by a random procedure so that each area has a randomly selected transverse joint location. At each location, five consecutive joints shall be tested.

Sections of continuous pavement constructed by the project less than 45 linear feet will not require Dowel Bar Placement Testing.

When any joint exceeds the rejection criteria, joints shall be tested in each direction from the rejected joint, until two consecutive joints in each direction are found to be acceptable.

All delays or costs associated with equipment being rejected for use by the Engineer will not be paid for by the Department and will be considered a Nonexcusable Delay

per subsection 108.08 (c) 2.

When concrete shoulders or widenings are constructed subsequent to the driving lanes, transverse weakened plane joints shall immediately be formed in the plastic concrete of these widenings to create an extension of the existing transverse joint. This tooled joint shall be formed in such a manner that it controls the cracking and shall be sawed and sealed per the above requirements.

(c) Expansion Joints. Preformed joint filler expansion joints shall be constructed at all existing or proposed structures and features projecting through, into, or against the pavement and at other locations specified in the Contract.

412.14 Curing. Immediately after the finishing operations have been completed the entire surface and exposed sides of the newly placed concrete, shall be sprayed uniformly with a curing compound meeting the requirements of ASTM C309, Type 2. The ASTM C309 Type 2 curing compound shall be volatile organic content (VOC) compliant.

The curing compound shall be applied within 10 minutes after the final finish has been applied. Failure to cover the surface of the concrete within 10 minutes shall be cause for immediate suspension of the paving operations.

An initial application of curing compound shall be applied under pressure by mechanical sprayers at the rate of at least 1 gallon per 180 square feet of pavement surface. A second application of curing compound shall be applied within 30 minutes after the initial application. The second application rate shall be at least 1 gallon per 180 square feet of pavement surface. Alternatively, the Contractor may apply the curing compound in one application of at least 1 gallon per 120 square feet. Additional curing compound shall be applied as needed to ensure that 100 percent of the pavement is covered. The spraying equipment shall be fully automated, equipped with a tank agitator, and a wind guard. During application, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle and the compound shall be stirred continuously by effective mechanical means. Hand spraying of irregular widths or shapes and surfaces exposed by removal of forms will be permitted. Curing compounds shall not be applied to the inside faces of joints to be sealed.

Should the curing film become damaged from any cause, within 72 hours after concrete placement, except for concrete open to traffic, the damaged portions shall be repaired immediately with additional curing compound, payment for which shall be at the Contractor's expense.

The sides of pavement slabs shall be immediately sprayed with curing compound when the forms are removed.

412.15 Cold Weather Concrete Paving. The Contractor is responsible for the strength and quality of the concrete placed during cold weather. Before starting paving operations, the Contractor shall be prepared to protect the concrete from freezing. Maturity meters, to monitor and record time and pavement temperature, shall be installed at the time of placement when the air temperature is expected to fall below 40 °F during the next three days or as requested by the Engineer when the air temperature is expected to fall below 45 °F during the next three days. The Contractor shall maintain the temperature of the pavement at or above 40 °F until the pavement has attained a compressive strength of at least 2000 psi. The compressive strength of the concrete shall be determined by the use of maturity meters. Maturity meters shall be placed in three locations for each day's concrete paving operations. One maturity meter shall be placed in the final 15 feet of paving, and the two other maturity meters shall be

placed at locations designated by the Engineer. The maturity meter probes shall be located on the outside edge of the slab, at least 1 foot and not more than 2 feet from the edge and at mid depth of the slab. Each maturity meter shall be capable of recording the time and temperature. The maturity meters shall remain in place until the concrete has attained a compressive strength of 2000 psi.

The Contractor shall develop maturity relationships for each mix placed during the cold weather conditions described above per CP 69:

The development of the maturity relationship is part of the trial mix and shall be submitted to the Engineer before cold weather concrete paving.

The Contractor shall provide the maturity meters and all necessary wires and connectors. The Contractor shall be responsible for the placement, protection and maintenance of the maturity meters and wires. Locations where the maturity meters are placed shall be protected in the same manner as the rest of the concrete pavement.

The following procedures shall be followed if the temperature of the concrete pavement falls below 32 °F before the concrete reaches 2,000 psi:

(1) The Contractor will take cores at locations designated by the Engineer.

(2) The Engineer will take immediate possession of the cores and submit the cores to a petrographer for examination per ASTM C856.

(3) All costs associated with coring, transmittal of cores, and petrographic examination shall be borne by the Contractor regardless of the outcome of the petrographic examination.

(4) Pavement damaged by frost as determined by the petrographic examination, shall be removed and replaced at the Contractor's expense.

412.16 Repair of Defective Concrete Pavement. Defective concrete pavement shall be repaired or replaced at the Contractor's expense. This corrective work shall be accomplished before joint sealing and final smoothness measurement. Defective concrete pavement replaced after smoothness measurement shall be retested for localized roughness. The Contractor's corrective work plan shall be approved before performing the work.

When necessary, the extent of defects will be determined by the inspection of cores drilled at the Contractor's expense. Crack depth shall be determined by taking one core at the center of the crack or as approved by the Engineer. The Contractor shall take the cores and supply to the Engineer immediately after the coring.

1. Pavement thickness (T) shall be as shown on the plans.
2. Pavement slabs with any of the following conditions are unacceptable and shall be removed and replaced:
   A. Pavement slabs in driving lanes containing one or more cracks that are T/3 in depth or greater that separate the slab into two or more parts.
   B. Pavement slabs in driving lanes containing one or more cracks that are 30 inches or greater in length and T/3 in depth or greater.
   C. Pavement slabs containing honeycombed areas.
   D. Pavement slabs containing an extreme void as defined below.

E. Pavement slabs containing more than one void greater in depth than half the pavement thickness.

F. Pavement slabs containing a cumulative surface area of moderate and severe voids, as defined below, greater than one percent of the slab's total area.

G. Pavement slabs containing 20 or more severe voids as defined below.

Voids are defects in a slab consisting of air pockets, clay balls, or foreign materials such as cans, rags, bottles, etc. Voids may also consist of clumps of sand, cement or reinforcing fibers caused by incomplete mixing. The defect will be considered a moderate void when the largest dimension, either height, width or length is at least 1/2 inch but not more than 2 inches. The defect will be considered a severe void when the largest dimension, either height, width or length is greater than 2 inches. The defect will be considered an extreme void when the largest dimension, either height, width or length is greater than the thickness of the pavement.

When the Engineer determines that voids are at an unacceptable level, the paving shall stop, and the cause shall be identified and corrected by the Contractor before paving operations are allowed to resume.

Concrete slabs that are determined by the Engineer to be acceptable if repaired shall have voids filled using materials from the Department's Approved Products List and methods approved by the Engineer.

When portions of concrete pavement are removed and replaced, the portion removed shall be the full width of the lane and length of the affected slab. Slabs with cracks penetrating the full depth of pavement shall be removed as required above. Cracks that are 30 inches or longer and are between 1 inch and T/3 in depth shall be repaired. The Contractor shall submit in writing a plan to repair the partial depth cracks for approval by the Engineer. The Engineer will have seven calendar days to review and approve the Contractor's repair plan in writing.

Joints and cracks that are spalled shall be repaired as follows:

(1) A saw cut at least 1 inch outside the spalled area and to a minimum depth of T/3 shall be made parallel to the joint or crack.

(2) The concrete between the saw cut and the joint or crack shall be chipped out to solid concrete to a minimum depth of T/3.

(3) The cavity formed shall be thoroughly cleaned.

(4) A prime coat of epoxy-resin binder shall be applied to the dry, cleaned surface on all sides of the cavity, except the face of the joint. The prime coat shall be applied by scrubbing prime coat material into the surface with a stiff bristle brush.

(5) Placement of portland cement concrete or epoxy-resin concrete shall immediately follow the application of the prime coat.

If the spalled area, to be repaired, abuts a working joint or a working crack that penetrates the full depth of the pavement, an insert or other bond-breaking medium shall be used to maintain the working joint or crack during the repair work.

If concrete paving exhibits the above defects for two or more days, production will be suspended. The Contractor shall submit a written plan to correct these defects. The plan shall detail, at a minimum, changes in paving procedures, materials and

equipment required to construct concrete pavement that meets the specifications. The Engineer will approve the Contractor's plan before the continuation of the concrete paving operation.

412.17 Surface Smoothness. The roadway surface smoothness shall be tested per subsection 105.07.

412.18 Sealing joints. Before installation of the backer rod or sealant, the following shall be completed:

(1) Repair of defective pavement slabs and repair and proper curing of cracks or spalls per subsection 412.16.

(2) Corrective work for texturing.

(3) Corrective work for pavement smoothness per subsection 105.07.

A copy of the manufacturer's recommendations pertaining to the storage, heating and application of the sealant shall be submitted to the Engineer before commencing work. These recommendations shall be adhered to by the Contractor, with such exceptions as required by these specifications.

The Contractor shall cut the transverse and longitudinal joints to the width and depth required. The cut shall be made with a power drive saw equipped with diamond blades. The residue from sawing shall be removed from the pavement by the Contractor. The material shall be removed at the time of the sawing operation. Any damage to the concrete pavement such as spalling or fracturing shall be repaired by the Contractor as directed by the Engineer at no cost to the project. Sawing residue shall be immediately removed from all joints.

Cleaning, repairing, and proper curing of all spalls, fractures, breaks, and voids in the concrete surface of the joints shall be accomplished before installing the backer rod material or joint sealant.

The backer rod shall be placed in such a manner that the grade for the proper depth of the seal material is maintained.

The Contractor shall thoroughly clean the joint and adjacent pavement for a width of at least 1 inch on each side of the joint of all scale, dirt, dust, residue, and other foreign material that will prevent bonding of the joint sealant. This operation is to be accomplished by sandblasting or jet water-blasting on the same day as the joint sealing operation.

Immediately before the placement of backer rod material and sealant, the joints shall be cleaned using a minimum of 100 psi of compressed air. Work shall be stopped when and if it is found that there is oil or moisture in the compressed air. Work shall not resume until oil and moisture are removed from the compressed air.

Sealant shall not be placed unless the surfaces of the joint and the pavement are dry, and the weather is dry. Joint sealing will not be allowed when the air or surface temperature falls below 50 °F. Manufacturer's recommendations shall be followed if a higher temperature is recommended. Sealant shall not be placed before expiration of the sealant manufacturer's recommended concrete pavement curing period, if any.

The Contractor shall not place the sealant if there is dust, moisture, oil, or foreign material on that portion of the concrete that is to receive the backer rod or sealant.

The Contractor shall prevent smearing of the joint sealant material onto the concrete pavement driving surface. Smeared joint sealant shall be removed from the pavement before it is opened to traffic.

Sealing shall be completed before opening the pavement to traffic, unless otherwise specified or approved.

412.19 Construction by Form Method. Straight side forms shall be made of a metal having a thickness of at least 7/32 inch and shall be furnished in sections at least 10 feet in length. Forms shall have a depth equal to or greater than the specified edge thickness of the concrete, without horizontal joint, and a base width equal to or greater than the depth of the forms. Top surface of the forms shall be set flush with the proposed concrete surface. Flexible or curved forms of proper radius shall be used for curves of 100 feet radius or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure setting so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Flange braces shall extend outward on the base at least ⅔ the height of the form. Forms with battered top surfaces, and forms that are bent, twisted, or broken shall not be used. Repaired forms shall not be used until inspected and approved. Built-up forms shall not be used except where the total area of the pavement, of any specified thickness, on the project is less than 2,000 square yards. The top face of the form shall not vary from a true plane by more than 1/8 inch in 10 feet, and the vertical leg shall not vary more than 1/4 inch from vertical. The forms shall contain provisions for locking the ends of abutting form sections together tightly, and for secure setting.

Forms for bridge approach slabs or for pavement areas with irregular dimensions shall be made of metal or straight, sound timber. Forms shall be free from warp and of sufficient strength to resist springing out of shape. Forms shall be staked securely to line and grade to the satisfaction of the Engineer. All mortar and dirt shall be removed from the forms.

(a) Setting Forms. The foundation under the forms shall be compacted true to grade so that the form, when set, will be firmly in contact for its whole length and at the specified grade. The roadbed shall be prepared per subsection 412.08; however, where the grade at the form line is found to be below specified grade it shall be filled and thoroughly compacted to specified grade with granular material in lifts of 1/2 inch or less. Imperfections or variations above grade shall be corrected by tamping or by trimming as necessary.

Forms shall be set sufficiently in advance of concrete placement to provide time for the Engineer to check the line and grade and allow a continuous concrete placement operation. Forms shall be staked in place and free from play or movement in any direction. The forms shall not deviate from true line by more than 1/4 inch at any point. No excessive settlement or springing of the forms under the finish machine will be tolerated. Forms shall be cleaned and coated with a form release agent or oiled before placement of concrete.

The alignment and grade elevations of the forms shall be checked, and corrections made by the Contractor immediately before concrete placement. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

(b) *Removing Forms.* Unless otherwise provided, forms shall not be removed from freshly placed concrete until the concrete is strong enough to withstand damage when the forms are removed. After the forms have been removed, the sides of the slab shall be cured per subsection 412.14.

412.20 Construction by Slip Form Method. The subgrade shall be completed per subsection 412.08 and then checked and approved by the Engineer before installation of load transfer units, if required, and placement of concrete. Concrete shall not be placed on a subgrade that has not been approved. If any traffic uses the finished subgrade, the grade shall be checked and corrected immediately before placement of the concrete.

The concrete shall be finished with an approved, self-propelled slip form paver capable of spreading, consolidating, screeding, and finishing the freshly placed concrete with one pass of the paver. The paver shall be capable of providing a dense and homogeneous pavement with an even texture and no porous areas, and to the slope and elevation specified. The alignment and elevation of the paver shall be automatically controlled from outside reference lines established to obtain a smooth alignment and profile.

For mainline paving of Pavement Smoothness Category I roadways, as defined in Table 105-14 all slip form paving shall be accomplished by a machine capable of paving at least a 24 feet minimum width as recommended by the equipment manufacturer.

(a) *Stabilized Bases.* The Contractor is responsible for irregularities in the stabilized base and payment will not be made for overruns in concrete quantities if extra concrete is used to correct the irregularities.

(b) *Concrete Pavement Overlays.* Trimming will not be required. The Contractor shall place a bond breaker, if specified in the Contract, before placing the concrete. Payment will be made for irregularities under pay item of Furnish Concrete Pavement.

The Contractor shall furnish a machine to develop and establish a profile grade for the new pavement. The method used will be by dual slope laser mounted on a 30-foot ski. The Engineer may approve an alternative method of establishing the profile grade, if the Contractor demonstrates that equal or superior results will be achieved by the alternative method.

412.21 Determining Pavement Thickness. Pavement thickness will be determined by cores or magnetic pulse induction (MPI). The Contractor shall select the pavement thickness determination method at the Pre-paving Conference.

(a) *Pavement Thickness Using Cores.* The Contractor shall perform the process control (PC) testing for pavement thickness. A process control testing plan shall be submitted and must be approved before the start of paving. This PC testing plan shall include determining the thickness of freshly finished concrete pavement at a minimum frequency of one measurement per 1,250 linear feet of each traffic lane. All shoulders 8 feet or greater in width shall be tested as a separate traffic lane. Shoulders less than 8 feet wide shall be included in the adjacent lane. Areas such as sections of mainline pavement that are less than 1,250 linear feet long, intersections, entrances, crossovers, ramps, shall be grouped into units of 1,000 square feet or remaining fraction. A minimum of one random measurement shall be taken in each unit.

The Engineer may inspect the Contractor’s PC tests at any time during the paving operations. Approval and inspection of the Contractor’s PC plan and operations does not

constitute acceptance of the pavement thickness and does not relieve the Contractor of the responsibility for providing the required hardened pavement cores for project acceptance testing. The Contractor shall provide daily written reports to the Engineer listing the results of the day's PC thickness measurements.

Project acceptance (PA) testing will be the responsibility of the Engineer. PA testing consists of determining pavement thickness by measuring the length of cores taken by the Contractor from the hardened pavement as outlined below. Acceptance of the pavement thickness and price adjustment for deficient thickness will be based on project acceptance tests.

The Engineer will designate the time and location of the coring and will be present during the coring operation. The Contractor shall obtain 4-inch or 6-inch nominal diameter cores from the hardened pavement that are suitable for measuring per AASHTO T148. When the cores are removed from the pavement, the Engineer will take possession and determine their length per AASHTO T148.

The lower tolerance limit (TL) for pavement thickness shall be Plan Thickness (PT) minus 0.4 inches. This TL shall be used in the formulas in Section 105 for Incentive and Disincentive Payments (I/DP), Quality Levels (QL) and Pay Factor (PF) determinations. Any pavement thickness test value that exceeds the PT by more than 1.0 inch shall be assigned a value of PT plus 1.0 inch for the purpose of calculating the QL, PF and I/DP.

Core locations shall be determined by a random procedure so that each area has a randomly selected coring location. One core will be taken at each location.

Where the new portland cement concrete pavement (PCCP) overlays an existing roadway, cores for measuring pavement thickness shall be determined by a stratified random procedure in the longitudinal direction and by the point of minimum required thickness in the lateral direction as shown in the plans. If existing field conditions show a condition where the point of minimum thickness in the lateral direction as shown in the plans is not appropriate, the Contractor shall identify the location and extent of the area to the Engineer at least 24 hours before paving. The Engineer may exclude this area from pavement thickness measurements for incentive and disincentive payments.

Pavement thickness tests will be evaluated per subsection 105.06.

Additional cores will be taken at the direction of the Engineer as follows:

(1) One additional core at the location of each PC or PA test that is less than PT minus 1.0 inch.

(2) If the length of the additional core is greater than PT minus 1.0 inch, no additional actions will be taken, and the PA test core will be used to compute I/DP for the process that includes this material.

(3) If the length of the additional core is less than PT minus 1.0 inch, the area represented by this core shall become a separate process and this core will not be used to compute an I/DP. Exploratory cores shall be taken at intervals of 15 feet or less, parallel to the centerline in each direction from the affected location until two consecutive cores are found in each direction which are not less than PT minus 1.0 inch. Four additional randomly selected cores will be taken within the area represented by these cores. The four additional cores will be used to compute an I/DP per Section 105. Cores taken at locations not randomly determined, such as process control cores will not be used to compute I/DP.

Pavement areas found to be less than PT minus 1.0 inch shall be removed and replaced at the Contractor's expense.

When the removal and replacement have been completed, four additional randomly selected cores will be taken within the area represented by this core. The four additional cores will be used to compute an I/DP per subsection 105.06. Exploratory cores will not be used to compute I/DP.

The Contractor shall repair all core holes by filling them with an approved nonshrink high strength grout.

(b) *Pavement Thickness Using MPI*. The Contractor shall perform the process control (PC) testing for pavement thickness using MPI. A process control testing plan shall be submitted and must be approved before the start of paving. This PC testing plan shall include determining the thickness of hardened concrete pavement at a minimum frequency of one measurement per 1,250 linear feet of each traffic lane. All shoulders 8 feet or greater in width shall be tested as a separate traffic lane. Shoulders less than 8 feet wide shall be included in the adjacent lane. Areas such as sections of mainline pavement that are less than 1,250 linear feet long, intersections, entrances, crossovers, ramps, etc., shall be grouped into units of 1,000 square feet or remaining fraction thereof. A minimum of one random measurement shall be taken in each unit.

The Contractor's PC test results using MPI for pavement thickness will be used for Project Acceptance (PA) and used to calculate I/DP. PC testing will be witnessed by the Engineer.

The MPI results will be considered acceptable when the range of the three individual scans is less than or equal to 0.10 inches. If the three scans are not within 0.10 inches, a second set of three scans shall be taken. The three new scans will be considered acceptable when the range of the three individual scans is less than or equal to 0.10 inches. If the second set of three scans are not within 0.10 inches, the MPI for this location will not be used. A MPI test will be the result of the average of a set of three acceptable scans at a location. The average of the set of three scans shall be rounded to the nearest 0.04 inches. If a MPI location is unable to obtain three acceptable scans, a core shall be taken and used for thickness determination and I/DP.

A test section shall be conducted to verify the calibration and correlation of the MPI pavement thickness determination at the start of PCCP operations. The test section correlation shall be established in the first 7,500 square yards of PCCP per a stratified random sampling schedule as established in CP 75. The test section correlation verification shall consist of conducting ten pavement thickness measurements by taking a core at the MPI test locations. The Contractor shall obtain 4-inch nominal diameter cores from the hardened pavement that are suitable for measuring per AASHTO T148. When the cores are removed from the pavement the Contractor shall determine their length and then the Engineer will take possession and determine their length per AASHTO T148. A verification must be run for each MPI device used on the project. The verification of any MPI device can be run at the initial verification locations. The comparison of the PC MPI measurements and hardened concrete cores shall be within 0.15 inches to be considered a valid correlation between the two test methods.

After successful completion of the thickness measurement correlation verification process, a minimum of one hardened concrete core will be taken for every 25 MPI thickness measurements for core thickness determination. When a change in thickness or process occurs, the first three MPI location shall be cored for thickness. At a minimum, one MPI test location will be cored for thickness for each pavement thickness process, or as directed by the Engineer. A core may be taken when the MPI result is in doubt. The correlation between core and MPI thickness measurements shall be verified to be within 0.15 inches at the same location. If the thickness difference between the methods exceeds 0.15 inches, the next five MPI locations will be cored. If the thickness difference between the two methods exceeds 0.15 inches on any location the contractor shall use the coring method for acceptance until the MPI is repaired or replaced and verified. Previous MPI locations shall be cored until three successive thickness differences between the two methods is equal to or less than 0.15 inches. If the MPI device is not able to be repaired or replaced within 10,000 sq yd of paving, the acceptance method will revert to coring acceptance from the last acceptable MPI measurement. A new process for pavement thickness will be started for the change in method of measurement.

The lower tolerance limit (TL) for pavement thickness shall be Plan Thickness (PT) minus 0.4 inches. This TL shall be used in the formulas in Section 105 for Incentive and Disincentive Payments (I/DP), Quality Levels (QL) and Pay Factor (PF) determinations. Any pavement thickness test value that exceeds the PT by more than 1.0 inch shall be assigned a value of PT +1.0 inch for the purpose of calculating the QL, PF and I/DP.

MPI test locations shall be determined by a random procedure so that each area has a randomly selected coring location. A MPI test plate will be installed before paving. The location of the MPI test plate shall be at least 4 feet from any dowel bar locations, tie bar location and utility box cover locations. The operator of the MPI device should use composite safety boots to not interfere with the device.

Where the new PCCP overlays an existing roadway, MPI test locations shall be determined by a stratified random procedure in the longitudinal direction and by the point of minimum required thickness in the lateral direction as shown in the plans. If existing field conditions show a condition where the point of minimum thickness in the lateral direction as shown in the plans is not appropriate, the Contractor shall identify the location and extent of the area to the Engineer at least 24 hours before paving. The Engineer may exclude this area from pavement thickness measurements for incentive and disincentive payments.

Pavement thickness tests will be evaluated per subsection 105.06. Additional cores will be taken at the direction of the Engineer at the contractor’s expense as follows:

One additional core at the location of each process control (PC) test that is less than PT minus 1.0 Inch.

(1) If the length of the additional core is greater than PT minus 1.0 inch, no additional actions will be taken, and the core test result will replace the MPI result to compute I/DP

(2) If the length of the additional core is less than PT minus 1.0 inch the area represented by this PC test shall become a separate process and will not be used to compute an I/DP. The thickness of the pavement in this area will be determined by taking cores. Cores shall be taken at intervals of 15 feet or less, parallel to the centerline in each direction from this location until two consecutive cores are found in each direction which are not less than PT minus 1.0 inch. The pavement found to be less than PT minus 1.0 inch shall be removed and replaced at the Contractor's expense.

When the removal and replacement have been completed, four additional randomly selected cores will be taken within the area represented by this core. The four additional cores will be used to compute an I/DP per subsection 105.06.

The Contractor shall repair all core holes by filling them with an approved non-shrink high-strength grout.

412.22 Opening to Traffic. The pavement shall not be opened to traffic until the concrete has achieved a compressive strength of 3,000 psi. Concrete compressive strength shall be determined by maturity meters. Before opening the pavement to traffic the roadway shall be cleaned, as approved.

Before placement of concrete whose strength will be determined with maturity meters, the Contractor shall provide the Engineer a report of maturity relationships per CP 69. The Contractor shall provide maturity meters and all necessary wires and connectors. The Contractor shall be responsible for the placement and maintenance of the maturity meters and wires. At a minimum a maturity meter will be placed once per day and then once per 5,000 square yards. Placement shall be as directed by the Engineer.

For placements with multiple maturity meters, the lowest compressive strength shall determine when the pavement may be opened to traffic.

If a maturity meter fails, is tampered with, is destroyed or was not placed, the section of pavement represented by the maturity meter shall remain closed to traffic for a period of 28 days. The Contractor may choose at his own expense to core the section of pavement represented by the maturity meter. Cores will be obtained and tested according to CP 65. Cores will be a minimum of 4 inches in diameter. A minimum of three cores in a two square foot area will be obtained. If the compressive strength of any one core differs from the average by more than 10 percent that compressive strength will be deleted and the average strength will be determined using the compressive strength of the remaining two cores. If the compressive strength of more than one core differs from the average by more than 10 percent, the average strength will be determined using all three compressive strengths of the cores. To open the section of pavement, the average compressive strength of the cores shall be a minimum of 3,000 psi.

METHOD OF MEASUREMENT

412.23 The quantities of Concrete Pavement, and Place Concrete Pavement to be paid for under these items will be the number of square yards completed and accepted. The width for measurement will be the width of the pavement shown on the typical cross section of the plans, including additional widening where called for, or as otherwise directed by the Engineer in writing. The length will be measured horizontally along the centerline of each roadway or ramp.

The quantity of Furnish Concrete Pavement to be paid for under this item will be the number of cubic yards of concrete delivered and accepted. The concrete volume will be based on batch weights of the concrete converted to volumes by use of the conversion factor developed with the specific mix design. Quantities of concrete that are wasted, spilled, or used as a result of excessive thickness shall be deducted from the pay quantity. Excessive thickness shall be considered any thickness in excess of 1/2 inch greater than the specified depth that continues for a length of 200 feet or more. Yield shall be determined per AASHTO T 121. Where concrete is paid for by cubic yard batched, the pay quantities for all concrete produced with a relative yield less than 0.99 shall be corrected per the following formula:

Corrected cubic yards = (cubic yards batched) • (relative yield)

Reinforcement other than dowels, tie bars, and other joint material will be measured by the pound.

BASIS OF PAYMENT

412.24 General. The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Concrete Pavement (__Inch)	Square Yard
Place Concrete Pavement	Square Yard
Furnish Concrete Pavement	Cubic Yard

The price per square yard of Concrete Pavement shall be full compensation for furnishing and placing all materials, including dowels, tie bars, joint materials, texturing, sawing, finishing, and rumble strips.

The price per square yard for Place Concrete Pavement shall include everything included in the pay item, Concrete Pavement, except furnishing concrete.

The price per Cubic Yard for Furnish Concrete Pavement shall be full compensation for furnishing the concrete to the project site.

Reinforcing steel will be measured and paid for per Section 602.

Furnishing, installing, and monitoring vibrators and vibrator monitoring device will not be measured and paid for separately, but shall be included in the work for concrete pavement.

Incentive and Disincentive Payments (I/DP) will not be made on interim estimates. I/DP will be made when the concrete pavement or a major phase of the concrete pavement has been completed and all the data for computing the I/DP is available.

Furnishing, calibrating and use of maturity meters, wire and other appurtenances including the molding, curing and breaking of cylinders for calibration and placement of calibration slabs will not be measured and paid for separately, but shall be included in the work.

All costs associated with developing correlation curves used to evaluate low flexural strength results per the Contract, or as requested by the Engineer, shall be included in the work. This shall include all materials, forms, testing, equipment and labor.

(a) Where the pavement thickness is more than Plan Thickness (PT) minus 1.0 inch, I/DP for the element of pavement thickness will be applied to the contract unit price per subsections 105.06 and 412.21. I/DP for other elements will be applied to the contract unit per Section 105.

Adjustments in payment because of deviations in air content will be per subsection 601.17 using $100 per cu. yd. for the unit bid price.

DESCRIPTION

412.25 Cross Stitching. This work consists of cross stitching longitudinal cracks and joints by directionally drilling holes in concrete pavement, injecting grout, and inserting deformed steel reinforcing bars per these specifications and the details shown on the plans. Cross stitching shall not be used for thin concrete overlays (8 inches or less).

MATERIALS

412.26 Materials for cross stitching shall be #6 or #8 deformed steel reinforcing bars, grade 60, epoxy coated, with length as specified on the plans.

Epoxy or cementitious grout shall be on the Department's Approved Products List. The epoxy shall be either an epoxy or polyester resin. The epoxy or cementitious grout shall be submitted to the Engineer for approval at least five working days in advance of the commencement of cross stitching work.

412.27 Placement. Directionally drilled holes shall be 1.000 to 1.125-inch diameter for #6 bars and 1.125 to 1.375-inch diameter for #8 bars and drilled at an angle from the horizontal designated on the plans. Holes shall be started at a distance shown on the plans on a line perpendicular to the crack/joint and shall extend through the crack/joint. Drilled holes shall be spaced on 20-inch centers and shall alternate from side to side along the full length of the crack/joint. Holes shall not be drilled within 24 inches of an existing transverse joint. Holes shall not extend through the bottom of the slab.

Drilled holes shall be blown free of drill dust, dirt, and moisture with oil and moisture-free compressed air immediately before placing the grout.

Holes shall be filled with epoxy/grout by injecting from the bottom of the hole. The Contractor shall insert the tie bar and remove excess epoxy/grout and finish flush with the pavement surface.

Pavement may be opened to traffic when the epoxy/grout is dry to the touch.

412.28 Equipment. The drill for boring the cross stitch holes shall be selected to minimize damage to the concrete surface. The drill shall be capable of low-impact operation in order to minimize spalling damage and prevent bottom breakout of the concrete pavement. The drill shall be skid or frame mounted. Handheld drilling will not be allowed.

The first ten holes shall be visually inspected to determine if the bottom of the slab has broken out and measured for length of minimum embedment. Installation of the tie bars and epoxy shall not occur until the Contractor's drilling method has been inspected and approved. After the Contractor's method has been approved, the Contractor may proceed with cross stitching so long as the method and equipment remain the same.

Drill bit changes do not require re-inspection. If the Contractor's method or equipment changes, the first10 holes made with the new method shall be visually inspected to determine if the bottom of the slab has broken out and measured for length of minimum embedment.

BASIS OF PAYMENT

412.29 Cross stitching will be measured for payment by the number of cross stitches placed.

Payment will be made under:

Pay Item	**Pay Unit**
Cross Stitching	Each

The accepted quantity of drilled holes, filled with epoxy/grout and reinforcing bars will be paid for at the contract unit price per each hole drilled. Payment for deformed bars, grout, labor, materials, equipment, tools and incidentals necessary for completion of the work will not be measured and paid for separately but shall be included in the work.

DESCRIPTION

412.30 Slot Stitching. This work consists of installing tie bars across cracks in concrete pavement per these specifications and the details shown on the plans. Slot stitching shall not be used for thin concrete overlays (4 inches or less).

MATERIALS

412.31 Concrete patching material to be used as backfill shall be a product on the Department's Approved Products List. Concrete patching material shall attain an average compressive strength of at least 4,500 psi at 24 hours. Concrete patching material compressive strengths shall be tested according to ASTM C39 or ASTM C109. Concrete patching material shall provide a minimum bond strength of 1,000 psi at 24 hours, as tested by ASTM C882. Concrete patching material shall have a relative durability factor greater than 90 as tested by ASTM C666 method A. Concrete patching material shall have a maximum shrinkage of 0.13 percent at four days as tested by ASTM C157.

Steel tie bars shall be 18 inches long #6 deformed steel tie bars, grade 60, and epoxy coated.

CONSTRUCTION REQUIREMENTS

412.32 Slot Formation. Slots shall be made from multiple saw cuts made with a diamond impregnated saw blade to a depth as shown on the plans. Slots shall be approximately perpendicular to the general trend of the crack. Slots shall be 1.75 to 2.25 inches wide. Lightweight jackhammers weighing less than 35 pounds or hand tools shall be used to remove the "fins" formed by sawing. The length of the slot shall allow the tie bar to be placed at the mid-depth of the slab with a 1-inch space between the ends of the tie bar and the ends of the slot. Deviations from this method require a method statement detailing the means and methods for how the Contractor will perform the work.

The Contractor shall demonstrate slot stitching work for approval using the proposed equipment and procedures. The first five slots shall be visually inspected for bottom of the slab breakouts and minimum dimensions. Installation of tie bars and concrete patching

material shall not occur until the Contractor's method has been inspected and approved. After the Contractor's method has been approved, the Contractor shall proceed with slot stitching as long as the method and equipment remain the same. Saw blade changes do not require re-inspection. If the Contractor's method or equipment changes, the first five slots of the new method shall be visually inspected for bottom of the slab breakouts and measured for minimum dimensions. Tie bars shall be provided at locations and spacing as detailed on the plans.

Damages to the concrete pavement caused by the Contractor's operations shall be repaired at the Contractor's expense.

Slots shall be sand blasted or water blasted to remove saw slurry and blown clean with high pressure oil-free air to remove sand, water, and dust.

Tie bars shall be placed on support chairs to rest horizontal at the mid-depth of the slab.

Concrete patching material mixing, placement, placement during cold temperatures, consolidation, and curing shall be per the manufacturer's recommendations. A mix may be extended with aggregate per the manufacturer's recommendations up to 90 percent of the manufacturer's maximum extension. The maximum aggregate size shall be 3/8 inch for the extending aggregate.

Patching material shall be placed and consolidated in the slot. Patching material shall fill the space under and around the bar. Tie bars shall not be dislodged or moved out of position.

The surface of the concrete patching material shall be level with the adjacent pavement.

412.33 Opening to Traffic. The pavement shall not be opened to traffic until all tie bars have been installed at a joint and the concrete has obtained a minimum compressive strength of 3,000 psi. Pavement shall be cleaned before opening to traffic.

METHOD OF MEASUREMENT

412.34 Method of Measurement. Slot stitching will be measured for each completed and accepted tie bar complete in place.

BASIS OF PAYMENT

412.35 The accepted quantities will be paid for at the contract unit price for the pay item listed below.

Payment will be made under:

Pay Item	**Pay Unit**
Slot Stitching	Each

The work performed and materials furnished per this item will be paid for at the unit price bid. This price is full compensation for furnishing all materials, tools, labor, equipment and incidentals necessary to complete the work. Payment will not be made for extra work required to repair damage to the adjacent pavement that occurs during slot stitching.

DESCRIPTION

412.36 Dowel Bar Retrofit. This work consists of placing epoxy coated smooth dowel bars in transverse joints as identified on the plans. This shall be done by cutting slots into the existing concrete pavement, installing dowel bars, and filling the slots at locations as shown on the plans. The surface shall be finished as approved by the Engineer. All work, including the concrete pavement slot preparation, inserting dowel bars, filling the slot with backfill material, and finishing the surface shall be performed per these specifications and the details shown on the plans.

MATERIALS

412.37 Materials for dowel bars shall meet the requirements in subsection 709.03. Dowels shall be equipped with tight fitting, non-metallic end caps to allow 1/4-inch bar movement.

Concrete patching material to be used as backfill shall be a product on the CDOT Approved Products List. Concrete patching material shall attain an average compressive strength of at least 4,500 psi at 24 hours. Concrete patching material compressive strengths shall be tested according to ASTM C39 or ASTM C109. Concrete patching material shall provide a minimum bond strength of 1,000 psi at 24 hours, as tested by ASTM C882. Concrete patching material shall have a relative durability factor greater than 90 as tested by ASTM C666 method A. Concrete patching material shall have a maximum shrinkage of 0.13 percent at four days as tested by ASTM C157. The proposed material shall be submitted to the Engineer for approval at least five days in advance of the start of dowel bar placement. Installation of dowel bars shall not begin until approval has been received in writing from the Engineer.

CONSTRUCTION REQUIREMENTS

412.38 Slots for dowel bars shall be cut perpendicular to the transverse joint as shown on the plans by using a slot cutting machine or walk-behind saw. Slots shall be of adequate length and width to accommodate the dowel bar, as shown on the plans or as directed. The concrete in the slot shall be removed by using a lightweight jackhammer weighing a maximum of 30 pounds, or hand tools, to half slab depth. All damage to the concrete slab outside of the slot shall be repaired or replaced at the Contractor’s expense. Slots shall be placed at locations shown on the plans.

Slots shall be removed of all debris and cleaned before placement of dowel bars by sandblasting or other procedure so that clean aggregate is exposed. Before placement of backfill material, each dowel bar shall be equipped with a 1/4- to 3/8-inch-thick foam core board to provide a tight seal at the joint. Dowels shall be placed on chairs so that the bar is sitting a minimum of 1/2 inch above the bottom of slot and perpendicular to the transverse joint. The chairs shall be epoxy-coated steel or plastic rigid enough to hold the dowel in place during grout placement. The existing transverse joints shall be sealed with an approved joint sealant along the bottom and sides of the slot to prevent backfill material from infiltrating the joint. The joint sealant material shall be on the CDOT Approved Products list and shall be approved by the Engineer before use.

Backfill material to be placed shall be mixed according to the manufacturer’s recommendations. Once in the slot, the material shall be vibrated thoroughly so that the entire bar is encased with the consolidated material. The slot shall be slightly overfilled, and the area shall be diamond ground once the material has cured to provide a smooth pavement surface.

After grinding, transverse joints shall be sawed and sealed per subsection 412.18.

412.39 Opening to Traffic. The pavement shall not be opened to traffic until all dowel bars have been installed at a joint and the concrete has obtained a minimum compressive strength of 3,000 psi. Pavement shall be cleaned before opening to traffic.

METHOD OF MEASUREMENT

412.40 Dowel bar retrofit in concrete pavement will be measured as the actual number of dowel bars placed and accepted.

BASIS OF PAYMENT

412.41 The accepted quantities will be paid for at the contract unit price for the pay item listed below.

Payment will be made under:

Pay Item	Pay Unit
Concrete Pavement Dowel Bar Retrofit	Each

The accepted quantity of dowel bar slots cut, filled with accepted patching material, and dowel bars will be paid for at the contract unit price per each bar installed. Payment for cutting slots, support chairs, joint sealant, patching, and all labor, materials, equipment, tools and incidentals necessary for completion of the work will not be measured and paid for separately but shall be included in the work. Payment will not be made for extra work required to repair damage to the adjacent pavement that occurs during dowel bar retrofitting.

SECTION 420

GEOSYNTHETICS

DESCRIPTION

420.01 This work consists of furnishing and installing geotextiles and geomembranes for paving, impervious lining, erosion control, drainage, separators and landscape weed barrier.

MATERIALS

420.02 Geotextiles and geomembranes shall meet the applicable requirements of subsections 712.07 and 712.08 for the use intended. Geotextiles for erosion control for drainage or for separators may be Class 1, Class 2, or Class 3, conforming to subsection 712.08, if the class is not specified on the plans.

Asphalt cement binder for the paving geotextile shall be the same grade as the asphalt cement used for Item 403.

Paving geotextile shall be a minimum Class 3, conforming to subsection 712.08.

CONSTRUCTION REQUIREMENTS

420.03 Areas where the geosynthetic is to be placed shall have a uniform slope, be reasonably smooth, free from mounds and windrows, and free of any debris or projections that could damage the material.

Riprap or cobbles placed on the geosynthetic shall not be dropped from a free fall greater than 3 feet. The cushion layer or initial layer of riprap may require careful placement without free fall to avoid geosynthetic damage. Geosynthetics damaged or displaced before or during placement of overlying layers shall be replaced or repaired per the requirements of this section and to the satisfaction of the Engineer, at the Contractor's expense.

420.04 Paving. The areas to be treated shall be as designated on the plans. The pavement surface shall be broomed clean immediately before beginning the crack reduction geotextile treatment using a self-propelled power broom.

The asphalt cement binder shall be applied to the pavement surface at the rate of approximately 0.25 gallon per square yard. The exact application rate shall be as recommended by the geotextile manufacturer, and at a temperature of 300 to 350 °F. Paving geotextile shall be applied, per the manufacturer's recommendations, immediately after the application of asphalt cement binder.

Construction equipment, including dump trucks, shall not make sudden stops or starts or sharp turning movements on the geotextile. Dump trucks shall not park on the geotextile before dumping into the asphalt paver.

Traffic shall be kept off all newly placed binder and geotextile material until the asphalt surface has been placed.

The minimum temperature of the hot mix asphalt at the time compaction begins shall be 250 °F.

The Contractor shall make arrangements with the geotextile supplier to have a technician, skilled in this paving geotextile work, present at the project site during this work to give any technical assistance needed.

420.05 Impervious Lining. Geomembranes for lining shall be loosely laid (not stretched) to avoid any rupture of the lining. If field lap joints are necessary, the joints shall be formed by lapping the edges of panels per the manufacturer's recommendations. The contact surfaces of the panels shall be cleaned to remove all dirt, dust, and other foreign materials. Sufficient cold-applied vinyl to vinyl bonding adhesive shall be applied to the contact surfaces in the joint area and the two surfaces pressed together immediately. Wrinkles in the joints shall be smoothed out.

Necessary repairs to the geomembrane shall be patched using the geomembrane material itself and cold-applied vinyl to vinyl bonding adhesive. The bonding adhesive shall be applied to the contact surfaces of both the patch and the lining to be repaired and the two surfaces pressed together immediately. Any wrinkles in the repair joints shall be smoothed out.

420.06 Erosion Control and Drainage. Geotextiles for erosion control or drainage shall be loosely laid (not stretched) with the roll direction the same as the anticipated water flow, and in a manner that avoids any rupture of the cloth.

The geotextile may be anchored in place with securing pins at 3-foot spacing along but not closer than 2 inches to all edges and to the extent necessary to prevent displacement. When shown on the plans, erosion control geotextile may be held in place using 6 inches of clean embankment with a minimum 6-inch trench at the top of the slope. Overlaps shall be at least 12 inches on slopes 3:1 and flatter, and at least 24 inches on slopes steeper than 3:1. Laps shall be made with the uphill layer on top. Sewn seams per the manufacturer's recommendations may be used in place of overlaps. Full rolls shall be used whenever possible in order to minimize the number of roll end laps. Lengths and widths of individual sheets shall be at the Contractor's option.

420.07 Geotextile Separator. The geotextile shall be unrolled as smoothly as possible on the prepared subgrade in the direction of construction traffic. The geotextile shall be placed by machinery or by hand labor. The geotextile shall not be dragged across the subgrade. Wrinkles and folds in the geotextile (not associated with roadway curves) shall be removed by stretching and staking as required. The geotextile may be held in place before placement of cover by pins, staples or piles of fill or rock. On curves, the geotextile may be folded to conform to the curve. The fold or overlap shall be in the direction of construction and held in place as prescribed above. Adjacent geotextile rolls shall be overlapped in the direction of subbase placement using the guidelines in Table 420-1. Before covering, the condition of the geotextile will be inspected by the Engineer to determine that no holes, rips or other defects exist. If any defects are observed, the section of the geotextile containing the defect shall be repaired by placing a new layer of geotextile extending beyond the defect in all directions a minimum distance equal to the overlap shown in Table 420-1. Alternatively, the defective section may be replaced.

Either sewn seams or overlaps (unsewn seams) shall be used in construction. The widths of the overlaps shall conform to Table 420-1. Sewn seams shall be per the manufacturer's recommendations.

The first lift of cover material shall be end-dumped or spread over the geotextile from the edges of the geotextile. The height of the dumped pile shall be limited to avoid local bearing capacity failures. The first lift of cover material shall be graded to a 12-inch thickness or to top of grade whichever is less and compacted. Equipment shall not be on the treated area with less than the minimum thickness of compacted cover material over the geotextile. Small dozer equipment or front-end loader shall be used to spread the cover material.

Construction vehicles shall be limited in size and weight such that rutting in the initial lift is no deeper than 3 inches. If rut depths exceed 3 inches, the Contractor shall use a smaller size and weight of construction vehicles. Ruts shall be filled in with cover material.

Compaction of lifts shall be accomplished without damaging the geotextile.

Construction equipment shall not make turns on the first lift of cover material.

Table 420-1
MINIMUM REQUIRED OVERLAP

Subgrade Strength R-Value	Overlap Width (Unsewn Seam) Inches
5 – 10	30
10 – 20	24
>20	18

420.08 Landscape Weed Barrier. Landscaped and mulched areas to be covered by geotextile shall be brought to finish grade below the depth of the mulch material shown on the plans. All soil preparation shall be completed before geotextile application.

Geotextile for landscape weed barrier shall be a minimum Class 3, conforming to subsection 712.08.

The geotextile shall be rolled directly onto prepared soil in the direction of water flow. The geotextile shall be applied loosely without stretching. The top edge of the geotextile shall be buried in a 6-inch check slot at the top of the slope and stapled. When specified, metal landscape border shall be placed adjacent to check slot on the uphill side, so as not to puncture the geotextile.

Where one roll of geotextile ends and a second roll begins, the upslope piece shall be brought over the start of the second roll and overlapped per the manufacturer's recommendation. Where two or more widths of geotextile are applied side by side, they shall be overlapped per the manufacturer's recommendation. Staples shall be inserted at a 2-foot spacing along the outer edges of the geotextile where a metal border is not used.

In level planting beds, geotextile shall be secured under metal landscape border by extending the geotextile 6 inches beyond the metal landscape border and driving stakes through the geotextile.

METHOD OF MEASUREMENT

420.09 Geomembranes and geotextiles will be measured by the square yard of surface area covered, complete in place.

BASIS OF PAYMENT

420.10 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Geomembrane	Square Yard
Geotextile (Erosion Control) (Class__)	Square Yard
Geotextile (Drainage) (Class__)	Square Yard
Geotextile (Weed Barrier)	Square Yard
Geotextile (Paving)	Square Yard
Geotextile (Separator) (Class__)	Square Yard

Securing pins, staples, adhesives, sewn seams, asphalt cement, brooming, skilled technician, and other work and materials necessary for placement will not be measured and paid for separately but shall be included in the work.

DIVISION 500
STRUCTURES

SECTION 501
STEEL SHEET PILING

DESCRIPTION

501.01 This work consists of furnishing and driving corrugated steel sheeting or steel sheet piling per these specifications and in conformity to the lines and grades shown on the plans or established.

MATERIALS

501.02 Type I Steel Sheet Piling shall be used where shown on the plans and shall be a corrugated steel sheeting non-galvanized interlocking type, at least 8 gauge in thickness with a minimum section modulus of 1.300 cubic inches per unit of 12 inches in width. Steel sheeting shall conform to ASTM A857, Grade 36 for 7 gauge or 8-gauge steel, Grade 30 for heavier gauges. The sides for each piece of sheeting shall be furnished with an interlock that is continuous for the full length of the sheeting. The interlock shall have an opening of sufficient width to allow free slippage of the adjoining sheet.

501.03 Type II Steel Sheet Piling shall be of the type and weight shown on the plans and shall conform to the requirements of AASHTO M 202 or AASHTO M 270, Grade 50.

CONSTRUCTION REQUIREMENTS

501.04 Steel sheet piling shall be driven to form a tight bulkhead. A driving head shall be used and any piling that does not provide a tight bulkhead shall be pulled and replaced at the Contractor's expense.

Steel sheet piling that is full length as shown on the plans and is required to be driven below the specified cut-off elevation shall be spliced with additional steel sheet piling with a full penetration butt weld. Splicing will be limited to three per pile sheet. A splice shall not be less than 3 feet from another splice on the same pile.

Welding shall conform to the applicable requirements of ANSI/AWS D 1.1.

Where specified on the plans, sheet piling shall be painted as described in subsection 509.24.

METHOD OF MEASUREMENT

501.05 Steel sheet piling will be measured by the square foot, complete in place and accepted, to cut-off elevation. Each approved splice will be measured as an additional 3 square feet of sheet pile.

The area of sheet piling cut-off to be measured will be those random areas of sheet piling that result from cutting off the tops of driven sheet piling and not used in the work.

BASIS OF PAYMENT

501.06 The accepted quantities of steel sheet piling will be paid for at the contract unit price per square foot of each type used.

Payment will be made under:

Pay Item	Pay Unit
Steel Sheet Piling (Type__)	Square Foot

Sheet piling cut-offs 10 square feet or less in area will be paid for at the contract unit price less 20 percent. These cut-offs shall become the property of the Contractor.

Sheet pile cut-offs greater than 10 square feet will not be paid for.

SECTION 502
PILING

DESCRIPTION

502.01 This work consists of furnishing and driving foundation piles, other than sheet piling.

MATERIALS

502.02 Rolled Structural Steel Piles. Steel used in rolled structural steel piles shall conform to the requirements of ASTM A572/A572M or ASTM A992/A992M. Sections of piles shall be of "H" or "W" shape. The flange projection shall not exceed 14 times the minimum thickness of metal in either the flange or the web, and flange widths shall not be less than 80 percent of the depth of the section. The nominal depth in the direction of the web shall not be less than 8 inches. Flanges and web shall have a minimum nominal thickness of 0.375 inches or greater.

502.03 Steel Pipe Piles. Steel pipe piles shall conform to the requirements of ASTM A252, Grade 2 or higher. Ends of closed-end pipe piles shall be closed with a flat plate, forged or cast steel conical point, or other end closure design approved by the Engineer. End plates used on closed-end pipe piles shall be made of ASTM A36/A36M steel or better. End plates shall have a minimum thickness of 0.75 inches. The diameter and thickness of the end plates shall be as shown on the plans. The end plate shall be cut flush with the outer pile wall. The end of the pipe shall be beveled before welding to the end plate using a partial penetration groove weld.

502.04 Protective Coatings. If there is a required protective coating, the Contractor shall restore or repair any damage to the coating.

CONSTRUCTION REQUIREMENTS

502.05 Pile Driving Equipment. All equipment, including the pile driving hammer, hammer cushion, helmet, pile cushion, and other appurtenances to be furnished by the Contractor shall be approved in advance by the Engineer before any driving can begin. Pursuant to obtaining this approval, the Contractor shall submit a description of pile driving equipment to the Engineer at least two weeks before pile driving is to begin. The description shall contain sufficient detail so that the proposed driving system can be evaluated by wave equation analysis. The Contractor shall submit to the Engineer results of a wave equation analysis to show that the piles are drivable.

Hammer efficiencies shown in Table 502-1 shall be used in the wave equation analysis of vertical piles unless better information is available. Hammer efficiencies shall be adjusted for batter driving.

Table 502-1
PILE DRIVING HAMMER EFFICIENCIES

Hammer Type	Hammer Efficiency (%)
Single-acting steam/air	67
Double-acting steam/air	50
Diesel	80
Hydraulic or diesel with built-in energy measurement	90

For steam, air, and diesel hammers, a minimum manufacturer's rated energy for specific HP Piles sizes shall be used as shown in Table 502-2.

Table 502-2
MINIMUM MANUFACTURER'S PILE DRIVING
HAMMER RATED ENERGY PER PILE SIZE

Pile Size	Area (Square Inches)	Minimum Energy (Foot-Pounds)
HP 10x42	12.4	26,000
HP 10x57	16.8	26,000
HP 12x53	15.5	26,000
HP 12x74	21.8	42,000
HP 14x89	26.1	52,000
HP 14x117	34.4	68,000

The rated energy of the hammer shall not be greater than 2,500 foot-pounds per square inch of unit area. Exceptions to these limits are permissible if it is demonstrated by wave equation analysis that the piles can be safely and efficiently installed with hammers having ratings outside of these energy limits.

The criteria that the Contractor and the Engineer will use to evaluate the driving equipment shall consist of both the required number of hammer blows per foot at the required nominal resistance and the pile driving stresses over the entire driving process. The required number of hammer blows indicated by the wave equation analysis at the required nominal driving resistance shall be between 30 and 120 blows per foot for the driving equipment to be deemed acceptable.

In addition, the piles stresses, which are determined by the wave equation analysis for the entire driving operation, shall not exceed 90 percent of the yield point of the steel pile material.

During pile driving operations, the Contractor shall use the approved system. Any change in the driving system shall be considered only after the Contractor has submitted revised pile driving equipment data and wave equation analysis. The Contractor shall be notified of the acceptance or rejection of the driving system changes within two working days of the Engineer's receipt of the requested change. The time required for submission, review, and approval shall not constitute the basis for a contract time extension to the Contractor.

Approval of the piling driving equipment shall not relieve the Contractor of responsibility to drive piles, free of damage, to the required nominal resistance and, if specified, the minimum penetration, shown in the contract documents.

(a) Pile Hammers. Steam, air, diesel, or hydraulic impact hammers shall be used to drive all types of piles.

1. Single or Double Acting Steam and Air Hammers

Proximity switches and an electronic readout device shall be provided before driving piling. Hammer performance shall be evaluated by the Contractor at the end of driving each pile by measuring blows per minute and comparing these blows with the manufacturer's recommendations.

2. Diesel Hammers

If open-end (single-acting) diesel hammers are not equipped with a device to measure impact velocity at all times during pile driving operations, the stroke shall be obtained by the Contractor by measuring the speed of operation either manually or with a device that takes the measurement automatically.

Closed-end double acting diesel hammers shall be equipped with an accurate bounce chamber pressure gauge. The Contractor shall provide the Engineer a calibrated chart equating bounce chamber pressure to either equivalent energy or stroke for the closed-end diesel hammer to be used. A copy of calibration records of actual hammer performance performed within 90 days before the beginning of the work shall be submitted to the Engineer.

3. Hydraulic Hammers

Hydraulic hammers shall be equipped with a controlled variable stroke system and a readout device to measure ram energy. The plant and equipment shall be equipped with accurate pressure and velocity gauges and an energy readout device.

4. Vibratory Hammers

Vibratory or other pile driving methods may be used only when specified in the Contract or in writing by the Engineer. Except when pile lengths have been evaluated from static load test piles, the nominal driving resistance of piles driven with vibratory hammers shall be verified by additional driving of the first pile driven in each group of 10 piles with an impact hammer of suitable energy to measure the nominal resistance before driving the remaining piles in the group. In case of variable soils, additional piles shall be verified by an impact hammer as directed by the Engineer. All piles that rely primarily on point bearing capacity shall be re-driven with an impact hammer.

(b) Hammer Cushion. All impact pile driving equipment shall be equipped with a suitable hammer cushion to prevent damage to the hammer or piles and to ensure uniform driving behavior. Wood, wire rope, and asbestos cushion material shall not be used. A striker plate recommended by the hammer manufacturer shall be used. Any hammer cushion whose thickness is reduced by 10 percent or more of the original thickness shall be replaced at the Contractor's expense before driving is permitted to continue.

(c) Leads. Pile driving leads shall be constructed in a manner that affords the pile hammer freedom of movement while maintaining alignment of the pile hammer and the pile to ensure concentric impact for each blow. Leads may be either fixed or swinging. Swinging leads shall be fitted with a pile gate at the bottom of the leads and shall be long enough to be securely fixed at the ground at all times.

(d) Followers. Followers shall be used only when specified on the plans or approved in writing by the Engineer. The follower and pile shall be maintained in proper alignment during driving. The follower shall be of such material and dimensions to permit the piles to be driven to the blow count determined to be necessary.

(e) Jetting. Jetting is permitted only if specified in the Contract or approved in writing by the Engineer. The Contractor shall determine the number of jets and the volume and pressure of water at the jet nozzles necessary to freely erode the material adjacent to the pile.

The Contractor shall control and dispose of all jet water per subsection 107.25. If jetting is specified or approved by the Engineer and is performed according to the specifications or as approved by the Engineer, the Contractor shall not be held responsible for any damage to the site caused by jetting operations. If jetting is used for the Contractor's convenience, the Contractor shall be responsible for all damages to the site caused by jetting operations.

Unless otherwise specified by the Engineer or the Contract, jet pipes shall be removed before or when the pile tip is 5 feet above the minimum or final tip elevation, and the pile shall be driven with an impact hammer, without jetting, to the final tip elevation or to the required nominal resistance. If the required nominal resistance is not reached at the final tip elevation, the pile may be set up and the required nominal resistance will be determined by re-striking the pile.

502.06 Driving Piles. Piles shall not be driven until required excavation or fill placement is complete, unless authorized by the Engineer. After driving is complete, all loose and displaced material shall be removed from around the piling before pouring any concrete.

Piles shall be driven within a variation of 1/4 inch or less per foot from the vertical or from the batter shown on the plans. The tendency of steel piles to twist or rotate shall be prevented and corrected. Foundation piles shall be within 6 inches of the position shown on the plans after driving. No pile shall be closer than 4 inches from an edge of the pile cap. Pulling or pushing laterally on installed piles to correct misalignment or splicing a properly aligned section on a misaligned section will not be allowed. The at cutoff elevation shall be within 2 inches of plan elevation for bent caps supported by piles.

Piles driven at integral end bents shall be installed so that the axial alignment of the top 10 feet of the pile is within two percent of the specified alignment.

The order of placing individual piles within a pile group shall begin from the center of the group and proceed outward in both directions unless an alternate installation sequence is approved by the Engineer in writing. For a bent with a single row of piles, pile driving shall begin at one end of the bent and proceed toward the opposite end.

If the location or alignment tolerances are exceeded, the extent of overloading shall be investigated. If the Engineer determines that corrective measures are necessary, such corrective measures shall be designed and constructed by the Contractor. Proposed corrective measures will be subject to approval by the Engineer.

502.07 Predrilling to Facilitate Pile Driving. Drilled holes shall be 2 inches smaller than the diameter or diagonal of the pile cross-section. If subsurface obstructions, such as boulders or rock layers, are encountered, the hole diameter may be increased to the least dimension that is adequate for pile installation. Except for end bearing piles, drilling shall be stopped at least 5 feet above the pile tip elevation shown on the plans. The pile shall then be driven with an impact hammer to the specified penetration resistance. Where piles are to be end bearing on rock or very dense cobbles and gravels (hardpan), drilling may be carried to the surface of the rock or the hardpan. The piles shall then be driven with an impact hammer to ensure proper seating. Any void space remaining around the pile after completion of driving shall be filled with sand, pea gravel, concrete, or other materials as specified in the Contract. If the diameter of the drilled hole is exceeded due to sloughing, drifting, over-drilling, or other causes, additional material required to fill this added void area will be at the Contractor's expense.

The Engineer will determine if shooting holes with explosives or redesign is necessary when piles cannot be driven or holes drilled.

When test piles are shown on the plans they shall be used to determine if drilling or jetting holes to facilitate pile driving is required. If the test pile or piles do not reach the minimum tip elevation shown on the plans and do not develop the required nominal resistance as specified in subsection 502.09, holes shall be drilled or jetted to facilitate pile driving.

502.08 Filling and Capping Piles. Steel pipe piles will be inspected after all adjacent piles within a 5-foot radius have been driven. Before concrete is placed in the pipe pile, it shall be inspected by an acceptable method to confirm the full pile length and dry bottom condition. If accumulations of water in the pipe piles are present, the water shall be removed before the concrete is placed. The concrete for concrete-filled pipe piles shall be Class BZ and shall conform to the requirements of section 601.

Concrete shall be placed in each pipe pile in a continuous operation. No concrete shall be placed until all driving within a radius of 15 feet of the pipe pile has been completed, or all driving within a 15-foot radius shall be discontinued until the concrete in the last pipe pile cast has set for at least two days.

502.09 Determination of Nominal Driving Resistance. The Engineer will use one of the following methods as specified to determine the nominal driving resistance of a driven pile.

(a) Wave Equation Analysis. The Engineer will use a wave equation analysis to determine the driving criterion necessary to reach the required nominal driving resistance of the pile. Soil and pile properties to be used in this analysis shall be as shown in the Contract or as determined by the Engineer. The Contractor shall supply the Engineer the necessary information on the proposed driving equipment to perform the wave equation analysis.

(b) Dynamic Testing. The length of the pile used in the dynamic test shall be a minimum of 10 feet greater than the estimated length of production piles in order to provide for variation in soil conditions. Dynamic monitoring shall be performed to obtain the nominal driving resistance, pile driving stresses, pile integrity, pile driving system performance, and final driving criteria. Dynamic monitoring shall be conducted by Pile Driving Analyzer (PDA) per ASTM D4945. PDA shall be performed on the first pile driven to the plan requirements.

A minimum of one production pile per bent (abutment or pier foundation) shall be monitored as a test pile. Dynamic monitoring shall be conducted by the Contractor's Engineer. The Contractor's Engineer conducting the PDA shall be a licensed Professional Engineer who has achieved one of the following certification levels: intermediate, advanced, master, or expert through the Dynamic Measurement and Analyses Proficiency Test conducted by Pile Dynamics, Inc., and the Pile Driving Contractors Association. A Contractor's Engineer with a lower certification level than intermediate can provide dynamic monitoring as long as this individual is under the direct supervision of an Engineer with intermediate certification level or higher.

The Contractor shall notify the Project Engineer at least seven calendar days before the scheduled date of driving piles to be monitored by PDA. The Contractor shall confirm the driving date three calendar days before the scheduled driving date. The Contractor shall indicate where foundation production pile driving is to begin. The Contractor's Engineer conducting the PDA will provide final driving criteria for the indicated foundation.

Each pile to be tested shall be instrumented with force and acceleration transducers. The transducers shall be installed before striking the pile. The pile driving may need to be temporarily interrupted for the transducers to be adjusted or replaced, or for the monitoring results to be assessed.

The Contractor shall drive the test pile to the minimum tip elevation and to the penetration depth that the dynamic test equipment indicates that the nominal driving resistance shown on the plans has been achieved. The Contractor may reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer in order to maintain stresses below the value shown in subsection 502.05. If non-axial driving is indicated by the dynamic test equipment measurements, the Contractor shall immediately realign the hammer system.

If restriking is specified in the Contract documents, the Contractor shall wait at least one hour before the restriking of the test pile. The hammer shall be warmed up before restriking begins by applying at least 20 blows to another pile or other fixed object. The maximum amount of penetration required during restrike shall be 3 inches, or the total number of hammer blows shall be 20, whichever occurs first. If the pile does not achieve the required nominal driving resistance during restrike, the Contractor's Engineer conducting the PDA shall specify additional pile penetration and testing.

If the required nominal driving resistance has been reached in natural ground and piles have not been driven to the estimated tip elevation, but have been driven below minimum tip elevation, the Contractor's Engineer conducting the PDA may direct the driving to be continued for 40 additional blows.

Once the dynamic monitoring is complete, the Contractor's Engineer conducting the PDA shall run Case Pile Wave Analysis Program (CAPWAP) analyses and shall provide the final driving criteria the same day of the test to the Engineer. Production piles driven before receipt of the final driving criteria shall be done at the Contractor's risk. Final driving criteria for additional structures shall be provided within two business days of the test or when multiple test piles are dynamically tested the same day. A detailed report electronically sealed by the Contractor's Engineer conducting the PDA shall include the pile driving criteria with the PDA and CAPWAP results and shall be submitted to the Engineer for acceptance within two business days after the dynamic monitoring.

If changes are made to the pile driving system (hammer, fuel setting, piling, cushioning, etc.) after the dynamic monitoring has been completed and driving criteria established, new driving criteria shall be determined using the PDA. New criteria shall be determined at the Contractor's expense. If the Engineer requests additional piles to be monitored, pile monitoring will be paid for per subsection 502.16.

(c) Static Load Test. If a static load test is used to determine the pile axial resistance, the test shall not be performed less than five days after the test pile was driven unless approved by the Engineer or otherwise specified in the Contract. The static load test shall follow the procedures specified in ASTM D1143/D1143M, and the loading procedure shall follow the Quick Load Test Method, unless detailed longer-term load-settlement data are needed, in which case the standard loading procedure shall be used. Testing equipment and measuring systems shall conform to ASTM D1143/D1143M.

The Contractor shall submit detailed documents for the proposed loading apparatus, prepared by a Licensed Professional Engineer, to the Engineer for review. The submittal shall include calibrations for the hydraulic jack, load cell, and pressure gauge conducted within 30 days before mobilization to the job site. Tension (anchor) piles that will later be used as permanent piles in the work shall be of the same type and size as the production piles and shall be driven at the same time as the test pile in the location of permanent piles, where feasible.

While performing the static load test, the Contractor shall provide safety equipment and employ adequate safety procedures. Adequate support for the static load test plates, jack, and ancillary devices shall be provided to prevent them from falling in the event of a release of load due to hydraulic failure, test pile failure, or other cause.

The method of defining failure of the static load test shall be as defined in the Contract. Based on the static load and dynamic test results, the Contractor's Engineer conducting the PDA will provide the final driving criteria for production pile acceptance.

When specified, tension static load tests shall be conducted per ASTM D3689. When specified, lateral load tests shall be conducted per ASTM D3966.

502.10 Nominal Driving Resistance of Production Piles Production piles shall be driven to the depth necessary to obtain the required nominal driving resistance as determined by subsection 502.09. If a minimum pile tip elevation is shown on the plans, in addition to obtaining the required nominal driving resistance, production piles shall also be driven to the minimum pile tip elevation.

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When the nominal driving resistance is determined per subsection 502.09(a) or subsection 502.09(b) for acceptance, the Engineer will record the blow count per inch or foot of pile movement and the associated hammer stroke for the last two consecutive feet of driving, and the final pile tip elevation as per the pile driving criteria established through the wave equation analysis or dynamic test.

Practical refusal will be defined as 10 blows per inch of penetration for a maximum of three consecutive inches of pile penetration and with the hammer operated at its maximum fuel or energy setting, or at a reduced fuel or energy setting recommended by the Engineer based on pile installation stress control and less than 1/4 inch rebound per blow. The Contractor shall stop driving as soon as the Engineer determines that the pile has reached practical refusal.

Absolute refusal is defined as 20 blows for 1 inch or less of pile penetration. Driving shall terminate immediately if this criterion is achieved. In the case of hard rock, an absolute refusal criterion of 5 blows per 1/4 inch or 10 blows per 1/2 inch should be adopted to reduce the risk of pile toe or driving equipment damage.

The nominal driving resistance of jetted piles shall be based on impact driving penetration resistance after the jet pipes have been removed. Jetted piles not attaining the nominal driving resistance at the ordered length shall be spliced and driven with an impact hammer until the nominal driving resistance is achieved per the driving criteria in subsection 502.09.

502.11 Piling Length. The lengths of piles shown on the plans and in the Schedule of Pay Items are estimated lengths and are for bidding purposes only. Piles may be ordered in plan lengths or standard production lengths. The Contractor shall provide the actual length of piles necessary to obtain the nominal driving resistance and penetration depth required as determined from results obtained from driving representative test piles or other pertinent data. There will be expected variations in final tip elevations due to differences in nominal pile driving resistance. The final tip elevation of each pile shall be determined during the driving operation.

A minimum pile penetration of 10 feet below the bottom of the footing elevation in natural ground is required for all piles. This requirement may be waived by the Engineer if the subsurface material at the pile tip location is bedrock or other acceptable bearing material provided that the bearing elevation is below scour depth.

If minimum tip elevations are specified, the Contractor shall drive piles to a penetration depth that satisfies this requirement in addition to the nominal driving resistance. If the pile cannot be driven to the minimum tip elevation, the Engineer will determine if pre-drilling is required.

Water jets may be used in conjunction with the hammer to obtain the specified penetration only with approval by the Engineer. The last 5 feet of penetration shall be obtained by driving without the use of water jets. Test blows to determine average penetration shall be applied after the jets have been removed. The use of water jets shall not modify any of the requirements of this specification.

502.12 Extensions and Splices. When the American Welding Society (AWS) D1.1 Structural Welding Code is cited in this section, it shall be the current edition.

Full length piles shall be used where practicable. The number of splices shall be kept to a minimum. Commercially available splices may be used if approved by the Engineer.

All welded splices shall be partial joint penetration (PJP) unless designated otherwise on the plans. All welded splices shall be made by using a prequalified joint designation per AWS D1.1. The CJP design shall include beam copes (weld access holes) through the web of the pile at the junctures with the flanges. Copes shall be made per AWS D1.1, section 5.17. If backing is used it shall be per AWS D1.1. Removal of the backing after welding is not required.

Personnel performing welding inspection shall be a certified welding inspector (CWI) per AWS D1.1, Chapter 6. All welded pile splices shall be made per a written Welding Procedure Specification (WPS) that shall be reviewed and approved by the Contractor's CWI, before welding any piling splices on the project. The WPS shall list all essential variables of the process per AWS D1.1. The WPS shall be available for review by the Engineer.

All welded splices shall be made with low hydrogen electrodes. The Contractor shall adhere to the low hydrogen practice for electrodes per AWS D1.1.

All cuts at splices shall be made normal to the longitudinal axis of the pile. The cut-off portion may be driven to start the next pile, or it may be welded to previously driven piles to provide the necessary extension length.

All welders shall be currently qualified per AWS D1.1. Welder qualifications shall be approved by the Contractor's CWI before the start of welding. The welder shall be requalified if any essential variables listed in AWS D1.1 are not met.

The Contractor shall provide an AWS Certified Welding Inspector (CWI) on the project site for quality control. The CWI shall inspect all production stages of the welded splice, including assembly of the splice joint, during welding, and after welding to ensure that workmanship and materials meet the requirements of the Contract. The CWI shall submit a record of all weld inspection documentation to the Engineer.

The Contractor's inspector performing UT testing of CJP splices shall be qualified per the current edition of the American Society for Nondestructive Testing Practice No. SNT-TC-1A. Individuals who perform nondestructive testing shall be qualified for NDT Level II.

The first two CJP welded splices shall be ultrasonically tested (UT) for acceptance per Table 6.3 of AWS D1.1. If both of the UT tested CJP splices are determined to be acceptable, no further UT testing of CJP splices will be required. If either of the first two UT tested CJP splices are not acceptable, UT testing of CJP splices shall continue until two consecutive tests are acceptable.

502.13 Defective Piling. Piles damaged in driving by reasons of internal defects or improper driving shall be corrected by one of the following approved methods:

(1) The pile shall be withdrawn and replaced by a new, and if necessary, longer pile.

(2) A second pile shall be driven adjacent to the defective pile.

Piles driven below the specified butt elevation shall be corrected by one of the following approved methods:

(1) The pile is spliced or built up as otherwise provided.

(2) A sufficient portion of the footing is extended down to properly embed the pile.

A pile driven out of its proper location per subsection 502.06 shall be corrected by one of the following methods:

(1) One or more replacement piles are driven next to the out-of-position piles.

(2) The footing is extended laterally to incorporate the out-of-location pile.

(3) Additional reinforcement is added.

All such remedial materials and work shall be approved by the Engineer and furnished and performed at the Contractor's expense.

All piles pushed up by the driving of adjacent piles shall be driven down again.

502.14 Pile Tips. If difficult driving conditions are encountered, the Engineer may direct the Contractor to furnish and attach pile tips even though tips are not required on the plans.

METHOD OF MEASUREMENT

502.15 Piling will be measured by the linear foot in place. Measurement shall be from the tip to the cut-off elevation.

Where piling is driven to within 1 foot of the elevation of cut-off, butt ends will be included in the length measured for piling actually driven.

Measurement of splices will be limited to two per steel pile.

Partial Joint Penetration (PJP) welded splices for piles, when specified on the plans, will be measured as additional length of pile. The additional length for each PJP splice will be measured as follows: steel "H" piles, 3 linear feet; steel pipe piles, 3 linear feet. CJP welded splices, when specified in the plans, will be the actual number completed and accepted per splice.

Pile tips and end plates for steel pipe piles will be measured by the actual number installed.

Drilled holes to facilitate pile driving will be measured by linear foot.

BASIS OF PAYMENT

502.16 The accepted quantities will be paid for at the contract unit price per unit of measurement for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	**Pay Unit**
Steel Piling (size)	Linear Foot
Steel Pipe Piling (size)	Linear Foot
Drilling Hole to Facilitate Pile Driving	Linear Foot
End Plate	Each
Pile Tip	Each
Dynamic Pile Test	Each
Static Pile Load Test	Each
Complete Joint Penetration (CJP) Splice	Each

All costs for providing Certified Welding Inspector (CWI) services for Partial Joint Penetration (PJP) welded splices shall be included in the additional measured length of pile per subsection 502.12.

Complete Joint Penetration (CJP) splices shall be paid for at the contract unit price for each completed and accepted CJP Splice. All costs for completing the CJP welded splices including, but not limited to, Ultrasonic Testing, Certified Welding Inspector (CWI) services, and required documentation shall be included in the price per each for Complete Joint Penetration (CJP) Splice.

Steel cut-offs 10 feet or less in length will be paid for at the contract unit price minus 20 percent. These cut-offs shall become the property of the Contractor.

Steel cut-offs greater than the above specified lengths will not be paid for.

Authorized jetting, blasting, or other work necessary to obtain the specified penetration of piles will be paid for per subsection 109.04.

Concrete used to fill steel pipe will not be measured and paid for separately but shall be included in the work.

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SECTION 503
DRILLED SHAFTS

DESCRIPTION

503.01 This work consists of furnishing all materials, labor, tools, equipment, services and incidentals necessary to construct the drilled shafts (also referred to as drilled caissons, drilled piers, cast-in-place-drilled-holes, or cast-in-situ piles) per the Contract Documents and this Specification.

SUBMITTALS AND MEETINGS

503.02 Submittals. At least 30 days before the start of drilled shaft construction, the Contractor shall submit to the Engineer an electronic file of a project reference list verifying the successful completion by the Contractor of at least three separate foundation projects within the last five years with drilled shafts of similar size (diameter and depth) and construction difficulty to those shown on the Plans in similar subsurface geotechnical conditions. A brief description of each project and the project owner's contact name and current phone number shall be included for each project listed. Work shall not begin until all required submittals have been received by the Engineer.

(a) Experience and Personnel. The personnel assigned to the project shall have the following minimum experience:

1. On-site supervisors shall have a minimum of two years of experience in supervising construction of drilled shaft foundations of similar size (diameter and depth) and installation method to those shown on the Plans and similar geotechnical conditions to those described in the geotechnical report. The work experience shall be direct supervisory responsibility for the on-site drilled shaft construction operations. Project management level positions indirectly supervising on-site drilled shaft construction operations are not acceptable for this experience requirement.

2. Drill rig operators shall have a minimum of one year of experience in construction of drilled shaft foundations.

   The Engineer may request a list identifying on-site supervisors and drill rig operators assigned to the project for review. The list shall contain a detailed summary of each individual's experience in drilled shaft excavation operations. The Contractor shall inform the Engineer in writing of changes to field personnel.

(b) Drilled Shaft Installation Plan. At least 30 days before the start of drilled shaft construction the Contractor shall submit an electronic file of a Drilled Shaft Installation Plan narrative. In preparing the narrative, the Contractor shall reference the available subsurface geotechnical data provided in the Contract and any geotechnical reports prepared for this project. This narrative shall provide at a minimum the following information:

1. Description of overall construction operation sequence and the sequence of drilled shaft construction when in groups or lines.

2. A list, description, and capacities of proposed equipment including but not limited to cranes, drills, augers, bailing buckets, final cleaning equipment and drilling unit. As appropriate, the narrative shall describe why the equipment was selected and suitability to the anticipated site and subsurface conditions.

3. Details of drilled shaft excavation methods, including proposed drilling methods, methods for cleanout of the bottom of the excavation hole and a disposal plan for excavated material including drilling slurry (if applicable). This shall include means and methods to address subsurface geotechnical conditions including boulder and obstruction removal techniques if such are indicated in the Contract subsurface geotechnical information or Contract Documents.
   Details of the methods to be used to ensure drilled shaft hole stability (i.e., prevention of caving, bottom heave, etc. using temporary casing, slurry, or other means) during excavation and concrete placement.

4. Detailed procedures for mixing, using, maintaining, storing, and disposing of the slurry shall be provided if applicable. A detailed mix design (including all additives and their specific purpose in the slurry mix) and a discussion of its suitability to the anticipated subsurface geotechnical and site conditions shall also be provided for the proposed slurry.

5. The submittal shall include a detailed plan for process control of the selected slurry including property tests, test methods, and minimum and maximum property requirements that must be met to ensure that the slurry functions as intended for the anticipated subsurface conditions and shaft construction methods per the slurry manufacturer's recommendations and these specifications.

6. When casings are proposed or required, casing dimensions and detailed procedures for casing installation, removal, advancing the casing, and excavating the drilled shaft hole per subsection 503.12 (b) shall be provided.

   When removing casing, detail the method to extract the casing to maintain shaft reinforcement in proper alignment and keep concrete workable during casing extraction.

7. Details of concrete placement including proposed equipment and procedures for delivering concrete to the drilled shaft, placement of the concrete into the shaft, placement and raising of the tremie or pump line during placement, size of tremie and pump lines, operational procedures for pumping, and a sample uniform yield form to be used by the Contractor for plotting the volume of concrete placed versus the depth of shaft for all shaft concrete placement. Describe the method to be used to form a horizontal construction joint during concrete placement. Include details of procedures to prevent loss of slurry or concrete into waterways, and other areas to be protected.

8. Describe the method and materials that will be used to fill or eliminate all voids below the top of shaft between the plan shaft diameter and excavated shaft diameter, or between the shaft casing and surrounding soil if permanent casing is specified.

9. Details of any required load tests or shaft integrity tests including equipment, instrumentation, procedures, calibration data for test equipment, calculations and drawings.

10. Details and procedures for protecting existing structures, utilities, roadways and other facilities during drilled shaft installation. The stability of the existing structures is the responsibility of the Contractor. Any new drilled shaft that is placed next to existing structures/drilled shafts with the potential to affect stability shall be considered

safety critical work and shall follow the submittal requirements as specified in subsection 107.06.

(c) Slurry Technical Assistance. If slurry is to be used to construct the drilled shafts, the Contractor shall provide or arrange for technical assistance from the slurry manufacturer as specified in subsection 503.12 (b)5(A). The Contractor shall submit three copies of the following to the Engineer at least 14 days before the start of drilled shaft construction:

(1) The name and current phone number of the slurry manufacturer's technical representative assigned to the project.

(2) The names of the Contractor's personnel assigned to the project and trained by the slurry manufacturer's technical representative in the proper use of the slurry. The submittal shall include a signed training certification letter from the slurry manufacturer for each individual including the date of the training.

(d) Logs of Shaft Construction. The Contractor's Quality Control staff shall prepare inspection logs using CDOT Form 1333 – Inspector's Report of Caisson Installation documenting each shaft construction activity. In addition, the Contractor shall prepare and submit the logs documenting any subsurface investigation borings or rock core holes performed by the Contractor at drilled shaft foundation locations.

In addition to the information required on the Form 1333, the Contractor shall provide the following information: type and dimensions of tools and equipment used, any changes to the tools and equipment; type of drilling fluid if used, the results of slurry tests, any problems encountered, and method used for bottom cleaning.

In addition to the information required on the Form 1333, concrete placement records shall include at least the following information: tremie tip elevation during concrete placement, and concrete yield curve (volume versus concrete elevation, actual and theoretical).

A complete set of shaft inspection logs for an individual drilled shaft shall be submitted to the Engineer within 48 hours of the completion of concrete placement at the shaft.

503.03 Meetings The Engineer will evaluate the Drilled Shaft Installation Plan for conformance with the Contract within10 working days after receipt of the submission. At the option of the Department, a Shaft Installation Plan Submittal Meeting may be scheduled following review of the Contractor's initial submittal of the Plan. Those attending the Shaft Installation Plan Submittal Meeting, if held, shall include the following: The superintendent, on-site supervisors, and other Contractor personnel involved in the preparation and execution of the Drilled Shaft Installation Plan.

(1) The Project Engineer and Owner's personnel involved with the structural, geotechnical, and construction review of the Drilled Shaft Installation Plan together with Owner's personnel who will provide inspection and oversight during the drilled shaft construction phase of project.

The Contractor shall submit to the Engineer updates or modifications to the Drilled Shaft Installation Plan whenever such updates or modifications are proposed. The Engineer will evaluate the new information for conformance with the Contract Plans and Specifications and respond within10 working days after receipt of the submission.

A shaft Pre-construction meeting shall be held at least five working days before the Contractor beginning any shaft construction work at the site to discuss investigative boring information, construction procedures, personnel, and equipment to be used, and other

elements of the accepted Shaft Installation Plan as specified in subsection 503.02(b). If slurry is used to construct the shafts, the frequency of scheduled site visits to the project site by the slurry manufacturer's representative shall be discussed. Those attending shall include:

(2) The superintendent, on-site supervisors, and other key personnel identified by the Contractor as being in charge of excavating the shaft, placing the casing and slurry as applicable, placing the steel reinforcing bars, and placing the concrete. If slurry is used to construct the shafts, the slurry manufacturer's representative and a Contractor's employee trained in the use of the slurry, as identified to the Engineer per subsection 503.04(c)4(1), shall also attend.

The Engineer, key inspection personnel, and appropriate representatives of the Department. If the Contractor's key personnel change, or if the Contractor proposes a significant revision of the approved Drilled Shaft Installation Plan, an additional conference may be held at the request of the Engineer before any additional shaft construction operations are performed.

503.04 Control and Disposal of Materials. The Contractor shall collect and properly dispose offsite all slurry and water displaced during final cleaning and concrete placement. Open pits for collection of materials may be allowed during construction activities for later disposal. Control all excavated material, slurry, water, and other matter so that at no time it enters or encroaches upon the adjacent travel lanes, railroad, water ways, and environmentally sensitive or restricted areas as shown on the plans. All environmental regulations for handling, discharge, and disposal of all construction materials shall be followed.

MATERIALS

503.05 Concrete. Concrete used in the construction of drilled shafts shall be Class BZ per Section 601. If the concrete does not meet the requirements of Section 601, price reductions shall be applied to the drilled caisson pay item. The Contractor may elect to use Self Consolidating Concrete (SCC) Class BZ.

503.06 Reinforcing Steel. Reinforcing steel shall be per Section 602. When necessary, vertical bars shall be bundled in order to maximize clear space between vertical reinforcement. Rolled hoops or bundled spirals shall be used in order to maximize the clear space between horizontal reinforcement. Reinforcing steel cages for drilled shafts with varying shaft and socket diameters shall be designed with a single, uniform diameter. At all times, the reinforcing bars and fabricated steel reinforcing cage shall be supported off the ground surface and shall be protected from contamination of mud, oils and solvents, and other deleterious materials. The steel shall be free of excessive rust (flaking, peeling, and thick coating) at the time of cage placement into the hole. Any contamination or excessive rust shall be cleaned and removed by the Contractor to the Engineer's acceptance before placement.

503.07 Casings. All permanent structural casing shall be of steel conforming to ASTM A36/A36M or ASTM A252 Gr 2 unless specified otherwise on the Plans. All splicing of permanent structural casing shall be per AWS D 1.1 Bridge Welding Code. All casing shall be watertight and clean before placement in the excavation. Where the minimum thickness of the casing is specified on the Plans, it is specified to satisfy structural design requirements only. The Contractor shall increase the casing thickness from the minimum specified thickness, as necessary and accepted by the Engineer, to satisfy the construction installation requirements.

All permanent casing shall be of ample strength to resist damage and deformation from transportation and handling, installation stresses, and all pressures and forces acting on the casing. For permanent nonstructural casing, corrugated casing may be used. The diameter of permanent casing shall be as shown on the Plans unless a larger diameter casing is approved by the Engineer. When a larger size permanent casing is approved by the Engineer, no additional payment will be made for the increased weight of casing steel or the increased quantity of drilled shaft excavation and concrete.

All temporary casing shall be a smooth wall structure steel except where corrugated metal pipe is shown on the Plans as an acceptable alternative material. All temporary casing shall be of ample strength to resist damage and deformation from transportation and handling, installation and extraction stresses, and all pressures and forces acting on the casing. The casing shall be capable of being installed and removed without deforming and causing damage to the completed shaft and without disturbing the surrounding soil. Temporary casing shall be completely removed, unless otherwise shown on the Plans or approved by the Engineer. The outside diameter of temporary casing shall not be less than the specified diameter of the shaft.

503.08 Mineral Slurry. Mineral Slurry shall be used per the quality control plan specified in subsection 503.02(b)(5).

Mineral slurry shall conform to the following requirements:

Table 503-1

DRILLED CAISSON MINERAL SLURRY REQUIREMENTS

Property	Test	Requirement
Density (pcf)	Mud Weight (Density) API 13B-1, Section 1	64.3 to 72
Viscosity (seconds/quart)	Marsh Funnel and Cup API 13b-1, Section 2.2	28 to 50
pH	Glass Electrode, pH Meter, or pH Paper	8 to 11
Sand Content (%)	API 13B-1, Section 5	4.0 max. immediately before placing concrete

503.09 Polymer Slurry. Polymer slurries, either natural or synthetic, shall be used per the manufacturer's recommendations, and shall conform to the quality control plan specified in subsection 503.02(b)(5). The polymer slurry shall conform to the following requirements:

Table 503-2

DRILLED CAISSON POLYMER SLURRY REQUIREMENTS

Property	Test	Requirement
Density (pcf)	Mud Weight (Density) API 13B-1, Section 1	64.3 max
Viscosity (seconds/quart)	Marsh Funnel and Cup API 13b-1, Section 2.2	32 to 135
pH	Glass Electrode, pH Meter, or pH Paper	8 to 11.5
Sand Content (%)	API 13B-1, Section 5	1.0 max. immediately before placing concrete

The sand content of polymer slurry before final cleaning and immediately before placing concrete shall be less than or equal to 1.0 percent, per American Petroleum Institute API 13B-1, Section 5. Slurry temperature shall be at least 40 °F when tested.

503.10 Water Slurry. Water may be used as slurry when casing is used for the entire length of the drilled hole, or to stabilize the bedrock below the temporary casing provided that the method of drilled shaft installation maintains stability at the bottom of the shaft excavation. Water slurry shall conform to the following requirements:

Table 503-3

DRILLED CAISSON WATER SLURRY REQUIREMENTS

Property	Test	Requirement
Density (pcf)	Mud Weight (Density) API 13B-1, Section 1	64 max
Sand Content (%)	API 13B-1, Section 5	1.0 max

503.11 Access Tubes for CSL Testing. Access tubes for CSL testing shall be steel pipe of 0.145-inch minimum wall thickness and at least 1.5 inches inside diameter. The access tubes shall have a round, regular inside diameter free of defects and obstructions, including all pipe joints, in order to permit the free, unobstructed passage of 1.3 inches' maximum diameter source and receiver probes used for the CSL tests. The access tubes shall be non-galvanized, watertight, free from corrosion, and with clean internal and external faces to ensure good bond between the concrete and the access tubes. The access tubes shall be fitted with watertight threaded caps on the bottom and the top. Grout for filling the access tubes at the completion of the CSL tests shall be a neat cement grout with a maximum water/cement ratio of 0.45. Drilled shafts for structures as shown on the CDOT S-Standard drawings shall be excluded from this testing, except as noted on the plans.

CONSTRUCTION REQUIREMENTS

503.12 Drilled Shaft Excavation. The excavation and drilling equipment shall have adequate capacity, including power, torque and down pressure to excavate a hole of both the maximum diameter and to a depth of 20 feet or 20 percent beyond the maximum shaft length shown on the Plans, whichever is greater. Blasting will only be permitted if specifically stated on the Plans or authorized in writing by the Engineer. Once the excavation

operation has been started, the excavation shall be conducted in a continuous operation until the excavation of the shaft is completed except for pauses and stops. Pauses or interruptions during this excavation operation will not be allowed except for casing installation, casing splicing and removal of materials or obstructions. Drilled shaft excavation operation interruptions not conforming to this definition shall be considered stops. The Contractor shall provide temporary casing at the site in sufficient quantities to meet the needs of the construction method.

If the drilled shaft excavation is not complete at the end of the shift or series of continuous shifts, the drilled shaft excavation operation may be stopped provided the Contractor protects the shaft as indicated in subsection 503.12(b) before the end of the workday.

If slurry is present in the shaft excavation, the Contractor shall conform to the requirements of subsection 503.12 (b)5(2) regarding the maintenance of the minimum level of drilling slurry throughout the stoppage of the shaft excavation operation and shall recondition the slurry to the required slurry properties per subsections 503.09, 503.10, and 503.11 before recommencing shaft excavation operations.

Sidewall over-reaming shall be performed when the time for shaft excavation exceeds 24 hours (measured from the beginning of excavation below the casing when casing is used). Sidewall over-reaming shall also be performed when the sidewall of the hole is determined by the Engineer to have softened due to the excavation methods, swelled due to delays in the start of concrete placement, or degraded because of slurry cake buildup. Over-reaming thickness shall be a minimum of 1/2-inch or as directed by the Engineer. Over-reaming may be accomplished with a grooving tool, over-reaming bucket, or other equipment approved by the Engineer. If over-reaming is required as a result of the excavation time exceeding the time limit specified, the Contractor shall bear the costs associated with both sidewall over-reaming and additional drilled shaft concrete related to over-reaming.

Excavation to the foundation cap elevation shall be completed before drilled shaft construction begins unless otherwise noted in the Contract Documents or approved by the Engineer. Any disturbance to the foundation cap area caused by shaft installation shall be repaired by the Contractor before placing the cap concrete. When drilled shafts are to be installed in conjunction with embankment construction, the Contractor shall construct drilled shafts after placement of the embankment fill unless otherwise shown on the Contract Documents or approved by the Engineer. Drilled shafts installed before the completion of the embankment fill shall not be capped until the fill has been placed to the bottom of cap level.

(a) Dry Construction Method. The dry construction method consists of drilling the shaft excavation, removing accumulated water and loose material from the excavation, placing the reinforcing cage, and concreting the shaft in relatively dry excavation. The dry construction method may only be used if the shaft excavation demonstrates that the following conditions are met: less than 12 inches of water accumulates above the base of excavation over a period of one hour when no pumping is performed, the sides and bottom of the hole remain stable without detrimental caving, sloughing, or swelling between the completion of excavation and concrete placement, all loose material and water can be satisfactorily removed before inspection and concrete placement (no more than 2 inches of water will be permitted in the bottom of the shaft excavation at the time of concrete placement), and the Engineer can visually inspect the sides and bottom of the shaft before placing the concrete. The drilled shaft excavations shall not be left open overnight unless cased full depth or otherwise protected against sidewall instability. An open excavation is

defined as a drilled shaft that has not been filled with concrete, or temporarily backfilled with a material approved by the Engineer per subsection 503.12(b) or protected per subsection 503.12 (b). The use of slurry to protect a drilled shaft during a drilling stoppage or overnight shutdown shall be approved by the Engineer. The excavation shall be protected with a suitable cover that will prevent persons or materials from falling into the hole. Casing of drilled shafts in stable rock formations during stoppages is not required if accepted by the Engineer unless shown on the Plans or specified.

(b) Protection Methods. The Contractor bears full responsibility for selection and execution of the methods of stabilizing and maintaining the drilled shaft excavation. The walls and bottom of the drilled shaft excavation shall be protected so that sidewall caving and bottom heaves are prevented from occurring. For shafts where the soils above the bedrock do not contribute to the bearing calculations as shown on the Plans, the soils surrounding the temporary casing may be disturbed during the installation of temporary casing using uncontrolled in-situ slurries.

Acceptable protection methods include the use of casing, drilling slurry, or both:

1. Temporary Casing Construction Method. The Contractor shall conduct casing installation and removal operations and drilled shaft excavation operations such that the adjacent soil outside the casing and drilled shaft excavation for the full height of the drilled shaft is minimally disturbed. For shafts where the soils above the bedrock do not contribute to the bearing calculations as shown on the Plans, the soils surrounding the temporary casing may be disturbed during the installation of temporary casing using uncontrolled in-situ slurries.

   If the Contractor is utilizing casing that is sealed into the underlying bedrock, water may infiltrate the shaft below the casing. Excavation of the bedrock may continue without the use of casing or slurry if the shaft remains stable.

   The Contractor shall remove all temporary casings from the excavation as concrete placement is completed, unless approval has been received from the Engineer to leave specified temporary casings in place. As the temporary casing is withdrawn, sufficient head of fluid concrete must be maintained to ensure that water or slurry outside the temporary casing will not breach the column of freshly placed concrete. Casing extraction shall be at a slow, uniform rate with the pull in line with the shaft axis. Excessive rotation of the casing shall be avoided to limit deformation of the reinforcing steel cage.

2. Permanent Casing Construction Method. After the casing has been filled with concrete, all void space occurring between the casing and drilled shaft excavation shall be filled with a material that approximates the geotechnical properties of the in-situ soils, per the Drilled Shaft Installation Plan specified in subsection 503.02(b).

   Tops of permanent casings for the drilled shafts shall be removed to the top of the drilled shaft or finished ground line, whichever is lower, unless the top of permanent casing is shown in the Plans at a different elevation. For those drilled shafts constructed within a permanent body of water, tops of permanent casings for drilled shafts shall be removed to the low water elevation unless otherwise shown on the Plans or directed by the Engineer. Casing used for forming shafts installed through a body of water shall not be removed.

3. Alternative Casing Methods. When approved by the Engineer, installation of casing using rotating or oscillating methods will be permitted. Use of this alternative casing method shall be per the equipment and procedures shown in the approved Drilled Shaft Installation Plan and shall comply with all other requirements specified. Drilled shaft casing shall be equipped with cutting teeth or a cutting shoe and installed by either rotating or oscillating the casing.

4. Uncontrolled In-Situ Slurry. The uncontrolled in-situ slurry consists of in-situ soils from the drilled shaft mixed with water. For shafts where the soils above the bedrock do not contribute to the bearing calculations as shown on the Plans, the Contractor may use uncontrolled in-situ slurry to install temporary casing. For shafts where the soils above the bedrock do contribute to the bearing calculations, the use of uncontrolled in-situ slurry to install temporary casing shall not be allowed. Slurry per subsections 503.08, 503.09, and 503.10 or temporary casing per subsections 503.07 and 503.12 is required if the drilled shaft does not remain stable using uncontrolled in-situ slurry.

5. Slurry. The Contractor may use slurry per subsections 503.08, 503.09, and 503.10 to maintain a stable excavation during drilled shaft excavation and concrete placement operations once water begins to enter the drilled shaft excavation and remain present.

   The Contractor may use slurry to maintain stability during drilled shaft excavation and concrete placement operations in the event that water begins to enter the drilled shaft excavation at a rate of greater than 12 inches per hour, or if the Contractor is not able to restrict the amount of water in the drilled shaft to less than 3 inches before concrete placement, or to equilibrate water pressure on the sides and base of the drilled shaft excavation when groundwater is encountered or anticipated based on the available subsurface data.

   A. Slurry Technical Assistance

      If slurry is used, the manufacturer's representative, as identified to the Engineer per subsection 503.02(c), shall provide technical assistance for the use of the slurry.

      The manufacturer’s representative or the Contractor’s employee trained in the use of the slurry, as identified to the Engineer per subsection 503.02(c), shall be present at the site throughout the shaft slurry operations for this project to perform the duties specified above.

   B. Minimum Level of Slurry in the Excavation

      When slurry is used to maintain a stable excavation, the slurry level in the excavation shall be maintained to obtain hydrostatic equilibrium throughout the construction operation at a height required to provide and maintain a stable hole, but not less than 5 feet above the water table.

      Slurry levels shall be as follows:

      (1) Not less than five feet above the water table for mineral slurries

      (2) Not less than10 feet above the water table for water slurry and uncontrolled in-situ slurries

      (3) Not less than 10 feet above the water table for polymer slurries, except when a lesser dimension is specifically recommended by the slurry manufacturer for the site conditions and construction methods.

The Contractor shall provide casing, or other means, as necessary to meet these requirements.

The slurry level shall be maintained above all unstable zones a sufficient distance to prevent bottom heave, caving, or sloughing of those zones.

Throughout all stops in drilled shaft excavation operations, the Contractor shall monitor and maintain the slurry level in the excavation the greater of the following elevations:

(1) No lower than the groundwater level elevation outside the drilled shaft

(2) Elevation as required to provide and maintain a stable hole.

C. Cleaning Slurry

The Contractor shall clean, re-circulate, de-sand, or replace the slurry, as needed, in order to maintain the required slurry properties. Sand content will only be required to be within specified limits immediately before concrete placement.

503.13 Obstructions. When obstructions are encountered, the Contractor shall notify the Engineer promptly. An obstruction is defined as a specific object not identified on the Plans or Geotechnical Report per subsection 102.05 (including, but not limited to, boulders, logs, and manmade objects) encountered during the drilled shaft excavation operation that prevents or hinders the advance of the drilled shaft excavation. When efforts to advance past the obstruction to the design drilled shaft tip elevation result in the rate of advance of the drilled shaft drilling equipment being significantly reduced relative to the rate of advance for the portion of the drilled shaft excavation in the geological unit that contains the obstruction, then the Contractor shall remove, bypass or break up the obstruction under the provisions of subsection 503.23(a). Blasting will not be permitted unless approved in writing by the Engineer.

Drilling tools that are lost in the excavation will not be considered obstructions and shall be promptly removed by the Contractor. All costs due to lost tool removal will be borne by the Contractor including, but not limited to, costs associated with the repair of hole degradation due to removal operations or an excessive time that the hole remains open.

503.14 Protection of Existing Structures and Drilled Holes. The Contractor shall control operations to prevent damage to existing structures and recently drilled holes, utilities, roadways and other facilities. Preventative measures shall include, but are not limited to, selecting construction methods and procedures that will prevent excessive caving of the drilled shaft excavation and monitoring and controlling the vibrations from the driving of casing or sheeting, drilling of the shaft, or from blasting, if permitted.

503.15 Slurry Sampling and Testing. Mineral slurry and polymer slurry shall be mixed and thoroughly hydrated in slurry tanks, lined ponds, or storage areas. The Contractor shall draw sample sets from the slurry storage facility and test the samples for conformance with the appropriate specified material properties before beginning slurry placement in the drilled hole. Slurry shall conform to the quality control plan included in the Drilled Shaft Installation Plan per subsection 503.02(b)(5) and approved by the Engineer. A sample set shall be composed of samples taken at mid-height and within 2 feet of the bottom of the storage area.

The Contractor shall sample and test all slurry in the presence of the Engineer, unless otherwise approved by the Engineer. The date, time, names of the persons sampling and testing the slurry, and the results of the tests shall be recorded. A copy of the recorded slurry test results shall be submitted to the Engineer at the completion of each drilled shaft, and during construction of each drilled shaft when requested by the Engineer.

Slurry samples shall be taken at mid-height and within 2 feet of the bottom of the drilled shaft and tested during drilling as necessary to verify the control of the properties of the slurry. As a minimum, sample sets of polymer slurry shall be taken and tested at least once every four hours after beginning its use during each shift. Sample sets of all slurry shall be taken and tested immediately before placing concrete.

503.16 Drilled Shaft Excavation Inspection. The Contractor shall use best methods such as a cleanout bucket, air lift, or hydraulic pump to clean the bottom of the excavation of all drilled shafts. For wet drilled shaft excavation in soils, the base of the excavation shall be covered with not more than 3 inches of sediment or loose or disturbed material just before placing concrete. For dry drilled shaft excavations in soils, the base of excavation shall be covered with not more than 1.5 inches of sediment or loose or disturbed material just before placing concrete. For wet and dry drilled shaft excavations in rock, the base of the excavation shall be covered with not more than 0.5 inch for 50 percent of the base area of sediment or loose or disturbed material just before placing concrete.

The excavated drilled shaft will be inspected and approved by the Engineer before proceeding with construction. The bottom of the excavated drilled shaft shall be sounded with an airlift pipe, a tape with a heavy weight attached to the end of the tape, a borehole camera with visual sediment depth measurement gauge, or other means acceptable to the Engineer to determine that the drilled shaft bottom meets the requirements in the Contract. The Contractor shall supply all needed equipment required to inspect the drilled shaft excavation.

503.17 Assembly and Placement of Reinforcing Steel. The Contractor shall show bracing and any extra reinforcing steel required for assembling, transportation, or placement of the cage on the shop drawings. The Contractor shall be responsible for engineering the temporary support and bracing of the reinforcing cages to ensure that they maintain their planned configuration during assembly, transportation, and installation.

The reinforcing cage shall be rigidly braced to retain its configuration during handling and construction. Individual or loose bars will not be permitted. All intersections of vertical and horizontal bars shall be tied. At least four vertical bars of each cage, equally spaced around the circumference, shall be tied at all reinforcement intersections with double wire ties. The remaining reinforcement intersections in each cage shall be tied with single wire ties.

The reinforcement shall be carefully positioned and securely fastened to provide the minimum clearances specified or shown on the Plans, and to ensure that no displacement of the reinforcing steel cage occurs during placement of the concrete. Splicing of the reinforcement cage during placement of the cage in the shaft excavation will not be permitted unless otherwise shown on the Plans or approved by the Engineer. If the reinforcing cage is spliced during placement of the cage into the drilled shaft excavation, the splice details and location of the splices shall be per the Plans and the accepted Drilled Shaft Installation Plan. In addition, the work shall be performed within the time limits specified in subsection 503.12.

The steel reinforcing cage shall be securely held in position throughout the concrete placement operation. The reinforcing steel cage shall be supported from the top during the placement of the concrete to achieve the clearances shown on the Plans. Setting the cage on the bottom of the hole will not be permitted. The support system shall be concentric to prevent racking and displacement of the cage. The reinforcing steel in the drilled shaft shall be tied and supported so that the location of the reinforcing steel will remain within allowable tolerance. Concrete spacers or other approved non-corrosive spacing devices shall be used at sufficient intervals (near the bottom, the top, and at intervals not exceeding 10 feet vertically) to ensure concentric spacing for the entire cage length. The number of spacers required at each level will be one spacer for each foot of excavation diameter, with a minimum of four spacers at each level. The spacers shall be of adequate dimension to ensure an annular space between the outside of the reinforcing cage and the side of the excavation along the entire length of the drilled shaft as shown on the Plans. Acceptable feet made of plastic or concrete (bottom supports) shall be provided to ensure that the bottom of the cage is maintained at the proper distance above the base of the excavation unless the cage is suspended from a fixed base during the concrete pour.

Concrete cover for the reinforcing steel shall be 3 inches at the bottom of the drilled shaft. Minimum concrete cover on the sides of the reinforcing steel shall be as follows:

Table 503-4

DRILLED CAISSON MINIMUM CONCRETE SIDE COVER OVER REINFORCING STEEL

Drilled Shaft Diameter	Minimum Concrete Side Cover
Less than or equal to 3 feet	3 inches
Greater than 3 feet and less than 5 feet	4 inches
Greater than or equal to 5 feet	6 inches

Drilled shafts for structures as shown on the CDOT S-Standard drawings shall be excluded from the minimum cover concrete requirements, except as noted on the plans.

If concrete placement does not immediately follow the cage placement, the Engineer may order the steel to be removed from the excavation so that the integrity of the excavation, including the presence of loose material in the bottom of the hole, and the surface condition of the reinforcing steel may be determined by inspection.

Bracing steel that constricts the interior of the reinforcing cage shall be removed after lifting the cage if freefall concrete or wet tremie methods of concrete placement are to be used.

The elevation of the top of the steel cage shall be checked before and after the concrete is placed. If the upward displacement of the rebar cage exceeds 2 inches, or if the downward displacement exceeds 6 inches, the drilled shaft shall be considered defective. No additional drilled shafts shall be constructed until the Contractor has modified the rebar cage support in a manner satisfactory to the Engineer.

503.18 Concrete Placement, Curing, and Protection. Concrete placement shall be per Section 601 and shall commence as soon as possible after completion of drilled shaft excavation by the Contractor and inspection by the Engineer. Immediately before commencing concrete placement, the drilled shaft excavation and the properties of the slurry (if used) shall be per subsections 503.08, 503.09, and 503.10. The CSL access tubes shall be filled with potable water before concrete placement and the top watertight threaded caps shall be reinstalled. Concrete placement shall be one continuous placement to the top of the drilled shaft, or as shown on the Plans.

If water is not present the concrete shall be deposited through the center of the reinforcement cage by tremie, pump or free-fall preventing segregation of aggregates. The concrete shall be placed such that the free-fall is vertical down the center of the drilled shaft without hitting the sides or steel reinforcing cage.

If water exists in amounts greater than 2 inches in depth or enters at a rate of more than 12 inches per hour, then the drilled shaft concrete shall be placed per subsection 601.12(f).

Before placing any fresh concrete against concrete deposited in water or slurry (construction joint), the Contractor shall remove all scum, laitance, loose gravel, and sediment on the surface of the concrete deposited in water or slurry, and chip off any high spots on the surface of the existing concrete that would prevent any steel reinforcing bar cage from being placed in the position as shown on the Plans.

The Contractor shall not perform foundation piling driving or casing installation using oscillation method within a radius of 20 feet or drilled shaft excavation operations within a clear distance of 3 diameters of a newly poured drilled shaft until a minimum of 24 hours has passed after the placement of concrete and the concrete has reached a minimum compressive strength of 1,800 psi.

For any portion of the caisson socketed in fine grained bedrock susceptible to slaking and degradation such as, but not limited to, claystone, siltstone, or shale and provided the proper slurry properties have been achieved. If the concrete is not placed within four hours of drilling, the Contractor shall drill into the bedrock an additional 1/3 of the plan specified rock socket before placing the concrete. The reinforcing cage shall extend to the new tip elevation. For the use of polymer slurry this requirement will be waived.

503.19 Drilled Shaft Construction Tolerances. Drilled shafts shall be constructed so that the center of the poured shaft at the top of the drilled shaft or mudline, whichever is lower, is within the following horizontal tolerances:

Table 503-5
DRILLED CAISSON MAXIMUM HORIZONTAL DISTANCE TOLERANCES

Drilled Shaft Diameter	Maximum Horizontal Tolerance
Less than or equal to 2 feet	3 inches
Greater than 2 feet and less than 5 feet	4 inches
Greater than or equal to 5 feet	6 inches

Drilled shafts in soil and rock shall be within 1.5 percent of plumb. Plumbness shall be measured from the top of poured drilled shaft elevation or mudline, whichever is lower. During drilling or excavation of the drilled shaft, the Contractor shall make frequent checks on the plumbness, alignment, and dimensions of the drilled shaft. Any deviation exceeding the allowable tolerances shall be corrected with a procedure approved by the Engineer. Drilled shaft steel reinforcing bars shall be no higher than 6 inches above or 3 inches below the plan elevation.

The reinforcing cage shall be concentric with the drilled shaft excavation within a horizontal tolerance of 1-1/2 inches.

The top elevation of the completed drilled shaft shall have a tolerance of plus 1 inch or minus 3 inches.

The diameter of the drilled shaft shall not be less than the diameter shown on the Plans.

Tolerances for casings shall be per American Pipe Institute tolerances applicable to regular steel pipe.

Drilled shaft excavations and completed drilled shafts not constructed within the required tolerances will be considered defective. The Contractor shall be responsible for correcting all defective drilled shafts to the satisfaction of the Engineer. Materials and work necessary, including engineering analysis and redesign, to complete corrections for out-of-tolerance drilled shafts shall be furnished without cost to the Owner or an extension of the completion date of the project. The Contractor shall submit redesign drawings electronically sealed by the Contractor's Engineer.

TESTING AND VERIFICATION

503.20 Integrity Testing. Crosshole Sonic Log (CSL) testing shall be performed per ASTM D6760. The minimum number of shafts tested shall be indicated on the plans. CSL testing shall be performed on shafts constructed using tremie concrete placement methods and drilled shafts selected by the Engineer. Drilled shafts for structures as shown on the CDOT S-Standard drawings shall be excluded from this testing, except as shown on the plans. The Engineer may increase the number of shafts tested as deemed necessary. The Contractor shall accommodate the CSL testing by furnishing and installing access tubes per subsection 503.12.

The Contractor shall install access tubes for CSL testing in drilled shafts as shown on the plans selected by the Engineer to permit access for the CSL test probes. If the condition of the drilled shaft excavation permits drilled shaft construction in the dry, the Engineer may specify that the testing be omitted.

The Contractor shall securely attach the access tubes to the interior of the reinforcement cage of the drilled shaft. One access tube shall be furnished and installed for each foot of drilled shaft diameter, rounded up to the nearest whole number, unless otherwise shown on the Plans. A minimum of three tubes will be required. The access tubes shall be placed around the drilled shaft, inside the spiral or hoop reinforcement and 3 inches clear of the vertical reinforcement, at a uniform spacing measured along the circle passing through the centers of the access tubes. If these minimums cannot be met due to close spacing of the vertical reinforcement, then the access tubes shall be bundled with the vertical reinforcement.

If trimming the cage is required and access tubes for CSL testing are attached to the cage, the Contractor shall either shift the access tubes up the cage or cut the access tubes, provided that the cut tube ends are adapted to receive the watertight cap as specified.

The access tubes shall be installed in straight alignment and as near to parallel to the vertical axis of the reinforcement cage as possible. The access tubes shall extend from 1 to 2 inches below the bottom of the reinforcing steel to at least 2 feet above the top of the drilled shaft. Couple tubes as required with threaded couplers, such that inside of tube remains flush. The Contractor shall clear the access tubes of all debris and extraneous materials before installing the access tubes. Care shall be taken to prevent damaging the access tubes during reinforcement cage installation and concrete placement operations in the drilled shaft excavation.

The access tubes shall be filled with potable water before concrete placement, and the top watertight threaded caps shall be reinstalled.

Before performing CSL testing operations, the Contractor shall remove the concrete at the top of the drilled shaft down to sound concrete.

The Contractor shall engage a qualified Specialty Engineer to perform the CSL testing. The qualified CSL Specialty Engineer shall have a minimum three years of experience of CSL testing and have a Colorado Licensed Professional Engineer supervising the collection and interpretation of data. The Contractor shall provide all necessary assistance to the CSL Specialty Engineer to satisfactorily perform the testing.

The testing shall be performed after the drilled shaft concrete has cured at least 96 hours. Additional curing time before testing may be required if the drilled shaft concrete contains admixtures, such as set retarding admixture or water reducing admixture. The additional curing time before testing required under these circumstances shall not be grounds for additional compensation or extension of time to the Contractor. No subsequent construction shall be performed on the completed drilled shaft until the CSL tests are approved and the drilled shaft accepted by the Engineer.

After placing the drilled shaft concrete and before beginning the CSL testing of a drilled shaft, the Contractor shall inspect the access tubes. Each access tube that the test probe cannot pass through shall be replaced, at the Contractor’s expense, with a 2-inch diameter hole cored through the concrete for the entire length of the drilled shaft. Unless directed otherwise by the Engineer, cored holes shall be located approximately 6 inches inside the reinforcement and shall not damage the drilled shaft reinforcement. Descriptions of inclusions and voids in cored holes shall be logged and a copy of the log shall be submitted to the Engineer. Findings from cored holes shall be preserved, identified as to location, and made available for inspection by the Engineer.

The Engineer will approve the continuation of drilled shaft construction before approval and acceptance of the first shaft if the Engineer’s observations of the construction of the first shaft are satisfactory, including, but not limited to, conformance to the Drilled Shaft Installation Plan as approved by the Engineer, and the Engineer’s review of Contractor’s daily reports and inspector’s daily logs concerning excavation, steel reinforcing bar placement, and concrete placement.

Drilled shafts with velocity reduction exceeding 30 percent are not acceptable without additional offset CSL testing and three-dimensional (3D) Tomography analysis.

If subsequent testing at a drilled shaft indicates the presence of a defect in the drilled shaft, the testing costs and the delay costs resulting from the additional testing shall be borne by the Contractor. If this additional testing indicates that the drilled shaft has no defect, the testing costs and the delay costs resulting from the additional testing will be paid by the Owner. If the drilled shaft construction is on the critical path of the Contractor's schedule, a time extension equal to the delay created by the additional testing will be granted.

If the Engineer determines a drilled shaft is unacceptable based on the CSL tests and tomographic analyses, or observes problems during drilled shaft construction, coring of the shaft to allow further evaluation and repair shall be required, or the shaft shall be replaced. If coring to allow further evaluation of the shaft and repair is chosen, one or more core samples shall be taken from each unacceptable shaft for full depth of the shaft or to the depth directed by the Engineer. The Engineer will determine the number, location, and diameter of the cores based on the results of 3D tomographic analysis of offset and horizontal CSL data. The Contractor shall provide an accurate log of cores, label and place the cores in a crate showing the shaft depth at each interval of core recovery, transport the cores along with five copies of the coring log to the Engineer, and perform strength testing by an AASHTO certified lab on portions of the cores that exhibit questionable concrete as determined by the Engineer.

If the coring or testing indicates the shaft is defective, the Contractor shall propose remedial measures for approval by the Engineer, repair all detected defects, and conduct post repair integrity testing using horizontal and offset CSL testing, and 3D tomographic imaging as described. The coring costs and remedial measure costs shall be borne by the Contractor. If the additional coring indicates that the drilled shaft has no defect, the coring costs resulting from the additional coring will be paid by the Owner. If the drilled shaft construction is on the critical path of the Contractor's schedule, a time extension equal to the delay created by the additional testing will be granted.

All access tubes and cored holes shall be dewatered and filled with a 4,000-psi grout after tests are completed and the drilled shaft is accepted. The access tubes and cored holes shall be filled using grout tubes that extend to the bottom of the tube or hole or into the grout already placed.

503.21 Drilled Shafts Load Tests. Test shafts shall be installed at the locations shown on the Plans unless otherwise directed or approved by the Engineer.

Test shafts shall be installed to the same dimensions, details, and elevations shown on the Plans, and shall be installed using the same equipment and installation procedures proposed for installation of the foundation drilled shafts.

If the methods or procedures are changed following the completion of load testing, the Contractor shall install additional load test shafts and conduct additional load tests as directed by the Engineer at no additional cost to the Owner.

An electronically sealed report of load test results shall be submitted within five business days of the testing completion. Load testing results will be evaluated by the Engineer before installing any production drilled shafts, to allow for design modifications based on the load test results. Load test data as reported shall conform to the Drilled Shaft Foundation Testing (DSHAFT) and be available in electronic form at the project website.

(a) Static Load Tests. Static load tests shall be performed per the procedures specified in ASTM D1143.

(b) Force Pulse (Rapid) Load Tests. Force pulse (rapid) load tests shall be performed per the procedures specified in ASTM D7383.

METHOD OF MEASUREMENT

503.22 Drilled shafts will be measured by the linear foot from the elevation shown on the plans to the bottom of the hole as drilled.

Each approved splice of the reinforcing cage for additional length of shaft will be measured as 1/2 linear foot of additional length of drilled shaft.

BASIS OF PAYMENT

503.23 The unit price of drilled shafts shall be full compensation for making all excavations; hauling and disposal of excavated material; provision and disposal of slurry, performing all necessary pumping; furnishing and placing required concrete and reinforcement steel, including the reinforcement projecting above the tops of the drilled shafts necessary for splicing and any intermediate reinforcement splices; furnishing and placing of CSL tubes; all backfilling; furnishing, placing, and removing temporary casings; furnishing permanent casing if required to complete the work; and for furnishing all tools, labor, equipment, and incidentals necessary to complete the work. Costs associated with repairing defects found in the drilled shaft shall be included in the cost of the drilled shaft.

(a) Payment. The accepted quantities for drilled shafts will be paid for at the Contract unit price per linear foot except for price adjustments allowed in (b) below.

Payment will be made under:

Pay Item	Pay Unit
Drilled Shaft (Inch)	Linear Foot
Drilled Shaft Load Test	Each
CSL Testing	Each

Obstruction Encounter and Removal will not be measured and will be paid for per subsection 109.04 under Force Account item Obstruction Encounter and Removal.

(b) Price Adjustments. When the Engineer orders holes to be drilled to a lower elevation than shown on the plans, compensation for additional depth will be as follows:

Table 503-6

DRILLED CAISSON ADDITIONAL LENGTH COMPENSATION

Additional Length	Compensation
Less than or equal to 5 feet	Contract Unit Price
Greater than 5 feet and less than 15 feet	Contract Unit Price plus 15%
Greater than or equal to 15 feet	As provided in subsection 109.04

Additional compensation will not be paid for the portions of a drilled shaft that are extended due to the Contractor's method of operation, as determined by the Engineer.

SECTION 504
WALLS

DESCRIPTION

504.01 This work consists of constructing a Concrete Panel Facing Mechanically Stabilized Earth (MSE) Retaining Wall System at the locations and to the lines and grades shown on the plans. Either metallic or geosynthetic reinforcement (woven fabrics or geogrids) as specified in this specification may be used as MSE reinforcement in the reinforced structure backfill zone. The retained structure backfill zone is the structure backfill retained by the reinforced structure backfill zone as shown on the plans.

This work consists of constructing a permanent soil nailed retaining wall (also referred to as ground nail wall), with complete details starting in subsection 504.23.

MATERIALS

504.02 Shop Drawings. The Contractor shall submit one electronic submittal of shop drawings and certified material test reports for review before construction of the wall. See subsection 504.07, for a complete list of submittal requirements. Shop drawings shall be submitted per subsection 105.02.

The shop drawings shall provide the details necessary to demonstrate compliance with the Contract, including:

(a) Wall Layouts. Wall layouts shall conform to lines and grades on the plans including start, corner, and end stations, leveling pad step breaks, total number of panels, and top and bottom of wall elevations. For walls with rail anchoring slabs, the top of panel elevations shall be within 8 inches of the elevation shown on the plans measured from the bottom of the anchoring slab. The construction batter required to achieve the batter shown on the plans shall be shown on the shop drawings. If temporary walls are required for the construction of the permanent wall, the permanent wall vendor shall provide the shop drawings and certified material test reports for temporary walls.

(b) Panel and Reinforcement Locations. Unless otherwise shown on the plans, each layer of soil reinforcement shall be connected to the back of each facial panel and the panel numbering and placement sequence shall be shown. The back of each panel shall be logically numbered with its location.

Panel to panel, panel to reinforcement connection detail, and limits of special panels at curved wall corner shall be shown.

(c) Wall Elevations. Except for the top of the leveling pad, wall elevations given on the plans are based on the desirable wall height. The actual panel and reinforcement elevations shall be marked on the shop drawings by taking into account the supplied panel as well as special panel heights for matching the front and top finished grade.

(d) Soil Reinforcement Material. The soil reinforcement type, Minimum Average Roll Value of the Ultimate tensile strength TULT (MARV) for geosynthetic soil reinforcement or yield strength for metallic soil reinforcement, spacing, lengths, elevations, and the corresponding wall design height shall be shown on the shop drawings. The starting and ending stations for change in grade of reinforcement material shall be shown for walls with

different grade of reinforcement material at the same elevation. Material grade shall be clearly identified on each roll of reinforcement to avoid errors in placement. Elevations of the reinforcement layers shall be as specified on the shop drawings.

(e) Soil Reinforcement Length (RL). The soil reinforcement length shall be measured from the front face of wall for panel less than 12 inches deep and from the back face of wall for panel greater than 12 inches deep to the end of the soil reinforcement as measured to the neat end. Soil reinforcement lengths shall not be less than the lengths specified on the plans.

The Reinforcement Lengths shown on the shop drawings shall be the reinforcement length required for internal stability and pull-out only. External stability (bearing pressure, sliding, and overturning) and global stability shall already be checked by the design Engineer.

(f) Panel Size and Soil Reinforcement Spacing.

1. Except for full height panels, the maximum panel size is 50 square feet, and the minimum panel height shall be 30 inches.
2. For full height panels, the maximum panel width shall be 10 feet and the maximum panel height shall be 40 feet. Differential deflection between adjacent panels shall be limited to 1per 500. The vendor shall supply design calculations regarding panel concrete crack size control during shipment and construction and estimated joint width and differential deflection limits. The use of full height panels with widths greater than 10 feet or heights greater than 40 feet shall be approved by the Engineer.
3. The maximum vertical spacing between layers of adjacent soil reinforcement shall not exceed 30 inches. Except the half height panel used at the top and bottom of the wall, including all partial and extended height panels at the top of the wall, there shall be at least two layers of reinforcement per panel.
4. The first and bottom layers of reinforcement shall be within 15 inches measured from the top of panel and from the top of leveling pad accordingly.
5. Shiplap joints shall be required at horizontal and vertical joints for segmental panel walls and all vertical joints for full height panel walls. The gap between two adjacent panels shall be 1/2 to 1 inch. Shiplap joints are not required at the vertical joints of segmental and full height panel when a minimum of 12 inches' depth of continuous crushed rock wrapped with Class 1 Geotextile is installed behind the joints as shown in the shop drawings. Geotextile (Class 1) and crushed rock will not be measured and paid for separately but shall be included in the work. Neoprene cushions shall be provided at horizontal joints as shown on the plans.

(g) Long Term Design Strength (LTDS) of Reinforcement.

1. The design charts on the plans define the strengths required for the zone of mechanical reinforcement of soil. Based on the total summed LTDS, the reinforcement proposed by the shop drawings for a specific wall height shall meet or exceed the total LTDS shown on the plans. This proposed reinforcement shall allow for a maximum of plus or minus 15 percent variation in each individual layer.

2. Metallic (Inextensible) Soil Reinforcement. The net section at the soil reinforcement to block connection shall be used for the sacrificial thickness calculation. The following minimum sacrificial thickness for reinforcement shall be applied to the 75-year LTDS

calculations:

Table 504-1
MINIMUM LOSS RATES

Galvanization Loss	15 µm/year for first 2 years 4 µm/year for subsequent years
Carbon Steel Loss	12 µm/year after zinc depletion

Steel Soil Reinforcement

$$\mathrm{LTDS} = \frac{\phi A_c F_y}{b}$$

Where:

Φ = 0.75 (Strip reinforcement)
= 0.65 (Grid reinforcement)

A_c = Area of reinforcement corrected for corrosion loss (in^2)
F_y = minimum yield strength of steel (ksi)

b = unit width of reinforcement (ft)

3. Geosynthetic Soil Reinforcement. Geosynthetic soil reinforcement shall be either a geogrid or woven geotextile. For polyester (PET), polypropylene (PP), and polyethylene (PE) reinforcement, the LTDS of material shall be determined using the following K percentages to ensure the required design life. Unless otherwise specified, LTDS shall not exceed the following K percent of its ultimate tensile strength, T_{ULT} (MARV):

LTDS = K * T_{ULT} (MARV)

$$Where\ K = \frac{\phi}{RF(ID)\ \mathrm{X}\ RF(D)\ \mathrm{X}\ RF\ (CR)}$$

RF(ID): Installation damage reduction factor

RF(D): Durability reduction factor

RF(CR): Creep reduction factor

Meet AASHTO LRFD and/or FHWA GRS design method for 75 years' design life.

A. Geogrid or Geotextile sheet reinforcement (PE, PET, PP):

Table 504-2
MAXIMUM K VALUES FOR GEOGRID OR GEOTEXTILE SHEET REINFORCEMENT

Products	K (Geogrid)	K (Geotextile)
PE and PP	27%	18%
PET	35%	30%

B. Woven Geotextile shall meet minimum bi-axial MARV of ultimate tensile of 4,800 LB/FT and a minimum tensile strength of 2,400 LB/FT at 5 percent strain based on ASTM D4595.

C. All products not listed above: Follow AASHTO equations 11.10.6.4.3b-1 and 11.10.6.4.3b-2 using independently certified test results.

(h) Design Heights and Supplied Reinforcing Material. Unless otherwise defined on the plans, the wall design height shall be measured vertically from the top of the leveling pad to the top of the concrete rail anchoring slab for walls with railing, or to the top of the cast-in-place concrete coping for walls without railing. For walls that are in front of a bridge abutment that is founded on a GRS foundation, the design height used to determine the soil reinforcement length shall be measured vertically from the top of the leveling pad to the top of the roadway carried by the bridge and the wall. Bridge approach slabs shall not be considered in the design of the MSE wall.

For both geosynthetic and metallic reinforcement, the required reinforcement LTDS and the supplied LTDS (determined per the K factors or depletion of material as defined above) with corresponding brand and grade of material shall be marked clearly on the elevation view or in a tabulation summary. The LTDS of the supplied reinforcement grade must meet or exceed the required LTDS corresponding to the reinforcement spacing provided.

(i) Tiered Walls. For the reinforcement layouts of tiered walls, the overall geometry, the reinforcement length, and the sum of the LTDS provided from all layers in all tiers shall be in close conformity with the retaining wall system shown on the plans in order to ensure that local, global, and internal stability requirements have been met.

(j) Obstructions. Details for the placement of soil reinforcement around obstructions (i.e., steel piles, concrete piers, concrete boxes, pipes, etc.) shall be shown on the shop drawings. Design calculations shall be provided showing that the internal stability of the wall meets the required safety factors in the area of the obstruction.

(k) Table of Quantities. A table comparing the Structure Backfill (Class 1), Mechanical Reinforcement of Soil, Geomembrane, and Panel Facing quantities shown on the plans to the quantities shown in the shop drawings and the percent difference (positive percent indicates an increase in shop drawing quantities from the plans) shall be shown on the shop drawings. Structure Backfill (Class 1), Mechanical Reinforcement of Soil, Geomembrane, and Panel Facing quantities shall be calculated per the Contract. The Contractor shall notify the Engineer of the difference in plan and shop drawing quantities before wall construction begins.

(l) Placement Schedule. Geomembrane placement schedule and clearances to soil reinforcements shall be shown.

(m)Vertical Slip Joints. Locations of vertical slip joints for differential settlement relief shall be as specified in subsection 504.13.

504.03 Backfill. Unless otherwise specified on the plans, wall backfill material in the reinforced structure backfill zone and the associated trapezoidal retained structure backfill zone shall conform to the requirements for Structure Backfill (Class 1) of Section 206. For reinforcement tensile stress and associated pullout, a friction angle of 34 degrees shall be assumed for Structure Backfill (Class 1). Structure Backfill (Class 1) shall be considered to be non-aggressive soil for corrosion and durability computations. All reinforcing elements shall be designed to ensure a minimum design life of 75 years for permanent structures.

504.04 Leveling Pad. Concrete for the leveling pad shall be Concrete (Class D) conforming to the requirements of Section 601. Unless specified on the plans, the maximum vertical step shall be no greater than 36 inches. The leveling pad shall be reinforced as shown on the plans. When the toe of wall is founded on slope steeper than 1.5 (H) to 1 (V), the leveling pad shall be constructed with reinforced concrete with same reinforcing schedule as at its steps. Leveling pad concrete shall be cured for at least 12 hours before placement of the concrete panels.

504.05 Geomembrane and Joints. A geomembrane shall be installed on all walls at the top of the reinforced structure backfill zone and retained structure backfill zone to intercept surface runoff and prevent salt penetration into the backfill of the wall as shown on the plans. The geomembrane shall meet the requirements of subsection 712.07 for geomembrane and be LLDPE with a minimum thickness of 30 mils. It shall be spliced with a dual track field seamed joint per ASTM D4437 and ASTM D5820. For small local coverage areas, less than 30 square feet, the membrane may be spliced using a 6-inch minimum overlap and an adhesive or a single seam portable thermal welding tool, as suggested by the membrane manufacturer and approved by the Engineer. Unless otherwise shown on the plans, the membrane shall have a minimum coverage length measured perpendicular to the wall face of at least the Pay Length for Geomembrane (PLG) as shown on the plans. The membrane shall be installed with a slope between 20:1 (minimum) and 10:1 (maximum), as shown on the plans, from the block facing to a drainage system located at the cut or pre-filled slope as shown on the plans. The Contractor shall provide a site-specific working drawing that indicates sheet splices, pattern, slope, and daylight location. Before membrane installation, the working drawing shall be submitted by the Contractor and approved by the Engineer.

The drainage system shall consist of a 12-inch-wide geocomposite strip drain inserted into a slot in the geomembrane, at 10-foot maximum spacing, that collects the water from the membrane and conveys it to a water collector system at the toe of the excavation slope as shown on the plans. The water collector system shall consist of a 4-inch diameter perforated collector pipe surrounded by Filter Material Class B and wrapped with Class 1 Geotextile. A 4-inch diameter non-perforated drainpipe, at 100-foot maximum spacing, shall be used to discharge the water in the water collector system out the face of the wall.

Alternatives for the drainage system shown on the plans may be used by the Contractor. A detailed layout of this equivalent water collection system shall be provided by the Contractor and approved by the Engineer.

For tiered walls, a geomembrane shall be installed between the top of the bottom wall and the toe of the top wall as shown on the plans.

504.06 Pre-Cast Concrete Panel Facing Unit and Panel Joint Material. The pre-cast concrete panels shall conform to the requirements shown on the plans and these specifications including the color, texture, dimensions and pattern. These facing units shall be factory made with an approved Class D or G Concrete and shall conform to the requirements of Section 601. The Contractor may elect to use an approved self-consolidating Class D or G Concrete. Pre-cast panels shall be cured per AASHTO M170.

504.07 Certifications, Calculations, and Testing Reports. The Contractor shall provide the following reports, certifications, calculations, and checklists as needed to accompany the shop drawing submittal. The Contractor's Engineer shall electronically seal all engineering calculations, as stated in subsections 504.02(f), 504.02(g), 504.02(j), 504.02(k), 504.07(e), 504.07(f), 504.07(g), and 504.07(h).

(a) Certification of T_{ULT} (MARV). For geosynthetic reinforced system only, the Contractor shall submit a certification letter from the manufacturer that provides the T_{ULT} (MARV) and certifies the T_{ULT} (MARV) of the supplied materials have been determined per ASTM D4595 or ASTM D6637 as appropriate.

(b) Mill Report for Metallic Reinforcements and Connectors. This includes, but is not limited to, mill certifications on weldability, ultimate tensile strength, and yield strength.

(c) Report of The Panel-Reinforcement Connection Test. The test report shall be prepared and certified by an independent laboratory. The panel to reinforcement connection test method shall conform to the industrial standards. The report shall provide data on the ultimate as well as service limit state.

(d) Report for Soil to Reinforcement Interface Pullout Test. The test report shall be prepared and certified by an independent laboratory. The soil to reinforcement interface pullout test method shall conform to the requirements of ASTM D6706. Tests shall include the full range of overburden pressures defined by wall design heights.

(e) Certification of Facial Panel to Reinforcement Long-Term Connection Strength. Certification shall include calculations to demonstrate that the facial panel to reinforcement connection meets or exceeds current AASHTO 75 years' design life requirements.

(f) Certification of Reinforcement Pullout. Certification shall be provided with detail calculations to demonstrate that reinforcement pullouts meet or exceed current AASHTO requirements. For metal reinforcement breakage and pullout, calculations shall include a combination of 75 years' material depletion of carbon steel and galvanization loss.

(g) Report and Certification for the Initial Concrete Compression Strength, Shipping and Handling Stress. Cylinder compressive test is acceptable to verify the initial concrete strength of panel at time of shipping. Concrete tensile stress shall not exceed the modulus of rupture. The report shall include calculations of panel cracking stress according to the proposed method of lifting and shipping. Before panel shipping from precast yard to wall site, the Engineer will approve the time of shipping, method of lifting and supporting condition during shipping, as well as storage condition at the site before panel installation.

(h) Calculations. Calculation of the LTDS of reinforcement shall conform to current AASHTO LRFD or latest interim requirements.

(i) Efflorescence and Air Content Test. Panel shall be visually efflorescence free. Efflorescence control agent shall be used in concrete mix design. When fly ash is used as the efflorescence control agent, the fly ash shall be ASTM C618 Class F fly ash and shall be a minimum of 20 percent by weight of the total cementitious material content. Air Content shall be determined per AASHTO T152. Concrete shall be tested a minimum of the first three batches each day and then once per five batches for the rest of the day to assure specified air entrainment.

(j) Submittal Checklist. The Contractor shall submit the wet cast facing or Panel Faced MSE Wall Submittal Checklist, Form 1402 with the Certifications, Calculations and Testing Report submittal package included with the shop drawing submittal.

504.08 Hybrid or Smaller Panel MSE Wall Systems.

A hybrid system is one that combines elements of both externally and internally stabilized systems.

An externally stabilized system uses a physical structure to hold the retained soil. The stabilizing forces of this system are mobilized either through the weight of a shape stable structure or through the restraints provided by the embedment of wall into the soil, if needed, plus the tieback forces of anchorages.

An internally stabilized system involves reinforced soils to retain fills and sustain loads. Reinforcement may be added to either the selected fills as earth walls or to the retained earth directly to form a more coherent stable slope. These reinforcements can either be layered reinforcements installed during the bottom-to-top construction of selected fills or be driven piles or drilled caissons built into the retained soil. All this reinforcement shall be oriented properly and extend beyond the potential failure mass.

Hybrid MSE wall systems may be used unless otherwise noted on the plans. Hybrid MSE wall systems are subject to the same design requirements for MSE walls and this specification. The shop drawings for the Hybrid MSE wall system shall include a combination of design calculations and appropriate test results to demonstrate that it meets or exceeds the regular system. Hybrid MSE wall systems shall have a modular facing and be stabilized by a counterfort or a coherent mass such as interlocked wire basket system. The Certifications, Calculations, and Testing Reports in subsection 504.07(e) are not required for Hybrid MSE wall systems. The facing to soil reinforcement connection test, subsection 504.07(c), may be waived only if the soil reinforcing spacing is less than or equal to 8 inches or the facing is secured and stabilized by hybrid components with primary reinforcement spacing less than 24 inches.

The Contractor shall provide the following additional reports, certifications and calculations to accompany the shop drawing submittal for Hybrid MSE wall systems:

(1) The facing to counterfort or coherent mass long-term connection test.

(2) 75-year design of wire basket and filter fabrics for avoiding migration of fine soil.

The Contractor shall submit the dry cast facing MSE Wall Submittal Checklist, Form 1401, or the wet cast facing MSE Wall Submittal Checklist, Form 1402, with the Certifications, Calculations, and Testing Report submittal package included with the shop drawing submittal.

CONSTRUCTION REQUIREMENTS

504.09 Approval and Qualifications of MSE Wall Installer. The job site wall foreman shall have experience in construction of at least five transportation-related MSE walls within the last three years. Transportation related MSE walls are walls that carry or are adjacent to vehicular traffic and are constructed with MSE reinforcement in the reinforced structure backfill zone. The foreman shall have prior experience or adequate training on the products that the Contractor elects to use on the project. The resume and credentials of the foreman shall be submitted to the Engineer for approval before the Pre-construction Conference. The foreman shall be on the site for 100 percent of the time during which the work is being done.

504.10 Wall Test Segment. The wall test segment shall be the first segment of the wall constructed. The wall test segment shall be constructed in the presence of the Technical Representative and the Engineer and shall include construction of each of the five elements listed in subsection 504.11. The minimum length of the wall test segment shall be 40 feet or the full length of the wall if less than 40 feet. A wall test segment shall be constructed for the first wall constructed from each wall product used on the project.

504.11 Technical Representative of Wall Product Supplier. The Contractor shall arrange for a technical representative (Tech Rep) of the manufacturer of the selected wall products to be present during the construction of each wall test segment. If the selected wall products are supplied from different manufacturers, a Tech Rep from each wall product shall be present. The Tech Rep shall be present for construction of the wall test segment and each of the following elements:

(1) Placement of a minimum of the first four layers of primary soil reinforcement and backfill.
(2) If obstructions (steel piles, concrete piers/abutments, concrete boxes, pipes, etc.) exist, placement of primary soil reinforcement and backfill at obstructions.
(3) Placement of a minimum of the first two rows of panels or a minimum of a four-foot wall height.
(4) If a vertical slip joint is required, construction of the vertical slip joint in a minimum of a two-row portion of panels or a minimum of a four-foot wall height.
(5) If corners are required, construction of a corner representative of the corners in the wall in the project in a minimum of a two-row portion of panels or a minimum of a four-foot wall height.

Before construction of the wall test segment, the Tech Rep shall provide the Contractor and the Engineer the following:
(1) Technical instructions as required for the construction of the earth retaining wall system.
(2) Product specific specifications for the placement of the soil reinforcement and backfill per the wall system.
(3) Guidelines for placing the facing units and attaching them to the soil reinforcement per the system requirements.
(4) Technical assistance to the facing unit fabricator.

At the completion of the wall test segment, the Tech Rep shall provide the following:
(1) Documentation that the wall test segment was constructed per the product specific specifications. This documentation shall include a location description (starting and ending stations and elevations) of the wall test segment.
(2) Documentation that the job site wall foreman is familiar with the wall products used to construct the walls on the project.

After completion of the wall test segment the Tech Rep shall be available when there is any special field condition such as change of geological condition, when there are equipment or personnel changes, or when requested by the Engineer.

504.12 Facial Panel Quality Control, Placing Plan, and Daily Placement Logs. Before the start of wall construction, the Contractor shall provide a panel-placing plan and shall supply daily placement logs to the Engineer weekly and at the completion of the wall. The daily placement log shall consist of an elevation view of the wall showing the dates, number of panels placed, and the serial numbers of the panels placed. The panel quality control shall contain multiple submittals if required by subsections 504.07(g) and (h). Panels shall be labeled with a serial number for each panel and corresponding certification with one set of random samples tested for each 220 panels or 5,500 square feet of wall face. At least one certification with supporting test results is required for each wall. Test results will be reviewed and pre-approved by the Engineer before shipment. The Contractor shall coordinate and mark the panel and backfill placing sequence on the daily placement logs. The log serves as means for the Engineer to identify where each panel was placed.

504.13 Wall With Curved Alignments, Tight Curved Corners, and Sections Adjacent to Bridge Abutment. The Contractor shall provide a placement plan that shows curved layouts, special corner panel, sequence of panel placement, and construction offsets as recommended by the manufacturer. The Contractor shall install vertical slip joints as shown on the shop drawings for tight curved corners (8-foot radius or less) and dissimilar foundations such as bridge abutments, to avoid panels with random cracks.

504.14 Excavation and Backfill. The base of leveling pad shall receive the same compaction as cut area required by subsection 203.07. The Contractor shall report to the Engineer in writing density test results for any unsatisfactory bearing material that does not meet the minimum 90 percent compaction for walls less than 16 feet high and 95 percent of AASHTO T 180 for walls higher than 16 feet. If the excavation for the placement of the leveling pad exposes an unsatisfactory bearing material, the Engineer may require removal and replacement of that material. The removed material shall be replaced with Structure Backfill (Class 1) compacted in conformance with subsection 206.03. The Engineer with the assistance of the geotechnical engineer of record will provide the limits including the depth of removal. As directed by the Engineer, and if required, Structure Backfill (Class 1) shall be reinforced with soil reinforcements in conjunction with wick drains and outlet pipes.

The Contractor shall grade the foundation for the bottom of the wall for a width equal to or exceeding the limits of the Reinforcement Length (RL) plus 18 inches as shown on the plans. This graded area shall be compacted with an appropriate vibratory roller weighing a minimum of 8 tons for at least five passes or as directed by the Engineer. For cut wall with continuous seepage, phasing of foundation construction or a different drainage and foundation improvement plan may be necessary.

The reinforced structure backfill zone and the retained structure backfill zone portion immediately behind the wall as defined on the plans shall be Structure Backfill (Class 1). Recycled asphalt, recycled concrete, and flow-fill material shall not be substituted for Structure Backfill (Class 1). Each compacted layer of backfill within a distance equal to the reinforcement spacing away from the back of the panels shall not exceed 4 inches. The triangular or trapezoidal portion behind the concrete panels and above the spill of backfill, as shown on the plans, shall be filled with 3/8-inch or larger crushed rock, filter aggregates with

filter fabric, or wall system specific fill as approved by the Engineer. Density tests behind and parallel to the wall in the triangular or trapezoidal portion above the backfill spill zone are not required. Each compacted layer of backfill shall be in even increments up to 8 inches thick. The fill and compaction operation shall start 3 feet from the wall back face and progress toward the end of the reinforcement. All Structure Backfill (Class 1) including fill material under the wall and on-site material as allowed by subsection 504.03 shall be compacted to a density of at least 95 percent of the maximum density according to AASHTO T 180. For on-site foundation material containing more than 30 percent retained on the 3/4-inch sieve, a method of compaction consisting of a conventional heavy vibratory roller starting with minimum 5 passes shall be used to establish the number of passes required to exceed the 95 percent T180.

At least 6 inches of material shall be in place before operation of tracked vehicles over soil with reinforcement. Only power operated roller or plate compaction equipment weighing less than 1,000 pounds is allowed within 3 feet of the front of the wall face. The reinforcement shall not be connected to the wall until the compacted fill is at or slightly higher than the location of the connector.

Backfill containing frost or frozen lumps shall not be used. Backfill that has been placed and becomes frozen shall be removed and replaced at the Contractor's expense. If cold weather conditions prevent the placement of Structure Backfill (Class 1), the Contractor may use Filter Material Class B as backfill without compaction at the Contractor’s expense and approved by the Engineer. The Contractor shall provide a test report, prepared and certified by an independent laboratory, that the internal friction angle of soil for the Filter Material Class B meets or exceeds that shown on the plans.

The Contractor shall place additional panels including partial height panels and properly compacted fill material to return the finished grade to the plan elevations if settlement, as determined by the Engineer, has occurred. A final inspection before the installation of rail anchoring slab will be made after construction settlement, if any, has occurred or 30 days after the completion of the wall. The Contractor shall provide immediate temporary stormwater protection and wind erosion control at the end of each day during construction. If settlement occurs as the result of loss of backfill due to wind or water erosion, non-conforming backfill such as frozen fill or over-saturated fill, or if the backfill does not meet compaction requirements, the Contractor shall remove the backfill, wash the soil reinforcement, and bring the elevation to the finished grade at the Contractor's expense. Before final project acceptance, the Contractor shall repair all backfill losses due to wind and water erosion.

To avoid the foundation of the leveling pad being washed out by rain, the area in front of the wall and around the leveling pad shall be backfilled as soon as practicable.

504.15 Reinforcement. Steel reinforcement shall be slack free and geosynthetic reinforcement shall be slightly pre-tensioned. The minimum coverage ratio for geogrid reinforcement shall be 67 percent and the spaces between rolls shall be staggered between layers of soil reinforcement. The minimum coverage ratio for woven fabric reinforcement shall be 100 percent and an overlap between rolls is not required. Soil reinforcement shall not be cut to avoid obstruction unless shown on the shop drawings.

504.16 Leveling Pad. The foundation of the leveling pads shall meet the requirement of subsection 504.04 for steel and concrete. The leveling pad shall be level within the tolerance of 1/8 inch for any two points along the length of a panel, and within 1/4 inch for any two points 10 feet apart.

Cushion or shimming material (expansion joint material, concrete mortar grout, roofing felt, or geosynthetic reinforcement) shall be used to support panels directly founded on the leveling pad. Before starting a new course of panels, the Contractor shall take steps to ensure that the wall elevations are matched at the neighboring panels. Cushion or shimming material shall be used to obtain necessary panel elevations at next leveling pad step. No more than two shims (each 3/16 inch thick) shall be required to level the panels on the leveling pad.

504.17 Wooden Wedges. Wooden wedges may be used to help to hold the panels at the correct batter during the backfill operation. The wooden wedges shall be made from hard wood (such as oak, maple or ash). Wooden wedges shall be removed as soon as the precast panels above the wedged panels are completely erected and backfilled. There shall not be more than three rows of wooden wedges in place at one time. Panels that crack or spall due to failure to remove the wooden wedges shall be repaired or replaced.

504.18 Panel Facing. For walls that support a roadway, the wall layout line at the leveling pad shall be set back and pre-measured with appropriate batter (5 to 8 percent) from the top of the panels according to the offset with respect to the centerline of the road. For walls adjacent to a roadway, the wall layout line at the leveling pad shall be directly offset from the centerline of the road. An overall negative batter (wall face leaning outward) between the bottom and the top of the wall is not allowed. Unless otherwise noted on the plans for battered walls, the final wall face shall be vertical, or have a positive batter of not greater than 5 percent for construction control purpose. The surface of the wall face shall be tested with a 10-foot straightedge laid along the surface in horizontal and vertical directions. Except as necessary for horizontal alignment of the wall, convex deviation of the wall face from the straightedge (belly wall) shall not be allowed, and concave deviation from the straightedge shall be less than 1/2 inch.

Walls without a rail-anchoring slab, cast-in-place reinforced concrete coping with uniform exposed height is required to match the required finished elevations as well as to retain the panels' lateral deformation.

For walls with rail anchoring slabs, the top of panel elevations shall be within 8 inches of the bottom of the anchoring slab. Cast-in-place concrete or saw-cut partial height panels may be used to accomplish this.

Where the geomembrane for drainage interferes with the continuation of reinforcement, the panels beyond the termination shall be reinforced with the same grade of additional soil reinforcing material to maintain the total amount of reinforcement per panel. To avoid leaking or soil erosion through the joint, a filter fabric at least 12 inches wide shall be glued to the panels behind all vertical joints.

As shown on the plans, facing panels directly exposed to spray from deiced pavements and indirect windborne spray shall have three coats of water resistant or repellant concrete sealer applied to the front face of the wall before the wall is opened to traffic.

All damages to a completed wall or parts of a completed wall, including blemishes and discoloring of panels, shall be replaced or repaired before final payment is made. Sand blasting may be used if approved by the Engineer.

504.19 Fill under Leveling Pad. For walls requiring fill under the planned elevation of the leveling pad, the Contractor may lower the elevation of the leveling pad as approved by the Engineer, except that the finished elevation at the top of the wall shall not be altered. As requested by the Contractor, and with the Engineer's approval, the higher wall shall be redesigned with longer reinforcement length and revised reinforcement schedule.

METHOD OF MEASUREMENT

504.20 MSE retaining walls will not be measured for payment in the field but will be paid for by the calculated quantities shown on the plans for the five major components of the wall: structure excavation, structure backfill, concrete panel facing, mechanical reinforcement of soil, and geomembrane. The Contractor's construction of a system that requires increased or decreased quantities of any of the components to complete the wall to the dimensions shown will not result in a change in pay quantities. Exceptions will be made when field changes are ordered or when it is determined that there are discrepancies on the plans in an amount of at least plus or minus five percent of the plan quantity.

(1) The panel facing quantity was calculated for the square foot of wall front face area from the top of the leveling pad (or average pad elevations) as shown on the plans to the top of the anchoring slab for walls with railing, or to the top of the cast in place coping for walls without railing.

(2) The structure excavation quantity was calculated for the total volume of earth to be removed before the installation of the reinforced zone as shown on the plans.

(3) The structure backfill quantity was calculated for the total volume behind the wall (the retained structure backfill zone) including the material in the reinforced zone as shown on the plans.

(4) The mechanical reinforcement of soil quantity was calculated for the total volume of the reinforced zone as shown on the plans.

(5) Geomembrane was calculated as the design height (DH) plus soil reinforcement length (RL) plus 1.5 feet, disregarding the slope of the membrane.

The square foot and cubic yard quantities computed for payment are the wall plan quantities based on the height measured at 20-foot maximum intervals along the wall layout line.

BASIS OF PAYMENT

504.21 The accepted quantity will be paid for at the contract unit price per unit of measurement for the pay items listed below:

Payment will be made under:

Pay Item	Pay Unit
Panel Facing	Square Foot

Structure excavation will be paid for under the Section 206 Pay Item Structure Excavation. Structure backfill will be paid for under the Section 206 Pay Item Structure Backfill (Class 1). Soil reinforcement will be paid for under the Section 206 Pay Item Mechanical Reinforcement of Soil. Geomembrane will be paid for under the Section 420 Pay Item Geomembrane.

Rail anchoring systems (slabs) at the tops of walls and leveling pads at the bottom of wall will be measured and paid for separately under the Section 601Pay Item Concrete and the Section 602 Pay Item Reinforcing Steel.

Payment will be full compensation for all work and materials required to construct the concrete panel facing MSE wall. Miscellaneous items such as dual track welding of geomembrane, drainage ditches, rundowns, filter material, filter fabric, grout, pins, shimming material, 1/4-inch-thick expansion joint material, concrete coating and providing a technical representative will not be measured and paid for separately but shall be included in the work.

504.22 Panel Facing Payment Reductions. In this subsection, a "panel" refers to either a concrete panel or a hybrid unit. Each of the following shall be considered a defect:

(1) Dislocated Panel. A dislocated panel is an individual panel, or its corner located outward more than 1/4 inch from the adjacent panels.
(2) Cracked Panel. A cracked panel is an individual panel with any visible crack when viewed from a distance equal to the wall height in natural light.
(3) Corner Knock Off. A corner knock-off is a panel with any missing facial corners or architectural edges.
(4) Substandard panel. Substandard panels are concrete panels installed in wall segments that do not meet the certified values for compressive strength. Each substandard panel counts as one defect.
(5) Oversize Joints. Panels with oversize joints are two adjacent panels that do not meet the required values in subsection 504.02(f).
(6) Panels Failing the 10-Foot Straightedge Test. Straightedge test failures are joints that deviate from even by more than 1/4 inch when measured by placing a 10-foot straightedge across the joint.

Defects shared by two adjacent panels such as oversized joint, dislocated panel and panels not passing 10-foot straight edge test will be count as one defect.

In the completed wall or completed portion of the wall the number of defects, as described above, in each 40-foot section (horizontal or arc length) will be counted. If there are defects, the number of defects in the 40-foot section will be considered for price reduction according to the table below. For panels subjected to price reduction, if the defects are repairable or the overall quality of wall can be improved, with the consent from the Engineer, the Contractor may elect to repair and reduce the percent of price reduction. If the finished wall facing profile outside of acceptable zone or into negative batter is not repairable, the non-repairable portion shall receive a 21 percent price reduction for each wall pay item. A walkthrough inspection will be made as requested by the Contractor before final payment.

Table 504-3
PRICE REDUCTION FOR PANEL FACING DEFECTS

No. of Defects in 40 Foot Section	Percent of Price Reduction for that section
2	3
3	9
4	15
5	21
> 5	Rejection

When the number of defects exceeds five, the Engineer will reject the entire wall or portions thereof. The Contractor shall replace the rejected wall at his own expense.

SOIL NAIL WALL

DESCRIPTION

504.23 Soil Nail Wall. This work consists of constructing a permanent soil nailed wall (also referred to as ground nail wall) as specified, and as shown on the plans. Temporary soil nail walls and the final facing are not covered in this specification. The work includes:

(1) Excavating staged lifts per the plans and approved submittals.
(2) Drilling soil nail holes to the diameter and length required to develop the specified capacity as shown on the plans.
(3) Installing soil nails including placement and grouting.
(4) Performing soil nail testing and providing test results to the Engineer.
(5) Providing and installing the specified drainage features.
(6) Providing and installing bearing plates, washers, nuts, couplers, and other required miscellaneous materials.
(7) Constructing the initial shotcrete face.

MATERIALS

504.24 Materials shall meet the following requirements:

(1) Concrete shall be Class D, conforming to the requirements of Section 601.
(2) Reinforcing Steel shall conform to the requirements of Section 602.
(3) Shotcrete shall conform to the requirements of Section 641.
(4) Forms and falsework shall conform to the requirements of subsections 601.09 and 601.11.
(5) Geocomposite strip drains shall comply with Section 712.12.

(6) Underdrains and pipes shall comply with Sections 712.11 and 712.13.

504.25 Soil Nails

(a) Solid Bar Soil Nail. Bars shall conform to AASHTO M31 for Grade 75 or ASTM A722 for Grade 150. Bars shall be threaded, continuous without splices or welds, new, straight, undamaged, epoxy-coated or encapsulated as shown on the plans. Bars shall be threaded a minimum of 6 inches on the wall anchorage end to allow proper attachment of bearing plate and nut. Threading may be continuous spiral deformed ribbing provided by the bar deformations (continuous thread bars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, the next larger bar number designation from that shown on the plans shall be provided at no additional cost.

(b) Bar Coupler. Bar couplers, where allowed by the plans, shall be designed to develop the full ultimate tensile strength of the bar as certified by the manufacturer.

(c) Fusion Bonded Epoxy Coating. Epoxy coating for bars and end hardware shall conform to ASTM A775 or A934. The minimum thickness shall be 0.012 inch and shall be electrostatically applied. Bend test requirements are waived. Coating at the wall anchorage end of epoxy-coated bars may be omitted over the length provided for threading the nut against the bearing plate. Coating at the end of the bar of epoxy-coated bars may be omitted over the length provided for threading a coupler if bars are to be joined. Galvanization may be substituted for epoxy. Bars should be galvanized according to ASTM A767/A767M. A minimum galvanization coating of 3.4-mil thickness is required. Galvanization shall be applied per ASTM A153 for nuts, plates, and other hardware.

(d) Encapsulation. Encapsulation shall be a sheathing of either corrugated high density polyethylene (HDPE) tube with a minimum 0.06-inch thickness conforming to AASHTO M252 or corrugated PVC tube with a minimum 0.04-inch thickness conforming to ASTM D1784, Class 13464-B. The level of corrosion protection shall be as shown on the plans.

(e) Centralizer. Centralizers shall be manufactured from Schedule 40 PVC pipe or tube, or other material not detrimental to the soil nail steel or corrosion protection. Wood shall not be used. Centralizers shall be:

1. Securely attached to the soil nail bar.
2. Sized to position the soil nail bar within 1 inch of the center of the drill hole.
3. Sized to allow tremie pipe, grout tube, or casing insertion along the full length of the drill hole.
4. Sized to allow grout to freely flow up the drill hole.

(f) Soil Nail Grout. The minimum compressive strength for grout should be 1,500 pounds per square inch (psi) at 3 days, and 3,000 psi at 28 days, as tested per ASTM C109. If sand is used in the grout mixture, it shall meet the requirements of subsection 703.01. A batch ticket shall be supplied for each grout delivery to be used during construction of the soil nail wall. If grout is mixed on site, all materials shall be weighed and recorded prior to mixing or incorporation into the mixer. The water/cementitious ratio and specific gravity may be used as a primary quality control of the neat cement grout mix if the Contractor can demonstrate the materials and mix design consistently produce a grout of the minimum specified strength. Neat cement grout cubes shall be molded by the Contractor in the

presence of the Engineer and tested by the Department on the grout used in production soil nails and the adjacent test soil nail.

(g) Fine Aggregate. Fine aggregate shall conform to subsection 703.01.

(h) Cementitious Materials. Cementitious materials shall conform to Section 701. The cement used for shotcrete and grout shall meet the sulfate resistance requirements of subsection 601.04.

(i) Admixtures. Admixtures shall conform to Section 711. Admixtures that control bleed, improve flowability, reduce water content, reduce washout, and retard set may be used in the grout as approved by the Engineer. Accelerators are not permitted. Expansive admixtures may be used only in grout used for filling sealed encapsulations. Admixtures shall be compatible with the grout and mixed per the manufacturer's recommendations.

(j) Film Protection. Polyethylene film for moisture loss control shall conform to AASHTO M171.

504.26 Bearing Plates, Washers, Nuts, and Headed Studs.

(a) Bearing Plates. Bearing plates shall conform to AASHTO M183/ASTM A36.

(b) Beveled Washers. Beveled washers shall conform to ASTM F436, with an angle matching the inclination of the soil nail to provide uniform bearing.

(c) Nuts. Nuts shall be hexagonal and fitted with beveled washer or spherical seat to provide uniform bearing to develop the full ultimate tensile strength of the bar as certified by the manufacturer and conform to AASHTO M292/ASTM A194.

(d) Headed Studs. Headed studs on the bearing plate shall conform to requirements of Section 509.12.

504.27 Welded Wire Fabric. Welded Wire Fabric shall conform to AASHTO M55, AASHTO M221, or ASTM A1064.

CONSTRUCTION REQUIREMENTS

504.28 Contractor Qualifications. The Contractor shall provide on-site supervisors and drill operators with experience installing permanent soil nails on at least 3 permanent soil nail retaining wall projects during the past 3 years totaling at least 10,000 square feet of wall face area and at least 500 permanent soil nails.

504.29 Submittals. The following documents shall be submitted per subsection 105.02. No work relating to soil nail wall construction including ordering materials shall be performed before the following submittals have been reviewed and reviewed by the Engineer.

(a) Qualifications. The soil nailing Contractor shall submit a brief description of at least 3 completed projects, including the owning agency's name, address, current phone number, location of project, project contract value, square foot of wall, the number of nails, scheduled completion date, and actual completion date for the project.

(b) Personnel. At least 14 calendar days before starting soil nail work, the soil nailing Contractor shall identify on-site supervisors and drill operators assigned to the project and submit a summary of each individual's experience. Only those individuals designated as meeting the qualifications requirements shall be used for the project. The soil nailing Contractor shall not substitute for any of these individuals without written approval by the Engineer. The Engineer will review the soil nailing Contractor qualifications and staff within 15 working days after receipt of the submission. The Engineer may suspend the work if the soil nailing Contractor substitutes unqualified personnel for qualified personnel during construction. If work is suspended due to the substitution of unqualified personnel per subsection 504.29 (a), the Contractor shall be fully liable for additional costs resulting from the suspension of work and no adjustment in contract time resulting from the suspension of the work will be allowed.

(c) Construction Plan. At least 14 days before starting soil nail work, the soil nailing Contractor shall submit a Construction Plan to the Engineer for review that includes the following:

1. The start and finish date and proposed detailed wall construction sequence. Include schedule entries and anticipated durations for each lift excavation, soil nail installation for each lift, grout curing, soil nail testing, and shotcrete placement and curing.
2. Drilling and grouting methods and equipment, including the drill hole diameter proposed to achieve the specified pullout resistance values shown on the plans and any proposed variation of these along the wall alignment.
3. Soil nail grout mix design, including compressive strength test results supplied by a qualified independent testing lab verifying the specified minimum 3-day and 28-day grout compressive strengths. Previous test results for the same grout mix completed within one year of the start of grouting may be submitted for verification of the required compressive strengths.
4. Soil nail grout placement procedures and equipment.
5. Shotcrete materials and methods including methods to address soil fall out, perched water, and anti-washout as needed based on site condition or review of the Geotechnical Report per subsection 102.05.
6. All materials, methods, and control procedures for the initial shotcrete facing.
7. Soil nail testing methods and equipment setup.
8. Identification number and certified calibration records for each test jack, pressure gauges, and load cell to be used. Jack, load cell, and pressure gauge shall be calibrated as a unit. Calibration records shall include the date tested, the device identification number, and the calibration test results and shall be certified for an accuracy of at least 2 percent of the applied certification loads by a qualified independent testing laboratory within 6 months before submittal.
9. Certificates of Compliance for:
   A. The soil nail bar yield or ultimate tensile strength.
   B. Soil nail bar steel type.
   C. Bearing plates, washers, nuts, and couplers.
   D. Corrosion protection.
   E. Geocomposite strip drain and underdrain material.

   The Engineer will review the soil nailing Contractor's Construction Plan within 10

working days after the submission.

504.30 Protection and Cleanup. During work operations, the Contractor shall take such precautions as may be necessary to prevent shotcrete overspray, drill cuttings, equipment exhaust, oil, wash water, and other materials from defacing or damaging private and public property including adjacent landscaping per subsections 107.12 and 107.25. The Contractor shall furnish all equipment as may be necessary to handle wastewater and material from the operations and clean up all waste resulting from the operations. The Contractor is responsible for the stability of the highway facility and nearby structures.

504.31 Storage and Handling. Soil nail bars shall be stored and handled in a manner to avoid damage, excessive bending, permanent deformation, or corrosion. Bars exhibiting abrasions, cuts, welds, weld splatter, corrosion, or pitting shall be replaced. Bars exhibiting damage to encapsulation or epoxy coating shall be repaired or replaced. Repaired epoxy coating areas shall have a minimum 0.012-inch-thick coating. Bars exhibiting damage shall be repaired or replaced at the Contractor's expense.

504.32 Excavation. The Contractor shall be responsible for providing the necessary survey and alignment control during the excavation for each lift, locating drill holes, and verifying limits of the soil nail wall installation. Before any excavation, surface water controls shall be installed around the wall area as needed to prevent surface water, seepage, or springs from flowing within or into the excavation or as determined by the Engineer. The Engineer shall be notified 14 days before the beginning of excavation to allow scheduling of qualified representatives of the soil nail wall design professional engineer to observe the excavation and drilling as needed. The Engineer and the soil nail wall design engineer shall be contacted immediately if the Contractor encounters any ground conditions or materials during the excavation or drilling that is not shown on the plan set or unanticipated seepage, springs, or other sources of groundwater to allow for review of the design. The Contractor shall reference available Geotechnical Reports or other site condition reports per subsection 102.05 for additional information concerning the ground conditions that are anticipated during excavation.

During construction of the soil nail wall, excavation not associated with the soil nail wall construction shall not be performed within a horizontal distance equal to the total height of the final soil nail wall face excavation. The height of the exposed unsupported final excavation face cut shall not exceed the vertical soil nail spacing plus the required reinforcing lap or the short-term stand-up height of the ground, whichever is less. Each lift excavation shall be completed to the final wall excavation line and shotcrete applied in the same work shift, unless otherwise approved by the Engineer. Application of the shotcrete may be delayed up to 24 hours if the Contractor can demonstrate that the delay will not adversely affect the excavation face stability.

The Contractor shall modify excavation procedures and soil nail wall installation procedures to prevent the loss of material from the excavation face or from behind the previously installed shotcrete lift (chimneying). This may require adjustments to the sequencing between excavation, soil nail drilling and shotcreting to shorten the time the excavation lift is unsupported, drilling and installing the soil nails through temporary berms before final excavation and/or installing the initial shotcrete before drilling the soil nails. All voids that develop behind the shotcrete shall be filled with grout at no additional cost to the Department.

Excavation of the next-lower lift shall not proceed until soil nail installation, initial shotcrete face placement, attachment of bearing plates and nuts, and soil nail testing have been completed and accepted per subsection 504.39 and 504.42 in the current lift. Soil nail grout and shotcrete shall have achieved a compressive strength of at least 1000 psi before excavation of the next underlying lift.

Where the Contractor's excavation and installation methods result in a discontinuous wall along any soil nail row, the ends of the upper lift excavation shall extend beyond the ends of the next lower excavation lift by at least 10 feet. Slopes at these discontinuities shall be constructed to prevent sloughing or failure of the temporary slopes. If sections of the wall are to be constructed at different times, the Contractor shall prevent sloughing or failure of the temporary slopes at the end of each wall section.

The Contractor shall remove all or portions of cobbles, boulders, rubble or other subsurface obstruction encountered at the cut line which will protrude into the shotcrete facing including a method to safely secure remnant pieces remaining behind the excavation face and promptly backfilling voids resulting from removal of protrusions extending behind the excavation face. Voids, over-break or over-excavation beyond the plan wall excavation line resulting from the removal of face protrusions or the excavation operation shall be backfilled with shotcrete, concrete, or grout.

504.33 Soil Nail Installation. Soil nail length and drill hole diameter used shall be those necessary to develop the specified load capacity to satisfy the acceptance criteria, but not less than the lengths or diameters shown on the plans. The Contractor shall modify their drilling procedures, as needed, to achieve the required soil nail pullout resistance specified in the plans. All work required to achieve the required soil nail pullout resistance including modifications to the drilling procedures will not be measured separately but shall be included in the unit price of the work. Holes shall be drilled for the soil nails at the locations, elevations, orientations, and minimum lengths shown on the plans. Drilling equipment and methods shall be suitable for the ground conditions and conform to the installation methods submitted by the soil nailing Contractor. Drilling muds or other fluids shall not be used to remove cuttings. If caving ground is encountered, cased drilling methods shall be used to support the sides of the drill holes. Self-drilling soil nail bars (also known as hollow, self-grouting or pressure grouted soil nail bars) shall not be used unless indicated on the plans. Soil nail bars shall be as shown on the plans. Provide centralizers per Section 504.25 (e).

504.34 Grouting. The drill hole shall be grouted after installation of the soil nail bar and within 2 hours of completion of drilling. The grout shall be injected at the lowest point of each drill hole through a tremie pipe, grout tube, or casing. The outlet end of the grout tube or casing shall be kept below the surface of the grout as the conduit is withdrawn to prevent the creation of voids. The drill hole shall be completely filled in one continuous operation. Cold joints in the grout column are not allowed except at the top of the test bond length of proof tested production soil nails. Excessive grout take is defined as twice the theoretical grout volume to grout the drill hole. The Engineer shall be notified of excessive grout take to allow for modification of the wall design and construction. The Contractor shall maintain the stability of borings through the temporary unbonded length of proof test soil nails for subsequent grouting. If the unbonded test length of production proof test soil nails cannot be satisfactorily grouted subsequent to testing, the Contractor shall install a new soil nail in its place.

In some granular soils with an open matrix with no cohesion, the potential for drill hole collapse or grout leakage may be large. In this case, a grout containment device or "sock" may

be used as approval by the Engineer to reduce excessive grout take in the highly permeable soil.

504.35 Underdrain. The underdrain shall be installed per Section 605.03. The underdrain should be installed as part of the soil nail wall construction. If the underdrain is to be installed at a time after construction of the soil nail wall, the Contractor shall notify the Engineer to review any proposed excavation at the foot of the wall for stability.

504.36 Soil Nail Testing. Both verification and proof testing of designated test soil nails shall be performed. Proof tests shall be performed on production soil nails at locations selected by the Engineer or as shown on the plans. Testing of a soil nail shall not be performed until the soil nail grout and shotcrete facing have cured for at least 72 hours or attained their specified 3-day compressive strength.

The Contractor shall provide all necessary equipment to perform the soil nail testing including, but not limited to, dial gauges, dial gauge support, jack and pressure gauge, electronic load cell with machined platens placed at either end of the load cell, and a reaction frame. In non-creep susceptible soils and as approved by the Engineer, the use of a load cell may be replaced with a dual pressure gauge system with the low reading gauge being used for soil nail acceptance.

The pressure gauge shall be graduated in 100-psi increments or less. The soil nail head movement shall be measured with a minimum of two dial gauges capable of measuring to 0.001 inch. The Contractor shall have available calibrated back up gauges and test loading equipment to minimize down time due to testing equipment failure.

The Contractor shall not apply loads greater than 80 percent of the minimum ultimate tensile strength of the tendon for Grade 150 bars or 90 percent of the yield strength of the tendon for Grade 75 bars. Preliminary results shall be submitted to the Engineer within 24 hours of the test completion. A full report containing test load results shall be submitted to the Engineer within 5 working days of the test completion.

504.37 Verification Testing of Sacrificial Soil Nails. The total number and location of tests shall be determined and spaced to evaluate soil nail performance in each soil strata encountered along the total length of the wall. A minimum of two verification tests shall be performed on sacrificial test soil nails at each soil nail wall as shown on the plans or as directed by the Engineer. Verification testing shall be performed before installation of production soil nails to confirm the appropriateness of the Contractor's drilling and installation methods and verify the required soil nail pullout resistance. If the Contractor makes changes to the drilling or soil nail installation operation or variability in the soil conditions is encountered, the Engineer may request additional verification tests.

Verification test soil nails shall have both bonded and unbonded lengths. Along the unbonded length, the soil nail bar shall not be grouted. The unbonded length of the test soil nails shall be at least 3 feet as measured from the back of the bearing plate to the top of the grout.

Verification tests shall be conducted according to the loading schedule of Table 504-4. Each load increment shall be held for at least 10 minutes. The Contractor shall record soil nail movements at each load increment and the time intervals shown in the table for each load step. Creep tests shall be performed at 0.75 VTL. The alignment load (AL) should be the minimum load required to align the testing apparatus and shall not exceed 5 percent of the VTL. The dial gauges shall be

set to "zero" after applying the alignment load. Following application of the maximum load, the load shall be reduced to the alignment load and the dial gauge readings recorded as the permanent set.

Each load increment shall be held for at least 10 minutes. The Contractor shall monitor the verification test soil nail for creep at the 0.75 VTL load increment by measuring and recording soil nail movement. The load shall be maintained during the creep test within 2 percent of the intended load by use of the load cell. The test results shall be presented for the Engineers review and acceptance before production. The Engineer shall have 10 working days to review the report and based on the results, design modifications may be required.

The bonded length of the soil nail during verification tests ($L_{B\ VT}$) shall be:

(a) For Grade 75 and other mild steel per ASTM A615, the maximum bond length ($L_{B\ VTmax}$), is defined as:

$$L_{B\ VTmax} = \frac{A_t \cdot f_y \cdot C_{RTY}}{r_{PO}}$$

(b) For Grade 150 and other high-strength steel per ASTM A722, the maximum bond length ($L_{B\ VTmax}$), is defined as:

$$L_{B\ VTmax} = \frac{A_t \cdot f_u \cdot C_{RTU}}{r_{PO}}$$

where:

C_{RTY} = reduction coefficient for mild-grade steel = 0.9

C_{RTU} = reduction coefficient for high-strength steel = 0.8

A_t = cross-sectional steel area of the test soil nail in square inches

f_y = nominal yield strength of test soil nail (mild steel) in kips per square inch

f_u = nominal tensile strength of test soil nail (high-strength steel) in kips per square inch

r_{PO} = nominal pullout resistance in kips per foot of test soil nail per plans = $\pi \times q_u \times D_{DH}$

q_u = nominal bond strength in kips per square foot

D_{DH} = drill hole diameter in feet

(c) If $L_{B\ VTmax} > 10$ feet, select $L_{B\ VT}$ to be 10 feet $\leq L_{B\ VT} \leq L_{B\ VTmax}$.

(d) If $L_{B\ VTmax} < 10$ feet, to avoid tensile breakage, select $L_{B\ VT} = 10$ feet and increase the test soil nail bar size as needed, and recalculate $L_{B\ VTmax}$ until $L_{B\ VTmax} > 10$ ft.

(e) The maximum (nominal) load during the verification test is defined as the Verification Test Load (VTL) and is calculated as VTL = $L_{B\ VT} \times r_{PO}$.

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Table 504-4
VERIFICATION TEST LOADING SCHEDULE

Load	Hold Time (minutes)#
AL*	1
0.13 VTL	10 (recorded at 1, 2, 4, 5, 10)
0.25 VTL	10 (recorded at 1, 2, 4, 5, 10)
0.38 VTL	10 (recorded at 1, 2, 4, 5, 10)
0.50 VTL	10 (recorded at 1, 2, 4, 5, 10)
0.63 VTL	10 (recorded at 1, 2, 4, 5, 10)
0.75 VTL (Creep Test)^	60 (recorded at 1, 2, 4, 5, 6, 10, 20, 30, 50, 60)
0.88 VTL	10
1.00 VTL%	10
AL	1$

Table 504-4 Notes: *AL = alignment load, which is less than or equal to 0.05 VTL.
#Soil nail movement shall be measured after each load increment has been achieved and at each time step.
^Maintain the load during the creep test within 2 percent of the intended load by use of the load cell.
%The Engineer may allow loading to failure to determine nominal soil conditions.
$Permanent soil nail movement shall also be recorded.

504.38 Proof Testing of Production Soil Nails. Successful proof testing shall be performed on 5 percent of the production soil nails in each soil nail row or a minimum of one per row. Verification tests shall not be included in the 5 percent; except that the Engineer may allow the verification tests to be included based on the plans and site conditions. The Engineer will determine the locations and number of proof tests before soil nail installation in each row unless otherwise shown on the plans. Production proof test soil nails shall have both bonded and temporary unbonded lengths. Fully grouted test soil nails shall not be proof tested. The Contractor shall maintain the stability of the hole for the temporary unbonded test length for subsequent grouting. If the unbonded test length of production proof test soil nails cannot be satisfactorily grouted subsequent to testing, the proof test soil nail shall become sacrificial and shall be replaced with an additional production soil nail installed at the Contractor's expense. The temporary unbonded length of the test soil nail shall be at least 3 feet as measured from the back of the bearing plate to the top of the grout.

Proof tests shall be conducted according to the loading schedule of Table 504-5. Unless the soil is susceptible to creep and tests modified per Note 3 of Table 504-5, each load increment shall be held until readings are stable as defined by three readings within 0.005 inches taken one per minute over three minutes. The Contractor shall record soil nail movements at each load increment and the time intervals shown in the table for each load step. Creep tests shall be performed at 1.00 PTL. The alignment load (AL) shall be the minimum load required to align the testing apparatus and shall not exceed 5 percent of the PTL. Set dial gauges to “zero” after applying the alignment load. Following application of the maximum load, reduce the load to the alignment load and record the permanent set.

The creep period shall start as soon as the maximum test load (1.0 PTL) is applied and the soil nail movement shall be measured and recorded at 1 minute, 2, 3, 5, 6, and 10 minutes. Where the soil nail movement between 1 minute and 10 minutes exceeds 0.04 inch, the maximum test

load shall be maintained for an additional 50 minutes and movements recorded at 20 minutes, 30, 50, and 60 minutes. All load increments shall be maintained within 5 percent of the intended load.

The bonded length of the soil nail during verification tests, $L_{B\ PT}$, shall be:

(a) For Grade 75 and other mild steel per ASTM A615, the maximum bond length ($L_{B\ PTmax}$), is defined as:

$$L_{B\ PTmax} = \frac{A_t \cdot f_y \cdot C_{RTY}}{r_{PO} \cdot 0.75}$$

(b) For Grade 150 and other high-strength steel per ASTM A722, the maximum bond length ($L_{B\ PT\ max}$), is defined as:

$$L_{B\ PTmax} = \frac{A_t \cdot f_u \cdot C_{RTU}}{r_{PO} \cdot 0.75}$$

(c) Select $L_{B\ PT}$ to be 10 ft or $L_{B\ PTmax}$, whichever is smaller, to avoid tensile breakage.

(d) Production proof test soil nails that are shorter than 13 feet may be tested with less than the minimum 10 feet bond length. The maximum load in the proof test (PTL) is calculated as PTL = $L_{B\ PT} \times r_{PO} \times 0.75$

Table 504-5
PROOF TEST LOADING SCHEDULE

Load	Hold Time (minutes)#
AL*	1
0.17 PTL	Until Movement Stabilizes^
0.33 PTL	Until Movement Stabilizes
0.50 PTL	Until Movement Stabilizes
0.67 PTL	Until Movement Stabilizes
0.83 PTL	Until Movement Stabilizes
1.0 PTL (Creep Test)+	10 (recorded at 1, 2, 4, 5, 6, and 10)
AL	1

Table 504-5 Notes:
*AL = alignment load, which is less than or equal to 0.05 PTL.
#Times are measured after the target load has been achieved in each increment.
^If the soils reinforced with soil nails are relatively susceptible to deformation of creep, it is recommended to hold each load increment for 10 minutes and to record the soil nail movement at 1, 2, 5, and 10 minutes.
+If the soil nail movement measured between 1 and 10 minutes exceeds 0.04 in., PTL must be maintained for 50 additional minutes and movements must be recorded at 20, 30, 50, and 60 minutes. The permanent soil movement must also be recorded.

504.39 Test Soil Nail Acceptance Criteria. A test soil nail shall be considered acceptable when the following criteria are met.

(a) Verification testing. The following criteria shall be met for acceptance of the soil nail:

(1) Pullout shall not occur at loads less than 1.00 VTL.

(2) The total movement (Δ_{VTL}) measured at VTL shall exceed 80 percent of the theoretical elastic elongation of the unbonded length (L_{UB}), as defined by:

$$\Delta_{VTL} > 0.8 \frac{VTL \cdot L_{UB}}{E \cdot A_t}$$

where E = Young's modulus of steel (29,000 ksi).

(3) The creep movement between the 1 and 10-minute readings at 0.75 VTL shall be less than 0.04 in.

(4) The creep movement between the 6 and 60-minute readings at 0.75 VTL shall be less than 0.08 in.

(5) The creep rate shall be linear or decreasing throughout the creep test load-hold period.

(b) Proof testing. The following criteria shall be met to acceptance of the soil nail:

(1) No pullout occurs.

(2) The total soil nail movement (Δ_{PTL}) measured at PTL shall be greater than 80 percent of the theoretical elastic elongation of the unbonded length, as defined by:

$$\Delta_{PTL} > 0.8 \frac{PTL \cdot L_{UB}}{E \cdot A_t}$$

(3) The creep movement shall be less than 0.04 in. between the 1 and 10-minute readings.

(4) If this movement is exceeded, PTL shall be maintained for an additional 50 minutes with readings recorded at 20, 30, 50, and 60 minutes.

(5) If the creep test is extended, the creep movement between the 6 and 60-minute readings shall be less than 0.08 in.

504.40 Test Soil Nail Rejection. If a test soil nail does not satisfy the acceptance criterion in subsection

(a) Verification test soil nails. The Engineer will evaluate the results of each verification test. The Contractor shall propose and provide plans and calculations for alternative methods for review and acceptance by the Engineer and shall install replacement verification test soil nails. Replacement test soil nails shall be installed and tested at the Contractor's expense. The production soil nails shall be installed using the same installation procedures (drill equipment, drill tooling, drill hole diameter, grouting, etc.) used to provide successful verification tests at no additional cost to the Department.

(b) Proof test soil nails. The Engineer may require the Contractor to replace some or all of the installed production soil nails between a failed proof test soil nail and the adjacent passing proof test soil nail. Alternatively, the Engineer may require the installation and testing of additional proof test soil nails to verify that adjacent previously installed production soil

nails have sufficient load carrying capacity. Installation and testing of additional proof test soil nails or installation of additional or modified soil nails as a result of proof test soil nail failures shall be at the Contractor's expense.

504.41 Wall Drainage Network. All elements of the wall drainage network shall be installed and secured as shown on the plans. The drainage network shall consist of installing geocomposite strip drains, PVC connection pipes, wall footing drains, and weepholes as shown on the plans. Exclusive of the wall footing drains, all elements of the drainage network in the current lift shall be installed before shotcreting.

(a) Geocomposite Strip Drains. Geocomposite strip drains shall be centered between the columns of soil nails as shown on the Plans. The strip drains shall be at least 12 inches wide and placed with the geotextile side in contact with excavation face. The strips shall be secured to the excavation face and shotcrete shall be prevented from contaminating the geotextile. Strip drains shall be vertically continuous. Splices shall be made with a 12-inch minimum overlap such that the flow of water is not impeded. Drain plate and connector pipe shall be installed at the base of each strip as shown on the plans. Damage to the geocomposite strip drain which may interrupt the flow of water shall be repaired.

(b) Underdrains. Underdrains shall collect groundwater from the drainage network and be installed at the bottom of each wall as shown on the plans. The drainage geotextile shall envelope the footing drain aggregate and pipe and conform to the dimensions of the trench. The drainage geotextile shall overlap on top of the drainage aggregate as shown on the plans. Damaged or defective drainage geotextile shall be repaired or replaced.

504.42 Initial Shotcrete Facing. The initial shotcrete facing shall be installed per Section 641. Membrane curing compound shall not be used. Maturity meters shall be used to monitor all shotcrete per subsection 641.05.

(a) Initial Face Finish. Shotcrete finish shall be either an undisturbed gun finish as applied from the nozzle or a rod, broom, wood float, rubber float, steel trowel or rough screeded finish as shown on the Plans.

(b) Attachment of Soil Nail Head Bearing Plate and Nut. Bearing plate, washers, and nut shall be attached to each soil nail head as shown on the plans. While the initial shotcrete facing is still plastic and before its initial set, the plate shall be uniformly seated on the shotcrete by hand-wrench tightening the nut. Where uniform contact between the plate and the shotcrete cannot be provided, the plate shall be set in a bed of grout. After grout has set for 24 hours, the nut shall be hand-wrench tightened. Bearing plates and headed studs shall be located within the tolerances shown on the Plans.

(c) Shotcrete Facing Tolerances. Construction tolerances for the shotcrete facing from plan location and plan dimensions shall be as shown in Table 504-6.

Table 504-6
INITIAL SHOTCRETE FACING TOLERANCES

Item	Tolerance
Horizontal location of welded wire mesh, reinforcing bars, and headed studs measured horizontally from wall face	3/8 in.
Location of headed studs on bearing plate	1/4 in.
Spacing between reinforcing bars	1 in.
Reinforcing lap length	1 in.
Thickness of shotcrete, if troweled or screeded	9/16 in. [approximation of 0.6 in.]
Thickness of shotcrete, if left as shot	1-1/8 in. [approximation of 1.2 in.]
Planeness of finish face surface, gap under 10-ft straightedge, if troweled or screeded	9/16 in. [approximation of 0.6 in.]
Planeness of finish face surface, gap under 10-ft straightedge, if left as shot	1-1/8 in. [approximation of 1.2 in.]
Soil nail head bearing plate deviation from parallel to wall face	10 degrees

504.43 Forms and Falsework. Forms and falsework shall conform to subsections 601.09 and 601.11 respectively.

504.44 Reinforcing Steel. Reinforcing steel shall be installed per this specification and Section 602.

504.45 Structural Concrete. Structural concrete shall be placed per this specification and Section 601.

504.46 Acceptance. Material for the soil nail retaining wall will be accepted based on the manufacturer production certification or from production records. Construction of the soil nail retaining wall will be accepted based on survey, visual inspection, and the relevant production testing records.

METHOD OF MEASUREMENT

504.47 Soil nail walls will be measured by the quantities for the five major components of the wall: soil nail, initial shotcrete facing, verification testing, excavation and underdrain.

Soil nail will be measured by the linear foot of nail installed and accepted.

Verification testing will be measured by the number of verification tests performed.

BASIS OF PAYMENT

504.48 The accepted quantities, measured as provided above, will be paid for at the contract unit price for the pay items listed below that are shown on the bid schedule. Payment will be made under:

Payment will be made under:

Pay Item	**Pay Unit**
Soil Nail	Linear Foot
Verification Testing	Each

Payment for Soil Nail Wall will be full compensation for all work and materials required to complete soil nail wall. This work shall include but is not limited to soil nails, geocomposite strip drains, proof testing, drilling, grouting, bearing plates, end hardware (nuts, washers, couplers), certificates of compliance, and incidentals necessary to acceptably fabricate and construct the soil nail walls exclusive of any final facing items that may be tabulated on the plans.

All excavation work required to construct the soil nail wall and the initial shotcrete facing to the lines and grades indicated on the plans will be measured and paid for per Section 203 or 206. Additional earthwork outside of excavation for the wall installation and backfilling before or post wall construction will not be measured and paid for separately but shall be included in the work.

Underdrain will be measured and paid for per Section 605.

Initial Shotcrete Facing will be measured and paid for per Section 641under Pay Item Initial Shotcrete Facing.

Incidental shotcrete required for over-break will be measured and paid for per Section 641 under Pay Item Shotcrete.

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SECTION 506

RIPRAP

DESCRIPTION

506.01 This work consists of the construction of riprap per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

506.02 Riprap shall consist of hard, dense, durable stone, angular in shape and resistant to weathering. Rounded stone or boulders shall not be used as riprap material. The stone shall have a specific gravity of at least 2.5. Each piece shall have its greatest dimension not greater than three times its least dimension.

Material used for riprap may be approved by the Engineer if, by visual inspection, the rock is determined to be sound and durable. The Engineer may require the Contractor to furnish laboratory results if, in the Engineer's opinion, the material is marginal or unacceptable. At the request of the Engineer, the Contractor shall furnish laboratory test results indicating that the material meets the requirements for abrasion resistance or compressive strength as indicated in Table 506-1.

Table 506-1

RIPRAP MATERIAL TEST REQUIREMENTS

Test Description	Test Method	Specification Requirement
Abrasion Resistance by Los Angeles Machine	ASTM C535	50% Loss, max.
Unconfined Compressive Strength of Drilled Core Specimen	AASHTO T 24	2500 psi, min.

Riprap shall conform to the gradation requirements given in Table 506-2.

Table 506-2
RIPRAP GRADATION REQUIREMENTS

Pay Item	Stone Size d50* (Inches)	Percent of Material Smaller Than Typical Stone#	Typical Stone Dimensions^ (Inches)	Typical Stone Weight+ (Pounds)
Riprap	6	70-100 50-70 35-50 2-10	12 9 6 2	85 35 10 0.4
Riprap	9	70-100 50-70 35-50 2-10	15 12 9 3	160 85 35 1.3
Riprap	12	70-100 50-70 35-50 2-10	21 18 12 4	440 275 85 3
Riprap	18	100 50-70 35-50 2-10	30 24 18 6	1280 650 275 10
Riprap	24	100 50-70 35-50 2-10	42 33 24 9	3500 1700 650 35

Table 506-2 Notes: *d50 = nominal stone size
#based on typical rock mass
^equivalent spherical diameter
+based on a specific gravity = 2.5

Nominal stone size and total thickness of the riprap shall be as shown on the plans.

Control of gradation will be by visual inspection. The Contractor shall provide two samples of rock at least 5 tons each, meeting the gradation specified. One sample shall be provided at the construction site and may be a part of the finished riprap covering. The other sample shall be provided at the quarry.

These samples will be used as a reference for judging the gradation of the riprap supplied. When it is determined necessary, conformance of the gradation will be verified by dumping and checking the gradation of two random truckloads of stone. Mechanical equipment, a sorting site, and labor needed to assist in checking gradation shall be provided at the Contractor’s expense.

CONSTRUCTION REQUIREMENTS

506.03 Stones with typical stone dimensions that are equal to d50 and larger shall be placed at the top surface with faces and shapes matched to minimize voids and form as smooth a surface as practical. Dumping and backhoe placement alone is not sufficient to ensure a properly interlocked system. The material may be machine-placed and then arranged as necessary by use of an excavator with a multi-prong grappling device or by hand to interlock and form a substantial bond.

Excavation for toe or cut-off walls shall be made to the neat lines of the wall. Allowance will not be made for work outside the neat lines.

METHOD OF MEASUREMENT

506.04 Riprap of the sizes specified in the Contract will be measured by the ton or by the cubic yard. Cubic yards will be by the method of average end areas based on dimensions shown on the plans or ordered.

BASIS OF PAYMENT

506.05 The accepted quantities of riprap will be paid for at the contract unit price per cubic yard or per ton.

Payment will be made under:

Pay Item	Pay Unit
Riprap (___inch)	Cubic Yard or Ton

Structure excavation will be measured and paid for per Section 206.

RIPRAP (GABIONS) AND SLOPE MATTRESS

DESCRIPTION

506.06 This work consists of the construction of riprap in wire mesh gabions and in wire mesh slope mattresses per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

506.07 The wire, wire mesh, cages, anchor stakes and riprap shall conform to subsection 712.09.

CONSTRUCTION REQUIREMENTS

506.08 Gabions and Slope Mattresses. Gabions and slope mattresses shall be placed to conform to the plan details. Riprap material shall be placed in close contact in the unit so that maximum fill is obtained. The units may be filled by machine with sufficient hand work to accomplish requirements of this specification.

Where the length of the unit exceeds its horizontal width, the gabion is to be equally divided by diaphragms, of the same mesh and gauge as the body, into cells whose length does not exceed the horizontal width. The unit shall be furnished with the necessary diaphragms secured in proper position on the base section in such a manner that no additional tying at this juncture will be necessary.

(a) Gabions. All perimeter edges of gabions are to be securely selvedged or bound so that the joints formed by tying the selvedges have approximately the same strength as the body of the mesh.

The gabion bed shall be excavated to the width, line, and grade as staked by the Engineer. The gabions shall be founded on this bed and laid to the lines and dimensions required.

Excavation for toe or cut-off walls shall be made to the neat lines of the wall.

All gabion units shall be tied together each to its neighbor along all contacting edges in order to form a continuous connecting structure.

(b) Slope Mattresses. Slope mattresses shall be filled with angular or fractured stone. Rounded boulders will not be permitted. Before the mattress units are filled, the longitudinal and lateral edge surfaces of adjoining units shall be tightly connected by means of wire ties placed every 4 inches or by a spiral tie having a complete loop every 4 inches. The lid edges of each unit shall be connected in a similar manner to adjacent units. The slope mattress shall be anchored as shown on the plans.

The Contractor shall determine whether the holes for the soil anchor stakes are to be drilled or whether the stakes may be driven. Care shall be taken to avoid drilling holes to a greater depth than is necessary to place the top of the finished stake slightly above the top of the finished mattress.

The Contractor will be allowed to assemble, partially fill, and tie together mattress-units on the subgrade provided they can be placed on the slope without abrading the zinc coating on the wire mattress or permanently distorting the shape of the mattress in transporting and installing the units on the slope. All prefabrication procedures shall be subject to approval.

METHOD OF MEASUREMENT

506.09 The quantity to be measured under this item will be the number of cubic yards of riprap required to fill the gabions and slope mattresses per the dimensions shown on the plans or ordered.

BASIS OF PAYMENT

506.10 The accepted quantity measured as provided above will be paid for at the contract unit price per cubic yard for “Riprap (Gabions)” or “Slope Mattress” as the case may be.

Payment will be made under:

Pay Item	Pay Unit
Riprap (Gabions)	Cubic Yard
Slope Mattress	Cubic Yard

Structure excavation and structure backfill will be measured and paid for per Section 206.

SECTION 507

SLOPE AND DITCH PAVING

DESCRIPTION

507.01 This work consists of the construction of slope and ditch paving per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

507.02 Concrete Slope and Ditch Paving. Concrete shall conform to the requirements of Section 601. Concrete shall be Macro Fiber-Reinforced Class B Concrete.

507.03 Dry Rubble Slope and Ditch Paving. Stone shall conform to the material requirements of subsection 506.02. Size of stone and total thickness of paving shall be as shown on the plans.

507.04 Grouted Rubble Slope and Ditch Paving. Stone shall conform to the material requirements of subsection 506.02. Size of stone and total thickness of paving shall be as shown on the plans.

Mortar shall consist of one part portland cement and three parts of fine aggregate by volume thoroughly mixed with as much water as is necessary to obtain the required consistency. Materials shall meet the requirements specified in the following subsections:

Hydraulic Cement	701.01
Fine Aggregate	703.01
Water	712.01

Mortar shall be used within 45 minutes after mixing and shall not be re-tempered. Class B concrete, conforming to the requirements of Section 601, may be substituted for mortar.

507.05 Grouted Riprap Slope and Ditch Paving. Concrete mortar for grouted riprap slope and ditch paving shall meet the requirements of Section 601 and the following:

Table 507-1

GROUTED RIPRAP CONCRETE MORTAR REQUIREMENTS

Field Compressive Strength (28 days) (Not a specification requirement)	2000 psi
Minimum Cement Content	560 lb/cu yd
Air Content	6-9%
Slump, AASHTO Designation T-119	5-9 inches
Fine Aggregate, AASHTO M-6	65-75%
Coarse Aggregate, AASHTO M-43	3/8" nominal maximum size
Polypropylene Fibers (1" fiber length or equivalent)	1.5 lb/cu yd

Riprap stone shall conform to the quality requirements of subsection 506.02 and the classification and gradation requirements specified in the following table:

Table 507-2
CLASSIFICATION AND GRADATION
OF ROCK FOR GROUTED RIPRAP

Riprap Designation	Percent Smaller Than Given Size by Weight	Intermediate Rock Dimension, Inch
d50 = 24" (Type HG)	100	30
d50 = 24" (Type HG)	50 - 70	24
d50 = 24" (Type HG)	0 - 5	18
d50 = 18" (Type MG)	70 - 100	21
d50 = 18" (Type MG)	50 - 70	18
d50 = 18" (Type MG)	0 - 5	12

507.06 Asphalt Slope and Ditch Paving. The mixture used shall conform to the requirements for the asphalt pavement used on the project.

CONSTRUCTION REQUIREMENTS

507.07 Paving thickness shall be as specified on the plans. In ditch construction, the excavated areas adjacent to the paving that are not occupied by the paving shall be refilled to the level of original ground with acceptable material and thoroughly tamped.

Excavation for toe or cut-off walls shall be made to the neat lines of the wall. Allowance will not be made for work outside the neat lines.

507.08 Concrete Slope and Ditch Paving. Concrete shall be mixed, placed and cured per Section 601.

Unsuitable soil shall be removed and replaced with a suitable soil as designated by the Engineer.
Where the thickness of concrete lined ditch as shown on the plans is less than 4 inches, this concrete slope and ditch paving shall be installed with slip-form machine, except for the following:

(1) Where it is deemed impossible to construct the ditch lining by the slip-form method, the lining shall be hand formed and the thickness shall be at least 1 inch greater than the thickness shown on the plans.

(2) The Contractor may use hand method of placement in lieu of the slip-form method, provided the thickness of this hand-placed lining is at least 1 inch greater than the thickness shown on the plans.

Where the thickness of concrete lined ditch as shown on the plans is 4 inches or greater, the Contractor will be permitted to place the material with a slip-form machine or by hand method.

507.09 Dry Rubble Slope and Ditch Paving. Stones shall be placed with close joints, which shall be broken to minimize straight construction joints. The stones shall be placed to give the appearance of plating the fill slope.

Larger stones shall be placed on the lower courses. Open joints shall be filled with spalls.

Oversize stones and protrusions that present a safety hazard will not be permitted.

507.10 Grouted Rubble Slope and Ditch Paving. Stones shall be laid as specified in subsection 507.09, with care to prevent earth and sand filling the joints. Joints shall be filled with grout from bottom to top and the surfaces swept with a stiff broom.

Grouting shall not be done in freezing weather. In hot, dry weather, the work shall be protected and kept moist for at least three days after grouting, or clear membrane curing compound may be used.

507.11 Grouted Riprap Slope and Ditch Paving. All placement of concrete mortar shall be in conformance with subsection 601.12 with the following exceptions:

(1) All concrete mortar shall be delivered by means of a low pressure (less than 10 psi) grout pump using a 2-inch diameter nozzle.

(2) Full depth penetration of the concrete mortar into the riprap shall be required. To achieve this, a pencil vibrator shall be used.

(3) The top 6 inches of the rock layer shall be left exposed.

(4) After placement, all exposed rocks shall be cleaned with a wet broom.

(5) All concrete mortar between rocks shall be finished with a broom finish.

(6) Weep holes constructed of 1 1/2- inch or 2-inch PVC pipe shall be installed when required by the Engineer. The PVC pipe shall be cut flush with the surrounding grout. To alleviate plugging, the PVC pipe shall be pushed into the bedding, or if bedding is not required, under the rock layer. The PVC pipe shall be wrapped in a coarse geotextile fabric filled with 1 1/2-inch rock.

(7) All concrete mortar shall be sprayed with a clear liquid membrane-curing compound as specified in subsection 601.13(b).

(8) Cold weather curing shall be per subsection 601.13(d).

507.12 Asphalt Slope and Ditch Paving. The asphalt mixture shall be properly shaped to the required cross section and thoroughly compacted.

A fog seal shall be placed on the exposed surfaces of the paving at the rate of approximately 0.1 gallon per square yard. Material for fog seal shall be Emulsified Asphalt (CSS-1) or as designated.

METHOD OF MEASUREMENT

507.13 Asphalt slope and ditch paving will be measured by the ton and shall include asphalt. Slope and ditch paving of the other various types will be measured by the cubic yard by the method of average end areas based on dimensions shown on the plans or ordered.

When the plans call for concrete lined ditch less than 4 inches thick, but the actual thickness placed is greater than the plan thickness, measurement and payment will be made only for the thickness shown on the plans.

BASIS OF PAYMENT

507.14 The accepted quantities will be paid for at the contract unit price for the various items below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Concrete Slope and Ditch Paving	Cubic Yard
Concrete Slope and Ditch Paving (Reinforced)	Cubic Yard
Dry Rubble Slope and Ditch Paving	Cubic Yard
Grouted Rubble Slope and Ditch Paving	Cubic Yard
Grouted Riprap Slope and Ditch Paving	Cubic Yard
Asphalt Slope and Ditch Paving (Asphalt)	Ton

Structure excavation will be measured and paid for per Section 206.

Polyolefin fiber reinforcement will not be measured and paid for separately but shall be included in the work.

Fog seal and asphalt required for asphalt slope and ditch paving will not be measured and paid for separately but shall be included in the work.

Mortar or concrete used for grout in grouted rubble slope and ditch paving will not be measured and paid for separately but shall be included in the work.

Payment for Grouted Riprap Slope and Ditch Paving will be full compensation for all work and materials required to complete the item.

SECTION 508

TIMBER STRUCTURES

DESCRIPTION

508.01 This work consists of the construction of timber structures and timber portions of other structures per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

508.02 Sawn lumber and timber shall conform to AASHTO M 168. Timber shall be Douglas Fir of the coast region or Southern Yellow Pine. “Native” timber may be used when noted on the plans. “Native” timber shall be Red Cedar, Douglas Fir of the inland region, Lodgepole Pine, Ponderosa Pine, Spruce, as listed and described in AASHTO M 168, or any other native wood specifically approved for the intended purpose. All timber shall be of the grade or shall meet the working stresses shown on the plans. Timber used in non-structural applications, whose working stresses are not shown on the plans, shall be graded to produce a working stress of 1,000 pounds per square inch on the extreme fibers when subjected to bending and 800 pounds per square inch when subjected to compression parallel to the grain. Material of equal or greater stress values may be used.

All lumber shall be manufactured per Product Standard 20-70 as published by the Department of Commerce and shall be grade-marked by a grading agency or have an accompanying certificate from a grading agency. The grading agency shall be certified by the Board of Review of the American Lumber Standards Committee.

508.03 Treated Timber. The preservative to be used shall be as specified on the plans. The preservatives and entire treatment process shall be as described in AASHTO M 133 or by the American Wood Protection Association (AWPA) standards.

508.04 Inspection. All timber furnished shall be covered by a certificate of inspection issued by the American Lumber Standard Committee (ALSC) or the International Accreditation Service (IAS) accredited inspection agency. Inspection approval shall be marked on each piece.

Shop drawings shall be submitted per subsection 105.02 for all major structures and for other structures when specified.

The Department may provide an inspector at the treating plant for material quality review and inspection of the treatment process for treated timber. The plant shall notify the Engineer sufficiently in advance of time of treating so that inspection may be arranged.

508.05 Hardware. Hardware shall include all bolts with necessary nuts and washers, timber connectors, drift pins, dowels, nails, screws, spikes, metal pile protectors, steel anchor plates and all other metal fastenings as shown on the plans. Bolts shall conform to the requirements of Section 509. Bolts over 12 inches long shall be threaded at least 4 inches. Drift bolts, spikes, boat spikes and other spikes shall be wrought iron or steel. Washers shall be standard cast iron ogee or malleable cast washers. Timber connectors and common nails shall be of the type and size specified on the plans. All hardware, except timber connectors and common nails, shall be galvanized per AASHTO M 232.

CONSTRUCTION REQUIREMENTS

508.06 Timber for the various portions of the structure shall be treated or untreated as stipulated on the plans.

Treated timbers shall not be sized or trimmed in the field, except when ordered. The Contractor shall not make temporary use of treated timber. All pieces that have been field cut shall be treated per AWPA Standard M4.

Untreated stringer ends shall be separated at least 1/2 inch and shall be secured to the timber where they rest.

Sway bracing shall be securely bolted to piling or post and caps as shown on the plans. Treated filling pieces shall be used in lieu of framing or dapping to bring bracing into a plane. Bulkheads, where required, shall be full size timber. Posts for framed bents shall be of the proper length for their position and provide an even bearing on cap and sill. All untreated caps shall be sized over the piles or posts to a uniform thickness and even bearing on piles or posts. Caps shall be within 1/4 inch of nominal depth before treatment and may be surfaced on the vertical grain face.

Before the timber capping is placed, a No. 20 gauge galvanized sheet metal cap shall be placed on each pile per the plans. In lieu of the sheet metal cap, three layers of heavy burlap may be used. Each layer of burlap shall be cut square to a dimension of 12 inches greater than the diameter of the pile head and shall be thoroughly swabbed with hot asphalt. The overhanging ends shall be turned down and secured to the pile with galvanized wire. The entire wrapping shall then be swabbed with a heavy application of hot asphalt.

Longitudinal X-braces shall be properly framed and secured to piles or posts. Truss and bent timbers shall be cut and framed in such manner that they will have even bearing over the entire contact surface of the joint. Blocking or shimming will not be allowed in making joints. Open joints will not be accepted. Stringers shall not be more than 1/4 inch off nominal size, before treatment.

Floors shall be constructed as shown on the plans. The plank shall be secured to each stringer with two 7-inch spikes. Half-inch cracks between planks shall be left in plain plank floors without surfacing. Laminated floors shall be secured as shown on the plans.

508.07 Holes and Bolts. All holes bored shall be treated per AWPA M4. Holes drilled for drift bolts shall be 1/32 inch smaller than the diameter of the bolt. All other holes shall be bored to such size as to ensure a snug fit. Unless otherwise designated, all bolts shall be provided with two ogee washers.

508.08 Painting. All paint shall conform to the requirements of Section 708. Timber to be painted shall be surfaced on four sides and shall be cleaned immediately preceding painting.

New timber to be painted shall receive one coat of primer. “White Wood Primer” shall be used when the surface is to be finished with “Outside White Paint.” For “Exterior Black Paint,” the specification paint shall be thinned by adding one part linseed oil and one part turpentine to eight parts paint for use as a primer.

The surfaces of all untreated timber to be painted shall be primed with one coat of primer immediately after the material is delivered to the project. Unless otherwise designated, pieces shall be primed as specified for the finish coat of paint, or “White Wood Primer” shall be used when additional painting is not required. Untreated timber will not require additional priming.

All handrails and handrail posts shall be of untreated timber and shall be painted as described hereafter. Contact surfaces shall receive the primer and one coat of paint before placing handrails.

Parts specified, parts shown on the plans, and all exposed non-galvanized iron and steel shall, after the prime coat, be given two coats of the specified paint, which shall be thoroughly brushed in. Paint shall be applied only to thoroughly dry surfaces. All previous coats shall have thoroughly dried before subsequent coats are to be applied. Portions to be painted above the wheel guards or top wales shall be painted white and those portions below the wheel-guards or top wales to be painted shall be painted black.

508.09 Structure Number. The location, letters, figures, and paint used for stenciling shall be per the plan details.

METHOD OF MEASUREMENT

508.10 Timber will be measured by the thousand feet board measure [MFBM] actually incorporated in the structure and shall include hardware unless otherwise designated on the plans.

BASIS OF PAYMENT

508.11 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Untreated Timber	MFBM
Treated Timber	MFBM

Structure excavation and structure backfill will be measured and paid for per Section 206.

Timber piling will be measured and paid for per Section 502.

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SECTION 509
STEEL STRUCTURES

DESCRIPTION

509.01 This work consists of furnishing, fabricating, erecting, and painting structural steel per these specifications and to the dimensions, shapes, and design shown on the plans, and to the lines and grades established. Structural steel shall include galvanizing, bolting, welding, special and alloy steels, electrodes, and steel forgings.

When the term “main stress carrying members” or “main members” is used, it shall include girder web and flange plates and splice plates, pier and abutment diaphragm web and flange plates and splice plates.

509.02 The latest edition of the AASHTO LRFD Bridge Design Specifications, with current interim specifications, will govern the design of steel bridges, unless otherwise noted on the plans. Welding and fabrication of steel structures shall conform to the Bridge Welding Code ANSI/AASHTO/AWS D1.5, as amended by the contract documents. When AWS D1.5 is cited in the Standard Specifications, the reference shall be to the latest edition of the Bridge Welding Code.

MATERIALS

509.03 Structural Carbon Steel. Structural carbon steel for bolted or welded construction shall conform to AASHTO M270 (ASTM A709) Grade 36. Material supplied for main members in tension as designated in the Contract shall meet a longitudinal Charpy V-notch (CVN per AWS D1.5. Testing shall be per AASHTO T 243 (ASTM A673). The H frequency of heat testing shall be used.

509.04 High-Strength Low-Alloy Structural Steel. High-strength low-alloy structural steel for welding shall conform to the following requirements:

High-Strength Low-Alloy Columbian-Vanadium Steels of Structural Quality, Grade 50 shall meet the requirements of AASHTO M270 (ASTM A709).

High-Strength Low-Alloy Structural Steel with 50 ksi Minimum Yield Point to 4 inches thick shall meet the requirements of AASHTO M270 (ASTM A709).

Steel conforming to AASHTO M270 (ASTM A709) Grade 50W shall not be painted unless otherwise shown on the plans.

Material supplied for main members in tension, as designated in the Contract, shall meet the longitudinal Charpy V-notch (CVN) tests as specified for Zone 2 in AASHTO M270.

509.05 Self-Weathering Tubing. Self-weathering structural steel tubing shall conform to ASTM A847, Cold-Formed Welded and Seamless High Strength, Low Alloy Structural Tubing with Improved Atmospheric Corrosion Resistance.

509.06 Structural Tubing. Steel base metal to be used for tubular structures, including bridge rail, shall conform to the plans or AWS D1.1. The grade and specification to be used shall be specified in the Contract.

509.07 Bolts. Bolts not otherwise specified in the Contract shall be zinc plated and meet the requirements of ASTM A307 for Grade A Bolts. Bolts shall have single self-locking nuts or double nuts unless otherwise specified in the Contract. Beveled washers shall be used when bearing surfaces have a slope exceeding 1:20 with respect to a plane normal to the bolt axis.

509.08 High-Strength Bolts. Unless otherwise shown in the Contract, all bolts for fastening of structural steel shall be high-strength bolts. High strength bolts, including suitable nuts and plain hardened washers, shall conform to ASTM F3125. In general, Type 1 bolts shall be used and bolts for self-weathering steel shall be Type 3, unless otherwise shown in the Contract.

Bolt and nut dimensions shall conform to the current edition RCSC unless otherwise noted. Threads for all bolts shall conform to the United Standard Series UNC-ANSI B1.1, Class 2A for external threads and Class 2B for internal threads. Sufficient thread must be provided to prevent the nut from encountering thread runout.

Nuts shall conform to ASTM A563.

Washers and beveled washers shall conform to ASTM F436. Washers and beveled washers for AISC American Standard beams and channels or when bearing surfaces have a slope exceeding 1:20 with respect to a plane normal to the bolt axis shall be square or rectangular, shall taper in thickness, and shall conform to the dimensions given in AISC.

509.09 Pins and Rollers. Steel for pins and rollers shall conform to ASTM A668, Class C, D, F, or G as specified in the Contract. They shall be accurately manufactured to the dimensions shown in the Contract. Pins larger than 9 inches in diameter shall have a hole at least 2 inches in diameter bored longitudinally through their centers. The hole shall be bored before the pin is subjected to heat treatment. Threads for all pins shall conform to the United Standard Series UNC-ANSI B1.1, Class 2A for external threads and Class 2B for internal threads, except that pin ends having a diameter of 1 1/2 inches or more shall have six threads per 1 inch.

509.10 Anchor Bolts. Unless otherwise shown in the Contract, all anchor bolts shall conform to ASTM F1554 and shall be zinc plated.

509.11 Galvanized and Metallized Steel. When shown in the Contract, structural steel shall be galvanized per AASHTO M111. Steel surfaces to be metallized shall be coated per AWS C2.2, Recommended Practice for Metallizing with Aluminum and Zinc for Protection of Iron and Steel. When the Contract specifies galvanizing, metallizing may be substituted.

509.12 Welded Stud Shear Connectors. Studs shall meet the requirements of ASTM A108, grades 1010 through 1020, killed or semi-killed. In addition, studs shall conform to the current edition of AWS D1.5 unless otherwise noted. Furnishing, testing, and qualifying of stud welding procedures shall be at the Contractor's expense. Manufacturer shall furnish the Engineer certification as required by AWS D1.5.

509.13 Mill Test Reports. The fabricator shall furnish the quality assurance inspector with copies of the certified mill test reports on all material that will be used. Mill test reports shall be furnished before cutting of the steel or any other fabrication. The fabricator may furnish, with approval of the Engineer, material from stock, provided it can be identified by rolling direction (where orientation is specified), heat number, and mill test reports.

Rotational-Capacity Test Reports (RC). RC testing by the Manufacturer shall be required for all fastener assemblies per AASHTO. RC testing reports shall be furnished with shipment of assemblies.

Proof Load Tests. Proof load tests (ASTM F606 Method 1) are required for the bolts. Wedge tests of full-size bolts are required per section 10 of ASTM F3125. Galvanized bolts shall be wedge tested after galvanizing. Proof load tests per ASTM F563 are required for the nuts. The proof load tests for the nuts to be used with galvanized bolts shall be performed after galvanizing, overtapping, and lubricating.

Material that has been used elsewhere shall not be used in any part of this work without written approval or unless specifically provided for in the Contract.

SHOP FABRICATION AND INSPECTION REQUIREMENTS

509.14 Notice of Fabrication.

(a) Process Control and Quality Assurance. Process Control (PC) of structural steel fabrication is the responsibility of the Contractor. The PC inspector is the duly designated person who acts for and on behalf of the fabricator on inspection, testing, and quality matters within the scope of the contract documents. PC inspection and testing shall be performed at least to the extent specified in the inspection clause of AWS D1.5, and additionally as necessary to ensure conformance with the requirements of the contract documents.

Quality Assurance (QA) is the prerogative of the Engineer. The QA inspector is the duly designated person who acts for and on behalf of the Engineer on all matters within the scope of the Contract documents as delegated by the Engineer. QA inspection and testing shall be performed to the extent necessary to verify that an acceptable product is being finished per the provisions of the Contract documents. The QA inspector shall have the authority to verify the qualifications of PC inspectors and nondestructive testing (NDT) personnel to specified levels by written or performance tests or other means as determined necessary.

(b) Start of Shop Work. Shop work shall not be started until the Contractor notifies the Engineer, in writing, where the shop orders were placed. The fabricator shall give 14-day notice before beginning of shop work, so that inspection may be provided. The proposed production schedule, including the start of production and shipment dates, shall be submitted to the Engineer.

(c) Notice of Shipment. The Department's QA inspector shall be notified seven days in advance of shipment of structural steel to the jobsite. Notification shall include all part numbers included in the release. Before final QA inspection the contractor shall provide copies of the QC test reports, copies of the MTRs for the material that is included in the release, and certificates of conformance (COC) per the contract documents.

509.15 Plans and Shop Drawings. The Contractor shall furnish shop drawings in conformity with subsection 105.02 for all structural steel bid under this section. Shop drawings shall specifically identify each piece, the direction of rolling for plates where specific orientation is required, the location of all welded splices, and the location, the extent, and the criteria of nondestructive testing. Pieces of steel that require Charpy V-Notch tests shall be identified and listed as to the frequency of test used. The detail drawing shall include a "T" designation for weld joints that are considered as tension.

509.16 Shop Facilities for Fabrication. Structural steel fabricators for all bridge structures as a minimum shall be certified under the AISC Quality Certification Program, per the category of the bridge being fabricated. The fabricator shall have successfully built at least two steel bridges of similar design within the last 5 years. The experience shall be submitted for acceptance to the Engineer at the Pre-construction Conference. If painting is required, the fabricator shall be certified to the AISC program for Complex Coatings Endorsement. Portions of work exposed to view shall be neatly finished. Lifting chains shall be provided with adequate softeners to prevent damage to the material while lifting and turning. If hooks are used for lifting, they shall have sufficient width of jaw and throat to prevent overstress and distortion from handling. Spreader beams, or multiple cranes, shall be provided for lifting plates and long members to prevent overstress and distortion. Welds and tack welds shall not be cracked from moving of members. Such occurrence shall require a written distortion control plan and complete inspection until the problem is corrected. The distortion control program and process control reports shall be forwarded to the QA inspector.

All cutting, fitting, welding, and painting shall be done in areas that are kept dry.

509.17 Inspection.

(a) Process Control Plan. The contractor shall submit a written "Welding Process Control Plan" (WPCP) to the Engineer before the beginning of fabrication. The WPCP shall outline the quality control tasks to be performed by the fabricator to ensure that all work conforms to the Contract. The WPCP shall include the following items at a minimum:

- Name of the welding firm, welding quality control inspection firm, and Non-Destructive Testing (NDT) firm hired by the contractor as applicable. Name and qualifications of the welding Quality Control Manager and Quality Control Inspectors.
- Documentation of all qualifications for welders, welding operators and tack welders, including continuity records.
- Name and qualifications of NDT personnel including level of certifications and expiration date.
- WPSs and supporting PQRs.
- Quality Control Procedures:
  - Methods and frequencies for performing all required visual inspection and NDT.
  - Methods of documentation for identification and tracking of welds including rejected lengths.
  - Procedures for identifying members distorted by welding and monitoring methods for straightening.
  - Calibration procedures for all NDT equipment.
  - Procedures for performing all NDT required.

The WPCP shall be subject to approval by the Engineer.

(b) *Frequency.* Inspection of all intervals of fabrication welding, including each shift on a daily basis, shall be performed by an AWS certified welding inspector, or an AWS certified assistant welding inspector under the direct supervision of the certified welding inspector. Direct supervision shall be defined as onsite monitoring of all inspection activities anytime welding or cutting operations are being performed.

(c) *Supervision.* Adequate supervision and process control inspection of all welding shall be provided to ensure satisfactory, consistent, and uniform workmanship. Recurring weld defects shall be considered as evidence that proper control and supervision are not being provided. Welding and associated fabrication operations shall be suspended when, in the opinion of the QA inspector, there is a lack of proper process control. Operations shall not resume until the fabricator has made a significant change in procedure. Proposed changes shall be defined and submitted in writing and approved by the QA inspector before resuming fabrication. Changes shall both correct the problem and prevent reoccurrence.

(d) *Edge Discontinuities.* All plates and shapes shall be inspected at the edges for the presence of laminar discontinuities and inclusions before welding or fitting to other pieces. The extent of all areas to be repaired shall be reported to the QA inspector.

(e) *Welding Meters.* Verification of welding meters shall be performed no less than once every three months. A calibrated tong ammeter and voltmeter, external to the welding machine, shall be used. Records of these calibrations shall be available for review by the QA inspector.

(f) *Reports.* The PC inspector shall submit the following reports to the QA inspector before acceptance: all nondestructive test reports, including tests of all repaired areas, the visual test report for all welds, dimensions, camber, and sweep measurements, welder qualification records, welding procedure specifications, procedure qualification records, welding machine settings, material traceability to each main member plate, and paint inspection reports. After each girder has been inspected by process control and has been accepted as conforming to the contract requirements, but before painting, the QA inspector shall be notified. The QA inspector shall determine the acceptability of the girder.

All contract deficiencies discovered shall be corrected by the fabricator before acceptance. Material subsequently found defective due to damage incurred in shipping and handling may be rejected even if previously accepted.

Materials rejected by the QA inspector will be subject to re-inspection before shipment. Re-inspection will normally be made at the next regular inspection; however, if no regular inspection is scheduled, and re-inspection is deemed necessary by the Engineer to assure compliance with the contract documents, the Contractor will be responsible for the transportation and per diem cost for the re-inspection. A deduction shall be made from the bid item cost for the item requiring re-inspection.

A request for quality assurance inspection shall be given seven days in advance. If it is determined that materials are not acceptance-stamped because they were not offered for shop inspection, or shipped after rejection at the shop, the materials shall be returned to the shop for inspection and correction as necessary. The cost of inspection and corrections made to rejected material at the project site shall be borne by the Contractor.

509.18 Nondestructive Testing.

(a) Written Practice and Records. The fabricator's Process Control Plan shall detail the nondestructive testing procedures, including the weld identification and location system. It shall also include the fabricator's Written Practice for the Administration of Personnel Qualification and Certification Program per The American Society for Nondestructive Testing SNT-TC509.18

1. The written practice shall indicate the specific requirements of the fabricator. Qualification records of all nondestructive testing personnel shall be included in the written practice. Each fabricator's written practice shall be subject to the approval of the QA inspector. All nondestructive test results shall be available for review during fabrication and forwarded to the QA inspector before acceptance of the assembly.

(b) Ultrasonic Inspection of Complete Penetration Groove Welds.

1. Weld Stress Categories. The following weldments shall be categorized as follows:

   A. Attachments. Longitudinal and transverse stiffeners, gussets, pintles, and all other attachments shall be considered as part of the flange, web, end, or pier diaphragm to which they are welded.

   B. Pier and End Diaphragms. Pier and end diaphragms shall be considered as part of the web or flange to which they are welded.

   C. Splices. Splices of main members, secondary members, or backing, when approved to be left in place, which attach to a main member, shall be ultrasonically tested and accepted before attaching to another member. Ultrasonic acceptance-rejection criteria shall be per AWS D1.5 as determined by the category of stress of the main member to which the secondary member is attached. All flanges that connect at a splice, indicating a change from tension to compression, shall be tested per the tension criteria of AWS D1.5.

   D. Sequence. All flange and web splices shall be welded and tested before fitting of the web to the flange.

2. Extent and Acceptance Criteria of Ultrasonic Testing. Ultrasonic testing of complete penetration groove welds shall be performed by PC to the extent listed in Table 509-1. The percent inspection indicated for each category is the minimum percent of the total length of each weld that must be tested.

Table 509-1
UT ACCEPTANCE-REJECTION CRITERIA
COMPRESSIVE STRESS

Element	Tension-Compression*	Weld Orientation#	Percent Inspection^
Flange	Tension	Transverse	100
Flange	Tension	Longitudinal	25
Flange	Compression	Transverse	25
Flange	Compression	Longitudinal	10
Web	Tension+	Transverse	100
Web	Tension+	Longitudinal	25
Web	Compression	Transverse	25
Web	Compression	Longitudinal	10
Pier & End Diaphragms	Tension+	Transverse	100
Pier & End Diaphragms	Tension+	Longitudinal	25
Pier & End Diaphragms	Compression	Transverse	25
Pier & End Diaphragms	Compression	Longitudinal	10

Table 509-1 Notes:

*Tension areas shall be tested per the current edition of AWS DI.5. Compression areas shall be tested per the current edition of AWS D1.5.

#The orientation is referenced with respect to the longitudinal center line of the girder for flanges and webs. The orientation is referenced parallel to the center line of bearing for end and pier diaphragms.

^If any rejectable discontinuities are found in any weld tested less than 100%, the remaining length of that weld and all similar welds in that member shall be tested.

+ The tension area of webs and end or pier diaphragms is defined as $^{1}\!\!»_{6}$the depth of the web from the tension flange.

3. Preparation of Test Material and Testing Procedures. All groove welds shall be ground flush to a maximum surface roughness (ANSI B46.1) of 125 microinches and a medium range waviness such that no gap greater than 0.020 inch is present beneath a 2-inch-long straightedge placed anywhere on the test surface. The test surface shall be ground to bright metal and allow intimate coupling with the search unit. Failure to provide this condition shall result in repair or removal and re-welding of the joint, or alternative nondestructive testing methods, as determined by the QA inspector. The testing procedures established in the current edition of AWS D1.5 shall be amended as follows:

   A. Splices. All materials spliced shall be tested before attaching into the assembly.

   B. Alternate Procedures. Scanning of welds may be made using other methods, as approved by the Engineer, provided evaluation is made per clause 8, part C of AWS D1.5.

C. Butt Joints. All butt joints shall be ground flush and shall include mandatory scanning using pattern "D" (Figure 8.7 of AWS D1.5) longitudinal to their axis.

D. Scanning Procedure. AWS D1.5, UT Acceptance-Rejection Criteria – Compressive Stress, shall be amended as follows:

(1) Testing from both sides of the weld axis shall be made in both Leg I and Leg II.

(2) Face A on both connecting members of flanges at a butt weld must lie in a single plane. Scanning of butt welds where Face A and Face B individually lie within the same plane shall be performed in Leg I and Leg II from each side of the weld axis. Should neither Face A nor Face B lie in a single plane, the testing procedure shall be as follows: Face A from the thinner material shall be tested both in Leg I and Leg II. The thicker material shall be tested from Leg I from both Face A and Face B. Leg II from Face A shall be evaluated when it originates from the thinner material. Transducers with frequencies greater than 2.25 MHZ may be used to facilitate locating the discontinuities, but evaluation for acceptance shall be made per AWS D1.5.

(3) T joints shall be evaluated from both Face A and Face B in Legs I, II, and III. In addition, scanning pattern E shall be performed. All indications that are up to and including 6 dB less critical than reject shall be recorded on the test report and reported to the Engineer for acceptance evaluation.

(4) The Testing Angle and UT Acceptance-Rejection Criteria Tables of AWS D1.5 shall include the following: Flaws evaluated with 60- or 45-degree search units and rejected, but which have indication levels at or above the minimum level listed for a 70-degree search unit, shall be evaluated with 70-, 60-, and 45-degree search units. If this testing reveals that the sound beam of the 60- or 45-degree search unit is striking the flaw at 90- plus or minus 15 degrees, the acceptance level listed for a 70-degree search unit shall be used as the basis for acceptance, regardless of the angle of the search unit used to evaluate the flaw.

(5) Evaluation using reject may be used to evaluate flaws, only if calibration is per AWS D1.5, and the vertical linearity is within plus or minus 1 dB for a 60 dB range.

E. Index Marking. Two low stress die stamp marks shall be located on Face A, 12 inches from the centerline of the joint on one side of the joint, and 3 inches from each edge of the plate.

4. Through Thickness Tension Plate. Ultrasonic testing of plates as identified in the plans as exhibiting tension in the through thickness direction shall be performed per ASTM A578. Plates greater than 3/4 inch thick shall be tested using 2.25 MHZ 1 inch diameter transducers. Plates less than and including 3/4 inch thick shall be tested with a 5 MHZ 1/2-inch diameter transducer. Supplementary requirement S2 shall be used as the acceptance standard.

(c) Dye Penetrant Testing. Dye penetrant testing per ASTM E165 may be substituted for magnetic particle testing with approval of the Engineer.

(d) Magnetic Particle Testing. Magnetic particle testing shall be performed on areas defined in AWS D1.5 and this subsection. Magnetic particle testing shall be conducted per ASTM E709 and AWS D1.5, except as amended. Alternating current shall be used. The yoke spacing shall be between 2 and 4 inches. The minimum lifting power shall be 10 pounds. Red dry particles shall be used. The light intensity shall meet ASTM E709, Section 7.

The yokes shall be set in two positions when testing the weld or base metal. They shall be positioned both normal and parallel with respect to the weld axis and rolling direction of the base metal.

Magnetic particle tests shall be performed at the following locations:

1. Base metal. All areas contacted by the carbon arc gouge electrode, the electrode cup, and the welding electrode. All three conditions are arc strikes.

2. Fillet Welds. Each design weld size on main member to main member and secondary member to main member weldments. All stop-starts and weld termini. All linear indications shall further be evaluated with 10x or 30x magnification. Verification shall be resolved by excavation.

3. Groove welds. All through thickness edges on transverse butt joint weldments in tension areas.

4. Repairs. All repair welds to correct defects in groove and fillet welds, plate cut edges, correction of fabrication errors in cutting, punching, drilling, or fitting, and members that are tacked or welded and subsequently cut apart and re-welded.

(e) Radiographic Testing. When radiographic testing is specified, it shall be performed per AWS D1.5, except that *edge blocks shall be used. Radiographs shall be identified as follows:*

1. Contract Number.

2. Weld Identification Number. The fabrication number of the girder where the radiographed weld occurs, followed by a dash (-).

3. Letter Designation. Letter combination designating the section as follows: TF (top flange); BF (bottom flange); W (web); and when applicable, N (near side) and F (far side).

4. Joint Designation. A letter preceded by a space followed by a number. The number shall designate the joint where the radiograph occurs and shall correspond to the number of welded joints between the reference end of the section and the radiographed weld.

5. Defect Description. All defects shall be outlined on the radiograph clearly showing the rejected areas. The report shall indicate the type of discontinuity and its location from a reference point on the film.

(f) Hardness Testing. Hardness testing shall be conducted as required by AWS D1.5. Oxygas cutting procedures used on tension flanges shall be qualified before fabrication. The procedure shall be qualified on all of the following parameters: the grade and type of steel, thickest material cut, highest carbon equivalency, and lowest base metal temperature at the time of cutting. Tests shall be witnessed by the Inspector.

The test equipment and procedures shall be per ASTM E18. Each test area shall be contained within 6 square inches.

The mean value of five readings, within a test area, shall not exceed 30 HRC. Excessive values shall require establishing higher material temperatures at the time of cutting. The base metal temperature shall be measured on the surface opposite the cutting source: 3 inches from the point on the surface nearest to the heat source.

Production Process Control tests shall be performed by the Contractor. The number of tests shall be the next highest whole number calculated as follows: total number of tension flanges on the bridge divided by 10.

Production Process Control tests shall include the first production cut of the thickest fabricated flange. A minimum of 50 percent of production Process Control tests shall be performed on the thickest flanges fabricated.

All test results shall document the base metal thickness and temperature measured at the time of cutting. Test reports shall be forwarded to the QA Inspector. Test values greater than Rockwell C 30 shall be reported to the QA Inspector immediately.

509.19 General Fabrication Requirements.

(a) Identification of Steels During Fabrication. Materials received from the mill shall be stored so that heat numbers are visible. Plates shall be step stacked with the heat number of each plate marked at the end, along with the contract number and size of the plate as received from the mill.

Shapes, bars, and other materials that are furnished in tagged lifts or bundles, shall be received and stored with identification as required by AASHTO M160. Pieces of steel which, before assembling into members, will be subject to painting, galvanizing, or any other operations that will obliterate the heat numbers shall be marked with the heat number and plate number (CVN plate frequency, if applicable) with low stress die stamp (spherical indent).

Any excess material placed into stock for future use shall be marked with the heat number, rolling direction, and plate number if applicable, and grade of steel. Secondary members shall be identified at a frequency of once for every 20 pieces (or less) per heat.

The fabricator shall furnish to the QA inspector cutting lists indicating the rolling direction, heat numbers (plate number for P frequency when applicable), and fabrication piece number marked in a timely manner during fabrication.

If requested by the Engineer, the Contractor shall furnish an affidavit that certifies that the identification of steel has been maintained per this specification.

(b) Location of Splices. Groove welded splices shall be located a minimum of 5 feet from the centerline of field splices and 1 foot minimum from centerline of the nearest bolt hole.

(c) Location of Stiffeners and Connections. Intermediate stiffeners or connection plates shall be placed at least 6 inches from a groove welded splice in the web or flange. Welder identification marks shall be made using low stress die stamps (spherical indent) near the weld, but not closer than 1 inch from the heat affected zone.

(d) Rolling Direction and Cutting. Unless otherwise shown on the plans, steel plates for girder flanges, webs, and splice plates shall be cut and fabricated so that the primary direction of rolling is parallel to the longitudinal centerline of the girder. Abutment and pier diaphragm plates (includes flanges, webs, and splice plates) shall be cut and fabricated so that the primary direction of rolling is parallel to the centerline of bearing. Sheared edges of plates more than 5/8 inch thick and carry calculated stress shall be milled or sawn to a depth of ¼ inch. Reentrant corners shall be pre-cut to a minimum radius of 1 inch before cutting. The procedure for cutting plate edges of tension flanges shall be qualified per subsection 509.18(f).

(e) End Treatment of Webs and Flanges. The ends of webs and flanges shall be flush and within the same plane so as to leave no reentrant corners.

(f) Minimum Base Metal Temperature. The minimum base metal temperature qualified to cut flanges and webs in tension, shall be established by hardness testing per subsection 509.18(f).

(g) Straightening Material. Rolled material, before being worked, must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal and is subject to the Engineer's approval.

(h) Bent Plates. Un-welded cold-bent steel plates shall conform to the following:

1. Rolling Direction. The bend line shall be at right angles to the direction of rolling.

2. Minimum Radii. Bending shall be such that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, shall be 5t for all grades and thicknesses of steel conforming to AASHTO M270 (ASTM A709) unless approved by the Engineer.

3. Bending Temperature. If a shorter radius is essential the plates shall be bent hot at a temperature not greater than 1200 °F. Hot-bent plates shall conform to subsection 509.19(i).

4. Corner Radii. The corners of the plate shall be rounded to a radius of $^{1}\!\!»_{16}$ inch before bending throughout the portion of the plate where the bending is to occur.

(i) Curving and Cambering of Rolled Beams and Welded Girders. Heat curving of beams and girders will be allowed when the horizontal radius of curvature measured to the centerline of the member web is greater than both values calculated by the following two equations, and greater than 150 feet at any and all cross sections throughout the length of the member.

$$R = \frac{14bD}{\sqrt{F_y}\Psi t}\ ,\ \ R = \frac{7500b}{F_y\,\Psi}$$ where:

F_y = specified minimum yield point in ksi of the member web.
Ψ = ratio of the total cross-section area to the cross-sectional area of both flanges.
b = width of the widest flange in inches.
D = clear distance between flanges in inches.
t = web thickness in inches.
R = radius in inches.

In addition to the above, when the required radius of curvature is less than 1000 feet, and the flange thickness exceeds three inches, or the flange width exceeds 30 inches, heat curving will not be allowed. Heat curving requirements shall be as follows:

1. Materials. Steels that are manufactured to a yield point greater than 50,000 psi shall not be heat-curved.

2. Type of Heating. Beams and girders may be curved by either continuous or V-type heating as approved by the Engineer. For the continuous method, a strip along the edge of the top and bottom flange shall be heated simultaneously; the strip shall be of sufficient width and temperature to obtain the required curvature. For the V-type heating, the top and bottom flanges shall be heated in truncated triangular wedge-shaped areas having their base along the flange edge and spaced at regular intervals along each flange; the spacing and temperature shall be as required to obtain the required curvature, and heating shall progress along the top and bottom flange at approximately the same rate.

   For the V-type heating, the apex of the truncated triangular area applied to the inside flange surface shall terminate just before the juncture of the web and the flange is reached. To avoid unnecessary web distortion, special care shall be taken when heating the inside flange surfaces (the surfaces that intersect the web) so the heat is not applied directly to the web. Asbestos sheet material 1/4 inch thick shall be placed against the web before applying heat to the inside flange surface. When the radius of curvature is 1000 feet or more, the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend to the juncture of the flange and web. When the radius of curvature is less than 1000 feet, the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend past the web for a distance equal to 1/8 of the flange or 3 inches, whichever is less. The truncated triangular pattern shall have an included angle of approximately 15 to 30 degrees, but the base of the triangle shall not exceed 10 inches. Variations in the patterns prescribed above may be made upon approval by the QA inspector.

For both types of heating, the flange edges to be heated are those that will be on the inside of the horizontal curve after cooling. Heating both inside and outside flange surfaces is only mandatory when the flange thickness is 1 1/4 inches or greater, in which case, the two surfaces shall be heated concurrently. The minimum temperature shall be as prescribed below.

Preload compressive stresses will be permitted up to a maximum of 60 percent of the specified yield strength of the steel to reduce the number of heat patterns required to produce the desired curvature. Loading that causes the member to distort permanently (yield without the application of heat) will result in rejection of the member. All nondestructive testing to evaluate damage and corrective work ordered by the Engineer to compensate for overstressing shall be performed at the Contractor's expense.

3. Temperature. The heat curving operation shall be conducted in such manner that the temperature of the steel does not exceed 1150 °F as measured by temperature indicating crayons or other suitable means. The inspector shall take heat measurements after the heating flame has been removed from the steel. The girder shall not be artificially cooled until after naturally cooling to 600 °F; the method of artificial cooling is subject to approval. Heat curving shall be directly supervised by the PC inspector.

4. Position for Heating. The girder may be heat curved with the web in either a vertical or a horizontal position. When curved in the vertical position, the girder must be braced or supported in such a manner that the tendency of the girder to deflect laterally during the heat curving process will not cause the girder to overturn.

   When curved in the horizontal position, the girder must be supported near its ends and at intermediate points, if required, to obtain a uniform curvature; the bending stress in the flanges due to the dead weight of the girder must not exceed the usual allowable design stress. When the girder is positioned horizontally for heating, intermediate safety catch blocks must be maintained at the mid-length of the girder within 2 inches of the flanges at all times during the heating process to guard against a sudden sag due to plastic flange buckling.

   Horizontal curvature shall be checked with the girder in the vertical position by measuring off-sets from a string line or wire attached to both flanges or by using other suitable means.

5. Sequence of Operation. Members shall be heat curved before the completion of the following:

   A. Attachment of end bearing stiffeners.

   B. Attachment of lateral gusset plates.

   C. Attachment of longitudinal stiffeners.

   D. Welding of intermediate stiffeners and connection plates to the flanges. When longitudinal stiffeners are required, they shall be heat curved, or oxygen-cut to the required radius before being welded to the curved girder. The girder shall be heat curved in the fabrication shop before it is painted. When cover plates are to be attached to rolled beams, they may be attached before heat curving if the total thickness of one flange and cover plate is less than 2 1/2 inches and the radius of

curvature is greater than 1000 feet. For other rolled beams with cover plates, the beams must be heat curved before the cover plates are attached; cover plates must be either heat-curved or oxygen-cut separately and then welded to the curved beam.

6. Camber. Cambering of welded plate girders, except for minor adjustments required after welding, shall be achieved by curved cutting of web plates before welding to flanges. Girders shall be cambered before heat curving. Heat cambering procedures shall be per subsection 509.19(i) and shall be approved by the Engineer before beginning of work. Vertical camber shall not be measured for final acceptance before all welding and heating operations are completed and the flanges have cooled to a uniform temperature. Triangular heating patterns shall be spaced throughout the length of the member.

   The apex of the triangle shall be located in the web at a point not less than 75 percent of the depth of the member from the flange that will be concave after cambering. Heat shall begin at the apex and progress slowly toward the base. The included angle shall not exceed 20 degrees. The maximum width at the base shall not exceed 10 inches.

(j) Facing of Bearing Surfaces. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the following ANSI B46.1 surface roughness requirements in microinches:

Steel Slabs	ANSI 2000
Heavy plates in contact in shoes to be welded	ANSI 1000
Milled ends of compression members, milled or ground ends of stiffeners and fillers	ANSI 500
Bridge rollers and rockers	ANSI 250
Pins and pin holes	ANSI 125
Sliding bearings	ANSI 125

The maximum deviation from flatness of the contact area of every steel bearing surface shall not exceed 1/32 inch. Deviation shall be measured by placing measured offset blocks of equal dimension outside the bearing contact area and placing a straightedge across the blocks. Measurements from the flange surface to the bottom of the straight edge shall not deviate by more than 1/32 inch from the offset block dimension. Flatness shall be checked in both the longitudinal and transverse directions at 4-inch intervals within the area of bearing contact.

(k) Holes for Fasteners. All holes for bolts in main members, or secondary members that weld to main members, shall be either sub-punched and reamed, subdrilled and reamed, or drilled from the solid. Holes shall be sub-punched or subdrilled 1/16 inch smaller than the nominal diameter of the fastener and reamed to 1/16 inch larger than the nominal diameter of the fastener or drilled to 1/16 inch larger than the nominal diameter of the fastener. For bolts 1 inch and larger, bolt holes shall be reamed to 1/8 inch larger than the bolt diameter. Subsized holes before reaming shall not be offset more than 1/16 inch. Reaming or drilling full sized holes shall be done using a template with hardened bushings or with a numeric control (N/C) machine such that no offset equal to 1/32 inch

(l) occurs in more than 15 percent of the connection. Enlarged or slotted holes for high strength bolts may be used only when shown on the plans or authorized. Holes shall be clean cut, without torn or ragged edges. All burrs shall be removed, as well as oil and other foreign matter. Holes shall be cylindrical within 1/32 inch and perpendicular to the member. Connection parts requiring reaming or drilling shall be assembled and securely held and shall be match marked before disassembling. Poor matching of holes will be cause for rejection.

(m) *Boring Pin Holes.* Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut. The distance outside to outside of holes in tension members, and inside to inside of holes in compression members shall not vary more than 1/32 inch from that specified. Boring of holes in built-up members shall be done after fabrication of the member is completed. The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins 5 inches or less in diameter, or 1/32 inch for larger pins. Two pilot nuts and two driving nuts for each size pin shall be furnished unless otherwise specified.

509.20 Welding.

(a) *Process.* Welding of steel structures shall conform to AWS D1.5 as amended. All web and flange butt joints and web to flange welds shall be made using the submerged arc welding process (SAW). Alloy "active" fluxes shall not be used in groove welds or fillet welds with more than three passes. Repairs may be made using submerged arc welding or shielded metal arc welding (SMAW). Flux cored arc welding (FCAW) will be permitted on secondary to main member attachments when performed in the flat or horizontal positions. Vertical or overhead welding positions using the FCAW process shall not be used unless approved by the Engineer of Record.

The ratio of the width of the face to the depth of penetration of each Submerged Arc Welding fillet pass shall be a minimum of 1.1:1. This shall be verified by macroetch testing and included in the *Procedure Qualification Record (PQR)*. The test heat input and voltage qualified shall establish the maximum values used in fabrication welding. These values shall be indicated in the Welding Procedure Specification.

The macroetch shall be performed per AWS D1.5, with the following exception: The T-joint shall contain an acute angle less than or equal to the smallest acute angle to be used in fabrication. The acute angle tested qualifies all angles equal to or greater than this angle. Both sides of the T-joint shall be welded.

(b) *Base Metal Preparation.* The preparation of base metal shall be per AWS D1.5, with the following exception: All mill scale and rust shall be removed from the surfaces of main members where all welds are made by any process. Surfaces and edges to be welded shall not exceed an ANSI B46.1 roughness value of 500 microinches.

(c) *Run On-off Plates.* Run-on and run-off plates shall be used on all butt joints. They shall be of the same base metal as the material being welded. Removal of these plates shall be accomplished by cutting the plates off and grinding to a surface finish per AWS D1.5.

(d) *Undercut.* Undercut in the stiffener, web or flange shall not exceed 0.01 inch in areas of tension as indicated on the plans when the axis of the undercut is normal to the longitudinal

centerline of the girder, or normal to the centerline of bearings in the case of plate diaphragms. Undercut in compression areas shall not exceed 1/32 inch.

(e) Temporary Tack Welds. Temporary tack welds will not be permitted on splice plates to facilitate stack drilling. All temporary tack welds not incorporated into the final weld, shall be submitted to the Engineer for approval. Temporary tack welds that are approved shall be removed by grinding such that the plate thickness is not reduced by more than five percent and tested per subsection 509.18(c).

(f) Gusset Plates. Lateral gusset plates welded to girder flanges in tension shall be pre-heated to a minimum 250 °F. Maximum shall be specified in the approved WPS.

(g) Repairs. All welding required to repair cracks, oxygen cut gouges, porosity, and undercut, shall conform to the following:

1. General. Repairs made to correct undercut, craters, undersized welds, porosity, excessive roughness on oxygen cut gouges, and cracks shall not be performed without the knowledge of the PC inspector. Undercut may be prepared by contour grinding when approved by the Engineer. Areas repaired shall be recorded per AWS D 1.5, paragraph 6.5.8. Surfaces that are air carbon arc gouged shall be ground to bright metal before welding. Repair areas shall be preheated to a temperature of 200 to 300 °F before welding. Cracks removed before welding shall be penetrant tested or magnetic particle tested to assure their complete removal before welding. All repairs shall be penetrant or magnetic particle tested for soundness. This requirement applies equally to tack welds.
2. Groove Welds. The number of repairs shall be limited to three or fewer heat cycles in any groove weld, unless approved by the Engineer.
3. Cut Edges. Cavities resulting from the removal of cut edge discontinuities in plates shall be prepared before welding using a minimum 1/4-inch radius and a minimum 40-degree angle. The base metal shall be ground to bright metal before welding.
4. Mislocated Holes. Misfit holes shall not be repaired, unless approved by the Engineer. When holes are repaired per an approved welding procedure, the soundness shall be established by ultrasonic testing. In addition, the hardness, preheat, and post-weld heat shall be per AWS D1.5.

(h) Stud Welding. Stud welding shall conform to AWS D1.5 as amended.

Studs shall not be welded to top flanges until after the formwork for the deck is in place per Occupational Safety and Health Administration (OSHA) regulations 29 CFR 1926 Subpart R.

Stud attachments for fall protection systems or other temporary works are allowed on the top flange in locations where permanent shear studs will be attached. These attachments are allowed to be placed before formwork for the deck being installed.

1. Camber. Adequate provisions shall be made in fabrication of structural members to compensate for loss of camber due to welding of the shear connectors.
2. Production Tests. The first two studs welded on each beam or girder, after being allowed to cool, shall be bent 45 degrees by striking the stud with a hammer. If failure occurs in the weld of either stud, the weld procedure shall be corrected, and

two successive studs successfully welded on separate material and tested before any more studs are welded to the beam or girder. The QA inspector shall be promptly informed of all changes in the welding procedure at any time during fabrication.

(i) Weld Termini Treatment. All gussets, stiffeners, diaphragms, or other attachments at a corner of intersecting plates joined by a fillet or groove weld, shall be clipped 1½ inch minimum. Intersecting fillet welds will not be allowed. Treatment of all end weld termini on transverse secondary attachments to main members shall be such that the welds terminate ¼ inch short of the end of the attachment.

(j) Gas Certification. The Contractor shall furnish certification that the gas or gas mixture is suitable for the intended application per AWS D1.5 and the manufacturer's recommendations.

(k) Miscellaneous Attachments. Attachments shall not be welded to main members, unless approved.

509.21 Shop Assembly.

Field Connections. Of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames shall be assembled in the shop with milled ends of compression members in full bearing and the subsize holes reamed to the specified size while the connections are assembled. Assembly may be full truss or girder assembly, progressive truss or girder assembly, full chord assembly, progressive chord assembly, or special complete structure assembly at the fabricator's option unless assembly methods are specified on the plans.

(a) Full Truss or Girder Assembly. Full truss or girder assembly shall consist of assembling all members of each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at one time.

(b) Progressive Truss or Girder Assembly. Progressive truss or girder assembly shall consist of assembling initially for each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at least three contiguous shop sections or all members in at least three contiguous panels, but not less than the number of panels associated with three contiguous chord lengths (i.e. length between field splices) and not less than 150 feet in the case of structures longer than 150 feet. At least one shop section or panel or as many panels as are associated with a chord length shall be added at the advancing end of the assembly before any member is removed from the rearward end, so that the assembled portion of the structure is never less than specified above.

(c) Full Chord Assembly. Full chord assembly shall consist of assembling, with geometric angles at the joints, the full length of each chord of each truss or open spandrel arch, or each leg of each bent or tower, then reaming the field connection holes while the members are assembled and reaming the web member connections to steel templates set at geometric (not cambered) angular relation to chord lines. Field connection holes in web members shall be reamed to steel templates. At least one end of each web member shall be milled or scribed normal to the longitudinal axis of the member and the templates at both ends of the member shall be accurately located from one of the milled ends or scribed lines.

(d) *Progressive Chord Assembly.* Progressive chord assembly shall consist of assembling contiguous chord members in the manner specified for full chord assembly and in the number and length specified for progressive truss or girder assembly.

(e) *Special Complete Structure Assembly.* Special complete structure assembly shall consist of assembling the entire structure, including the floor system. Each assembly, including camber, alignment, accuracy of holes, and fit of milled joints shall be per dimensional requirements before reaming or full-size drilling of holes.

(f) *Fit.* Surfaces of metal in contact shall be cleaned before assembling. The parts of members to be assembled shall be well pinned and firmly drawn together with bolts before reaming operations.

(g) *Match Marking.* Connecting parts assembled in the shop for field connections shall be match-marked, and a diagram showing such marks shall be furnished to the Engineer.

(h) *Drifting of Holes.* The drifting done during assembling shall be only that necessary to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. If holes must be enlarged to admit bolts, they shall be reamed.

(i) *Abutting Joints.* Abutting joints in compression members and girder flanges, and in tension members when so specified on the plans, shall be faced and brought to uniform bearing. Where joints are not faced, the opening shall not exceed 1/4 inch.

(j) *Camber Tolerance.* Deviation from the design camber between any two supports (points of fixed elevations) shall be limited to:

+L/1200 -L/2880

Where: L = length in feet between supports

This requirement is in addition to the camber requirements of AWS D1.5 subsection 3.5.

509.22 Shop Connections Using High-Strength Bolts. Unless otherwise specified, all shop connections shall be made with high-strength bolts. All connections which remain in the permanent structure shall be made per subsection 509.28.

509.23 Galvanizing. Bolts, washers, and nuts used in the assembly and erection of galvanized railing and posts or where specified, shall be galvanized per AASHTO M232 Class C or shall be zinc coated per AASHTO M298. Structural steel shall be galvanized per AASHTO M111. Uncleaned slag lines, bare spots, blisters, flux spots or inclusions, dross, acid, or black spots that exceed 1 square inch or occur on more than 5 percent of the pieces in the lot shall be cause for rejection of the lot. The materials may be stripped, regalvanized, and again submitted for test and inspection; otherwise, the entire lot shall be rejected. Pieces less than 5 percent of the lot may, with the approval of the Engineer, be zinc coated by an approved zinc rod, per ASTM A780, if applied to correct areas less than 1 square inch. Materials may only be stripped and regalvanized a single time.

509.24 Shop Cleaning and Painting of Steel. Graffiti shall be removed before painting, or in the case of ASTM A 709 Grade 50W steel, before shipping.

(a) *Cleaning of Unpainted ASTM A709 Grade 50W Steel.* The exterior surfaces of unpainted ASTM A 709 Grade 50W steel shall be cleaned with abrasive blasting to a minimum standard of Sa2 to remove mill scale and foreign material that would prohibit rusting to a uniform color. This cleaning shall occur after fabrication and before shipping. The use of paint, wax, crayon or similar materials for making steelwork during fabrication and erection shall not be permitted. Care shall be taken on site with both storage and handling of the girders such that the developing rust is not damaged.

(b) *Cleaning of Surfaces to be Painted.* Structural steel cleaning shall meet the requirements of the Steel Structures Painting Council Surface Preparation Specification No. 6 (SSPC-SP 6, Commercial Blast Cleaning). Painting shall be accomplished before new rust forms.

(c) *Paint Systems.* All structural steel shall be painted using a two-coat system with inorganic zinc-rich primer (shop coat) and high-build urethane topcoat as described in subsection 708.03. The shop coat shall have a dry film thickness of 3.0 mils. The topcoat shall have a thickness of 3.0 mils.

(d) *Sequence.* Unless otherwise specified, steel work shall be given the shop coat of approved paint after it has been accepted by the QA inspector and before it is shipped from the plant. Shipping pieces shall not be loaded for shipment until they are thoroughly dry. Painting shall not be done after loading material on cars except for retouching areas damaged by loading or handling operations.

(e) *Procedure.* Application of paint shall be per the manufacturer's recommendations.

(f) *Surfaces in Contact with Concrete.* The areas that will come in contact with concrete shall not be painted.

(g) *Field Weld Areas.* Areas of structural steel to be field welded shall not be painted before welding is completed.

(h) *Erection Marks.* Erection marks for field identification of members shall be readily visible on shop painted surfaces.

(i) *Faying Surfaces of Connections.* When splices are specified on the plans to be Class B slip critical, the contact surfaces of unpainted ASTM A709 Grade 50W steel shall be blast cleaned to a SSPC-SP6 commercial blast. When the inorganic zinc-rich primer is provided, the manufacturer shall qualify the paint by test per “Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints” as adopted by the Research Council on Structural Connections. The manufacturer shall certify in writing that the slip coefficient is no less than 0.48.

509.25 Marking. Each member shall be painted or marked with an erection mark for identification, and an erection diagram shall be furnished to the Contractor and Engineer with erection marks shown.

CONSTRUCTION REQUIREMENTS

509.26 Field Welding and Inspection. Field welding will not be permitted unless shown on the plans or approved by the Engineer, except to attach studs. Before the start of any field welding, all required welding documentation including welder qualifications (WQTRs), WPSs, and PQRs shall be submitted to the Engineer for review and approval. All field welding will shall be completed by a qualified welder qualified per the given process and AWS D1.5 welding code requirements. All field welding and inspection shall be performed per this specification and AWS

D1.5. All field welding shall be inspected by a CWI included in the Contractor's Process Control Plan and shall be included in the cost of the work. Welding on metal deck forms shall be per AWS D1.3.

(a) Field Welding Process Control Plan. The Contractor shall submit a written "Field Welding Process Control Plan" (FWPCP) to the Engineer before beginning field welding operations on permanent bridge structures. The FWPCP shall outline the quality control tasks to be performed by the contractor to ensure that all work conforms to the Contract. The FWPCP shall include the following items at a minimum:

1. Names, qualification documentation and continuity records of for all welders, welding operators and tack welders, who will be performing field welds.
2. Welding Procedure Specifications (WPS) and supporting Procedure Qualification Records (PQRs), if required, for welds to be performed.
3. Location and types of welds to be performed.
4. Number and type of welding equipment to be used and records of Welding Meter calibrations.
5. Method of electrode protection and storage.
6. Quality control procedures:
   A. Name of welding quality control inspection firm, and NDT firm hired by contractor who will be inspecting field welds.
   B. Names and qualifications of, Quality Control Inspector (QCI), CWI and NDT personnel including level of certification and expiration date.
   C. Frequency of visual and NDT inspection.
   D. Calibration documentation of all NDT equipment.
   E. Method for documenting that welding has been performed per contract requirements.

The FWPCP shall be submitted at least one week before the Pre-Erection Conference and be subject to approval by the Engineer.

Welding on driven pile shall be performed per requirements of section 502.

(b) Strengthening and repair of existing structures. If welding is to be performed to existing components on structures built before 1970, metallurgical analysis will be provided by the Engineer. Contractor shall develop and submit to the engineer any WPS, PQR and WQTR documentation based on metallurgical analysis to ensure proper welding procedures are used. Engineer shall review and approve all welding documentation before contractor performing welding.

Studs shall be free from rust, rust pits, scale, oil, moisture, paint, and other deleterious matter that would adversely affect the welding operation. Surfaces where studs are to be welded shall be free of scale, rust, moisture, paint, and other injurious material that would prevent proper welding or produce objectionable fumes. Additional studs shall be tested per AWS D1.5 when the base metal temperature is below 32° F at the time of welding. Stud welding shall not be done when the base metal temperature is below 0° F at the time of welding.

(c) Stud welding in the field. Automatic stud welding guns shall be used to weld studs to girders. The operator shall be qualified per AWS D1.5. The base metal where the stud is to be welded shall be ground to bright metal immediately before the weld being made.

Manual welding will not be allowed except to make repairs. Stud welding shall be per subsection 509.20 (h).

(d) Repairing Stud Welds. Stud welds may be repaired using a low-hydrogen SMAW process. Electrodes used to repair stud welds shall be kept in rod ovens per AWS D1.5. The fillet weld size shall be a minimum of 5/16 inch. The welder shall be prequalified for the welding process used and stud welding.

509.27 Erection of Steel Structures.

Structural steel members shall be erected to prevent damage to all elements of the structure and in a safe manner. Structural steel members to which the erection specification applies are those members that bear on the substructure of a bridge. The primary members such as beams and girders shall be temporarily anchored and braced as they are erected to preclude detrimental movement in any direction, and to prevent overturning and buckling. Struts, bracing, tie cables, and other devices used for temporary restraint shall be considered falsework and shall be designed to resist all loads imposed during each stage of construction until the deck concrete has attained the Field Compressive Strength shown in Table 601-1.

At least two steel girders shall be erected when girders are initially placed in any span, unless the Engineer provides a written waiver to this requirement. Diaphragms and cross frames between girders shall be connected to the girders and all diaphragm or cross frame connection bolt holes filled with bolts that are at least snug tight during erection. Steel box girders need not be erected in pairs.

At least one week before the Pre-Erection Conference, the Contractor shall submit an Erection Plan to the Engineer. The Erection Plan will be reviewed by the Engineer and Staff Bridge concurrently and combined comments will be submitted in writing within one week. These comments shall be addressed in the final plan. The Final Erection Plan shall be signed and sealed by the Contractor's Engineer and marked "Approved for Construction". If falsework drawings are required, they shall conform to and be submitted per subsection 601.11.

The Contractor performing steel bridge erection shall be an AISC Certified Steel Erector (CSE) when field assembly is required. The erector shall have successfully completed erection of at least 2 bridge structures of the same category as the project within the last 5 years and have a minimum of 5 years of experience with the erection of bridges. The experience shall be submitted for acceptance to the Engineer. This requirement shall not apply to sign structures.

The Erection Plan and procedure shall provide complete details of the erection process with dimension tolerances including:

(1) Temporary falsework support, struts, bracing, tie cables and other devices, material properties and specifications for temporary works, bolt torque requirements before releasing girders from the cranes (if required), connection details and attachments to other structure components or objects.

(2) Procedure and sequence of operations, including a detailed schedule with completion times for work items that complies with the working hour limitations.

(3) Minimum load chart lift capacity, outrigger size, and reactions for each crane.

(4) Assumed loads and girder weights, lift points, lifting devices, spreaders, and angle of lifting cables.

(5) Girder stresses at critical points along the girder length during progressive stages of erection shall be investigated to assure that the structural integrity and stability of the girders is maintained. Stresses at lift points induced as a result of lifting shall be investigated and adequate bracing provided as indicated by the analysis.

(6) Locations of cranes, trucks delivering girders, and the location of cranes and outriggers relative to other structures, including retaining walls, wing walls and utilities.

(7) Drawings, notes, catalog data showing the manufacturer's recommendations or performance tests, and calculations clearly showing the above listed details, assumptions, and dimensions.

(8) Contingency plans detailing what measures the Contractor will take in case of inclement weather (forecast or actual), equipment failure, delivery interruption, and slower than planned production.

A Pre-Erection Conference will be held at least one week before the beginning of erection. The Engineer, Contractor, erection subcontractor, and the Contractor's Engineer shall attend the meeting. The erection subcontractor shall demonstrate his knowledge and familiarity of where the piece marks are located on the components to be erected, their orientation in the erected structure, and the shop drawing piece mark convention used by the girder fabricator at the Pre-Erection Conference. The girder fabricator shall participate in the conference, by way of speaker telephone, during only that portion that the piece marks are discussed. The girder fabricator shall state whether the erection subcontractor has demonstrated a correct understanding of the piece marks, and if not, correct any misunderstanding.

Additional Pre-erection Conferences may be required for subsequent phases of construction, or for phases that differ from the original construction plan, as directed by the Engineer. Additional conferences may also be requested by the Contractor and approved by the Engineer.

The Contractor shall submit a final Erection Plan to the Engineer before girder erection for record purposes only. The Contractor's Engineer shall sign and seal (1), (5), and (7) listed above in the final Erection Plan. The final Erection Plan shall be stamped "Approved for Construction" and signed by the Contractor.

When a bridge spans traffic of any kind, including those where vehicles, railroad, watercraft or pedestrians have access onto, under or adjacent to the bridge, the Contractor's Engineer shall inspect and provide written approval that the erected girders are safe before opening the area beneath the girders to traffic. For this specification, traffic is defined as the vehicles, railroad, pedestrians, and watercraft moving along a route. The Contractor shall perform daily inspections of the erected girders and other permanent and temporary bridge elements until the deck concrete has attained the Field Compressive Strength. The Contractor's Engineer shall provide an inspection form to the Engineer and the Contractor that lists the items the Contractor will document during the daily inspection of the erected girders. The inspection form shall include inspection items specific to each bridge being constructed. The Contractor shall provide the Engineer and the Contractor's Engineer with written documentation of these inspections within 24 hours of each inspection.

All temporary struts, bracing, tie cables, other devices and extra material required shall be removed upon completion of the structure.

(a) Equipment. The Contractor shall provide the falsework and all tools, machinery, and supplies, including drift pins and fitting up bolts, necessary to complete the work.

(b) Field Inspection. Material and work not previously inspected will be inspected after delivery to the job site. The quality of all field welds, including inspection and testing, shall meet the requirements of this section.

(c) Storage. Girders and beams shall be placed upright and shored. Long members such as columns and chords shall be supported on skids placed in such positions as to prevent damage by deflection.

(d) Falsework. Falsework shall conform to subsection 601.11.

(e) Bearings. Bearings and bearing seats shall conform to Section 512.

(f) Anchorage. Anchor bolts in piers, abutments, or pedestals shall be accurately set either in the concrete as it is being placed, or in holes formed while the concrete is being placed, or in holes drilled after the concrete has set. Bolts placed in formed or drilled holes shall be grouted in place with a nonshrink or epoxy grout that shall completely fill the holes. Location of anchors and setting of rockers shall take into account any variation from mean temperature at time of setting and anticipated lengthening of bottom flange due to dead load after setting. At mean temperature and under dead load the rockers shall be set vertical and anchor bolts at expansion bearings shall be centered in their slots. Care shall be taken that full and free movement at the movable bearings is not restricted by improper setting or adjustment of bearings or anchor bolts and nuts.

(g) Straightening. The straightening of bent material, when permitted, shall be done by methods that will not produce fracture or other damage. Distorted members shall be straightened by mechanical means or, if approved, by application of a limited amount of localized heat. Heat shall not be applied directly on the weld metal. The temperature of heated areas shall not exceed 1200 °F as controlled by temperature indication crayons. The surfaces of metal for all steels will be inspected visually, and by magnetic particle or dye penetrant tests for evidence of fracture following the straightening procedures.

(h) Galvanizing. Galvanized units where the spelter coating has been burned by welding or damaged during erection shall be repaired by a hot dip or metallizing process as described in AASHTO M36 or shall be painted with one full brush coat of a zinc-rich paint meeting Military Specification DOD-P21035A. Spray can applications of zinc will not be allowed.

(i) Handling and Installation. During erection the parts shall be accurately assembled, as shown on the plans, and match-marks shall be followed. The material shall be so handled that parts will not be bent, broken, or otherwise damaged. Hammering that will damage or distort the members will not be permitted on exterior surfaces. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled.

For fit up of girder field splices and field connections of main stress carrying members, erection pins shall be installed in all corner bolt holes on each side of splice, plus a minimum of 25 percent of the bolt holes, evenly distributed throughout the splice. The diameter of the

erection pins shall be no less than the hole diameter minus 1/32 inch. At least 25 percent of the bolt holes shall be filled with high strength bolts. These bolts shall be fully tensioned before external support systems are removed and the connections completed by bolting, unless otherwise specified. The requirement for erection pins in the corner bolt holes does not apply to diaphragms and lateral bracing in straight girder spans, provided the member is adequately supported before removal of the external support. Members that are assembled before being erected shall have all bolts installed and fully tensioned. The structure shall not carry traffic or construction loads without approval of the Engineer.

(j) Pin Connections. Pilot and driving nuts shall be used in driving pins. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed tight, and the threads burred at the face of the nut with a pointed tool.

(k) Misfits. Any error in shop fabrication or deformation resulting from handling and transportation that prevents proper assembling and fitting up of parts by moderate use of drift pins shall be reported immediately to the Engineer. The Engineer's approval shall be obtained for methods of correction, such as reaming, and the correction shall be made in the Engineer's presence.

(l) Cleaning of Connections. When splices are designated Class B slip critical on the plans, the contact surfaces of splices shall be field inspected immediately before assembly. All foreign material shall be removed before fitting and bolting of the splices.

509.28 Connections Using High-Strength Bolts.

(a) Certification. The Contractor shall submit the supplier's certified test reports which provide a corresponding lot number appearing on the shipping package and the certification. The supplier's certification shall state when and where all testing was completed and indicate the zinc thickness when galvanized bolts and nuts are used.

(b) Materials. Washer type direct tension indicators shall conform to ASTM F959.

Bolts shall be F3125 Type 1 for connections that are painted. Bolts for unpainted ASTM A709 Grade 50W steel shall be ASTM F3125 Type 3. High strength bolt tensile strength requirements relative to bolt diameter shall be in conformance with ASTM F3125. Nuts shall be AASHTO M292 grade 2H or AASHTO M291 grade DH for plain or galvanized fasteners, except connections for unpainted ASTM A709 Grade 50W steel, in which case nuts shall be AASHTO M291 grade DH3 or C3. For galvanized fasteners, the nuts shall be over-tapped to the minimum amount required for the fastener assembly. All nuts, bolts, and washers shall have the manufacturer's markings on them.

All galvanized nuts shall be lubricated with a lubricant containing a visible dye so a visual check can be made for the lubricant at the time of field installation. Galvanized or coated bolts of any Group or Grade, galvanized or coated spline end bolting assemblies of any Group or Grade, and F3125 [Grade A490] heavy hex bolts shall not be reused after tensioning.

Plain bolts shall be "oily" to the touch when installed. Weathered or rusty items shall be cleaned and relubricated per the manufacturer’s instructions before installation. Plain finish F3125 [Grade A325] heavy hex bolts may be reused (1) in snug-tightened joints without the Engineer’s approval and (2) in pretensioned joints and slip-critical joints with the Engineer’s approval.

(c) Contractor's Process Control Plan. The contractor performing erection shall submit a written 'Bolting Process Control Plan' (BPCP) to the Engineer before beginning of tensioning operations of bolting assemblies. The BPCP shall outline the quality control tasks to be performed by the contractor to ensure that all work conforms to the Contract. The BPCP shall include the following items at a minimum:

1. Name and qualifications of the tensioning Quality Control Manager and Quality Control Inspectors.
2. Sequence of structure assembly.
3. Procedures of collecting bolting assembly lot numbers as they will be tested and installed in the structure.
4. Quality control procedures:
   A. Method of tensioning
   B. Method and frequency of RC and PIV testing
   C. Method and frequency for performing required inspections to ensure required tension has been achieved in all bolting assemblies.
   D. Method for documenting that tensioning has been performed per contract requirements.
   E. Method for ensuring bolting hardware is protected from the elements.
   F. Calibration documentation for all tensioning and/or torque equipment.

   The BPCP shall be submitted at least one week before the Pre-Erection Conference and be subject to approval by the Engineer.

(d) Tests Requirements before tensioning of fastening assemblies in structures. Before commencing with any tensioning of fastening assemblies in a structure, all high strength fastener assemblies shall be subjected to a field rotational-capacity (RC) test per ASTM F3125 as well as a Pre-Installation Verification (PIV) test for the selected bolt installation method(s). All testing shall be performed in compliance with all of the following:

1. At the site of installation in the presence of the Engineer or designee.
2. BPCP shall be submitted and approved.
3. Before the placement of bolting assemblies of verified lots in the work.
4. On a sample of not fewer than three complete bolting assemblies for PIV and two complete bolting assemblies for RC, of each combination of diameter, length, grade and lot to be used in the work.
5. Using bolting assemblies that are representative of the condition of those that will be pretensioned in the work.
6. Using ASTM F436 washers positioned per RCSC Section 6.2.
7. Testing shall be performed daily, before installation, for the calibrated wrench method.
8. The accuracy of the BTMD shall be confirmed through calibration at least annually.

(e) Rotational Capacity (RC) Test:

1. Tension Procedure. Fasteners shall be turned two times the required number of turns (from snug tight conditions) indicated in RCSC in a Calibrated Bolt Tension Measuring Device (BTMD), without stripping or failure.

2. Minimum Tension. During this test the maximum record tension shall be equal to or greater than 1.15 times the required fastener tension, per RCSC.

3. Maximum Torque. The measured torque to produce the required fastener tension shall not exceed the following equation:

   Torque = 0.25 PD

   Where:
   Torque = Measured torque in foot-pounds
   P = Measured bolt tension in pounds
   D = Nominal diameter in feet

(f) Pre-installation verification test (PIV). PIV testing shall be performed per RCSC. The bolting assembly shall be tested in a BTMD to verify that the pretensioning method to be used in the work develops a pretension that is equal or greater than that specified in table 509-2.

Table 509-2
MINIMUM BOLT PRETENSION
FOR PRE-INSTALLATION VERIFICATION

Nominal Bolt Size (in)	Group 120 [A325] (lb)	Group 150 [A490] (lb)
1/2	13,000	16,000
5/8	20,000	25,000
3/4	29,000	37,000
7/8	41,000	51,000
1	54,000	67,000
1 1/8	67,000	84,000
1 1/2	85,000	107,000
1 3/8	102,000	127,000
1 1/2	124,000	155,000

(g) Snug Tight. Installation of all high strength bolts shall be per RCSC. The "snug tight" condition as defined in RCSC shall be accomplished for any method of tensioning.

(h) Field Connections. Unless otherwise specified or approved, all field connections shall be made with ASTM F3125 Grade F2280 (Type 3) tension control bolts, or F3125 Grade A325 (Type 3) bolts using the Turn-of-Nut Method or Direct Tension Indicator method, per RCSC. Direct tension indicators shall be either washer type direct tension indicators or tension control bolts.

(i) Bolted Parts. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material. All joint surfaces, when assembled, shall be free of scale, except tight mill scale; dirt; burrs; other foreign material; and other defects that may prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or rust inhibiter. Contact surfaces may be galvanized only when specified on the plans.

(j) Installation. Fasteners and contact surfaces of splices shall be protected from dirt and moisture at the jobsite. All fasteners shall then be tightened, progressing systematically from the center or most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. In some cases, proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final tightening to obtain proper tension. A minimum of 10 percent of the bolts (must be at least six bolts) in each splice shall be snug tightened to assure all plates are in firm contact before final tensioning is started. When all fasteners in the joint are tight, each fastener shall have a tension no less than the minimum bolt tension shown in Table 509-3 for the size of fastener used, and a minimum of two threads shall project beyond the surface of the nut.

(k) Impact Wrenches. Impact wrenches, if used, shall be of adequate capacity to perform the required tightening of each bolt in approximately 10 seconds.

(l) Washer Location. In addition to load indicating washers, each fastener shall have a hardened washer under the turning element.

(m) Beveled Washers. Where the outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for lack of parallelism.

(n) Reusing Fasteners. Reuse of fastening assemblies shall adhere to 509.28 (b)

(o) Locknuts and Lock Washers. Subsections 509.28 (c), (e), and (f) shall not apply to bolts where the plans specify lock washers or locknuts. Fasteners with lock washers or locknuts shall be snug tight only.

(p) Inspection. The Contractor shall provide an acceptable platform where the Engineer can inspect bolt tensioning operations and determine whether the work meets specification requirements. The following inspection and testing procedure shall be used for all high strength bolts used in structural connections unless a more extensive or different inspection is specified.

(q) Quality Assurance. The Engineer will inspect a sufficient number of fasteners to ensure compliance with the RCSC Minimum Bolt Pretensioned and Slip-Critical Joints Table using a method commensurate with the type of fastener used. All loose fasteners shall be brought into compliance.

Table 509-3
MINIMUM BOLT PRETENSION,
PRETENSIONED AND SLIP-CRITICAL JOINTS

Nominal Bolt Size (in)	Group 120 [A325] (lb)	Group 150 [A490] (lb)
1/2	12,000	15,000
5/8	19,000	24,000
3/4	28,000	35,000
7/8	39,000	49,000
1	51,000	64,000
1 1/8	64,000	80,000
1 1/4	81,000	102,000
1 3/8	97,000	121,000
1 1/2	118,000	148,000

509.29 Field Cleaning and Painting of Steel.

(a) Self-Weathering Steel. Unpainted ASTM A709 Grade 50W steel shall be cleaned of foreign material after erection to ensure uniform weathering of the steel. It may be necessary to perform a final blast cleaning after deck construction at locations specified by the Engineer.

(b) Minimum Surface Preparation. For painted steel, when the erection is completed, including all bolting and straightening of bent metal, all adhering dirt, grease, and foreign material shall be removed. Rust and scale shall be removed to bare metal.

(c) Damaged Areas. After the inspector has examined and approved the field connections and before application of topcoats, all uncoated areas and areas with damaged shop primer shall receive one coat of shop primer. The shop primer shall be thoroughly cured before application of the topcoat.

(d) Topcoat. After retouching the shop coat and field cleaning has been satisfactorily completed, all steel work shall be painted with the required topcoat as specified in subsection 509.24. When the manufacturer of the topcoat is different than the manufacturer of the shop primer, the Contractor shall submit written documentation that the paints are compatible.

(e) Materials Handling. All paints, solvents, coatings, and other chemical products or solutions shall be mixed, handled, applied, stored, and disposed of in such a manner that any spill, splash, or drip will be contained without contamination of the soil, vegetation, streams, or other water bodies.

509.30 Fracture Control Plan. The Contractor shall submit a Fracture Control Plan (FCP) before fabrication. The FCP applies to all main stress carrying members identified on the plans as fracture critical. Welded butt joints spliced within fracture critical members (FCMs), including weld and fillet weld attachments to FCMs, shall be welded and tested per this plan. The FCP shall be per AWS D1.5. Chemical and mechanical tests, as required by this plan, shall be the responsibility of the fabricator.

509.31 Structure Number. The location, letters, figures, and paint used for stenciling shall be per the plan details. Payment for structure number shall be included in the work.

METHOD OF MEASUREMENT

509.32

(a) Computed Weight. Computed weight for unit measurement will be used for estimating the quantities shown on the design plans and for determining overruns or underruns.

1. The weight of metal in pounds per cubic foot, unless otherwise provided, will be assumed as follows:

Steel, cast or rolled, including alloy	490.5
Cast Iron	445.0

2. The weight of rolled shapes, pipe, and structural tubing will be computed on the basis of their nominal weight and dimensions as shown in the latest edition of the Manual of Steel Construction published by AISC.
3. The weight of plates will be computed on the basis of their nominal dimensions as shown on the approved shop drawings with no additions for overrun.
4. Allowance will not be made for the weight of shop paint in computing the pay weight of metal.
5. Allowance will not be made for the weight of the spelter coating in computing the pay weight of galvanized steel.
6. The pay weight will be computed on the basis of net finished dimensions of the part, deducting for copes, cuts, clips, and all open holes except bolt holes.
7. The computed weight of high-strength bolts will be based on the portions outside the grip, including one washer and one nut, as tabulated in Table 509-4.

Table 509-4
NET BOLT WEIGHT
(head, nut, and stick-out)

Nominal Bolt Size (In Inches)	Weight of 100 Bolts in Pounds
5/8- 11 UNC	32
3/4 - 10 UNC	53
7/8 - 9 UNC	81
1 - 8 UNC	117
1 1/8 - 7 UNC	165
1 1/4 - 7 UNC	212
1 3/8 - 6 UNC	280

8. The weight of castings will be computed from the dimensions shown on the shop drawings with an additional five percent allowance for fillets and overruns.

9. Allowance will not be made for weight of welds in computing the pay weight of structural steel.

10. All castings, anchor bolts, expansion devices, shoes, rollers, rockers, weld metal, railing, and rail posts will be paid for as structural steel unless otherwise specified.

11. The weight of erection bolts or shapes, field paint, boxes, crates, or other containers used for packing, together with sills, struts, or rods used for supporting members during transportation will not be included in the pay weight.

(b) The weight of structural steel will not be remeasured but shall be the quantities shown on the plans. Exception will be made for changes in design or for an error of plus or minus 2 percent of the total design weight shown on the plans for the project. Payment for increased quantity, deduction due to decreased quantity, or stipulated error will be made on the basis of the unit price bid, per subsection 104.02.

(c) Prospective bidders shall verify the weight of structural steel before submitting a bid. Adjustment, other than for approved changes or for an error as stipulated in subsection 509.32(b), will not be made in the design weight shown on the plans even though the actual weight may deviate from the design weight.

BASIS OF PAYMENT

509.33 The accepted quantities of structural steel will be paid for at the contract unit price per pound.

Payment will be made under:

Pay Item	Pay Unit
Structural Steel	Pound
Structural Steel (Galvanized)	Pound

All costs associated with implementing the Fracture Control Plan shall be included in the price paid for structural steel of which the fracture critical members are a part.

All costs associated with the preparation and implementation of the Erection Plan will not be measured and paid for separately but shall be included in the work.

SECTION 510
STRUCTURAL PLATE STRUCTURES

DESCRIPTION

510.01 This work consists of the construction of structural plate structures of the shape and dimensions called for on the plans per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

510.02 Steel structural plate materials shall conform to the requirements of AASHTO M 167.

A copy of the base metal manufacturer's certificate showing the results of tests, plus the fabricator's certificate showing the results of spelter tests shall be provided to the Engineer before installation.

Aluminum alloy structural plate materials shall conform to AASHTO M 219. There is no limit on overthickness.

Bolt and washer shapes shall be as shown on the plans. All bolts shall be sufficiently long to provide full penetration of the nut by the threaded end.

A field applied two coat coating system using materials specified in AASHTO M 243 shall be applied when called for in the Contract. The coating shall be uniformly applied by spray, brush, or trowel to the entire surface of the culvert, both inside and outside. Each coating shall be applied at the approximate rate of 60 square feet per gallon. The first coat shall be dry to touch before the second coat is applied and the second coat shall be dry to touch before any backfill operations.

Thicker invert plates for round pipes shall be construed as the bottom plate. This plate shall be installed with the center of the plate as nearly on the centerline of the pipe as practicable; however, it shall extend at least 23 inches on either side of centerline, measured on the arc. Thicker invert plates for arch pipes shall be constructed as the bottom plate (or plates) between the corner plates.

The Contractor shall state at the Pre-construction Conference, the type of structural plate material (steel or aluminum) intended to be furnished, unless a specific material is specified in the Contract.

CONSTRUCTION REQUIREMENTS

510.03 Fabrication. When the completed structure is to be a full circle pipe, the plates shall be so curved that when bolted together, true circles shall be formed of the required diameter. When the completed structure is to be an arch pipe, the plates shall be so curved as to produce a structure with the span and rise dimensions shown on the plans. Each manufacturer of corrugated structural plates shall furnish data sheets showing the physical and chemical properties of all plates to be supplied under this specification.

Each plate shall be curved to the proper radius, and the bolt holes shall be so punched that all except end plates shall be interchangeable in the erection process.

All structural plates made from steel shall be made from plates formed and punched per Section 6 of AASHTO M 167.

All structural plates made from aluminum shall be made from plates formed and punched per Section 6 of AASHTO M 219.

Plates for forming skewed or sloped ends shall be so cut as to give the angle of skew or slope specified. Units where the spelter coating has been burned by welding or otherwise damaged in fabrication shall be repaired as provided in subsection 707.09. Cut plates shall present a workmanlike finish with legible identification numerals placed on each plate to designate its proper position in the finished structure.

510.04 Excavation. Trenches shall be excavated to the widths required by the plans.

When the installation is to be placed in embankment fill, the excavation shall be made after the embankment has been completed to a height 0.3 times the diameter or 0.3 times the rise above the flow line of the structure.

The Contractor shall excavate three test pits to a depth of approximately 6 feet below proposed flow line. Pits shall be located at each end and near the center of the trench as directed. If the foundation is deemed unsuitable, a minimum of 1 foot underlying the structure shall be excavated and backfilled with suitable material per Section 206.

510.05 Erection. Plates at longitudinal and circumferential seams shall be connected by bolts. Joints shall be so staggered that no more than three plates come together at any one point.

Nuts shall be so tightened that when tested with a calibrated torque wrench furnished by the Contractor, a torque of between 150- and 250-foot pounds is attained. Tightening of bolts to a torque in excess of 250-foot pounds will not be permitted. The use of wrench sockets that will damage the metal or metal coating will not be permitted.

Before backfilling operations, the full length of each round culvert shall be distorted from a true circle by pre-forming to an elliptical shape. This elongation shall approximate 5 percent of the nominal diameter of the culvert. The preformed pipe shall be placed with its greatest dimension in the vertical axis.

510.06 Backfilling. Backfilling shall conform to the details shown on the plans.

Pipe damaged due to Contractor's operations shall be repaired or replaced at the Contractor's expense.

METHOD OF MEASUREMENT

510.07 Structural plate structures will be measured by the linear foot in place. Length of round or elliptical structures shall be the average of measurements along the top and bottom. Length of structural plate arch pipe will be measured along the bottom centerline only.

BASIS OF PAYMENT

510.08 The accepted quantities of structural plate structures will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Structural Plate Pipe (_____)	Linear Foot
Structural Plate Arch Pipe (____x____)	Linear Foot

Structure excavation and structure backfill, including test pits, will be measured and paid for per Section 206.

Coating, when specified, will not be paid for separately but shall be included in the work.

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SECTION 512
BEARING DEVICE

DESCRIPTION

512.01 This work consists of furnishing and placing bearing devices per these specifications and in conformity with the plan details.

MATERIALS

512.02 Elastomeric bearing pads shall include plain bearings and laminated bearings. Plain bearings are unreinforced pads, consisting of elastomer only, and laminated bearings are reinforced with steel laminates. The elastomer compound shall be classified as being of low temperature grade 3, 4 or 5. The grades are defined by the testing requirements of subsection 705.06, Tables 705-1 and 705-2. A higher grade of elastomer may be substituted for a lower grade. Elastomer grade, AASHTO Design method (A or B), elastomer shear modulus and elastomer hardness shall be shown in the contract documents. The sheer modulus shall be within 15 percent of the specified value.

Materials requirements for elastomeric bearing pads, sheet lead, polytetrafluoroethylene (PTFE) sheets, stainless-steel sheets and adhesive material shall conform to the requirements of subsection 705.06.

Leveling pads are unlaminated bearings as called for on the plans. They shall be cut or molded from AASHTO elastomer grade 3, 4, or 5 as described in Tables 705-1 and 705-2 with a durometer (duro) (Shore “A”) hardness of 60.

The sealing mechanism used in pot bearing devices to prevent extrusion of the elastomer shall be of brass or bronze metal.

All steel, except stainless-steel, used in fabricating bearing devices shall conform to AASHTO M 270 (ASTM A709) Grade 36 unless otherwise required in the Contract. ASTM A709 Grade 50W or ASTM A709 Grade 50 may be substituted for ASTM A709 Grade 36. Anchor bolts shall be ASTM A449 zinc plated. All welding shall conform to the applicable requirements of ANSI/AWS D1.1 and Standard Specification 509.

Structural steel elements of Type II Bearing Devices shall be painted per Section 509.

All metal surfaces of Type III Bearing Devices shall be completely zinc metallized per AWS C2.2 to a thickness of 8 mils, except the surfaces covered with PTFE and surfaces with stainless-steel. The internal pot cavity and bottom surface of the piston for Type III bearings shall be zinc metallized to a thickness of 3 mils and polished to 125 microinches after zinc metallizing.

FABRICATION

512.03 Type I Bearing Device. A Type I Bearing Device consists of either a plain or laminated elastomeric bearing pad with an optional machined sole plate as shown on the plans.

Pads 3/4 inch or less in thickness may be either laminated or plain. Pads over 3/4 inch in thickness shall be laminated.

Laminated pads shall be individually molded and shall consist of alternate laminations of elastomer and metal laminates. The bearings shall be vulcanized under heat and pressure. The mold finish shall conform to standard shop practice. The internal steel laminates shall be sandblasted and cleaned of all surface coatings, rust, mill scale, and dirt before bonding, and shall be free of sharp edges and burrs. Laminations of elastomer shall be 1/2 inch, plus or minus 1/8 inch in thickness. Unless otherwise noted on the plans, the top and bottom layers of metal shall be uniformly covered with a maximum of 1/8 inch of elastomer. The edges of the metal shall be uniformly covered with a minimum of 1/8 inch of elastomer, except at laminate restraining devices and around holes that will be entirely closed on the finished structure. Variations in the location of the metal reinforcement from its theoretical location shall not exceed 1/8 inch.

Plain bearings may be molded individually, cut from previously molded strips or slabs, or extruded and cut to length. Cut edges shall conform to the requirements of ANSI B46.1.

512.04 Type II Bearing Device. The upper sliding element shall consist of a polished stainless-steel sheet finished to a No. 7 high luster polish (glossy, bright, buffed finish) and attached to a sole plate. The stainless-steel sheet shall be seal welded to the sole plate. The operating coefficient of either static friction or sliding friction between the stainless-steel and the PTFE sheet, when loaded to 1,000 psi, shall not exceed 0.06.

Pads less than 3/4 inch in thickness may be either laminated or plain. Pads 3/4 inch and greater in thickness shall be laminated.

The lower sliding element shall consist of a filled or unfilled PTFE sheet with a minimum thickness of 3/32 inch, vulcanized to a stainless-steel substrate. The stainless-steel substrate shall be capable of resisting bending stresses that the sliding surface may be subjected. The other side of the substrate material shall be vulcanized to an elastomeric pad as described in subsection 512.03 and as shown on the plans. The stainless-steel substrate material shall have a thickness as shown on the plans or shall have sufficient tensile strength to restrain the elastomeric pads.

512.05 Type III Bearing Device. The manufacturer of Type III bearings shall be preapproved and listed in the Contract. Type III Bearing Devices are designed as Pot type or Disc type. Bearing devices shall be fabricated as fixed, guided expansion, or non-guided expansion bearings as designated in the Contract. Bearings shall satisfactorily provide for thermal expansion and contraction, rotation, camber changes, and creep and shrinkage of the structural members they support. Bearings shall be designed and fabricated so that they can be readily inspected and easily removed and replaced during the service life of the bridge. This shall include provisions to allow removal and replacement of all components of the bearing device, excluding sole plates, by lifting the superstructure no more than 1/4 inch. The static coefficient of friction shall be determined based on the force required to cause first movement under the vertical load applied during the test. The operating coefficient of static friction or sliding friction between the stainless-steel and the PTFE sheet, when subjected to a 3,500-psi load, shall not exceed 0.03.

(a) Fixed Bearing. A fixed bearing shall allow rotation but no longitudinal or transverse movement in the bearing plane.

(b) Guided Expansion Bearing. A guided expansion bearing shall allow rotation and longitudinal movement and shall restrict transverse movement in the bearing plane.

(c) Nonguided Expansion Bearing. A non-guided expansion bearing shall allow rotation and longitudinal and transverse movement in the bearing plane.

(d) *Pot Bearings.* The bearing device shall consist of a masonry plate, a sole plate, a top plate, an optional guide plate, a loading piston, and a cylindrical steel retainer (pot) to confine an elastomeric pad. The piston and pot shall each be machined from a solid steel plate. The piston may be welded to a guide or top plate as approved by the Engineer. The shape characteristics, clearances, and sealing mechanism of the piston and cylinder shall be designed to prevent extrusion of the elastomer material under rotational movement, vertical load, and where applicable, horizontal load. When a bearing must accommodate movement in the plane of the bearing (guided or non-guided type), the top surface of the piston plate shall be faced with PTFE sheet and the mating surface of the steel shall be faced with polished stainless-steel finished to No. 8 mirror finish or better. When a bearing device restricts transverse movement (guided type), the device shall contain either a guide bar or a keyway system. These systems shall be designed so that the vertical interfaces are parallel throughout the range of rotation of the bearing device. The mating steel surfaces of the guide bar or keyway systems shall be faced with strips of PTFE and stainless-steel.

(e) *Disc Bearings.* The bearing shall consist of an elastomeric rotational element (disc) confined by upper and lower steel bearing plates. The bearing shall be equipped with a shear restricting mechanism to prevent horizontal movement of the disc. When a bearing device must accommodate movement in the plane of the bearing (guided or non-guided type), the top surface of the upper steel bearing plate shall be faced with PTFE sheet and the mating surface of the steel plate shall be faced with polished stainless-steel finished to a No. 8 mirror finish or better. Bearing devices designed to restrict transverse movement (guided type) shall contain either a guide bar or a keyway system. These systems shall be designed so that the vertical interfaces are parallel throughout the range of the rotation of the bearing device. The mating steel surfaces of the guide bar or keyway systems shall be faced with strips of PTFE and stainless-steel.

(f) *Sliding Surfaces of Plates for Pot and Disc Bearings.* The PTFE sheet affixed to the top surface of a piston plate or upper steel bearing plate shall have a minimum finished thickness of 3/16 inch and shall be recessed for half its thickness into its steel substrate. The PTFE sheet shall be bonded to the steel substrate using an epoxy resin applied to the full area of the contact surfaces. The surface of the PTFE sheet to be bonded shall be treated with sodium naphthalene or sodium ammonia process before bonding. Bonding shall be performed at the manufacturer's factory under controlled conditions and per the instructions of the manufacturer of the epoxy material. At the completion of the bonding operation, the surface of PTFE shall be smooth and free of bubbles.

Lubricants of any kind shall not be used in the sliding surfaces of bearing devices. The PTFE strips on the mating surfaces of guide systems shall be 3/16 inch minimum and shall be recessed and bonded or may be bonded and mechanically fastened to the mating steel surfaces of the guide bar or keyway systems. The fasteners shall provide full bearing on the PTFE strip and the steel surfaces where the PTFE is attached.

The mating surfaces of structural steel elements shall be ground to a flatness of 0.01 inch per linear foot. Maximum surface roughness shall be ANSI 500 per American National Standards Institute B 46.1.

Bearing devices shall be designed so that stainless-steel will cover the PTFE throughout the range of movement for the bearing device. The surface of stainless-steel that slides on the PTFE shall have a flatness of 0.01 inch per linear foot.

512.06 Reserved.

512.07 Reserved.

512.08 The bearings shall be completely factory-produced assemblies and shall include all directly connected or welded anchorage hardware. The bearings shall adequately provide for the amount of movement due to temperature changes, post tensioning offsets, or girder rotation as shown on the plans.

512.09 Testing and Acceptance. The materials for elastomeric bearings and finished bearings shall be subjected to the tests described in this subsection. Material tests shall be per Table 705-1 or 705-2 and as described. The manufacturer shall furnish facilities for the testing and inspection of the completed bearings in the plant or at an independent test facility. At the Engineer's discretion, testing may be performed in the presence of the Engineer or a designated representative. The Engineer or the Engineer's representative shall be allowed free access to the necessary parts of the manufacturer's plant and test facility, as arranged by the Contractor. The Contractor shall inform the Engineer a minimum of two weeks in advance of a date and time when a visit to the plant and test facility would be permitted.

(a) Test Specimens. One bearing per lot shall be tested. The Engineer will randomly select samples from the production bearings for testing. A lot shall be defined as the smallest number of bearings as determined by the following criteria:

1. One lot shall not exceed a single contract or project quantity.
2. One lot shall not exceed 25 bearings.
3. A lot shall consist of those bearings of the same type within a load category. The types of bearing devices are defined as fixed, guided expansion, and nonguided expansion, which includes Type I, Type II, and Type III, bearings.
4. Load categories are 0 to 999 kips, 1,000 to 2,999 kips, and 3,000 kips or more.

(b) Test Method. The test for the sliding coefficient of friction for Types II and III bearing devices consists of determining the sliding coefficient of friction between the PTFE and stainless-steel elements of an expansion type bearing device by using equipment and a test procedure approved by the Engineer. Specially made bearings shall not be used; only actual bearings to be used in the project shall be tested.

1. Clean all bearing and sliding surfaces, assemble the bearing device and place it into the test apparatus.
2. Type III bearings shall be subjected to a rotation of 0.02 radian, or the rotation specified in the Contract, if larger.
3. The test shall be conducted at maximum working stress for the PTFE surface with the test load applied continuously for 12 to 24 hours before measuring friction.
4. At first movement, the static and dynamic coefficients of friction shall be determined by applying an approximate horizontal force to the bearing device in a cyclic manner to cause slipping along the PTFE stainless-steel surface at a speed of less than 1 inch per minute and shall not exceed the coefficient of friction specified.

   The bearing shall then be subjected to a minimum of 100 movements of at least 1 inch in each direction from the centerline of the device at a speed of less than 12 inches per minute. After cycling, the static and dynamic coefficients of friction

shall be determined again at a speed of less than 1 inch per minute and shall not exceed the coefficient of friction specified. After the load is removed the bearings shall be disassembled and the components carefully examined. Any visible damage to a component shall be cause for rejection.

5. *Rotational Test (Type III).* This test consists of applying a vertical load to the bearing device equal to 150 percent of its rated capacity and subjecting the bearing to the greater value of either rotation of 0.02 radians or the designed rotation for a period of one hour. During the testing of pot bearings, if the confined elastomer extrudes beyond the sealing mechanism, the bearing shall be rejected. During the testing of disc bearings, any observed lift off between the rotational element and other components of the bearing shall be cause for rejection. After the load is removed the bearing device shall be disassembled and the components carefully examined. Any visible damage to the disk bearing components shall be cause for rejection.

6. Type I and II bearings incorporating laminated elastomeric pads shall be loaded and tested as follows:

   A. *Short-Duration Compression Test*. The bearing shall be loaded in compression to 1.5 times the maximum design load. The load shall be held constant for 5 minutes, removed and reapplied for another 5 minutes. The bearing shall be examined visually while under the second loading. Bulges indicating laminate nonparallelism or a layer thickness that is outside the specified tolerances, or poor laminate bond, shall result in the bearing being rejected. If there are three or more separate surface cracks that are greater than 0.08-inch-wide and 0.08-inch-deep, the bearing shall be rejected.

   The short duration test shall be performed for bearings designed under AASHTO method A or B.

   B. *Long-Duration Compression Test*. The bearing shall be loaded in compression to 1.5 times its maximum design load for a minimum period of 15 hours. If during the test, the load falls below 1.3 times the maximum design load, the test duration shall be increased by the period of time that the load is below this limit. The bearing shall be examined visually at the end of the test while it is still under load. If the bulging pattern suggests laminate non-parallelism or a layer thickness that is outside the specified tolerances, or poor laminate bond, the bearing shall be rejected. If there are three or more separate surface cracks that are greater than 0.08-inch-wide and 0.08-inch-deep, the bearing shall be rejected.

   The long duration test shall be performed for bearings designed under AASHTO Method B.

   Bearings represented by test specimens passing the above requirements will be approved for use in the structure subject to on-site inspection for visible defects.

(c) Certification.

1. Certification for Type I, II, and III Bearings:

   The manufacturer shall certify that each bearing satisfies the requirements of the plans and these specifications.

   The manufacturer shall submit:

(1) Manufacturer’s certification of the steel, elastomer, PTFE, and other materials used in the construction of the bearings.

(2) Details and calibration of the test equipment before testing.

(3) Certified test results on the samples of the completed bearing devices, which show they conform to the requirements of this specification.

(4) Notification when fabrication is completed and when testing is to be performed.

2. Certification for leveling pads:

   The supplier shall submit a Certificate of Compliance to the Engineer for acceptance.

512.10 Packaging. The bearings shall be packaged and protected in such a manner that they will not be damaged, and the contact surfaces of the sliding elements will not be contaminated while being handled, transported, or stored. Each completed bearing shall have its components clearly identified and marked with an upstation arrow and the location on the structure. Except for Type I bearings, the markings shall be on a face that is visible after erection of the bridge. The bearing assemblies shall be furnished as a complete unit from one manufacturing source, unless otherwise approved.

CONSTRUCTION REQUIREMENTS

512.11 The concrete where the bearings are to be placed shall be free of honeycomb. The concrete bearing contact surface shall be finished to a level plane with a flatness tolerance of 1/16 inch for bearing seats up to 30 inches, 3/32 inch for bearing seats over 30 inches and under 45 inches, and 1/8 inch for bearing seats over 45 inches as measured using a straight edge placed in any direction across the area. The finished plane shall not vary more than 1/8 inch from the elevation shown on the plans.
The initial installations of Type III bearings shall be performed by the Contractor in the presence of a representative of the manufacturer. This representative shall be experienced in such installations and provide information to the Contractor on handling and installation procedures. The representative shall provide information to the Engineer on inspection of the bearing installation and shall provide assistance until the Contractor and the Engineer agree that they understand the installation and inspection procedures.

Upon completion of the superstructure placement, the Contractor, Engineer and bearing manufacturer's representative, together, shall inspect each bearing's placement and alignment for Type III bearings. Subsequent to the inspection, and after correction of all deficiencies, the Contractor shall certify in writing that the bearing installation is correct.

512.12 Masonry plates of Type III bearing assemblies shall be set on a single thickness of sheet lead or preformed fabric pad when a monolithic cap seat is used.

512.13 Placement of elastomeric bearing pads or bearing devices on grout pads will not be permitted unless called for on the plans.

512.14 Non-metallic bearing pads shall be protected from damage due to welding heat. The Contractor shall submit a welding procedure for approval before beginning welding. Field welding to steel plates that have a bonded PTFE surface will be permitted provided that the welding procedure used does not increase the temperature of the area of the steel where PTFE is bonded above 300 °F. Temperature indicating wax pencils or other approved means shall be used to determine whether this temperature limit is being exceeded.

512.15 Type II and Type III Bearing Devices shall not be disassembled during installation unless otherwise permitted. The Contractor shall protect all bearings from contamination and damage due to paint overspray or when placing concrete or other materials.

512.16 The Contractor shall furnish a manufacturer's certification that all components meet the Contract requirements.

512.17 The Contractor shall submit shop drawings, design calculations and load data for review of Type III Bearing Devices as specified in subsection 105.02. The shop drawings shall include installation procedures and address storage, handling, disassembly, placement, alignment, offsets, protection during welding to steel girders, protection during painting of structure, and removal of banding or retaining clamps.

METHOD OF MEASUREMENT

512.18 Bearing devices will be measured by the unit.

BASIS OF PAYMENT

512.19 The accepted quantities of bearing devices will be paid for at the contract unit price each.

Payment will be made under:

Pay Item	Pay Unit
Bearing Device (Type_____)	Each

Elastomeric bearing pads, preformed fabric pads, and sheet lead when not included in Bearing Device (Type) will not be measured and paid for separately but shall be included in the work. Leveling pads will not be paid for separately but shall be included in the work.

The presence of a manufacturer’s representative will not be measured and paid for separately but shall be included in the work.

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SECTION 514

PEDESTRIAN AND BIKEWAY RAILING

DESCRIPTION

514.01 This work consists of the construction of the designated type of railing per these specifications and in conformity with the details, lines and grades shown on the plans or established.

MATERIALS

514.02 Pipe Railing. Pipe for railing shall be standard steel, black or galvanized as specified. The pipe, and galvanizing when specified, shall conform to the requirements of ASTM A53, Types E or S, Grade A, schedule 40 or better, for steel pipe. Threaded fittings shall be made from malleable iron, plain or galvanized, as specified, and slip-on fittings shall be of the type shown on the plans. Steel shapes shall conform to the requirements of Section 509.

514.03 Steel Tube Railing. Steel for this type of railing shall conform to the requirements of Section 509 and the following:

1. Steel tubes shall conform to the requirements of ASTM A500 Grade B.

2. Steel plates and bars shall conform to the requirement of ASTM A709 Grade 36.

3. Bolts shall conform to the requirements of ASTM A307.

4. Zinc coating shall conform to the requirements of ASTM A123, A153, A385 and A386.

5. Welding shall conform to the American Welding Society Structural Welding Code - Steel, D1.1.

Steel for uncoated railing shall conform to the requirements of ASTM A847 for structural steel tubing and ASTM A709 Grade 50W for plates and shapes.

514.04 Timber Railing. Timber for posts and rails shall be pressure treated and shall be per Section 508. Timber for posts shall be Douglas Fir - Larch, #2 or equivalent. Timber for rails shall be Douglas Fir -Larch #1. Pressure treated timber shall conform to the requirements of the American Wood Preservers Association (AWPA) Standards, Section C1 and C2 (Soil Contact) Either Ammoniacal Copper Arsenate (ACA) or Chromated Copper Arsenate (CCA) preservative conforming to the requirements of Section P5 (Standards for Waterborne Preservatives of the AWPA Standards shall be utilized and total absorption shall be 0.4 pounds per cubic foot of timber. Redwood or cedar will not require a preservative treatment.

All steel hardware and bolts for timber railing shall be galvanized or zinc coated.

514.05 Combination Railing. Pedestrian or bikeway railing combined with traffic railing shall conform to the requirements of this section. Traffic Railing and Traffic portion of Combination Railing shall conform to the plans and shall be per Section 606.

CONSTRUCTION REQUIREMENTS

514.06 Before construction of any type of railing, the Contractor shall submit working drawings per Sections 101 and 105.

Posts shall be aligned and plumb within a tolerance of 1/4 inch. The finished rail shall be rigidly braced and secured to surrounding construction and shall be tight, and free of rattle, vibration, or noticeable deflection.

Rail elements shall be erected in a manner resulting in a smooth continuous installation. All bolts in the finished rail shall be drawn tight. Bolts shall be of sufficient length to extend beyond the nuts. Fasteners projecting toward the pathway shall be carriage bolts with smooth, round heads with nuts oriented away from the pathway. Bolts in timber rails shall be recessed. Handrails and rubrails shall not have projecting fasteners.

Welding shall be per Section 509 and AWS D1.1. Gas Metal-Arc Welding (GMAC) will be permitted. Where welds are designated, connections shall be continuously welded. All cut edges shall be rounded and all welds ground smooth. Punched, cut, drilled, or tapped holes shall be free of burs and sharp edges. After field welding, damaged paint and galvanized coatings shall be repaired.

Electrolytic isolation shall be provided to prevent contact of dissimilar metals. Asphaltic paint shall not be permitted to remain on surfaces to be exposed or to receive a sealant or paint.

Pipe railing with threaded fittings shall screw into end fittings but may slide through intermediate fittings. Splices shall be made inside of fittings and clearance shall be allowed for expansion. Each piece of railing shall be securely fastened at one end by a setscrew in the fittings or by sufficient threads to develop its strength.

All steel railing shall be galvanized or painted per Section 509 unless uncoated railing of corrosion resistant steel is specified. The color of paint shall be as shown on the plans or as directed.

METHOD OF MEASUREMENT

514.07 Railing will be measured by the linear foot from end to end of the railing. Payment will be full compensation for all work and materials required to complete the installation including foundations, anchorages, attachments, fabrication, painting, and installation.

BASIS OF PAYMENT

514.08 The accepted quantities of railing will be paid for at the contract unit price per linear foot. Payment will be made under:

Pay Item	Pay Unit
Bikeway Railing (____)	Linear Foot
Hand Railing	Linear Foot
Pedestrian Railing (____)	Linear Foot
Pipe Railing	Linear Foot
Pipe and Redwood Railing	Linear Foot

Payment for Traffic Railing, Combination Pedestrian and Traffic Railing, and Combination Railing shall be per Section 606 for the applicable type of bridge railing or guardrail.

SECTION 515
WATERPROOFING MEMBRANE

DESCRIPTION

515.01 This work consists of furnishing and placing an approved waterproofing membrane and protective covering over a prepared concrete bridge deck surface or furnishing and placing an approved chemical concrete sealer (sealer) on the surface of a concrete bridge deck, approach slabs, and all adjacent sidewalk and curb, and other applications designated on the plans.

MATERIALS

515.02 The waterproofing membrane shall consist of one of the following:

1. A prefabricated reinforced membrane and primer or,
2. A single component, hot-applied elastomeric membrane and primer if required.

Materials for the waterproofing membrane shall meet the requirements specified in the following subsections:

Protective Covering	705.07
Prefabricated, Reinforced Membrane and Primer	705.08
Single Component, Hot Applied, Elastomeric Membrane	705.09

515.03 Concrete sealer shall consist of an alkyl-alkoxy silane and shall be a penetrating type with 40 percent solids in water or a high flash organic solvent. The sealer shall be compatible with the curing compound used on the concrete and shall be one that is included on the approved products list of the Department. A certificate of compliance shall be provided with each shipment of sealer.

CONSTRUCTION REQUIREMENTS

515.04 Waterproofing Membrane.

(a) Condition of Concrete Deck for Application of Waterproofing Membrane. The entire deck and the sides of the curbs for a height of 2 inches above the plan thickness of the hot mix asphalt shall be free of all foreign material such as dirt, grease, old pavement and primer. All decks shall be sand blasted or shot blasted. Immediately before the application of primer or any type of membrane, all dust and loose material shall be removed. The deck condition will be approved before application of the membrane.

(b) Weather and Moisture Limitations for Application of Waterproofing Membrane. Application of primer or membrane shall not be done during inclement weather conditions, or when deck and ambient air temperatures are below 50 °F. The deck surface shall be dry at the time of application of primer and membrane.

(c) Application, Prefabricated, Reinforced Membrane. Primer shall be applied to the prepared concrete surface at the rate and according to the procedure recommended by the membrane manufacturer. Placement of the membrane shall not begin until the volatile material in the primer has dissipated. The membrane shall be placed in such a manner that a shingling effect will be achieved, and any accumulation of water will be directed toward curbs and drains. Primer and membrane shall be placed on the curb faces for a height of 2

inches above the plan thickness of the hot mix asphalt. The entire membrane shall be essentially free of wrinkles, air bubbles and other placement defects. Blisters or bubbles larger than 2 inches in diameter, which develop after placement of the membrane and before placement of protective covering, shall be punctured, the air expelled, and membrane patched in a manner satisfactory to the Engineer. At all expansion joints, and other joints, membrane shall be flashed up to the top of the joint and secured with primer. At drainpipes, membrane shall be placed in such a manner that it extends down inside the drain and is secured with primer.

(d) *Application, Single Component, Hot Applied, Elastomeric Membrane*. Hot applied membrane shall be applied to the prepared deck surface at a uniform minimum rate of 1/2 gallon per square yard thickness of 90 to 110 mils, 1 mil = 0.001 inch. During application the thickness may be measured by the Engineer. Lack of uniform application shall be cause for termination of the work until remedial measures are taken. Primer, if required, and membrane shall be placed up the curb faces for a height of 2 inches above the plan thickness of hot mix asphalt.

(e) *Application of Protective Covering*. As soon as practical, but in all cases the same day as membrane application, protective covering shall be placed from gutter line to gutter line. Protective covering shall be laid parallel to the centerline of the bridge. The protective covering shall be butted together at longitudinal and transverse joints. Overlapping will not be permitted. The maximum allowable space between adjoining sections of protective covering shall be 1 inch. Following placement of protective covering, a bead of compatible mastic or hot applied membrane shall be applied where the protective covering contacts the curbs, and in cracks between adjoining sections that are apart by more than 3/8 inch. The bead shall fill the void preventing water from entering at this point.

(f) *Inspection*. Upon completion of the membrane and protective covering the Engineer will inspect the membrane system.
Approval in writing from the Engineer shall be obtained before application of hot mix asphalt. The Contractor shall be responsible for maintaining the condition of the membrane system on the bridge deck until covered with hot mix asphalt to the thickness required by the Contract.

(g) *Overlay*. Hot mix asphalt shall be placed, spread and compacted, per the specifications or as approved.

515.05 Concrete Sealer.

(a) *Condition of Surface for Application of Sealer*. The surface of bridge deck, approach slabs, sidewalks, and curbs and the interior concrete surface of drains shall be free of all residue and other surface contaminants. Within 48 hours before the application of the sealer these surfaces shall be cleaned with dustless abrasive shot blasting. Other methods of blasting, power washing, or cleaning may be used if approved. The amount of shot blasting or cleaning shall be sufficient to remove all visual evidence of curing compound residue, dirt, grease, and surface contaminants. When wet methods are used the surface shall be dried per subsection 515.04.

(b) Weather and Moisture Limitations for Application of Sealer. Sealer shall not be applied when the deck or ambient air temperature is below 40 °F, above 90 °F, or outside the manufacturer's recommended temperature range. The concrete shall have aged a minimum of 28 days and the surface shall be dry at the time of application of the sealer. When the surface is wet because of inclement weather, power washing, or other moisture, it shall be permitted to dry at least 24 hours before the sealer is applied.

(c) Application of Sealer. Sealer shall be applied uniformly at the manufacturer's recommended rate. The sealer shall be applied to the surface of the concrete bridge deck, approach slabs, curbs including the face of concrete bridge rail for 6 inches above the bridge deck, sidewalks, and the interior concrete surface of drains. Two copies of the manufacturer's literature for the sealer including the recommended application procedure shall be provided to the Engineer before application. The literature shall include a product material safety data sheet.

All solvents, coatings, or other chemical products, or solutions, shall be mixed, handled, applied, stored and disposed of in such a manner that spills, splashes, and drips shall be contained without contamination of the soil, vegetation, streams, or other water bodies.

The Contractor shall provide two approved respirators for use by Department personnel.

Traffic shall not be allowed on the treated surface until the sealer has penetrated the concrete and the liquid sealer is no longer visible on the surface. The Contractor shall follow all the manufacturer's recommendations, including penetration time, before opening to traffic.

METHOD OF MEASUREMENT

515.06 Waterproofing membrane including protective covering, complete in place, will be measured by the number of square yards of bridge deck covered. Material placed on curb faces will not be measured.

Concrete sealer will be measured by the number of square yards of concrete surface covered, except material placed on drains will not be measured.

BASIS OF PAYMENT

515.07 The accepted quantities of waterproofing membrane including protective covering will be paid for at the contract unit price per square yard.

The accepted quantities of concrete sealer, including surface preparation, will be paid for at the contract unit price per square yard of concrete surface covered. Preparation and sealing of drains will not be paid for separately but shall be included in the work.

Payment will be made under:

Pay Item	Pay Unit
Waterproofing (Membrane)	Square Yard
Concrete Sealer	Square Yard

Hot mix asphalt will be measured and paid for per Section 403.

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SECTION 516
DAMPPROOFING

DESCRIPTION

516.01 This work consists of dampproofing concrete surfaces per these specifications and in conformity with the plans or as ordered.

MATERIALS

516.02 Materials for dampproofing with asphalt shall conform to the requirements of subsection 702.01.

CONSTRUCTION REQUIREMENTS

516.03 Surfaces to be dampproofed shall be cured, dry and free of all frost, loose material and dirt.

The surface that is to be protected by dampproofing shall be thoroughly cleaned before the primer is applied. The surface shall then be brush or spray painted with two coats of asphalt for primer treatment at a rate of 1/8 gallon per square yard for each coat. After the primed surface has dried one application of asphalt dampproofing material shall be applied by brush, at a rate of 1/10 gallon per square yard.

Care shall be taken to prevent discoloration of other parts of the structure not to be dampproofed, by the dripping or spreading of asphalt.

METHOD OF MEASUREMENT

516.04 Dampproofing will be measured by the square yard of surface area dampproofed.

BASIS OF PAYMENT

516.05 The accepted quantities of dampproofing, including absorptive primer coats, will be paid for at the contract unit price per square yard.

Payment will be made under:

Pay Item	Pay Unit
Dampproofing (Asphalt)	Square Yard

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SECTION 517
WATERPROOFING

DESCRIPTION

517.01 This work consists of waterproofing concrete surfaces per these specifications and in conformity with the plans or as directed.

MATERIALS

517.02 Materials for waterproofing shall conform to the following:

Item	ASTM Designation	Use
Asphalt Primer	D41	Primer under asphalt mop coats
*Asphalt Mop Coat	D449	Mop coats with or without membrane
Woven Cotton Fabric	D173	With asphalt membrane

* Type I is for use below ground and shall be heated to a temperature of between 225 and 275 °F. Type II is for use above ground and shall be heated to a temperature of between 275 and 325 °F. Type II shall be used unless otherwise specified.

For hot application, materials for waterproofing shall be heated to a temperature of between 175 and 225 °F in a heating kettle or tank constructed as a double boiler, with a space between the inner and outer shells filled with oil, asphalt, or other material for heat transfer and for positive temperature control. Heating kettles shall be equipped with thermometers and the material shall be stirred continuously to avoid overheating.

CONSTRUCTION REQUIREMENTS

517.03 All concrete surfaces to be waterproofed shall be free of loose material and dirt and shall be reasonably smooth and free of projections or holes. Waterproofing shall not be started without approval in wet weather or when the temperature is below 35 °F.

The waterproofing shall in all cases be started at the low point of the surface to be treated so that water will run over and not against or along the laps.

Beginning at the low point of the properly prepared surface to be waterproofed, a priming coat shall be brushed or sprayed on the surface to penetrate and prepare it for the first mop coat of hot asphalt coating.

After the primer has cured, a section about 20 inches wide and the full length of the surface shall be mopped with the hot asphalt. The first strip of half-width fabric shall be rolled into the mop coat immediately after it is placed. The first strip and all following strips shall be rolled into place to eliminate air bubbles and obtain close conformity with the surface being treated. The first strip and an adjacent section of the surface of a width equal to slightly more than half

the width of fabric being used, shall then be mopped with hot asphalt and a second strip shall then be rolled into it. The second strip shall completely cover the first strip. The second strip and an adjacent surface of concrete shall then be mopped with hot asphalt and a third strip of fabric “shingled” on. The third strip shall lap the first strip by at least 2 inches. This process shall be continued until the entire surface to be treated is covered and each strip of fabric shall lap at least 2 inches over the next to last strip. The entire surface shall then be given a final mopping of hot asphalt.

The completed waterproofing shall consist of a firmly bonded membrane composed of two layers of fabric and three moppings of asphalt, together with the required prime coat. Each layer must be separated from the concrete surface or other layers of fabric by an intervening mop coat.

The mopping on the concrete shall cover the surface so that no gray spots appear, and on the fabric, it shall be sufficiently heavy to completely conceal the weave. At least 12 gallons of asphalt shall be used for each 100 square feet of horizontal surface and at least 15 gallons for each 100 square feet of vertical surface for each mop coat. The work shall be so regulated that, at the close of a day’s work, all fabric that has been laid shall have received the final mopping of asphalt and the edges of all laps shall be thoroughly sealed down.

Suitable provisions shall be made to prevent water from getting between the waterproofing and waterproofed surface at the edges of the membrane and at any point where it is punctured by such appurtenances as drains or pipes.

METHOD OF MEASUREMENT

517.04 The accepted quantities of waterproofing will be measured by the square yard based on the surface area waterproofed.

BASIS OF PAYMENT

517.05 The accepted quantities of waterproofing will be paid for at the contract unit price per square yard.

Payment will be made under:

Pay Item	Pay Unit
Waterproofing (Asphalt)	Square Yard

SECTION 518
WATERSTOPS AND EXPANSION JOINTS

DESCRIPTION

518.01 This work consists of furnishing and installing waterstops, expansion joints, and end dams of the sizes and types required per these specifications and in conformity with the details shown on the plans, or as directed.

This work consists of furnishing and placing a Polyester Concrete End Dam system, which includes Polyester-based Polymer Concrete (PPC) and High-Molecular-Weight Methacrylate (HMWM) resin primer. The system shall be used for Portland Cement Concrete blockouts (PCC) of bridge expansion devices on the concrete bridge deck, abutment backwalls, and approach slabs as shown on the plans.

MATERIALS

518.02 Waterstops. Waterstops shall be manufactured either from neoprene or polyvinyl chloride (PVC) meeting the requirements described in subsection 705.10. The Contractor will have the option of furnishing either material unless otherwise specified.

The Contractor shall submit a certificate of compliance for each type of waterstop proposed for use on the project to the Engineer.

518.03 Asphaltic Expansion Devices. This device consists of an expansion joint system composed of a blended polymer modified asphalt and special aggregate per these specifications and in conformity with the details shown on the plans or established. The joint system shall be installed in a prepared expansion joint blockout and shall be designed for a rated joint movement of 0 to 2 inches including rotations.

The polymer modified asphalt, aggregate, backer rod, bridging plate, and joint binder shall conform to recommendations of the manufacturer of the approved joint system installed. Approved joint systems shall be those shown on the plans.

The Contractor shall furnish manufacturer's certification that all materials furnished have been pre-tested and meet the requirements set forth in the specifications and conform to the materials listed in the latest product literature. No substitution of materials will be permitted.

518.04 Elastomeric Expansion Devices. This device consists of an elastomeric expansion joint device and curb cover plates as shown on the plans and per these specifications. The expansion joint device shall seal the deck surface as indicated on the plans and prevent water from seeping through the superstructure slab. Seeping of water through the joint will be cause for rejection of the expansion device. The Contractor shall state at the Pre-construction Conference the specific manufacturer and model number of the device the Contractor intends to furnish and install.

The device shall consist of a continuous pre-molded elastomeric expansion joint seal, anchors and steel extrusions as shown on the plans, required by the manufacturer, or specified for attaching the elastomeric expansion joint seal to the steel armor. The expansion device shall have a rated movement of 0 to 4 inches including rotations.

The Contractor shall furnish manufacturer's certification that the materials proposed for use on the project have been pre-tested and will meet the requirements as set forth in these specifications and the manufacturer's current literature. The materials shall not be installed in the work before the Engineer's approval.

Structural steel sections shall conform to the specifications of AASHTO M 270 (ASTM A709 Grade 36). Fabrication of structural steel shall conform to the requirements of Section 509. All welding on elastomeric expansion devices shall conform to AWS D1.1. The material designations for all steel components shall be shown on the Contractor's working drawings.

All structural steel elements of the bridge expansion device, including cover plates, shall be galvanized after fabrication per Section 509, whether or not they are in contact with the elastomeric seals.

518.05 Modular Expansion Devices. This device consists of a modular expansion joint device and curb cover plates at the locations shown on the plans and per these specifications. The modular expansion joint device shall seal the deck surface, gutters, curbs, and walls as indicated on the plans, and prevent water from seeping through the bridge deck. Seeping of water through the joint will be cause for rejection of the expansion device. The Contractor shall state at the Pre-construction Conference the specific manufacturer and model number of the device the Contractor intends to furnish and install.

The expansion device shall have a rated movement greater than 4 inches but not exceeding 28 inches.

The modular expansion joint device supplied shall be one of the approved devices as shown on the plans.

The modular expansion device system shall be designed, fabricated, and delivered to the jobsite as a continuous unit, unless otherwise approved by the Engineer. Field splices shall not be located on the vehicle wheel path. The maximum length of completed expansion device assemblies shall be determined by practical shipping limitations. Handling and storage of the expansion joint device shall be per the manufacturer's written recommendations and as approved by the Engineer.

Only one type of modular joint device will be permitted to be installed at all locations. The installation of two different types at separate locations will not be permitted.

The device shall consist of pre-molded elastomeric expansion joint seals (strip seals) mechanically held in place by steel center beams and edge beams. Each transverse center beam shall be individually supported by and connected by full penetration weld to an independent support bar. The device shall provide equal-distance control of the pre-molded elastomeric seals.

(a) The center beam/support bar connection, field-splice, and other bolted and welded connection details in the joint shall be fatigue tested and designed following the guidelines provided in Appendix A19 of the latest edition of the AASHTO LRFD Bridge Construction Specification as well as the provisions included in Chapter 14 of the latest edition of the AASHTO LRFD Design Specification. The Contractor shall provide calculations electronically sealed by the Contractor's Engineer to the Engineer.

(b) The following components shall meet the listed requirements:

Table 518-1
EXPANSION JOINT COMPONENT REQUIREMENTS

Structural Steel (except center beams, edge beams and support bars)	AASHTO M 270 (ASTM A709) Grade 36
Center Beams, Edge Beams and Support Bars	AASHTO M 270 (ASTM A709) Grade 50 or AASHTO M 270 (ASTM A709) Grade 50W
Headed Studs	ASTM A108
Pre-molded Seals, Lubricant Adhesive, and Sliding Surfaces	Conforming to manufacturer's current literature
Stainless-steel Bearing Surfaces	Subsection 705.06

The steel fabricator for modular expansion devices shall be certified under the AISC Quality Certification for Simple Steel Bridges category, as a minimum.

All structural steel elements of the bridge expansion device, including cover plates, shall be galvanized after fabrication per 509, whether or not they are in contact with the elastomeric seals.

All welding on modular expansion devices shall conform to AWS D1.1.

The manufacturer shall furnish certification that the materials proposed for use on the project have been pre-tested and will meet the requirements as set forth in these specifications and the manufacturer's current literature. The material shall not be installed in the work before the Engineer's approval. All components of the expansion joint device, including stiffening plates and anchorages, shall be supplied by the manufacturer. The material designations for all components shall be shown on the shop drawings.

518.06 Polyester Concrete End Dam.

(a) Submittals. Fifteen days before the Polyester Concrete Pre-placement Conference the Contractor shall submit the following:

1. Polyester Concrete End Dam System. The Contractor shall submit to the Engineer two copies of the Manufacturer's written instructions for the installation of the Polyester Concrete End Dam system. The literature shall contain pertinent materials and installation data for the PPC supplied on the project. The Contractor shall submit the proposed testing procedures, mix design, form installation, and criteria for all PPC materials.
2. Manufacturer Qualifications. The Contractor shall install a Polyester Concrete End Dam system with all components of PPC provided through a single manufacturer. The manufacturer shall have documented experience supplying five successful projects of similar size and scope within the past five years. The Contractor shall submit documentation of the manufacturer's project experience including the following:

A. Project construction dates.
B. PPC quantities.
C. Reference names and contact information for owner representatives.

3. Contractor Qualifications. The Contractor shall submit documentation of at least 10 successful projects with one or more of the following: (1) Thin Bonded Overlay (Polyester Concrete), and (2) Polyester Concrete End Dam, to established grade lines using similar equipment as specified in subsection 518.11(c) below within the past five years. The documentation of Contractor qualifications shall include the following:

   A. Project construction dates.
   B. PPC quantities.
   C. Reference names and contact information for owner representatives.

   If the Contractor does not have at least 10 documented successful projects of experience with placing PPC systems, the Contractor shall arrange for a qualified Manufacturer's Technical Representative with at least five documented successful projects of experience with PPC system placements within the past five years to be on-site throughout the duration of the project to provide technical support for the material mixing and placement.

   If the Contractor has at least 10 documented successful projects of experience with placing PPC systems, the qualified Manufacturer's Technical Representative with at least five documented successful projects of experience with PPC system placements within the past five years shall, at a minimum, be on-site the first day of PPC placements, and shall be available as requested by the Engineer if necessary.

4. Manufacturer's Technical Representative Qualifications. The Manufacturer's Technical Representative shall have at least five documented successful projects of experience of similar size and scope with PPC system placements using similar equipment as specified, within the past five years, and be competent in all aspects of the work including all materials to install the PPC systems. This includes, but is not limited to, surface preparation, PPC application and PPC curing. The Technical Representative shall be available on-site for the first day of PPC placement to facilitate the installation.

   The Contractor shall submit documentation of the Technical Representative's experience including the following:

   A. Years of experience with PPC systems.
   B. Project construction dates.
   C. PPC quantities.
   D. Reference names and contact information for owner representatives.

5. Certified Test Report. The Contractor shall furnish a Certified Test Report, per subsection 106.13, confirming that all materials required for a Polyester Concrete End Dam system have been pre-tested, and meet all requirements.

6. Placement Plan. The Contractor shall submit a Polyester Concrete Placement Plan that includes the following:

   A. Schedule of work and required testing.
   B. Placement sequence and procedure.
   C. Description of all equipment used.
   D. Method for preventing leakages of HMWM primer and Polyester Concrete.
   E. Method for measuring and maintaining thickness and profile for each lift.

F. Finishing surface method including sequence and repair of damaged sections.
G. Cure time for Polyester Concrete.
H. Storage and handling of resin and PPC components.
I. Procedure for disposal of excess resin, PPC and containers.
J. Procedure for cleanup of mixing and placement equipment.

7. Equipment. The Contractor shall submit documentation of certification of scales that will be used to calibrate the mobile mixing truck. The certification shall be dated within the last month. A new certification shall be done if any adjustments are made to the scales.

8. Material Samples. Representative material samples used for the project shall be submitted to the Engineer a minimum of 30 days before the PPC application. The exact samples of materials from the same lots used for the project, for all components of the PPC system shall be submitted by the manufacturer, if requested, a minimum of 15 days before the PPC application. The quantities of the material samples shall consist of one 4-liter sample for each liquid with corresponding amounts of catalysts and accelerators, and a 50-pound sample for each dry component.

(b) Material Requirements. Materials for the Polyester Concrete End Dam shall be as follows:

1. PPC. The PPC shall consist of Polyester Resin Binder, catalysts and dry aggregate specified in Table 518-4. It shall also include a compatible primer applied on the prepared concrete areas, which when mixed with other specified materials and applied as specified, shall produce a PPC meeting the requirements of this specification. Accelerators may be required to speed up the chemical reaction and achieve proper Set Time of the PPC. They shall be used as recommended by the PPC Manufacturer.
2. Polyester Resin Binder. Polyester Resin Binder shall have the following properties:
   A. Be an unsaturated Isophthalic Polyester-styrene Co-polymer. The Polyester Resin content shall be 12 percent $\pm$1 percent of the weight of the dry aggregate.
   B. Contain at least 1.0 percent by weight Gamma-methacryloxypropyltrimethoxysilane, an Organosilane Ester Silane coupler.
   C. Be used with a promoter that is compatible with suitable Methyl Ethyl Ketone Peroxide and Cumene Hydroperoxide initiators.
   D. Have the values for the material properties shown in Table 518-2.

Table 518-2
POLYESTER RESIN BINDER PROPERTIES
(Tested each lot sent to the job)

Property	Test Method	Value
Viscosity*	ASTM D2196	0.1×10^{-5} to 2.9×10^{-5} psi-sec (0.075 to 0.20 Pa-s) RVT No.1 Spindle, 20 RPM at 77 °F
Specific Gravity*	ASTM D1475	1.05 to 1.10 at 77 °F
Elongation	ASTM D638	35% minimum Type I specimen, thickness 0.25 ± 0.03" at Rate = 0.45 inch/minute.
Elongation	ASTM D618	Sample Conditioning: 18/25/50+5/70
Tensile Strength	ASTM D638	2,500 psi, minimum Type I specimen, thickness 0.25 ± 0.03" at Rate = 0.45 inch/minute.
Tensile Strength	ASTM D618	Sample Conditioning: 18/25/50+5/70

Table 518-2 Notes: * Test shall be performed before adding initiator.

3. Primer. Primer for the concrete blockout surfaces shall be a wax-free low odor, High-molecular-weight Methacrylate primer (HMWM), and consist of a resin, initiator, and promoter.

When initiators and promotors are required to achieve proper modifications for working under different temperature conditions and applications of the primer, they shall be used as recommended by the PPC Manufacturer.

HMWM primer shall be applied to bond in PCC surfaces and promote adhesion to the PPC materials. The primer shall be tested for the Bond Strength per CP-L4302. The primer shall have a maximum volatile content of 30 percent before adding the initiator, when tested per ASTM D2369, and conform to Table 518-3.

Initiators for the Methacrylate Resin shall consist of a metal drier and Peroxide. If supplied separately from the resin, the metal drier shall not be mixed with the Peroxide directly. The containers shall not be stored in a manner that allows leakage or spilling to contact the containers or materials of the other.

Table 518-3
HIGH MOLECULAR WEIGHT METHACRYLATE RESIN PROPERTIES
(Tested yearly)

Property	Test Method	Value
Viscosity*	ASTM D2196	4.0×10^{-5} psi-sec (0.025 Pa-s) maximum (Brookfield RVT with UL adapter, 50 RPM at 77 °F)
Volatile Content*	ASTM D2369	30% maximum
Specific Gravity*	ASTM D1475	0.90 minimum at 77 °F
Flash Point*	ASTM D3278	180 °F minimum
Vapor Pressure*	ASTM D323	0.04 inch Hg, maximum at 77 °F
PCC Saturated Surface-Dry Bond Strength (Adhesive)	CP-L4302	700 psi, minimum at 24 hours and 70 $\pm$ 1 °F (with Polyester Concrete at 12 % resin content by weight of the dry aggregate)

Table 518-3 Notes: * Test shall be performed before initiator is added

4. Aggregate. Aggregate for Polyester Concrete shall:

   A. Have not more than 45 percent crushed particles retained on the No. 8 sieve when tested per AASHTO Test Method T335.
   B. Provide fine aggregate consisting of natural sand.
   C. Have a weighted-average aggregate absorption of no more than 1.0 percent when tested under AASHTO Test Methods T84 and T85.
   D. At the time of mixing with resin, have moisture content of not more than one-half of the weighted-average aggregate absorption when tested under AASHTO Test Method T255.
   E. Comply with the requirements for the aggregate gradation shown in Table 518-4.

Table 518-4
AGGREGATE GRADATION
(Tested yearly)

Sieve Size	Percent Passing
3/8”	100
No. 4	62 - 85
No. 8	45 - 67
No. 16	29 - 50
No. 30	16 - 36
No. 50	5 - 20
No. 100	0 - 7
No. 200	0 - 3

5. Sand. Sand for abrasive sand finish shall:
   A. Be commercial-quality blast sand.
   B. Have not less than 95 percent pass the No. 8 sieve, and not less than 95 percent retained on the No. 20 sieve when tested under AASHTO Test Method T27.
   C. Have an average absorption of not more than 1.0 percent when tested under AASHTO Test Method T85.

6. Composite System Properties. Polyester Concrete End Dam system shall have the values for the composite system properties shown in Table 518-5:

Table 518-5
COMPOSITE SYSTEM PROPERTIES
(Tested every 2 years)

Property	Test Method	Values
Abrasion Resistance	CP-L4301	< 2g weight loss (at 12% resin content by weight of the dry aggregate)
Modulus of Elasticity	ASTM C469	1,000,000 psi to 2,000,000 psi (at 12% resin content by weight of the dry aggregate)
PPC (Bond Strength)	CP-L4302	500 psi minimum at minimum of 24 hours and 70 °F (without Primer, at 12% resin content by weight of the dry aggregate, and saturated surface dry specimen)
Compressive Strength at Final Set Time	ASTM C805	3,000 psi at minimum of 4 hours
Compressive Strength at Cure Time	ASTM C39	4,500 psi at minimum of 24 hours

CONSTRUCTION REQUIREMENTS

518.07 Waterstops. Waterstops shall be furnished full length for each straight portion of the joint, without field splices. Field splices shall have a full-size tensile strength of 100 pounds per inch of width. Waterstops, when being installed, shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion of the web or flange.

If, after placing concrete, waterstops are substantially out of position or shape, the surrounding concrete shall be removed, the waterstop reset or replaced if damaged, and the concrete replaced at the Contractor's expense.

518.08 Asphaltic Expansion Devices The joint system shall be installed according to the manufacturer's recommendation and specifications and according to the details on the plans.

The backer rod shall be secured and sealed in the joint opening according to the manufacturer's directions.

The bridging plate shall be centered and secured over the joint opening according to the manufacturer's directions.

The joint binder, polymer modified asphalt, and aggregate shall be placed in the sequence and by the methods recommended by the manufacturer. The completed joint shall be compacted by the methods recommended by the manufacturer.

The final grade of the joint after compaction shall match the finished grade of the deck. The final thickness of the joint shall be 2.5 inches minimum.

A representative of the joint manufacturer shall be on site during the installation of each of the joint components. The representative shall certify that the joint was installed per manufacturer's recommended procedures and per the attached details. If a joint fails to meet the manufacturer's specifications, it shall be removed and replaced with a properly installed joint at the expense of the Contractor.

Two copies of the manufacturer's product literature, specifications and installation instructions shall be provided to the Engineer.

518.09 Elastomeric Expansion Devices. The Contractor shall submit working drawings as specified in subsection 105.02. The manufacturer's instructions for proper installation of the expansion joint device shall be included in the working drawings. Working drawings that lack manufacturer's installation instructions shall be returned for resubmittal.

Where applicable according to the plans, details of the expansion device through the curb, and details of the curb cover plates and connections, shall be shown on the working drawings.

At the discretion of the Engineer, the manufacturer may be required to furnish facilities for testing and inspecting of the completed device or a representative sample in the plant or at an independent test facility. The inspectors shall be allowed free access to the necessary parts of the manufacturer's plant and test facility.

The manufacturer shall provide a technical representative to be present at all times while the expansion device is being installed. The expansion device shall be installed in strict accordance with the manufacturer's written instructions and these specifications.

The expansion device shall be anchored as shown on the plans. Curb cover plates, where called for by the plans, shall be anchored to the concrete with cast-in-place inserts. Bolts shall be zinc or cadmium plated. The expansion device shall be accurately set and securely supported at the correct grade and elevation and the correct joint opening as shown on the plans and on the working drawings.

If portland cement concrete end dams are specified on the plans, the area beneath the expansion device angles shall be pressure injected by approved methods with an approved epoxy grout until all voids beneath the angles are eliminated. This shall be performed before the installation of the elastomeric expansion joint seal and after the concrete end dams have cured for a minimum of 120 hours.

Epoxy grout shall not be placed when the ambient temperature is 35 °F or below, or when temperatures are expected to fall to or below 35 °F at any time during the period of 12 hours following placement, unless the entire expansion device is protected from freezing by a heating enclosure.

Before the pre-molded elastomeric expansion joint seal is installed, the contact surfaces of the adjacent steel shall be thoroughly cleaned of mill scale and foreign material that will affect the installation or the sealing capabilities of the elastomeric expansion joint seal.

The cleaned metal surfaces shall be protected from rusting until the pre-molded elastomeric expansion seal and lubricant adhesive are placed against the metal surface. All cleaned metal surface where rusting appears shall be re-cleaned at no additional expense to the State.

After the expansion joint device has been permanently installed the Contractor shall test the full length of the device for watertight integrity. The Contractor shall employ a method satisfactory to the Engineer. The entire joint system shall be covered with water, either ponded or flowing, for a minimum duration of 15 minutes. The concrete surfaces under the joint shall be inspected, during this 15-minute period and also for a minimum of 45 minutes after the supply of water has stopped, for any evidence of dripping water or moisture. Watertightness shall be interpreted to be no free dripping water on any surface on the underside of the joint. Patches of moisture shall not be cause for non-acceptance.

If the joint system exhibits evidence of water leakage at any place whatsoever, the Contractor shall locate the leakage and correct the leakage as approved by the Engineer. Subsequent to corrective measures, the watertight integrity test shall be performed subject to the same conditions as the original test. This work and subsequent tests shall be done at the Contractor’s expense. The watertight integrity test is not required for joints at the ends of approach slabs.

The words “permanently installed” as used above include completion of the portions of the curb and deck that cannot be constructed until after the expansion device is installed. This applies even though this work is to be paid for under other items of the Contract.

The Contractor shall provide written certification to the Engineer that the expansion joint device was installed per the manufacturer's instructions, the advice of their technical representative, and these specifications. Any certification from the joint manufacturer's technical representative, provided by the Contractor to the Engineer, shall be in writing.

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518.10 Modular Expansion Device.

(a) The Contractor shall submit shop drawings as specified in subsection 105.02. The manufacturer's instructions for proper installation of the expansion joint device shall be included in the shop drawings.

Details of the expansion device through the curb, and details of the curb cover plates and connections, shall be shown on the shop drawings.

At the discretion of the Engineer, the manufacturer may be required to allow inspection of the completed device in the plant. The inspectors shall be allowed full access to the parts of the manufacturer’s plant necessary for the fabrication and assembly of the expansion joint device. The Contractor and Engineer shall ensure that the time of inspection does not result in a delay in fabrication.

The manufacturer shall provide a technical representative to be present at all times while the expansion device is being installed. The Contractor shall notify the expansion device manufacturer of the scheduled installation a minimum of two weeks before the installation date.

The modular expansion joint device shall be installed in strict accordance with the manufacturer's written instructions, the advice of the manufacturer's technical representative, and these specifications. The permanently installed expansion joint device shall match exactly the finished roadway profile and grade, and specified recesses as shown on the plans.

Immediately before installation, the expansion joint device shall be inspected by the Engineer for proper alignment, and complete bond between the pre-molded elastomeric seals and the steel, and proper stud placement and effectiveness. Pre-molded elastomeric seals not fully bonded to the steel shall be made fully bonded at the expense of the Contractor. All bolted connections shall be checked and tightened if found to be loose.

Bends or kinks in the expansion joint device steel will not be allowed (except as necessary to follow the roadway grades). Straightening of bends or kinks will not be allowed. If an expansion joint device exhibits bends or kinks, it shall be removed from the work site, and replaced by a new expansion joint device, at the expense of the Contractor.

The expansion joint device shall be preset by the manufacturer before shipment. Presetting shall be done per the joint opening at 70 ºF as indicated on the Contract Plans. Mechanical devices, supplied to set the expansion joint device to the proper width shall be disposed of by the Contractor following final adjustment for temperature.

Anchorages shall be inspected visually and shall be given a light blow with a 4-pound hammer. If an anchorage does not have a complete weld or does not emit a ringing sound when struck with a light blow of a hammer, it shall be replaced. All anchorage replacements shall be at the expense of the Contractor.

Stainless-steel sheet shall be welded to the support member. Adhesive will not be permitted.

The expansion device shall be anchored as shown on the plans. Curb cover plates shall be anchored to the concrete with cast-in-place inserts. Bolts shall be zinc or cadmium plated. The expansion device shall be accurately set for the correct joint opening and field conditions before placement in the blockout, and then secured at the correct grade and elevation and the correct joint opening as shown on the plans and on the shop drawings.

(b) The structure temperature shall be measured by recording the surface temperature of the concrete, steel, or both with a surface thermometer as described below.

1. Concrete Bridges: Record the temperature of the underside of the concrete slab at each end of the superstructure element adjacent to the expansion joint. Take the average of the readings to use with the temperature chart shown on the plans. In lieu of surface readings, internal slab readings may be taken by drilling a 1/4-inch diameter hole 3 inches into the concrete slab, filling the hole with water, and inserting a probe thermometer.

2. Steel Bridges: Record the concrete slab temperature as described above. In addition, record the surface temperature of the shaded portion of the girder web at each location. Average the readings of the steel and concrete to use with the temperature chart.

(c) All non-galvanized metal surfaces to come in contact with the pre-molded elastomeric seal shall be blast cleaned per the requirements of Steel Structures Painting Council Surface Preparation Specification No. 6 (SSPC-SP6, Commercial Blast Cleaning). After cleaning, all cleaned surfaces shall exhibit a clean quality of CSA2, or better, as defined by Steel Structures Painting Council Standard SSPC-VIS l.

The cleaned metal surfaces shall be protected from rusting until the pre-molded elastomeric seal and lubricant adhesive are placed against the metal surface. Any cleaned metal surface where rusting appears shall be recleaned per the foregoing, at no additional expense to the State.

In order to perform the work of installing the expansion joint device in a proper manner, some portions of the curb and bridge deck cannot be constructed until after the expansion device is installed. After the modular expansion joint device has been set to its final line and grade, recess openings in the deck and curb shall be filled with deck concrete or as shown in the plans. Grout shall be required below the support bar boxes where clearance will not allow proper consolidation of deck concrete. In such cases, grout shall be placed before pouring concrete, and techniques utilized will assure full support of the support bar boxes. This shall be verified by visual inspection. The grout shall be a CDOT-approved grout, and strict adherence to the grout manufacturer's instructions shall be followed. The uppermost surface of the concrete placement shall have a broom finish. The cost of this work including grout placement shall be included in the unit price bid for deck concrete.

(d) After the expansion joint device has been permanently installed the Contractor shall test the full length of the device for watertight integrity. The Contractor shall employ a method satisfactory to the Engineer.

The entire joint system shall be covered with water, either ponded or flowing, for a minimum duration of 15 minutes. The concrete surfaces under the joint shall be inspected, during this 15-minute period and also for a minimum of 45 minutes after the supply of water has stopped, for any evidence of dripping water or moisture. Watertightness shall be interpreted to be no free dripping water on any surface on the underside of the joint. Patches of moisture shall not be cause for non-acceptance.

If the joint system exhibits evidence of water leakage at any place whatsoever, the Contractor shall locate the leakage and take measures to correct the leakage as approved by the Engineer. Subsequent to corrective measures, the watertight integrity test shall be performed subject to the same conditions as the original test. This work shall be done at the Contractor's expense.

The words "permanently installed" as used above include completion of the portions of the curb and deck that cannot be constructed until after the expansion device is installed. This applies even though this work is to be paid for under other items of the Contract.

(e) The Contractor shall provide written certification to the Engineer that the expansion joint device was installed per the manufacturer's instructions, the advice of their technical representative, and these specifications. Any certification from the joint manufacturer's technical representative, provided by the Contractor to the Engineer, shall be in writing.

518.11 Polyester Concrete End Dam.

(a) Pre-placement Conference. A Polyester Concrete Pre-placement Conference shall be held at least 15 days before any PPC placement operation begins. Attendees shall include all parties involved in the work.

(b) Trial Application. The Contractor shall construct a test box for a test pour. The test box shall be at least 2 feet long, the depth of the Polyester Concrete End Dams, and the maximum width of the End Dams, or as approved by the Engineer. Before constructing the Polyester Concrete End Dams, one or more trial applications shall be placed in the test box to determine the Initial Set Time (Gel Time), Final Set Time, and Cure Time and to demonstrate the effectiveness of the mixing, placing, and finishing equipment proposed. The Final Set Time can be determined when the in-place PPC cannot be deformed by pressing with a finger, indicating the resin binder is no longer in a liquid state.

The trial application shall replicate field conditions and be constructed using the same installer and equipment as the production work. The location of the trial application shall be as approved by the Engineer. Trial applications shall be properly disposed of off-site by the Contractor.

The number of trial applications required shall be as many as necessary for the Contractor to demonstrate the ability to construct an acceptable trial end dam section and competency in ability to perform the work. All Set Times are based on anticipated application temperatures, conditions, and lane closure timing. The Contractor shall adjust the mix design, and construct a test box, and demonstrate that the adjusted mix consolidates and sets properly. The methods, installer, or the PPC system may be rejected after three trial applications if not shown to be adequate or in compliance with this specification as directed by the Engineer.

Acceptable test results shall be achieved on a trial application before installation may proceed.

(c) Equipment. All equipment for cleaning the existing concrete surface and mixing and applying the PPC system shall be per the Material Manufacturer's recommendations as approved by the Engineer before commencement of any work.

1. Measuring Equipment. The following equipment shall be provided:
   A. Certified Scales used to calibrate the mobile truck mixing equipment.
   B. Means to measure the resin levels in the tank of the mobile truck mixer during PPC placement operations and access to the resin tank.

2. Mixing Equipment. A continuous mixer shall be used for all PPC applications. The continuous mixer shall:
   A. Employ an auger screw/chute device.
   B. Be equipped with an automatic metering device that measures and records aggregate and resin volumes. Record volumes at least every five minutes, including time and date. Submit recorded volumes at the end of the work shift.
   C. Have a visible readout gauge that displays volumes of aggregate and resin being recorded.
   D. Produce a satisfactory mix consistently during the entire placement.
   E. Be calibrated by certified scales provided by the Contractor. Calibration shall be demonstrated by comparing the computer tickets to three consecutive batches of aggregate verified to be within 2 percent of one another. The process shall be repeated for three consecutive batches of resin, also verified to be within 2 percent of one another. This calibration process shall be witnessed by the Engineer, and the calibration shall be done every 90 days.

      A portable mechanical mixer of appropriate size for proposed batches, as recommended by the manufacturer and approved by the Engineer, may be used for all PPC applications and for smaller area applications of less than 2,000 cubic feet per contract.

3. Finishing Equipment: PPC materials shall be placed using hand tools such that the finish shall match the adjacent deck or pavement surfaces and meet the requirements of the project.

(d) Surface Preparation. Before HMWM primer and PPC applications, the concrete surfaces to be treated shall be cleaned by shot-blasting, scarifying, chipping, or sandblasting until all unsound materials and contaminants that may interfere with the primer and PPC have been removed from the concrete blockouts. Exposed concrete surfaces shall be protected from precipitation and heavy dew during and after the application of the primer.

(e) Forms. Forms of the concrete blockouts shall be tight, and sufficiently rigid to prevent distortion due to the pressure of the PPC and other loads incidental to the PPC. The formwork shall be inspected by the Engineer before the PPC placements. The forms shall be sealed watertight so that there is no leakage.

(f) HMWM Primer Application. Before placing HMWM primer in the concrete blockouts, the exposed surfaces of the existing concrete shall be completely dry and blown clean with oil-free compressed air. However, the primer shall be placed after 28-day curing time of new concrete.

After the exposed concrete surfaces have been prepared and cleaned, the primer shall be applied per the Manufacturer's recommendations. The primer shall be applied within five minutes of mixing at a spread rate of approximately 90 square feet per gallon, and uniformly spread to completely cover any surfaces where PPC materials will bond. The primer shall be reapplied to any areas that appear dry after 15 minutes of absorbing the materials. The concrete surface temperature shall be at 40 °F and rising to 95 °F maximum, and the relative humidity shall be not more than 85 percent.

(g) Polyester Concrete Application. The Polyester Concrete shall be applied in the concrete blockouts within two hours after the primer has been applied. Before PPC placement, the surface temperature of the concrete blockouts to receive PPC shall be at 40 °F and rising to 95 °F maximum.

The PPC shall be placed before the Initial Set Time and 15 minutes following addition of an initiator, whichever occurs first, or within a more restrictive temperature range if recommended by the manufacturer. After placing PPC in the concrete blockouts, if the Initial Set time of the PPC has exceeded 120 minutes, the materials shall be removed and replaced at the Contractor's expense.

Two-unit weight tests shall be performed on site for each lift and each day's production of PPC material using 4 inch x 8 inch cylinders. The average of the two test results shall be within 135 +/- 5 pounds per cubic foot. If the average of the unit weight tests is not within this specified range, adjustments shall be made to the PPC, and the tests performed again. Any material placed that is outside the specified range shall be removed and replaced at the Contractor's expense.

After a minimum of four hours and before opening to traffic, the Compressive Strength Test for Polyester Concrete End Dams shall be performed per the Rebound Hammer of Hardness Concrete, ASTM C805. The test results shall achieve the Compressive Strength of 3,000-psi minimum before opening traffic. In addition, one-unit weight test cylinder shall be stripped after 90 minutes and examined for evidence of poor consolidation. If uncured or unconsolidated material is determined to be present, the in-place end dam material shall be removed and replaced at the Contractor's expense.

If the depth of the Polyester Concrete End Dams exceeds 6 inches, the PPC materials shall be placed in lifts. The maximum thickness of each lift shall be recommended by the manufacturer or approved by the Engineer. Each lift of the PPC shall be consolidated and achieve a relative compaction in the concrete blockouts to the satisfaction of the Engineer.

A minimum of two 4-inch x 8-inch test cylinders shall be made for each day's production of PPC for expansion joint end dams. The test cylinders shall be broken at intervals as directed by the Engineer to verify a minimum compressive strength of 4,500 psi has been achieved. If the material has not reached 4,500 psi at 28 days, the Engineer has the option of price reducing the material or remove and replace per subsection 601.17.

(h) Surface Finishing. The proposed surface of Polyester Concrete End Dams shall be consolidated and finished to the required grade and cross slope using finishing equipment as approved by the Engineer.

Sand finish shall be applied by either mechanical means or hand broadcasting onto the glossy surface at a minimum rate of 2.2 lbs. per square yard immediately after finishing and before the Initial Set Time occurs. The smoothness of the PPC surface shall be tested with a 10-foot straightedge transversely and longitudinally. Deviations greater than 3/8 of an inch shall be diamond ground to the proposed finish grade. The thickness of the PPC shall not be reduced by more than 3/8 of an inch. Where there is a low spot reduced by more than 3/8 of an inch on the PPC surface, the low area shall be removed at least 3/4" and replaced with new PPC system to the proposed finish grade as directed by the Engineer. If there is a damaged surface on the PPC, the Contractor shall remove unsound PPC surface and replace it with new PPC system per the Finishing Surface Method.

After final surface finishing, traffic or equipment shall not be allowed on the treated surface until the PPC has achieved the Final Set Time. The Polyester Concrete End Dams shall be protected from moisture until Final Set Time has been obtained. The Contractor shall follow all Manufacturer's recommendations including surface preparation and all Set Times before opening treated surfaces to traffic or completing the work.

METHOD OF MEASUREMENT

518.12 Waterstop will be measured by the number of linear feet installed and accepted.

Asphaltic expansion devices will be measured by the number of linear feet from curb face to curb face along the joint installed and accepted.

Elastomeric expansion device will be measured by the linear foot between faces of curbs, parallel to the expansion device, completely installed, tested, and accepted. Portions of devices required in faces of curbs, including cover plates and hardware, will not be measured for payment.

Polyester Concrete End Dam will not be measured but will be the quantity designated on the plans.

Exceptions for each structure will be:

(1) when field changes are ordered, OR
(2) when it is determined that there are discrepancies on the plans in an amount plus or minus 2 percent of the plan quantity for the structure.

Polyester Concrete End Dam will be measured by the number of cubic feet completed in place and accepted. The pay volume for each discrete location (a contiguous treated area not touching other treated areas) shall be rounded up to the next whole cubic foot.

BASIS OF PAYMENT

518.13 The accepted quantities of waterstop will be paid for at the contract unit price per linear foot.

The accepted quantity of asphaltic expansion joint will be paid for at the contract unit price per linear foot and shall include all preparation materials, installation, compacting and final treatments associated with the particular joint provided.

The accepted quantity of elastomeric expansion device will be paid for at the contract unit price per linear foot and shall include all work necessary to complete the item, including furnishing and installing steel extrusions, steel angles, steel anchors, cover plates and hardware, bolts, inserts, epoxy grout, lubricant adhesive, pre-molded elastomeric joint seal and all miscellaneous hardware required.

The accepted quantity of modular expansion device will be paid for at the contract unit price per linear foot and shall include all work necessary to complete the items, including furnishing and installing modular expansion device, steel angles, concrete anchorages, cover plates and hardware, bolts, inserts, lubricant adhesive and all miscellaneous hardware required.

The accepted quantity of Polyester Concrete End Dam will be paid for at the contract unit price per cubic foot and shall include all work and materials necessary to complete the item including surface preparation, HMWM primer application, PPC application, surface finishing, trial application test boxes, testing, the on-site Technical Representative and all miscellaneous work required.

Payment will be made under:

Pay Item	**Pay Unit**
Waterstop (Inch)	Linear Foot
Bridge Expansion Device (2 Inch)	Linear Foot
Bridge Expansion Device (0 - 4 Inch)	Linear Foot
Bridge Expansion Device (0 - __Inch)	Linear Foot
Polyester Concrete End Dam	Cubic Foot

DIVISION 600
MISCELLANEOUS CONSTRUCTION

SECTION 601

STRUCTURAL CONCRETE

DESCRIPTION

601.01 This work consists of furnishing and placing hydraulic cement concrete per these specifications and in conformity with the lines, grades, and dimensions as shown on the plans or established.

This work includes preparing concrete surfaces designated in the Contract and applying an approved colored Structural Concrete Coating.

601.02 Classification. The classes of concrete shown in Table 601-1 shall be used when specified in the Contract.

Table 601-1
CONCRETE FIELD REQUIREMENTS

Concrete Class	Required Field Compressive Strength (psi)	Air Content: % Range (Total)	Slump#	Maximum Water/Cementitious Material (w/cm) Ratio:
B	4500 at 28 days	5 - 8	+/- 2" of Form 1373 Slump	w/cm on Form 1373
BZ	4000 at 28 days	N/A*	6" – 9"	w/cm on Form 1373
D	4500 at 28 days	5 – 8	+/- 2" of Form 1373 Slump	w/cm on Form 1373
DF	4500 at 28 days	4 - 8	+/- 2" of Form 1373 Slump	w/cm on Form 1373
DT	4500 at 28 days	5 – 8	+/- 2" of Form 1373 Slump	w/cm on Form 1373
PS (Girders)	8500 at 28 days	N/A*	9" maximum	0.45
PS (Deck Panels)	6000 at 28 days	N/A*	9" maximum	0.45
P	4500 at 28 days	4 – 8	+/- 2" of Form 1373 Slump	w/cm on Form 1373
S35	5000 at 28 days	5 – 8	+/- 2" of Form 1373 Slump	w/cm on Form 1373
S40	5800 at 28 days	5 – 8	+/- 2" of Form 1373 Slump	w/cm on Form 1373
S50	7250 at 28 days	5 – 8	+/- 2" of Form 1373 Slump	w/cm on Form 1373
Shotcrete	4500 at 28 days	7-10^	N/A	0.45

Table 601-1 Notes: * 5 - 8% when specified.
Slump shall be a maximum of 9.0 inches for all classes of concrete. Concrete may have a slump above 9.0 inches when designed as Self Consolidating Concrete (SCC). The requirements for slump flow, blocking assessment, and segregation shall apply.
^ Before pumping for wet process.

Class B concrete is air-entrained concrete for general use. Class D or P concrete may be substituted for Class B concrete. Additional requirements are:

(1) The coarse aggregate shall have a nominal maximum size of 1 1/2 inches or smaller.
(2) Class B Concrete for Slope and Ditch Paving shall be macro-fiber reinforced.

Class BZ concrete is concrete for drilled shafts. Additional requirements are:

(1) Entrained air is not required unless specified in the Contract. When entrained air is specified in the Contract, the air content shall be 5 to 8 percent.
(2) Slump shall be a minimum of 6 inches and a maximum of 9 inches. A minimum slump of 6 inches shall be maintained during the anticipated pour period. The use of retarders and hydration stabilizers are allowed to extend the slump life of the concrete. When the Contractor elects to use SCC, the slump requirement for Class BZ Concrete does not apply.
(3) The coarse aggregate size shall be AASHTO M43 size #8 unless otherwise approved by the Engineer.
(4) The mix shall either have a permeability not exceeding 2,500 coulombs at an age of not more than 56 days when tested per ASTM C1202 or have a surface resistivity of at least 12 kΩ-cm at 28 days using AASHTO T358.
(5) The unrestrained shrinkage shall not exceed 0.050 percent at 28 days when tested by CP-L 4103.

Class D concrete is a denser general use concrete. Additional requirements are:

(1) The mix shall either have a permeability not exceeding 2,500 coulombs at an age of not more than 56 days when tested per ASTM C1202 or have a surface resistivity of at least 12 kΩ-cm at 28 days using AASHTO T358.
(2) The unrestrained shrinkage shall not exceed 0.050 percent at 28 days when tested by CP-L 4103.
(3) The mix may use an optimized gradation (OG) with a nominal maximum aggregate size of at least 3/4 inch.
(4) The mix shall have a nominal maximum aggregate size of at least ¾ inch if an OG is not used.
(5) When used in slip forming, an edge slump less than 6 mm (0.25 in.) and less than 30 percent surface voids (ranking of 2 or less) is required. The box test is described in CP 63.
(6) Class D Concrete for sidewalks on bridge decks and bridge rail shall be macro-fiber reinforced.

Class DF concrete is a macro fiber-reinforced concrete. Additional requirements are:

(1) The concrete mix shall include approved macro or hybrid polyolefin fibers at a minimum dosage of 4 lb/cy, or the minimum dosage specified on the Department's Approved Product List (APL), whichever is greater.
(2) The unrestrained shrinkage shall not exceed 0.050 percent at 28 days when tested by CP-L 4103.
(3) The mix shall either have a permeability not exceeding 2,500 coulombs at an age of not more than 56 days when tested per ASTM C1202 or have a surface resistivity of at least 12 kΩ-cm at 28 days using AASHTO T358.

(4) The mix may use an OG with a nominal maximum aggregate size of at least 3/4 inch.

(5) The mix shall have a nominal maximum aggregate size of at least 3/4 inch if an OG is not used.

(6) When used in slip forming, an edge slump less than 6 mm (0.25 in.) and less than 30 percent surface voids (ranking of 2 or less) is required. The box test is described in CP 63.

(7) Shrinkage reducing admixtures may be incorporated into the mix.

(8) An expansive cement additive may be added to an ASTM C150 Type I/II cement and fly ash to produce an ASTM C845 Type K cement. The proportion of the expansive cement additive will be determined by testing the cementitious material blend per ASTM C806. The blended material shall have an expansion of 0.04 to 0.10 percent at 7 days when tested per ASTM C806. When an expansive cement is used, the w/cm ratio shall be 0.45 to 0.55 and the expansion of the laboratory trial mix shall be 0.05 to 0.09 percent at 7 days when tested per ASTM C878.

Class DT concrete is used for bridge deck resurfacing. Additional requirements are:

(1) The concrete mix shall consist of a minimum of 50 percent AASHTO M 43 size No. 7 or No. 8 coarse aggregate by weight of total aggregate.
(2) The mix shall either have a permeability not exceeding 2,500 coulombs at an age of not more than 56 days when tested per ASTM C1202 or have a surface resistivity of at least 12 kΩ-cm at 28 days using AASHTO T358.
(3) The unrestrained shrinkage shall not exceed 0.050 percent at 28 days when tested by CP-L 4103.

Class P concrete is used in pavements. Additional requirements are:

(1) The Required Field Flexural Strength shall be 650 psi.
(2) The concrete mix shall consist of a minimum 55 percent AASHTO M 43 sizes No. 57, No. 6, No. 67, No. 357, or No. 467 coarse aggregate by weight of total aggregate.
(3) The mix may use an OG with a nominal maximum aggregate size of at least ¾ inch.
(4) ASTM C150 Type III cement may be used for early opening.
(5) The mix shall either have a permeability not exceeding 2,500 coulombs at an age of not more than 56 days when tested per ASTM C1202 or have a surface resistivity of at least 12 kΩ-cm at 28 days using AASHTO T358.
(6) The unrestrained shrinkage shall not exceed 0.050 percent at 28 days when tested by CP-L 4103.
(7) When concrete is to be placed using a paver, an edge slump less than 6 mm (0.25 in.) and less than 30 percent surface voids (ranking of 2 or less) is required. The box test is described in CP 63.
(8) A minimum of 20 percent Class F fly ash or High Reactivity Pozzolan or 30 percent Slag cement by weight shall be used to replace any ASTM C150 cement, or ASTM C595 Type IL cement. ASTM C595 Type IT(MS), IT(HS), IP(MS) or IP(HS) cements may be used without cement substitutions. Class C fly ash may be used if the calcium oxychloride is determined to be less than 15 g CaOXY/100 g cementitious paste as determined per AASHTO T 365 for Class 0 Sulfate Exposure.

Class PS Class PS concrete is used for prestressed concrete members. Requirements for Class PS concrete are specified in subsection 618.11. ASTM C150 Type III cement may be used.

Class S35, S40, and S50 concretes are dense, high-strength concretes. Additional requirements are:

(1) The concrete mix shall be made with AASHTO M 43 sizes No. 57, No. 6, No. 67, No. 7, or No. 8 coarse aggregate.
(2) When placed in a bridge deck, the mix shall have a nominal maximum aggregate size of at least 3/4 inch.
(3) The mixes may use an OG with a nominal maximum aggregate size of at least 3/4 inch.
(4) For S35 and S40 concretes, the unrestrained shrinkage shall not exceed 0.050 percent at 28 days when tested by CP-L 4103.
(5) For S50 concretes, the unrestrained shrinkage shall not exceed 0.040 percent at 28 days when tested by CP-L 4103.
(6) For S35 and S40 concretes, the mix shall either have a permeability not exceeding 2,000 coulombs at an age of not more than 56 days when tested per ASTM C1202 or have a surface resistivity of at least 14 kΩ-cm at 28 days using AASHTO T358.
(7) For S50 concrete, the mix shall either have a permeability not exceeding 1,500 coulombs at an age of not more than 56 days when tested per ASTM C1202 or have a surface resistivity of at least 18 kΩ-cm at 28 days using AASHTO T358.

Class Shotcrete concrete is used for shotcrete applications. Additional requirements are:

(1) The required air content before the pump for wet process applications shall be 7–10 percent.
(2) Additional requirements are listed in subsection 641.02.

The Contractor may design Class B, Class BZ, Class D, Class PS, Class S35, Class S40, and Class S50 concrete to be Self Consolidating Concrete (SCC) with the following requirements:

(1) SCC shall have a slump flow of 20 to 26 inches when tested per ASTM C1611 using an inverted slump cone.
(2) SCC shall have a maximum blocking assessment of 2.0 inches when tested per ASTM C1621.
(3) SCC shall have a maximum static segregation of 10 percent when tested per ASTM C1610.

MATERIALS

601.03 Materials shall meet the requirements specified in the following subsections:

Fine Aggregate	703.01
Coarse Aggregate	703.02
Portland Cement	701.01
Fly Ash	701.02
Silica Fume	701.03
Water	712.01
Air Entraining	711.02
Pigments and	711.03
Curing Materials	711.01
Preformed Joint	705.01
Reinforcing Steel	709.01
Bearing Materials	705.06
Epoxy	712.10
Structural Concrete	708.08
High-reactivity	701.04
Slag Cement	701.05

Pozzolans shall consist of fly ash, silica fume, and high-reactivity pozzolan.

Prestressing steel shall meet the requirements of subsection 714.01 except as noted on the plans.

Calcium Chloride shall not be used in reinforced concrete. Calcium Chloride shall be used in non-reinforced concrete only when specified.

Where Fiber-Reinforced Concrete is specified or designated on the plans, the concrete mix shall include approved polyolefin fibers. Unless otherwise specified, a minimum of 1.5 pounds or the manufacturer's recommended dose per cubic yard of polyolefin fiber reinforcement shall be evenly distributed into the mix. Mixing shall be as recommended by the manufacturer such that the fibers do not ball up. Polyolefin fibers shall meet the requirements of ASTM C1116 and ASTM D7508.

Where Macro Fiber-Reinforced Concrete is specified or designated on the plans, the concrete mix shall include approved macro or hybrid polyolefin fibers at a minimum dosage of 4 lb/cy or the minimum dosage specified on the APL, whichever is greater. The dosage of the fiber may be reduced if trial mix data shows a minimum residual strength of 150 psi as determined per ASTM C1609 using a load support apparatus compliant with the requirements of ASTM C1812, "Standard Practice for Design of Journal Bearing Supports to be Used in Fiber Reinforced Concrete Beam Tests." Mixing shall be as recommended by the manufacturer such that the fibers are evenly distributed in the mix and do not ball up. Macro or hybrid polyolefin fibers shall meet the requirements of ASTM C1116 and ASTM D7508.

601.04 Sulfate Resistance. The Contractor shall provide protection against sulfate attack on concrete structures and pavements by providing concrete manufactured according to the requirements of the specified Sulfate Exposure Class. The sulfate exposure class for all concrete except Class PS shall be Class 2 unless otherwise specified on the plans. The sulfate exposure class for Class PS shall be Class 0. The requirements for a higher sulfate exposure class may be used for lower sulfate exposure classes.

The Contractor may request to test the soil and water at a structure location to change the sulfate exposure class. Testing and sampling of the location shall be at a frequency approved by the Engineer, in consultation with the Region Materials Engineer. If the Contractor provided test reports that show another class of exposure exists at a structure location, the Engineer may accept a concrete mix for that location at the changed sulfate exposure class.

Cementitious material requirements for each Sulfate Exposure Class are as follows:

Class 0 requires that the concrete have a maximum Water/Cementitious Material Ratio of 0.45 and one of the following:

(1) ASTM C150 Type I, II, III, or V

(2) ASTM C595 Type IL, IP, IP(MS), IP(HS), or IT

Class 1 requires that the concrete have a maximum Water/Cementitious Material Ratio of 0.45 and one of the following:

(1) ASTM C150 Type II or V

(2) ASTM C595 Type IP(MS) or IP(HS)

(3) ASTM C150 Type III. Type III shall have no more than 8 percent C3A.

(4) ASTM C595 Type IL(MS), IL(HS), IT(MS), or (HS)

Class 2 requires that the concrete have a maximum Water/Cementitious Material Ratio of 0.45 and one of the following:

(1) ASTM C150 Type V with a minimum of a 20 percent substitution of Class F fly ash or slag cement by weight

(2) ASTM C150 Type II or III or ASTM C595 Type IL with a minimum of a 20 percent substitution of Class F fly ash, High-Reactivity Pozzolan, or slag cement by weight. The Type II,III, or IL cement shall have no more than 0.040 percent expansion at 14 days when tested according to ASTM C452.

(3) A blend of portland cement meeting ASTM C150 Type II or III with a minimum of 20 percent Class F fly ash, High- Reactivity Pozzolan, or slag cement by weight, where the blend has less than 0.05 percent expansion at 6 months or 0.10 percent expansion at 12 months when tested according to ASTM C1012

(4) ASTM C595 Type IP(HS), IL(HS), or IT(HS). Class F fly ash, slag cement, or High-Reactivity Pozzolan may be substituted for Type IL(HS) cement.

(5) ASTM C595 Type IL(MS) or IT(MS) plus Class F fly ash, slag cement, or High-Reactivity Pozzolan where the blend has less than 0.05 percent expansion at 6 months or 0.10 percent expansion at 12 months when tested according to ASTM C1012

Class 3 requires that the concrete have a maximum Water/Cementitious Material Ratio of 0.40 and one of the following:

(1) A blend of portland cement meeting ASTM C150 Type II, III, or V or ASTM C595 Type IL(MS) with a minimum of a 20 percent substitution of Class F fly ash, High-Reactivity Pozzolan, or slag cement by weight, where the blend has less than 0.10 percent expansion at 18 months when tested according to ASTM C1012

(2) ASTM C595 IT(MS) plus High-Reactivity Pozzolan where the blend has less than 0.10 percent expansion at 18 months when tested according to ASTM C1012

(3) ASTM C595 Type IP(HS), IL(HS), or IT(HS) having less than 0.10 percent expansion at 18 months when tested according to ASTM C1012. Class F fly ash, slag cement, or High-Reactivity Pozzolan may be substituted for Type IL(HS) cement.

(4) ASTM C150 Type I, II, III, or V or ASTM C595 Type IL(MS) plus a minimum of 20 percent Class F fly ash when the R factor of the fly ash is less than 0.75. R factor is determined using the following from the chemical composition of the fly ash:

$$R = \frac{CaO - 5}{Fe_2O_3}$$

ASTM C150 Type III cement may only be used in Class P or PS Concrete when approved by the Engineer.

Class C fly ash shall not be substituted for cement when Class 1, 2, or 3 sulfate resistance/exposure class is specified.

The maximum Water/Cementitious Material Ratio may be exceeded when an expansive cement additive is used.

When fly ash or high-reactivity pozzolan is used to enhance sulfate resistance, it shall be used in a proportion greater than or equal to the proportion tested per ASTM C1012, shall be the same source, and shall have a calcium oxide content no more than 2.0 percent greater than the fly ash or high-reactivity pozzolan tested according to ASTM C1012. ASTM C1012 test results are acceptable for up to two years from the completion date of the test.

Table 601-2
CONCRETE SULFATE EXPOSURE CLASS

Water-Soluble Sulfate (SO_4) in Dry Soil, (%)	Sulfate (SO_4) in Water, ppm	Sulfate Exposure Class
0.00 to 0.10	0 to 150	Class 0
0.11 to 0.20	151 to 1,500	Class 1
0.21 to 2.00	1,501 to 10,000	Class 2
2.01 or greater	10,001 or greater	Class 3

CONSTRUCTION REQUIREMENTS

601.05 Mix Design Submittal Requirements. The Contractor shall submit a Concrete mix design for each class of concrete being placed on the project. Concrete shall not be placed on the project before the Concrete mix design has been approved by the Engineer. The Concrete mix design will be reviewed following the procedures of CP 62. The Concrete mix design will not be approved when the laboratory trial mix data or aggregate data are the results from tests performed more than two years in the past. The concrete mix design shall show the weights and sources of all materials including cements, pozzolans, aggregates, fibers, pigments, water, additives, and the water to cementitious material ratio (w/cm). When determining the w/cm, the weight of cementitious material (cm) shall be the sum of the weights of the cement, slag cement, fly ash, silica fume, and high-reactivity pozzolan. Water from dosages of admixtures greater than 10 ounces per 100 pounds of cementitious materials shall be included in the calculation of w/cm.

The laboratory trial mix data shall include results of the following:

(1) AASHTO T 119 (ASTM C143) Slump of Hydraulic Cement Concrete, except when the concrete is SCC.

(2) AASHTO T 121 (ASTM C138) Weight per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete

(3) AASHTO T 152 (ASTM C231) Air Content of Freshly Mixed Concrete by the Pressure Method

(4) ASTM C39 Compressive Strength of Cylindrical Concrete Specimens shall be performed with at least two specimens at 7 days and three specimens at 28 days.

(5) Class P concrete shall include AASHTO T97 (ASTM C78) Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading). At least two specimens will be tested at 7 days and four specimens at 28 days. The lab trial mix shall produce a flexural strength at 28 days of at least 650 psi.

(6) Concrete with an OG shall indicate the gradation of the blended aggregates. Optimized gradations shall be developed by an approved mix design technique such as Tarantula Curve, Shilstone, or KU mix.

(7) SCC concrete shall include ASTM C1611 Standard Test Method for Slump Flow of Self-Consolidating Concrete. Slump flow shall be measured using an inverted slump cone.

(8) SCC concrete shall include ASTM C1621 Standard Test Method for Passing Ability of Self-Consolidating Concrete by J-Ring.

(9) SCC concrete shall include ASTM C1610 Standard Test Method for Static Segregation of Self-Consolidating Concrete Using Column Technique.

(10) When concrete is to be placed using a paver, the edge slump and surface voids shall be reported per CP 63.

Before placement of accelerated Class P Concrete, the Contractor shall provide the Engineer a report of maturity relationships per CP 69.

Except for Class PS concrete, the laboratory trial mix must produce an average compressive strength of at least the required field compressive strength specified in Table 601-1. For Class PS concrete, the laboratory trial mix must produce an average compressive strength of at least 115 percent of the required field compressive strength specified in Table 601-1.

When entrained air is specified in the Contract for Class BZ concrete, the trial mix shall be run with the required air content.

The laboratory trial mix shall have a relative yield of 0.99 to 1.02.

Aggregate data shall include the results of the following:

(1) AASHTO T 11 (ASTM C117) Materials Finer Than 75 um (No. 200) Sieve in Mineral Aggregates by Washing

(2) AASHTO T 19 (ASTM C29) Unit Weight and Voids in Aggregate

(3) AASHTO T 21 (ASTM C40) Organic Impurities in Fine Aggregate for Concrete

(4) AASHTO T 27 (ASTM C136) Sieve Analysis of Fine and Coarse Aggregates

(5) AASHTO T 84 (ASTM C128) Specific Gravity and Absorption of Fine Aggregate

(6) AASHTO T 85 (ASTM C127) Specific Gravity and Absorption of Coarse Aggregate

(7) AASHTO T 96 (ASTM C131) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

(8) AASHTO T 104 (ASTM C88) Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate

(9) CP 37 Plastic Fines in Graded Aggregates and Soils by use of the Sand Equivalent Test

(10) ASTM C535 Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

(11) ASTM C1260 Determining the Potential Alkali Reactivity of Aggregates (Accelerated Mortar-Bar Method). When an aggregate source is known to be reactive, ASTM C1567 results may be submitted in lieu of ASTM C1260 results.

Aggregate tested by ASTM C1260 with an expansion of 0.10 percent or more, or that is known to be reactive, shall not be used unless mitigative measures are included in the mix design.

Mitigative measures shall be tested using ASTM C1567 and exhibit an expansion less than 0.10 percent by one of the following methods:

(1) Combined Aggregates. The mix design sources of aggregates, cement, and mitigative measures shall be tested. The proportions of aggregates, cement, and mitigative measures shall be those used in the mix design.

(2) Individual Aggregates. Each source and size of individual aggregates shall be tested. The source of cement and mitigative measures shall be those used in the mix design. The highest level of mitigative measures for any individual aggregate shall be the minimum used in the mix design.

For all concrete mix designs with ASTM C150 and ASTM C595 Type IL cements, the total substitution of cement shall not exceed 50 percent by weight of total cementitious material.

For all concrete mix designs with ASTM C595 Type IP, IP(MS), IP(HS), or IT cements: fly ash or high-reactivity pozzolan shall not be substituted for cement.

For all concrete mix designs with ASTM C595 IT cements, slag cement shall not be substituted for cement.

For all concrete mix designs with ASTM C595 Type IP, IP(MS), IP(HS) cements, when slag cement is substituted for cement, the total substitution of cement shall not exceed 50 percent by weight of total cementitious material.

The Contractor shall submit a new Concrete Mix Design Report meeting the above requirements when a change occurs in the source, type, or proportions of cement, slag cement, fly ash, high-reactivity pozzolan, silica fume, or aggregate. Addition, removal, change of source, dosage change, or type of fibers to an approved mix design shall require a new mix design. Adjustments to aggregate weights may be made to adjust yield if the combined gradation remains constant (+/-1 percent) or within the optimized band.

When a change occurs in the source or type of approved admixtures or the addition of approved accelerating, retarding, or hydration stabilizing admixtures to existing mix designs, the Contractor shall submit a letter stamped by the Concrete Mix Design Engineer approving the changes to the existing mix design. The change shall be approved by the Engineer before use.

Unless otherwise permitted by the Engineer, the product of only one type of hydraulic cement from one source of any one brand shall be used in a concrete mix design.

Approval of the concrete mix design by the Engineer does not constitute acceptance of the concrete. Acceptance will be based solely on the test results of concrete placed on the project.

Once approved for a project, the mix design may be used for the duration of the project.

601.06 Batching. Measuring and batching of materials shall be done per AASHTO M 157 (ASTM C94).

The Contractor shall furnish a batch ticket (delivery ticket) with each load for all classes of concrete. Concrete delivered without a batch ticket containing complete information as specified shall be rejected. The Contractor shall collect and complete the batch ticket at the placement site and deliver all batch tickets to the Engineer on a daily basis. The Engineer shall have access to the batch tickets at any time during the placement. The following information shall be provided on each batch ticket:

(1) Supplier’s name and date
(2) Truck number
(3) CDOT Project number and location
(4) Concrete class designation and item number
(5) Cubic yards batched.
(6) Time batched
(7) CDOT mix design number.
(8) Type, brand, and amount of each admixture and pigment
(9) Type, brand, and amount of cement, slag cement, fly ash, and high-reactivity pozzolan.
(10)Weights of fine and coarse aggregates or combined weight when an OG is pre-blended.
(11)Moisture of fine and coarse aggregates or combined moisture when an OG is pre-blended.
(12)Gallons (Pounds) of batch water (including ice)
(13)Weight of polyolefin fiber reinforcement

The Contractor shall add the following information to the batch ticket at the placement site:

(14)Gallons of water added by the truck operator, the time the water was added, and the quantity of concrete in the truck each time water is added.

(15)Number of revolutions of the drum at mixing speed (for truck mixed concrete)

(16)Discharge time

(17)Location of the batch in placement

(18)Water to cementitious material ratio

Electronic tickets are allowed as long as CDOT has access to the batch ticket and the batch ticket can be downloaded and saved by the Engineer in PDF format before placement, at any time during placement, and until the project is accepted.

(a) Hydraulic Cement, Fly Ash, High-Reactivity Pozzolan, Slag Cement and Silica Fume. All cementitious material shall be measured by mass. Supplementary cementitious materials may be weighed cumulatively with cement. Cement and other cementitious material shall be weighed on a scale and in a weigh hopper, which is separate and distinct from those used for other materials. When the quantity of cementitious material exceeds 30 percent of the full capacity of the scale, the quantity of cement and the cumulative quantity of cement plus supplementary cementitious material shall be within plus or minus 1 percent of the required mass. For small batches to a minimum of 1 cubic yard, the quantity of cement and the quantity of cement plus supplementary cementitious material used shall not be less than the required amount or more than 4 percent in excess. A fraction of a bag of cement shall not be used unless weighed.

(b) Water. Mixing water shall consist of water added to the batch, ice added to the batch, water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures. The added water shall be measured by mass or volume to an accuracy of 1 percent of the required total mixing water. Added ice shall be measured by weight. In the case of truck mixers, wash water retained in the drum for use in the next batch of concrete shall be accurately measured or shall be discharged before loading the next batch of concrete. Total water (including any wash water) shall be measured or weighed to an accuracy of plus or minus 3 percent.

(c) Aggregates. Aggregates from different sources and of different gradings shall not be stockpiled together.

Aggregate shall be handled from stockpiles or other sources to the batching plant in such a manner as to secure a uniform grading of the material. Aggregates that have become segregated, or mixed with earth or foreign material, shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipment requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage. In case the aggregates contain high or non-uniform moisture content, storage or stockpile period in excess of 12 hours may be required.

Aggregate shall be measured by mass. The quantity of aggregate used in any batch of concrete as indicated by the scale shall be within plus or minus 2 percent of the required mass when weighed in individual weigh batchers. In a cumulative aggregate weigh batcher, the cumulative mass after each successive weighing shall be within plus or

minus 1 percent of the required cumulative amount when the scale is used in excess of 30 percent of its capacity. For cumulative mass for less than 30 percent of scale capacity, the tolerance shall be plus or minus 0.3 percent of scale capacity or plus or minus 3 percent of the required cumulative mass, whichever is less.

(d) Bins and Scales. The batching plant may include bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. A bin, hopper, and scale for cementitious material shall be included. A single weighing hopper with an accumulative scale will be permitted, provided a separate scale is used for weighing cementitious material.

Scales shall meet the requirements of subsection 109.01.

601.07 Mixing. Mixing of materials shall be done per AASHTO M 157 (ASTM C94). Concrete shall be mixed in stationary mixers, in a central mix plant, in truck mixers, or in self-contained mobile mixers. Mixing time shall be measured from the time all materials, except water, are in the drum.

Admixtures listed in the mix design, or admixtures approved per subsection 601.04 and water may be added at the project.

(a) Mixing General. Concrete shall be deposited in place within 90 minutes after batching when concrete is delivered in truck mixers or agitating trucks, and within 60 minutes when delivered in non-agitating trucks.

The 90-minute time limit for a mixer or agitating trucks may be extended to 120 minutes if:

(1) No water is added after 90 minutes.

(2) The concrete temperature before placement is less than 90 °F.

The 90-minute time limit for a mixer or agitating trucks may be extended to 180 minutes if:

(1) No water is added after 90 minutes.

(2) The concrete temperature before placement is less than 90 °F.

(3) The approved concrete mix contains an approved retarding admixture.

The 90-minute time limit for a mixer or agitating trucks may be extended longer than 180 minutes if:

(1) An Extended Set Control Admixture (ESCA) is added at the time of batching. Procedures and doses shall be per manufacturer's recommendations. The ESCA shall be on the approved products list.

(2) The concrete temperature before placement is less than 90 °F.

(3) Each load of concrete shall be sampled and tested by the Contractor for air content according to CP 61.

(4) The Department will cast three additional acceptance cylinders. If the acceptance cylinders tested at 28 days do not meet design strength, the additional cylinders will be tested at 56 days for acceptance.

(b) Central-Mixed Concrete. Concrete that is mixed completely in a stationary mixer and transported to the point of delivery either in a truck agitator or a truck mixer operating at agitating speed, or in non-agitating equipment approved by the Engineer, shall conform to the following:

(1) The mixing time shall be counted from the time all the solid materials are in the drum.

(2) The batch shall be so charged into the mixer so that some water will enter in advance of the cement and aggregate.

(3) All water shall be in the drum by the end of the first one-fourth of the specified mixing time.

(4) The volume of concrete mixed per batch may exceed the mixer's nominal capacity, as shown on the manufacturer's standard rating plate on the mixer, by up to 10 percent provided concrete test data for strength, segregation, and uniform consistency are satisfactory, and provided spillage of concrete does not occur.

(5) Where no mixer uniformity tests are made, the acceptable mixing time for mixers having capacities of 1 cubic yard or less shall be not less than 1 minute. For mixers of greater capacity, this minimum shall be increased 15 seconds for each cubic yard or fraction thereof of additional capacity. Uniformity testing shall be per AASHTO M157 (ASTM C94).

(c) Truck Mixing. Truck mixed concrete shall conform with one of the following:

(1) Concrete that is completely mixed in a truck mixer shall be mixed 70 to 100 revolutions at the mixing speed to produce uniform concrete. Concrete uniformity tests shall be made per AASHTO M157 (ASTM C94). Additional revolutions of the mixer beyond the number found to produce the required uniformity of concrete shall be at a designated agitating speed.

(2) For concrete that is partially mixed in a stationary mixer, and then mixed completely in a truck mixer (shrink mixed concrete), the time of partial mixing shall be the minimum required to intermingle the materials. After transfer to a truck mixer, it shall be mixed at a speed to produce uniform concrete. Concrete uniformity tests shall be made per AASHTO M157 (ASTM C94). Additional revolutions of the mixer beyond the number found to produce the required uniformity of concrete shall be at a designated agitating speed.

(3) Concrete mixed entirely in a stationary mixer and delivered to the job in a truck mixer shall be remixed for a minimum of 20 revolutions of the mixing drum at mixing speed at the job site before discharge.

When water is added at the delivery site to control the consistency of the concrete, the concrete shall be mixed for at least 30 revolutions of the mixer drum at mixing speed for each addition of water before discharge. These revolutions are in addition to the minimum revolutions required for mixing at the delivery site. The added water shall not cause the w/cm ratio to exceed the approved mix design w/cm ratio. Water from all sources shall be documented by the Contractor on the delivery slip for each load of concrete.

The Contractor shall provide a Concrete Truck Mixer Certification. This certification shall show the various pick-up and throw-over configurations and wear marks so that the wear on the blades can be checked. Blades shall be replaced when any part or section is worn 1 inch or more below the original height of the manufacturer's design. A copy of the manufacturer's design, showing the dimensions and arrangement of blades, shall be available to the Engineer at all times.

The Contractor shall furnish a water-measuring device in good working condition, mounted on each transit mix truck, for measuring the water added to the mix after the truck has left the charging plant. Each measuring device shall be equipped with an easy-to-read gauge. Water shall be measured to an accuracy of plus or minus 3 percent.

(d) Self-Contained Mobile Mixer. Proportioning and mixing equipment shall be of the self-contained, mobile, continuous mixing type per ASTM C685 and subject to the following:

(1) The mixer shall be self-propelled and capable of carrying sufficient unmixed dry, bulk cementitious materials, fine aggregate, coarse aggregate, admixtures, and water to produce on the site at least 6 cubic yards of concrete. The mixer shall have one bin for each size aggregate.

(2) The mixer shall be capable of positive measurement of cementitious materials being introduced into the mix. A recording meter visible at all times and equipped with a ticket printout shall indicate the quantity of total concrete mix.

(3) The mixer shall provide positive control of the flow of water into the mixing chamber. Water flow shall be indicated by a flow meter and be readily adjustable to provide for minor variations in the aggregate moisture.

(4) The mixer shall be capable of calibration to automatically proportion and blend all components of indicated composition on a continuous or intermittent basis as required by the finishing operation and shall discharge mixed material through a conventional chute directly in front of the finishing machine.

(5) The Contractor shall perform calibration tests according to the equipment manufacturer's recommendations at the beginning of each project, and when there is a change in the mix design proportions or source of materials. The Engineer may require a calibration test or yield check when a change in the characteristics of the mixture is observed. The tolerances in proportioning the various materials shall be according to ASTM C685.

601.08 Air Content Adjustment. When a batch of concrete delivered to the project does not conform to the minimum specified air content, an air-entraining admixture conforming to subsection 711.02 may be added per subsection 601.17. After the admixture is added, the concrete shall be re-mixed for a minimum of 20 revolutions of the mixer drum at mixing speed. The concrete shall then be re-tested by PC.

601.09 Forms.

(a) Design. Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the concrete operations, including vibration.

The rate of depositing concrete in forms shall be controlled to prevent deflections of the form panels in excess of the deflections permitted by these specifications.

Forms for exposed concrete surfaces shall be designed and constructed so that the formed surface of the concrete does not undulate excessively in any direction between studs, joists, form stiffeners, form fasteners, or wales. Undulations exceeding 3/32 inch between the center-to-center distance of studs, joists, form stiffeners, form fasteners, or wales will be considered excessive. Should any form or forming system, even though previously approved for use, produce a concrete surface with excessive undulations, its use shall be discontinued until modifications satisfactory to the Engineer have been made. Portions of concrete structures with surface undulations in excess of the limits may be rejected by the Engineer.

Forms for drainage inlets may be constructed of any suitable material that will produce a structure with the inside dimensions and at least the wall thicknesses shown on the plans. Undulations of finished interior wall surfaces shall not exceed 0.5 inch.

Where called for in the Contract, the Contractor shall design and construct a permanent bridge deck forming system. Based on what is indicated, the Contractor will be permitted one of the following sets of options:

(1) If the plans indicate that permanent deck forms are optional, the Contractor shall have the option of constructing a cast-in-place bridge deck using conventional forms, a full-depth cast-in-place bridge deck using permanent steel bridge deck forms, or a partial depth cast-in-place bridge deck using precast panel deck forms as a portion thereof.

(2) If the plans indicate that permanent deck forms are required, the Contractor shall have the option of constructing a full depth cast-in-place bridge deck using permanent steel bridge deck forms, or a partial depth cast-in-place bridge deck using precast panel deck forms as a portion thereof.

(3) If the plans indicate that precast panel deck forms are required, the Contractor shall construct a partial depth cast-in-place bridge deck using precast panel deck forms as a portion thereof.

When SCC is used, forms shall be designed for loads as defined in American Concrete Institute (ACI) 347. Design calculations and form details shall be provided to the Engineer per Working Drawing requirements as defined in subsection 105.02.

(b) Construction. Forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber. The use of ties consisting of twisted wire loops to hold forms in position will not be permitted. Deck slab forms between girders shall be constructed with no allowance for settlement relative to the girders.

The inside surfaces of forms shall be cleaned of all dirt, mortar, and foreign material. Forms that will later be removed shall be thoroughly coated with form oil before use. The form oil shall be a commercial quality form oil or other equivalent coating that will permit the ready release of the forms and will not discolor the concrete.

Concrete shall not be deposited in the forms until all work connected with constructing the forms has been completed; all materials required to be embedded in the concrete have been placed, unless otherwise specified on the plans or approved; and the Engineer has inspected said forms and material. Such work shall include the removal of all dirt, chips, sawdust, water, and other foreign material from the forms.

Anchor devices may be cast into the concrete for later use in supporting forms or for lifting precast members. The use of driven types of anchorages for fastening forms or form supports to concrete will not be permitted.

Backforms may be omitted with the approval of the Engineer in cases involving footings that can be placed in the dry without the use of cribs or cofferdams. In such cases, the entire excavation shall be filled with concrete to the required elevation of the top of the footing. The additional concrete required shall be placed at the expense of the Contractor, except when footings are poured out to rock. Extra concrete required to pour footings out to rock will be allowed in the concrete quantities, provided that no allowance will be made for any concrete extending more than 6 inches in any direction beyond the neat lines of the footings as shown on the plans.

Forms for the placement of deck concrete or other concrete work associated with structural steel girders shall be constructed so that any concentrated loads applied to girder webs shall be within 6 inches of a flange or stiffener. Where loads are applied to steel girder webs, they shall be applied in a manner that will not produce distortion to the web.

For structural steel girders, temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girder flanges and to prevent appreciable relative movement between the edge of deck form and the adjacent steel girder.

When SCC is used, forms shall be constructed and maintained to meet aesthetic or smoothness criteria for the project. Form material other than plywood may be required.

(c) Form Lumber. Form lumber for all exposed concrete surfaces shall be dressed at least on one side and two edges and shall be constructed so as to produce mortar-tight joints and smooth, even concrete surfaces. Forms shall be filleted and chamfered as shown on the plans and shall be given a bevel or draft in the case of all projections, such as girders and copings, to assure easy removal.

Unless otherwise specified, forms for exposed surfaces shall be constructed with triangular fillets 3/4 inch by 3/4 inch at all exterior corners.

(d) Metal Ties. Metal ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 1/2 inch from the face without injury to the concrete. When wire ties are used, the wires shall be cut back at least 1/4 inch from the face of the concrete upon removal of the forms. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in color.

(e) Walls. Where the bottom of the forms is inaccessible, the lower form boards shall be left loose, or other provisions made so that extraneous material may be removed from the forms immediately before placing the concrete.

(f) Surface Treatment. All forms shall be treated with oil before placing reinforcement except that an approved non-petroleum base form release agent shall be used for surfaces that are to receive stain or where petroleum based agents would be incompatible with the structural concrete coating. Wood forms shall be thoroughly moistened with water immediately before placing the concrete.

For rail members or other members with exposed faces, the forms shall be treated with an approved form release agent to prevent the adherence of concrete. Material that will adhere to or discolor the concrete shall not be used.

All concrete forms for surfaces that Structural Concrete Coating is to be applied shall be treated with a water-based concrete form release agent before placing reinforcement.

(g) Metal Forms for General Use. The specifications for forms, regarding design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and oiling, apply to metal forms. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms that do not present a smooth surface or do not line up properly shall not be used. Metal forms shall be free from rust, grease or other foreign matter. Permanent steel bridge deck forms shall be as described in subsection 601.10.

(h) Removal of Forms. The forms for any portion of the structure shall not be removed until the concrete is strong enough to withstand damage when the forms are removed.

Unless specified in the plans, forms shall remain in place for members that resist dead load bending until the concrete has reached a compressive strength of at least 80 percent of the required 28-day strength, $0.80f'_c$. Forms for columns shall remain in place until the concrete has reached a compressive strength of at least 1,000 psi. Forms for sides of beams, walls, or other members that do not resist dead load bending shall remain in place until the concrete has reached a compressive strength of at least 500 psi.

Forms and supports for cast-in-place concrete box culverts (CBCs) shall not be removed until the concrete compressive strength exceeds $0.6f'_c$. for CBCs with spans up to and including 12 feet, and $0.67f'_c$. for CBCs with spans exceeding 12 feet but not larger than 20 feet. Forms for CBCs with spans larger than 20 feet shall not be removed until after all concrete has been placed in all spans and has attained a compressive strength of at least $0.80f'_c$.

Concrete compressive strength shall be determined by maturity meters per CP 69. At the Pre-pour Conference, the Contractor shall submit the location where maturity meters will be placed.

The Contractor shall provide maturity meters and all necessary wires and connectors. The Contractor shall be responsible for the placement and maintenance of the maturity meter and wire. At a minimum, a maturity meter shall be placed at the mid-span of beams and at support locations. Placement shall be as directed by the Engineer.

For structures with multiple maturity meters, the lowest compressive strength shall determine when the forms can be removed.

Acceptance cylinders shall not be used for determining compressive strength to remove forms.

When field operations are controlled by maturity meters, the removal of forms, supports, and housing and the discontinuance of heating and curing may begin when the concrete is found to have the required compressive strength.

Forms for the median barrier, railing, or curbs may be removed at the convenience of the Contractor after the concrete has hardened.

All forms shall be removed except permanent steel bridge deck forms and forms used to support hollow abutments or hollow piers when no permanent access is available into the cells. When permanent access is provided into box girders, all interior forms, falsework, and loose material shall be removed, and the inside of box girders shall be cleaned with an industrial vacuum.

When ESCAs are used, the removal of forms, supports and housing, and the discontinuance of heating and curing may begin when the concrete is found to have the required compressive strength.

(i) Patching. The mixed formula for patch mortar shall be determined by trial to obtain a good color match with the concrete when both patch and concrete are cured and dry.

(j) Re-use of Forms. The shape, strength, rigidity, watertightness, and surface smoothness of reused forms shall be maintained at all times. Warped or bulged lumber shall not be used.

(k) Precast Panel Deck Forms. Working drawings for precast panel deck forms shall be submitted to the Engineer in conformity with subsection 105.02.

Prestressing for precast panel deck forms shall be per subsection 618.07(a).

Concrete for precast panel deck forms shall be cured per subsection 618.12.

Precast panel deck forms shall be stored and transported in a horizontal position and shall conform to the requirements of subsections 618.14(c) and 618.15.

When precast panels are erected, the fit of mating surfaces shall have no more than a 1/8-inch gap to prevent concrete leakage. If such fit cannot be provided, the joint shall be filled with grout or sealed with an acceptable caulking compound before the placing of the cast-in-place portion of the slab.

Precast panels and their accessories, including components to set grade, shall not be attached by welding to steel girders or other structural steel elements or reinforcing steel. Welding, including arc strikes or grounding on any structural steel element, is prohibited. The Engineer will inspect all girder flanges for blemishes from arc strikes. All identified blemishes shall be repaired per AWS D1.5 Section 3.10. Repair of all blemishes shall be at the Contractor's expense.

Support angles or other steel components that will be left in place and exposed to the atmosphere in the final product shall be galvanized per subsection 509.11.

601.10 Permanent Steel Bridge Deck Forms.

(a) General. Permanent steel bridge deck forms for concrete deck slab may be used as an alternate to removable forms pursuant to this specification and when specified on the plans. Permanent steel bridge deck forms shall not be used in the cantilever portions of the deck slab.

(b) Materials. Permanent steel bridge deck forms and supports shall be fabricated from steel conforming to ASTM A653 (Grades A through E) having a galvanized coating designation of Z600 (G165) according to ASTM A653.

(c) Design. The following criteria shall govern the design of permanent steel bridge deck forms:

1. The steel forms shall be designed on the basis of dead load of form, reinforcement, and plastic concrete plus 50 pounds per square foot for construction loads. The unit working stress in the steel sheet shall be not more than 0.725 of the specified minimum yield strength of the material furnished, but not to exceed 36,000 pounds per square inch.

   If permanent steel bridge deck forms are used, the depth of slab shown on the plans shall be provided above the forms. The weight of additional concrete to fill form flutes and the steel form dead load shall not exceed a total of five pounds per square foot from edge to edge of flanges in each bay and from front face to front face of abutments.

2. Deflection under the mass of the forms, the plastic concrete and reinforcement shall not exceed 1/180 of the form span or 1/2 inch whichever is less, but in no case shall the design loading be less than 120 psf total.

   The permissible form camber shall be based on the actual dead load condition. Camber shall not be used to compensate for deflection in excess of the foregoing limits.

3. The design span of the form sheets shall be the clear span of the form plus 2 inches measured parallel to the form flutes.

4. Physical design properties shall be computed per requirements of the American Iron and Steel Institute (AISI) Specification for the Design of Cold Formed Steel Structural Members, latest published edition.

5. All reinforcing steel shall have a minimum concrete cover of 1 inch.

6. Permanent steel bridge deck form shall not be used in panels where longitudinal deck construction joints are located between stringers.

7. Permanent steel bridge deck forms and their accessories shall not be attached by welding to steel girders or other structural steel bridge elements or reinforcing steel. Welding, including arc strikes or grounding, on any structural steel element, is prohibited. Blemishes, when found, shall be removed per AWS D1.5 Section 3.10. A determination that a blemish exists will be made by the Engineer and the repair shall be at the Contractor's expense.

8. The Contractor shall submit two sets of the fabricator's shop and erection drawings to the Engineer. The drawings shall be designed and electronically sealed by the Contractor's Engineer. The drawings will not be approved or returned to the Contractor. The drawings shall indicate the grade of steel, the physical and section properties of all permanent steel bridge deck form sheets, and attachment details.

(d) Construction. All forms shall be installed per fabrication and erection plans submitted to the Engineer per subsection 601.10(c)8.

Form sheets shall not be permitted to rest directly on the top of the girder flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 1 inch at each end. Form supports shall be placed in direct contact with the girder flange. All attachments shall be made by bolts, clips, or other approved means. Welding will not be permitted to flanges.

Permanently exposed form metal, where the galvanized coating has been damaged, shall be thoroughly cleaned, wire brushed and painted with two coats of zinc oxide-zinc dust primer, Federal Specification TT-P-641d, Type II, no color added, to the satisfaction of the Engineer. Minor heat discoloration in areas of welds need not be touched up.

Transverse construction joints shall be located at the bottom of a flute and 1/4-inch weep holes shall be field drilled at not more than 12 inches on center along the line of the joint.

(e) Placing of Concrete. Concrete shall be placed with proper vibration of the concrete to avoid honeycomb and voids, especially at construction joints, expansion joints, valleys, and ends of form sheets. Placement sequences, procedures, and mixes shall be approved by the Engineer. Calcium chloride or any other admixture containing chloride salts shall not be used in the concrete placed on permanent steel bridge deck forms.

When SCC is used, vibration shall not be used to consolidate the concrete.

(f) Inspection. If the Engineer determines that the procedures used during the placement of the concrete warrant inspection of the underside of the deck, the Contractor shall remove at least one section of the forms at a location and time selected by the Engineer for each span. This will be done as soon after placing the concrete as practicable in order to provide visual evidence that the concrete mix and the Contractor's procedures are obtaining the desired results. An additional section shall be removed if the Engineer determines that there has been any change in the concrete mix or in the Contractor's procedures warranting additional inspection.
After the deck concrete has been in place for a minimum period of two days, the concrete shall be tested for soundness and bonding of the forms by sounding with a hammer as directed. If areas of doubtful soundness are disclosed by this procedure, the Contractor shall remove the forms from such areas as ordered, for visual inspection. If corrective action is not required, the cost of form removal will be borne by the Department. If corrective action is required, the cost of form removal and corrective action shall be borne by the Contractor.

The Contractor shall provide inspection platforms or other approved means of stationary support where the above visual inspection can be made.

601.11 Falsework.

(a) General. The Contractor shall be responsible for designing and constructing falsework. The Contractor's Engineer shall determine whether falsework is necessary. When the Contractor's Engineer determines falsework is unnecessary, the Contractor shall submit a written statement signed by the Contractor's Engineer so stating. The Contractor's Engineer shall prepare and electronically seal all falsework drawings including revisions, which shall meet the requirements of subsection 601.11. The Contractor shall stamp the drawings "Approved for Construction" and submit to the Engineer. The Engineer will not approve the drawings.

(b) Certification. Before placement of any concrete supported by falsework, the Contractor's Engineer shall certify that falsework materials and construction have been inspected and that all falsework design, materials, and construction conform to the requirements of the Contract and are safe for the placement of concrete. A copy of the certification on an acceptable form shall be submitted to the Engineer for record purposes.

(c) Falsework Design.

1. The falsework design drawings shall show the stresses and deflections in all load supporting members and anticipated total settlement of falsework footings and joint take-up. Anticipated settlements shall not exceed 1 inch. The maximum deflection used in the design of the falsework shall be 1/270 of clear span, irrespective of the fact that the deflection may be compensated for by camber strips.
2. The design of falsework shall be based on the use of loads and conditions that are no less severe than those described in this section. The stresses listed are based upon the use of undamaged, high-quality materials and such stresses shall be reduced by the Contractor if lesser quality materials are to be used. The Contractor is responsible for the proper evaluation of the falsework materials and design of the falsework to safely carry the actual loads imposed.
3. The design load for falsework shall consist of the sum of dead and live vertical loads and an assumed horizontal load.
   A. Dead loads shall include the weight of concrete, reinforcing steel, forms, and falsework. The weight of concrete and reinforcing steel shall be assumed to be at least 150 pounds per cubic foot for normal concrete and at least 120 pounds per cubic foot for lightweight concrete.
   B. Timber dead load is 50 pounds per cubic foot. The dead load of timber forms may be assumed at 10 pounds per square foot for members smaller than 6-inch x 6 inch. Dead load for steel and steel forms shall be 490 pounds per cubic foot. The weight of any other forming materials shall be specified on the drawings.
   C. Live loads shall consist of the actual weight of any equipment to be supported by falsework applied as concentrated loads at the points of contact and a uniform load of at least 50 pounds per square foot applied over the area supported.

4. The assumed horizontal load to be resisted by the falsework bracing system shall be the sum of the actual horizontal loads due to equipment, construction sequence or other causes and an allowance for wind; however, the assumed horizontal load to be resisted in any direction shall not be less than 2 percent of the total dead load for falsework up to 30 feet high, and four percent for falsework over 30 feet high. The falsework shall be designed so that it will have sufficient rigidity to resist the horizontal load before the placement of concrete.

5. The entire bridge superstructure cross-section, except railing, shall be considered to be placed at one time except as provided. Girder stems and connected bottom slabs, if placed more than five days before the top slab, may be considered to be self-supporting between falsework posts at the time the top slab is placed, provided that the distance between falsework posts does not exceed four times the depth of the portion of the girder placed in the first pour.

6. Falsework footings shall be designed to carry the load imposed upon them without exceeding the estimated soil bearing values and anticipated settlements.

7. Foundations for individual towers where the maximum leg load exceeds 30 kips shall be designed and constructed to provide uniform settlement under all legs of each tower under all loading conditions.

8. If the concrete is to be post-tensioned in the field, the falsework shall be designed to support all increased or readjusted loads caused by the prestressing forces, as shown on the plans.

9. The falsework design drawings shall include the following minimum information:

   (1) Type and grade of structural materials.

   (2) Allowable material stresses in bending, compression, and shear.

   (3) Modulus of elasticity, “E”.

   (4) Stress factors if used for short-term duration loading (timber only).

   (5) Summary of critical tower leg loads and locations on falsework drawings.

   (6) Weight of deck finishing machine and wheel or support spacing.

   (7) References for load data used for standardized falsework components.

   (8) Specification references for design criteria.

   (9) The bearing value of the soil as determined by the Contractor when footing type foundations are to be used.

10. Falsework design shall be based on the current edition of one of the following applicable specifications. However, it shall be based on AASHTO Specifications if highway traffic is to be supported.

AASHTO	American Association of State Highway and Transportation Officials, Load and Resistance Factor Design Bridge Design Specifications.
AISC	American Institute of Steel Construction, Manual of Steel Construction.
ACI	American Concrete Institute, Formwork for Concrete SP4 Building Code Requirements for Reinforced Concrete.
NFPA	National Forest Products Association, National Design Specifications for Stress Grade Lumber.
AITC	American Institute of Timber Construction Manual.

11. Manufactured Assemblies. Loading of jacks, brackets, columns, joists, and other manufactured devices shall not exceed the manufacturer's recommendations or 40 percent of the ultimate load-carrying capacity of the assembly based on the manufacturer's tests or additional tests as necessary. The maximum allowable dead load deflection of joists shall be limited to 1/500 of their spans.

    The Contractor shall furnish catalog or equivalent data showing the manufacturer's recommendations or perform tests, as necessary, to demonstrate the adequacy of any manufactured device proposed for use. The Contractor shall not substitute other manufacturer's components unless the manufacturer’s data encompasses such substitutions or field tests affirm the integrity of the system.

12. Connection details shall be so designed that structural shoring members are secure for all loading conditions.

(d) Falsework Construction. The falsework shall be constructed per the falsework drawings. Suitable jacks, wedges, or camber strips shall be used to set the forms to the required grade or camber and to take up any settlement in the formwork either before or during the placing of concrete. Supports for deck slab forms shall be constructed so as to prevent settlement relative to the girders. The amount of camber to be used to represent the behavior of the permanent structure is shown on the plans.

Falsework and formwork for the placement of deck concrete or other concrete work associated with structural steel girders shall be constructed so that any concentrated loads applied to girder webs shall be within 6 inches of a flange or stiffener. Where loads are applied to steel girder webs, they shall be applied in a manner that will not produce distortion to the web.

For structural steel girders, temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girders and to prevent movement between adjacent steel girders. Where the deck overhang exceeds 1/ 3 of the distance between steel girders, bracing shall be provided to prevent rotation of the exterior girder due to the weight of the overhang falsework and formwork and concrete placement operations. Struts and ties shall also be provided between interior steel girders to prevent movement between girders. Falsework drawings for bracing, struts, and ties shall be submitted and conform to the requirements of subsection 601.11(a).

The Contractor shall provide tell-tales attached to the forms and readable from the ground, in enough systematically placed locations, to determine the total settlement of the entire portion of the structure where concrete is being placed.

Should unanticipated events occur, including settlements that deviate more than plus or minus 3/8 inch from those indicated on the falsework drawings, which in the opinion of the Engineer would prevent obtaining a structure conforming to the requirements of these specifications, the placing of concrete shall be discontinued until the corrective measures satisfactory to the Engineer are provided. In the event satisfactory measures are not provided before the initial setting of the concrete in the affected area, the placing of concrete shall be discontinued at a location determined by the Engineer. All unacceptable concrete shall be removed.

(e) Falsework Removal. Unless specified in the plans or specifications, falsework shall remain in place until the concrete has attained a minimum compressive strength of $0.80f'_C$.

Falsework supporting any span of a simple span bridge shall not be released until after all concrete, excluding concrete above the bridge deck, has attained a compressive strength of at least $0.80f'_C$.

Falsework supporting any span of a continuous or rigid frame bridge shall not be released until after all concrete, excluding concrete above the bridge deck, has been placed in all spans and has attained the compressive strength of at least $0.80f'_C$.

Falsework for arch bridges shall be removed uniformly and gradually, beginning at the crown, to permit the arch to take its load slowly and evenly.

Falsework supporting overhangs and deck slabs between girders shall not be released until the deck concrete has attained a compressive strength of at least $0.80f'_C$.

Falsework for pier caps that will support steel or precast concrete girders shall not be released until the concrete has attained a compressive strength of at least $0.80f'_C$. Girders shall not be erected onto such pier caps until the concrete in the cap has attained the compressive strength of at least $0.80f'_C$.

Falsework for cast-in-place prestressed portions of structures shall not be released until after the prestressing steel has been tensioned.

Concrete compressive strength shall be determined by maturity meters per CP 69. At the Pre-Pour Conference, the Contractor shall submit the location that maturity meters will be placed.

The Contractor shall provide maturity meters and all necessary wires and connectors. The Contractor shall be responsible for the placement and maintenance of the maturity meters and wires. At a minimum, a maturity meter shall be placed at the mid-span of beams and at support locations. Placement shall be as directed by the Engineer.

For structures with multiple maturity meters, the lowest compressive strength shall determine when the falsework can be removed.

Acceptance cylinders shall not be used for determining compressive strength to remove falsework.

601.12 Placing Concrete.

(a) General. A Pre-placement Conference shall be held with the selected Contractor and Department personnel before the placement of concrete bridge decks to discuss the method and sequence of placing concrete.

At the Pre-placement Conference, the Contractor shall present a concrete winter protection plan for acceptance by the Engineer. The accepted concrete winter protection plan shall contain information on the number and type of heat sources to be used, a sketch detailing the enclosure materials, and all other pertinent information. Sufficient equipment shall be supplied to continuously maintain the specified temperature uniformly in all parts of the enclosure. Insulated blankets on top of the bridge deck and freely circulated artificial heat below the deck will be permitted.

Concrete shall not be placed until forms have been completed and materials required to be embedded in the concrete have been placed, and the Engineer has inspected the forms and materials. The forms shall be cleaned of all debris before concrete is placed.

The external surface of all concrete shall be thoroughly worked during the placing by means of tools of an approved type. The working shall be such as to force all coarse aggregate from the surface and to bring mortar against the forms to produce a smooth finish substantially free from water and air pockets, or honeycomb.

Water or finishing aids shall not be added to the surface of the concrete to assist in finishing operations.

Hand finishing shall be minimized wherever possible. The hand finishing methods shall be addressed in the Process Control Plan for concrete finishing. Hand-finished concrete shall be struck off and screeded with a portable screed that is at least 2 feet longer than the maximum width of the surface to be struck off. It shall be sufficiently rigid to retain its shape. Concrete shall be thoroughly consolidated by hand vibrators. Hand finishing shall not be allowed after the concrete has been in place for more than 30 minutes or when the initial set has begun. Finishing tools made of aluminum shall not be used.

The Contractor shall provide a Process Control Plan (PCP) to ensure that proper hand finishing is accomplished per current industry standards. It shall identify the Contractor's method for ensuring that the provisions of the PCP are met. The PCP shall be submitted to

the Engineer at the Pre-construction Conference. Concrete placement shall not begin until the Engineer has approved the PCP. The PCP shall identify and address issues affecting the quality of finished concrete including but not limited to:

(1) Timing of hand finishing operations.

(2) Methodology to place and transport concrete.

(3) Equipment and tools to be utilized.

(4) Qualifications and training of finishers and supervisors.

When the Engineer determines that any element of the approved PCP is not being implemented or that hand-finished concrete is unacceptable, work shall be suspended. The Contractor shall supply a written plan to address improperly placed material and to remedy future hand-finishing failures and bring the work into compliance with the PCP. The Engineer will review the plan for acceptability before authorizing the resumption of operations.

(b) Hot Weather Limitations. Placing of concrete during hot weather shall be limited by the temperature of the concrete at the time of placing. Mixed concrete that has a temperature of 90 ºF or higher, shall not be placed.

The Contractor shall provide fogging equipment and keep the concrete surface moist at all times by fogging with an approved atomizing nozzle until the curing material is in place.

The aggregate stockpiles shall be kept moist at all times.

(c) Cold Weather Limitations. The mixed concrete temperature shall be between 50 and 90 ºF at the time of placement. Water, aggregates, or both shall be heated, when necessary, under such control and in sufficient quantities to avoid fluctuations in the temperature of the concrete of more than 10 ºF from batch to batch.

To avoid the possibility of flash set when the water is heated to a temperature in excess of 100 ºF, the water and the aggregates shall be charged into the mixer before the cement is added.

Heating equipment or methods that alter or prevent the entrainment of the required amount of air in the concrete shall not be used. The equipment shall be capable of heating the materials uniformly. Aggregates and water used for mixing shall not be heated to a temperature exceeding 150 ºF. Materials containing frost or lumps of frozen material shall not be used.

Stockpiled aggregates may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over fire.

When aggregates are heated in bins, steam-coil or water-coil heating, or other methods that will not be detrimental to the aggregates may be used. The use of live steam on or through binned aggregates will not be permitted.

Concrete shall not be placed on frozen ground. Before concrete placement, all ice, snow, and frost shall be completely removed from within formwork. Salt shall not be used to thaw ice, snow, or frost.

(d) Chutes and Troughs. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement.

Concrete shall not be dropped more than 5 feet unless confined by closed chutes or pipes. Care shall be taken to fill each part of the form by depositing the concrete as close to the final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After the initial set of the concrete, the forms shall not be jarred, and strain shall not be placed on the ends of projecting reinforcement.

Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement.

The Contractor shall not use pipes, fittings, chutes, troughs, spouts, or tremies that are fabricated of aluminum materials for pumping, conveying, or placing concrete.

Concrete shall not be pumped through aluminum alloy pipe.

All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete.

(e) Vibrating. Unless otherwise directed, the concrete shall be consolidated with suitable mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate consolidation.

Vibrators shall be of a type and design approved by the Engineer. They shall be capable of frequencies of at least 10,000 vibrations per minute, in air.

Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and embedded fixtures and into corners and angles of the forms. Vibrators shall not be used as a means to cause concrete to flow or run into position in lieu of placing. The vibration at any point shall be of sufficient duration to accomplish consolidation but shall not be prolonged to the point where segregation occurs.

When SCC is used, vibrators shall not be used to consolidate the concrete.

(f) Depositing Concrete Under Water. Concrete, except for cofferdam seals, shall not be deposited under water, unless approved by the Engineer. If approved, care shall be exercised to prevent the formation of laitance. Concrete shall not be deposited until all laitance, which may have formed on concrete previously placed, has been removed. Pumping shall be discontinued while depositing foundation concrete if it results in a flow of water inside the forms. Concrete deposited under water shall be carefully placed in a compact mass in its final position by means of a concrete pump and tremie. The discharge or bottom end of the tremie shall be lowered to contact the foundation at the start of the concrete placement and shall be raised during the placement at a rate that will ensure that the bottom or discharge end of the tremie is continuously embedded or buried in fresh concrete a minimum of 12 inches. Air and water shall be excluded from the tremie pipe by keeping the pipe continuously filled. The continuity of the placement operation shall be maintained without breaking the seal between the concrete mass and the discharge end of the tremie until the lift is completed. The placed concrete shall not be disturbed after it has been deposited.

(g) *Placement*. Concrete shall be placed in horizontal layers not more than 18 inches thick except as provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and consolidated before the preceding batch has taken an initial set. Each layer shall be so consolidated as to avoid the formation of a construction joint with a preceding layer that has not taken an initial set. Bridge deck concrete on superelevation or grade that exceeds 2 percent shall be placed from the low point upward.

When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. The top surfaces of concrete adjacent to the forms shall be smoothed with a trowel to minimize visible joints upon exposed faces. Work shall not be halted within 18 inches of the top of any face, unless provision has been made for a coping less than 18 inches thick, in which case the construction joint may be made at the underside of the coping.

Immediately after the work of placing concrete is halted, all accumulations of mortar splashed upon the reinforcement and surfaces of forms shall be removed before the concrete takes its initial set. Care shall be taken when cleaning reinforcing steel to prevent damage to or breakage of the concrete-steel bond.

Where Class DT concrete is used for patching, repair, or topping of existing concrete, the area that the Concrete Class DT contacts shall be prepared by shot blasting 1/8 to 3/16 inch deep or rotomilling. If Class DT concrete is not placed within one week of the shot blasting or rotomilling the area shall then be sandblasted and cleaned of all sand, concrete fragments, dirt, and other foreign material within one week of placement. The area shall be moistened two to four hours before placement and shall be free of standing water at the time of placement.

When concrete is placed by pumping, the pumping equipment shall be thoroughly cleaned before concrete placement. Excess form release agent shall be removed from the hopper. The pump shall be primed at the Contractor’s expense by pumping and discarding enough concrete to produce a uniform mix exiting the pump. At least 0.25 cubic yards of concrete shall be pumped and discarded to prime the pump. Water or admixtures shall not be added directly into the concrete pump hopper after placement has commenced. If water or admixtures are added to the concrete pump hopper, all concrete in the concrete pump hopper and the line shall be discarded and the pump shall be re-primed at the Contractor’s expense.

The pump operator shall have a valid operator’s certification from the American Concrete Pumping Association or approved equal. Boom pumps shall have a documented current inspection as required by American Society of Mechanical Engineers (ASME) B30.27. Equipment added to the pump shall meet the pump manufacturer’s specifications. The Contractor shall submit the specifications of the pumping equipment and the qualifications of the operator to the Engineer for review at least two weeks before pumping concrete. Equipment and operators rejected by the Engineer shall be replaced at the Contractor’s expense.
The pump shall be operated so that a continuous stream of concrete is produced. The pump equipment shall use a minimum of one of the following to maintain concrete uniformity:

(1) A 360-degree loop immediately before the delivery end of the pump line.

(2) A minimum one-inch reducer installed at the entry to the delivery hose.

(3) A minimum one inch reducing delivery hose.

(4) A cable attached to the pump boom creating a minimum 90-degree bend in the steel braided flexible hose. The point of discharge from the flexible hose at the end of the boom shall be at or above the lowest point of the bend.

(5) On horizontal pours, a 10-foot minimum horizontal delivery system placed on the deck.

(6) Other approved methods.

Metal pump lines or couplings shall not rest directly on epoxy-coated reinforcing steel.

The point of discharge of the pump shall be as close to the bridge deck elevation as possible.

When SCC is used, concrete should be placed in one layer for the full depth of the formwork. No maximum layer thickness applies.

(h) Placing Sequence. Unless otherwise shown on plans, or ordered, the concrete placing sequence shall be as follows:

Concrete in columns shall be placed in one continuous operation. The concrete in columns shall be allowed to set at least 12 hours before caps are placed. Each span of simple span concrete slab and girder bridges less than 30 feet in length shall be placed in one continuous operation.

Concrete for simple or continuous girder spans greater than 30 feet shall be placed in two operations; the first operation shall consist of placing the girder stems and any slab at the bottom of the stems, and the second operation shall consist of placing the top deck slab. The second pour shall not be made until the first pour has reached a compressive strength of twice the design unit stress shown on the plans.

Transverse construction joints shall be located as shown on the plans, or as approved.

Concrete slabs on simple span steel girder bridges shall be poured in one continuous operation for each span. If approval is given to place the deck of the entire structure, the Contractor shall use an approved retarder, when necessary, to retain the workability of the concrete and to obtain the desired finish.

Concrete slabs on continuous span steel girder bridges shall be placed per the placing sequence shown on the plans. The Contractor may place the deck of the entire structure in one operation when approved. An approved retarder shall be used, when necessary, to retain the workability of the concrete and to obtain the desired finish. The leading edge of the freshly placed concrete shall be kept parallel to the substructure so that the girders will be loaded evenly during the placing and screeding operation.

(i) Drainage and Weep Holes. Drainage and weep holes shall be constructed at locations shown on the plans or as ordered. Ports or vents for equalizing hydrostatic pressure shall be placed below low water.

Forms for weep holes shall consist of approved form material. Wooden forms shall be removed after the initial set of concrete has taken place.

Inlets of weep holes shall be surrounded with 1 cubic foot of filter material in a burlap sack, securely tied.

(j) Construction Joints. Construction joints shall be made only as located on the plans or shown in the placing schedule, unless otherwise approved.

All construction joints shall be cleaned of surface laitance, curing compound, and other foreign materials before fresh concrete is placed against the surface of the joint. Abrasive blast methods shall be used to clean construction joints between concrete girders and adjoining deck slabs. When the optional construction joints shown on the plans are used, any additional reinforcing steel shall be furnished and placed by the Contractor at no expense to the Department.

Surfaces where concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete. When concrete is to be placed on or adjacent to hardened concrete surfaces, the surface shall be saturated surface dry. Saturated surface dry concrete has no water on its surface. The pores of the concrete beneath the surface are moist.

Where construction joints are allowed on visible surfaces, chamfer strips attached to the forms or other approved methods shall be utilized to provide an even joint appearance.

When the plans show new concrete to be joined to existing concrete by means of bar reinforcing dowels placed in holes drilled in the existing concrete, the diameter of the holes shall be the minimum needed to place nonshrink grout or epoxy grout and the dowel. Immediately before placing the dowels, the holes shall be cleaned of dust and other foreign material and sufficient grout placed in the holes so that there are no voids in the drilled holes after the dowels are inserted.

(k) Float Finish on Horizontal Surfaces. All freshly placed concrete on horizontal surfaces shall be given a float finish except as otherwise provided in the plans. Bridge decks and bridge sidewalks shall be finished per subsection 601.15(e). A float finish shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar surface. Creation of concave surfaces shall be avoided. After the concrete has been struck off, the surface shall be thoroughly worked and floated with a suitable floating tool. Before the finish has set, the surface cement film shall be removed with a fine brush in order to have a fine-grained, smooth but sanded texture.

(l) Loading Piers and Abutments. Superstructure dead loads shall not be applied until piers and abutments have attained a compressive strength of $0.80f'_c$.

Concrete compressive strength shall be determined by maturity meters per CP 69.

The Contractor shall provide an as-constructed survey of the abutments and piers before girder erection. The Contractor shall submit to the Engineer a copy of the survey notes detailing the girder seat elevations, anchor bolt locations and projections, and span distances from centerline of bearing to centerline of bearing. The survey notes shall indicate all adjustments necessary for bearing device dimensions other than those shown on the plans. The Contractor shall submit details for all adjustments to the Engineer for approval.

(m) Opening to Traffic. Concrete structures shall remain closed to traffic and shall not carry the Contractor's equipment, for 21 days after placement of the concrete deck is completed. The structure may be opened to traffic earlier if the concrete deck and all other concrete has attained the Field Compressive Strength given in Table 601-1. Concrete compressive strength shall be determined by maturity meters per CP 69.

In addition, for cast-in-place prestressed bridges, construction vehicles whose gross weight exceeds 2,000 pounds, shall not be allowed on any span until prestressing steel for that span has been tensioned.

(n) Epoxy Bonder. An epoxy bonder meeting the requirements of subsection 712.10 shall be used where epoxy bonder is called for on the plans.

(o) Backfilling Structures that Support Lateral Earth Pressure. Concrete compressive strengths shall reach f´c before backfilling operations can begin with heavy equipment, such as skid-steers or self-powered riding compactors. Concrete compressive strengths shall reach $0.80f'_c$. before backfilling operations can begin with hand-operated equipment. Concrete compressive strength shall be determined by maturity meters per CP 69.

601.13 Curing Concrete Other Than Bridge Decks. When the ambient temperature is below 35 °F the Contractor shall maintain the concrete temperature above 50 °F during the curing period. It shall be the Contractor's responsibility to determine the necessity for undertaking protective measures.

The minimum curing period shall be determined by one of the following methods. The Engineer shall review for adequacy, the Contractor's determination of the curing period.

(1) The minimum curing period shall be 120 hours.

(2) The minimum curing period shall be from the time the concrete has been placed until the concrete has met a compressive strength of 80 percent of the required field compressive strength. The Contractor shall develop a maturity relationship for the concrete mix design per CP 69. The Contractor shall provide the maturity meter and all necessary thermocouples, thermometers, wires and connectors. The Contractor shall place, protect and maintain the maturity meters and associated equipment. Locations where the maturity meters are placed shall be protected in the same manner as the rest of the structure.

Enclosures with artificial heat sources will be permitted. If enclosures are used the Contractor shall monitor the structural integrity of the enclosure. Artificial heat sources shall not be placed in such a manner as to endanger formwork or expose any area of concrete to drying due to excessive temperatures. At the end of the curing period, the protection shall remain in place until it can be removed without permitting the concrete temperature to fall more than 50 °F in a 24-hour period. Sudden changes in concrete temperature shall be prevented.

Immediately after placing fresh concrete, all concrete shall be cured by one of the following methods. The Engineer shall review for adequacy, the curing method proposed by the Contractor.

(a) Water Method. All surfaces other than slabs shall be protected from the sun and the whole structure shall be kept wet throughout the curing period. Surfaces requiring a Class 2 finish may have the covering temporarily removed for finishing, but the covering must be restored as soon as possible. All concrete slabs shall be covered as soon as possible with suitable material so that concrete is kept thoroughly wet for at least five days. The concrete surface shall be kept moist at all times by fogging with an atomizing nozzle until the covering is placed.

(b) Membrane Forming Curing Compound Method. Curing compound may be applied only to those surfaces that are to receive a Class I or Class 4 final finish. A volatile organic content (VOC) compliant curing compound conforming to ASTM C309, Type 2 shall be used on surfaces where curing compound is allowed, except that Type 1 curing compound shall be used on exposed aggregate or colored concrete, or when directed by the Engineer.

Curing compound shall not be used on construction joints. The rate of application of curing compound will be per the manufacturer's recommendation but shall not be more than 300 square feet per gallon. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after stripping of forms and acceptance of the concrete finish. If the surface is dry, the concrete shall be thoroughly wet with water and the curing compound applied just as the surface film of water disappears. The second application shall be applied after the first application has set. During curing operations, all unsprayed surfaces shall be kept wet with water. The coating shall be protected against marring for a period of at least 10 days after application. Coating marred, or otherwise disturbed, shall be given an additional coating. Should the surface coating be subjected continuously to injury, the Engineer may require that water curing, as described in subsection 601.13(a) be applied at once. When using a curing compound, the compound shall be thoroughly mixed within an hour before use. If the use of a curing compound results in a streaked or blotchy appearance, its use shall be discontinued. Water curing, as described in subsection 601.13 (a), shall then be applied until the cause of the defective appearance is corrected.

(c) Form Method. Concrete shall be protected by forms during the curing period. Forms shall be kept moist, when necessary, during the curing period to ensure the concrete surface remains wet.

(d) Blanket Method. Electrically heated curing blankets or insulation blankets may be used in cold weather to maintain the specified curing temperature and to retain moisture in the concrete. Blankets shall be lapped at least 8 inches and shall be free of holes. Blankets shall be secured at laps and edges to prevent moisture from escaping.

(e) The following procedures shall be followed if the temperature of the concrete structure falls below 32 °F before the concrete reaches 80 percent of the required field compressive strength:

(1) The Contractor will take cores at locations designated by the Engineer.
(2) The Engineer will take immediate possession of the cores and submit the cores to a petrographer for examination per ASTM C856.
(3) All costs associated with coring, transmittal of cores, and petrographic examination shall be borne by the Contractor regardless of the outcome of the petrographic examination.
(4) Concrete damaged by frost as determined by the petrographic examination shall be removed and replaced at the Contractor's expense.

601.14 Finishing Hardened Concrete Surfaces.

(a) General. Unless otherwise authorized, all formed surfaces shall be finished with Class 1 finish. Generally, for form-cured surfaces, this finish will be constructed immediately following curing.

Where curing compound is allowed by subsection 601.13(b), the Class I finish shall be applied immediately after the forms are removed and forms may be removed for only that portion of the work that can be finished in the remainder of a workday. The exposed concrete shall be kept damp during the finishing period and covered with the curing compound immediately following the completion of the finishing.

Structural Concrete Coating shall be the final finish for all concrete surfaces designated on the plans and in these specifications.

(b) Classes of Finish. The various classes of finish are described as follows:

1. Class 1, Ordinary Surface Finish. All fins and irregular projections shall be removed from all surfaces except those that are not to be exposed or are not to be waterproofed. On all surfaces, the cavities produced by form ties, honeycomb spots, broken corners or edges, and other defects shall be thoroughly cleaned, moistened with water, and carefully pointed and trued with a mortar consisting of cement and fine aggregate and the surface left sound, smooth, even, and uniform in color. Mortar used in pointing shall be not more than 30 minutes old. The mortar patches shall be cured as specified in subsection 601.13 or other approved methods. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

2. Class 2, Rubbed Finish. After completion of Class 1 Ordinary Surface Finish, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work the concrete shall be moistened with water. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing to thoroughly set. Surfaces to be finished shall be rubbed with a medium-coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in the same proportions as the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place.

   After all concrete above the surface being treated has been cast; the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform color.

   After the final rubbing is completed and the surface has dried, it shall be wiped with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder, and objectionable marks.

3. Class 4, Sand Blasted Finish. The cured concrete surface shall be sandblasted with hard, sharp sand to produce an even, fine-grained, uniform surface in which the mortar has been cut away. An exposed aggregate finish will not be required. However, aggregate exposed incidentally to achieving the specified surface will be acceptable.

4. Structural Concrete Coating. Unless otherwise shown on the plans, the coating shall be applied to all exposed concrete elements of the structure above the ground line, including the tops of all pier caps and abutment seats, and shall extend 1 foot below the finished ground line. Bridge bearing devices, curb and barrier cover plates, fence, and steel bridge rail shall be masked or otherwise protected to prevent structural concrete coating from coming into contact with them.

The final color of the Structural Concrete Coating shall have the Engineer's written approval before batching and application on the project. Approval of the final color of the coating will be determined by the Engineer as follows:

A. A 1-foot-by-1-foot sample of each color required by the plans shall be submitted to the Engineer. The sample coating shall be applied to surfaces similar in texture to the concrete surfaces where the coating will be applied on the project. The sample coating shall be applied by the same methods to be used in field application.

B. At least three weeks before beginning application of the Structural Concrete Coating, 100 square foot test panels shall be prepared for each color selected by the Engineer. The test panels shall be produced on the actual concrete surface where the final product will be placed, at a location designated by the Engineer where all the required color and texture combinations may be viewed adjacent to each other. The coatings shall be applied to the test panels by the same methods to be used in the final field application. The Engineer shall be allowed one week after application of the last test panel for review and approval.

Concrete surfaces that the structural concrete coating will be applied shall be prepared as follows:

(1) Following curing of the concrete per subsection 601.13, all projections and bulges shall be removed and the surface sandblasted. Sandblasting shall profile the concrete surface, remove all form release agents, and all other deleterious materials that would inhibit the bond of the Structural Concrete Coating. The profile of the sandblasted concrete surface shall be equivalent to Concrete Surface Profile Three (CSP 3) as defined in Technical Guideline No.03732, "Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays" by the International Concrete Repair Institute. The Contractor shall provide a CSP 3 chip for use on the project.

(2) A mortar mix, proportioned by volume, consisting of one part portland cement, two to three parts sand (conforming to the requirements of ASTM C144), and an approved bonding agent shall be used to patch all holes produced by form ties, honeycombing, voids 1/2 inch or larger in any dimension, broken corners and edges, and other defects. The mortar mix shall include an approved bonding agent. The quantity and application procedure of the bonding agent shall be per the recommendations of the manufacturer of the bonding agent. Areas to be patched shall be moistened with water before the mortar is applied, and the patched area shall be float finished and left flush with the concrete surface without checking or cracking of patches. Patching shall be done when the ambient temperature is at least 40 °F. Holes deeper than 3/4 inch shall be filled in layers that do not exceed 3/4 inch in thickness.

(3) Within 24 hours before applying Structural Concrete Coating, the concrete surface to be coated shall be cleaned by water blasting at a minimum pressure of 3,000 psi to remove dust, dirt, and other materials that would inhibit the bonding of the coating. If the surface is contaminated before application of the coating, it shall be recleaned as required before application of the coating.

New concrete shall be at least 28 days old or as approved in writing by the coating manufacturer before the coating is applied.

The coating shall be applied at a rate that will provide a minimum dry film thickness of 10 to 12 mils without texturing agent. The coating shall be mixed by a mechanical mixer and applied by spraying. Workmanship shall be such that the final coated surface is colored and textured uniformly and presents a pleasing appearance. All areas determined by the Engineer to be insufficiently coated shall be recoated.

The coating shall be applied only when the ambient temperature is between 40 °F and 90 °F and is anticipated to remain above 40 °F for a minimum of 24 hours. The surface to be coated shall be dry and free of frost.

601.15 Bridge Deck Placing, Consolidating and Finishing. The Contractor shall prepare a written Process Control Plan (PCP) that defines the process control measures the Contractor will use to ensure the placing, consolidating, and finishing, curing, and weather protection of the bridge deck conforms to the Contract requirements. The Contractor may refer to the Structural Concrete Pre-pour Conference Agenda in the department's Construction Manual for examples of items that should be included in the PCP. It shall also identify the Contractor's method for ensuring that the provisions of the PCP are met. The Contractor shall submit the PCP to the Engineer for written approval before the Pre-pour Conference.

A Pre-placement Conference shall be held at a time mutually agreed upon before the initial placement of bridge deck concrete. Representatives of the ready-mix producer and the Contractor shall meet with the Engineer to discuss the following topics:

- Concrete Mix materials and Proportions (cement content, effect of admixtures, etc.).
- Work Schedule.
- Applicable Specifications and Special Notes.
- Delivery Details.
- Planned Construction Joint Locations.
- Role of All Personnel.
- Construction Details - surface preparation, finish, joint locations, etc.
- Testing Requirements.
- Acceptance Criteria.
- Contingency Plans for Wind, Rain, Breakdown, etc.
- Curing Details.

(a) Surface Preparation. Tops of girders, precast deck panels, pier caps, and abutments that will come into contact with bridge deck concrete shall be heated to raise the temperature above 35 °F before concrete placement. The proposed preheating method is subject to approval by the Engineer.

(b) Placing. Concrete shall be placed per the requirements of subsection 601.12 except for the following:

Concrete shall be placed in such manner as to require as little handling as possible and at sufficient depth to provide adequate material for screeding and finishing operations. The concrete shall be discharged as near its final location as practicable. The pattern of placement shall be such that lateral flow will be minimized. Concrete shall be placed against the leading edge of fresh concrete where practicable.

Transverse joints may be used when the Engineer determines that the work is not progressing in a satisfactory manner, or when required by a change in weather conditions.

The Engineer may approve transverse joint locations to accommodate phased overlay construction.

(c) Consolidating. Consolidation shall conform to subsection 601.12(e) and to the following: The Contractor shall provide suitable mechanical vibrators to disperse the batch at the point of discharge and to densify the concrete within the forms. The bond of fresh concrete to concrete previously placed shall be achieved by vibrating the new concrete together with the old. Immersion vibrators shall operate at a speed of at least 10,000 vibrations per minute in air. Internal vibration may be used along the edges of forms and in areas of congested reinforcing. A combination of immersion vibration and surface consolidation shall be used.

(d) Finishing. Following consolidation, the concrete shall be struck off and finished by mechanical longitudinal floating, mechanical rolling, surface vibration, or a combination of any of these methods. Surface vibrators shall be of the low frequency, high-amplitude type, operating at a speed of 3,000 to 4,500 vibrations per minute.

A paver's steel scraping straightedge or lute, 4-inch maximum width, shall be the only hand tool permitted on deck surfaces, except for a minimum use of hand floats and edgers along the forms and in areas where machine finishing cannot be effectively used. Only minimum hand finishing will be permitted. If the surface of the deck slab becomes dry immediately following finishing operations, due to an excessive evaporation rate, it shall be covered with wet burlap or fogged with water covering the entire deck surface using pneumatic atomizing nozzles. The fog spray shall be just enough to retard surface evaporation and shall not change the water-cement ratio. During periods of excessive drying, a cover of wet burlap or plastic sheeting shall be maintained on the slab at all times until final cure is placed. Monomolecular film coatings applied to the surface of the slab to retain moisture may be used provided they effectively retard surface evaporation and are adequately maintained until the final cure is placed.

Surfaces of bridge decks and bridge approach slabs that will be the final riding surface shall be finished as follows:

1. Final Finish. For the final finish a seamless strip of plastic turf shall be dragged longitudinally over the full width of the bridge deck after a seamless strip of burlap or other approved fabric has been dragged longitudinally over the full width of bridge deck to produce a uniform surface of gritty texture.

   The drags shall be mounted on a bridge other than the bridge to be furnished for Department use. The dimensions of the drags shall be such that a strip of material at least 3 feet wide is in contact with the full width of pavement surface while each drag is used. The drags shall consist of sufficient material and be maintained in such a condition that the resultant surface finish is of uniform appearance and reasonably free from grooves over 1/16 inch in depth. Where more than one layer of burlap drag is required, the bottom layer shall be approximately 6 inches wider than the layer above. Drags shall be maintained clean and free from encrusted mortar. Drags that cannot be cleaned shall be discarded and new drags installed.

2. Texturing. When posted speeds are 40 mph or higher, the finish shall be a grooved finish conforming to the following:

   After the Engineer has accepted the finished surface, and after the concrete has cured for at least seven days, the bridge deck surface shall be textured by grooving with a mechanized saw (sawed grooves). Grooving shall be done before the application of the concrete sealer. Only multi-blade saw cutting equipment furnished with circular blades may be used. Single blade equipment may be authorized by the Engineer where multi-blade assemblies do not allow sawing a distance of one foot from obstructions.

   The grooving shall be rectangular and conform to the following:

   Depth:1/8 inch ± 1/32 inch
   Width:1/8 inch ± 1/32 inch
   Spacing:3/4 inch ± 1/32 inch center to center

   Grooves shall be longitudinal and parallel to the centerline of the roadway. Overlapping of grooves by succeeding passes will not be permitted. The grooves shall terminate 1.5 feet from the face of the curb or bridge rail on each side of the overlaid bridge deck.

3. Grooving To Bridge Joint System. For joint systems that are perpendicular to the roadway centerline, grooving shall extend to 9 inches plus or minus 3 inches from the armor of the joint.

   For the joint systems that are not perpendicular to the centerline of the roadway, grooving shall remain parallel to the centerline and shall not be nearer than 6 inches to the joint armor nor farther than 4 feet from the joint armor. The distance between grooves, from one side to the other of the joint system, shall not exceed 5 feet.

   The Contractor shall maintain the grooving equipment so that aggregate particles or cement build-up on the saws is promptly cleared or cleaned so that the grooves are neat, true, and in conformance with the specified dimensions.

(e) Surface Smoothness – All Bridge Deck Surfaces. Acceptability of the deck surface will be determined as follows: The Contractor shall furnish a 10-foot straightedge or other approved device. When the concrete is sufficiently hard, the Contractor shall test the bridge deck surface with the 10-foot straightedge or other approved device. Areas showing high spots of more than 1/8 inch but not exceeding 1/2 inch in 10 feet shall be marked. The marked area shall be immediately ground with an approved grinding tool so that the surface deviation will not be in excess of 1/8 inch in 10 feet. Grinding shall not reduce the concrete cover on reinforcing steel to less than 1 3/4 inches, (2 3/4 inches for bare decks without an overlay). Decks that require additional corrective action shall be corrected with a concrete overlay approved by the Engineer.

(f) Movable Bridges. Movable bridges or platforms shall be provided by the Contractor and moved as directed to allow the inspectors to work over the freshly placed plastic concrete. A movable bridge shall be kept as close to the finishing screed as practical. The deck of the movable bridges shall be a minimum of 24 inches wide and no more than 24 inches above the surface of the concrete and shall be capable of supporting two people. The Contractor shall provide additional movable bridges as appropriate for the work.

(g) Concrete Bridge Sidewalks. Bridge sidewalks shall receive a final transverse broom finish.

(h) Crack Repair. If cracks in the deck concrete with a width of 0.035 inches or greater occur within two weeks of placement, those cracks shall be repaired at the Contractor's expense. Cracks will be measured by the Engineer by insertion of a wire gauge at any time and temperature within the two weeks. The repair shall consist of filling the cracks with low viscosity, two-part, methacrylate, or an approved equal. The repair shall be per the recommendations of the manufacturer of the crack filling material.

601.16 Curing Concrete Bridge Decks.

The minimum curing period shall be 120 hours.

The concrete surface shall be kept moist at all times by fogging with an approved atomizing nozzle or applying a monomolecular film coating to retard evaporation until the curing material is in place.

Concrete bridge decks, including bridge curbs and bridge sidewalks, shall be cured as follows:

(a) Decks placed from May 1 to September 30 shall be cured by the membrane-forming curing compound method followed by the water cure method as follows:

1. Membrane Forming Curing Compound Method. A volatile organic content (VOC) compliant curing compound conforming to ASTM C309, Type 2 shall be uniformly applied to the surface of the deck, curbs, and sidewalks at the rate of 1 gallon per 100 square feet. The curing compound shall be applied as a fine spray using power-operated spraying equipment. The power-operated spraying equipment shall be equipped with an operational pressure gauge and a means of controlling the pressure. Before and during application the curing compound shall be kept thoroughly mixed by recirculation or a tank agitator. The application shall be within 20 feet of the deck finishing operation. When the finishing operation is discontinued, all finished concrete shall be coated with curing compound within1/ 2 hour. The curing compound shall be thoroughly mixed within one hour before use.
2. Water Cure Method. The water cure method shall be applied as soon as it can be without marring the surface. The surface of the concrete, including bridge curbs and bridge sidewalks, shall be entirely covered with wet burlap and polyethylene sheeting. Before being placed, the burlap shall be thoroughly saturated with water. The wet burlap and polyethylene sheeting shall extend at least twice the thickness of the bridge deck beyond the edges of the slab and shall be weighted to remain in contact with the surface. The wet burlap and polyethylene sheeting shall remain in contact and be kept wet for the entire curing period.

(b) Decks placed between November 1 and March 31 shall be cured by application of a membrane-forming curing compound followed by the blanket method as follows:

1. Membrane Forming Curing Compound Method. This method shall be applied per subsection 601.16(a)1.

2. Blanket Method. Curing blankets with a minimum R-Value of 0.5 shall be placed on the deck as soon as they can be without marring the surface. Blankets shall be loosely laid (not stretched) and adjacent edges suitably overlapped with continuous weights along the lapped joints. The blankets shall remain in place for a minimum of five days after placement.

(c) Decks placed in April or October may be cured per either subsection 601.16(a) or 601.16(b).

(d) For decks above an elevation of 8,000 feet above mean sea level, the Engineer may modify the time of year requirements for the cure methods defined in subsection 601.16(a) and 601.16(b).

(e) When the ambient temperature is expected to fall below 40 °F during the curing period, the Contractor shall maintain the internal concrete temperature above 50 °F during the curing period and until the concrete has developed a compressive strength of 0.80f'c. The Contractor shall provide suitable measures such as straw, additional burlap, ground heaters, or other suitable blanketing materials, and/or housing and artificial heat to maintain the internal concrete temperature above 50 ºF.

Concrete shall not be placed on forms, girders, or deck panels that have a surface temperature less than 35 °F. Forms, girders, or deck panels where concrete is to be placed shall be free of snow, ice, and frost. Salt shall not be used to thaw ice, snow, or frost. Heating forms, girders, or deck panels prior to concrete placement may be required.

When the Contractor chooses to use an enclosure, the Contractor shall enclose the area underneath the deck and heat it so that the temperature of the enclosed air is as close as possible to the temperature of the enclosed air above the concrete. When artificial heating is used to maintain the concrete temperature, adequate ventilation shall be provided to limit exposure to carbon dioxide, and the enclosed air temperature shall not exceed 90 ºF. During the curing period, the Contractor shall monitor the air temperature within the enclosure at intervals acceptable to the Engineer. The Contractor shall monitor and maintain the structural integrity of the enclosure. Heating of the enclosure may be stopped after 72 hours if the air achieved 0.80f'c. For every day that the internal temperature of the concrete is below 50 ºF during the curing period, an additional day of curing with a minimum internal concrete temperature of 50 ºF will be required unless the concrete has achieved 0.80f'c. After completion of the required curing period, the Contractor shall remove the enclosure in such a manner that the temperature of the concrete during the following 24 hours does not fall by more than 25 °F.

When the Contractor chooses not to use an enclosure, after the curing period and after the concrete has achieved 0.80f'c, the Contractor shall remove the protection in such a manner that the temperature of the concrete during the following 24 hours does not fall by more than 25 °F. For every day that the internal temperature of the concrete is below 50 ºF during the curing period, an additional day of curing with a minimum internal concrete temperature of 50 ºF will be required unless the concrete has achieved 0.80f'c.

Internal concrete temperature shall be determined by using thermocouples. Thermocouple wire, connectors, and handheld thermometer shall be supplied by the Contractor. The Contractor shall install the thermocouples at locations designated by the Engineer.

Concrete compressive strength shall be determined by maturity meters. The Contractor shall develop maturity relationships for each mix placed during the cold weather conditions in accordance with CP 69. The maturity relationship shall be submitted to the Engineer prior to cold weather concrete placement. The Contractor shall provide the maturity meters and all necessary wires and connectors. The Contractor shall be responsible for the placement, protection, and maintenance of the maturity meters and wires. Locations where the maturity meters are placed shall be protected in the same manner as the rest of the concrete.

Heat sources shall not be placed in such a manner as to endanger formwork or expose any area of concrete to drying due to excessive temperatures.

If the internal concrete temperature at any location in the bridge deck concrete falls below 32 °F during the first 24 hours of the curing period, the Engineer may direct the Contractor to core the areas in question at the locations indicated by the Engineer. The Engineer will take immediate possession of the cores. The Engineer will submit the cores to a petrographer for examination in accordance with ASTM C856. Concrete damaged by frost, as determined by the petrographer, shall be removed and replaced at the Contractor's expense. All costs associated with coring, transmittal of cores, a petrographic examination shall be borne by the Contractor regardless of the outcome of the petrographic examination.

601.17 Acceptance and Pay Factors. These provisions apply to all concrete. The Contractor shall sample concrete for both Process Control (PC) and Owner Acceptance (OA) per CP 61. The Engineer will witness the sampling and take possession of the OA samples at a mutually agreed upon location. The Contractor shall be responsible for Process Control (PC) testing for concrete. PC testing shall be performed at least once per day and then once per 50 cubic yards for concrete slump, unit weight, and concrete temperature.

If the produced concrete does not have a relative yield of 0.99 to 1.02 for two consecutive yield determinations, concrete production shall cease, and the Contractor shall present a plan to correct the relative yield to the Engineer.

When SCC is used, the Contractor shall test the first load of SCC before placement for Slump Flow (ASTM C1611) and Blocking Assessment (ASTM C1621). The Contractor shall take a sample from the first portion of the load and complete the slump flow and blocking assessment before depositing any portion of the load. The tests shall not be performed more than 15 minutes before placement. The slump flow shall be 20 to 26 inches. The blocking assessment shall be less than or equal to 2.0 inches. The Contractor will be allowed to make adjustments to the load with admixtures. After adjustments have been made, the slump flow and blocking assessment shall be retested. Each subsequent load of SCC shall be tested for Slump Flow. If the slump flow differs from the first load by more than 2.0 inches, the load shall be adjusted to have a slump flow within 2.0 inches of the first load, or the load may be tested for Blocking Assessment (ASTM C1621). If the load is tested for and meets the requirements for Blocking Assessment (ASTM C1621), the load’s slump flow will be used for the acceptance of the following loads. When concrete placement is halted for more than 15 minutes, the slump flow and blocking assessment shall be retested before resuming placement. When the slump flow exceeds 26 inches, the concrete may be placed if the depth of penetration is less than 11 millimeters when tested using ASTM C1712 Test Method for Static Segregation Resistance of Self-Consolidating Concrete. If a load of concrete has a

slump flow greater than 26 inches and a depth of penetration less than 11 millimeters, the next load shall be tested for slump flow and blocking assessment to establish a new slump flow target.

When SCC is used, subsection 601.17(b) does not apply.

When SCC is used, the test methods for fabricating specimens per subsections 601.17(a) and 601.17(c) acceptance shall be modified to use ASTM C1758, Practice for Fabricating Test Specimens with SCC, for filling the test specimens with concrete.

(a) Air Content. The first three batches at the beginning of each day's production shall be tested by the Contractor's PC and CDOT's OA for air content. When the PC and OA air content measurements differ by more than 0.5 percent, both the PC and OA air meters shall be checked per ASTM C231. When air content is below the specified limit, it may be adjusted per subsection 601.08. Successive batches shall be tested by the Contractor's PC and witnessed by the Engineer until three consecutive batches are within specified limits. After the first three batches, CDOT will follow the random minimum testing schedule. After the first three batches, the Contractor shall perform PC testing at a frequency of one random sample per 50 cubic yards. Air content shall not be adjusted after a CDOT OA test.

At any time during the placement of the concrete, when an OA test on a batch deviates from the minimum or maximum percent of total air content specified, the batch that deviates from the specified air content by 1 percent or less may be accepted at a reduced-price using Table 601-3.

Portions of loads incorporated into structures before determining test results that indicate rejection as the correct course of action shall be subject to acceptance at reduced price, no payment, or removal as determined by the Engineer.

(b) Slump. Except for Class BZ concrete, the slump of the delivered concrete shall be the slump of the approved concrete mix design plus or minus 2.0 inches. The maximum slump shall be 9.0 inches. Slump acceptance, but not rejection, may be visually determined by the Engineer. Any batch that exceeds the slump of the approved concrete mix design by more than 2.0 inches will be retested. If the mix design slump is exceeded by more than 2.0 inches a second time, that load will be rejected. If the slump is greater than 2 inches lower than the approved concrete mix design, the load may be adjusted by adding a water reducer or by adding water (if the w/cm allows) and retested.

Portions of loads incorporated into structures before determining test results that indicate rejection as the correct course of action shall be subject to reduced payment or removal as determined by the Engineer.

(c) Strength (When Specified). The concrete will be considered acceptable when the running average of three consecutive strength tests per mix design for an individual structure is equal to or greater than the specified strength and no single test falls below the specified strength by more than 500 psi. A test is defined as the average strength of three test cylinders cast in plastic molds from a single sample of concrete and cured under standard laboratory conditions before testing. If the compressive strength of any one test cylinder differs from the average by more than 10 percent, that compressive strength will be deleted and the average strength will be determined using the compressive strength of the remaining two test cylinders.

When the average of three consecutive strength tests is below the specified strength, the individual low tests will be used to determine the pay factor per Table 601-3. If less than three strength tests are available the individual low tests, if any, will be used to determine the pay factor per Table 601-3. The pay factor will be applied to the quantity of concrete represented by the individual low test. For concrete having a specified strength of less than 4,500 psi, when the compressive strength test is below the specified strength by more than 500 psi, the concrete represented will be rejected. For concrete having a specified strength of 4,500 psi or greater, when the compressive strength test is below the specified strength by more than 500 psi but not more than 1,000 psi, the concrete represented will be evaluated by the Department for removal, corrective action, or acceptance at a reduced price. All costs of the evaluation shall be at the Contractor's expense. When the compressive strength test is below the specified strength by more than 1,000 psi, the concrete represented will be rejected.

The Contractor may take cores at its own expense and per Colorado Procedure 65 within 10 working days of being notified of a price reduction or up to 45 days after placement, whichever is later, to provide an alternative determination of strength. Price reduction for strength will be based on the 28-day compressive strength of acceptance cylinders or corresponding cores strength, whichever is greater. If the core compressive strength is at least 90 percent of the specified field compressive strength, the concrete represented by the cores will be accepted with no price reduction.

The Engineer may use cores to determine acceptance or rejection of a part of the structure instead of acceptance cylinders. The Engineer will notify the Contractor in writing that CDOT will core the structure. The location of the coring will be directed by the Engineer. Coring and testing will be performed at the expense of the Department regardless of the result. Cores will be taken and tested per AASHTO T24 between 28 days and 45 days after concrete placement. Cores will be a minimum of 4 inches in diameter unless otherwise approved by the Engineer. A minimum of three cores in a two-square-foot area will be obtained for locations of the structure that are suspect. If the compressive strength of any one core differs from the average by more than 10 percent, that compressive strength will be deleted and the average strength will be determined using the compressive strength of the remaining two cores. If the compressive strength of more than one core differs from the average by more than 10 percent, the average strength will be determined using all three compressive strengths of the cores. If the average core compressive strength is greater than or equal to 85 percent of the specified 28-day compressive strength, the concrete represented by the cores will be accepted. If the average core compressive strength is less than 85 percent of the specified 28-day compressive strength, the structure will be evaluated by the Department according to subsection 105.03 for removal and replacement. Pay factors will not be based on cores taken by the Engineer. If the concrete represented by the cores is accepted, all costs associated with the repair of the core holes, including preparation and submittal of the repair method, will be measured and paid for separately.

After the Department performs additional core testing as described above, the Contractor may make one request that the structure be cored by the Contractor, tested and re-evaluated by the Department within 45 days after concrete placement. Coring and testing costs will be at the expense of the Contractor regardless of the result. Cores shall be taken at the same area of the structure as those obtained by the Engineer. The Engineer will approve the location of the cores before the Contractor coring the structure. All costs associated with the repair of these core holes including preparation and submittal of the repair method, will not be measured and paid for separately but shall be included in the work.

If the concrete in the structure is found to be sufficient resulting time delays will be considered excusable. If the concrete in the structure is still found to be deficient, resulting time delays will be considered nonexcusable for this evaluation. Compensation for time delays will be evaluated by the Engineer per subsection 108.08.

The Contractor shall submit a proposed repair method for the core holes for approval before coring. The method shall use an approved nonshrink concrete patching material with a minimum compressive strength of 4,500 psi. The Contractor shall submit the manufacturer's recommendations along with the repair method. The Engineer will review and approve the proposed methodology before patching.

The Engineer will distribute electronically to the concrete supplier all compressive strength Owner Acceptance (OA) data for the concrete supplied to the project. The Engineer will distribute the OA compressive strength data within two business days of the 7-day and 28-day compressive strength testing. The data will include the compressive strength and batch ticket number at a minimum. The Contractor shall not have a valid dispute or claim as a result of any action or inaction by the Department related to the distribution of test results.

(d) Pay Factors. The pay factor for concrete that is allowed to remain in place at a reduced price shall be determined according to Table 601-3 and shall be applied to the unit price bid for the Item.

If deviations occur in air content and strength within the same batch, the pay factor for the batch shall be the product of the individual pay factors.

Table 601-3
PAY FACTORS FOR DEVIATIONS ON
CONCRETE AIR CONTENT AND STRENGTH

Below Specified Strength (psi) [≥ 4500 psi Concrete]	*Pay Factor (Percent)
1 – 100	98
101 – 200	96
201 – 300	92
301 – 400	84
401 – 500	75
	Reject
501 – 600	65
601 – 700	54
701 – 800	42
801 – 900	29
901 – 1000	15
Over 1000	Reject

Below Specified Strength (psi) [< 4500 psi Concrete]	*Pay Factor (Percent)
1 – 100	98
101 – 200	96
201 – 300	92
301 – 400	84
401 – 500	75
Over 500	Reject

Deviations From Specified Air (Percent)	*Pay Factor (Percent)
0.0 – 0.2	98
0.3 – 0.4	96
0.5 – 0.6	92
0.7 – 0.8	84
0.9 – 1.0	75
Over 1.0	Reject

Table 601-3 Notes: *Concrete represented by out-of-spec tests will only be priced reduced with the lowest pay factor, not for each pay factor.

(e) Bonding of Bridge Deck Overlay. After the curing period for Class DT concrete has elapsed, the overlay shall be "sounded" by the Contractor per ASTM D4580 Standard Practice for Measuring Delamination in Concrete Bridge Decks by Sounding to determine if the Class DT concrete has bonded to the bridge deck. In areas where the Class DT concrete has not bonded to the bridge deck, it shall be removed and replaced at the Contractor's expense.

(f) Maturity Meter Strength. When maturity meters are specified for determining strength for removing forms, removing falsework, backfilling against structures, or loading the structure, the Contractor shall provide the Engineer a report of maturity relationships per CP 69 before placement of concrete.

If a maturity meter fails, is tampered with, destroyed, or was not placed, the following shall apply:
The minimum curing time or waiting time for removing forms, removing falsework, backfilling against structures, or loading the structure shall be 28 days.

The Contractor may choose at his own expense to core the structure represented by the maturity meter. Cores shall be obtained and tested according to CP 65. Cores shall be a minimum of 4 inches in diameter. A minimum of three cores in a two-square-foot area shall be obtained. If the compressive strength of any one core differs from the average by more than 10 percent, that compressive strength will be deleted and the average strength will be determined using the compressive strength of the remaining two cores. If the compressive strength of more than one core differs from the average by more than

10 percent, the average strength will be determined using all three compressive strengths of the cores. The average compressive strength of the cores shall achieve the specified compressive strength of the structure. A structure may be cored only once.

(g) Water to Cementitious Material Content (w/cm) Ratio. The maximum w/cm ratio is the ratio that was used in the laboratory trial mix for the Concrete mix design. The w/cm ratio shall be determined for each batch of concrete by the Contractor and provided to the Engineer for approval before placement. If an adjustment to the mix is made after the Engineer's approval, the w/cm ratio shall be determined and submitted to the Engineer before the continuation of placement. Concrete that is placed without the Engineer's approval shall be removed and replaced at the Contractor's expense.

601.18 Unless otherwise stated in the plans or specifications, tolerances for concrete construction and materials shall be per ACI 117.

Cast in place bridge decks and bridge slabs shall be no more than 1/2 inch thicker nor more than 1/4 inch thinner than the cross-sectional vertical dimension shown on the plans.

METHOD OF MEASUREMENT

601.19 Concrete will be measured by the cubic yard per the dimensions shown on the plans. Plan quantities reflect deductions for all voids designed into the structure except, deductions will not be made for the volume occupied by pipes or conduits less than 3 inches in diameter, ducts for prestressing steel, reinforcing steel, anchors, weep holes, piling, and form liner textures and nominal chamfers.

Concrete of the various classes will not be remeasured but will be the quantities shown on the plans. Exceptions for each class for each structure will be:

(1) when field changes are ordered,

or

(2) when it is determined that there are discrepancies on the plans in an amount plus or minus 2 percent of the plan quantity for the structure.

Bridge concrete shall consist of structural concrete, of the designated class, required for bridge construction shown on the plans, completed and accepted.

Box culvert concrete shall consist of structural concrete, of the designated class, required for concrete box culvert construction including wingwalls, shown on the plans, completed and accepted.

Wall concrete shall consist of reinforced structural concrete, of the designated class, required for the construction of walls that are not part of bridges or box culverts, completed and accepted.

Miscellaneous concrete shall consist of the structural concrete of the designated class shown on the plans, except bridge, box culvert, or wall concrete, completed and accepted.

Bridge Deck Finish (Sawed Grooves) will be measured by the square yard. The area includes the length of the bridge and approach slabs, with deductions for areas occupied by expansion devices as specified, multiplied by the width of the roadway between the faces of curb or bridge rail on each side, less 3.0 feet. Bridge Deck Finish (Sawed Grooves) will not be measured in the field but will be the quantity shown on the plans. Exceptions for each structure will be:

(1) when field changes are ordered, or
(2) when it is determined that there are discrepancies on the plans in an amount of plus or minus 2 percent of the plan quantity for the structure.

When permanent deck forms are optional, bridge deck concrete and reinforcing steel shown on the plans, which are based on a conventionally reinforced deck, will be paid for per Sections 601 and 602, under Pay Item 601, Structural Concrete, and Pay Item 602, Reinforcing Steel. Quantities of bridge deck concrete and reinforcing steel will not be measured in the field, but will be the quantities shown on the plans, except when a plan change is ordered or when it is determined that there are discrepancies in an amount of plus or minus 2 percent of the plan quantity.

When permanent deck forms are required, bridge deck concrete and reinforcing steel will be paid for per Section 601 and 602, under Pay Item 601, Structural Concrete, and Pay Item 602, Reinforcing Steel. Quantities of bridge deck concrete and reinforcing steel will not be measured in the field, but will be the quantities shown on the plans, except when a plan change is ordered or when it is determined that there are discrepancies in an amount of plus or minus 2 percent of the plan quantity.

When precast panel deck forms are required, they will be measured and paid for per Section 618. Concrete and all reinforcing or prestressing steel required for the panels will not be measured and paid for separately but shall be included in the work.

Structural Concrete Coating will not be measured in the field but shall be the surface area quantity shown on the plans; except those measurements to be made when field changes are ordered, or for an error of plus or minus 5 percent of the plan quantity for each structure to be coated.

Maturity meters, thermocouples, and information cylinders will not be measured and paid for separately but shall be included in the work.

BASIS OF PAYMENT

601.20 The accepted quantities will be paid for at the contract unit price per unit of measurement for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Concrete Class _____	Cubic Yard
Concrete, Class_____(Bridge)	Cubic Yard
Concrete, Class_____(Box Culvert)	Cubic Yard
Concrete, Class_____(Wall)	Cubic Yard
Concrete, Class_____(Miscellaneous)	Cubic Yard
Bridge Deck Finish (Sawed Grooves)	Square Yard
Structural Concrete Coating	Square Yard

Payment will be full compensation for all work necessary to complete the designated Pay Item per subsection 109.02.

Polyolefin fiber reinforcement will not be measured and paid for separately but shall be included in the work.

Payment for structural concrete coating will be full compensation for all work and materials necessary to complete the item and shall include, but is not limited to:

(1) Water based form release agent.

(2) Sample preparation.

(3) Abrasive blasting.

(4) Patching materials and application.

(5) Structural Concrete Coating and application.

When requested by the Engineer, the Contractor shall provide the Engineer with a certified invoice from the coating supplier indicating the total volume of Structural Concrete Coating supplied to the project.

Epoxy bonder material when specified on the plans will not be paid for separately but shall be included in the work.

When permanent steel bridge deck forms are specified or allowed by the Contract, they will not be paid for separately but shall be included in the work, including all labor and additional concrete and other materials required to use these forms.

Concrete finish is included in the work unless a separate pay item is included in the bid schedule.

The Contractor's PC testing will not be measured and paid for separately but shall be included in the work.

DESCRIPTION

601.21 This work consists of furnishing and placing concrete patching material on existing bridge decks and expansion joint replacements per these specifications and in conformity with the lines, grades and dimensions as shown on the plans or established.

MATERIALS

601.22 The concrete patching material may be pre-packaged Concrete patching material or Class DR concrete.

(a) Pre-Packaged Concrete Patching Material. Concrete patching material shall be polymer-modified hydraulic cement from the CDOT Approved Products List (Concrete/Repair/Patching/Class DR [Pre-Packaged]). Concrete patching materials shall demonstrate 1/32-inch maximum mid panel and end crack widths, 0 percent delamination, and 0 percent spalling as tested by National Transportation Product Evaluation Program (NTPEP) in a one-year field evaluation. The Contractor shall refer to rapid-set concrete patch materials at www.ntpep.org.

The Contractor shall obtain and provide to the Engineer documentation from the Concrete patching material supplier stating the expiration dates of the material components that will be used on the project.

Concrete patching material shall attain an average compressive strength of at least 2,500 psi before placing traffic and 4,500 psi at 28 days. Concrete patching material compressive strengths shall be tested according to ASTM C39 or ASTM C109. The compressive strengths shall be used to develop a strength versus time curve for the material. Three strength data points shall be determined to assess the necessary time to wait before traffic is allowed on the material. Maturity meter data will be submitted to allow the use of the maturity meter to determine when the patching material has gained the required strength for opening to traffic.

Concrete patching material shall provide a minimum bond strength of 2,000 psi at 28 days, as tested by ASTM C882.

Concrete patching material shall have a relative durability factor greater than 90 and a mass loss not to exceed 2.0 percent as tested by ASTM C666.

Concrete patching material shall have a maximum expansion of 0.05 percent, at 28 days as tested by ASTM C157

ASTM C39, C109, C882 and C157 testing shall be from the same lot of concrete patching material being used on the project. A CTR, per subsection 106.13, shall be submitted to the Engineer for approval at least 2 weeks before placement.

Two bags of the concrete patching material, and two bags of the extending aggregate if used, from the same lot to be used on the project shall be submitted to an accredited Lab to verify compressive strength, and set time properties, by the Contractor before the concrete patching material is to be used on the project. Test results shall be submitted to the Engineer for acceptance. Verification of the strength properties will be achieved if the test results are either equal in strength or stronger than those advertised. Verification of the set time will be achieved if the set time is equal or less than the advertised value. Testing shall be included in the cost of the materials. Test results from other projects using the same lot may be submitted. If the project uses material from more than one lot, test results are required for each lot used.

(b) Class DR Concrete. Class DR Concrete shall have an air content of 5 to 8 percent, a maximum water to cement ratio of 0.44, a minimum 6-hour compressive strength of 2,500 psi, and a minimum 28-day compressive strength of 4,500 psi. The concrete mix shall consist of a minimum of 50 percent AASHTO M 43 Size No. 7 or Size No. 8 coarse aggregate by weight of total aggregate. Lab test results shall show that the unrestrained shrinkage is less than 0.050 percent when tested by CP-L 4103 and ASTM C1202 test results shall not exceed 2500 coulombs at 56 days of age. ASTM C150 Type III cement may be used.

Materials, proportioning, batching, and mixing requirements of subsections 601.03 through 601.07 shall apply to Class DR concrete. Concrete Class DR shall meet Sulfate Level 0 requirements.

The Contractor shall develop maturity relationships per CP 69. The Contractor shall provide a multi-channel maturity meter and all necessary wire and connectors. The Contractor shall be responsible for the placement and maintenance of the maturity meter and wire. Placement shall be as directed by the Engineer.

CONSTRUCTION REQUIREMENTS

601.23

(a) Pre-Packaged Concrete Patching Material. Concrete patching material shall be placed in the repair areas before the expiration date of the material. Proportions of all mix components shall be measured by volume measurement (number of bags of standard weight and quantity of water or liquid component in gallons or quarts). If partial bags are used the bagged mix, extending aggregate, and water shall be weighed on a calibrated scale provided by the Contractor. The Contractor shall submit the Concrete patching material mix design for approval two weeks before any concrete patching material is placed. The Contractor shall also submit a method statement describing what type of equipment will be used to batch the patching material, including the type of mixer, the type of material, volume measures to be used, scales for partial bags, procedures to ensure accurate proportioning of the patching material components, and tools to be used in placing and finishing the surface of the patch.

The Contractor shall produce a batch ticket for each mixed batch of concrete patching material with the following information shown on each ticket:
(1) Project Number
(2) Bridge Number
(3) Structure Temperature
(4) Date and Time of batch
(5) Material Type, name, and manufacturer
(6) Material expiration date
(7) Weight or volume of bag mix concrete
(8) Weight or volume of extending aggregate.
(9) Weight or volume of water or liquid component
(10)Location of placement (Lane and Station Limits)

The tickets shall be available on site for CDOT personnel to inspect.

Each day the Contractor shall provide to the Engineer tickets for each bridge in separate envelopes stating Project Number, Bridge Number, Date of Paving, Type of Material, Daily Total, and Cumulative Total.

Concrete patching material minimum and maximum thicknesses shall be per the recommendation of the material manufacturer.

Concrete patching material site preparation, batching, extending with aggregate, mixing, placement, placement during cold temperatures, consolidation, and curing shall be per the manufacturer's recommendations. A mix may be extended up to 90 percent of the manufacturer's maximum extension.

The surface of concrete patching material shall have a similar texture as the adjacent driving surfaces.

The Contractor shall submit a report consisting of the mix proportions and compressive strength vs time curve information to the Engineer at least two weeks before the material is to be used on the project.

Field cast cylinders or cubes shall be taken by a qualified testing representative and test results shall be submitted to the Engineer within 24 hours, each day deck patching material is placed with compressive strength determined at 24 hours according to ASTM C 39 or ASTM C109.

Areas patched with Pre-Packaged Concrete Patching Material shall not be opened to traffic until concrete patching material has reached a compressive strength of 2,500 psi using the compressive strength versus time curve developed for the material.

Areas of the deck patched with Pre-Packaged Concrete Patching Material shall not receive a waterproof membrane until 4 hours after placement.

(b) Class DR Concrete. Class DR Concrete shall be placed per Class D concrete with the following changes:

The area to be patched with Class DR Concrete shall be saturated surface dry before placement and shall be free of standing water at the time of placement.

Portions of decks patched with Concrete Class DR shall not be opened to traffic until the concrete's compressive strength, determined by CP 69, has achieved at least 2500 psi.

Areas of the deck patched with Concrete Class DR shall not receive a waterproof membrane until the concrete patches have cured for a minimum of 5 days or have a moisture content of 5percent or less as measured by a moisture meter approved by the Engineer.

Concrete Class DR shall be cured until a compressive strength of at least 2500 psi has been achieved. The curing compound shall conform to ASTM C309, Type 2 applied at a rate of 1 gallon per 100 square feet. The curing compound shall be applied as a fine spray within 10 minutes of discontinuing the finishing operation. Before and during application the curing compound shall be kept thoroughly mixed. Curing blankets with a minimum R-value of 0.5 shall be provided and shall be placed as soon as they can be placed without marring the surface. When the ambient temperature is below 50°F, the Contractor shall maintain the concrete temperature above 50°F during the curing period.

METHOD OF MEASUREMENT

601.24 Concrete (Patching) will be measured and paid for as the actual quantity placed and accepted by the Engineer.

BASIS OF PAYMENT

601.25 The accepted quantities will be paid for at the contract unit price per unit of measurement for each of the pay items listed below that appear in the bid schedule.

Pay Item	Pay Unit
Concrete Class DR	Cubic Yard

Payment for Concrete (Patching) will be full compensation for all the work, materials, tools, equipment, testing, and incidentals required to complete patching, excluding the special installation of anodes when specified, when required.

Furnishing all appurtenances including the molding, curing, and breaking of cylinders or cubes for generating the strength versus time curve and for determining the information cylinder or cube strength will not be measured and paid for separately, but shall be included in the work. Concrete patching material or Class DR Concrete will not be measured and paid for separately but shall be included in the Concrete (Patching) bid item.

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SECTION 602
REINFORCING STEEL

DESCRIPTION

602.01 This work consists of furnishing and placing reinforcing steel per these specifications and in conformity with the plans.

MATERIALS

602.02 Reinforcing steel and welded wire fabric that will be furnished either uncoated or epoxy coated shall meet the requirements of subsection 709.01.

The coating material shall be a light-colored powdered epoxy resin that will highlight rusting of untreated bar areas.

Reinforcing steel that requires welding shall conform to ASTM A706. Welding shall be done per ANSI/AWS D1.4.

All accessories, including reinforcing steel supports, ties, and splicers used in conjunction with reinforcing steel, shall be of the same, or compatible, coating as the reinforcing utilized.

Reinforcing steel not identified on the plans as epoxy coated may be supplied as epoxy coated, at the Contractor's option, at no additional cost to the Department. Epoxy coated reinforcing steel may not be substituted for Stainless, Continuous Hot dipped Galvanized, Zinc Coated (Galvanized), and Chromium reinforcing alternatives.

Reinforcing alternatives such as Stainless, Continuous Hot dipped Galvanized, Zinc-Coated (Galvanized), and Chromium reinforcing may be supplied for reinforcing steel or epoxy coated reinforcing, at the Contractor's option, at no additional cost or time to the Department as approved by the Engineer.

Length of lap splices for epoxy-coated reinforcing steel shall be per AASHTO LRFD Bridge Design Specifications, unless otherwise specified.

CONSTRUCTION REQUIREMENTS

602.03 Bar List. Two copies of a list of all reinforcing steel and bending diagrams shall be furnished to the Engineer at the site of the work at least one week before the placing of reinforcing steel is begun. Such lists will not be reviewed for accuracy. The Contractor shall be responsible for the accuracy of the lists and for furnishing and placing all reinforcing steel per the details shown on the plans.

Bar lists and bending diagrams that are included on the plans, do not have to be furnished by the Contractor. When bar lists and bending diagrams are included on the plans, they are intended for estimating approximate quantities. The Contractor shall verify the quantity, size, and shape of the bar reinforcement against those shown on the plans and make all necessary corrections before ordering.

602.04 Protection of Materials. Reinforcing steel and its coating shall be protected at all times from damage. When placed in the work, the reinforcing steel shall be free from dirt, loose mill scale, paint, oil, loose rust, or other foreign substance.

602.05 Bending. Unless otherwise permitted, all reinforcing bars shall be bent cold. Bars partially embedded in concrete shall not be field bent except as shown on plans or permitted. Bars shall not be bent or straightened in a manner that will injure the material or the epoxy coating. Should the Engineer approve the application of heat for field bending reinforcing bars, precautions shall be taken to assure that the physical properties of the steel will not be materially altered.

Hooks and bends shall conform to the provisions of the AASHTO LRFD Bridge Design Specifications.

Bars that are shown as "hooked" on the plans shall have "standard hooks" unless otherwise indicated. The term "standard hook" as used shall mean one of the following:

1. A 180-degree turn plus an extension of four bar diameters but at least 2 1/2 inches at the free end of the bar, or
2. A 90-degree turn plus an extension of 12 bar diameters at the free end of the bar, or
3. For stirrup and tie anchorage only:

A. No. 5 bar and smaller, 90-degree turn plus an extension of six bar diameters at the free end of the bar.
B. No. 6, 7, and 8 bar, 90-degree turn plus an extension of 12 bar diameters at the free end of the bar.
C. No. 8 bar and smaller, 135-degree turn plus an extension of six bar diameters at the free end of the bar.

The inside diameter of bend measured on the inside of the bar, other than for stirrups and ties, shall be as follows:

Table 602-1
TENSION BAR BENDING RADII

Bar Size	Grade 60
No. 3 thru No. 8	6 bar diameter
No. 9, No. 10, and No. 11	8 bar diameter
No. 14 and No. 18	10 bar diameter

The inside diameter of bend for stirrups and ties shall not be less than four bar diameters for sizes No. 5 and smaller, and five bar diameters for No. 6 to No. 8 inclusive.

Inside diameter of bend in welded wire fabric, smooth or deformed, shall not be less than four wire diameters for deformed wire larger than D6 and two wire diameters for all other wires. Bends with an inside diameter of less than eight wire diameters shall not be less than four wire diameters from the nearest welded intersection.

602.06 Placing and Fastening. The minimum spacing center to center of parallel bars shall be 2 1/2 times the diameter of the bar. However, the clear distance between the bars shall not be less than 1 1/2 times the maximum size of the coarse aggregate or 1 1/2 inches, whichever is greater.

Bundle bars shall be tied together at not more than 6-foot centers.

All reinforcement shall have a clear coverage of 2 inches, except as shown on the plans. Clear coverage shall be measured from the surface of the concrete to the outside of the reinforcement.

Reinforcement used in post-tensioned concrete shall be adjusted or relocated during the installation of prestressing ducts or tendons, as required, to provide a location and planned clearances to the prestressing tendons, anchorages, jacks, and equipment as approved by the Engineer.

All reinforcement shall be tied at all intersections except where spacing is less than 1 foot in each direction, in which case, alternate intersections shall be tied.

In concrete bridge decks the upper mat of bars shall be tied to the lower mat of bars at a 4-foot maximum spacing in each direction. Slab bolsters for the bottom mat and highchairs for the top mat shall each be placed at a maximum spacing of 4 feet on centers.

Welding on reinforcing bars will not be permitted except as noted on the plans. Reinforcement placed in any member shall be inspected and approved before any concrete is placed.

The placing, fastening, splicing, and supporting of reinforcing steel and wire mesh or bar mat reinforcement shall be per the plans and the latest edition of Concrete Reinforcing Steel Institute (CRSI)'s "CRSI Recommended Practice for Placing Reinforcing Bars." In case of discrepancy between the plans and the CRSI publication stated above, the plans shall govern. Automated tie wire devices may be used. The total cross-sectional area of the automated tie wire wrap shall roughly equal the total cross-sectional area of a manually installed tie wire wrap. The tie wire shall be epoxy coated or plastic coated for use with epoxy-coated reinforcing steel. All epoxy coating on the reinforcing steel that is damaged from the use of automated tie wire devices shall be repaired at the Contractor's expense.

Precast concrete blocking or other approved blocking material shall be used to support footing bars and bars in slabs on grade. All other reinforcing steel shall be supported with steel chairs or precast mortar blocks. All chairs coming in contact with forms shall be CRSI Class 1 or Class 2, Type B.

The location of splices, except as shown on the plans, shall be based upon using 60-foot stock length bars for No. 6 bars and larger and 40-foot stock length bars for No. 4 and No. 5 bars (this does not preclude the use of 60 foot). Minimum splice lengths are as shown on the plans. Where bars of different sizes are spliced together, the splice length for the smaller bar will govern.

Unless otherwise shown on the plans or approved, splices in adjacent lines of reinforcing bars shall be staggered. The minimum distance between staggered splices for reinforcing bars shall be the length required for a lapped splice in the bar.

Lapped splices will be permitted only at locations where the concrete section is sufficient to provide a minimum clear distance of 2 inches between the splice and the nearest adjacent bar. The clearance to the surface of the concrete shall not be reduced.

Reinforcing bars may be continuous at locations where splices are shown on the plans. Reinforcing bars No. 14 and No. 18 shall not be spliced by lapping, but shall be joined by butt welding, per AWS D1.4 in such a way as to develop at least 125 percent of the specified yield strength of the bar in both tension and compression. Alternate systems of welding or mechanical butt splices may be submitted for approval.

METHOD OF MEASUREMENT

602.07 The weight of reinforcing steel for payment will not be measured but shall be the quantities designated in the Contract; except, measurements will be made for revisions requested by the Engineer, or for an error of plus or minus 2 percent of the total weight shown on the plans for each structure.

Prospective bidders shall verify the weight of reinforcing steel before submitting a proposal. An adjustment will not be made in the weight shown on the plans, other than for approved design changes or for an error as stipulated above, even though the actual weight may deviate from the plan weight.

The computed weight of epoxy-coated reinforcing bars will be based on the nominal weight before application of the epoxy coating. Nominal weights for various bar sizes are shown below.

Table 602-2
NOMINAL WEIGHTS FOR BAR SIZES

Bar Size	Weight per Linear Foot in Pounds
1/4 inch	0.167
No. 3	0.376
No. 4	0.668
No. 5	1.043
No. 6	1.502
No. 7	2.044

Bar Size	Weight per Linear Foot in Pounds
No. 8	2.67
No. 9	3.4
No. 10	4.303
No. 11	5.313
No. 14	7.65
No. 18	13.6

BASIS OF PAYMENT

602.08 The accepted quantities of reinforcing steel will be paid for at the contract unit price per pound. No allowance will be made for supports, clips, wire, or other material used for fastening reinforcement in place.

Payment will be made under:

Pay Item	Pay Unit
Reinforcing Steel	Pound
Reinforcing Steel (Epoxy Coated)	Pound
Reinforcing Steel (Galvanized)	Pound
Reinforcing Steel (Stainless)	Pound
Reinforcing Steel (High Performance)	Pound

SECTION 603
CULVERTS AND SEWERS

DESCRIPTION

603.01 This work consists of the construction of culverts (cross drains), side drains, storm drains, and sanitary sewers referred to as "conduit", where a specific pipe material is required, and nestable semicircular pipe for encasement. Work shall be per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

603.02 Materials shall meet the requirements shown on the plans and in the following subsections:

Corrugated Steel Pipe and Pipe Arches	707.02
Corrugated Steel Pipe Nestable	707.02
Corrugated Aluminum Pipe	707.06
Reinforced Concrete Pipe	706.02
Nonreinforced Concrete Pipe	706.01
Pipe Joint Sealing Compounds	705.04
Plastic Pipe	712.13
Vitrified Clay Pipe	706.06
Ductile Iron Pipe	707.01
Gaskets	705.03
Resilient Compression Ring Material	705.05
Reinforced Concrete Pipe (Jacked)	706.02

Plastic end sections shall not be used. When plastic pipe is to be installed with end sections, steel end sections conforming to Standard Plans M-603-10 and M-603-12 shall be used.

CONSTRUCTION REQUIREMENTS

603.03 General. Pipe shall be protected during handling against impact shocks and free fall.

When new sanitary sewer facilities interfere with the existing flow of sewage, the Contractor shall provide satisfactory bypass facilities at no expense to the Department.

Sanitary sewers and all appurtenances shall be thoroughly cleaned before final acceptance of this work.

603.04 Excavation. Trenches shall be excavated per the requirements of Section 206 to a width sufficient to allow for proper jointing of the conduit and thorough compaction of the bedding and backfill material under and around the conduit.

The completed trench bottom shall be firm for its full length and width. The trench for cross drains shall have a minimum longitudinal camber of 1 percent of the length of the pipe. Camber may be increased to suit the height of fill and supporting soil.

When conduits are to be installed in new embankments, the embankment shall first be constructed to the required height of at least 0.3 times the outside diameter or raise of the conduit, and for a distance each side of the conduit location of at least 5 times the diameter or span of the conduit, after which, the trench shall be excavated, and the conduit installed.

Excavation shall be by open cut from the surface, except when pipe jacking is specified or directed in writing by the Engineer.
When pipe is to be jacked, trenching will not be permitted. Pipe must be jacked without disrupting traffic. Methods of installing pipe other than by jacking may be used only with written approval from the Engineer. Methods that may cause damage to the embankment or roadway area will not be approved. Damage to the pipe or installation area caused by jacking operations shall be repaired or replaced at the Contractor's expense. The area around the outer surface of the pipe shall be thoroughly grouted. The grout mixture shall consist of one part portland cement and three parts of fine aggregate by volume, or it may be determined by prior documented experience with similar materials, equipment, and field conditions. The grout shall be thoroughly mixed with the minimum quantity of water needed to obtain the proper consistency for the existing soil conditions.
603.05 Bedding for Concrete or Clay Conduit. Bedding shall be prepared per details as shown on the plans. The bed shall consist of a layer of loose structure backfill at least 3 inches in thickness. Recesses shall be made to accommodate the bell of bell-and-spigot pipe. Adjustments to line and grade shall be made by scraping or filling under the body of the conduit. Wedging or blocking the bell will not be permitted.

603.06 Placing Conduit. The conduit laying shall begin at the downstream end of the conduit line. The lower segment of the conduit shall be in contact with the prepared bedding throughout its full length. Bell or groove ends of concrete or clay conduits and outside circumferential laps of metal or plastic conduits shall be placed facing upstream. Paved or partially lined conduit shall be placed so that the longitudinal centerline of the paved segment coincides with the flow line.
Elliptical-shaped pipe and circular pipe with elliptical reinforcement shall have the top clearly marked with paint or with imprinted letters and with lifting eyeholes where laying pins can be used. Holes shall be finished smooth with grout or with plugs. Conduits shall be placed with the vertical axis within five degrees of a vertical plane through the longitudinal axis of the conduit.
603.07 Joining Conduit. Joint systems for siphons, irrigation systems, and storm drains shall be watertight.

(a) Concrete or Clay Conduit. Conduit sections shall be joined in such a manner that the ends are fully entered, and the inner surfaces are reasonably flush and even.
At locations where rubber gaskets are specified in the Contract for conduits used for storm drains and cross culverts, rubber gaskets conforming to subsection 705.03 shall be used. At locations where the type of joint is not otherwise specified in the Contract for conduit used for storm drains and cross culverts, joints shall be made with joint sealing compound. Primer shall be furnished when recommended by the manufacturer of the joint sealing compound. Primer shall conform to and shall be applied per the manufacturer's recommendations to both surfaces of the conduit sections being joined, for the full circumference. Sealing compound shall be applied according to the manufacturer's recommendations. When a specific type of sealing compound is desired, it shall be as shown in the Contract.

Rubber gaskets conforming to subsection 705.03 shall be used for concrete pipe sanitary sewer joints.

Resilient pressure ring material conforming to subsection 705.05 shall be used for clay pipe sewer joints.

(b) *Metal Conduit*. Corrugated metal pipe sections shall be placed and aligned to within 3/4 inch of the adjacent section and shall be firmly joined with either one-piece or two-piece coupling bands. Pipe with helical corrugations shall be joined with the corrugations matched across the joints and with all corrugations of the pipe completely engaged by the corrugations or dimples of the coupling band.

Where existing corrugated metal pipe culverts are to be extended, damaged ends shall be cut off or repaired in an approved manner. All ends of pipes requiring extensions shall be cleaned within the area necessary for proper installation of connecting bands.

Arch culverts shall be extended with pipe having a compatible arch shape.

When special joint treatment is called for on the plans to prevent infiltration or exfiltration, the joints shall be made using a sealing compound conforming to subsection 705.04, with the connecting band.

(c) *Plastic Conduit*. Couplings shall be as recommended by the conduit manufacturer. Watertight joint systems for plastic pipe shall conform to subsection 705.02.

603.08 Elongation. Where required by the plans, round metal and plastic conduit shall be preformed to an elliptical shape by elongating the vertical axis 5 percent.

603.09 Backfilling. After the conduit or section of conduit is placed, it shall be inspected before any backfill is placed. Reinforced concrete pipe (RCP) shall be visually inspected per AASHTO LRFD Bridge Construction

Specifications, Section 27.6. Conduit found to be damaged shall be replaced, and conduit found to be out of alignment or unduly settled shall be taken up and relaid. The trench shall then be backfilled with material per Section 206.

Sanitary sewer lines, when completed, shall be tested for watertightness before any backfill is placed. The installation shall not show infiltration or exfiltration in excess of 0.6 gallon per inch of internal pipe diameter per 100 feet of sewer line per hour when tested at 10 psi by hydraulic means. Testing of joints shall be performed by the Contractor per approved methods. Should any section of the sewer line fail to meet the test requirements, it shall be corrected at the Contractor’s expense.

Special care shall be taken when backfilling around conduit to bring the backfill materials up on both sides of the conduit, evenly and simultaneously. Protection of conduits during construction shall be the Contractor's responsibility. Damage to the conduit due to the Contractor’s operations shall be repaired or replaced at the Contractor's expense.

Trenches in existing streets, except streets that are to be closed or abandoned, shall be resurfaced as soon as practicable with the type and thickness of bases and pavement shown in the Contract or as designated.

After culvert pipe is backfilled and earthwork over the pipe is complete to the top of the subgrade, the pipe deflection shall be measured in the presence of the Engineer. The

maximum allowable deflection shall be 5 percent. Deflection is a reduction in the inside diameter of the pipe measured in any direction. Measurement shall be made using a mandrel, laser profile, or other method approved by the Engineer. Measurement shall be made 30 days or more following the pipe installation. Pipe having any deflections in excess of 5 percent at any location within the pipe shall be removed and reinstalled. Pipe that is permanently deformed or damaged in any way shall be replaced. Replaced pipe shall be retested 30 days or more after the installation per the method described above.

603.10 Deflection Testing of Metal and Plastic Pipe. After a metal or plastic pipe is backfilled and earthwork over the pipe is complete to the top of the subgrade, the pipe deflection shall be measured in the presence of the Engineer. The maximum allowable deflection shall be 5 percent. Deflection is a reduction in the nominal diameter of the pipe measured in any direction. Measurement shall be made using a mandrel, laser profile, or other method approved by the Engineer. Measurement shall be made 30 days or more following the pipe installation. Pipe having any deflections in excess of 5 percent at any location within the pipe shall be removed and reinstalled at the Contractor's expense. Pipe that is permanently deformed or damaged in any way shall be replaced at the Contractor's expense. Replaced pipe shall be retested 30 days or more after the installation per the method described above.

603.11 Repair of Damaged Culvert. Coating on corrugated steel pipe and pipe arches, and corrugated steel pipe nestable shall be repaired per the provisions of subsection 707.09. Damaged pipe shall not be repaired. The Engineer will determine when the pipe is either acceptable or unacceptable per the provisions of subsection 105.03. Unacceptable pipe shall be removed and replaced.

METHOD OF MEASUREMENT

603.12 Conduit used for culverts and storm drains of the different types and sizes and corrugated steel pipe nestable will not be measured but will be the net length of pipe called for on the plans, except when field changes are ordered or when there are errors on the plans. In case of exceptions, the quantity to be measured shall be the actual net length of the conduit measured along the bottom centerline. Extra length of the conduit due to joint creep will not be measured and paid for. Corrugated steel pipe nestable used for encasement will be measured as complete circular pipe.

Jacked pipe will be measured by the linear foot complete in place and accepted. Structure excavation, structure backfill, grout materials, and grouting operation for jacked pipe will not be measured and paid for separately but shall be included in the work.

End sections and safety grates will be measured by the number of units installed.

The size designation of metal pipe arch and metal pipe arch end section shall refer to the diameter of round pipe normally used to fabricate the pipe arch or the pipe portion of the end section.

Relaid pipe will be measured and paid for per Section 210.

BASIS OF PAYMENT

603.13 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule. Except as otherwise indicated on the plans or in the special provisions, all joints, elbows, concrete collars, connecting bands, and other connecting devices will not be paid for separately but shall be included in the work.

Payment will be made under:

Pay Item	Pay Unit
___Inch Corrugated Steel Pipe	Linear Foot
___Inch Corrugated Steel Pipe Nestable	Linear Foot
___Inch Steel End Section	Each
___Inch Equiv. Corrugated Steel Pipe Arch	Linear Foot
___Inch Equiv. Arch Steel End Section	Each
___Inch Corrugated Aluminum Pipe	Linear Foot
___Inch Aluminum End Section	Each
___Inch Equiv. Corrugated Aluminum Pipe Arch	Linear Foot
___Inch Equiv. Arch Aluminum End Section	Each
___Inch Reinforced Concrete Pipe	Linear Foot
___Inch Reinforced Concrete End Section	Each
___Inch Nonreinforced Concrete Pipe	Linear Foot
___Inch x ___Inch Reinforced Concrete Pipe Elliptical	Linear Foot
___Inch x ___Inch Reinforced Concrete End Section Elliptical	Each
___Inch Vitrified Clay Pipe	Linear Foot
___Inch Cast Iron Pipe	Linear Foot
___Inch Plastic Pipe	Linear Foot
___Inch Reinforced Concrete Pipe (Jacked)	Linear Foot
___Foot x ___Foot Concrete Box Culvert (Precast)	Linear Foot
___Inch Steel Safety Grate	Each

Structure excavation and structure backfill will be measured and paid for per Section 206 except that any void in the structure excavation prism created by the removal of pipe or box culvert will be excluded from measurement and payment of structure excavation.

Repair of damaged coatings will not be paid for separately but shall be included in the cost of the item.

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SECTION 604
MANHOLES, INLETS, AND METER VAULTS

DESCRIPTION

604.01 This work consists of the construction of manholes, inlets, and meter vaults per these specifications, and in conformity with the lines and grades shown on the plans or established.

MATERIALS

604.02 Concrete for these structures shall meet the requirements of Section 601-Structural Concrete.

Other materials shall meet the requirements specified in the following subsections:

Clay or Shale Brick	704.01
Concrete Brick	704.02
Concrete Masonry Blocks	704.03
Frames, Grates, Covers, and Steps	712.06
Grade Ring	712.05
Reinforcing Steel	709.01
Precast Concrete Units	712.05

CONSTRUCTION REQUIREMENTS

604.03 Excavation. Excavation shall be per the requirements of Section 206.

604.04 Manholes, Inlets, and Meter Vaults.

(a) General. Concrete construction shall conform to the requirements of Section 601. Masonry shall conform to the requirements for the respective type. When specified, the outside face of structures shall be plastered with a 1/2-inch-thick cement-sand mortar coat. Unless otherwise provided, exposed surfaces of concrete and masonry shall be cured as defined in subsection 601.13.

Pipe sections on the inside of manholes or inlets shall be treated as shown on the plans, or as directed, and shall project outside sufficiently for proper connection with the next pipe section. Masonry shall fit neatly and tightly around the pipe.

(b) Manholes. Wherever directed by the Engineer, pipes of the proper type and size shall be built into a manhole where future laterals are to be connected. These pipes shall be sealed at their outer ends and an invert shall be built into each manhole for such lateral connections.

When a manhole is located in the pavement area, it shall not be constructed to final grade until the pavement has been completed.

(c) Inlets. Where inlets are placed in existing curbs or gutters, the Contractor shall carefully remove sections of the present curb, gutter, or curb and gutter. All damage to sections to remain in place shall be repaired at the Contractor's expense. The top portion of inlets shall be constructed concurrently with the adjacent curb and gutter to ensure proper alignment of grades unless otherwise permitted in writing.

(d) Meter Vaults. Meter vaults shall be of sufficient size to properly accommodate the size of the meter installed including regulatory devices or fittings required for the utility supplied. Provisions for grounding, ventilation, drainage, or other safety precautions shall be constructed as required. Meter vaults may be cast-in-place or precast and shall conform to the rules and regulations for the utility service supplied in the vault.

(e) Brick Masonry. All bricks shall be thoroughly wetted, before being laid, either by immersion or in a manner satisfactory to the Engineer.

Special care shall be taken to make the face of the brickwork smooth. All joints on the interior surface of the manholes and appurtenances shall be carefully struck.

Brick shall not be laid upon a concrete foundation until the concrete has set.

604.05 Backfilling. Unless otherwise directed, all excavations shall be backfilled immediately after the structures are built. Backfilling shall conform with Section 206 and as shown on the plans.

Resurfacing. Excavations in existing streets, except streets that are to be closed or abandoned, shall be resurfaced as soon as practicable with the type and thickness of bases and pavement shown on the plans or as designated.

Cleaning. The structures and all appurtenances shall be thoroughly cleaned before final acceptance of the work.

When the new facilities interfere with the existing flow of sewage, the Contractor shall provide satisfactory bypass facilities at the Contractor's expense.

METHOD OF MEASUREMENT

604.06 Manholes and inlets will be measured by the complete unit including ring and cover or grating and frame.

Manhole ring and cover used separately will be measured by the unit.

Inlet grating and frame used separately will be measured by the unit.

Manhole and inlet depth, "H," will be measured as shown on the plans. Measured depth and pay depth of manholes and inlets shall conform to the following:

Table 604-1
MEASURED DEPTH AND PAY DEPTH
OF MANHOLES AND INLETS

Measured Depth	Pay Depth
0.0 to 5.0 feet	5 feet
5.1 to 10.0 feet	10 feet
10.1 to 15.0 feet	15 feet
(Continued thus)	

Meter vaults will be measured by the complete unit including ring and cover.

Structure excavation and structure backfill for manholes, inlets, and meter vaults will not be measured and paid for separately but shall be included in the work.

BASIS OF PAYMENT

604.07 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule. Except as otherwise indicated on the plans or in the special provisions, all connecting devices will not be measured and paid for separately but shall be included in the work.

Payment will be made under:

Pay Item	Pay Unit
Meter Vault	Each
Manhole _____ (____)	Each
Inlet, Type _____ (_____Foot)	Each
Manhole Ring and Cover	Each
___ Inlet Grating and Frame	Each

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SECTION 605
SUBSURFACE DRAINS

DESCRIPTION

605.01 This work consists of constructing underdrains, edge drains, geocomposite drains, and french drains, per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

605.02 Materials shall meet the requirements specified in the following subsections:

Corrugated Steel Pipe	707.04
Bituminous Coated Corrugated Steel Pipe	707.05
Drain Tile	706.04
Vitrified Clay Pipe	706.06
Corrugated Aluminum Pipe	707.07
Plastic Pipe	712.11
Gaskets	705.03
Filter Material	703.09
Geotextiles	712.08
Geocomposite Drains	712.12

Pipe for subsurface drains shall be any type of pipe material listed above. When corrosion resistant pipe is specified on the plans, the materials shall conform to the requirements of Section 624 for the corrosion resistance number specified.

Subsurface drain outlet pipe may be perforated or nonperforated, and shall meet the requirements specified in subsections 707.04, 707.05, 707.07, or 712.11.

CONSTRUCTION REQUIREMENTS

605.03 Pipe Underdrain and Pipe Edge Drain. The trench shall be excavated to the dimensions and grade shown on the plans. Sufficient Geotextile (Drainage) (Class 3) shall be placed along the bottom and sides of the trench as shown on the plans to provide the required overlap over the top of the filter material. Filter material of the class designated on the plans shall be placed in the bottom of the trench for its full width and length.

Perforated pipe shall be placed with the perforations down and the pipe sections shall be joined securely with the appropriate coupling fittings or bands. Joining shall conform to the applicable requirements of subsection 603.07 except as noted above.

After the pipe installation has been inspected and approved, the designated filter material shall be placed to a height of 12 inches above the top of pipe. Care shall be taken not to displace the pipe or the covering at open joints. The remainder of the filter material shall then be placed to the required height, the drainage geotextile folded over the top of the filter material, and the remainder of the trench backfilled.

605.04 Geocomposite Drains. The geocomposite drain for subsurface drainage behind a retaining wall shall be placed along the full length of the wall. It shall be attached to the wall with an approved adhesive or per the manufacturer's recommendations.

The trench for geocomposite underdrain and geo-composite edge drain, for subsurface drainage at pavement edge and elsewhere as specified on the plans, shall be excavated to the dimensions and grade shown on the plans. The geocomposite drain material shall then be placed along the downhill side, or the pavement side, of the trench and secured to the trench side.

Backfill shall be placed to avoid damage to the geocomposite drain material.

605.05 French Drain. The trench for French drain shall be excavated to the width and depth shown on the plans. The trench shall be lined with Geotextile (Drainage) (Class 3) and filled with the designated filter material to the depth shown on the plans. The drainage geotextile shall be folded over the top of the filter material. Any remaining unfilled upper portion of trench shall be backfilled with embankment material.

605.06 Subsurface Drain Outlet. The trench for subsurface drain outlet shall be excavated to the width and depth necessary to place the pipe on a drainable grade, as shown on the plans or as directed. Pipe shall be laid in the trench with all ends joined securely with the appropriate couplings, fittings or bands. After inspection and approval of the pipe installation, the trench shall be backfilled and compacted per subsection 206.03.

Where the outlet pipe ends on a slope or ditch, it shall be constructed with an erosion control pad, and an animal guard. The location shall be marked with a delineator post that conforms to Section 612. The animal guard screen shall be held securely in place with a coupling or fastening band or by another approved method.

METHOD OF MEASUREMENT

605.07 Pipe underdrain and pipe edge drain will be measured by the linear foot of pipe of the size specified placed and accepted. French drain will be measured by the linear foot of trench excavated and filled with filter material and accepted. Geocomposite underdrain and geocomposite edge drain will be measured by the linear foot along the base of the geocomposite drain material for the full length installed and accepted. Geocomposite drain both with and without pipe will be measured by the square yard of geocomposite drain material placed on the vertical wall surface and accepted. Subsurface drain outlet will be measured by the linear foot of pipe placed and accepted from the end of a subsurface drain to the discharge end of the outlet pipe.

BASIS OF PAYMENT

605.08 The accepted quantities of subsurface drains will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
___Inch Perforated Pipe Underdrain	Linear Foot
French Drain	Linear Foot
Geocomposite Underdrain	Linear Foot
Geocomposite Drain without Pipe	Square Yard
Geocomposite Drain with Pipe	Square Yard
Geocomposite Edge Drain	Linear Foot
Pipe Edge Drain	Linear Foot
Subsurface Drain Outlet	Linear Foot

Payment shall be full compensation for all work and materials required to complete the item including drainage geotextile, drainage core, securing devices, adhesives, sewn seams, pipe, filter material, excavation, and backfill. Payment for subsurface drain outlet shall include the erosion control pad, the animal guard, and the delineator post.

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SECTION 606
GUARDRAIL

DESCRIPTION

606.01 This work consists of the construction of guardrail per these specifications and in conformity with the lines and grades shown on the plans or established.

The construction of the various types of guardrail shall include the assembly and erection of all component parts and materials complete at the locations shown on the plans or as directed.

The types of guardrail are designated as follows:

Type 3 Guardrail – Midwest Guardrail System (MGS) W-Beam 31 Inches

Type 6 Guardrail – Thrie Beam

Type 7 Guardrail – F-Shape Concrete Barrier (Precast) (Temporary)

Type 9 Guardrail – Single Slope Concrete Barrier

Use of Type 4 Precast Concrete Barrier not permitted.

MATERIALS

606.02 Materials shall meet the requirements specified in the following subsections:

"W" Beam Rail and Thrie Beam Rail	710.05
Guardrail Hardware	710.09
Guardrail Posts	710.08

Paint for field painting of guardrail shall conform to subsection 708.03, Structural Steel Bridge Paint.

Concrete for precast or cast-in-place barrier shall be made with an approved Class D Concrete and shall conform to the requirements of Section 601. The Contractor may elect to use an approved self-consolidating Class D concrete. Reinforcing steel, unless otherwise noted, shall be epoxy coated and conform to the requirements of Section 602.

Concrete for bridge rail shall be Class DF Concrete and conform to the requirements of Section 601.

CONSTRUCTION REQUIREMENTS

606.03 Post and Rail Elements.

(a) Posts. Posts shall be set firm and aligned with a tolerance of plus or minus 1/4 inch from plumb, grades and lines as staked. All fittings and metal plates shall be placed securely in position to conform to designated dimensions and requirements.

Posts shall be set by one of the following methods:

(1) Driven in place.

(2) Set in dug holes.

(3) Set in a concrete base.

(4) Posts on bridges shall be as shown on the plans.

Driving of posts shall be accomplished by methods and equipment that will leave the posts in their final position free from any distortion, burring, or any other damage.

Excavated post holes shall have a firm bottom and be backfilled with acceptable material placed in layers and thoroughly compacted.

Dissimilar metal-to-metal or aluminum-to-concrete post or rail installations shall have contact surfaces separated by an approved protective coating.

Wood posts cut in the field shall have the cut surfaces protected with two coats of an approved preservative. When the cut surface is above ground, the treating solution to be used shall be the same type as was used in the original treatment.

(b) Rail. Rail elements shall be erected in a manner resulting in a smooth, continuous installation. All bolts in the finished rail shall be drawn tight. Bolts shall be of sufficient length to extend beyond the nuts. Rail shall be shop bent for installations on horizontal curves having a radius of 150 feet or less.

(c) Temporary End Treatment. In construction zones not closed to traffic, installation of rail element shall closely follow the setting of posts to keep the number of posts without rail at a minimum. When necessary to minimize potential hazards, the Engineer will specify the direction that the rail installation is to advance, and the number of posts installed ahead of rail installation. At the end of the Contractor's workday, the Contractor shall treat the ends of the installed guardrail as follows:

(1) If the end is at the location of a planned end section, install the end section.

(2) If the end is not at the location of a planned end section, the last rail section shall be installed with one end attached to the rail already in place and the free end resting on the ground. The free end on the ground shall be restrained by tying the rail to the posts by ropes or cables. The guardrail shall not be left in this configuration for more than 24 hours unless protected by an approved attenuating device.

606.04 Concrete. Where paving is removed or damaged due to the Contractor's operations, the Contractor shall furnish an approved mix and shall repair the paving as required, at the Contractor's expense.

In construction zones not closed to traffic, the Contractor shall treat the ends of the installed concrete guardrail at the end of the workday as follows:

(1) If the end is at the location of a planned end section, install the end section.

(2) If the end is not at the location of a planned end section, install a temporary impact attenuator or provide treatment as shown in the Contract.

(a) Permanent Concrete Barrier. The permanent concrete barrier shall be Type 9 constructed by cast-in-place or slipform methods. The trench for the base of the cast-in-place reinforced barrier end anchorages shall be excavated to the lines and grades shown on the plans or established. The bottom of the trench shall be compacted to the density specified in subsection 203.07(a). The compacted trench bottom shall be watered and approved before placing concrete.

Concrete finish for all cast-in-place barriers shall be Class 1 per subsection 601.14. Slipform barriers shall not receive additional finishing unless permitted by the Engineer. Exposed vertical surfaces of slipformed barrier shall receive a vertical broom finish. When hand finishing is allowed, it shall be performed in conformance with subsection 601.12(a).

The Engineer may determine that the exposed surfaces of the guardrail shall be tested with a 10-foot straightedge laid along the exposed surface in a longitudinal direction. The Contractor shall furnish an approved 10-foot straightedge and provide an operator to aid the Engineer in testing the exposed surfaces. All surface tolerances shall be measured in a longitudinal direction. Deviation of any exposed surface in excess of the tolerance specified shall be corrected at the Contractor's expense.

Longitudinal surface tolerances for the top of the barrier and the sides of the barrier from the top to a line 7 inches below the top of the barrier are:

1. On tangent roadway alignments and curves with a radius greater than 1,000 feet: 0.25 inch from the edge of the straightedge.
2. On sharp vertical curves and horizontal curves with a radius of 1,000 feet or less: 0.25 inch from the edge of the straightedge with allowance made for curve deflection.

Longitudinal surface tolerances for the remaining surfaces of the barrier are:

1. On tangent roadway alignments and curves with a radius greater than 1,000 feet: 0.75 inch from the edge of the straightedge.
2. On sharp vertical curves and horizontal curves with a radius of 1,000 feet or less: 0.75 inch from the edge of the straightedge with allowance made for curve deflection.

The Contractor will be allowed a maximum of three days of slipform production if the barrier being placed does not meet the specified tolerances. After the third day of placement of out-of-tolerance slipform barrier, the Contractor shall stop production. The Contractor shall submit a corrective action plan to the Engineer for review. The plan shall address corrective actions to the equipment and materials and a time frame for completion of the corrective actions. The plan shall address methods and materials to be used to correct out-of-tolerance barrier. Patching will not be allowed to correct out-of-tolerance barrier. Further placement of barrier will not be allowed until all previously placed barrier that failed to meet tolerances is corrected or removed. Each occurrence of out-of-tolerance slipform barrier shall be subject to the same corrective cycle.

(b) Temporary Precast Type 7 Concrete Barrier. Precast Type 7 Concrete Barrier (conforming to Standard Plan M-606-14) may be formed upside down to minimize air pockets and improve surface finish. Concrete finish for precast barriers shall be Class 1 per subsection 601.14. Each segment of the precast barrier shall not have spalls, corner breaks, and bottom spalls totaling more than 5 square feet of surface area, which includes the base. All required hand finishing shall be performed in conformance with subsection 601.12(a).

Connecting loops shall not be frayed, stretched, or deformed. Gaps between units shall not exceed the dimensions shown on the plans. Precast barrier units shall not be lifted or stressed in any way before they have developed the strength of the concrete specified. Units shall be supported at designated pickup points. Connecting loops shall not be used as pickup points. Care shall be taken during fabrication, storage, handling, and transporting to prevent cracking, twisting, or other damage. Minor chips on edges may be patched with the approval of the Engineer. Breakage and chipping may be cause for rejection. Units damaged in such a way as to impair their appearance or suitability, in the opinion of the Engineer, shall be replaced at the Contractor's expense. Units rejected by the Engineer shall be marked on both sides with an orange painted "R" approximately 12 inches high and 6 inches wide.

The base for placing precast barrier shall be prepared to the lines and grades shown on the plans or established. When it becomes necessary to connect cast-in-place barrier sections to precast barrier installations during construction, the cast-in-place sections shall be constructed complete with connecting hardware per Standard Plan M-606-14 to join the cast-in-place sections to the abutting precast sections. A fifteen-foot transition section shall be provided when attaching barriers of differing shapes.

METHOD OF MEASUREMENT

606.05 Guardrail will be measured by the linear foot along the centerline of the rail from end to end of completed and accepted rail as shown on the plans, excluding end anchorages, median terminals, and transitions.

End anchorages, median terminals, and transitions will be measured by the actual number placed and accepted. Each end anchorage, median terminal, or transition shall include all concrete, reinforcing steel, anchor bolts, cable, rods, turnbuckles, backing rail, plates, bolts, nuts, washers, and all other work and material necessary to complete the item.

Posts will be included in the quantities of guardrail of the specified type and not measured separately. Additional posts required for guardrail adjacent to bridges and obstructions, as shown on the plans, will not be measured and paid for separately but shall be included in the work.

BASIS OF PAYMENT

606.06 The accepted quantities of guardrail will be paid for at the contract unit price for the type specified.

Payment will be made under:

Pay Item	**Pay Unit**
Guardrail, Type___	Linear Foot
End Anchorage, Type___	Each
Guardrail, Type___ (____Post Spacing)	Linear Foot
Median Terminal	Each
End Anchorage (_____)	Each
Transition, Type _____	Each

All work and materials necessary and incidental to the temporary treatment of guardrail ends will not be measured and paid for separately but shall be included in the work.

Partial payments will not be made for partially completed guardrail runs that do not conform to the end treatments specified in subsections 606.03(c) or 606.04.

Polyolefin fiber reinforcement will not be measured and paid for separately but shall be included in the work.

SECTION 607
FENCES

DESCRIPTION

607.01 This work consists of the construction of fence and gates, and removal of temporary plastic fence per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

607.02 Materials shall meet the requirements specified in the following subsections:

Woven Wire	710.02
Barbed Wire	710.01
Chain Link Fabric	710.03
Fence Posts	710.07
Snow Fence	710.04
Timber for Wood Noise Barrier	710.06

Reinforcing steel shall conform to Section 602.

Concrete shall conform to Section 601.

Foundation concrete for fence posts, braces, anchors, and gates shall be Class B. Concrete with lightweight aggregates conforming to ASTM C330 will be permitted. Field mixed concrete consisting of a minimum of one part cement to six parts of aggregate by volume may be used in lieu of Class B if approved. Pre-packaged concrete may be used if approved.

Fence (Plastic) shall be orange-colored material, at least 4 feet in height.

CONSTRUCTION REQUIREMENTS

607.03 The Contractor shall perform such clearing and grubbing as may be necessary to construct the fence to the required grade and alignment.

The right-of-way fence shall be constructed approximately 6 inches inside the boundary of the highway right of way shown on the plans or as staked. Anchorages, footings or fence appurtenances shall not extend beyond the limits of the highway right of way without the written consent of the abutting property owner.

At locations where breaks in a run of fencing are required, at intersections with existing fences, or at ditch, canal, or channel crossings, appropriate adjustments in fence alignment and post spacing shall be made to satisfy the requirements for the type of closure indicated or the conditions encountered.

When the plans require that posts, braces, or anchors be embedded in concrete, they shall be securely braced to hold the posts in proper position until the concrete has set sufficiently to hold the posts. Unless otherwise permitted, materials shall not be installed on posts, or stress placed on guys and bracing set in concrete until the concrete has set sufficiently to withstand the stress.

The tops of all posts shall be set to the required grade and alignment. Cutting of the tops or bottoms of treated timber posts will be allowed only with the approval of the Engineer. Posts cut in the field shall have the cut surfaces protected with two coats of an approved wood preservative.

Wire or fencing of the size and type required shall be firmly attached to the posts and braces in the manner indicated. All wire shall be stretched taut and be installed to the required spacing.

Wood noise barrier fence shall be constructed according to the details shown on the plans. All fence boards shall be tightly butted to minimize cracks.

Fence (Plastic) shall be placed as shown on the plans or as directed to define the limits of the work area beyond which no access is allowed to the surrounding wetlands or vegetation to be protected.

METHOD OF MEASUREMENT

607.04 Fence will be measured by the linear foot. Measurement will be along the base of the fence from outside to outside of end posts for each continuous run of fence, including length of barbed wire gates, but excluding the length of driveway gates and walk gates.

Driveway gates and walk gates will be measured as complete units of the size and type specified. Gates shall be the same type and height as the adjacent fence unless otherwise designated.

End posts, corner posts, and line brace posts required for chain link fence, barbed wire, and combination wire fence will be measured by the actual number used.

End posts, corner posts, and line brace posts for snow fence or barrier fence will not be measured and paid for separately but shall be included in the work.

Line posts required for reset fence will be measured by the actual number used.

Line posts required for new fence will not be measured separately but shall be included in the contract unit price for new fence.

End Posts Special, Corner Posts Special, and Line Brace Posts Special required for Fence (Deer) will be measured by the actual number used.

Fence Wood (Noise Barrier) will be measured by the linear foot.

Fence (Plastic) will be measured by the linear foot. Posts will not be measured and paid for separately but shall be included in the work.

Measurement will be along the base of the fence from outside to outside of end posts for each continuous run of fence, and shall include all wood, hardware, concrete, reinforcing steel, excavation and backfill, and all other incidentals to the erection of the fence.

BASIS OF PAYMENT

607.05 The accepted quantities of fence will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Fence (____) (_____Inch)	Linear Foot
(____Foot) Gate (____)	Each
Line Post	Each
End Post	Each
Corner and Line Brace Post	Each
End Post (Chain Link)	Each
Corner and Line Brace Post (Chain Link)	Each
End Post Special	Each
Corner and Line Brace Post Special	Each
Deer Gate	Each
Fence Wood (Noise Barrier) (_____Inch)	Linear Foot
Fence (Plastic)	Linear Foot

Payment for Fence (Plastic) shall be full compensation for furnishing, erecting, maintaining, removing, and disposing of all materials required. Fence (Plastic) shall remain the property of the Contractor.

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SECTION 608
SIDEWALKS AND BIKEWAYS

DESCRIPTION

608.01 This work consists of the construction of bituminous or concrete sidewalks, bikeways, and curb ramps per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

608.02 Materials shall meet the requirements specified in the following subsections:

Joint Fillers	705.01
Bed Course Material	703.07

Concrete for sidewalks, bikeways, and curb ramps shall be Class B and meet the requirements of Section 601.

Bituminous material for sidewalks, bikeways, and curb ramps shall meet the requirements of Section 403.

Concrete and bituminous mixes will be subject to inspection and tests as required to ensure compliance with quality requirements.

CONSTRUCTION REQUIREMENTS

608.03 Concrete Sidewalks and Bikeways.

(a) Excavation. Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms. The foundation shall be shaped and compacted to a firm even surface conforming to the section shown on the plans or as staked. When the Engineer determines that material is uncompactable, the material shall be removed and replaced per subsection 206.03.

(b) Forms. Forms shall be of wood, metal, or other suitable material, and shall extend for the full depth of the concrete. All forms shall be straight, free from warp, and of sufficient strength to resist the pressure of the concrete without springing. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal. A satisfactory slip-form method may be used.

(c) Placing Concrete. The foundation shall be thoroughly moistened immediately before the placing of the concrete. The proportioning, mixing, and placing of the concrete shall be per the requirements for the class of concrete specified.

(d) Finishing. The surface shall be floated with a wooden or magnesium float and given a transverse broom finish. Plastering of the surface will not be permitted. All required hand finishing shall be performed in conformance with subsection 601.12(a).

All outside edges of the slab and all joints shall be edged with a 1/4-inch radius-edging tool.

(e) Joints. Expansion joints, at intervals of not more than 500 feet, shall be filled with 1/2-inch-thick full depth, preformed expansion joint filler. The sidewalk or bikeway shall be divided into sections by dummy joints formed by a jointing tool or other acceptable means as directed. These dummy joints shall extend into the concrete for at least a quarter of the depth and shall be approximately 1/8 inch wide. Dummy joints shall be spaced at intervals approximately equal to the width of the sidewalk or bikeway.

Construction joints shall be formed around all appurtenances such as manholes, and utility poles, extending into and through the sidewalk. Preformed expansion joint filler 1/2 inch thick shall be installed in these joints. Expansion joint filler 1/2 inch thick or the thickness indicated shall be installed between new concrete and any fixed structure such as a building or bridge. This expansion joint material shall extend for the full depth of the contact surface.

(f) Curing. Immediately upon completion of the finishing, sidewalks and bikeways shall be moistened and kept moist for three days, or they shall be cured by the use of membrane-forming curing compound. The method and details of curing shall be subject to the approval of the Engineer.

During the curing period, all traffic, both pedestrian and vehicular, shall be excluded. Vehicular traffic shall be excluded for such additional time as the Engineer may direct.

608.04 Bituminous Sidewalks and Bikeways.

(a) Excavation and Forms. Excavation and forms shall meet the requirements of subsection 608.03(a) and (b).

(b) Bed Course. Bed course material shall be placed in layers not exceeding 4 inches in depth and each layer shall be thoroughly compacted.

(c) Placing Bituminous Material. Bituminous sidewalk and bikeway material shall be placed on the compacted bed course in one or more courses as indicated to give the required depth when rolled. When practicable, spreading, finishing, and compaction shall be accomplished by equipment conforming to the requirements of Section 401. When the Engineer determines such equipment is not practicable, bituminous material may be spread by small or special pavers, by spreader boxes, or by blade graders and may be compacted by small self-propelled rollers or vibratory compactors acceptable to the Engineer. In areas inaccessible to the roller, hand or mechanical tamping will be permitted. Bituminous material shall be uniformly compacted.

The Contractor shall state at the Pre-construction Conference what type of paving equipment will be used.

METHOD OF MEASUREMENT

608.05 Concrete sidewalks, bikeways, and curb ramps will be measured by the square yard of finished surface. Bituminous sidewalks, bikeways, and curb ramps will be measured by the ton of bituminous mixture placed.

BASIS OF PAYMENT

608.06 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Concrete Sidewalk	Square Yard
Bituminous Sidewalk	Ton
Concrete Curb Ramp	Square Yard
Bituminous Curb Ramp	Ton
Concrete Bikeway	Square Yard
Bituminous Bikeway	Ton

Bed course material will be measured and paid for per Section 206.

All work necessary and incidental to the construction of sidewalks, bikeways, and curb ramps will not be measured and paid for separately but shall be included in the work.

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SECTION 609
CURB AND GUTTER

DESCRIPTION

609.01 This work consists of the construction of curb, gutter or combination curb and gutter per these specifications and in conformity with the lines and grades shown on the plans or established.

The types of curb are designated as follows:

Type 2 Cast-in-Place Concrete Curb
Type 4 Dowelled Concrete Curb
Type 6 Sloping Curb

The section will be as shown on the plans.

MATERIALS

609.02 Except as provided below the materials used shall meet the requirements of the following subsections:

Bed Course Material	703.07
Joint Filler	705.01
Reinforcing Steel	709.01

Concrete for curb shall be Class B and meet the requirements of Section 601.

Bituminous curb shall be constructed of the same gradation of aggregate and the same grade of bituminous material as the top layer or top course of bituminous pavement used on the project.

Concrete and bituminous mixes will be subject to inspection and tests at the plants for compliance with quality requirements.

CONSTRUCTION REQUIREMENTS

609.03 Cast-in-Place Concrete Curb. All required hand finishing shall be performed in conformance with subsection 601.12(a).

(a) Excavation. Excavation and bedding shall conform to the requirements of subsection 608.03(a).

(b) Forms. Forms shall be of wood or metal, straight, free from warp and of such construction that there will be no interference to the inspection of grade or alignment. All forms shall extend for the entire depth of the curb and shall be braced and secured sufficiently so that no deflection from alignment or grade will occur during the placing of the concrete.

(c) Mixing and Placing. Concrete shall be proportioned, mixed, and placed per the requirements for the class of concrete specified. Compaction of concrete curb, gutters, or combination curb and gutter, placed in forms shall have thorough consolidation that shall be achieved by tamping and spading, vibrating, or other acceptable methods. Forms shall be left in place until the concrete has set sufficiently so that they can be removed without injury to the curb. Upon removal of the forms, the exposed curb face shall be immediately finished to a uniform surface. For the purpose of matching adjacent concrete finishes or for other reasons, the Engineer shall approve methods of finishing. Plastering will not be permitted.

(d) Sections. Curb shall be constructed in sections having a uniform length of 10 feet unless otherwise ordered. Sections shall be separated by open joints 1/8 inch wide except at expansion joints.

(e) Expansion Joints. Expansion joints shall be formed at the intervals shown on the plans using a 1/2-inch preformed expansion joint filler. When the curb is constructed adjacent to or on concrete pavement, expansion joints shall be located opposite the expansion joints in the pavement.

Expansion joints shall be installed between the concrete curb and any fixed structure or bridge. Expansion joint material shall extend the full depth of contact surface.

(f) Curing. Immediately upon completion of the finishing, the curb shall be moistened and kept moist for three days, or the curb shall be cured by the use of membrane-forming curing compound. The method and details of curing shall be subject to the approval of the Engineer.

(g) Backfilling. After the concrete has set sufficiently, the spaces in back of the curb shall be backfilled to the required elevation with suitable material, which shall be thoroughly tamped.

(h) Curb Machine. With the approval of the Engineer, the curb may be constructed by the use of a curb-forming machine.

(i) Surface Tolerance. The Engineer may determine that the exposed surfaces of the concrete curb, gutters, or combination curb and gutter shall be tested with a 10-foot straightedge laid along the exposed surface in a longitudinal direction. The Contractor shall furnish an approved 10-foot straightedge and provide an operator to aid the Engineer in testing the exposed surfaces. All surfaces shall be measured in a longitudinal direction. Deviation of any exposed surface in excess of that specified shall be corrected at the Contractor's expense.

Longitudinal surface tolerances for the top and face are:

1. On tangent roadway alignments and curves with a radius greater than 1,000 feet: 0.25 inch from the edge of the straightedge.
2. On sharp vertical curves and horizontal curves with a radius of 1,000 feet or less: 0.25 inch from the edge of the straight edge with allowance made for curve deflection.

609.04 (unused)

609.05 Bituminous Curb.

(a) Preparation. Bituminous curb shall be placed on a clean dry surface. Immediately before placing the bituminous mixture, the surface shall receive a tack coat of bituminous material of the type and grade approved by the Engineer. The rate of application of the tack coat material shall be 0.05 to 0.15 gallons per square yard of surface. In the application of this tack coat, the Contractor shall prevent the spread of this tack coat to areas outside of the area to be occupied by the curb.

(b) Placing. Bituminous curb shall be constructed by using a self-propelled curb machine or a paver with curb attachments.

The automatic curb machine shall meet the following requirements and shall be approved before its use:

(1) The weight of the machine shall be such that compaction is obtained without the machine riding above the bed where the curb is constructed.

(2) The machine shall form curb that is uniform in texture, shape and density.

(3) The Engineer may permit the construction of curb by other means, when short sections or sections with short radii are required, or for such other reasons as warranted. The resulting curb shall conform in all respects to the curb produced by the use of the machine.

Upon completion of placement of bituminous curb, a fog coat of emulsified asphalt shall be placed on the exposed surfaces of the curb at the rate of approximately 0.1 gallon per square yard.

(c) Painting and Sealing. When sealing or painting is required, it shall be performed only on a curb that is clean and dry and that has reached the ambient temperature.

METHOD OF MEASUREMENT

609.06 Curb will be measured by linear foot along the front face of the section at the finished grade elevation. Gutter will be measured along the centerline of the gutter. Curb and gutter will be measured along the face of the curb. Deduction in length will be made for drainage structures, such as catch basins, drop inlets, etc., installed in the curb, gutter, or curb and gutter.

BASIS OF PAYMENT

609.07 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule, including dowels and expansion joint material.

Payment will be made under:

Pay Item	Pay Unit
Curb, Type__ (Section____)	Linear Foot
Gutter, Type__ (____Foot)	Linear Foot
Curb and Gutter, Type__ (Section____)	Linear Foot

Bed course material will be measured and paid for per Section 206.

Fog coat and tack coat for Curb Type 6 will not be measured and paid for separately but shall be included in the work.

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SECTION 610
MEDIAN COVER MATERIAL

DESCRIPTION

610.01 This work consists of the construction of median cover over the median area, or over other areas designated, per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

610.02 Bituminous median cover material shall conform to the requirements of Section 403 and as shown on the plans.

Concrete shall be Class B and shall conform to Section 601. Coloring agent, if required, shall be as shown on the plans or specified.

Aggregate for median cover shall conform to the requirements of subsection 703.10.

Plastic sheeting shall be black polyethylene with a minimum thickness of 10 mils or approved equal.

Herbicides shall conform to the requirements of Section 217.

CONSTRUCTION REQUIREMENTS

610.03 Median cover operations shall not be started until the underlying surface has been compacted, smoothed and, if required, treated with herbicides. Other requirements are as follows:

(a)Bituminous Median Cover Material. Bituminous median cover material shall be placed in conformance with the requirements of subsection 608.04(c).

(b)Concrete. Construction requirements shall conform to the requirements of subsection 608.03. The surface finish or pattern shall be as shown on the plans or per the recommendations of the supplier of the median cover material.

(c)Stone. Areas to receive stone median cover shall be treated, if required, with an approved herbicide treatment per Section 217 or as directed. Immediately after the placement of the herbicides, the plastic sheeting and stones shall be placed per details shown on the plans, or as specified.

METHOD OF MEASUREMENT

610.04 Bituminous median cover material will be measured by the number of tons of bituminous material placed and accepted.

Concrete median cover material will be measured by the square foot of surface placed and accepted.

Stone median cover material will be measured by the number of tons of aggregate placed and accepted.

BASIS OF PAYMENT

610.05 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Median Cover Material (Bituminous)	Ton
Median Cover Material (Concrete)	Square Foot
Median Cover Material (Patterned Concrete)	Square Foot
Median Cover Material (Stone)	Ton

Herbicide treatment will be measured and paid for per Section 217.

Subgrade compaction and plastic sheeting will not be measured and paid for separately but shall be included in the work.

SECTION 611
CATTLE GUARDS

DESCRIPTION

611.01 This work consists of the construction of cattle guards per these specifications and in conformity with the lines, grades, and details shown on the plans or established.

MATERIALS

611.02 Concrete shall conform to the requirements of Section 601. Reinforcing steel shall conform to the requirements of Section 602. Structural steel shall conform to the requirements of Section 509. Timber shall conform to the requirements of Section 508. Fencing items shall conform to the requirements of Section 607.

CONSTRUCTION REQUIREMENTS

611.03 Cattle guards shall be constructed per the details shown on the plans. All work shall be done per the applicable construction methods contained in these specifications.

METHOD OF MEASUREMENT

611.04 Cattle guards will be measured by the number of units of the various sizes installed and accepted.

BASIS OF PAYMENT

611.05 The accepted quantities of cattle guards of the various sizes will be paid for at the contract unit price each when included in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
_____Cattle Guard	Each

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SECTION 612

DELINEATORS AND REFLECTORS

DESCRIPTION

612.01 This work consists of the installation and furnishing of delineators and reflectors per these specifications and in conformity with the lines, grades and details shown on the plans or established.

MATERIALS

612.02 Materials for the various types of delineators and reflectors shall be as follows:

(a)Delineators.

1.Steel Posts. Details for each type of delineator are shown on the plans. Posts shall conform to the requirements shown on the plans, and reflectors shall conform to the requirements in subsections 713.07 and 713.10.

2.Flexible Posts. Flexible posts shall be selected from CDOT's Approved Products List (APL) and shall conform to the requirements in subsection 713.06.

(b)Reflectors:

1. Reflector Strip. Reflector strips shall be selected from CDOT's APL. Details for reflector strips are shown on the plans. Reflectivity shall conform to the requirements in subsection 713.07 and 713.10.

2. Guardrail Reflector Tabs. Details for the guardrail reflector tabs are shown on the plans. Reflectivity shall conform to ASTM D4956 Type IV.

3. Barrier Reflector. Details for barrier reflectors are shown on the plans. Reflectivity shall conform to the requirements in subsection 713.10.

4. Median Barrier Reflector. Details for median barrier reflectors are shown on the plans. Reflectivity shall conform to the requirements in subsection 713.10.

CONSTRUCTION REQUIREMENTS

612.03 Spacing, location, color of reflectors and placement of delineator posts shall be as shown on the plans.

The Contractor shall install reflector strips in conformance with manufacturer's recommendations.

The length of each reflector strip shall be 34 inches, unless otherwise approved. The Contractor shall adjust the spacing between reflector strips as recommended by the manufacturer to fit the location called for in the Contract. Cutting of the reflector strips will not be permitted.

METHOD OF MEASUREMENT

612.04 Delineators and reflectors will be measured by the actual number of the various types installed and accepted.

BASIS OF PAYMENT

612.05 The accepted quantities will be paid for at the contract unit price each for the pay items listed below that are included in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Delineator (Type_____)	Each
Delineator (Flexible) (Post Mounted)	Each
Delineator (Flexible) (Clamp Mounted)	Each
Delineator (Flexible) (Cup Mounted)	Each
Delineator (Flexible) (Surface Mounted)	Each
Delineator (Flexible) (Type___)	Each
Delineator (Drivable) (Type___)	Each
Delineator (Barrier) (Type___)	Each
Reflector (Median Barrier)	Each
Reflector Strip (__ Inch)	Each

Concrete for anchor embedment will not be measured and paid for separately but shall be included in the work.

Surface preparation, brackets, fasteners and adhesive for reflector strips will not be measured and paid for separately but shall be included in the work.

Guardrail reflector tabs will not be paid for separately but shall be included in the work.

Payment will be full compensation for all work, materials, and equipment required to install delineators.

SECTION 613
LIGHTING

DESCRIPTION

613.01 This work consists of furnishing and installing foundations, light standards, luminaires, light sources, conduit, cable, wiring, and incidental materials for highway lighting and electrical systems per these specifications and in conformance with the details, lines, grades, and locations shown on the plans or established.

MATERIALS

613.02 Roadway lighting materials shall conform to Section 715 and shall be compatible with the requirements of the local agency having jurisdiction.

(a) Foundation. Concrete Foundation Pads and Light Standard Foundations shall be cast-in-place concrete. A complete foundation includes the concrete, reinforcing steel, grounding electrode, connector bolts, and anchor bolts.

Connector bolts and anchor bolts shall accommodate the anchorage of the light pole from its base flange to the base or transformer base, and from the base or transformer base to the light standard foundation.

(b) Light Standard. A complete light standard includes the metal light pole, mast arm or arms, base or transformer base, approved breakaway device (optional), in-use receptacles (optional), grounding system, and all hardware. When a transformer base is not used, the pole shall have a handhole.

(c) Conduit. Conduit includes all junction boxes, pull wire, weatherheads, adaptors, and expansion joints for conduit required to install complete runs.

(d) Electrical Warning Tape. Electrical warning tape shall consist of pre-manufactured non-adhesive polyethylene material that is unaffected by acids, alkalis, and other soil components. The tape shall be detectable. The color of the tape shall be red, and it shall be a minimum 3.5 mils thick and 6 inches wide. Its tensile strength shall be 1,750 psi lengthwise.

The electrical tape shall include the following identification printed in black letters continuously along the length of the tape: “CAUTION BURIED ELECTRIC LINE BELOW”.

The identification note and color of tape shall conform to the requirements of the “American Public Works Association (APWA) Uniform Color Codes (Red) – Electrical Power Lines, Cables, Conduit and Lighting Cables”.

(e) Luminaire. A complete luminaire includes the housing, lens, Light Emitting Diode (LED) board, dimming driver, slip-fitting clamp or approved manufacturer mounting, all necessary internal wiring, and 7-pin photoelectric control receptacle. Luminaires shall operate at either 120 VAC (Volts Alternating Current), 60 Hz, 277 VAC, 60 Hz or 120-277VAC, 60 Hz.

(f) *Lighting Control Center*. A complete lighting control center includes the load center, grounding system, contactors, relays, meter housing (optional per region requirements), meter disconnect (optional per region and utility company requirements), maintenance receptacle, photoelectric control, National Electrical Manufacturers' Association (NEMA) 4 enclosure, HVAC (optional per region requirements), snow skirt (optional per region requirements) and all related components, and connections to the power supply.

(g) *Meter Power Pedestal*. A complete pedestal includes the NEMA 3R enclosure and all related components, load center, grounding system, meter housing, meter disconnect (optional per utility company requirements) maintenance receptacle (optional), photoelectric control, and connections to the power supply.

(h) *Secondary Service Pedestal*. A complete pedestal includes the NEMA 3R enclosure and all related components and connections to the power supply.

(i) *Heavy Duty Safety Switch*. Provide switches, mounted on the cabinet, with the following ratings:

1. 30 to 1200 amperes.
2. 250 volts AC; 600 volts AC.
3. 2, 3, 4 and 6 poles (2, 3 and 4 poles on 800 A; 2 and 3 on 1200 A).
4. Fusible and non-fusible.
5. Mechanical lugs suitable for copper conductors.

(j) *Wiring*. Complete wiring includes control wiring, luminaire wiring, traffic signal wiring, main circuit wiring, ground wiring, service entrance wiring, and all other wiring necessary for a complete installation.

(k) *Materials List*. At the Pre-Construction Conference, the Contractor shall submit to the Engineer three copies of a list of all materials and equipment to be incorporated into the work. The Contractor shall include the following items on the list:

1. Light standard foundations.
2. Foundation pads.
3. Light standard type (steel or aluminum).
4. Luminaire manufacturer's product information including data in Illuminating Engineering Society (IES) format, IES photometric distribution type for vertical and lateral distribution and IES TM-15-11 rating (example: B2-U0-G1, Type III), and a photograph or line drawing.
5. Luminaire mounting hardware.
6. Luminaire initial lumen output.
7. LED dimming driver or power supply.

8. Lighting control center(s) and photoelectric control device(s).

9. Secondary service pedestals.

10. All other items required for a complete installation.

The Engineer will return lists that are incomplete or that include unacceptable materials to the Contractor for correction and re-submission.

The Contractor shall not order materials or equipment until the Engineer and the party or agency responsible for maintenance have reviewed and approved the materials and equipment list. The Engineer's approval of the list shall not relieve the Contractor of responsibility for the proper functioning of the completed installation.

(l) LED Luminaire Warranty. The Contractor shall ensure that the LED luminaire has a manufacturer's minimum warranty of 10 years for all parts, materials, and shipping required to repair or replace the luminaire. The Contractor shall provide the manufacturer's warranty to the Engineer before installing the luminaire.

The warranty shall cover all failures including:

1. Failure in luminaire housing, wiring, connections, drivers, and photoelectric control devices.

2. More than 10 percent decrease in lumen output.

3. Significant change in color.

The warranty shall begin upon the date the Contractor receives the luminaire. The bill of lading shall be provided to the Engineer before final payment of the lighting.

(m)Technical Support. During the manufacturer's warranty period, technical support shall be available from the manufacturer via telephone within 24 hours of the time the call is made from the Contractor, and this support shall be made available from factory certified personnel or factory certified installers at no additional charge to the Department.

(n) Temporary Lighting. A complete temporary lighting system includes the temporary light standard, luminaire, mast arm, conduit, wiring, power source, temporary metering per the local utility standards, and all related components and connections to the power source.

CONSTRUCTION REQUIREMENTS

613.03 General. All work shall conform to these specifications and the National Electric Code (NEC) and shall comply with applicable regulations as specified in subsection 107.01.

Each system shall be installed as designated. The Contractor shall furnish and install all incidentals necessary to provide a complete working unit or system.

613.04 Concrete Foundation Pads and Light Standard Foundations. Foundations shall be installed complete with grounding electrodes. Concrete Class D shall be used for foundation pads and concrete Class BZ shall be used for the light standard foundation. Concrete Class D can be used for light standard foundation if the rebar spacing in the foundation is at least 3 inches and the slump of the concrete is 6 to 9 inches. All concrete shall meet the requirements of Section 601. The drilled shaft (caisson) of the light standard foundation shall meet the requirements of Section 503.

The Contractor shall test and report soil conditions to the Engineer if any of the following soil conditions are encountered during roadway work:

1. Light standards are not installed within the roadway earthwork prism.

2. The soil has a high organic content or consists of saturated silt and clay.

3. The site will not support the weight of the drilling rig.

4. The foundation soils are not homogenous.

5. Firm bedrock is encountered.

Between drilling of the shaft and placing of concrete the hole shall not be disturbed. Wet or caving holes shall be backfilled with flow-fill and re-drilled after a three-day curing period without the use of casing. If testing is required, then soil testing shall be performed at the lowest elevation light standard location for all light connected to a single electrical circuit. Foundations shall be installed at the final grade.

All anchor bolts shall be positioned by means of steel templates. The center of the template shall coincide with the center of the base.
Conduits shall be properly positioned and anchored before the concrete is placed.

All foundations shall have ground electrodes conforming to the NEC. All foundations on structures shall be bonded to the structure steel by a method that is per the NEC and is approved by the Engineer.

613.05 Light Standards. Poles shall be set plumb on the light standard foundation using non-corrosive metal shims or upper and lower nuts. Poles shall be level and plumb to the foundation. Defects and scratches on galvanized poles shall be given two coats of acceptable zinc-rich paint as directed. Defects and scratches on painted poles shall be primed and painted to match undamaged pole sections.

613.06 Luminaires, Light Sources, and Lamps. Roadway luminaires shall be mounted on the mast arm by a slip-fitter clamp or other approved device. Luminaires shall be adjusted vertically and horizontally to be plumb with the foundation and provide the required orientation and maximum light distribution on the roadway and meet IES TM-15 uplight rating of U0 (no uplight).

Luminaires are to be controlled by a centralized photoelectric control. For modified systems, individual photoelectric control may be used. The photoelectric control shall be positioned northward to minimize sun interference.

Luminaires of the specified type and initial lumen output shall be installed as specified. The type and initial lumen output shall be marked on each luminaire or pole per American National Standards Institute (ANSI) specifications. ANSI approved tags shall be provided and installed by the Contractor.

Wall type luminaires for use under overpass structures shall be mounted as specified. All wall type luminaires shall include side shielding to prevent glare in the motorist's view. The beam angle setting shall be adjusted to meet the project illumination requirements.

After installation and before acceptance, refractors and lenses shall be cleaned to provide maximum lumen output.

613.07 Conduit. The electrical conduit system shall be installed per subsection 715~~.07~~ Conduit and CDOT's "A Policy on the Accommodation of Utilities on Colorado Highways Rights-of-Way" and the following:

In the conduit system the locations of conduit, pull boxes, splice boxes and expansion joints shown on the plans are approximate. Actual locations shall be established during construction. The conduit system shall be located to avoid interference with known present or known future construction installations. All underground conduit runs and conduit risers on poles shall be installed as required for a complete installation.

All conduit installed under the roadway shall be at least 2-inch inside diameter unless otherwise designated. The Contractor may use larger conduit than specified at no additional cost to the project. If larger conduit is used, it shall be for the entire run from outlet to outlet. Reducer couplings shall not be used.

Existing underground conduit to be incorporated into a new system shall be cleaned with a round wire brush the same size as the internal diameter of the conduit, proofed with a mandrel 1/4-inch less in diameter than the conduit inner diameter size, and blown out with compressed air.

Where new conductors are to be added to existing conductors in a conduit, all conductors shall be removed, and the conduit cleaned as described above. All conductors shall be pulled into the conduit as a unit.

Conduit terminating in standards or pedestals shall extend approximately 2 inches vertically above the foundations and shall slope toward the handhole opening.

Conduit entering pull boxes shall terminate 2 inches inside the box wall and no more than 1.5 inches above the bottom and shall slope toward the top of the box to facilitate pulling of conductors. Conduit entering through the bottom of a pull box shall be located near the end walls to leave the major portion of the box clear. All conduits shall be labeled as to the direction of their run.

The ends of all conduits, whether shop or field cut, shall be reamed to remove burrs and rough edges. Cuts shall be made square and true so that the ends will butt or come together for their full circumference.

Slip joints or running threads shall not be used for coupling conduit. When a standard coupling cannot be used for coupling metal type conduit, an approved threaded union coupling shall be used. All threads on ferrous metal conduit, not previously treated with a corrosion preventative, shall be painted with rust preventive paint before couplings are connected. All couplings for metal type conduit shall be tightened providing a continuous connection throughout the entire length of the conduit run to increase raceway mechanical strength. Areas where the coating on ferrous metal conduit has been damaged shall be painted with rust preventive paint.

All metal conduit ends shall be threaded and capped until wiring is started. When caps are removed, the threaded ends shall be provided with conduit bushings.

Non-metallic conduit shall be cut with a hacksaw or other approved tool. Non-metallic conduit connections shall be solvent-weld type or approved equal. Non-metallic conduit ends shall be capped until wiring is started.

All conduit stub-outs shall include a sweeping elbow and shall terminate in the box. All conduit stub-outs shall be capped.

Surface conduit connections at junction or splice boxes shall be tightly secured and waterproofed. All conduit ends shall be sealed with duct seal after installation of wiring. The duct seal shall be rated for outdoor use and easily removable.

When specified, conduit shall be installed under existing pavement by jacking or drilling operations. Where plans show that existing pavement is to be removed, jacking the conduit is not required. Boring, jacking or drilling pits shall be kept a minimum of 2 feet clear of the edge of pavement. Water shall not be used as an aid in the jacking or drilling operations, except when required to cool the cone head for directional boring.

Red, detectable electrical warning tape shall be installed between 6 inches and 12 inches below finished grade for all underground trenched conduit runs.

Trenched PVC conduit shall use rigid metallic conduit for all elbows and sweeps. All rigid metallic conduit elbows and sweeps shall be a PVC-coated, schedule 40 galvanized rigid conduit (GRC) minimum 36-inch radius bent to shape at the factory. All connections to non-metallic conduit shall be made with threaded couplings.

When trenching is specified to place conduit under existing pavement that is not to be removed, the trench width shall be 6 inches or less. Trenches shall be filled to 2 inches below the existing grade with structure backfill (flowfill), or another material if directed. The remaining 2 inches shall be filled to existing grade with hot mix asphalt within one calendar day after the roadway is trenched, per section 403.

Trenching shall be backfilled and compacted as follows: backfill shall be deposited in uniform layers. The thickness of each layer shall be 6 inches or less before compaction under all hardscape. The space under the conduit shall be completely filled. The remainder of the trench and excavation shall be backfilled to the finished grade. The backfill material shall be compacted to the density of at least 95 percent of maximum dry density. The maximum dry density and optimum moisture content (OMC) for A-1, A-2-4. A-2-5 and A-3 materials will be determined per AASHTO T 180 as modified by CP 23. The maximum dry density and OMC for all other materials will be determined per AASHTO T 99 as modified by CP 23. Materials shall

be compacted at plus or minus 2 percent of Optimum Moisture Content (OMC). Materials having greater than 35 percent passing the 75 µm (No. 200) sieve shall be compacted at 0 to 3 percent above OMC. Each layer shall be mechanically compacted by tamping with power tools approved by the Project Engineer. Compaction methods or equipment that damage the conduit shall not be used.

Underground conduit shall be buried a minimum of 30 inches below finished grade. There shall be no sag between boxes. Conduit under roadways shall be buried at 48 inches below finished grade. If the Contractor encounters bedrock such that the minimum conduit depths cannot be achieved, the Contractor shall be allowed to cover the conduit with 2 inches or more of concrete at a lesser burial depth.

All schedule 80 PVC conduits shall have slip fit expansion fittings at 100-foot intervals and 6 feet maximum from each elbow. Expansion fittings will be installed per the NEC requirements for 65 °F temperature change.

Pull or splice boxes shall be installed at a maximum distance of 400 feet or less. Boxes shall be placed at conduit ends, at all wiring splices, at all conduit angle points where total conduit bends within a stretch of conduit exceeds 360 degrees, and at all other locations shown on the plans. The Contractor may install additional pull or splice boxes to facilitate the work at no additional cost to the project.

Where practical, pull and splice boxes near curbs shall be placed adjacent to the back of the curb. Pull boxes adjacent to light standards shall be placed behind or along the side of foundations.

Pull and splice boxes shall be installed so that the top of the covers are flush with the sidewalk and match the sidewalk slope and grade. Covers shall be level with the surrounding ground when no grade is established.

On bridges or other structures, rigid metallic conduits shall have an expansion fitting at every expansion joint of the bridge. Expansion joint fittings shall be precisely aligned with the conduit run to ensure proper expansion and deflection and to prevent binding. For vertical conduit runs, the fitting shall be installed close to the top of the structure to prevent water running across the fitting and entering the conduit. The fitting's deflection sleeve coupling, and pressure bushing at the barrel of the expansion body shall be installed flush with the structure ends; only the connecting expansion nipple shall cross the opening between structures. The fitting shall be supported by points on the conduit immediately adjacent to the fitting. The metal conduit fitting shall have an external bonding jumper.

613.08 Wiring. Unless otherwise authorized, the multiple system of electrical distribution shall be used. Conductors of the size and material required, whether single or in cable, shall be installed for control wiring, luminaire wiring, traffic signal wiring, main circuit wiring, ground wiring, service entrance wiring, and all other wiring necessary for a complete installation.

Conductors shall be sized to prevent a voltage drop of more than 3 percent per feeder run at the ambient temperature. All conductors shall be installed in conduit.

When 120-volt luminaires are installed, 120/240 VAC shall be brought to the base of each light standard, and individual luminaires shall be connected to one leg or the other in a manner that minimizes overall voltage drop.

A complete grounding system shall be installed for the entire electrical installation. Grounding shall consist of:
1. ground cables,
2. conduits,
3. grounding electrodes,
4. wire or strap, and
5. ground fittings, as required by the NEC.

Permissible grounding electrodes shall be:
1. ground rods,
2. concrete-encased electrodes,
3. grounding plates and grounding rings.

Alternative grounding electrodes per the NEC shall be approved by the Project Engineer before installation.

All electrical conductors shall be identified and tagged as follows: electrical conductor cable tags shall be located at each splice termination. The tags shall be attached with cable ties. The information shall be written on the tag with a permanent marker. The information shall include the direction and approximate length of the cable, and the feeder or circuit destination (line and load sides). Each incoming (line side) conductor shall be individually color coded with one tape mark; each outgoing conductor (load side) shall be coded with two tape marks.

613.09 Lighting Control Center, Meter Power Pedestal, and Secondary Service Pedestals. Each lighting control center, meter power pedestal, and secondary service pedestals shall include:

1. A load center, a panel board,
2. Contactors,
3. A maintenance receptacle,
4. A meter housing (if applicable),
5. A photoelectric control,
6. A grounding electrode system with ground wells (if applicable),
7. A NEMA 4 or NEMA 3R enclosure with all related components,
8. HVAC (optional per region requirements),
9. Snow skirt (optional per region requirements), and
10. Connections to the power supply.

One copy of the cabinet drawings, one-line diagram, luminaire schedule, and a list of all system components and their manufacturers shall be placed in a heavy-duty plastic envelope with side opening that is attached to the inside cabinet door.

613.10 Heavy Duty Safety Switch. Install disconnect (safety) switches as required for a complete operating system. Each safety switch shall include pad-lockable handle, reinforced, rejection type fuse clips, NEMA 3R enclosure unless otherwise noted, grounding system, and shall connect with conduit and wiring as required for a complete operating system.

613.11 Temporary Lighting. The temporary lighting system shall include the temporary light standard, luminaire, mast arm, conduit, wiring, power source, temporary metering per the local utility standards, and all related components and connections to the power source. Temporary lighting system shall meet the requirements of Section 715 unless otherwise approved by the Engineer. For temporary lighting, wood poles may be substituted for metal poles.

(a) Temporary Lighting Levels. Temporary lighting shall provide lighting levels equal to or exceeding the existing lighting levels and quality. Temporary luminaires shall meet backlight, uplight, and glare ratings listed in Table 715-1. Permanent luminaires shall meet all requirements listed in Section 715.

1. The Contractor shall keep the existing lighting system, the approved temporary replacements, or the temporary construction lighting in effective operation for the benefit of the traveling public during construction progress, except when shutdown is permitted to allow alteration or final removal of the system. Lighting system shutdowns shall not interfere with the regular lighting schedule unless otherwise permitted. Shutdown schedules are subject to approval by the Engineer. Existing installations to be removed shall be kept in operation until the new installations are operational, or as otherwise directed by the Engineer.

2. The Contractor shall maintain, provide, and install temporary roadway lighting within the project limits throughout the entire construction schedule. The contractor is responsible for the design and maintaining of all temporary roadway lighting throughout all stages of the project throughout the project duration. Use of the existing lighting system, temporary roadway lighting poles and installation of the permanent lighting shall be permitted to achieve the required lighting level criteria.

3. The Contractor shall submit a design for approval of the temporary roadway lighting. The submission shall show direct association to the proposed staging and construction schedule. No work shall commence until a temporary lighting design is approved by the Engineer.

(b) All luminaires that have been used for temporary lighting shall be cleaned before being reinstalled for other temporary lighting locations. The Contractor shall keep temporary construction lighting installations in effective operation until they are no longer required for the protection of the traveling public.

(c) Reusable equipment damaged when the Contractor is removing and salvaging existing material shall be replaced or repaired at the Contractor's expense.

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(d) Electrical Service. The Contractor is responsible for all work to gain approvals, coordinate with the appropriate electrical utility, and arrange for service work to provide power source location. The contractor is also responsible for the annual or monthly bill, and other tasks to provide electrical service for the temporary lighting.

(e) Existing Systems. All circuits to lighting outside of Project scope shall stay energized without interruption. If damage is caused by the Contractors' operations, damaged facilities shall be repaired or replaced promptly at the Contractor's expense ~~on~~. Where roadways are to remain open to traffic and existing lighting systems are to be modified, the existing systems shall be kept in operation until the final connection to the modified circuit(s) is made. The modified circuit(s) shall be complete and operating by nightfall of the same day the existing system is disconnected.

(f) The Contractor shall determine the exact location of existing conduit runs and pull boxes before using equipment that may damage such facilities or interfere with any system.

(g) Existing materials that interfere with or that are incompatible with new construction shall be removed or salvaged in the order directed or approved, before completion of the new construction. The Contractor shall notify CDOT and the appropriate utility at least four calendar days in advance of removing or salvaging the existing materials. Material damaged by the removal and salvage operations shall be repaired or replaced at the Contractor's expense.

(h) Temporary Service. All temporary lighting standards and temporary meters shall be located outside of the clear zone, or protected behind appropriate barrier or impact attenuator, as approved by the Engineer.

(i) The Contractor shall install and energize the temporary lighting system before de-energizing and removing the existing lighting system.

(j) The Contractor shall be responsible for obtaining and paying for temporary power through the duration of the project. The Contractor shall be responsible for removing the temporary lighting system after the permanent lighting system has been installed and energized. The Contractor shall be responsible for notifying CDOT and the appropriate utility of cancellation of temporary electrical service. After removing the temporary lighting and temporary meter, the Contractor shall be responsible for canceling the temporary power service with the utility.

613.12 Testing. Before final acceptance, the Contractor shall demonstrate to the Engineer's satisfaction that all electrical and lighting equipment installations are in proper working condition. Temporary power and all cable connections required for testing shall be provided by the Contractor.

The Contractor shall operate the lighting system from sunset to sunrise for10 consecutive days. Light sources, drivers or power sources, power generators, control systems, or photoelectric control that fail shall be replaced immediately. Replacement of these items will not require a restart of the test.

The Contractor shall perform grounding tests at each grounding system location including light standards, lighting control centers, meter power pedestals, and other grounding electrode locations. Grounding tests shall show that the ground resistance is 10 ohms or less. If the measured resistance to ground exceeds 10 ohms, additional grounding electrodes shall be added to the grounding electrode system at the Contractor's cost.

The Contractor shall perform voltage drop tests at a point ~~on~~ farthest from each circuit such that voltage drop is within 3 percent of supply voltage.

The Contractor shall certify the records of all testing including grounding, voltage drop (within 3 percent) and other required tests as meeting specification requirements and submit the records to the Engineer.

METHOD OF MEASUREMENT

613.13 Concrete Foundation Pads and Light Standard Foundations will be measured by the actual number installed and accepted.

Light standards will be measured by the number of light standards installed.

Luminaires will be measured by the number of luminaires of the specified initial luminaire lumens installed and accepted.

Lighting control centers will be measured by the number of control centers installed and accepted.

Meter power pedestals will be measured by the number of pedestals installed and accepted by the local electrical utility.

Secondary service pedestals will be measured by the number of pedestals installed. and accepted.

Heavy Duty Safety Switches will be measured by the number of switches installed. and accepted.

Conduit will be measured by the linear foot in place and shall include all expansion joints, conduit bodies, and other hardware for a complete installation.

All wiring necessary for the complete installation will be measured as a single lump sum.

Pull or splice boxes will be measured by number of boxes installed per the project plans.

Temporary lighting shall include install and removal of the temporary light standards, luminaires, mast arms, temporary conduit, temporary wiring, and all other equipment necessary for the complete installation and accepted. Temporary lighting shall be measured as a single lump sum.

BASIS OF PAYMENT

613.14 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Light Standard Foundation	**Each**
Concrete Foundation Pad	Each
Light Standard____(____Foot) (Furnish Only) (Install Only)	Each
Luminaire (____) (____Lumens)	Each
Luminaire (____) (____Lumens) (Furnish Only) (Install Only)	Each
____Inch Electrical Conduit (Furnish Only) (Install Only)	Linear Foot
____Inch Electrical Conduit (Plastic) (Furnish Only) (Install Only)	Linear Foot
____Inch Electrical Conduit (Jacked) (Furnish Only) (Install Only)	Linear Foot
Wiring	Lump Sum
Lighting Control Center	Each
Meter Power Pedestal	Each
Secondary Service Pedestal	Each
Temporary Lighting	Lump Sum
Power Transformer (____kVA, ___V-___V, ___ Phase)	Each
Circuit Breaker (____A, ____ Pole)	Each
Safety Switch NEMA 3R, ____ A, ____ pole, ____ V)	Each
Pull box (_____)	Each

The lump sum price bid for Temporary Lighting shall be full compensation for all work and materials, and the removal of all said temporary lighting at job completion.

Payment for the temporary power shall not be included in the lump sum but shall be paid for under the Force Account Furnish and Install Electrical Service.

When the Contractor, at their option, installs larger conduit than specified, it will be paid for at the original contract price for the size specified.

The following items will not be measured and paid for separately, but shall be included in the work:

(1) Soil testing for foundations.

(2) Junction boxes, pull wire, weatherheads, adaptors, and expansion joints for conduit.

(3) Additional pull or splice boxes installed at the Contractor's option.

(4) Saw cutting; trenching; excavation; backfill; jacking; drilling pits; underground electrical warning tape; removal of pavement, sidewalks, gutters, and curbs and their replacement in kind to match existing grade; and all other work necessary to complete conduit installation.

(5) Electrical conductor tagging.

(6) Direct burial cable in conduit.

(7) Testing of the lighting installation, including temporary power and all required cable connections.

The lump sum price bid for wiring will be full compensation for all electrical circuitry necessary to complete the electrical installation. All conductors in conduit, regardless of type, are part of the wiring item and will not be measured and paid for separately.

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SECTION 614
TRAFFIC CONTROL DEVICES

DESCRIPTION

614.01 This work consists of the construction of traffic signs and sign structures, traffic signals and systems, barricades, rumble strips, masking sign legends on new sign panels, providing and installing multi-directional steel sign break-away assemblies, and modification of signposts and legends. This work shall be done per these specifications, the latest revision of the "Manual on Uniform Traffic Control Devices (MUTCD)for Streets and Highways" published by the FHWA and adopted by CDOT, the latest revision of the Colorado Supplement thereto, and in conformity with the details shown on the plans or established.

This work includes the installation of single or double tubular steel signposts, supporting tubular sockets, and concrete footings at locations shown on the plans.

MATERIALS

614.02 Signposts and Sign Structures. Concrete shall conform to the requirements of Section 601. Reinforcing steel shall conform to the requirements of Section 602. Steel for Signposts and Sign Structures shall conform to the material grade and type specified in the Contract. Steel plates, shapes, and bars shall conform to the requirements of Section 509. Tubular steel shall conform to the requirements of ANSI/AWS D1.1. Timber signposts shall conform to the following:

1. Species: Douglas Fir South or Douglas Fir Larch, Grade No.1
2. Finish: S4S
3. Moisture content: 19 percent or less
4. 80 percent Free of Heart Center

Before use, all timber shall be stored, banded and kept dry.

All signposts shall be pressure treated according to AASHTO M-133 or AWPA Standards. All cuts, holes, and other related modifications made to the posts shall be treated per AWPA M-4.

Underground portions of timber signposts, plus at least 6 inches above groundline, shall be treated according to AWPA Standard M4.

Timber signposts size 6 inches by 6 inches shall be provided with two 2-inch diameter holes through the neutral axis at right angles to the roadway for induced breakaway function, one drilled at 4 inches and one at 18 inches above the ground level.

Tubular sockets shall be round 12-gauge galvanized steel that meet the requirements of ASTM A787.

Concrete footing shall be made of Class BZ Concrete. The Contractor may use an alternate material that meets the requirements for Class BZ concrete in Section 601, as approved by the Engineer.

Structure backfill around concrete footings shall be Class 2, per Section 206.

614.03 Overpass Mounted Sign Bracket. Material for overpass mounted sign bracket shall conform to the structural steel requirements of Section 509.

614.04 Sign Panels. Sign panel materials shall conform to Section 713 and to the details shown on the plans. Sign panels shall be produced per the retroreflective sheeting manufacturer's recommendations. Layout and font design shall conform to the "Standard Highway Signs" published by FHWA. Font selection for guide sign legends shall conform to the most recent version of the "CDOT Sign Design Manual". Sign layouts for special signs shall be per the detailed sign layouts proved on the plans or by the Engineer.

Silk screen and digital process figures shall be per the plans and series figures described in the current editions of "Standard Highway Signs", published by the FHWA, and the "Colorado Supplement to Standard Highway Signs".

All exposed lockbolt fastener heads on the faces of the sign panels shall be covered with material matching the background of the panel.

All sign panels shall be identified with the month and year that the sign was manufactured. The date shall be located on the lower right side of the back of the sign panel and shall be approximately 1/4 inch high. The date shall be stamped or adhered onto the sign panel material for a permanent record. This work will be paid for as part of the Item.

614.05 Sign Illumination and Illuminated Signs. Electrical work shall conform to Section 613. Lens and reflectors for flashing beacons shall be of a type as described in the November 1998 edition of the Institute of Transportation Engineers (ITE) Equipment Material Standards Chapter 2 Section 8.00, Traffic Signal Lenses, and Section 10, Reflectors.

LED modules shall meet the requirements described in the November 1998 edition of the ITE Equipment Material Standards Chapter 2a, Sections 1 through 7.2.2.

614.06 Flashing Beacon. Flashing beacon shall be as shown on the plans. If solar power is called for on the plans, or if the Engineer approves the use of solar power, then the beacon head shall be 12V LED type operated at 24 watts. The solar power system shall be capable of operating the flashing beacon continuously for 10 days without any sunlight. The solar panel and battery power system shall be augmented to protect it from vandalism or theft. The solar power system shall be complete including all elements required for an operational installation.

614.07 Barricades. Wood used in barricades shall be untreated S4S and shall conform to the applicable portions of subsections 710.07 and 710.08. Retroreflective sheeting shall be Type IV and shall conform to subsection 713.04.

Underground portions of timber barricade posts, plus at least 6 inches above ground line, shall be painted with any preservative listed in AASHTO M 133. Any portion of a timber barricade not covered with reflective sheeting or treated shall be painted white per subsection 508.08 and the plan details.

614.08 Traffic Signal Materials.

(a) General. At the Pre-construction Conference, the Contractor shall submit, for approval, a list of equipment and materials that will be installed. Each item shall be identified by trade name, size, and number. Materials shall conform to the requirements of Section 713, to the requirements shown on the plans or as designated, and to the following:

All electrical equipment shall conform to the standards of ITE, Institute of Electrical and Electronics Engineers (IEEE), UL, or Electronic Industries Association (EIA), wherever applicable. In addition to the requirements of the plans, these specifications, and the special provisions, all materials and workmanship shall conform to the requirements of the National Electrical Code (NEC), Rules for Overhead Electrical Line Construction of the Colorado Public Utilities Commission; standards of ASTM, ANSI, and all local ordinances that may apply.

Wherever reference is made to any of the standards mentioned above, the reference shall be construed to mean the code, order, or standard that is in effect on the date of advertisement for bids.

Materials and equipment for traffic signal installations and modifications within existing traffic signal systems shall be compatible and the equipment interchangeable with the existing equipment.

All traffic signal equipment supplied shall be of models that are currently manufactured by the suppliers of such equipment.

The locations of signals, standards, controllers, services and appurtenances shown on the plans are approximate and the exact locations will be established by the Engineer in the field.

Upon completion of the work, the Contractor shall submit record drawings or corrected plans, or any additional data required by the Engineer showing in detail all construction changes, including but not limited to wiring, cable, and location and depth of conduit.

The Contractor shall submit two sets of schematic wiring diagrams for the traffic signal controller, the signal installation's light circuits and all auxiliary equipment including units and values for each component used to the Engineer. These diagrams shall show in detail all circuits and parts. Such parts shown thereon shall be identified by name or number and in such manner as to be readily interpreted.

All diagrams, plans and drawings shall be prepared using graphic symbols shown in ANSI Y32.2, “Graphic Symbols for Electrical and Electronic Diagrams.” The cabinet drawings shall be non-fading prints using the xerography method. Blue line drawings will not be accepted.

One copy of the controller cabinet diagram and the intersection and phase diagram as approved by the Engineer shall be placed in a heavy-duty plastic envelope with side opening and attached to the inside of the door of each controller cabinet.

Manufacturer guarantees furnished with installed equipment shall be furnished to the Engineer. The extent of such guarantee will not be a factor in selecting the successful bidder.

Steel incorporated into Traffic Signals shall conform to the material grade and type specified in the Standard Plans Steel plates, shapes, and bars shall conform to the requirements of Section 509. Tubular steel shall conform to the requirements of ANSI/AWS D1.1.

(b) *Traffic Signal Controllers-General.* The traffic signal controller shall be a Type 170E constructed per the FHWA-IP-78-16 specification except as revised in 614.08(b)1.,2., and 3. below. The controller assembly shall consist of a controller unit, cabinet and all necessary auxiliary equipment to provide the operation as shown on the plans. The output file shall have eight "flash programming jumper blocks," one for each of the eight phases.

The power distribution assembly shall be the PDA No. 2. The PDA No. 2 shall have field circuit breakers 1-6 to provide 15 amperes of operating AC current to the field load switches. If one of the field breakers is set off, the indicating switch shall place power on the MC coil and FTR coils causing a flashing operation.

The Prom Module shall be a 412B System Memory Module.

The module shall comply with details and connections shown on the plans for the Model 170E Traffic prom Module.

All electrical connections in and out of the module shall be through a printed circuit connector having two rows of 36 independent bifurcated contacts on 0.10-inch centers.

The module shall be designed so that persons inserting or removing the assembly shall not be required to insert hands or fingers within the microprocessor unit housing this modular assembly. A handle or gripping device protruding no more than 1 1/4 inches from the front panel shall be attached to the front of the assembly. The front panel shall be connected to ground.

All Inputs and Outputs shall be Tri State Buffered enabling them to drive a load consisting of 10 TTL gates and 200 picofarads. When this module is not being addressed, the data inputs and outputs shall be disabled into a high impedance state and the data I/O lines shall not source or sink more than 100 micro amperes. All address inputs shall not load the bus by more than one TTL gate load and 100 picofarads.

There shall be provided a positive method to prevent this module from being inserted upside down in the prom slot with the front panel of the 170E closed.

The memory module shall consist of a minimum of three 28-pin sockets, for JDEC pin compatible memory devices ranging in sizes from 4K X 8 (2732) to 32K X 8 (27356).

The selection of address and backup power shall be made via soldered wire jumper options.

One 28-pin socket shall be designed to house only EPROM memory devices. The remaining two 28-pin sockets shall be designed to house RAM, NOVRAM or EPROM memory devices. Solder jumper options shall route the optional battery backup power to each of these two sockets, when specified. When specified, the backup battery power shall enable volatile memory devices to retain the data in their memory in the event of a power failure or when the module has been removed from the 170E controller for a period of at least one year.

The entire memory map address map shall be user definable such that each socket can be addressed independently. The decode shall be provided by bipolar prom. When the bipolar prom recognizes an address within the range of the prom module, the appropriate decode output shall become active thereby enabling the appropriate memory device. Resistors shall be used to pull up the memory select lines to the +5 Volt power bus if the device is selected for battery backup power. This shall provide data detention in the event of a controller power failure.

There shall be provided on the 412B SYSTEM MEMORY MODULE a regulated 5 volts' power supply, derived from the 12-volt supply available on the Prom Module. This supply shall provide a minimum of 500 milliamperes on the assembly. This 5-volt supply shall power only the module address bus, the data bus and the bus buffers.

There shall be a wire protect circuit to write protect the memory devices when power has been removed, and to delay writing for a short time after power has been restored.

The 412B shall have provisions for an optional battery backup supply voltage for RAM devices when the power is removed from the module. This optional battery, when called for, shall be an AA size lithium battery. All modules shall be provided with a battery disconnect switch and battery holder clip devices for the AA battery.

The assembly shall operate and mate with all Model 170E Controller Units.

The following configurations are required for the operation of Wapiti software used by CDOT.

The 412B Prom Module shall be configured for a 27256 EPROM at address 8000-FFFF and NOVRAMs at 1000-4FFF and 7000-7FFF unless otherwise specified.

When specified that the 412B Prom Module will be used for a master controller, a 27256 EPROM shall be used at address A000-FFFF, a RAM shall be used at 8000-9FFF, and NOVRAM configured for 0800-4FFF and 7000-7FFF.

The 170 PROM module shall be on the Colorado Qualified Products list.

1. 170E traffic Signal Controller. Each controller shall be a Type 170E with 4 ACIA connectors and two modem slots per FHWA-IP-78-16 specifications except as noted below.

   In addition to the manual (as specified in the FHWA-IP-78-16 specifications) two "D" size (24-inch x 34.5 inch) drawings of all schematics and assembly prints contained in the manual shall be supplied for each twenty controllers or revision change.

   The 170E Controller shall come with a blank panel to cover the Prom Module opening if the CDOT chooses to use a Prom Module. This panel will have all the necessary hardware to be attached to the Front panel.

   FHWA-IP-78-16 Specifications Vendor's Testing Certification shall be modified to read, "The Vendor shall supply with each shipment a full test report of the quality control and final test conducted on each item." In addition, the Contractor shall supply a statement with each 170E controller that the unit was tested per Section 1.8.5.3.3 as modified below.

   1.8.5.3.3 shall be modified to read "A minimum 100-hour burn-in of all modules. This burn-in shall include 48 hours of monitored testing at the high and low temperatures as described in 1.8.3.7.1 and 1.8.3.7.2."

2. Training. The Contractor shall provide 16 hours of training at a site designated by CDOT. This training shall include but not be limited to Diagnostic Software and circuit theory and operation of the 170E controller. The training will be provided by a person knowledgeable in the operation and repair of the 170E controller, 332 and 336 cabinets, and associated diagnostic software.

3. Prom Module. The Prom Module shall be a separate item that shall be provided only when requested. The Prom Module shall be a 412B type Prom Module unless otherwise specified. When the equipment is supplied for a project the Contractor shall contact the Regional Supervisor to obtain the Traffic Program Revision that is to be provided.

(c) Controller Cabinets. The controller cabinet shall be either a Model 332 or 336S as specified in the Contract. The 336S cabinet shall include a base extension assembly. Each cabinet shall be natural aluminum with anchor bolts per the FHWA-IP-78-16 specification. The input files shall meet the requirements of the split input file below. Unless otherwise specified in the Contract, the cabinet shall include the following:

Table 614-1

CONTROLLER CABINET CONTENTS

Quantity	Item
2	Internal (front/back) fluorescent lamps
4	Model 430 Transfer Relays
2	Model 204 2-Circuit Flasher (cube type, 25 AMP output)
12	Model 200 Load Switches (cube type, 25 AMP output)
3	Model 242 DC Isolators
6	Model 222 Loop Amplifiers
1	Model 210 Monitor with absence of red monitoring
1	New York 330 Pull-out Drawer Assembly
1	Auxiliary Detector Termination Panel Assembly
1	Transient Voltage Surge Suppression System

A 20-conductor cable assembly for monitoring the red outputs of all signal load switches shall be provided and mounted to the back panel assembly. The cable shall be routed to the front of the assembly and be plugged into the connector on the front of the conflict monitor.

A means of selecting the active red monitor channel shall be provided on the rear of the monitor panel. Selection shall be accomplished by means of a two-position jumper (shunt) with the center position wired to a red monitor input and select of 115V AC to the right and red load switch output to the left. Moving the jumper to the right will provide continuous red input and override, while moving a jumper to the left will attach the monitor channel to the corresponding load switch output.

This jumper assembly shall be accessible while the intersection is in operation. Means shall be provided to prevent shock to personnel operating jumper selection devices.

A minimum of 12 selections are required, eight phase selections and four overlap selections shall be provided with jumper selections.

Red monitoring disable control shall be provided within the red monitor cable assembly. Pin six on TB02 shall connect to a 24V DC relay coil. This relay is designated RM control relay. The normally closed contacts shall provide 115V AC to the red monitor select line and pin 17 on the monitor cable. When a logic ground signal is applied to TB02-6 the RM relay shall energize and open the cable. The relay power will be derived from the cabinet 24V DC cabinet power supply.

Electrical characteristics of the device that will be used for series transient protection on the 332 and 336S cabinet system shall include tests run using a Velonex 587 surge generator and Tektronix oscilloscope type 2430 or equivalent hardware. Using ANSI/IEEE 062.41-1980 waveforms for normal mode and common mode ring wave and impulse tests, each unit shall comply with the following minimum characteristics:

1. Clamping level 400V peak normal mode and 500V peak common mode. Trace photos and other test related information will be available upon request.
2. EMI/EFI noise rejection derived via standardized 50-ohm insertion loss tests shall have amplitude of at least -20db over a minimum spectrum from 50 kHz with a -40db being the most desirable.
3. Diagnostics indicators shall clearly display the status of the suppression circuit. The indication shall warn of the loss of protection.
4. Transient energy suppression shall be in excess of 250 Joules.
5. Rated voltage is 120V AC with rated output current minimum 10 amperes single-phase operation.

All of the above components provided on the project, excluding the signal monitor unit, shall be on the Colorado Qualified Products listing.

Split input file shall be an SF 170 that will operate in the 332/336S cabinets.

The Split Input File shall use the same form factors as the present (older) input file and shall be completely interchangeable with these older input files except as follows.

The input file shall use a split 22 pin connector (2 rows of 22 pins) that provide for 44 unique contacts, rather than the 22 double contacts as provided by the former input file. This design shall interface electrically with the older two and four channel devices available under the 170 and NEMA TS1 specification as well as the newer two and four channel devices as specified in the TS2 NEMA specification.

The input file shall be divided into two partitions. The first partition shall include the first eight slots from the left; the second partition shall include the next six slots. All 14 slots shall be able to be tied to one common communication drop if desired.

The serial/TTL Transmit and receive pairs shall be wired across the back panel. TXO, DXO, and Ground0 serve the first eight slots; TX1, DX1 and Ground1 serve the next six slots. Black plane addressing is automatically assigned in the rear of the input file, such that:

Slot 1 = Address 0

Slot 2 = Address 1....Slot 8 = Address 7 (all three-line low)

Addressing from the front of any input device shall override the back plane addressing.

Serial connections shall use a standard quick lock connection.

(d) Magnetic Detectors. Magnetic vehicle detectors shall have a moisture-proof housing and shall be capable of withstanding all types of soil conditions. The magnetic vehicle detector shall be designed for underground operation and installed in a nonmetallic conduit housing.

Magnetic detector amplifiers shall have a continuously adjustable sensitivity level control, which shall be adjustable over the full range of amplification of the unit.

Each magnetic detector shall be capable of being activated by a voltage induced in the coil of the sensing element by the passage of a vehicle at any speed from 3 to 80 miles per hour. Any vehicle passing within 18 inches of either end of the sensing element shall provide an output signal.

Each amplifier shall be provided with an integral power supply.

Each amplifier shall be designed to provide ease of maintenance with all electronic components readily accessible.

All input and output circuits for each amplifier shall enter via a single MS connector, circuitry that shall be as shown in the following table:

Table 614-2

CONNECTOR CIRCUITRY
FOR MAGNETIC DETECTOR AMPLIFIERS

MS Connector Circuit	18-8 Pin
Magnetic Detector (-)	A
Magnetic Detector (+)	B
AC+, 120 volts	C
Chassis Ground	D
Detector Common	E
Output N.O.	F
Output N.C.	G
AC-, Grounded Conductor	H

All controls, indicator lights, fuse holders, and connectors shall be mounted on the front panel of the amplifier.

The magnetic detector sensing element casing shall be constructed of nonferrous materials suitable for use in the environment that it will operate and shall be sealed to prevent the entrance of moisture. The sensing element shall be designed to facilitate easy installation, repositioning and removal.

(e) Micro Loop Detectors. Micro loop detectors shall conform to the following and to the details shown on the plans.

The sensing element shall be no larger than 2 inches in diameter by 4 inches high and shall contain no moving parts.

The unit shall be a passive transducer that converts magnetic field intensity into inductance for use with conventional inductive loop detector units for the passage detection of vehicles. The operating field shall be 0.2 to 1.0 oersted; inductance: 20uH and DC resistance of 0.5 ohms plus 20uH and 3.2 ohms per 100 feet of probe cable.

Each micro loop detector shall be capable of being activated by a change in magnetic field caused by the passage of a vehicle within the lane of required detection at any speed from 3 to 80 miles per hour.

The probe shall operate at temperatures from minus 35 to 165 °F and at a relative humidity of 0 to 100 percent including submersion in solutions of chemicals typical of roadway run-off.

Lead-in cable shall be factory assembled, polyurethane jacketed, four conductor No. 22 American Wire Gauge (AWG), and shall be of a length specified on the plans.

(f) Pedestrian Push Buttons. Pedestrian push buttons shall be a piezo, direct push button contact type and shall consist of electronic control equipment, mounting hardware, and push button.

The pedestrian push button shall be weatherproof, tamper-proof, constructed so that it will be impossible to receive any electrical shock under any weather condition, and operate on a voltage not to exceed 24 VAC.

The housing shall be shaped to fit the curvature of the pole where it is attached to provide a rigid installation. Saddles shall be provided to make a neat fit when required.

Materials for Pedestrian Push Button Post Assembly shall conform to the following:

1. The Pedestrian Push Button Post Assembly, sign, and push button shall conform to the following:

   A. The latest version of the ADA Standards for Accessible Design, Chapter 3, Section 309 Operable Parts.

   B. Current CDOT adopted Manual of Uniform Traffic Control Devices (MUTCD), Chapter 4E-Pedestrian Control Features.

   C. NEMA TS 2 Section 2.1 requirements for Temperature and Humidity, Transient Voltage Protection, and Mechanical Shock and Vibration.

   D. IEC 61000-4-4; 4-5 Transient Suppression requirements.

   E. FCC Title 47, Part 15, Class A, Electronic Noise requirements.

2. The post for the Pedestrian Push Button Post Assembly shall be aluminum Schedule 40.

3. Wiring for the Pedestrian Push Button Post Assembly shall conform to the manufacturer's recommendations.

4. A #10 AWG (minimum) bare copper wire shall be used to connect the Pedestrian Push Button to the signal grounding system.

5. For signalized intersection crossings, the system shall have a programmable Extended Push Activation feature with the ability to extend the Walk time. Activation shall be programmable from one to six seconds.

(g) Accessible Pedestrian Signals. The Accessible Pedestrian Signal (APS) shall be an audible vibro-tactile pedestrian signal system and shall consist of all electronic control equipment, mounting hardware, and push button, designed to provide both a push button with a raised, vibrating tactile arrow on the button as well as a variety of audible indications for differing pedestrian signal functions.

The integrated pedestrian push button shall be weatherproof, tamper-proof, constructed so that it will be impossible to receive any electrical shock under any weather condition, and operate on a voltage not to exceed 24 VAC.

The housing shall be shaped to fit the curvature of the pole where it is attached to provide a rigid installation. Saddles shall be provided to make a neat fit when required.

Materials for Pedestrian Push Button Post Assembly shall conform to the following:

1. The pedestrian push button post assembly, integrated push button, and sign shall meet the following requirements:

   A. The latest version of the ADA Standards for Accessible Design, Chapter 3, Section 309 Operable Parts.

   B. Current CDOT adopted Manual of Uniform Traffic Control Devices (MUTCD), Chapter 4E – Pedestrian Control Features.

   C. NEMA TS 2 Section 2.1 requirements for Temperature and Humidity, Transient Voltage Protection and Mechanical Shock and Vibration.

   D. IEC 61000-4-4; 4-5 Transient Suppression requirements.

   E. FCC Title 47, Part 15, Class A, Electronic Noise requirements.

   F. The APS pushbutton enclosure shall meet the NEMA 250 – Type 4X enclosure requirement.

2. The post for the Pedestrian Push Button Post Assembly shall be aluminum, Schedule 40.

3. Wiring for the Pedestrian Push Button Assembly shall conform to the manufacturer's recommendations.

4. A #10 AWG (minimum) bare copper wire shall be used to connect the Pedestrian Push Button Post Assembly to the signal grounding system.

5. For signalized intersection crossings, the system shall have a programmable Extended Push Activation feature with the ability to extend the Walk time and provide an informational audible message. Activation shall be programmable from one to six seconds.

The Accessible Pedestrian Signal (APS) shall have the following functional requirements:

1. APS functional features.

The APS shall be programmable and adjustable. Programming and adjustments shall be made using a laptop computer, smart device, or vendor supplied programmer. No additional hardware or equipment shall be required. The APS shall be fully compatible with the three latest versions of the Windows operating platform. The programmable features shall be:

A. Push-button locator tone.

B. Walk and Wait audible message.

C. Audible push-button informational message.

D. Audible crossing beacon.

E. Vibrating, tactile arrow push button.

F. Independent minimum and maximum volume limits for the Locator Tone, Walk, and Audible Beaconing features.

Audible features shall emanate from the pedestrian pushbutton housing. The APS shall utilize digital audio technology, having a minimum 12-bit sample at a 16k Hz sample rate. Total harmonic distortion shall be less than 3 percent at 75 decibels. The APS shall provide independent ambient sound adjustment for the Locator Tone feature. The APS shall allow for Locator Tone volume to be set below the ambient noise level. The system shall have a minimum of three programmable locator tones. All sound levels shall adjust automatically utilizing an internally mounted, interval ambient sensing microphone, per the MUTCD.

For signalized intersection crossings, the APS shall monitor the Walk condition for conflict operation. As a standalone unit, the APS shall disable the Walk functionality should a conflict be detected.

The APS system shall log cumulative call data. The data shall be date and time stamped and shall be accessible via laptop or smart device.

For signalized intersection crossings, the system shall provide a programmable audible Wait message when the button is pushed. The message shall only annunciate once per actuation.

2. Power Control Unit (PCU).

The PCU shall be mounted in the pedestrian signal head and shall be powered by the activation of Walk or Don’t Walk using 120 Volts Alternating Current (VAC).

The PCU shall utilize separate power inputs for Walk and Don’t Walk. The PCU shall not require more than four wires from the PCU to the corresponding push button.

3. Push Button Assembly (PBA).

The PBA shall be a single assembly containing an ADA compliant, vibro-tactile (signalized) directional arrow button, weatherproof audible speaker, and informational sign with optional placard braille messages. The PBA housing shall not incorporate any plastic or polycarbonate parts.

The PBA tactile arrow shall be 2 inches in length and shall be field adjustable to two directions.

The push button shall utilize Piezo switch technology rated at greater than twenty million operations. Vibro-tactile operation shall pulse at 20 Hz with a minimum 0.003-inch displacement against a 2-pound applied force.

The PBA assembly shall be capable of mounting on a curved or flat surface utilizing either machine screws or bolts or banding type mounting hardware. The PBA shall accommodate mounting to a minimum 4-inch diameter pole.

(h) Traffic Signal Poles. All traffic signal poles, mast arms, concrete foundations, and necessary hardware shall conform to the appropriate requirements of Sections 601, 613, 713, and 715, these specifications, and the details shown on the plans.

All traffic signal poles and mast arms shall be of like manufacture. Workmanship and finish shall be equal to the best general practice of metal fabrications shops.

Pole shafts shall be straight, with a permissive variation not to exceed 1 inch measured at the midpoint of a 30-foot or longer pole and not to exceed 3/4 inch measured at the midpoint of a pole shorter than 30 feet.

Plumbing the pole shall be accomplished by adjusting the nuts before the foundation is finished to final grade. Shims or other similar devices for plumbing or raking will be permitted only when approved.

Span wire poles may be seamless or may be fabricated as one piece without transverse joints or welds and with only one longitudinal seam, which shall be continuously welded, and ground, or rolled flush.

(i) Traffic Signal Faces. All pedestrian signal faces and all vehicle signal faces shall conform to the requirements of subsection 713.11, the plans, and the following:

All vehicle signal faces shall be of the adjustable, vertical type with the number and type of sections detailed and as shown on the plans. They shall provide a light indication in one direction only and shall be adjustable through 360 degrees about a vertical axis. They shall be mounted at the location and in the manner shown on the plans. Unless otherwise shown on the plans, all signal faces shall be standard and shall contain three sections arranged vertically; red-top; yellow-center; green-bottom.

All vehicle signal faces shall be focused to allow maximum visibility to approaching motorists. All new faces installed, at any one intersection, shall be of the same make and type.

When specified on the plans, the optical units of all vehicle signal faces and all pedestrian signal faces shall be an LED Traffic Signal Section Optical Unit conforming to the requirements of subsection 713.11. The LED optical units shall be installed per the manufacturer's instructions.

(j) Backplates. Where shown on the plans backplates shall be furnished and installed on signal faces. No background light shall show between the backplates and the signal face or between sections.

(k) Programmed Visibility Vehicle Signal Faces. All programmed visibility vehicle signal faces shall conform to the requirements of subsection 713.11, the plans, and the following:

Each programmed visibility signal section shall provide a nominal 12-inch diameter circular or arrow indication. Color and arrow configuration shall conform to ANSI D-10.1.

Each section shall be provided with a sun visor.

Each signal section shall be provided with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal while maintaining a common vertical axis through couplers and mountings. Terminal connection shall permit external adjustment about the mounting axis in five-degree increments.

The signal shall be mountable with ordinary tools and capable of being serviced without tools. Adjustment shall be preset at four degrees below the horizontal, unless otherwise specified.

Before programming, each signal section with a yellow indication shall provide a minimum luminous intensity of 3,000 candela on the optical axis, and a maximum intensity of 30 candela at 15 degrees horizontal from the axis. Each such signal section shall be capable of having its visibility programmed to achieve the following luminous intensities: a minimum of 3,000 candela on the optical axis, a maximum of 100 candela at from 1/2 to 2 degrees horizontal from the axis and a maximum of 10 candela at from 2 to 15 degrees horizontal from the axis. Under the same conditions, the intensities of the red indication and the green indication shall be at least 19 and 38 percent respectively of the yellow indication.

The Contractor shall program the head as recommended by the manufacturer or as directed.

The visibility of each programmed visibility signal face shall be capable of adjustment or programming within the face. When programmed, each signal face's indication shall be visible only in those areas or lanes to be controlled, except that during dusk and darkness a faint glow to each side will be permissible.

(l) Traffic Signal Electrical Conductors and Control Cable. Conductors and cables shall conform to subsection 713.11.

An 1/8-inch nylon rope shall be installed in all new conduit and all existing conduit where a cable is added or an existing cable is replaced. At least 2 feet of pull wire or rope shall be doubled back into the conduit at each termination.

Signal light conductors shall conform to the Red-Yellow-Green color sequencing with different colored tracers for each phase provided.

Sufficient signal light conductors shall be provided to perform the functional operation of the signal system. Additional conductors for service, interconnect, etc. shall be provided as noted on the plans.

A separate set of three spare conductors shall be provided from the controller cabinet to the base of each pole.

Conductors shall be permanently identified as to function. Identification shall be placed on each conductor, or each group of conductors comprising a signal phase, in each pull box and near the end of terminated conductors.

Identification shall be by bands fastened to the conductors in such a manner that they will not move along the conductors.

Loop detector wire shall consist of specified loop wire encased in 1/4-inch OD, 3/16 -inch ID vinyl or polyethylene tubing.

All inductive loop detector harness cables shall be shielded.

All detector and pedestrian push-button circuits shall consist of separate two conductor wire systems.

All signal light cable conductors shall have individual terminal lugs for connection to terminal strips.

All detector lead-in cable shall consist of two No. 14 copper conductors with each conductor insulated with high molecular weight, heat-stabilized, colored polyethylene. The conductors shall be twisted, and the twisted pair shall be protected with a shield of tinned copper-brass or aluminum-polyester. A No. 16 minimum, stranded, tinned, copper ground drain wire shall be provided. The cable shall be provided with a chrome vinyl outer jacket with a minimum thickness of 37 mils, suitable for use in conduit or for direct burial when used in conjunction with magnetic or magnetometer detectors.

Loop Detector Wire (Prefab) (Special) shall meet or exceed the following:

The loop shall consist of No. 14 AWG wire and the minimum number of turns as specified in the plans. The conductors shall maintain their relative position to each other throughout the entire loop configuration. Twisting of the conductors within the loop configuration will not be permitted.

The loop wires shall be installed in protective tubing constructed of a cross-linked polyethylene material or equivalent. The outside diameter shall not exceed 0.5 inches. The preformed loop shall be hermetically sealed at the tee and at the lead-in header to prevent the entrance of water.

The loop lead-in wires from the preformed loop to the pull box shall be a twisted 14 AWG wire, with at least five turns for every three feet. Wiring shall be encased in the same cross-linked polyethylene tubing material or equivalent.

Installation of preformed loops shall be per the manufacturer's recommendations. Before installation, the Contractor shall provide a paper copy of the installation procedures for the project.

The preformed loops shall be manufactured to the dimensions shown on the plans and designed to be laid in place immediately before paving operations.

The Contractor shall determine the length of the loop lead in wires required from the preformed loop to the first pull box outside the roadway and shall furnish a copy of the lengths to the Engineer.

Regardless of type, there shall be no splices in the pull box special.

The loops shall be delivered to the project at least seven days before installation and placement.

The Contractor shall check the continuity of the loops upon delivery to the project, once set on grade immediately before the paving operation, and after the paving operation. The Contractor shall check both continuity and resistance to ground the following day or as directed and shall record and submit the results.

(m)Traffic Signal Vehicle Detector Amplifier.

1. General System Requirements.

   Vehicle detector amplifier shall consist of high performance, multiple channel inductive loop vehicle detector units and data acquisition software that can provide binned traffic data and real-time traffic measurements on a vehicle-by-vehicle basis. The system shall provide current measurements and vehicle detection information on the last vehicle for use in local control, incident detection and advanced traffic management systems.

   A communication link shall provide remote access to the detector for reading unit configuration settings, for fault identification and verification, for real-time system monitoring and data collection on up to four channels of detection. It shall include password security to the detector to change configuration settings. The communication link shall provide for party line communication on up to eight units using 4-bit hardwired addresses to the card edge connector and 127 software programmable addresses in electronically erasable programmable read-only memory (EEPROM) memory.

   The interface and data acquisition software shall be organized by application and facilitate setup, real-time traffic monitoring and collection of binned count and occupancy data. A vehicle log shall provide a means for logging of vehicle speed, vehicle length, loop-to-loop travel time, and detection duration. Optional modes of operation shall include a vehicle travel direction detection setup capability using overlapped 6 foot by 6-foot loops, a long-loop count mode to provide turning movement counts and a microloop mode selection when channels are connected to microloop sensors.

   The Contractor shall supply data acquisition and interface software and vehicle detectors that meet all the operational and functional performance requirements per the terms and conditions of this specification.

   The Contractor shall obtain the manufacturer’s standard warranty and surrender it to the Engineer.

2. General Hardware - Standards and Performance Requirements.

   The inductive loop detector units shall be fully interchangeable, whether used for system counting, occupancy measurement, speed and length measurement, directional detection, binned data collection, remote data acquisition in advanced traffic management systems or for local intersection control (including long-loop counting).

Detector configuration data shall be entered using special interface and data acquisition software. A communication interface shall provide for remote connection and configuration of detectors, real-time activity monitoring and data acquisition via modem to remote devices.

Inductive loop detector units shall meet the latest edition of the National Electrical Manufacturers Association (NEMA) Standard TS2-1992 for Type 2 controller and cabinet assemblies plus the functional and performance requirements of this specification. The detectors shall be configured as plug-in devices that meet the requirements for NEMA TS2-1992 section 3.2, actuated Type 2 A2 operation and Type I Al operation in 44-pin input files.

Detectors shall comply with NEMA TS2-1992 Section 6.5.2.2.1, Table 6.5-1 for four-channel rack mount type units, NEMA designation "D," except that Delay and Extension Timing shall be provided on all four channels in lieu of NEMA TS2-1992 section 6.5.2.24 requirements.

Detectors shall also be suitable for use in California/New York TYPE 170/179 and ATC cabinets with 22-pin input files. Detectors shall detect and hold the presence of all licensable motor vehicles (including small motorcycles). This shall be accomplished, without detecting traffic in the adjacent lane (beyond 3 feet from the loops except as noted below), on the following loop configurations with from 100 feet up to 1,000 feet of home-run cable.

One to six series connected, 6-foot-by-6-foot square loops with three turns of #14 AWG wire or with four turns of #14 AWG wire.

A 6-foot-wide by 30-foot-long loop with two or three turns of #14 AWG wire (when set to detect small motorcycles, may detect adjacent lane traffic).

A 6-foot-wide by 20-foot to 60-foot-long quadruple loop with a winding of two-four-two turns of #14 AWG wire. When sensitivity is set to detect small motorcycles, adjacent lane traffic shall not be detected.

Single, double and triple microloop probe sets.

Each channel shall automatically self-tune with full sensitivity, to any loop and lead-in combination resulting in a total inductance of 20 to 2,500 microhenries with a Q factor of five or greater, within four seconds after application of power.

3. Special Features and Performance Requirements.

Detectors shall be microprocessor controlled and be capable of being configured with manual switch settings and via software settings in EEPROM memory.

Detectors shall include eight sensitivity settings (thresholds) in 2:1 steps. Threshold settings shall directly relate to nanohenries of inductance change (ΔL). Each increase in Presence or Pulse mode settings shall double the sensitivity (reduce the threshold) from the previous setting. The highest sensitivity (smallest change) setting shall have a ΔL threshold value of eight nanohenries while the lowest sensitivity setting shall have a ΔL threshold of 1024 nanohenries.

Each detector shall have a single, switched oscillator system to sequentially excite and measure each channel.

Each detector shall have a three-position toggle switch to manually select one of three operating frequencies. These three frequencies shall also be software selectable.

Each detector shall have two serial ports; a front panel RS232 port and transmit/receive pins on the card edge connector for serial communication.

Each serial port shall have a multi-drop mode and be capable of party line communication with up to eight detectors on the party line.

The detector unit shall be designed to accommodate the addition of either an optional plug-in memory module or a plug-in communication module.

The communication module shall allow expansion of the multi-drop capability to 32 devices on a common serial port bus and convert the rear port into an independent port. With the optional module installed, communication with a PC through the front port shall not interfere with system communication on the rear serial port, and the baud rates shall be independently settable for the front and rear serial ports.

Baud rates shall be selectable at 1200, 2400, 4800, 9600, or 19200 BPS using the interface software.

The memory module shall expand the memory used for on-board count and occupancy binning.

The front panel serial port shall have EIA-232 electrical characteristics and shall terminate with a front panel 6-pin circular Mini-DIN connector.

A communication cable with a DB-9 female connector (for a computer serial port connection) and a 6-pin Mini-DIN male connector (for the front panel serial port connection) shall be provided for direct communication with a remote reporting device or a PC running the interface and data acquisition software.

Units shall have software settable addresses from 128 to 254. Address 255 shall be assigned as a “wildcard” to be used only when connected to the front panel port to establish connection and read the correct address from the device.

Units shall have 4-bit back panel hardwired addressing capability to allow selection of one of 16 hard-wired addresses. Backpanel addressing shall be enabled via the interface software.

An external 24VDC Green control input shall be provided to control the output timing. If True (ground level = 0 to +8VDC), the Green input shall disable Delay and enable Extension Timing. If False (+16 to +30VDC or Open), the Green input shall disable Extension and enable Delay Timing. Software shall provide for an option to disable Green Gating so that Delay or Extension Timing is provided unconditionally.

Detector units shall have a Presence or Pulse mode output option. Selection shall be via front panel switches or software settable options.

Each channel shall have a pushwheel sensitivity switch to enable manual selection of one of seven Presence mode or eight Pulse mode settings or an OFF position.

Presence output shall hold vehicle detection for at least four minutes minimum for small, licensed motor vehicles (100 cc. motorcycles) and for at least 60 minutes for automobiles before tuning-out vehicles (dropping recognition of vehicle presence) over a 6 foot by 6-foot square loop with three or four turns of wire. The Presence output shall not tune out when vehicle motion exists (defined as vehicle entry and departures continue every few minutes and vehicles remain present in the sensing zone) for at least 60 minutes.

In Fast Recovery mode, the channel shall recover to full sensitivity within 750 milliseconds after all vehicles leave the inductive loop sensing zone.

Pulse mode shall provide a single, output pulse of 118 plus or minus 5 milliseconds in response to an 18-foot-long vehicle traveling over a 6 foot by 6-foot loop at 8 mph, and for successive vehicles traveling over the same loop at speeds ranging from 10 to 100 mph, with a one-second headway. Pulse width shall be programmable from interface software. If a vehicle remains over the loop, further detection shall be inhibited for a 1.9-second rephase delay and then full sensitivity shall return immediately regardless of continued presence of the vehicle. Pulse rephase shall be programmable from interface software.

Detector units shall have optically-isolated Field-Effect Transistor (FET) outputs to provide fail-safe solid-state operation. The field-effect transistor (FET) is a type of transistor that uses an electric field to control the flow of current in a semiconductor. FETs are devices with three terminals: source, gate, and drain.

Loop detector channels shall continue to function with a single point short to ground on the loop/lead-in system.

Each channel shall be capable of detecting and displaying current and historical faults (a short to ground, an open circuit or an inductance change P 25 percent) in the inductive loop or lead-in system.

Each channel shall have two LED indicator lights on the front panel: a green “Detect” LED and a red “Fault” LED.

The green “Detect” indicator shall indicate detection output status and output timing in process.

The green “Detect” indicator shall indicate an Extend flash while the call output is actuated following a directional detection unless fail-safe for a particular condition is disabled using the interface software.

The green “Detect” indicator shall flash during Delay and Extension Timing to provide a visual indication of timed output. Delay and Extension flash rates shall differ by at least four times the other’s rate. Delay shall be four flashes per second and Extension shall be 16 flashes per second.

The green “Detect” indicator shall be ON continuously during a fault condition. During a fault condition on a channel, the channel shall display a continuous call indication on its green “Detect” LED and generate a continuous, fail-safe output on the primary output, regardless of the pulse or presence operating mode selected.

A status output shall provide a serial coded message to external devices (controllers) that are capable of using the serial information per NEMA conventions described in TS2-1992.

A red "Fault" LED shall indicate current or historical channel fault condition (status) and type. The Fault indicator shall flash a coded message during an open loop condition, a shorted loop system condition and a ≥ 25 percent change of inductance condition. The associated channel's red “Fault” LED shall provide visual indication of fault type and current or historical status with a unique flash code.

A fault indication shall be enabled for as long as the fault remains, except by turning the channel OFF in software or by selecting the “X” setting on the sensitivity switch.

If the fault heals or is corrected, the affected channel shall immediately retune and be capable of normal detection. The visual fault indication shall remain active until reset by a momentary change in the mode or sensitivity setting, a momentary interruption of power or by pressing a reset switch.

Primary output of each detector channel shall provide accurate detect duration in response to an automobile over a three or four turn 6-foot by 6-foot square inductive loop to enable accurate speed, length and occupancy measurements by external devices. The detector channel, with a 100-microhenry loop/lead-in attached to each channel, shall for any negative inductive change that exceeds its sensitivity threshold generate a ground true logic level output response within 13 milliseconds for a sensitivity setting of 128 nanohenries and within 20 milliseconds for a sensitivity setting of 64 nanohenries.

Loop detectors shall have a multi-position switch to reset all channels and to provide Normal and Fast Recovery modes of operation. The Fast Recovery setting shall cause the detector to adapt instantly to large changes of apparent inductance in the non-call direction. The Normal Recovery mode shall cause the detector to adapt, at a default rate of 0.5 thresholds per second, to apparent changes of inductance in both directions.

Loop detectors shall have a Remote Reset input pin on the card edge connector. The unit shall reset and establish a new reference for each loop that is turned ON, when voltage on Pin C is less than 8 volts DC for a period of greater than 17 milliseconds.

Delay Timing shall be adjustable from zero to 31 seconds, minimum, in increments of 1.0 seconds in lieu of NEMA TS2-1992 section 6.5.2.24.1 increments. Delay timing shall occur if the green input is false.

Extension Timing shall be adjustable from zero to 7.75 seconds, minimum, in increments of 0.25 seconds in lieu of NEMA TS2-1992 section 6.5.2.24.2 increments. Extension timing shall occur if the green input is true.

Each channel shall be capable of being configured for Long-loop Count mode for counting each individual vehicle moving onto or over a single inductive loop that has a length greater than 20 feet, regardless of previous vehicles being stationary on, moving over or leaving the detection zone. The call output in the Long-loop Count mode shall be a presence output. The configuration of the channel and the retrieval of the long loop count shall be accomplished via the serial ports using the software.

Two channels (channels 1 and 2 or 3 and 4) shall be capable of being assigned to directional detection mode for detecting the direction of travel of a vehicle over two overlapping 6-foot by 6-foot loops with leading-edge-to-leading-edge spacing of 3 feet. A call output shall be generated and stored as a directional count by the second channel that detects the vehicle in the direction of the vehicle's travel. The configuration of the detector for directional detection and the retrieval of the directional count shall be accomplished via the serial ports using the software.

Each channel of the vehicle detector shall be capable of collecting and storing counts and occupancy in time bins. The detector memory shall allow storing count and occupancy in 15-minute time bins for a duration of 36 hours and with the optional memory module for a duration of 335 hours. The configuration of the time bin intervals and the retrieval of the stored counts and occupancy shall be accomplished via the serial ports using the software.

4. Interface Software Requirements.

The detector unit shall be capable of remote configuration, system diagnostic measurements and real-time data collection. A communication link shall provide remote access to the detector for reading its configuration, for fault identification and verification, for real-time monitoring and data collection on up to four channels. The link shall provide optional password protection to change unit configuration settings. Interface software shall display and report current loop inductance measurements, current or last (historical) fault information, and information specific to the last vehicle detected and vehicle counts. Vehicle information shall include vehicle change of inductance, speed, length and time over loop.

A Windows™ based interface and data acquisition software program shall be provided to perform these functions via a remote reporting device running under a Windows operating system compatible with the Region’s existing signal operating system software.

The software shall establish and maintain the communication link to a remote reporting device via a field modem or by direct connection to one of the serial ports on the detector.

The software shall be organized by application to simplify setup and monitoring of channel activity measurements, traffic counting, long-loop count, logging of vehicle speed and vehicle length, loop to loop travel time, detect duration, binning of count and occupancy, and sensing of vehicle travel direction with directional detection and call duration.

The software shall allow selection of the PC's communication port and baud rate.

The software shall include a phone book and dialing utility.

The interface and data acquisition software shall provide a Read from Device command on the File menu. The Read from Device shall allow the selection of an address to establish remote communication with a detector unit.

The initial screen shall open with a Settings icon, a Real-Time Vehicle Logging icon and a Traffic Data Binning icon. After communications have been established with a detector, other icons shall appear. These shall include the Real-Time Activity Monitoring icon, Force ALL Outputs and LEDs icon, a Reset icon and a Scan-Time Utility icon.

A Settings window shall be divided into nine tabs to organize the settings by application.

A General tab shall allow selection of the configuration source to be either from EEPROM or switches, the oscillator frequency for the unit, the vehicle count period and channel sensitivity and mode.

A Communications tab shall provide for the setting of a field modem command string, transmit delay, selection of the communication baud rates on the front and rear ports, for setting a programmable address and to enable a backpanel address. There shall be provisions to establish, cancel and change a password.

If password protection is set up in a detector, the unit shall not respond to any requests to perform a reset or change settings until the correct password has been issued. After a verified password has been issued, the detector shall respond to all requests for reset or settings changes for 60 minutes. After 60 minutes, the unit shall revert to password-protected mode until the password has been issued. Reset shall cause immediate reinstatement of password protection.

A Timing tab shall provide for setting the Delay or Extend Time options and the timing increments for each channel. There shall be an option to select “Enable” Green Gating to condition the timing functions to green inputs.

A Microloop tab shall provide for selecting microloop mode of operation and setting some of the parameters that are unique to the performance of microloop sensors in special applications.

A Long Loop tab shall provide for selecting the option to count vehicles over long loops set to operate in Presence mode. Setup options shall be included to allow for calibrating the algorithm to improve count accuracy on loops 20 to 60 feet long. Vehicle counts shall be available over the serial communication ports.

A Directional tab shall provide the option of setting up travel direction sensing on channel pairs 1 and 2 and 3 and 4. With the paired channels connected to 6-foot-by-6-foot loops that are overlapped by 3 feet, vehicles shall be counted in both directions. The directional detection call output shall be assigned to the last loop a vehicle crosses when traveling in the direction that is to be detected. Call Duration shall be selectable for the directional output on the trailing channel of the paired sets.

An Output tab shall provide for the option to enable the Status Output for NEMA TS2 Type controllers. Software provision shall also exist to disable the “fail-safe” Call Output.

A Noise Immunity tab shall provide for selecting several noise options including a power line filter that can be enabled.

An Adapt tab shall provide for selecting the adaptation parameters for the detector unit to modify default operation.

A Real-Time Vehicle Logging icon shall provide for setting up channels to monitor vehicle speed and length measurements. Facilities shall be provided to insert a loop description (ID label), a loop type (configuration) and a calibration utility to select effective magnetic field loop sizes to improve measurement accuracy. The utility shall also provide for setting up loop assignments and leading-edge distances from loop to loop to calculate vehicle speeds. Facilities shall be included to activate and view the log with channel ID, loop descriptions, dates, times, speeds, lengths, durations, loop-to-loop times displayed in real-time. Provisions shall be made to save the log to a file and print the log.

A Traffic Data Binning icon shall open a window to setup and collect binned count and occupancy data from the detector. A tab shall provide for setting up the channels to be binned, the start date and time, the end date and time and the binning intervals. Software shall be included to inform the user when the detector will run out of memory based on the setup information provided. If continuous binning is selected the data shall “wrap-around” so that the oldest data will be overwritten with the latest entries.

A Real-Time Activity window shall be provided to display all current detection information pertaining to each channel, including current measurements (loop inductance, loop frequency, reference frequency, green input state and loop status), last fault (or historical fault) information (fault type, time and date), plus information specific to the last vehicle detected (DL in nanohenries, detect duration, detect time, and detect date) and traffic counts (count, directional count and the count period remaining).

The Activity window shall include a freeze capability to capture the current activity information while the unit continues to display the most recent changes.

A window shall be included to verify the operation of a detector’s outputs and LEDs and confirm the wiring of a control cabinet to issue the call output to a device or controller. This utility shall allow selection of specific Detect LEDs, Call Outputs, Fault LEDs, and channel Status Outputs to be “forced” ON or OFF for testing the system.

A window shall be included to remotely reset a detector. It shall be possible to select specific channels, all channels or the entire unit.

A window shall be included to provide a real-time view of the detector's self-measured scan-time. This interactive utility shall continuously read and display the detector’s scan-time and display the theoretical detection performance based on user-selectable parameters.

The software shall allow printing of settings, activity measurements, and binned and logged vehicle data.

A comprehensive ON-LINE Help utility shall be included with detailed descriptions of unit features and setup information. The Help text shall include hyperlinks to all subjects related to applications or setup sequences. Help screens shall include a print function to print the page.

CONSTRUCTION REQUIREMENTS

614.09 Highway Signs and Traffic Signals. Aluminum shall be heliarc welded and conform to the AWS requirements for welding aluminum. Portions to be welded shall be cleaned and prepared to assure 100 percent penetration butt weld. Oxygen cutting will not be permitted. Preheating, if used, shall not exceed 400 °F for 30 minutes. Defective welds shall be removed and rewelded. Acceptable aluminum welds shall be per AWS with 17 ksi the minimum tensile strength for reduced section specimens.

Welding and fabrication of Traffic Control Devices shall conform to ANSI/AWS D1.1, as amended.

Fillet welds connecting tubular steel to a shape or plate shall be qualified per ANSI/AWS D1.1, section 4.11.1.

The fillet weld Procedure Qualification Record (PQR), all Welding Procedure Specifications (WPSs) and Welder Qualification Records (WQRs), Inspection, and Nondestructive Testing Reports shall be submitted to the CDOT Staff Bridge Fabrication Inspectors, 4201 East Arkansas Avenue, Denver, CO 80222 for approval before fabrication. CDOT acceptance of submitted PQRs, WPSs, and WQRs establishes prequalification to fabricate Traffic Control Devices.

All ungusseted traffic signal mast to pole bracket, pole bracket to pole, and pole to base plate attachment welds shall conform to ANSI/AWS D1.1, Section 2.36.6.6.

Before welding, base metal surfaces shall be blasted or ground to eliminate mill scale, visible rust, oil, or debris.

Welding shall be performed before galvanizing, metallizing, or application of zinc coatings to the piece.

The fabricator shall submit a Written Practice for the Administration of Personnel Qualification and Certification Program per the American Society for Nondestructive Testing (ASNT) SNT-TC-1A for approval. Personnel performing the weld evaluations shall be certified as ASNT Level I or II. Certification of Level I and Level II individuals shall be performed by a Level III individual who has been certified by (1) The American Society for Non-destructive Testing, or (2) has the education, training, experience, and has successfully passed the written examination prescribed in SNT-TC-1A.

All welds shall be visually inspected by the fabricator. All welds shall meet the acceptance criteria specified in ANSI/AWS D1.1, Table 6.1, Tubular Connections (All Loads).

The arm simplex plate, pole simplex plate to gusset, gusset to pole, pole to base plate, and all sign bridge beam to pole clamp welds shall be magnetic particle tested (MT). The alternating current (ac) yoke method shall be performed. The yoke spacing shall be 4 inches. The yoke shall be calibrated each day per ASTM E709. Daily calibration records shall be maintained and made available for review upon request. The acceptance criteria shall be as specified in ANSI/AWS D1.1, Table 6.1, Tubular Connections (All Loads).

Structural steel shall be galvanized per ASTM A123. Pole hardware shall be galvanized per ASTM A153. All signs must be clean before erection. Installation shall be of such sequence as to result in maximum traffic safety. Signs shall be erected in conformity with the plans. Before final positioning, the sign shall be inspected at night by the Engineer and adjustments will be made, if necessary, to eliminate specular reflection.

Footings for ground signs and overhead sign structures shall be per the Contract. The tops of drilled caissons used for overhead sign structure footings shall be formed to at least 6 inches below ground line per Section 601.

Timber signposts shall be set in drilled or excavated holes and tamped firm and plumb. U-2 posts and steel tubing posts may be driven plumb or set in the same manner as timber posts.

The sequence of erection of new and reset sign installations shall be correlated with the removal of the existing traffic controls. The decision regarding the sequence shall be worked out with the Engineer before starting the work.

Longitudinal and lateral adjustments of sign locations to fit field conditions shall be as directed.

Electrical service for all sign illumination shall consist of all the electrical circuitry necessary from the power source to the switch box at the structure. This includes grounding, fusing, direct burial cable or conductor in conduit. Electrical service shall be 110 to 115-volt AC, 15 amp., fused circuit, and shall be installed underground unless otherwise shown on the plans or permitted.

Electrical work, including photoelectric control, shall conform to Section 613 and to the details shown on the plans.

Mask sign legend shall consist of providing a separate removable aluminum panel at least 0.040 inches thick and of sufficient dimensions to completely mask the legend. This panel shall be furnished with retro-reflective sheeting conforming to Section 713 and shall be the same color as the background of the sign. Panels shall be securely fastened to the main panel by mechanical means using a minimum number of fasteners. Adhesives, glues or tapes shall not be used.

Modifications shall be as follows:

1. Steel Signposts. This work shall consist of providing breakaway devices as shown on the plans for existing steel posts and shall include shortening and repainting the posts.
2. Timber Signposts. This work shall consist of providing breakaway devices as shown on the plans for existing 6-inch-by-6-inch timber posts.
3. Sign Legend. This work shall consist of modifying the legend on existing signs as shown on the plans and shall include all work necessary to remove and re-space existing legend; to furnish and install new legend and border as required.
4. Tubular Steel Sign Supports. Tubular steel signpost, slipbase or socket and wedge, footing, and mounting clamps shall be installed per Standard Plan S-614-8 and the manufacturer's recommendations. The Contractor shall make all arrangements to have a manufacturer-trained installer of the manufacturer's products on-site during the construction of the entire assembly and associated signs to ensure proper installation. Before the placement of the posts, the Contractor shall submit to the Engineer, written documentation of the installer's qualifications and training in the construction of tubular steel sign supports. Upon completion of installation, the Contractor shall obtain and submit documentation from the trained installer that the installation of the signposts was per the manufacturer's recommendations.

   The flashing beacon shall be installed as shown on the plans. The solar power system shall be placed outside the clear zone of the roadway or behind guardrail. Batteries shall be placed in a lockable container attached to a supplemental pole supporting the solar panels that is installed outside the clear zone, or behind guardrail.

Before start of the installation of an APS, the Contractor shall submit all units for testing. Installation of the APS shall not begin until written approval of each unit has been received from the Engineer. If a unit fails to pass testing, the Contractor shall repair or replace the unit at their expense.

614.10 Traffic Signal Systems - Construction.

(a) General. The Contractor shall submit an as-constructed plan, showing in detail all construction changes including wiring, cabling, locations and depth of conduit. The as-constructed plan shall include a sketch identifying the cables by numbers and a code describing the function and color of each conductor contained within the cables.

(b) Traffic Signal Electrical Conductors and Control Cable. All cables and conductors not shown on the plans as aerial cable or embedded loop detector shall be installed in conduit unless installed in poles, pedestals or mast arms.

Each mast arm mounted signal face shall be wired separately back to the pole base. The signal face position farthest from the pole shall be wired from the face to the controller to accept a five-section left-turn signal face, whether such a signal face is called for or not.

Aerial cable shall be installed where specified on the plans and secured to messenger cable with rings. Self-supported cable shall not be installed unless that cable is specifically designed for this purpose. Drip loops shall be provided on all conductors where they enter pole weatherheads or signal heads.

Wiring and splices shall conform to NEC practices. Wiring within cabinets, junction boxes, etc., shall be neatly arranged and within cabinets shall be laced.

Splicing of cable will not be permitted in the conduit or outside of pull boxes, standards, or pedestals at the handhole locations.

Powdered soapstone, talc, or other approved lubricant shall be used in placing conductors in conduit.

When splices are made, soldered splices or approved solderless connectors shall be individually taped with an approved polyvinyl chloride tape with a rubber-based pressure sensitive adhesive. The outside sheath shall be replaced by a minimum of two layers of this approved tape. Shellac compounds shall not be used.

All overhead splices shall be “T-tapped” and either soldered or connected by an approved copper compression ring. If a compression ring connector is used, the ring shall be applied by a ratchet tool, which will not release until the proper crimping force is applied to the connector.

All splices in detector sensing circuits shall be soldered and taped to exclude moisture.

All splices done in cables containing solid wire shall be soldered. Splices in underground systems shall be waterproofed. All underground splices shall be capable of satisfactory operation under continuous submersion in water.

Conductors between detectors and the controller cabinet shall not be contained in the same cable with any other signal control circuits but may be carried in the same duct or conduit as other signal circuits with not more than one splice in each detector sensing circuit.

At least 5 feet of slack shall be left for each conductor at each support pole and at least 3 feet of slack at each pull box containing cable connections.

A minimum of 6 inches of slack shall be left at each splice except within handholes where 12 inches shall be left.

When conductors and cables are pulled into the conduit, ends of all these conductors and cables shall be taped to exclude moisture and shall be so kept until the splices are made or terminal appliances attached. Ends of spare conductors shall be taped.

Multi-conductor cables shall be spliced and insulated to provide a watertight joint and to prevent absorption of moisture by the cable.

(c) *Bonding and Grounding*. Metallic cable sheaths, conduit, metal poles and pedestals shall be made mechanically and electrically secure to form a continuous system and shall be effectively grounded. Bonding and grounding jumpers shall be a #6 AWG bare copper wire or copper strap of the same cross-sectional area. Sheath for detectors shall be grounded in control cabinet only. The other end of the sheath shall be taped and left ungrounded.

A ground electrode shall be installed at each pole, pedestal, and control box. Each ground electrode shall be one-piece copper-weld rod of 5/8 inch diameter and 8 feet in length, driven to a depth of at least 8 feet below the surface of the ground.

Bonding of poles and pedestals shall be by means of connecting to the ground rod a bonding strap attached to an anchor bolt or a 3/16 -inch diameter or larger brass or bronze bolt installed in the lower portion of the shaft.

(d) *Excavation and Backfilling*. Excavation and backfilling shall be performed per the requirements of Section 206 and to the following:

All excavation and backfilling shall be made before other improvements are completed so as to not require the repair or replacement of new sidewalks, pavement or landscaping.

Excavation for the installation of conduit, foundations and other appurtenances shall be performed in such a manner as to cause the least possible damage to the streets, sidewalks, landscaping and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the electrical appurtenances and foundations. Excavation shall not be performed until immediately before installation of conduit and other appurtenances. The material from the excavation shall be placed in a position that will not cause damage or obstruction to vehicular and pedestrian traffic or interfere with surface drainage.

Excavations, after backfilling, shall be kept well filled and maintained in a smooth and well-drained condition until permanent repairs are made.

Excavations in the street or highway shall be performed in such a manner that not more than one lane of traffic in each direction is restricted at any time unless otherwise approved by the Engineer or in the special provisions.

Improvements such as sidewalks, curbs, gutters, portland cement concrete and asphalt concrete pavement, underlying material, lawns and plants, and any other improvements removed, broken or damaged by the Contractor's operations, shall be replaced or reconstructed at the Contractor's expense with the same kind of material as found on the work or with materials of equal quality.

(e) Foundations. All foundations shall be portland cement concrete conforming to the applicable requirements of Section 601.

The bottom of concrete foundations shall rest on firm ground. Foundations shall be poured monolithically where practicable. For poles and pedestals, the top 2 inches shall be poured after the pole or pedestal is in proper position. The exposed portions shall be formed to present a neat appearance.

Forms shall be true to line and grade. Tops of foundations except as noted on the plans, shall be finished to curb or sidewalk grade or as ordered. Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be placed in proper position and to proper height and shall be held in place by means of a template until the concrete sets.

Both forms and ground that will be in contact with the concrete shall be thoroughly moistened before placing concrete.

Where obstructions prevent construction of a planned foundation, the Contractor shall construct an effective foundation as directed.

Strain and mast arm poles shall be installed with the proper rake as recommended by the manufacturer of the poles so as to assure a substantially vertical set when the specified signal and lighting equipment is installed.

(f) Loop Detector Installation. Loop detectors shall be installed in the configuration shown on the plans. A complete installation consists of a conductor loop or group of loops installed in a saw cut in the roadway, lead-in cable and a sensor unit with power supply installed in a traffic signal controller cabinet.

The saw cut shall be made 3/8 inch wide and a minimum of 3 inches deep. The slot shall be as straight as possible and shall not vary more than 1/2 inch when checked with a 10-foot straightedge.

Saw cuts shall be hydroblasted with a mixture of water and air and then blown free of water and debris with compressed air only. The cuts shall be as dry as possible before placement of wire. All corners shall be rounded to full depth as directed to prevent angle bends in the loop wire.

After saw cut is cleaned of debris, the wire shall be placed for the loop by pushing it into the slot with a blunt non-metallic object. A screwdriver or other sharp tool shall not be used. Care shall be used to avoid abrading or damaging the insulation.

After the loops are properly seated and tested for continuity and proper loop inductance, the slots shall be filled with an approved two-part self-curing, self-bonding weatherproof epoxy, or an approved alternative material.

One continuous length of wire shall be used for each loop from the signal base or pull box around the loop with the specified number of turns and back to the signal base or pull box. Detector lead-in pairs shall be symmetrically twisted, five turns per 1 foot.

Two-inch conduit shall be placed under the curb and into a signal base or pull box to accommodate detector loop wires. Conduit may be "pushed" or trench-laid, depending on conditions at project site and upon approval from the Engineer.

Conductors of all loops to be operated by each sensor unit shall be run continuously to the nearest signal base or pull box. The loops shall be joined in the signal base or pull box in combination of series and parallel as shown on the plans so that optimum sensitivity is obtained at the sensor unit. Final splices between loops and lead-in cable shall not be made until the operation of the loops under actual traffic conditions is approved by the Engineer.

The loop detector wires shall be spliced to the shielded lead-in cable in the signal base or pull box and then pulled into the controller cabinet via the shortest possible distance using other existing conduit or messenger cable. A minimum of 3 feet of slack shall be provided in the controller cabinet for attachment to the detector amplifier. Each detector cable shall be clearly labeled in the control cabinet identifying phase relationship and approach leg.

(g) Magnetic Detector Installation. Magnetic detector sensing elements shall be installed within 3 inch, UL approved, Schedule 40 PVC conduit, as directed.

Conduit shall extend across the traveled way as shown on the plans. Bottom of conduit shall be placed 12 inches below top of pavement.

(h) Painting. All paint shall conform to Section 708. The painting of all electrical equipment requiring paint shall be done per Section 509.

The painting of all electrical equipment specified to be painted may be required at any time as directed. All metal parts of poles, pedestals, standards, and fittings shall be cleaned of all rust, scale, grease, and dirt before applying paint.

If an approved prime coat has been applied by the manufacturer and it is in good condition, an application of primer by the Contractor, other than for repairs, will not be required.

All exterior surfaces shall be examined for damaged paint and all such damage shall be given a spot coat of primer and the entire exterior surface repainted. Factory finish on new equipment. will be acceptable if of proper color and if equal in quality to the specified finish.

Paint shall not be applied to aluminum controller cabinets or to aluminum or galvanized poles, pedestals, standards, hardware, conduit, etc. unless specified. All steel poles shall be galvanized, unless otherwise shown on the plans. Controller cabinets (including inside door surface) shall be wire brushed or sanded to reduce reflectivity.

All paint coats may be applied either by hand brushing or by approved spraying machine in the hands of skilled operators. The work shall be done in a neat and skillful manner. The Engineer. reserves the right to require the use of brushes for the application of paint should the work done by the paint-spraying machine prove unsatisfactory or objectionable as determined by the Engineer.

Conduit and conduit fittings above ground shall be given one coat of primer and one coat of enamel conforming to the color of the adjacent standard or pedestal.

(i) *Maintaining Existing and Temporary Electrical Systems.* The existing traffic signals shall be kept in effective operation for the benefit of the traveling public.

Where power to all signals must be turned off, the Contractor shall provide an off-duty police officer or other qualified person to direct traffic during the period the signals are off.

The local traffic enforcement agency shall be notified before any operational shutdown of a traffic signal.

The above does not apply to intersections that are completely closed to all traffic due to construction.
The Contractor shall maintain at all times a minimum of two, three-section (red, yellow, green) traffic signal heads for each approach. If temporary signals are necessary to maintain the minimum signal display, the Contractor shall be responsible for furnishing all materials, equipment, tools, and labor necessary to install and maintain the temporary signals.

The State or local agency will continue operation and maintenance of existing electrical facilities. The State or local agency will furnish electrical energy for operation and will repair or replace facilities damaged by public traffic.

Where damage is caused by the Contractor's operations, the Contractor shall, at his expense, repair or replace damaged facilities promptly per these specifications.

Signal faces that are installed before turning on shall be covered or directed away from traffic to clearly indicate that the signal is not in operation.

1. *Field Tests and Turn On.* Before completion of the work, the Contractor shall make the following tests on all traffic signal circuits in the presence of the Engineer. Each circuit shall be tested for continuity.
2. Each circuit shall be tested for grounds.
3. An insulation resistance test shall be made on each circuit between the circuit and a ground. The insulation resistance shall not be less than the values specified in the provisions of the NEC.
4. A functional test shall be made where it is demonstrated that each part of the system functions as specified or intended. The functional test for each traffic signal system shall consist of at least five days of continuous satisfactory operation. If unsatisfactory performance of the system develops, the condition shall be corrected, and the test shall be repeated until the five days of continuous, satisfactory operation is obtained.

   Functional tests shall start on any workday except Friday, or the day preceding a legal holiday.

   Turn on of new or modified signal systems shall be made only after all traffic signal circuits have been thoroughly tested as specified.

   The initial turn-on shall be made between 9:00 A.M. and 2:00 P.M. unless specified otherwise. Before turn-on, all equipment as shown on the plans shall be installed and operable. This includes pedestrian signals, pedestrian push buttons and vehicle detectors.

All louvers, hoods and signal heads shall be directed to provide maximum visibility.

During the test period, the State or local agency will provide the electrical energy and repair any damage caused by public traffic. All other maintenance will be the responsibility of the Contractor.

All systems shall be complete and in operation to the satisfaction of the Engineer.

A field test of a single APS shall be performed in the presence of the Engineer. All repairs or replacements required to ensure a fully operational system shall be at the Contractor's expense.

The APS shall be installed per the manufacturer's recommendations.

614.11 Barricades. Construction shall conform to the requirements of Section 508.

614.12 Rumble Strips. Rumble strips shall conform to the details and locations shown on the plans.

METHOD OF MEASUREMENT

614.13 Overhead sign structures (Sign Bridge Structures, Butterfly Structures, Sign Bridge Cantilever Structures and Cantilever Structures) will be measured by the number of units of the various types and sizes installed and shall include structural frame members, mounting brackets, posts, excavation and backfill, and when called for on the plans, safety walkways and light fixtures including all electrical equipment as required. Drilled caissons used for overhead sign structure footings will be measured and paid for per Section 503.

Installing only of sign structures will be measured by the number of units installed and shall include all hauling, concrete footings, removing existing sign panels, respacing and adding walkway brackets, adding walkways, repainting, excavation and backfill and furnishing and installing light fixtures including all electrical equipment as required.

Overpass mounted sign brackets will be measured by the number furnished and installed and shall include all structural members required to install sign panels on overpass structures as shown on the plans and all light fixtures including all electrical equipment as required. Sign panels shall be furnished and installed under the appropriate item.

Ground signs will be measured as follows: Concrete footings by the number used, signposts by the length in linear feet of the various types used, and sign panels by the square feet of facing. For signs other than rectangular or triangular shape, the area in square feet will be computed from dimensions of the smallest rectangular shape that a panel can be fabricated. Sign panels shall include all mounting and backing angles required.

Mask sign legend will be measured by the actual number of signs masked and shall include panel, reflective sheeting, and fastening the panel to the sign.

Steel signpost extensions, if required, will be measured and paid for as "Steel Signpost" of the type shown on the plans.

Sign panels shall include background, message, backing zees (Classes 2 and 3), date of manufacture, and all necessary hardware.

Multi-directional break-away assemblies will not be measured and paid for separately but will be paid for under the appropriate item: all brackets, nuts, bolts, shims, hinge plates, and couplings will be paid for as Steel Signpost of the appropriate size; anchors and concrete footings will be paid for as Concrete Footing of the appropriate size.

Steel Sign Support (Post) will be measured by the actual number of linear feet of posts (not to include length of T-brackets or U-brackets) that are installed and accepted. T-brackets, U-brackets, wedges and mounting clamps that are required to complete the assembly as shown on the plans will not be measured and paid for separately but shall be included in the work.

Steel Sign Support (Socket) will be measured by the actual number of sockets that are installed and accepted. Concrete footing will not be measured and paid for separately but shall be included in the work.

When called for on the plans, signposts, sockets and footings, wedges and mounting clamps will be regarded as a single assembly and will be measured by the actual number of Steel Sign Support (Post and Socket) that are installed and accepted.

Steel Sign Support (Slipbase) will be measured by the actual number that are installed and accepted. Concrete footing will not be measured and paid for separately but shall be included in the work.

When called for on the plans, signpost, slipbase and footing will be regarded as a single assembly and will be measured by the actual number of Steel Sign Supports (Post and Slipbase) that are installed and accepted.

Light fixtures shall include lamps, switch boxes, photoelectric controls, electrical conduit, electrical conduit in foundations, and all necessary wiring in the structure only.

Illuminated signs will be measured by the actual number installed including switch box, footing, electrical conduit in the footing, post, and shall also include the wiring from the light to the switch box.

Barricades will be measured by the number used.

Flashing beacon will be measured as a unit complete in place (including sign panel) and shall include all work necessary to complete the item. Solar power system for flashing beacons, poles, and lockable container will not be measured and paid for separately but shall be included in the work.

Traffic signal poles shall include mast arms and all necessary hardware required to complete the item in place. Drilled caissons used as foundations for traffic signal poles will be measured and paid for per Section 503.

Cabinets shall include pedestals and concrete foundations as required.

Span wire poles shall include span wire cable, jaw deadends, cable rings, concrete footings and all necessary hardware. Pole height shall be as indicated on the plans.

Traffic signal controllers (Type 170E) shall include the cabinet, pedestrian detectors, and all auxiliary equipment required on the plans and shall include all work necessary to provide and install a complete system.

Loop detector wire will be measured by the linear foot and shall include loop wire, pavement sawing, slot sealant, and lead-in conduit as shown on the plans, excavation, backfill, and all other work necessary to complete the item.

Preformed loop systems will be measured as the actual length in linear feet of the sealed continuous loop system that is run to the first pull box, regardless of type, and accepted.

Traffic signal magnetic detectors shall include all shielded lead-in wire and non-metallic conduit housing and all wiring necessary for the operation of the system.

Traffic signal loop detector amplifiers will be measured by the number of two channel units or four channel units and shall include all incidental materials and wiring necessary for the operation of the item.

Pedestrian push button post assembly will be measured by the actual number that are installed and accepted and shall include all work and materials required to complete the item.

Accessible Pedestrian Signals will be measured by the actual number that are installed and accepted.

All costs for making electrical service connections from the power source to the service switch will be paid for per subsection 109.04.

Rumble strips will be measured by the actual number of linear feet that are placed and accepted adjacent to or on the roadway surface, excluding gaps. Measurement of length for payment will be parallel to the roadway centerline or shoulder stripe.

Pedestrian Push Button will be measured by the actual number that are installed and accepted.

BASIS OF PAYMENT

614.14 The accepted quantities will be paid for at the contract price per unit of measurement for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Monotube Overhead Sign Cantilever (size)	Each
Monotube Overhead Sign Bridge (size)	Each
Monotube Overhead Sign Bridge with Cantilever (size)	Each
Sign Bridge Structure (Install Only)	Each
Overpass Mounted Sign Bracket	Each
Concrete Footing (_____)	Each
Steel Signpost (_____)	Linear Foot
Timber Signpost (_____)	Linear Foot
Steel Sign Support (2-Inch Round) (Post)	Linear Foot
Steel Sign Support (2-Inch Round) (Socket)	Each
Steel Sign Support (2-Inch Round) (Post and Socket)	Each
Steel Sign Support (2-1/2 Inch Round NP-40) (Post)	Linear Foot
Steel Sign Support (2-1/2 Inch Round NP-40) (Slipbase)	Each
Steel Sign Support (2-1/2 Inch Round NP-40) (Post and Slipbase)	Each
Steel Sign Support (2-1/2 Inch Round Sch 80) (Post)	Linear Foot
Steel Sign Support (2-1/2 Inch Round Sch 80) (Slipbase)	Each
Steel Sign Support (2-1/2 Inch Round Sch 80) (Post and Slipbase)	Each
Sign Panel (Class)	Square Foot
Mask Sign Legend	Each
Illuminated Sign	Each
Barricade (Type _____)	Each
Flashing Beacon	Each
Modification of Steel Signpost	Each
Modification of Timber Signpost	Each
Modification of Sign Legend	Each, Lump Sum
Pedestrian Signal Face (Type_____)	(Furnish Only) (Install Only) Each
Traffic Signal Face (Type_____)	(Furnish Only) (Install Only) Each
Traffic Signal Controller Cabinet	(Furnish Only) (Install Only) Each
Traffic Signal Controller (Type_____)	(Furnish Only) (Install Only) Each

Pay Item (cont'd)	Pay Unit (cont'd)
Loop Detector Wire (Furnish Only) (Install Only)	Linear Foot
Loop Detector Wire (Prefab) (Special)	Linear Foot
Traffic Signal Vehicle Detector Amplifier (Type_____) (Furnish Only) (Install Only)	Each
Traffic Signal Vehicle Detector (Type_____) (Furnish Only) (Install Only)	Each
Traffic Signal-Light Pole (Type_____) (Furnish Only) (Install Only)	Each
Traffic Signal Pole (Type_____) (Furnish Only) (Install Only)	Each
Traffic Signal Pedestal Pole (Type_____) (Furnish Only) (Install Only)	Each
Traffic Signal Span Wire Pole (Type_____) (Furnish Only) (Install Only)	Each
Pedestrian Push Button Post Assembly	Each
Accessible Pedestrian Signal	Each
Rumble Strip	Linear Foot
Pedestrian Push Button	Each

The traffic signal component item will be Furnish and Install unless the Summary of Approximate Quantities indicates whether it is to be (Furnish Only) or (Install Only) as appropriate.

The LED optical units will not be paid for separately but shall be included in the cost of the Traffic Signal Face. The pedestrian LED optical units will not be paid for separately but shall be included in the cost of the Pedestrian Signal Face.

All costs associated with the manufacturer's representative and obtaining the required documentation for tubular steel sign supports will not be measured and paid for separately but shall be included in the work.

Payment for Loop Detector Wire (Prefab) (Special) will include all loop wire, preformed loop conduit to the first pull box outside the roadway, excavation, backfill, and all other work and materials necessary to complete the item.

Wire from the first pull box outside the roadway to the controller will be measured and paid for per Section 613 under the pay item Wiring, Lump Sum. Conduit will be measured and paid for per Section 613, under the pay item for the appropriate diameter of conduit.

Payment for Pedestrian Push Button Post Assembly will be full compensation for all work and materials, including wiring, required to complete the item.

Payment will be full compensation for all work, materials and equipment required to install a completely operational APS per these specifications.

The sample APS will not be measured and paid for separately but shall be included in the work.

Testing of APS will not be measured and paid for separately but shall be included in the work.

BLANK OUT SIGN (LED) (SPEED RADAR)

DESCRIPTION

614.15 This work consists of furnishing and installing a Light Emitting Diode (LED) Blank Out Sign (Speed Radar) equipped with a directional radar unit for changing the message on the sign for oncoming traffic. The sign shall face one direction and shall display a primary and a secondary message.

MATERIALS

614.16 LED Blank out signs shall meet the requirements shown on the plans and detailed in this specification. The display shall be a character matrix configuration of two lines of 5 x 7-pixel matrix characters that will allow the display of a pre-determined message defined in this specification. All display elements and modules shall be solid state. No mechanical or electromechanical elements or shutters shall be used.

All materials furnished, assembled, fabricated or installed under this item shall be new, corrosion resistant and in strict accordance with the Contract. All details and functionality listed in this specification will be thoroughly inspected and tested by the Department. Failure to meet all details and functionality detailed in this specification shall be grounds for rejection of the equipment.

The radar unit shall operate with the Blank out Sign to turn on and then change the primary sign message to a secondary message for the oncoming vehicles. The sign shall include a lockable power shut off mounted to the sign structure within 6 feet of ground level. The sign shall be fully compatible with the mounting hardware and support structure shown on the plans. The sign shall have a minimum design life of 20 years.

(a) Materials shall conform to the applicable requirements of the National Electrical Code (NEC) and shall be a type currently recommended and approved by Underwriters' Laboratories, Inc.

(b) All Materials furnished, assembled, fabricated or installed shall be new, corrosion resistant, and in strict accordance with the Contract, and the NEC.

The blank out signs shall be able to alternately display two fixed sign messages from a single housing in one direction. The primary message shall be a static message illuminated when a radar indication is triggered. When the radar indication is triggered, the primary message shall turn on and once a speed threshold is reached a secondary message shall be illuminated intermittently. The intermittent display of the secondary message shall illuminate the message for a period of two seconds on, and then one second off, repeating for a period of 30 seconds or once it does not detect a vehicle exceeding the trigger speed. Once the 30 second period has been reached the display shall return to the static primary message being illuminated for an additional 30 seconds before being turned off completely or back to the second message if another vehicle approaches in excess of the selected speed. The entire message shall be able to be switched on or off. The sign layouts provided in the plans list the details for the message. The Contractor shall provide final message layouts to the Engineer for review and approval before fabrication of the blank out sign. When turned on, the blank out sign shall show the appropriate message and when turned off the sign shall be completely blank when not energized. No phantom words or legends shall be seen under any ambient light conditions when turned off.

The blank out signs shall be capable of dimming at night or during other low ambient light conditions.

The blank out sign shall be fully functional while operating over an ambient temperature range of –30 to +165 ° F including a relative humidity of 0 – 100 percent, condensing; and it shall be capable of withstanding wind speeds up to 120 mph per AASHTO *Standard Specifications for Structural Supports for Highway Signs Luminaires and Traffic Signals*.

614.17 Certifications. Before start of the installation of the LED Blank out Signs the Contractor shall provide the following documentation to the Engineer:

(a) Shop drawings showing the sign housing and mounting brackets. Shop drawings shall be submitted per subsection 105.02.

(b) Documentation and information on sign software and hardware.

614.18 Sign Housing. All component parts shall be easily and readily accessible by a single person for inspection and maintenance. Access shall be from the front by lifting the face of the sign. The housing shall be weather tight, and compliant to the NEMA 3R Standard. The sign housing shall be capable of withstanding a wind loading of 120 mph without permanent deformation or other damage. The performance of the sign, including the visibility and legibility of the display, shall not be impaired due to continuous vibration caused by wind, traffic or other factors. The housing shall be designed to accommodate mounting on the rear vertical plane and shall be structurally sufficient to be mounted to the sign support structure. The sign housing and structural components for the tilting system including bolts and welds, shall be structurally sufficient to perform under all applicable loading conditions including gravity, wind, traffic, weather, roadway deicers, maintenance, and other environmental factors. Certified shop drawings supporting the design of the sign housing and mounting system shall be submitted per subsection 105.02.

Except for the housing, all parts shall be made of corrosion resistant materials, such as plastic, stainless-steel, or aluminum. Painted steel is not acceptable. Self-tapping screws shall not be used. The exterior front face surfaces shall be finish coated by a system that meets or exceeds the American Architectural Manufacturers Association (AAMA) Specification No. 2605. The finish shall be matte black.

The housing shall be constructed of aluminum (minimum thickness of 0.100 inches) with a natural mill finish. All exterior seams shall be continuously welded by an inert gas process, except for the coated fascia material. The glazing shall be constructed of 0.236- to 0.250-inch-thick clear polycarbonate sheets with surfaces that resist hazing from UV light, abrasion, and graffiti.

The glazing shall be protected by a coated aluminum mask with apertures punched directly in front of each pixel. The coating shall meet or exceed the requirements of AAMA Specification No. 2605.

The external front face panels shall be thermally insulated from the rest of the sign housing. The glazing, aluminum mask, and the external front face panels shall be easily replaceable from within the sign housing.

The bottom panel of the housing shall have a minimum of four drain holes, with snap-in, drain filter plug inserts. The housing shall be rated for NEMA 3R with the door internally gasketed to provide the necessary seal. All corners shall be welded for stability and watertightness. Silicone or other sealant shall not be used to seal joints.

The sign housing shall come equipped with slotted aluminum extrusions mounted horizontally across the back of the sign. Each extrusion shall accept manufacturer supplied 1/2-inch stainless-steel mounting hardware with bolts that slide within the extrusion for complete adjustability in the horizontal direction. This configuration shall allow the sign to be mounted to one round vertical steel post member.

The angular alignment of the sign housing shall be adjustable in the vertical direction to optimize the viewing angle for approach vehicles.

The ventilation system shall be natural convection or forced air. The system shall be designed to adequately cool the LED pixels along with the front and rear of the display module and all other internal components.

614.19 Equipment. The equipment shall be modular in design such that major portions may be readily replaced in the field. Modules of unlike functions shall be mechanically keyed to prevent insertion into the wrong socket or connector.

All modules and assemblies shall be clearly identified with name, model number, serial number, and any other pertinent information required to facilitate equipment maintenance and replacement.

All external connections shall be made by means of connectors. The connectors shall be keyed to preclude improper hookups. All wires to and from the connectors shall be color-coded or appropriately marked.

614.20 Electronics. All electronic components, except printed circuit boards, shall be commercially available, easily accessible, replaceable and individually removable using conventional electronics repair methods.

All Printed Circuit Boards (PCBs) shall be completely conformal coated with a silicone resin conformal coat. The exception for this coating shall be the pixels on the front of the PCB of the LED motherboards and any components in sockets.

All discrete components, such as resistors, capacitors, diodes, transistors, and integrated circuits shall be individually replaceable. Components shall be arranged such that they are easily accessible for testing and replacement. A transformer shall be installed inside the casing if required to step down 110V service to 12V for the LED lighting and radar detection. All circuit designs shall utilize high quality electronic components and shall provide a meantime before failure of at least four years.

The color of the pixels shall be amber and shall be 40 candelas at 20 mA. The brightness and color of each pixel shall be uniform over the entire face of the sign within the 15-degree cone of vision from 1,100 feet to 200 feet in all lighting conditions. Each pixel shall contain two strings of LEDs. The pixel strings shall be powered from a regulated DC power source and the LED current shall be maintained at 25 plus or minus 3 mA per string to maximize life of the pixel. The failure of an LED in one string within a pixel shall not affect the operation of any other string or pixel. The LEDs shall be constructed of aluminum, indium, gallium, or phosphide.

Pixel power drawn from the DC supplies shall not exceed 1.5 watts per pixel, including the driving circuitry.

A photocell shall be installed on the sign. This device shall permit automatic light intensity measurement of light conditions at the sign location. The photocell shall be mounted in a manner to measure ambient light conditions.

Provisions shall be made to prevent perceivable brightening of the sign due to stray light from headlights shining upon the photo sensors at night.

The power supplies shall be paralleled in a diode OR configuration such that one supply may completely fail, and the sign will still be supplied with enough power to run 40 percent of all pixels.

All cables shall be securely clamped or tied in the sign housing. Adhesive attachments shall not be used.

The Contractor shall locate the electrical power, as directed, and connect the source to the appropriate termination within the Blank Out Sign. A manufacturer's representative shall be on site for the final inspection for up to three hours and to establish manufacturer's approval of the installation.

614.21 Communication. The controller software shall be capable of displaying the following types of messages:

Static messages capable of displaying one of two fixed messages.

(a) Flashing messages with the following ranges of adjustable timing:

1. Message time on from 0.5 to 60 seconds in 0.5 second increments.
2. Message time off from 0.5 to 60 seconds in 0.5 second increments.

(b) Alternating messages capable with the following ranges of adjustable timing:

1. Primary message time on from 0.5 to 60 seconds in 0.5 second increments.
2. Primary message time off from 0 to 60 seconds in 0.5 second increments.
3. Alternate message time on from 0.5 to 60 seconds in 0.5 second increments.
4. Alternate message time off from 0 to 60 seconds in 0.5 second increments.

It shall be possible to flash the design message in an alternating message at the adjustable frequencies listed above for flashing messages. The flashing period shall be a sub-multiple of the associated alternating on time. It shall also be possible to flash the design message in a static message. The sign shall also be capable of showing no messages (fully blank) until a radar trigger is registered by the system.

(c) Radar. The Blank Out Sign shall be equipped with a directional radar unit for sensing and determining the speeds of oncoming traffic only. The radar unit shall be capable of detecting approach speeds from 5 to 100 mph. The radar shall detect average size vehicles from a distance of approximately 2000 feet. The radar shall be compatible with the remote programming requirements. The radar shall operate in a Radar Trip Mode.

In the Radar Trip Mode, the Blank Out Sign shall remain blank until a trigger is received and then display one of two messages under control of the radar: one when the radar indicates a vehicle is traveling above a configurable speed (or "trigger speed") and a second message when the radar indicates no vehicle traveling over the trigger speed. Note that each of these messages shall allow from one to two pages. To prevent flickering of the message if a vehicle is near the trigger speed, a message dwell time shall keep the message displayed for a configurable number of seconds after the vehicle has dropped below the trigger speed. The dwell time shall default to two seconds.

The radar unit shall be mounted outside of the sign. The radar gun shall be mounted on an adjustable bracket, allowing for minor adjustment of both azimuth and elevation.

(d) *Warranty*. The Contractor shall ensure that the manufacturer will guarantee the product for a minimum of one year from the date of shipment. During the warranty period, the supplier or manufacturer shall repair with new or refurbished materials, or replace at no charge, any product containing a warranty defect. Product repaired or replaced under warranty by the manufacturer or supplier shall be returned with transportation prepaid.

During the warranty period, technical support shall be available from the manufacturer via telephone within 8 hours of the time a call is made by the Department, and this support shall be available from factory-certified personnel or a factory-certified installer at no additional charge to the Department.

(e) *Maintenance and Support*. The supplier shall maintain an adequate inventory of parts to support maintenance and repair of the blank out signs. These parts shall be available for delivery within 30 days of placement of an acceptable order at the supplier's then current pricing and terms of sale for said parts.

The supplier shall maintain an ongoing program of technical support for the blank out signs. This technical support shall be available via telephone, or via personnel sent to the installation site upon placement of an acceptable order at the supplier's then current pricing and terms of sale for on-site technical support services.

Installation or training support up to three hours shall be provided by a factory-authorized representative. All product documentation shall be written in the English language.

Four complete sets of operation and maintenance manuals shall be provided. The manuals shall include the following:

Complete and accurate schematic diagrams, including a wiring diagram.

1. Complete installation procedures.
2. Complete performance specifications (functional, electrical, mechanical and environmental) on the unit.
3. Complete parts list including names of vendors for parts not identified by universal part numbers such as JEDEC, RETMA or EIA.
4. Pictorial of component layout on circuit board.
5. Pin-out and pin-in of connectors.
6. Complete maintenance and troubleshooting procedures.
7. Complete stage-by-stage explanation of circuit theory and operation.

In-cabinet wiring diagram of the blank out sign shall be provided in each sign enclosure.

CONSTRUCTION REQUIREMENTS

614.22 The Contractor shall install the blank out sign as shown on the plans.

The Contractor shall conduct all tests described, which include the following operational tests.

The following blank out sign functions shall be demonstrated for each of the signs installed on the project before acceptance:
1. Turning on and off in daytime mode.
2. Turning on and off in nighttime mode.
3. Demonstration of the radar trip to change from the primary message to the secondary message.
4. Demonstration of the dwell and flashing adjustments.
5. Demonstration of the dimming features for the sign.

METHOD OF MEASUREMENT

614.23 The Blank Out Sign (LED) (Speed Radar) will be measured by the actual number that are furnished, installed and accepted.

BASIS OF PAYMENT

614.24 Payment will be made under:

Pay Item	**Pay Unit**
Blank Out Sign (LED) (Speed Radar)	Each

Payment will be made per the following:

The Engineer will authorize payment for 90 percent of the unit price bid upon completion of the installation and submittal of all certifications.

The Engineer will authorize payment for the remaining 10 percent of the unit price bid upon the successful completion of the testing and according to terms of the Contract.

Payment will be full compensation for all labor, materials, and equipment necessary to complete the work, including the directional radar gun, sign controller, controller interface box, sign housing, electronics, communications, and standard warranty.

Having a manufacturer’s representative on-site will not be measured and paid for separately but shall be included in the work.

Testing, training and providing manuals will not be measured and paid for separately but shall be included in the work.

SECTION 615
WATER CONTROL DEVICES

DESCRIPTION

615.01 This work consists of the construction of water and erosion control devices per these specifications, details shown on the plans and to the lines and grades established.

MATERIALS

615.02 Slide headgates and automatic drain gates shall be of the sizes designated and shall be approved by the Engineer.

Parshall measuring flumes including wings shall be made of galvanized sheet steel material. Galvanize coating shall be “light commercial” minimum. Thickness of material and fabrication method shall be as approved. Measuring flumes shall have reinforced edges and an inlet throat of the dimensions designated on the plans.

Embankment protectors shall be made from material conforming to the applicable sections of these specifications.

CONSTRUCTION REQUIREMENTS

615.03 Construction methods shall conform to the requirements of Section 603.

METHOD OF MEASUREMENT

615.04 Automatic drain gates, Parshall measuring flumes and embankment protectors will be measured by the number of units of the various sizes installed. Slide headgates will be measured by the number of units of the various sizes and frame heights installed.

BASIS OF PAYMENT

615.05 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
_____Inch Slide Headgate (_____Foot Frame)	Each
_____Inch Automatic Drain Gate	Each
_____Inch x _____Inch Parshall Measuring Flume	Each
Embankment Protector (Type_____)	Each

Pipe, concrete, or other material used with any of the above items will be bid under the appropriate Section.

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SECTION 616
SIPHONS

DESCRIPTION

616.01 This work consists of the construction of invert siphons per these specifications and in conformity with the lines, grades and details shown on the plans or established.

MATERIALS

616.02 Concrete Pipe. Concrete pipe shall conform to the requirements of subsection 706.02 except that pipe and gaskets shall be of a type that will ensure a watertight structure. Joints shall be self-centering. Gaskets shall meet the requirements of subsection 705.03.

616.03 Trash Guards. Steel shall conform to the requirements of subsection 712.06 and to the details shown on the plans. Trash guards shall be given one shop coat of primer and two field coats of aluminum paint in conformity with Section 509.

616.04 Drain Valves and Valve Boxes. Drain valves shall be gate type with flanged iron body, brass trim and brass fittings. Size will be as designated on the plans.

Valve boxes shall be the adjustable cast iron type with a 5 1/2-inch minimum inside diameter. Drain valves and valve boxes shall be approved before use.

616.05 Drainpipe. Pipe for the drain shall conform to Section 605. Concrete shall conform to Section 601 and reinforcing steel to Section 602.

The pipe attached to the siphon and leading to the drain valve may be non-perforated corrugated steel pipe conforming to AASHTO M 36 or of standard galvanized pipe conforming to the requirements of ASTM A53 (Schedule 40). This pipe, when attached to steel siphon pipe, shall be bituminous dipped along with the siphon pipe. Flanges for attaching the drain valve may be galvanized or asphalt dipped.

Any damaged spelter shall be repaired per subsection 707.09 both inside and outside the pipe.

CONSTRUCTION REQUIREMENTS

616.06 Siphon pipe including drains shall be installed per the requirements of Section 603. Siphons shall show no leakage when filled with water and allowed to stand full for 24 hours. This test shall be performed before backfilling.

METHOD OF MEASUREMENT

616.07 Siphon pipe, of the designated type, will not be measured but will be the net length of pipe called for on the plans, except when field changes are ordered or when there are errors on the plans. In case of exceptions, the quantity to be measured shall be the actual net length of conduit measured along the bottom centerline of the installed pipe. Trash guards, drain valves and valve boxes will be measured by the number installed and accepted. Drainpipe will be measured and paid for per Section 605. Concrete will be measured and paid for per Section 601. Reinforcing steel will be measured and paid for per Section 602. Structure excavation and structure backfill will be measured and paid for per Section 206.

Drain valves shall include the pipe for connecting the valve to the siphon, together with all necessary fittings and gaskets used.

BASIS OF PAYMENT

616.08 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
_____Inch Concrete Siphon Pipe	Linear Foot
_____Inch Trash Guard	Each
_____Inch Valve and Valve Box	Each

SECTION 618
PRESTRESSED CONCRETE

DESCRIPTION

618.01 This work consists of fabricating, furnishing, and installing prestressed concrete members per the requirements of the Contract.

This work includes the furnishing and installation of all appurtenant items necessary for the particular prestressing systems to be used, including but not limited to ducts, anchorage assemblies, and grout used for pressure grouting ducts.

For cast-in-place prestressed concrete the term "member" as used shall be considered to mean the concrete that is to be prestressed.

The term "tendon" as used shall be considered to mean the prestressing steel within a duct.

Both temporary and permanent post-tensioning shall comply with the requirements of this section.

The term temporary post-tensioning refers to the post-tensioning required to control stresses during handling and erection of precast elements.

MATERIALS

618.02 Materials shall conform to the following:

Anchorage devices shall meet the requirements of subsection 714.02. Prestressing steel shall meet the requirements of subsection 714.01.

Elastomeric bearing pads shall meet the requirements of subsection 512.

All reinforcing and embedment item supports, bolsters, chairs, and spacers shall be CDOT approved. These items shall be plastic, rubber, or epoxy coated at all areas that will contact external concrete surfaces, unless otherwise shown on the plans.

(a) Prepackaged Grout for Post-tensioned Ducts.

1. Water. The water used in the grout shall conform to subsection 712.01.
2. Grout. The grout shall meet the requirements of subsection 618.09(b).

(b) Steel and Metal for Prestress Members. All steel and metal products incorporated into the work shall meet the requirements of Section 106. The Contractor/Fabricator shall keep Certified Mill Test Reports (CMTRs) on file for all steel and metal products used and shall furnish copies of CMTRs when requested.

Galvanizing and metallizing of steel products shall be done per the product applicable ASTM method. The product shall be galvanized after welding and fabrication is complete. Minor repair of galvanizing shall be brush coated with an approved zinc-rich compound that is acceptable to the QA Representative.

Materials and fabrication procedures shall conform to ASTM or ANSI / AWS requirements. The materials and work shall conform to the following requirements and specifications, unless

otherwise indicated in the Contract.

1. Reinforcing Bars. All reinforcing bar material shall be Grade 60 minimum and shall conform to ASTM A615, or ASTM A706; epoxy coated bars shall also meet ASTM D3963. Reinforcing bars that require welding shall conform to ASTM A706. Welding of A706 bars shall be done per ANSI /AWS D.1.4.

2. Welded Wire Reinforcement. Steel welded wire reinforcement for concrete reinforcement shall conform to ASTM A497.

3. Plate Steel. All plate steel shall conform to ASTM A709 Grade 36 specifications. Fabrication and welding of plate steel products shall be done according to ANSI / AWS D.1.1.

4. Steel and metal products shall be free of loose rust and foreign substances before incorporation into the cast product.

   The presence of rust on strand shall not necessarily be cause for rejection. Light rust and rust that does not result in visible pitting of the prestressing steel with the unaided eye shall be acceptable. Before evaluation rust shall be removed from representative lengths of prestressing strand by heavy duty scouring pads or wire brush. After rust removal, visual comparisons shall be made to picture sets in the article Evaluation of Degree of Rusting on Prestressed Concrete Strand published in the 1992 May-June edition of the PCI Journal. Surface conditions comparable to picture sets 1 through 3 shall be acceptable, while conditions comparable to picture sets 4 and greater shall be cause for rejection of the prestressing strand.

(c) Concrete for Pretensioned and Combination Tensioned Products. Materials for Concrete class PS shall meet the requirements specified in the following subsections:

Hydraulic Cement	701.01	
Fly Ash	701.02	
Fine Aggregate	703.01	
Coarse Aggregate	703.02	
Curing Materials	711.01	
Air-Entraining Admixtures		711.02
Chemical Admixtures		711.03
Water	712.01	

(d) Concrete and Steel for Other Members. Concrete for other members shall conform to the requirements of Section 601 and the plans. Reinforcing steel for other members shall conform to the requirements of Section 602.

CONSTRUCTION REQUIREMENTS

618.03 Prestressed Members. Members may be pretensioned, post-tensioned, or a combination of pretensioned and post-tensioned. Members shall be fabricated and finished as shown in the Contract.

Minimum cover for prestressing steel shall be 1 1/2 inches, unless otherwise shown in the Contract. Minimum clearance for reinforcing steel shall be 1 inch unless otherwise shown in

the Contract.

If the plans show only pretensioning details, use of a post-tensioning system will be allowed only if complete details of all necessary modifications are approved by the Engineer of Record.

Cast-in-place members shall be post-tensioned unless otherwise shown on the plans. All falsework for cast-in-place members shall remain in place until all post-tensioning and grouting has been completed and accepted by the Engineer.

618.04 Shop Drawings.

(a) General. The Contractor shall furnish shop drawings in conformity with subsection 105.02 for all prestressed components. When the Contractor's Engineer completes or revises design details or engineering drawings, then those engineering drawings and details that are submitted to the Engineer shall contain the electronic seal of a Professional Engineer registered in the State of Colorado. CDOT review of the shop drawings does not relieve the Contractor of the responsibility for the adequacy of the prestressed members. Minor changes to design details or engineering drawings that do not represent a significant change to the original design will not require a Professional Engineer seal. The Contractor shall submit supporting calculations for these changes along with the shop drawings.

(b) Pretensioned Members. The shop drawings shall include the following:

1. Superstructure Framing Plan.
2. All unit dimensions.
3. Location and arrangement of prestressing strands.
4. Initial and final jacking forces.
5. Location, description, and detail of structural reinforcing items, excluding minor items used for field erection.
6. Location of all hold-down devices.
7. Location and description of all plates.
8. Provisions for diaphragm connections.
9. Blockout and keyway dimensions, if any.
10. Location and detail of debonded strands.
11. Strand de-tensioning sequence.

(c) Post-tensioned Members. The shop drawings for post-tensioned members shall show the following:

1. Strand and bar properties, including material type, modulus of elasticity, ultimate strength, diameter, and cross-sectional area assumed in the design.
2. Duct properties, including material type, and minimum inside and maximum outside diameters, and friction coefficients of the duct-strand system if different from shown on the plans.
3. The position and profile of the ducts and tendons along the length of the member. Each duct position shall be defined at tenth points along the length of the member. The minimum clearance from the edge of concrete to the edge of a duct shall be shown.
4. Location of closure pours and associated duct splices and details of duct splice, including the details and specifications of the shrink sleeve material.
5. The maximum offset between the center of the duct and the center of force in the duct for each unique strand and bar and duct combination. The resultant force of all

permanent tendons in the member shall match the profile indicated on the plans.

6. The initial and final force at each anchorage. The initial force is defined as the largest force at each anchorage before anchor set and after friction losses. The final force is defined as the residual force remaining after anchor set and long-term losses.
7. Complete dimensions and properties necessary to fabricate and install each unique anchorage device, including the type of materials, yield strengths, distribution plates, wedges, trumpets, anchorage blocks, and other appurtenant items. Adjacent reinforcement shall be detailed showing how it will coordinate with the anchorage device and its reinforcement.
8. The dimensions and properties necessary to fabricate and install the bursting, splitting, and other reinforcement required by the prestressing system, as shown on the plans or as proposed by the Contractor. Included shall be cross-sectional areas, yield strength, the location of the reinforcement, and the diameter and pitch of the spirals. If no additional bursting steel is required, it shall be so stated on the shop drawings.
9. The minimum length of strand or bar projection at the live ends and accessible dead ends.
10. The preload force for each unique tendon. The preload force is defined as 20 percent of the jacking force.
11. The required total jacking force for each unique tendon.
12. The total final elongation, after dead and live end anchor sets, and the measurable elongation for each tendon. The measurable elongation is defined as the total elongation at the live end after preload while the stressing equipment is tensioning the tendon to the total jacking force. The tendon length used for calculations shall include the full length of strand that is being stressed.
13. The sequence of stressing, including temporary and permanent post-tensioning.
14. Blockout or buildout concrete dimensions and reinforcement details.
15. If the Contractor elects to submit an alternative system, as defined in subsection 618.07(c)2, the Contractor shall also provide the following, as appropriate.

    If the anchorage device will differ from what is shown on the plans, the Contractor shall submit calculations or manufacturer test certification consistent with the Contract. The calculations shall show the complete design of the anchorage device, including splitting steel, bursting reinforcement, the distribution plate, and the bearing stresses transmitted to the concrete by the anchorage device. The manufacturer's test certification shall certify the adequacy of the anchorage device. The shop drawings shall reflect the anchorage device design.

    If the flare of the tendons is different from what is shown on the plans, the Contractor shall submit design and details of appropriate reinforcement and concrete dimensions to accommodate the flare.

    Along with the shop drawing details, six copies of computations for friction losses, calculated measurable elongations, the maximum offset between the center of force and center of duct for each unique tendon, and the stressing sequence shall be submitted for review. The friction losses shall be determined per the plans and as provided for in the current "AASHTO LRFD Bridge Design Specifications."

(d) For Combination Tensioned Members refer to subsections 618.04 (b) and (c).

618.05 Notification of Fabrication for Pretensioned and Combination Tensioned Members.

(a) Start of Work. Before beginning the work, the Contractor shall provide notice to the Engineer and the Quality Assurance (QA) Representative, as defined in subsection 618.06(a), so that QA services may be provided. The notice shall be at least seven days before fabrication begins.

The anticipated production schedule, including the start of work, phase work and shipment dates shall be submitted to the QA Representative before work begins. Fabrication shall not be started until the shop drawings have been returned with the Engineer's review stamp, indicating Reviewed, no exception taken; or Reviewed, revise as noted per subsection 105.02, and delivered to the Contractor's site of fabrication.

(b) Production Schedule Changes. Accelerated changes to the proposed production schedule, including start of work, phase work, and shipment dates, shall require advance notification be provided to the Engineer and the QA Representative. The Notice of change shall be received at least 48 hours before fabrication begins, unless otherwise approved in writing by the Engineer or the QA Representative.

(c) Notice of Shipment. The QA Representative shall be notified at least 72 hours before shipment of prestressed members to the job site.

(d) Notification. Failure to notify the Engineer or the designated QA Representative as described in this section may be cause for rejection.

618.06 Inspection of Pretensioned, Post-tensioned and Combination Tensioned Members.

(a) Process Control and Quality Assurance. Process Control (PC) of prestressed concrete fabrication is the responsibility of the Contractor. The fabrication plant shall possess and maintain a current Precast/Prestressed Concrete Institute (PCI) certification for Prestressed Concrete. The Contractor shall designate a PC Manager who shall be responsible for product quality requirements as defined in the specifications and the Contractor's approved PC plan (PCP). The PC Manager shall possess and maintain certification at Level II minimum, from the Prestressed Concrete Institute (PCI), and shall have one-year minimum of construction related experience. The PC Manager shall not be supervised by the Contractor's production section. If grouting for post-tensioning ducts of combination-tensioned members is done by the precast girder fabricator, the PC Manager shall possess and maintain an American Segmental Bridge Institute (ASBI) Certified Grouting Technician Certificate. If prestressing, duct and anchorage installation, duct and anchorage inspection, stressing of tendons, air testing of ducts, or grouting of ducts of bonded tendons of the post-tensioning system is done by the precast girder fabricator the PC Manager shall possess a PTI Level I – Bonded Tendon Training Certificate. The PC manager shall perform the inspection or directly supervise all phases.

Quality Assurance inspection shall be performed on all pretensioned, post-tensioned, and combination tensioned members. The QA Representative acts for and on behalf of the Engineer on all matters within the scope of the contract documents, as delegated by the Engineer. QA administration will be performed to the extent necessary to assure contract compliance. Fabrication inspection QA personnel shall have training, certification and work experience as described in Section 3.0 of the CDOT Staff Bridge Fabrication Inspection Manual.

Repeated out of tolerance work, including dimensional non-conformance, shall be considered as recurring deficiencies. Recurring deficiencies shall be considered as evidence that required PC is not being provided. When the QA Representative determines that fabrication operations are producing recurring defects that do not conform to the Contract and PCP requirements, the Contractor will be notified in writing that the present work is unacceptable. Work shall not continue until the PC Manager has submitted a written proposal addressing corrective procedures that the Contractor will take to prevent recurrence of the non-conforming work. Fabrication shall not resume until the proposal has been reviewed and accepted in writing by the QA Representative.

(b) *Process Control Plan (PCP).* The Contractor shall submit a written PCP to the QA Representative before the beginning of fabrication. The PCP shall be reviewed and approved in writing by the Contractor's PC Manager. The PCP shall list all methods utilized by the Contractor to ensure that the work conforms to contract requirements. The PC section is responsible for establishing the PCP, as well as conformance to the PCP. Fabrication shall not begin until the PCP has been reviewed and accepted in writing by the QA Representative.

If work methods for a specific project or product are not listed in the original PCP, the Contractor shall submit written addenda addressing the proposed methods that are necessary to meet contract requirements. Fabrication shall not begin until the addenda have been reviewed and accepted in writing by the QA Representative.

The PCP shall address the following:

1. Names and qualifications of the PC Manager and personnel conducting inspection and testing. This list shall be updated when changes in personnel occur.
2. List of material suppliers, post-tensioning system supplier, post-tensioning grout supplier, and certified testing agencies used; the list shall be updated when vendors change.
3. Materials sampling and testing schedule showing testing methods and frequencies.
4. PC inspection methods and procedures for all stages of fabrication operations.
5. Methods for curing products and test specimens.
6. Method and sequence for tensioning strands, including methods used for verifying equal distribution of jacking forces.
7. Method and sequence of de-tensioning strands and procedure.

8. Post-tensioning system. Duct and anchorage inspection schedule, duct splices at closure pour inspection schedule, and onsite duct air pressure testing schedule, including names of the responsible representatives who will conduct inspections and testing. The responsible representatives shall possess an "American Segmental Bridge Institute (ASBI) Certified Grouting Technician" certificate and a PTI Level 1 – Bonded Tendon Training certificate.
9. Written report format for materials sampling, testing, and inspection for all phases of the work.
10. Copies of all concrete mix designs to be used, including mix design computations and test data.
11. Provisions for fabrication operations during cold, windy, or hot weather conditions.
12. Procedures for patching small production holes and holes left by strand hold-down devices.
13. Procedures for identifying, evaluating and reporting defects, including dimensional non-conformance, discovered during PC/QA inspections and testing.
14. Procedures for notifying the QA Representative of structural defects, and submittal of written proposal for repairs.
15. Provisions for contingency operation when concrete delivery is interrupted due to malfunction of equipment during fabrication.

(c) Frequency. PC inspection and testing at all intervals of duct and anchorage placement, duct splices at closure pours, onsite duct air pressure tests, forming, tensioning, steel and concrete placement, curing, and storage operations shall be performed per the accepted PCP. The PCP shall contain provisions for increased frequencies of inspection and testing when operations or products do not conform to the Contract.

(d) Written Records and Reports. The PC Manager shall review and submit the following completed records and reports to the QA Representative before the product receives acceptance by the PC section:

1. Prestressing Steel - Tensioning reports for each setup, showing the jacking force calculations; initial and final jacking force used; calculated and final net measured elongation; applicable stressing corrections for seating, slippage, shortening, rotation movement, and temperature; Certified Mill Test Reports for prestressing steel used; jack identification number and calibration date; and date and time of stressing.
2. Concrete - A daily report of each mix design used, showing the fresh concrete slump, temperature, unit weight, and air content (if specified). The daily report shall also include the following data:

   A. Date and time of casting.

   B. Bed and setup location.

   C. Ambient conditions.

   D. Total cubic yards placed.

E. Girder mark and unique sub-mark identifications.

F. Actual product curing temperature charts or graphs.

G. Average release strength in psi.

H. Date and time of release strength.

I. Copies of individual batch tickets when requested by the QA Representative.

3. Pre-pour Inspection Records shall include the items to be checked as listed in the PCP.

4. Post-pour Inspection Records shall include the items to be checked as listed in the PCP. These records shall include all discovered variances from product dimensional tolerances.

5. Report of minor repairs made to each individual product.

6. Product camber and length measurements shall be submitted to the QA Representative a minimum of seven calendar days before shipping.

7. Steel and Metal. For reinforcing bars, welded wire reinforcement, plate steel, and miscellaneous steel and metal products incorporated into the work, the PC Manager shall review and maintain all certified mill test reports (CMTRs). The PC Manager shall certify in writing that all steel and metal products comply with the Contract. When requested, PC Manager shall furnish copies of CMTRs to the QA Representative.

8. Post-tensioning Ducts. The responsible representative meeting the requirements of subsection 618.06 (b)(8) shall submit to the QA Representative a letter certifying that the ducts, duct splices, and anchorages are installed according to the Contract and that they have been inspected by the responsible representative of the post-tensioning system supplier and adequately held an air pressure after stressing and before grouting.

   After stressing and before grouting, the Contractor shall install all grout caps, inlets, and outlets and test the duct with compressed air to determine if duct connections require repair. In the presence of the QA Representative, the Contractor shall pressurize the duct to 30 psi and lock-off the outside air source. Pressure loss shall be recorded for one minute. A pressure loss of 15 psi is acceptable for ducts having a length equal to or less than 150 feet and a pressure loss of 9 psi is acceptable for ducts longer than 150 feet. If the pressure loss exceeds the allowable, the Contractor shall repair leaking locations using methods approved by the Engineer and retest pressure loss.

618.07 Fabrication.

(a) Pretensioning - General. Prestressing shall be done with calibrated jacking equipment that conforms to the requirements of subsection 618.10. Strands shall be tensioned per the approved sequence as indicated in the PCP. All indicating dials shall be at least 6 inches in diameter; calibrated digital display equipment is also acceptable.

The stressing sheet shall show the measurements, factors and computations for tension and elongation, including all stressing corrections; if these factors are not shown on the stressing sheet, they must be submitted with the shop drawing and calculation index. The applicable stressing corrections shall be applied at the time of final stressing. Before using any stressing correction for friction, the need for corrections shall be proven by load cell or dynamometer checks at both ends of the setup. Temporary overstressing shall not exceed 80 percent of the minimum ultimate tensile strength of the prestressing steel. Tensioned strands shall not be seated during temporary overstressing.

Tensioned strands shall maintain vertical and horizontal position, within allowable tolerances, as specified in subsection 618.14(b), throughout the entire length of the member; intermediate strand supports shall be used if the tolerances cannot be maintained. Tensioned strands shall not be entangled or intertwined with other strands, except for draped strands in the bundled area between hold down devices.

A PC employee shall witness and verify final tensioning operations and record the jacking forces and the net measured elongations. Jacking force shall be recorded to the nearest 100-pound increment used. Net elongation shall be measured to the nearest 1/8 inch. Tensioning operations shall also meet the following requirements.

1. Initial tensioning shall not exceed 20 percent of the jacking force.

2. Tension load readings shall be taken from pressure gauges, dynamometers, or load cells. If pressure gauges or dynamometers are used, the applied load shall register between 20 and 80 percent of the total reading capacity of the system. If load cells are used, the applied load shall register between 10 and 90 percent of the total load cell capacity. If a master gauge system is used, a current certified calibrated graph or table correlating actual loads with the master gauge readings shall be given to the QA Representative.

3. The jacking force applied shall be within plus or minus 5 percent of the design jacking force. The net measured elongation shall be within plus or minus 5 percent of the calculated elongation; if net measured elongation is not within tolerance, the strand shall be stressed from both ends. The algebraic comparison of the variation between the jacking force and the net measured elongation shall agree within plus or minus 7 percent. If these three tolerances are not achieved, tensioning operations shall cease; all stressing deficiencies shall be corrected before regular tensioning operations resume.

4. If any wire or wires in a 7-wire strand breaks, whether or not that strand shall be removed and replaced shall be determined based on whether forces are within tolerances as specified in subsection 618.07(a)(3) and by referring to PCI MNL 116.

5. Strand or spliced strand that exhibits unraveling after stressing shall be removed and replaced with a sound strand. Strand splices shall not fall within the member to be cast.

6. Strands that have received final tensioning shall be protected from temperature fluctuations greater than 40 °F until the time of concrete placement. The Contractor may apply stress corrections at the rate of 1 percent per 11 °F, for temperature variation between final tensioning and concrete placement. This requirement does not apply to self-stressing bed setups. The total stressing force applied shall not exceed 80 percent of the minimum ultimate tensile strength of the prestressing steel.

7. Tensioned prestressing steel shall be free from dirt, mud, ice, snow build-up, oil, grease, paint, loose rust, and all other bond-inhibiting substances before concrete placement. Visibly pitted strand shall not be used.

8. Draped Strand - Final stressing shall be accomplished by any of the methods described below:

   A. Jacking in Draped Position. Final stressing shall begin at one end of the bed. Strands that do not meet the tension vs. elongation tolerances shall be jacked from the other end so that all tolerances are achieved. If all draped strands conform to tolerances after jacking at one end, the jacking force shall be verified on at least two strands at the opposite end.

   B. Partial Stressing and Subsequent Strain. Initial and partial stress may be induced from either end of the bed. Final stress shall be attained by lifting or depressing the strands to the design location. Final stress and strain shall be applied in such a manner that uniform distribution of jacking force is attained throughout the bed setup and all tension vs. elongation tolerances have been achieved. The distribution of force shall be verified on at least two strands at the opposite end.

   C. Stage Tensioning. Initial tensioning shall be done from one end. Partial tensioning may then be performed from either end. When final stressing is completed, the sum of the partial elongations shall be used to verify that all tension vs. elongation tolerances have been achieved. This method may also be used for tensioning of straight strands.

9. Hold-down devices shall be placed within +/- 20-inch horizontal tolerance from the locations shown on the plans. If minimum or maximum placement locations are shown on the plans, the placement tolerances shall not encroach beyond those locations.

   The hold-down device shall not encumber or displace adjacent straight strands out of tolerance; and shall not produce nicking of any drape or bundled strands. The device shall secure the draped or bundled strands in the positions shown on the shop drawings within all tolerances required by subsection 618.14(b).

(b) Combination Tensioned Members. Pretensioning of combination members shall be performed per subsection 618.07(a). All post-tensioning operations shall conform to subsection 618.07(c).

(c) Post-tensioning Method.

1. Bonded Post-tensioning and Grouting Systems Review. Upon review of the shop drawings, the Engineer will schedule a meeting with the Contractor to review the post-tensioning and grouting procedures to be used on the project. The following individuals shall attend this meeting:

   A. The Engineer and QA Representative.

   B. The Contractor's Superintendent.

   C. The post-tensioning system supplier. This individual shall have the following qualifications:

      (1) Be a Professional Engineer registered in the State of Colorado.

(2) Be knowledgeable in the analysis of post-tensioned structures, the design required for shop drawing development, field calculations for revising tendon elongations from the assumed parameters to the actual strand area and modulus used on the project as determined by tests conducted on the strand by CDOT and stressing of tendons.

(3) Be a holder of a current Certified Grout Technician Certificate from the American Segmental Bridge Institute (ASBI).

(4) Be able to be present during all tendon stressing and grouting to keep written records of these operations for submittal to the Engineer for review.

D. A grout manufacturer's field representative who is a full-time employee of the grout manufacturer. This representative shall provide technical product assistance to the grouting crew and shall be present during start-up of grouting operations. This representative shall be able to be present at the request of the Engineer should problems with the grout occur.

E. The Contractor's designee who will be in direct charge of the post-tensioning and grouting crews. This individual shall have the following qualifications:

(1) Be skilled in the use of the post-tensioning and grouting equipment.

(2) Have at least three years' experience on previous projects supervising the post-tensioning and grouting of structures of similar type and magnitude.

(3) Be present on the project during the installation of the post-tensioning system, stressing operations, and grouting operations.

(4) Be a holder of a current Certified Grouting Technician Certificate from the American Segmental Bridge Institute (ASBI).

F. Contractor's PC Manager.

G. Other individuals as deemed necessary by the Contractor or Engineer.

Ten days before the Post-Tensioning and Grouting System Review Meeting, the Contractor shall submit a written plan for grouting the ducts. Grouting shall not begin until the Engineer has provided written approval of the grouting plan. The grouting plan shall provide at least the following information:

(1) The name, training, and experience record of the person supervising the grouting operations.

(2) Other individuals as deemed necessary by the Contractor or Engineer.

(3) Name of the grout material and the required certifications and test results.

(4) Manufacturer and type of grout mixer and pump to be used, including provisions for back-up equipment and spare parts.

(5) Grouting procedure and the role of each person on the crew.

(6) Theoretical grout volume calculations.

(7) Method for closing all duct orifices as grouting progresses.

(8) Air testing of ducts.

(9) Grout mixing and pumping procedures.

(10) Location of grout inlet and direction of pumping.

(11) Procedures for handling blockages, procedures and equipment required for flushing ducts of grout if necessary, and how and when it will be decided whether or not to flush ducts.

(12) Methods to inspect behind anchorages, grout inlets and outlets, and vents for voids.

(13) List of production testing along with acceptable values according to Table 618-1.

(14) Acceptable specific gravities for mud balance test provided by the grout manufacturer.

(15) Procedures for post grouting repair of all grout voids detected.

(16) Procedure for installing corrosion inhibitor inside tendons if necessary.

2. Alternative Post-tensioning Systems. The Contractor may choose to supply the design and details of the prestressing system shown on the plans or submit an alternative for approval. The following alternatives may be presented to the Engineer for his review and approval:

   A. The shop drawings shall show the alternative anchorage systems, including all associated reinforcing steel required for the system. A Professional Engineer registered in the State of Colorado shall electronically seal the shop drawings.

   B. Alternative number or sizes of ducts. The duct pattern must conform to an acceptable pattern as indicated on the plans.

   C. Alternative jacking ends.

   D. Alternative number of strands, provided the minimum area of steel and the center of force matches that indicated on the plans.

   E. Alternative duct type, friction coefficients, or anchor set.

   The stressing sequence, details, or procedures shall not differ from what is called for on the plans, such that it would cause a change in the jacking force times initial stress ratios at the critical points identified on the plans, beyond an acceptable tolerance of 0 to +5 percent.

   A. If the Contractor elects to submit alternative details, the alternative details shall conform to the following:

   B. The final center of force shall match that as indicated on the plans.

   C. If the plans call for a tendon to be composed of a certain number of strands, the Contractor's alternative shall have that same tendon composed of the same number of strands.

D. If the plans call for a tendon to be composed of bars, the Contractor's alternative shall have that same tendon composed.

E. If the plans call for ducts and tendons internal to the member, the Contractor's alternative shall also have internal ducts. Similarly, if the plans call for ducts and tendons external to the member, then the Contractor's alternative shall also have external ducts.

F. The alternative shall include details or calculations supporting the adequacy of the Contractor's alternative as specified in the shop drawing and calculation requirements of this specification.

G. Bridge cross-sectional geometries, dimensions, and clearances shall match those indicated on the plans, with the exception of girder flares near anchorages.

3. Duct Fabrication and Placement. Duct enclosures for prestressing steel shall be either rigid, corrugated plastic or galvanized, corrugated, rigid ferrous metal.

   Metal ducts shall be fabricated with either welded or interlocked seams. Galvanizing of the welded seams for metal ducts will not be required.

   The ducts shall be mortar tight and accurately placed within 1/4 inch of the positions shown on the approved shop drawings. Ducts shall be securely fastened to maintain their correct alignment during placing of concrete. Joints between sections of duct shall be positive rigid connections, which do not result in angle changes at the joints. Waterproof tape shall be used at the connections. Ducts shall be bent without crimping or flattening. Transition couplings connecting ducts to anchoring devices need not be galvanized. Ducts shall be free of kinks. All changes of direction shall have a radius of 20 feet, unless otherwise shown on the plans. Shrink sleeves at duct splices at closure pours shall be used.

   The duct area shall be at least twice the net area of the prestressing steel for tendons composed of multiple wires, bars, or strands.

   The duct diameter shall be at least 1/4 inch larger than the nominal diameter of the wire, bar, or strand for tendons made up of a single wire, bar, or strand.

   All ducts shall have grout openings at each end. Grout vents shall be provided at all high points and low points of draped tendons. In addition, at draped tendon high points, two additional high point gout vents shall be located three feet beyond all high points in both directions.

   Grout openings and vents shall be securely fastened to the ducts and forms or reinforcing steel to prevent displacement while placing concrete. The vents shall be mortar tight, taped as necessary and shall provide means for injection of grout. Ends of grout vents shall be removed to 1 inch inside the face of concrete surface after the grouting has been completed and the holes filled with an approved epoxy or nonshrink grout and finished smooth.

Before installation of the prestressing steel, the Contractor shall show that the ducts are free from debris and water. For ducts that are internal to the member, the Contractor shall show that the ducts are free from any blockage or damage from the concrete placing operations. The Contractor shall do this immediately after the concrete encasing the duct has achieved initial set. The precast fabricator shall be responsible for the condition of the ducts during fabrication if the member is precast.

The precast fabricator shall demonstrate to the QA Representative that the ducts are free and clear of any obstructions or damage and are able to accept the intended post-tensioning tendons by passing a torpedo through the ducts. A torpedo that has the same cross-sectional shape as the duct and that is 1/8 inch smaller all around than the clear, nominal inside dimension of the duct shall be used. No deductions shall be made to the torpedo section dimensions allowed in the manufacture or fixing of the ducts. For curved ducts, the length shall be determined so that when both ends of the torpedo touch the outermost wall of the duct, the torpedo is 1/8 inch clear of the innermost wall. Acceptance shall be based on the torpedo passing through the duct easily. Nonconformance is when the torpedo does not pass through the ducts easily and shall be addressed per 618.13.

Once installed, the ducts (including the ends of the ducts at the anchorages, grout ports, and duct vents) shall be sealed immediately to prevent the entry of water or other debris until the tendons are grouted.
The use of water-soluble oil in the ducts and flushing the ducts with water will not be allowed.

4. Post-tensioning Equipment and Procedure.
   A. Installing Tendons. Excess water in ducts shall be removed by blowing oil-free compressed air through the ducts.

      Post-tensioning strands used to make up the tendon shall be pushed or pulled through the ducts using methods that will not snag the strands on any lips or joints in the ducts.
      The ends of strands that are pushed through the duct shall be rounded off or fitted with a smooth protective cap. Strand that is pushed shall not be intentionally rotated by any mechanical device during the installation of the post-tensioning into the duct.

      The ends of strands that are pulled through the duct shall be assembled to form the tendon and pulled using a special steel wire sock or other device attached to the end. The ends of the strands may be electric arc welded together for this purpose as long as at least 1 to 5 feet of the strands from the welded end, depending on size of tendon, is removed after installation. The ends of strands of the pre-assembled tendon shall be rounded to facilitate smooth passage through the duct.

      Strands shall be cut using an abrasive saw or equal. Flame cutting or plasma cutting of strands is allowed only with permission from the Engineer.

      The responsible representative identified in item (8) under subsection 618.06(b) shall be present at all times during stressing of bonded post-tensioned members.

B. Tensioning. Tensioning shall be done with approved jacking equipment. Hydraulic jacks shall be equipped with accurate pressure gauges at least 6 inches in diameter. The combination of jack and gauge shall have been calibrated within the last 12 months, per subsection 618.10(a). A certified calibration chart, graph, or table showing this calibration of the jack and gauge combination shall be furnished to the Engineer. The range of calibrations shall encompass the range of required forces indicated on the shop plans. The jacking equipment shall be capable of simultaneously stressing all wires, strands, or bars for each individual tendon.

Tendons shall be stressed per the sequence as indicated on the approved shop drawings. If the Contractor chooses to deviate from the sequence, the Contractor shall resubmit the shop drawings for approval. The sequence shall not cause stresses in excess of the maximum allowable stresses shown on the plans.

Tendons shall be preloaded to 20 percent of their total jacking force, before measuring elongations.

Measured elongations shall be within plus or minus 7 percent of the calculated values, unless otherwise approved by the Engineer.

A broken or damaged strand is cause for rejection of the tendon. If a strand is rejected, the remaining strands in the tendon will be evaluated by the Engineer for reuse.

Where dead end anchorages and tendons are accessible, the anchorage system and length of projecting prestressing steel shall permit jacking with the same jacking equipment that was used on the live end.

Tendon projections at the live end and accessible dead ends shall not be cut off until all post-tensioning is completed and accepted.

The representative of the post-tensioning system supplier shall keep a record of the following items for each tendon installed and provide a copy to the Engineer the day stressing is completed:

(1) Project name and number.

(2) Contractor and subcontractor.

(3) Tendon location, strand diameter, and number of strands.

(4) Date strand was first installed in the ducts.

(5) Heat number of the strands.

(6) Assumed and actual strand cross-sectional area and modulus of elasticity.

(7) Date stressed.

(8) Date of calibration of the jack and pressure gauge combination with their identification numbers.

(9) Required initial and final jacking force and the gauge pressure.

(10) Anticipated and actual elongations and anchor set.

(11) All deviations from the plans, specifications, and approved shop drawings shall be brought to the attention of the Engineer for immediate resolution.

618.08 Post-Tensioning Anchorages and Distribution. Prestressing steel shall be secured at the ends by means of approved permanent type anchoring devices.

Anchorages and couplers shall develop at least 95 percent of the minimum specified ultimate strength of the prestressing steel. The coupling of tendons shall not reduce the elongation at rupture below the requirements of the tendon itself. Couplers and coupler components shall be enclosed in housings long enough to permit necessary movements. Couplers for tendons shall be used only at locations specifically indicated or approved by the Engineer.

Couplers shall not be used at points of sharp tendon curvature.

Permanent anchorage grout caps are required and shall be installed before grouting begins.

Anchorage devices shall have a minimum clear concrete or grout coverage of 2 inches in every direction. Alternative corrosion protection methods for anchorages shall be shown on the shop drawings submitted by the Contractor.

The prestressing force shall be effectively distributed to the concrete by means of an approved anchoring device. Such devices shall conform to the following requirements:

(1) The average concrete bearing stresses on the concrete-created anchorage distribution plates shall not exceed the values allowed by the following equations:

During jacking:

$$f_{cp} = 0.8 f'_{ci} \sqrt{\frac{A'_b}{A_b} - 0.2} \leq 1.25 f'_{ci}$$

After jacking:

$$f_{cp} = 0.6 f'_{ci} \sqrt{\frac{A'_b}{A_b} - 0.2} \leq 1.25 f'_{c}$$

Where:

f_{cp} =permissible compressive concrete stress
f'_{ci} =compressive strength of concrete at time of jacking
f'_c=compressive strength of concrete
A'_b = maximum area of the portion of the concrete anchorage surface that is geometrically similar to and concentric with the area of the anchorage
A_b=bearing of the anchorage

If bursting steel is not used, the peak bearing pressure on the concrete at the time of jacking from the distribution plate shall not exceed $0.90f'_{ci}$. If the distribution plate or anchorage device is within 4 inches of any concrete edge or corner or another distribution plate or anchorage device, the pressure on the concrete shall not exceed $0.70f'_{ci}$. Construction joints shall not pass under distribution plates or anchors.

(2) Bending moments in the plates or assemblies induced by the pull of the prestressing steel shall not exceed the plastic strength of the material or cause visible distortion of the distribution plate when 100 percent of the ultimate prestress load is applied as determined by the Engineer.

(3) Distribution plates may be omitted if the anchorage device distributes the stresses in the concrete consistent with these specifications and provided that this anchorage device is used in conjunction with embedded bursting and splitting reinforcement.

618.09 Bonding and Grouting.

(a) General. Post-tensioned prestressing steel shall be bonded by completely filling the void space within a duct with grout. Prestressing steel to be bonded shall be free of dirt, loose rust, or other deleterious substances. The ducts shall be kept free of water, dirt, or other deleterious foreign materials that will inhibit bond until the tendons are grouted. Time from installing the prestressing steel in the ducts in an unstressed condition to grouting after stressing shall not exceed thirty days. If a corrosion inhibitor, as specified below, is used on the strands in the ducts, the time limit shall not exceed sixty days. Grouting shall proceed as soon as possible after stressing of the prestressing steel in the ducts. If a corrosion inhibitor is used on the strands in the ducts, it shall be applied after post-tensioning is completed and accepted and grouting accessories are installed so that tendons are sealed. The post-tensioning system installer shall submit an installation log. A copy of the log that documents the day the strands were installed within the duct and the corrosion inhibitor applied to the strands in the duct, with the duct given an identification easily referenced to the plans, shall be provided to the Engineer. All pertinent product numbers and the corrosion inhibitor brand and type shall be documented in the log. Verification shall be made weekly that the tendons remain sealed and grout vents, drains, and caps have not been damaged.

(b) Grout. Grout shall be prepackaged in bags.

The following information shall be printed on the grout bags: product name, name of the producer, date of packaging, lot number, and mixing instructions. Grout shall not contain any lumps or other evidence of hydration.

The grout shall not contain aluminum powder or compounds that will produce hydrogen gas, carbon dioxide, or oxygen. In addition, the grout shall not contain fluorides, sulphites, nitrates, or acid-soluble chloride ions that exceed 0.08 percent by weight of the cementitious materials. The Contractor shall provide the Engineer with written certification from the grout manufacturer that the grout does not contain or produce these elements or compounds with the grouting plan.

The grout shall conform to the following Standard and Modified ASTM Tests in Table 618-1 when mixed per the manufacturer’s instructions:

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Table 618-1

POST-TENSIONING GROUT REQUIREMENTS

Property	Test Value	Test Method
Total Chloride Ions	Max. 0.08% by weight of Cementitious material	ASTM C1152
Fine Aggregate (If utilized)	Max. Size: 300 µm (No. 50 Sieve)	ASTM C33
Volume Change at 24 hours and 28 days	0.0% to + 0.2%	ASTM C1090 *
Expansion	0.0% (minimum), 2% (maximum)	ASTM C940
Compressive Strength at 28 days (Average of 3 cubes)	7000 psi minimum	ASTM C942
Initial set of the grout	3 hours minimum, 12 hours maximum	ASTM C953
Bleeding at 3 hours	Maximum 0.0 %	ASTM C940 +
Permeability at 28 days	Maximum 2500 coulombs, At 30 Volts for 6 hours	ASTM C1202
FLUIDITY TEST ◂	**Efflux Time from Flow Cone**	**ASTM Method**
(a) Immediately after mixing	Min. 11 sec, Max. 30 sec	ASTM C939
(a) Immediately after mixing	OR Min. 5 sec, Max. 30 sec	ASTM C939 #
(b) 30 minutes after mixing with remixing for 30 seconds	Max. 30 sec	ASTM C939
(b) 30 minutes after mixing with remixing for 30 seconds	OR Max. 30 sec	ASTM C939 #

Table 618-1 and footnotes continued on next page.

Table 618-1 (continued)

Notes for Table 618-1:

* ASTM C1090 shall be modified to include verification at both 24 hours and 28 days.

◂ Adjustments to flow rates shall be achieved by strict compliance with the manufacturer's recommendations.

Grout fluidity shall meet either the Standard ASTM C939 flow cone test or the Modified Test described. Modify the ASTM C939 Test by filling the cone to the top instead of to the standard level. The efflux time is the time to fill a one-liter container placed directly under the flow cone.

+ ASTM C940 shall be modified to conform with the wick induced bleed test as follows:

(i) Use a wick made of a 20-inch length of ASTM A416 seven-wire 0.5-inch diameter strand. Wrap the strand with two-inch-wide duct or electrical tape at each end before cutting to avoid splaying to the wires when it is cut. Degrease (with acetone or hexane solvent) and wire brush to remove any surface rust on the strand before temperature conditioning.

(ii) Condition the dry ingredients, mixing water, prestressing strand and test apparatus overnight to 65 to 75 °F.

(iii) Mix the conditioned dry ingredients with the conditioned mixing water and place 800 ml of the resulting grout into the 1,000 ml cylinder. Measure and record the level of the top of the grout.

(iv) Completely insert the strand into the graduated cylinder. Center and fasten the strand so it remains essentially parallel to the vertical axis of the cylinder. Measure and record the level of the top of the grout.

(v) Store the mixed grout at the temperature range listed in (ii).

(vi) Measure the level of the bleed water every 15 minutes for the first hour and hourly for two successive readings thereafter.

Calculate the bleed water, if any, at the end of the three-hour test period and the resulting expansion per the procedures outlined in ASTM C940, with the quantity of bleed water expressed as a percent of the initial grout volume. Note if the bleed water remains above or below the top of the original grout height. Note if any bleed water is absorbed into the specimen during the test.

Grout used on the project shall have been sampled and tested within the last twelve months per the above referenced test procedures. The Contractor shall provide certified test reports for the grout used on the project from an independent AASHTO Accredited Laboratory and a sample of the grout for evaluation by the Department with the plan for grouting the ducts. The grout sample submitted to the Project shall be at least 2,000 grams in a sealed container. Grout that does not meet the above requirements shall not be used.

(c) Mixing of Grout. All grout shall be mixed with a high-speed shear (colloidal) mixer.

(d) Grouting. All grouting operations shall be performed under the immediate control of a person who has completed the American Segmental Bridge Institute (ASBI) Grouting Certification Training Program.

The Contractor shall perform the following tests and report the results to the Engineer:

(1) One pressure bleed test per day per lot per the requirements of Appendix C of the "Specification for Grouting of Post-Tensioned Structures" by the Post-Tensioning Institute. The Gelman filtration funnel shall be pressurized to a minimum of 50 psi and the maximum percent bleed shall be zero.

(2) Two mud balance tests per day or when there is a visual or apparent change in the characteristics of the grout per the API Recommended Practice 13B-1 "Standard Procedure for Field Testing Water-Based Drilling Fluids".

(3) Minimum of one strength test per day per lot per ASTM C942 and the minimum 28-day compressive strength shall be 7,000 psi.

(4) Minimum of two fluidity tests (flow cone) – one at the mixer and one at the duct outlet per ASTM C939, "Standard Tests Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)". The efflux time shall be within the values established in Table 618-1.

Grout shall be injected from the lowest end of a tendon to the highest end in an uphill direction. A continuous, one-way flow of grout shall be maintained for each duct.

All grout vent openings shall be open when grouting starts. Grout shall be allowed to flow to the first vent from the inlet pipe until residual slugs of water or entrapped air have been eliminated and the grout has the same consistency as that of the grout being injected. The vent shall then be capped or otherwise closed. Remaining vents shall be capped or closed in sequence in the same manner except that at draped tendon high points, the secondary vents placed a short distance downstream from the high point vent shall be closed before the highpoint vent.

The Contractor shall inspect the interiors of box girders during grouting operations for grout leakage. Leaks shall be sealed before grouting is continued.

Grout shall be pumped through the duct and continuously wasted at the outlet pipe until all visible slugs of water or air are ejected. To ensure that the tendon remains filled with grout, the outlet shall be closed, and the pumping pressure allowed to build to a minimum of 75 psi before the inlet vent is closed.

For all vertical tendons that are 20 feet and taller, a standpipe shall be provided at the upper end of the tendon to collect bleed water and allow it to be removed from the grout. This device shall be designed with commercial steel plumbing fittings so that the grout level will not drop below the elevation at the highest point in the upper anchorage device due to bleeding. If the level of the grout drops below the highest point in the upper anchorage device, additional grout shall immediately be added to the standpipe. After the grout has hardened, the standpipe shall be replaced with a cap.

For vertical internal tendons, if the grouting pressure exceeds the maximum recommended pumping pressure, the grout shall be injected at increasingly higher outlets (that become inlets) that have been or are ready to be closed as long as one-way flow of grout is maintained. Grout shall be allowed to flow from each outlet until all slugs of air and water have been purged before using that outlet for injection.

Plugs, caps, and valves thus required shall not be removed or opened until the grout has set.

The Contractor shall monitor all anchorages, grout ports, and vents periodically until the grout sets. The Engineer shall be notified if bleed water is dripping from these locations. Bleed water may be an indication of voids and will require investigation by the Contractor after the grout sets.

After the grout has set, the grout port and vent plugs shall be removed. The Contractor shall inspect the tendon anchorages, grout ports and vents for voids or other evidence of incomplete grouting. If evidence is found of voids in these areas, the Contractor shall submit a plan for regrouting the voids to the Engineer for approval. All costs for remedial grouting will not be measured and paid for separately but shall be included in the work.

(e) Temperature Considerations.

The temperature of the concrete adjacent to the ducts shall be 40 °F or higher from the time of grouting until site cured 2-inch grout cubes, tested per AASHTO T 106, reach a minimum compressive strength of 800 psi.

Grout shall be between 40 and 90 °F during mixing and pumping. If necessary, the mixing water shall be heated or cooled. Ice may be used to cool the water but shall not be added directly to the mixed grout. Dry ice and liquefied carbon dioxide shall not be used for cooling purposes.

618.10 Equipment. Equipment used for fabrication of pretensioned and combination tensioned members shall conform to the following requirements:

(a) Jacking Equipment and Load Cells. All equipment shall be calibrated as a system that represents actual use. Jacks, gauge and pump systems, and load cells shall be calibrated at intervals not longer than 12 months, or whenever the tensioning system yields erratic results. Master gauge systems shall be calibrated at intervals not longer than six months, or whenever the tensioning system yields erratic results. If load, sensor, or indicator components are replaced or repaired, the system shall be recalibrated before resuming jacking operations. System error shall not exceed plus or minus 1 percent of the applied loads.

Calibration shall be performed by an agency or service that uses equipment certified by the National Institute of Standards and Technology (NIST). Accuracy of the calibration equipment shall be traceable to the NIST records. The calibration procedures used shall conform to ASTM Standard Practices E 4 and E 74. Each time that calibration verification is performed, a copy of the certified test report shall be furnished to the QA Representative or the Engineer.

(b) Concrete Batching Equipment. The weighing system shall be calibrated at intervals no longer than 12 months. If disassembly, replacement, damage, or repair of scales or balance indicators should occur, the weighing system shall be recalibrated before resumption of mix operations. Scale calibrations shall be performed in conformance with the State of Colorado, Department of Agriculture requirements. Current calibration labels shall be visibly displayed on the equipment.

The batching system shall record the weights of all concrete mix ingredients for each batch. Ingredient weights shall meet the requirements of ASTM C94, Section 8, Measuring Materials.

The batching system shall be equipped with a flow meter that measures the weight or volume of the added mixing water within plus or minus 1 percent of the total water added to each batch.

(c) Concrete Load Testing Machine. The test machine shall meet the requirements of ASTM C39.

(d) Concrete Cylinder Molds. Molds shall meet the requirements of ASTM C470.

(e) Forms. Forms shall be sufficiently mortar tight to minimize fresh mortar paste leakage, and sufficiently rigid to prevent product distortion due to concrete pressure or consolidation operations. Form joints shall be kept clean, smooth, and adjusted to minimize form finish irregularities.

Forms shall be constructed and erected to produce units that conform to the product dimensional tolerances required by subsection 618.14(b); the forms shall also meet smoothness tolerances required by this subsection.

Forms shall be treated with a form release agent that does not adhere to or significantly discolor the final concrete product.

Forms that have known deviations from the typical sections shown on the plans shall be approved by the Engineer before use. The deviations shall be submitted on working or shop drawings.

(f) Miscellaneous Test Equipment. All miscellaneous test equipment used during fabrication shall be kept in a condition such that accurate test results are obtained. Proper equipment maintenance and calibration shall be the responsibility of the Contractor's PC section.

618.11 Concrete for Pretensioned and Combination Tensioned Products. The Contractor shall furnish and place concrete according to this subsection.

(a) Classification. Concrete shall be Class PS. Class PS concrete is used for prestressed concrete members. The required field compressive strength and air content shall be that stated on the plans. Class PS shall be made with an AASHTO M 43 size No. 8 or larger coarse aggregate. Class PS Concrete may be self-consolidating.

(b) Concrete Mix Components. The Contractor shall develop a mix design for Class PS concrete. The mix design shall conform to the requirements of Section 601 and CP-62. Materials sources shall be listed on the Contractor’s mix design. The PC manager must notify the QA Representative in writing before changing the sources as listed in the PCP. Changes in mix design material sources or proportions, except for admixtures, require a new mix design to be submitted to the Engineer for approval at least five days before the new mix being used in production.

(c) Equipment Calibration and Verification. The Contractor shall implement a plan for equipment calibration and verification of testing apparatus in compliance with ASTM C1077. The calibration records shall be made available to the QA Representative upon request.

(d) Batching and Mixing. Concrete shall be batched and mixed according to ASTM C94.

(e) Placing Concrete. Forms shall be free of dirt, mortar, debris, and foreign substances before depositing the fresh concrete. Rust areas shall be cleaned to prevent rust staining of the finished products. The concrete shall be consolidated with suitable mechanical vibrating equipment. Vibration time shall be of sufficient duration to accomplish adequate consolidation throughout the entire product but shall not be prolonged to the point that segregation of the fresh concrete occurs.

The Contractor shall use the procedures listed in the PCP, to protect the freshly deposited concrete from rapid drying and surface moisture loss due to extreme ambient or climatic conditions.

Temperature limitations are as follows:

1. The temperature of the plastic concrete during placement operations shall not be lower than 50 °F.
2. Mid concrete that has a temperature in excess of 90 °F shall not be placed.
3. Unless a suitable retarder is used the concrete shall be deposited in place within 90 minutes after batching; any load or portion of a load shall not be placed after the 90-minute limit.
4. Inner form temperature shall be within 40 °F of the fresh concrete temperature at time of concrete placement.
5. Minimum inner form temperature shall be 32 °F and free of ice at the time of concrete placement.
6. Maximum inner form temperature shall be 130 °F at the time of concrete placement.

(f) Finishing Fresh Concrete. Open surfaces of fresh concrete shall be worked as little as possible to obtain the finish shown on the plans. Water shall not be added to the surfaces to ease finishing. Excessive water or laitance brought to the surface through vibration shall be removed before the surface is final finished. All hand finishing, required for precast members that have surfaces that become part of the final bridge deck surface, shall be performed in conformance with subsection 601.12(a).

Monomolecular film coatings or fogging systems, as approved by the QA Representative, may be used to retard evaporation during extreme ambient conditions. Application methods shall deposit a fine mist spray over the concrete surface. Streaming, puddling, or droplet application of coatings shall not be permitted. The concrete surfaces shall not be reworked after application of mist.

(g) Concrete Testing. The Contractor's PC section shall make representative cylinder test specimens for PC/QA testing. The Contractor's PC representative casting QA concrete cylinders shall be ACI Concrete Field Testing Technician – Grade I certified. When self-consolidating Class PS is used, the Contractor's PC representative casting QA concrete cylinders shall also be ACI Self-Consolidating Concrete Testing Technician certified. The Contractor shall forward test cylinders to the QA representative, for 28-day strength tests, and for shipping strength tests as required by subsection 618.15. Concrete tests shall be performed per the following requirements:

1. Test cylinder specimens shall be prepared per ASTM C31.
2. Cylinders will be tested per ASTM C39 by the Engineer. The average strength of at least two test cylinders shall be equal to or greater than the specified strength. When evaluating a single test consisting of three 28-day standard cured cylinders, if the compressive strength of any one cylinder differs from the average by more than 10 percent, that cylinder will be discarded, and the average strength determined using the strengths of the remaining two cylinders. If the compressive strength of more than one cylinder differs from the average by more than 10 percent, all three cylinders will be used to determine the compressive strength.

   When the compressive strength of the concrete is less than that specified in the contract, the structural adequacy of the element will be evaluated by the Engineer. The Contractor may request to core the element represented by the low strength results. If approved by the Engineer, the locations of the cores shall be as directed by the Engineer. Coring shall be at the expense of the Contractor and witnessed by the Project Engineer or designee. Coring shall take place no more than 45 days after casting. A minimum of three cores shall be collected with a minimum diameter of 3 inches. The cores shall be obtained by the Contractor and immediately turned over to the Engineer for compressive strength testing. Cores shall be obtained per AASHTO T24 with the exception that immediately after removal from the structure, cores will be cured at a temperature between 60 to 80 °F and at a relative humidity below 60 percent for 24 to 48 hours before testing. When evaluating a single test consisting of three cores, if the compressive strength of any one core differs from the average by more than 10 percent, that core shall be discarded, and the average strength determined using the strengths of the remaining two cores. If the compressive strength of more than one core differs from the average by more than 10 percent, all three cores will be used to determine the compressive strength. If the average core compressive strength is greater than the average of the cylinder compressive strength, the core strength will be used in the Engineer's evaluation. If the core compressive strength is less than the cylinder compressive strength, the cylinder strength will be used in the Engineer's evaluation.

   Final determination of acceptance or rejection of the element shall be at the sole discretion of the Engineer based on evaluation of the cylinders and core strengths. If the element is accepted, the core holes shall be filled with a nonshrink grout or mortar approved by the Engineer. Patching of the core holes shall be at the expense of the Contractor/Fabricator.

3. Cylinder test specimens shall be made to verify stress transfer strength and to verify 28-day design strength. If the products will be shipped before 28-day testing, additional test specimens shall be available to verify product strength before shipment.

4. Representative cylinders shall be molded for each 50 cubic yards or portion thereof, for each different concrete mix design used per day per product line.

5. Air Content, when specified, shall be determined per either ASTM C173 or ASTM C231. Air entrained mixes shall be tested a minimum of once per day to assure specified air entrainment. This test shall be conducted for each load of concrete that compressive strength specimens are cast per ASTM C39.

6. Slump of fresh concrete shall be determined per ASTM C143. The slump shall be tested whenever test cylinder sets are made. This test shall be conducted for each load of concrete that compressive strength specimens are cast per ASTM C39. Slump testing is not required when self-consolidating Class PS concrete is used.

7. Unit Weight of fresh concrete shall be determined per ASTM C138. Unit weight shall be tested a minimum of once per day for each different concrete mix design used. This test shall be conducted for each load of concrete that compressive strength specimens are cast per ASTM C39.

8. Temperature of fresh concrete shall be taken as needed, to assure compliance with the temperature requirements. This test shall be conducted for each load of concrete that compressive strength specimens are cast per ASTM C39.

618.12 Curing.

(a) Pretensioned and Combination Tensioned Members. Members shall be uniformly cured from the time of concrete placement until at least two representative product test specimens achieve an average strength that meets or exceeds
0.7 f 'c, or the specified release strength, f 'ci, whichever is higher.
Where:

f'_c =28-Day Compressive Strength of Concrete

f'_{ci} =Required Concrete Strength at Release of Prestress Force

Additional curing requirements shall be maintained until the above strength requirements are achieved, and are as follows:

1. Exposed concrete surfaces shall be kept moist from the time of concrete placement until the freshly finished concrete is covered with an enclosure that retains heat and moisture. After enclosure, moist curing shall be maintained at a minimum 70 percent relative humidity.

   The Contractor shall monitor the temperature and humidity conditions from the initial curing period through the end of the accelerated curing stage.

2. Temperature of the concrete shall be maintained above 50 °F.

3. The internal and surface temperature of the concrete shall not exceed 160 °F. The Contractor shall monitor the internal concrete temperature using thermocouples with concrete temperature recorded at intervals not to exceed 15 minutes. A minimum of two thermocouples shall be installed in the element at a maximum spacing of 75 feet with a maximum distance from either end of 40 feet. Thermocouples shall be installed at the center of mass of the element as uniformly as practical to provide accurate temperature monitoring information. An element is defined as a single precast prestressed concrete girder or beam or cast-in-place span. When multiple elements are cast simultaneously in a single bed, the temperature monitoring thermocouples shall be at a maximum spacing of 75 feet. Temperature logs shall be submitted to the Engineer before transporting the element to the project site. When the internal temperature of the element exceeds 160 °F, the Contractor shall submit a mitigation plan to ensure future castings do not exceed the 160 °F maximum temperature requirement. The mitigation plan shall also include procedures for sampling and testing the element to identify the potential risk for Delayed

Ettringite Formation, and waterproofing applications to protect against moisture intrusion. The mitigation plan shall be submitted to the Engineer for review and approval. Acceptance or rejection of the element exceeding the temperature specification will be based on review and assessment of the specific curing temperature logs and the submitted documentation. The element shall not be shipped until the Contractor receives written acceptance from the Engineer.

4. Concrete shall attain initial set before application of the accelerated curing cycle. If initial set was not determined per ASTM C403, accelerated curing shall not be induced for 4 hours, or 6 hours if retarding admixtures are used.

   While waiting for the initial set period, low cycle heat may be applied to maintain the curing chamber temperature; however, the temperature rise shall not exceed 10 °F per hour during the waiting period.

5. The rise in temperature in the curing chamber during accelerated curing cycle shall not exceed 40 °F per hour.

(b) Cast-in-Place Members. The curing of cast-in-place members shall conform to the requirements of subsection 601.13. The concrete shall not be exposed to temperatures below freezing for six days after casting, or until it has reached the strength required for applying the prestressing force. The minimum strength of the concrete shall be at least, 3,500 psi for post-tensioned members, or as given on the plans whichever is greater, before prestressing.

(c) Other Precast Members. Precast members that do not contain pretensioned steel shall meet curing requirements as follows:

1. Exposed surfaces of freshly finished concrete shall be covered with moisture retaining material or shall be treated with a concrete curing compound approved by the QA Representative.
2. Temperature of the concrete shall be maintained above 50 °F from the time of concrete placement until the curing is complete.
3. Uniform curing shall continue until at least two representative product test specimens achieve an average strength that meets or exceeds 0.7 f'_c or the specified release strength f'_{ci}, whichever is higher.
4. The internal and surface temperature of the concrete shall not exceed 160 °F.

618.13 Repairs of Pretensioned and Combination Tensioned Members. Repairable product defects discovered during PC or QA inspection shall be corrected at the Contractor's expense before shipping. Damage incurred during handling, storage, shipment and erection shall be repaired or replaced at the Contractor's expense.

Defects shall be categorized as minor, structural, or rejectable. The PC section shall examine and record all defects. The PC section shall submit a written proposal for minor repairs to the QA Representative for review and acceptance before correcting the minor defects. The proposal shall also address the measures the Contractor will take to prevent recurring defects in future members. The QA Representative will accept, or reject, the finished repair work in writing.

Small production holes that are less than 1/2 inch in depth and less than 1 square inch in surface area shall not be considered defects. Larger production holes shall be repaired according to the procedures listed in the PCP.

Structural and rejectable defects shall be examined by the Contractor's Engineer. A written proposal for repair of structural or rejectable defects shall be submitted to the QA Representative for review and acceptance before correcting any defects. The proposal shall include a detailed description of repair materials, and the methods the Contractor intends to use to evaluate the finished repair work. The proposal shall also include the measures the Contractor will take to prevent recurring defects in future members.

Completed repairs shall be cured as needed to ensure soundness of the reworked area.

The defect categories and repair requirements are defined as follows:

(a) Minor Defects. Minor defects are those that do not affect the ability of the product to withstand service or construction loads. Minor defects include superficial discontinuities such as cracks; small spalls, voids, and honeycombed areas; and defects that do not extend beyond the centerline of any reinforcing steel or into any elements of the tensioning system. Minor defects of other types may also be designated by the QA Representative.

Repair methods shall not affect the structural integrity of the product. The finished repair work shall meet the approval of the QA Representative and the Engineer.

(b) Structural Defects. Structural defects, as determined by the QA Representative or the Engineer, include defects that may impair the ability of the product to adequately withstand construction or service loads. Defects that extend beyond the centerline of any reinforcing steel or into any element of the tensioning system are classified as structural defects. Such defects also include cracks, spalls, honeycombed areas, voided areas, significant concrete breakage areas, cold joints, and segregated concrete areas. Structural defects of other types may also be designated by the QA Representative or the Engineer.

The Contractor’s Engineer shall electronically seal a letter that the repair work meets all design serviceability criteria and include the evaluation and test data. Repair Methods shall adequately restore the structural integrity of the product. The finished repair work, including aesthetic acceptability, shall meet the approval of the Engineer.

(c) Rejectable Defects. Rejectable defects or damages, as determined by the QA Representative or the Engineer, are those that impair the ability of the product to adequately withstand construction or service loads, and that cannot be successfully repaired to structural and architectural acceptability. Structurally defective or rejected products shall not be incorporated into the work but shall be replaced with acceptable products supplied at the Contractor's expense.

Damaged and defective products will also be rejected by the QA Representative for the following reasons:

1. Failure by the Contractor's Engineer to approve and submit proposed repair procedures in writing before repair work begins.
2. Failure by the Contractor to execute the repair work according to QA approved procedures.

3. Failure by the Contractor to provide written certification of acceptable structural repair, along with submittal of evaluation and test data, if applicable.

4. Failure by the Contractor to correct recurring defects.

5. Determination by the QA Representative that the work, or materials used in the work, does not meet all contract requirements.

618.14 Other Fabrication Requirements for Pretensioned and Combination Tensioned Members.

(a) Finishing Hardened Concrete Products. Finished and repaired areas shall reasonably match the coloration and profile characteristics of the adjacent concrete. Loose concrete laitance shall be removed from the product before storage.

(b) Product Dimensional Tolerances. Tolerances for prestressed concrete products shall meet the unit tabulations listed in the PCI Manual MNL-135, unless otherwise stated in the Contract. The PCI tolerance figures and tabulations shall be specification requirements. Out-of-dimensional-tolerance variations shall be considered defects and shall be examined and evaluated by the Contractor's Engineer. The evaluation shall be submitted to the QA Representative in writing and shall contain written opinion of structural adequacy as determined by the Contractor's Engineer. The submittal shall meet the approval of the Engineer. Failure to submit the written evaluation and opinion will be cause for rejection.

The following work or products shall meet the specific PCI tolerance requirements described as follows, unless otherwise specified in the plans:

1. Bulb-Tee Sections shall conform to Section 10.10 I-Beams (Girders) or Bulb Tee Girders.

2. G-Series Sections shall conform to Section 10.10 I-Beams (Girders) or Bulb Tee Girders.

3. Box Girders and U-Girders shall conform to Section 10.10 Box Beams.

4. Deck Panels shall conform to Section 10.22 Bridge Deck Units.

(c) Handling, Storage, Shipment and Erection. The Contractor shall handle the product in such a manner as to prevent cracking or damage. Cracked or damaged products shall be inspected by the PC section and repaired per subsection 618.13 or replaced at the Contractor's expense.

Braces, trusses, chains, cables, or other metal devices used for handling, storing, shipping, or erecting shall be adequately padded at points in contact with the concrete, to prevent chipping of the finished product.

Beam sections shall be handled, stored, shipped, and erected with supports and devices that maintain the product in an upright position. Deck panels shall be lifted as directed in the Contract unless alternative lifting methods are allowed by the Engineer. Lifting of more than one panel at a time shall not cause panel cracking. Methods for multiple lifting of panels shall be shown on the working or shop drawings. Panel products shall be stacked in such a manner that damage does not occur.

Pre-cast concrete members shall be erected to prevent damage to all elements of the structure and in a safe manner. Pre-cast concrete members that the erection specification applies are those members that bear on the substructure of a bridge. The primary members such as beams and girders shall be temporarily anchored and braced as they are erected to preclude detrimental movement in any direction, and to prevent overturning and buckling. Struts, bracing, tie cables, and other devices used for temporary restraint shall be considered falsework and shall be designed to resist all loads imposed during each stage of construction until the deck concrete has attained the Field Compressive Strength shown in Table 601-1.

At least one week before the Pre-erection Conference, the Contractor shall submit an Erection Plan to the Engineer. The Engineer will review the and return comments within one week. The Contractor shall address the Engineer's comments in the final plan. The Contractor’s Engineer shall electronically seal and mark the Final Erection Plan "Approved for Construction".

If falsework is required, falsework drawings shall conform to and be submitted per subsection 601.11.

The Erection Plan and procedure shall provide complete details of the erection process with dimension tolerances including:

1. Falsework, struts, bracing, tie cables and other devices, material properties and specifications for temporary works, bolt torque requirements before releasing girders from the cranes (if required), connection details and attachments to other structure components or objects.

2. Procedure and sequence of operations, including a detailed schedule with completion times for work items that complies with the working hour limitations.

3. Minimum load chart lift capacity, outrigger size, and reactions for each crane.

4. Assumed loads and girder weights, lift points, lifting devices, spreaders, and angle of lifting cables.

5. Girder stresses at critical points along the girder length during progressive stages of erection shall be investigated to assure that the structural integrity and stability of the girders is maintained. Stresses at lift points induced as a result of lifting shall be investigated and adequate bracing provided as indicated by the analysis.

6. Locations of cranes, trucks delivering girders, and the location of cranes and outriggers relative to other structures, including retaining walls, wingwalls and utilities.

7. Drawings, notes, catalog data showing the manufacturer’s recommendations or performance tests, and calculations clearly showing the above listed details, assumptions, and dimensions; and

8. Contingency plans detailing what measures the Contractor will take in case of inclement weather (forecast or actual), equipment failure, delivery interruption, and slower than planned production.

A Pre-erection Conference will be held at least one week before the beginning of erection. The Engineer, Contractor, erection subcontractor, and the Contractor's Engineer shall attend the meeting. The erection subcontractor shall review and verify that the piece marks are properly located on the components to be erected, their orientation in the erected structure, and the shop drawing piece mark convention used by the girder fabricator at the Pre-Erection Conference. The girder fabricator shall either attend the meeting or participate in the conference by way of speaker telephone. Participation is required during that portion that the piece marks are discussed. The girder fabricator shall state whether the erection subcontractor has demonstrated a correct understanding of the piece marks, and if not, correct any misunderstanding.

Additional Pre-erection Conferences may be required for subsequent phases of construction, or for phases that differ from the original construction plan, as directed by the Engineer. Additional conferences may also be requested by the Contractor, if approved by the Engineer.

The Contractor shall submit a final Erection Plan to the Engineer before girder erection for acceptance. The Contractor's Engineer shall electronically seal (1), (5) and (7) listed above in the final Erection Plan. The final Erection Plan shall be stamped "Approved for Construction" and signed by the Contractor. The Contractor shall not proceed with the Erection Plan until the Engineer has provided written acceptance of the plan.

When a bridge spans traffic of any kind, including those where vehicles, railroad, watercraft, or pedestrians have access onto, underneath, or adjacent to the bridge, the Contractor's Engineer shall inspect and provide electronically sealed written approval of the stability of the erected girders before opening the area beneath the girders to traffic. The Contractor shall perform daily inspections of the erected girders and other permanent and temporary bridge elements until the deck concrete has attained the full design compressive strength. The Contractor's Engineer shall provide an inspection form to the Engineer that lists the items the Contractor will document during the daily inspection of the erected girders. The inspection form shall include inspection items specific to each bridge being constructed. The Contractor shall provide the Engineer and the Contractor's Engineer with written documentation of these inspections within 24 hours of each inspection.

All temporary struts, bracing, tie cables, other devices and extra material required shall be removed upon completion of the structure.

Falsework shall conform to subsection 601.11.

618.15 Product Shipping Strength for Pretensioned and Combination Tensioned Members. Products shall not be shipped before concrete strength meets or exceeds 0.95 f'_c. The average of at least two representative test specimens shall meet or exceed 0.95f'_c. No individual specimen strength shall be more than 7 percent below 0.95f'_c. The shipping strength test specimens shall be cured in the same environment as the actual product until the time of testing. The QC section shall test the specimens for actual shipping strength. The QA Representative may independently verify any shipping strength tests.

The Contractor may elect to take concrete cores from the actual product in lieu of curing cylinder test specimens with the product. If the Contractor chooses this test option, the QC Manager shall submit written request to the QA Representative. Core extraction shall not begin until the request has been accepted in writing by the QA Representative. The written request shall include the proposed location and time schedule for core extraction and testing.

The cores shall be delivered in a wrapped and moist condition to the certified test laboratory as listed in the PCP. The QA Representative may witness any or all stages of the core testing operations. The test laboratory shall provide a copy of the formal test report to the QA Representative.

The Contractor shall bear all expenses associated with the optional core testing requirements. Sampling and testing of the concrete core specimens shall conform to ASTM C42 with the following addenda:

(1) Samples may be removed at any age at the Contractor's sole risk of damage.

(2) Test cores shall not contain embedded reinforcement.

(3) A minimum of three core samples shall be taken from the product casting in question. Three specimens shall be tested for compressive strength. The average compressive strength of the three tests shall meet or exceed product f(c). If the compressive test result of any specimen differs from the average strength by more than 15 percent, those results shall be disregarded, and the compressive strength shall be determined from at least two remaining valid test results.

(4) If end capping of test specimens is necessary, the capping shall be done with sulfur mortar per ASTM C617. Specimens shall be kept moist until end-capping preparation begins.

Ends shall be trimmed or prepped as required, wiped with absorbent cloth and air-dried or fan-dried to prepare for end capping. The drying period shall not exceed 20 minutes before capping is completed.

Specimens shall be air-dried for 10 to 20 minutes after capping, and then wrapped with a double layer of wet, thick cloth or burlap. Compressive testing shall not be started for at least one hour after wet-wrapping. The wrapped specimens shall be kept moist until compressive testing begins.

The Contractor shall submit a written repair proposal to the QA Representative for patching the core holes. Repair work shall not begin until the proposal is accepted in writing by the Engineer.

METHOD OF MEASUREMENT

618.16 Prestressed units will be measured by one of the following methods as indicated in the Contract.

(1) Prestressed girders will be measured by the linear foot from end to end or by the square foot, based on the plan length multiplied by the plan width, whichever is specified on the plans.

(2) Prestressed concrete box girders and prestressed concrete slabs will be measured by the square foot based on the plan length multiplied by the plan width.

(3) When measured by component materials, concrete and reinforcing steel will be measured and paid for per Sections 601 and 602 respectively.

The quantities of prestressing steel will not be measured but shall be the quantities shown on the plans, completed and accepted. MKFT equals the jacking force, in thousands of KIPS, times the length in feet.

Precast panel deck forms that are required by the plans will be measured by the square foot. The quantity will not be remeasured, but will be the quantity shown on the plans, except when a plan change is ordered or when it is determined that there are discrepancies in an amount of plus or minus two percent of the plan quantity.

BASIS OF PAYMENT

618.17 The accepted quantities of prestressed units and prestressing steel will be paid for at the contract unit price per unit of measurement for each of the pay items listed below that is included in the bid schedule. Precast panel deck forms required by the plans will be paid for at the contract unit price for the area shown on the plans.

Payment will be made under:

Pay Item	Pay Unit
Prestressing Steel Bar	Pound or MKFT
Prestressing Steel Strand	Pound or MKFT
Prestressed Concrete ___ (___)	Linear Foot or Square Foot
Prestressed Concrete Box (___)	Square Foot
Prestressed Concrete Slab (Depth _____)	Square Foot

Payment will be full compensation for all work necessary to complete the designated pay item.

Prestressing steel bar and prestressing steel strand shall include but not be limited to all anchorage devices, prestressing steel, ducts, grout, and miscellaneous hardware. Elastomeric leveling pads, and galvanized steel diaphragms and connectors will not be paid for separately but shall be included in the work. Concrete and reinforcing steel not shown on the plans but required by the Contractor's alternative will not be paid for separately but shall be included in the work. All required testing will not be paid separately but shall be included in the work.

Concrete quantities will not be reduced for the volume occupied by the ducts, prestressing steel, anchorages, and blockouts for tensioning, and will not include web flares, projections, warts, etc., required to accommodate the prestressing system used.

All costs associated with the preparation and implementation of the Erection Plan will not be paid for separately but shall be included in the work.

Concrete, reinforcing steel, and prestressing steel for permanent steel bridge deck forms will not be measured and paid for separately, but shall be included in the work.

SECTION 619
WATER LINES

DESCRIPTION

619.01 This work consists of the construction of water lines per these specifications, the latest revision of the American Water Works Association (AWWA) Standards and in conformity with the lines and grades shown on the plans or established.

This work also includes furnishing pipe and installing it by jacking it into place at the location and in conformity with the lines and grades shown on the plans.

MATERIALS

619.02 Materials shall meet the requirements specified in the following subsections:

Cast Iron Pipe	716.01
Welded Steel Pipe	716.02
Galvanized Pipe	716.03
Copper Pipe	716.04
Plastic Pipe	716.05
Valves and Valve Boxes	716.07

Specific type of material, when required, will be shown on the plans or as designated.

The maximum working water pressure will be shown on the plans.

Welded steel pipe, when used as a casing and not as a carrier pipe, will not require full depth welds or welds from both sides, and will not require coatings. Sections of the casing shall be welded firmly together on the inside to prevent separation. Certification of the welder/operator will not be required.

CONSTRUCTION REQUIREMENTS

619.03 Trench shall be excavated to a width sufficient to allow for proper jointing of the water line and thorough compaction of the backfill material per Section 206.

Where ground water occurs, the bottom of the trench shall be kept free of water during pipe laying and until backfilled.

Backfilling shall consist of suitable materials uniformly distributed in layers of not more than 8 inches.

Each layer shall be thoroughly compacted as required. All joints, connections, valves and fittings shall be watertight.

(a) Jacked Pipe. The term “jacking” as used shall mean jacking, boring,' or other approved construction methods. Method of installing pipe other than jacking may be used only with written approval from the Engineer. Trenching, jetting, or any other method that may cause damage to the embankment or highway area, or be hazardous to the traveling public, will not be permitted. When jacking is specified, the pipe must be jacked without disrupting highway traffic.

The sides of the jacking pit shall be supported in such a manner as to prevent any movement or slippage of the earth during the jacking operations.

A jacking frame shall be constructed of guide timbers or rails to the exact line and grade of the casing and shall be capable of maintaining the desired alignment and gradient throughout the jacking operation.

Depending upon the soil conditions, the excavation operation inside the pipe shall proceed approximately 1 foot ahead of the lead pipe. The excavation around the pipe shall be cut accurately to line and grade and as reasonably close to the outside diameter of the pipe as possible.

Each section of pipe in its final position shall be straight and true in alignment and grade. Deviation in alignment and grade from beginning to end of the jacked pipe shall not exceed plus or minus 0.3 foot per 100 feet of length.

(b) Reserved

METHOD OF MEASUREMENT

619.04 Water lines of the various types and sizes will be measured by the linear foot in place and shall include all fittings. Valves, including valve boxes, will be measured by the actual number of the specified type and size used in the completed water lines and accepted.

The quantity of jacked pipe will be measured by the linear foot complete in place and accepted.

BASIS OF PAYMENT

619.05 The accepted quantities of water line will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
_____ Inch Cast Iron Pipe	Linear Foot
_____ Inch Welded Steel Pipe	Linear Foot
_____ Inch Galvanized Pipe	Linear Foot
_____ Inch Copper Pipe	Linear Foot
_____ Inch Plastic Pipe	Linear Foot
_____ Inch (Type) Valve and Valve Box	Each
_____ Inch Welded Steel Pipe (Jacked)	Linear Foot

Structure excavation and structure backfill for lines 12 inch and less will not be measured and paid for separately but shall be included in the work. Structure excavation and structure backfill for lines larger than 12 inch will be measured and paid for per Section 206.

All work incidental to installing jacked pipe will not be measured and paid for separately but shall be included in the work.

SECTION 620
FIELD FACILITIES

DESCRIPTION

620.01 The Contractor shall furnish field offices, sanitary facilities and field laboratories when called for on the plans or as directed. These units are to be maintained by the Contractor and shall be removed when the project is completed unless released earlier by the Engineer.

MATERIALS

620.02 Field Offices. Field offices, either Class 1 or Class 2 as designated on the plans, shall substantially conform to the details shown on the plans and to the requirements of this section.

The field office shall be equipped with a facsimile machine, copy machine, and telephone service that conform to the following:

(1) Facsimile Machine. The facsimile machine shall print on plain paper and shall be capable of sending 8 1/2 x 11-inch and 8 1/2 x 14-inch documents. The Contractor shall install and maintain the fax machine in the Engineer's field office. Should the fax require repair and be out of service for more than 24 hours, a replacement machine shall be supplied within 24 hours. The Contractor shall supply all necessary supplies, except paper, and a roll-around stand. Paper will be provided by the Department.

(2) Copy Machine. The Contractor shall provide a self-feeding plain paper photocopier, capable of making at least eight copies per minute. Copier shall also be capable of reproducing copies at standard sizes up to and including 11 x 17 inches. The copier shall be capable of reducing 11 x 17 plan sheets to 8 1/2 x 14 legal size and to 8 1/2 x 11 letter size. The Contractor shall supply all necessary supplies, except paper, and a roll-around stand. Paper will be provided by the Department. The Contractor shall maintain all furnished equipment in good working condition and shall provide replacement equipment due to breakage, damage, or theft within five workdays.

(3) Telephone Service. The Contractor shall provide telephone service as required by standard plans. This service shall include a long-distance carrier. The Department will be responsible for actual long distance toll charges.

620.03 Field Laboratories. Field laboratories, either Class 1 or Class 2 as designated on the plans, shall substantially conform to the details shown on the plans and to the requirements of this section.

Each laboratory shall be qualified per CP 10.

620.04 Commercial Plant Laboratory. The plant laboratory at the site of the commercial hot mix plant shall consist of weatherproof, insulated, mobile house-type trailer or other approved structure having equipment meeting the following minimum requirements.

Each laboratory shall be qualified per CP 10.

(1) Outside Dimensions: 28 feet long x 12 feet wide if a separate facility is provided, or inside area of 175 square feet with a minimum width of 7 feet when not a separate facility.

(2) Drinking Water Supply: Dispensed from an acceptable water-cooling device.

(3) Testing Water Supply: 100 gallons, insulated and pressurized by pump, minimum 30 psi delivery pressure.

(4) Shelving: 24 linear feet

(5) Sink: One, with faucet

(6) Fire Extinguisher: One, non-toxic, dry chemical, meeting Underwriters Laboratories, Inc. (UL) approval for 10-pound class ABC with 20 BC rating

(7) Work Bench: 19 feet x 30 inches x 36 inches high

(8) Lighting: Adequate fluorescent lighting directly over all work bench and desk areas

(9) Range: One, 30-inch free standing, oven with reinforced racks, and four surface burners

(10) Forced Air Convection Oven: Rated at least 1,500 watts.

(11) Sieve Shaker: One, motor-driven, standard portable, capable of handling a set of 8 inch or 12-inch US standard sieves, mounted 24 inches above floor in a soundproof, insulated enclosure having hinged openings.

(12) Heating: Furnace, 200 BTU per square foot, minimum, forced air type

(13) Telephone: Minimum flat rate service from nearest exchange

(14) Air Conditioner: Adequate for laboratory size

(15) Furniture: Desk with at least one drawer. One desk chair with rollers. One stool with height compatible with work bench

(16) Electronic Balance: Balance complying with AASHTO M 231 capable of weighing at least 35 pounds to an accuracy of 0.2 gram.

(17) Recording Thermometer: Electrical or mechanical thermometer for curing tanks

(18) Microwave Oven: One, 1.5 cubic foot, with at least five power levels, and revolving floor or rotating power source

620.05 Sanitary Facilities. Sanitary facilities shall consist of a portable chemical toilet fabricated from steel, fiberglass or wood, meeting the following minimum requirements:

Each facility shall be well ventilated, conform to State law, have a vented chemical tank, and a separate urinal.

CONSTRUCTION REQUIREMENTS

620.06 The Contractor shall furnish a suitable site for field facilities. The site may be located within the right of way with approval of the Engineer. If located within the right of way, the Contractor shall be responsible for restoring the area.

Facilities shall be on the project, leveled and ready for use before the start of any operations. Facilities shall be for the exclusive use of Department personnel.

Sanitary facilities shall be placed at least 50 feet from the nearest State Water, in locations accessible for servicing, and not in low-lying areas subject to ponding. They shall be anchored to prevent movement or overturning.

The Contractor shall provide replacement equipment due to breakdown, damage, or theft within five workdays.

620.07 Maintenance, Service and Utilities. The Contractor shall furnish the following:

Table 620-1

MAINTENANCE, SERVICE AND UTILITIES

FURNISHED BY CONTRACTOR

Fuel	Adequate supply for heating and testing operations.
Electricity	A 3,000 watt, 115-125-volt AC facility for each field office and field laboratory. Independent generators shall be provided where commercial power is not available.
Telephone	Minimum flat rate services from nearest exchange for each field office and field laboratory, as directed.
Sanitary	Sanitary facilities shall be serviced and maintained in a sanitary condition.
Trash	The Contractor shall provide and maintain suitable containers and shall haul away as necessary.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

620.08 The various facilities complete with utilities, will be measured and paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Field Office (Class_____)	Each
Sanitary Facility	Each
Field Laboratory (Class_____)	Each

Payment will be full compensation for Field Laboratory (Class1) or (Class 2), including all appurtenant items specified in the Contract.

Restoration of the field facility areas will not be paid for separately but shall be included in the cost of the item.

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SECTION 622

REST AREAS AND BUILDINGS

DESCRIPTION

622.01 This work consists of the construction of various facilities in rest areas and other areas per these specifications and in conformity to the lines, grades, dimensions and details shown on the plans or established.

When information shown on the plans are of general arrangements only, the Engineer will establish exact locations, measurements, levels, etc., at the site to adapt the work to suit actual conditions.

MATERIALS

622.02 All materials used in the construction shall conform to the requirements of Section 717 and to the details shown on the plans or established.

622.03 Shop Drawings and Descriptive Brochures. At the Pre-construction Conference, the Contractor shall submit to the Department five copies of shop drawings or descriptive brochures for all materials and equipment to be incorporated in the work for review by the Engineer.

All work where shop drawings or descriptive brochures are required must be performed per such drawings, and work on the item shall not be started until review of said drawings.

All shop drawings or descriptive brochures must be complete in every respect, numbered consecutively, have the name of the project printed thereon, and each transmittal must be accompanied by a letter directing the Engineer's attention to any changes from the plans.

After shop drawings and descriptive brochures have been reviewed, any portion of the work covered by the shop drawings that modify the plans shall be rejected as soon as such modification is discovered unless said modification has been specifically pointed out to the Engineer review.

The review of such shop drawings and descriptive brochures will be general in character and shall not relieve the Contractor from responsibility for their accuracy or for proper fitting and construction of the work, or from the necessity of furnishing any materials and workmanship required by the Contract, which may not be indicated on shop drawings when reviewed.

622.04 Construction Material. Structure excavation and structure backfill shall conform to the requirements of Section 206. Treated timber shall conform to the requirements of Section 508. Concrete shall be Class "B" and conform to the requirements of Section 601. Reinforcing steel and fabric shall conform to the requirements of Section 602.

CONSTRUCTION REQUIREMENTS

622.05 Services of Factory Representative. It is important that the Department be protected as far as possible against the discontinuance of the make of equipment to be purchased, and that repair parts and the services of expert factory representatives be available if desired. Under these conditions the Contractor shall not furnish equipment made by firms in the hands of receivers.

622.06 Maintenance Manuals. The Contractor shall furnish to the Engineer five copies of instructions for the operation, lubrication and maintenance for all major items of equipment. The Contractor shall assemble all literature into five coordinated manuals with additional information describing the combined operation of field-assembled units, including as-constructed wiring diagrams. Manuals shall also contain the names, addresses of the manufacturer, and the local representative who stocks or furnishes repair parts for all items of equipment. All five manuals shall be turned over to the Engineer for review and distribution to the Department. Manuals shall include but not be limited to the above information for the following equipment: Furnace, water heater, well pump, exhaust fan, incinerators, timer, septic tank, emergency battery charger, and area luminaires.

622.07 Temporary Heat. All heating and electrical service required during construction for the satisfactory prosecution of the work shall be furnished by the Contractor. Heating units must be of approved types, and equipment and surroundings shall be kept in a clean and safe condition. Open fires will not be permitted.

622.08 Temporary Utilities.

(a) Water for Construction Purposes. The Contractor may use water pumped by the permanent well pump and equipment, if approved by the Engineer. The Contractor shall provide potable water for construction purposes at his expense. If temporary pumps are approved, all sanitary precautions necessary to prevent contamination of the well shall be taken.

(b) Electrical. The Contractor shall furnish at his expense, all electrical power required for construction.

622.09 Barricades. When required, the Contractor shall barricade the entrance ramp to the rest area during construction with standard barricades. The barricades will not be paid for separately but shall be included in the work.

622.10 Masonry Work.

(a) Installation of Masonry. Concrete masonry units shall be placed in face shell mortar bedding with complete coverage of face shells. Extruded mortar shall be struck. After the mortar has stiffened somewhat, all joints shall be tooled with a rounded tool having a diameter slightly larger than the thickness of the joint. Mortar joints shall average 3/8 inch in thickness. Blocks shall be placed per local standard masonry practice. Reinforcement and wall ties shall be installed as indicated on the plans.

Standard shapes of concrete masonry units such as radius, corner, jamb blocks, control joint blocks, bond course units and square end blocks, shall be furnished as required by the Contract.

Structural glazed tile in toilets shall be placed with white mortar. Mortar joints shall not exceed 1/4 inch in thickness. All joints shall be tooled.

The Contractor shall furnish cap courses, base courses, covings, bull-nosed corners and any special units necessary to complete a first-class job. Special shapes of tile required are shown on the plans.

When cutting of tile is necessary, it shall be done with a special saw as recommended by the manufacturer. Chipped, warped or defective tiles will be rejected.

All face brick shall be placed with joints about 3/8 inch thick. Joints shall be concave tooled joints.

Brick will be rejected if the edges and corners of finished faces have chippage exceeding the following maximum sizes: Edges 5/16 inch (measured in from edge) and corners, 1/2 inch (measured in from edge), or for any other structural or color defect.

Each brick shall be placed in a full bed of mortar and shall be shoved in place. The Engineer may remove brick already placed to assure all joints are full. If joints are not completely filled, the Engineer can order brick removed until assured that the joints of all remaining brick are completely filled.

All face surfaces of the face brickwork shall be kept clean. After joints are struck, the surface shall be carefully cleaned.

The faces and angles of all walls shall be carefully plumbed, and all work carried up true and even, laying all walls to lines.

(b) Precautions and Protection. All work and materials shall be protected from the weather. Stored masonry units shall be stockpiled on planks to prevent contact with the ground.

(c) Masonry Work in Cold Weather. Masonry shall not be placed when the surrounding air temperature is 40 °F or less, except when the masonry work is housed in a temporary manner, suitable to the Engineer, and the inside air temperature is kept within 40 °F to 80 °F for a period of 24 hours after the masonry is placed. Mortar for masonry work during cold weather shall have a minimum temperature of 50 °F and a maximum temperature of 100 °F at the time it is applied to the masonry. This temperature shall be provided by heating the mixing water or the aggregate or both if necessary. Masonry materials shall also be heated, if necessary, to provide at least a minimum temperature of 40 °F at the time they are placed.

(d) Cleaning. After completion, all masonry units shall be thoroughly cleaned according to the masonry manufacturer's recommendations. The Contractor shall protect adjacent work from damage during the cleaning operations.

Cleaning shall start at the top and be continued down until such work is completed. All pointing will be inspected and the Contractor shall completely point up all voids.

622.11 Metal Specialties. Metal stalls or compartments for toilet rooms and mirrors shall be of the type and style specified and shall be installed as shown on the plans.

622.12 Sanitary Napkin Disposal. Sanitary napkin dispenser and disposal for Women's Rest Rooms shall be installed as shown on the plans and per the manufacturer's recommendations.

622.13 Comfort Station and Sanitary Station Signs. Comfort Station and Sanitary Station Signs shall be installed in the size and location shown on the plans.

622.14 Doors, Frames and Windows. Doors, frames, windows and door hardware shall be installed as shown on plans.

All doorframes shall have floor anchors installed to set flush with the finished floors. Two rubber door silencers shall be installed for strike jambs of each door. At least three masonry "T" anchors shall be installed at each jamb that is adjacent to masonry work.

622.15 Ceramic Tile.

(a) General. The work required under this heading shall include all labor, material, equipment and services necessary for the furnishing and setting of all tile, as shown on the plans and as specified. The floor slab shall be clean and free of oily or waxy films.

(b) Installation of Ceramic Floor Tile.

1. Mortar Setting Bed. A mortar setting bed shall be applied over the floor slab to give a true and even setting bed. This mortar shall be composed of one part portland cement, six parts sand.

2. Setting Floor Tile. Floor tile shall be set by troweling a skim coat of neat portland cement mortar on the setting bed and immediately floating the tile into place. Joint width shall not exceed 1/16 inch.

3. Grouting. All joints in ceramic floor tile shall be grouted full of a grout mixture and application as recommended by the tile manufacturer immediately after a suitable area of tile has been set. A 1/8-inch bronze edging strip shall be provided under the metal thresholds where the ceramic floor tile terminates at the door.

4. Defective Tiles. All tiles chipped, broken, stained or otherwise imperfect, shall be considered defective, and shall not be set; any such defective tiles set shall be removed and replaced with approved tiles at the Contractor's expense.

5. Cleaning. Upon completion of the work, all tile shall be thoroughly cleaned and left free from stains, scum, discoloration, and in an acceptable condition.

622.16 Roofing, Flashing and Roof Insulation. The work required under this heading shall include all labor, material, equipment and services necessary for the proper furnishing and installing of all roofing, flashing and insulation materials as shown on the plans.

(a) Flashing at Flues, Breather Vents, Vents, Roof Drains and Emergency Light Conduit. Flashings at sewer vent and roof drain shall be at least 2 feet square lead flanges soldered to lead sleeves of sufficient diameter to fit the pipe involved, placed over the last layer of felt and sealed in place with two plies of felt, hot mopped in place. The specified roofing shall be applied over this. At the vent, the lead sleeve shall be folded over the top of the 4-inch soil pipe. At the roof drain, the lead sleeve or flange shall be securely clamped in place to make a watertight joint. Other means of flashing may be used if approved. Flashing at emergency light and breather vents shall be as detailed on the plans or directed.

All flashing shall be installed before roofing operations begin.

(b) Roofing Construction (Shingle Roofing). Shingles as shown on the plans shall be applied over two layers of 15-pound asphalt felt in straight courses. Shingles shall be doubled at all eaves, and butts of first-course shingles shall project 1 1/2 inch beyond the first sheathing board. Spacing between adjacent shingles (joints) shall be 1/4 inch. Joints in any one course shall be separated at least 1 1/2 inches from joints in adjacent courses and joints in alternate courses shall not be in direct alignment. Exposure of shingles shall be 4 1/2 inches for 16-inch shingle, 5 inches for 18-inch shingle and 7 inches for 24-inch shingle.

(c) Roofing Construction (Membrane Roofing). Membrane roofing shall be installed as follows:

Starting at one side of the roof install one layer of 30-pound Per 100 square feet base sheet side lapped 2 inches and end lapped 4 inches. Nail and tin cap the base sheet to the deck with large-headed roofing nails through 1 1/2-inch diameter tin disks, 18 inches on centers. Over the base sheet in the same direction, install three layers of 15 pound per 100 square feet asphalt felt, solid mopped to the base sheet with 25 pounds per 100 square feet of specification asphalt. Felt sheets shall be lapped 24 inch over preceding sheet and solid-mopped full of 25 pounds per 100 square feet of specification asphalt. All starter courses shall be enveloped in order to prevent drippage if low-melting-point material is being used. After flashing has been installed at all vertical projections, the entire surface shall be given a 60 pound per 100 square feet pour coat of specification asphalt into which, while asphalt is hot, the Contractor shall embed 400 pounds per 100 square feet of clean gravel. Damp gravel is permissible. In cold weather, instead of applying roof three-ply solid, the 15 pounds per 100 square feet asphalt felts may be installed on a two and one application provided the entire roof is mopped at the end of each day's work. Where roofs pond water, the asphalt felt shall be coated at the end of the day's work.

The bitumen used shall not be heated above 425 °F. In order to get 25-pound Per 100 square feet between plies, a 40-ounce cotton mop when full and out of the mop bucket should not cover more area than a 3-foot-wide swath 9 feet long.

(d) Caulking. This work shall include all labor, materials, equipment and tools necessary for the proper gun or knife applied caulking wherever indicated and in all following locations:

1. Exterior joints between all metal and masonry.
2. Joints between roof and aluminum flashing.
3. Interior joints between hollow metal frames and wall tile.

Mixing of the caulking shall be in strict accordance with the manufacturer's instructions. Working times listed by the manufacturer shall not be exceeded.

Sealant application shall be as directed by the manufacturer, taking particular care to prepare the joints as directed. Metal surfaces to be sealed shall be bright metal clean before sealing. Window and door frames shall be cleaned before sealing. It is imperative that paint shall not remain on the surfaces to be sealed. Any joint showing sealant applied over paint will be cause for rejection of that complete joint.

622.17 Carpentry. The work under this heading shall include all labor, materials, equipment and services necessary for the proper completion of all rough and finish carpentry.

(a) Ceiling Panel Installation. Ceiling panels shall be fastened to gypsum board back up by use of adhesive and per the manufacturer's instructions. Each joint shall be concealed with colored aluminum moldings. Adhesive shall be applied over the entire back surface of each panel.

(b) Preservation Treatment. All wood blocking under gravel stops and wood nailers shall be treated timber.

622.18 Interior Insulation. This work shall include all labor, materials, equipment and Services necessary for and reasonably incidental to the proper completion of all insulating work.

Insulation for cavity walls shall be installed in the cavity after all excess mortar is cleaned from the face of the interior wall. Ties and insulation shall be pressed firmly together so that ties hold the insulation in place and ensure that the adjacent boards are butted tightly together. Cut ends shall be squared so that all joints will be tight. Asphalt emulsion shall be used, if necessary, to hold insulation against inner wall.

Insulation to be applied to underside of roof shall be secured by using suitable fasteners common to the industry and recommended by the insulation manufacturer.

622.19 Glass and Glazing.

This work shall include the furnishing of all labor, materials, equipment and services necessary for and reasonably incidental to the proper completion of all glass and glazing work.

(a)Installation. All glass shall be set in the best possible manner with polished side out and in such a way that there will be an equal bearing the entire width of each pane.

All putty shall be left smooth and free from marks and other defects and shall be painted. Putty shall be an approved type suitable for glazing.

(b)Cleaning and Replacing. Glass broken or damaged before completion of the building operations shall be replaced with glass of like kind and quality without cost to the Department. Upon completion of all construction work and approval of glazing, labels shall be removed and glass shall be cleaned.

622.20 Trash Receptacles. This work shall include furnishing of all labor, materials, equipment and services necessary for the proper installation of trash receptacles.

Receptacles with anchor shall be installed at locations shown on the plans.

622.21 Painting and Special Coating Application. This work shall include the furnishing of all labor, materials, equipment, and services necessary for the proper completion of painting and finishing of all unfinished metal throughout the interior and exterior of the building and the information center. It also includes the application of special coatings on concrete tables, benches and underside and edges of roof.

Colors and finishes shall be as specified on the plans. Sample panels to show proposed finish and color shall be prepared by the Contractor and approved by the Engineer before the painting work or special coating work is begun.

(a) Paint Application. Paint shall not be applied to wet surfaces. Exterior surfaces shall not be painted during rain or snow, or when temperature is below 40 °F, or when conditions are not conducive to acceptable painting.

All joints in plywood shall be sealed before paint is applied. Paint shall be spread evenly and smoothly without runs and sags.

All metal surfaces shall be thoroughly cleaned of rust and shall be thoroughly washed with non-flammable solvent to remove any dirt or grease before applying paint.

Before painting or application of special coatings, all hardware, accessories, plates, lighting fixtures and similar items shall be removed, and protection of such items shall be provided. Only skilled mechanics shall be used for removing and connecting the above items.

(b) Paint and Special Coating Schedule.

1. Interior Metal. This metal is defined as, but not limited to, all hollow metal frames, doors and grills. Ductwork, electrical devices and conduit, stainless-steel items and plumbing fixtures and devices shall not be painted.
   A. One field coat primer (omit this coat on previously primed surfaces).
   B. Two coats enamel, flat finish, color to match interior walls.
2. Exterior Non-Galvanized Metal. This metal is defined as, but not limited to, all exterior metal including structural steel, but not including finish hardware, vent stacks, and metal soffits.
   A. One field coat primer (omit this coat on previously primed surfaces).
   B. Two coats house paint, flat finish, color to match stain used on Redwood.
3. Concrete Benches, Tables, Table Supports and Table Slabs. Two coats of sealant. Application shall be per the manufacturer's directions.
4. Exterior Wood.
   A. Facing and fascia on buildings and information center shall be stained as scheduled on the plans.
   B. Plywood soffit on buildings and information center shall have one coat white prime and two coats semi-gloss white enamel.
   C. Information display board posts shall be stained the same as facing and fascia and the bulletin board shall have one coat white prime and two coats white paint, flat finish.

622.22 Plumbing and Drainage. This work shall include the furnishing, installation, and testing of a system of plumbing and drainage as described, and as shown on the plans, including such minor details not specifically mentioned or shown as may be necessary to complete the system for successful operation.

Also included in this work is the construction of the sewer line, which shall connect the building to the septic tank or treatment facility.

Fixtures specified shall be of one make or type throughout the work.

All work, materials and manner of placing materials shall be in strict accordance with the latest requirements of the Colorado Technical Plumbing Code.

(a) Data and Measurements. Data contained in these specifications and shown on the plans are of general arrangement only. The Engineer shall determine exact locations, measurements, levels, etc., at the site and adapt the work to suit actual conditions.

(b) Well Pump. The well pump shall be as shown on plans.

The wells shall be equipped with a well seal and a liquid level control relay to stop the pump if the well water falls below a safe level. All related fittings, piping and electrical work for proper operation of the well is also included in this item.

(c) *Drinking Fountains.* Drinking fountains shall be the style and type called for on the plans.

(d) *Plumbing Installation.* All fixtures and plumbing items shall be installed according to the manufacturer's recommendations complete with all necessary accessories and trimmings. All water supply connections shall have stops or shut off valves to facilitate maintenance. All waste connections shall be trapped and vented. Stops or shut off valves shall be so installed as to be readily accessible in the utility room.

Immediately after fixtures are set, they shall be covered, and this cover shall not be removed until the building is prepared for occupancy. In addition, the Contractor shall furnish and install such guards and boxing as may be required to protect fixtures against damage by any other craft.

The Contractor shall clean all fixtures with acceptable cleaning compounds before final acceptance of the work.

The Contractor shall install all piping in such a manner as to allow complete drainage of the piping system. This requirement shall be met by pitching all lines to low points where valves or capped nipples in threaded tees shall be installed to drain the lines. These fittings, which are required specifically for draining the various lines, are not shown on the plans, since the number required and their locations must be determined by the field conditions encountered and are considered subsidiary to the work.

(e) *Testing Interior Drainage and Vent System.* The waste drainage and vent system inside the building shall be tested and proved gastight and watertight before covering or concealment. The rough work shall be tested as a whole unit (as a whole stack or riser).

Testing shall be conducted using water as the media under a hydrostatic head of at least 10 feet above the highest joint being tested. If the vertical distance is less than 50 feet to the top of the highest vent above the roof, the entire stack-riser shall be tested by filling to the top of the highest vent. Other media may be used in lieu of water with the approval of the Engineer.

Testing shall be continuous for at least 30 minutes' duration for each separate test. At end of this time interval, there shall not be more than 3/4-inch drop in water level or not more than 1/16-inch drop in mercury level.

If lines prove tight, concealment of rough work may begin. If repairs are required, retesting shall be conducted as often as necessary until lines are proved gastight and watertight to the satisfaction of the Engineer.

(f) *Testing Water Piping System.* Upon completion of a section or of the entire hot- and cold-water piping systems, they shall be tested hydrostatically to a pressure of at least 50 percent in excess of the maximum pressure that the pipe will ordinarily be subjected, but not less than 100 pounds per square inch. Test shall not be less than two hours. Any leaks or defective pipe disclosed by the tests shall be repaired or replaced and the tests repeated until all piping shows tight.

All water for tests shall be furnished and disposed of by the Contractor at his expense. Piping shall not be insulated or concealed until it has been tested to the satisfaction of the Engineer.

(g) Fixtures Substitution. When substitutions for specified fixtures are requested, the Contractor shall submit a portfolio containing illustrations and complete descriptions of the fixtures, for approval. Portfolios shall state the make and weight of the proposed fixtures, shall clearly indicate the materials that the fixtures are made, and shall otherwise clearly describe in detail the fixtures proposed to be substituted.

(h) Air Chambers. Each water supply riser and fixture connection at all flush valves and lavatories shall terminate with an air chamber of diameter equal to the supply pipe and so located as to prevent water hammer. Approved shock absorbers may be substituted for air chambers.

(i) Trenching and Backfilling for Water Lines and Sewer Lines. The Contractor shall perform all excavation and backfilling per Section 206.

Trenches shall be only of sufficient width to provide a free working space and shall not be more than the outside diameter of the pipe bells plus 24 inches. They shall be dewatered and kept free from standing water until all joints are complete, the pipe tested, and the trench backfilled.

Backfilling around tanks may be puddled-in provided the tanks are first filled with water.

(j) Sterilization of Water Systems. The completed piping system including the piping from the well shall be sterilized per the regulations of the Department of Public Health and Environment, State of Colorado and as follows: Before final acceptance, the entire water system shall be thoroughly flushed. After flushing, chlorine or chlorine compound shall be introduced into the system. The dosage shall be sufficient to give an initial residual chlorine mass fraction of 50 ppm. Samples shall be collected from various taps and fixtures throughout the systems during the introduction of the chlorine to assure uniform distribution. After a 24-hour contact period, all traces of the heavily chlorinated water shall be flushed from the systems. After flushing is complete, the Contractor shall, at his expense, provide evidence of the effectiveness of the disinfection by filing with the Engineer, laboratory reports of bacteriological tests on samples taken from the system. The number and the locations for taking samples shall be as specified by the Engineer. Should other than satisfactory results be obtained, the above disinfection process shall be repeated until satisfactory tests are obtained.

(k) Cleaning and Adjusting. At the completion of the work and before final acceptance, all parts of the work installed under this specification, all equipment, fixtures, pipe, valves and fittings shall be thoroughly cleaned of grease, oils, metal cuttings, and sludge, etc., that may have accumulated by operation of installing these systems, of testing, or from other causes. Stoppage or discoloration or other damage to parts of the building, its finish or furnishing, due to failure of the Contractor performing the plumbing work to properly clean the piping system, shall be repaired at the Contractor's expense.

622.23 Heating and Ventilation. This work shall include furnishing and installing all units and duct work as set forth in the heating plans and installing the minor items necessary to complete the work outlined below:

The Contractor shall provide and install all other items, such as wiring, thermostats, sheet metal work, that are necessary for a complete and operating system.

(a) General. All exhaust fans, duct work, outlets, inlets, thermostats, grills, vents, electrical wiring, plumbing, etc., shall be new. Standard products of manufacturers regularly engaged in production of such equipment shall be as shown in the manufacturer's latest catalogue.

(b) Wall Heater, Exhaust Fans, Furnace and Duct Installation. Wall heaters, exhaust fans, furnace and duct work shall be installed as shown on the mechanical plans. The fresh air duct shall be provided with a close-fitting damper to vary the volume, or completely shut off the fresh air supply. For normal operation, the fresh air damper should be adjusted to take in a maximum of 20 percent fresh air with the remainder being re-circulated to the furnace through the return air grills. The fresh air duct shall run between the joists from the intake grill to above the furnace, and down to the return air plenum. A return air grill shall be installed in the return air plenum to pass re-circulated air to blower. Both fresh air duct and return air grill shall be installed so that all return air will pass through the furnace filters. The fresh air damper shall be manually operated.

622.24 Electrical Work. All electrical wiring shall be installed in conformance with the National Electrical Code and the National Electrical Safety Code.

These specifications and plans cover the furnishing and installation of a system of electric wiring and conduit and box work as described and as indicated on the plans of the building, and outdoor lighting including such minor details not specifically mentioned or shown as may be necessary to complete the system for a complete turnkey operation.

The Contractor shall, at the Pre-construction Conference or within 14 days after award of Contract, submit to the Engineer a complete list of electrical materials being proposed to furnish and install on the Contract. Five copies of the list, including manufacturer and catalogue numbers of devices and fixtures, shall be furnished per subsection 622.03.

(a) Symbols. Items of equipment and materials are indicated on the plans per the legend of symbols shown on the plans.

(b) Conduit. All conduit shall be installed in conformance with the National Electrical Code.

All conduit runs shown are diagrammatic. Exact locations will be determined in the field.

(c) Position of Outlets. Outlets shall be located as shown on the plans or as directed.

(d) Conductors. Conductors shall conform to the requirements of the National Electrical Code.

(e) Thermostat. A separate thermostat shall control the furnace so that the furnace or wall heaters will operate when the temperature drops to the thermostat setting.

A separate thermostat shall operate the emergency light to signal when the temperature in the building drops to a set temperature. Line voltage wiring complete in conduit shall be provided for this system.

(f) Emergency Light. Low voltage wiring, not in conduit, shall be provided for this circuit to the emergency battery charger.

(g) Emergency Battery Charger. The emergency light shall signal power failure and temperature drop in the building to below a pre-set temperature. Power failure or temperature drop below set temperature shall cause emergency battery charger to energize the emergency light. Upon correction of the emergency condition, the battery charger shall turn off emergency light and keep the batteries charged automatically by use of line current.

(h) Photoelectric Control. Photoelectric cells shall be located and mounted as indicated on the plans.

(i) Disconnect Switches. The Contractor shall furnish and install disconnect switches for means of disconnecting appliances at the location shown on the plans.

(j) Circuit Breakers. All electrical devices shall be protected by circuit breakers located in the main breaker panel. The circuit breakers shall be per the National Electrical Code.

(k) Grounding. All equipment and conduit shall be grounded per the National Electrical Code requirements.

Code color shall be adhered to for all ground conductors and ground continuity shall be positive throughout the entire project.

(l) Incoming Service. The Contractor shall furnish, install and connect the incoming service cable from the local utility company service pole to the building. This cable shall be as specified under conductors and shall be buried at the location shown on the plans. Details of the connections to the local utility company poles are not shown on the plans. The Contractor shall furnish and install all material and equipment required to make these connections in conformance with utility company recommendations. Materials required to make these connections shall be considered subsidiary to the electrical systems.

(m)Installation. Where sizes are not indicated or shown on the plans for junction boxes, a 4-inch square galvanized junction box with blank cover shall be used.

Mounting heights above finished floor shall be as indicated below, unless otherwise shown on the plans or indicated in these specifications. All mounting heights shall be verified by the Engineer.

Table 622-1

ELECTRICAL WORK

MOUNTING HEIGHTS ABOVE FINISHED FLOOR (A.F.F.)

Switches	48 inches
Convenience Outlets	48 inches
Panel to Center	54 inches
Lighting Fixtures	as shown on plans

622.25 Sanitary Sewer, Septic Tank, Leaching Field, Sewage Lift Station and Sanitary Station. This work shall include all labor, materials, equipment and services necessary for the installation of a sewer system including septic tank, leaching field and associated sewage piping as required for the comfort station, trailer pad and the trailer sanitary station, as shown on the plans and described as follows:

A sewage system shall be constructed, as shown on the plans or as directed, for each building.

A precast septic tank shall be installed for each trailer sanitary station and trailer pad as shown on the plans. Each septic tank shall be vented.

The septic tank required for the building may be cast-in-place or may be a precast unit or precast units in tandem of the capacity indicated on the plans.

Treatment plant and polishing tank or pond required for the building shall be installed as shown on the plans, or as directed.

Sewage lift station and wet well shall be installed as shown on the plans.

Leaching fields shall be constructed to the dimensions and details shown on the plans or as directed.

622.26 Flagpole. Flagpole shall be of the type and style specified and shall be installed as shown on the plans.

METHOD OF MEASUREMENT

622.27 The quantities to be measured under this Section will be the actual number of pay units, completed and accepted, of the various pay items that appear in the bid schedule, comprising the rest area, or other buildings.

All electrical work for the building including service from meter pole, shall be included as part of the building that appears in the bid schedule.

All electrical work for the information center shall be included as part of the information center.

Area lighting will be measured and paid for as luminaires, light standards and wiring per Section 613.

Shade shelter item shall include table and benches.

Septic tank, sewage lift station or treatment plants shall include the related mechanical devices and fittings and the sewer piping from the tank to the leaching field, wet well polishing tank or polishing pond. Sewage lift station shall also include the wet well.

Sewer piping, fittings, devices, etc., from the septic tank, treatment plant or sewer to the building, sanitary stations or trailer pad shall be included as part of the building, sanitary station or trailer pad.

Sewer piping from sewage lift station to point of discharge will be measured and paid for per in Section 619.

Polishing tanks or polishing ponds shall include all related pipe and fittings.

Sewage leaching field shall include all work associated with the leaching field. Measurement will be based on the square yards of leaching field trench excavated or linear foot of perforated pipe installed.

Trailer sanitary station shall include the water tower, hatch with cover, vacuum breaker, related fittings, sewer pipe to septic tank, and water line connections.

Storage tank shall include all controls, fittings and piping from the tank to the building and, unless otherwise stipulated, shall also include all controls, fittings and piping from the water source to the storage tank.

Trailer pad shall include water service valve and riser, electrical pedestal, intercom connection, and sewer pipe to septic tank.

Drinking fountains except for those on or in the buildings will be measured by the units installed and accepted.

Well pump shall include the pitless adapter, seal, electric controls, and all related pipe and fittings.

Flagpole shall include halyard, swivels, cleats, ornamental ball and base.

BASIS OF PAYMENT

622.28 The accepted quantities will be paid for at the contract unit price for the various items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	**Pay Unit**
Information Sign Board	Each
Information Center	Each
Shade Shelter	Each
Table	Each
Trash Receptacles	Each
Drinking Fountain	Each
Trailer Pad	Each
Well Pump	Each
Sewage Lift Station	Each
Comfort Station	Each
Trailer Sanitary Station	Each
Leaching Field	Square Yard
Leaching Field	Linear Foot
Septic Tank (____Gal.)	Each
Storage Tank (____Gal.)	Each
Sewage Treatment Plant (____Gal.)	Each
Polishing Tank (____Gal.)	Each
Scale Pit and Approach Slabs	Each
Flagpole	Each
_____Building	Each

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SECTION 623
IRRIGATION SYSTEM

DESCRIPTION

623.01 This work consists of furnishing and constructing an irrigation system per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

623.02 General. All materials and equipment incorporated into the irrigation system shall be new and of recognized standard quality. In the case of computer software or hard coded instructions, the latest available version from the manufacturer is required. All materials shall be of a standard line from a name brand manufacturer or must be approved**.**

623.03 Backflow Preventer. Pressure vacuum breakers shall be the pressure type with a bronze body and a machined valve seat. Reduced pressure-type backflow preventers shall include two check valves, a relief valve, two gate or ball valves, and test cocks for field testing. Vacuum breakers and reduced pressure-type backflow preventers shall meet the requirements in the Colorado Department of Health, Cross Connection Manual, and shall have a non-shock cold-water rating of at least 150 psi.

623.04 Automatic Controllers. The automatic controller shall be an electro-mechanical or microprocessor based/microelectronic solid-state type capable of operating in an automatic or manual mode. The controller shall have a minimum of six stations. Each station shall be programmed to operate for 1 to 99 minutes, or 0.1 to 9.9 hours. The controller shall have two independent programs with three automatic starts per day for each program. Each station on the controller shall be assigned to either or both programs. The controller shall be capable of watering any day or sequence of days on a six or seven-day cycle.

The controller shall operate on a minimum of 117 volts AC power input. Controller electrical output shall be capable of 26.5 volts AC at 1.5 amps. The controller shall have a reset circuit breaker (1.5 amps holding and 2.5 amps break) to protect it from power overload.

Primary surge protection for 117-volt lines and valve (24 volt) output surge protection shall be installed to protect the controller.

The automatic controller shall be grounded using two 5/8-inch x 8-foot copper clad grounding rods driven into the soil. A #10 AWG bare copper wire shall be used to connect the ground rods to the automatic controllers' protective grounding circuit. The resistance of the ground shall not exceed 5 ohms.

The controller enclosure (including satellite controllers) shall be of a vandal and weather-resistant nature, manufactured entirely of metal or steel mill-treated with zinc for rust resistance. The main housing shall have louvers in the upper and lower body to allow for crossflow ventilation.

623.05 Remote Control. Remote control shall consist of an FM, AM, UHF, or VHF radio transmitter/receiver pair with a minimum range of one mile in congested areas and shall include battery charger and replacement battery. The receiver shall plug into a receptacle installed in the enclosure or panel of the automatic controller. Remote control shall be capable of turning on/off any station in any order. Remote control shall comply with all applicable FCC rules and regulations.

623.06 Control Wiring 24 Volt. Connection between automatic controller and automatic control valves, flow sensors and moisture sensors shall be made with direct burial copper, 600 volt, UF, UL approved wire. Minimum wire size shall be #14 AWG. One wire shall be provided for each valve. Wires shall be color coded according to the basic plant materials irrigated by the lateral. Wire colors shall be:

Table 623-1
CONTROL WIRING COLOR KEY

Wire Color	Plant Materials
Black	Master (power)
Purple	Spares
Green	Turf
Brown	Tree
Yellow	Perennials
Red	Shrubs
White	"common" or ground wire

623.07 Sprinkler Heads. The sprinkler head shall be of the pop-up spray and pop-up rotor internal drive type. All sprinkler heads shall be capable of accepting a check valve where head elevation varies more than 5 feet within a control zone.

(a) Pop-up Sprays. The pop-up sprayhead body, stem, and screen shall be constructed of heavy-duty plastic. Spray heads shall have the following components:

(1) A soft pressure-activated wiper seal for cleaning debris from the pop-up stem as it retracts into the case to prevent stem and nozzle from sticking in the up position.

(2) A matched precipitation rate brass or plastic nozzle with an adjusting screw capable of regulating the radius and flow.

(3) A screen to protect it from clogging and a strong stainless-steel retract spring for positive pop-down.

(4) A threaded cap that will allow easy removal of the screen and all other internal components from the top without removing the body from the ground.

Minimum pop-up height for turf heads shall be 4 inches. Spray head pop-up height for turf in roadway medians shall be at least 6 inches, and shrub, flower, and ground cover spray heads shall be at least 12 inches.

(b) Rotor Heads. The pop-up rotor heads shall be an internal drive type, with heavy-duty plastic housings and non-corrosive internal components. The rotor head shall have a soft pressure-activated wiper seal for cleaning debris from the pop-up stem as it retracts into the case, to prevent the stem and nozzle from sticking in the up position. The rotor head shall have a screen to protect it from clogging and a strong stainless-steel retracting spring for positive pop-down. Minimum pop-up height for rotor heads shall be 3 inches. The rotor head shall have a fully adjustable arc or full circle capability and an adjustable break-up pin capable of reducing the radius up to 25 percent.

623.08 Flow Sensor. The flow sensor shall be an in-line type and shall transmit an electronic pulse through conductors to a compatible automatic controller with interface unit for subsequent transmission to a compatible central computer.

623.09 Drip Emitters. The drip emitter shall be of the pressure compensating type with flow rates of 0.5, 1, or 2 gallons per hour plus or minus a 10 percent deviation at 10 to 40 psi. The emitter shall be constructed of durable plastic with a barbed inlet, and the outlet shall be capable of a watertight connection compatible with the polyethylene capillary tubing. Emitters shall be of the self-flushing type and capable of clog-free operation with a 150-mesh strainer. Emitters shall be multi-outlet (six outlets) and shall be installed on the polyethylene drip lateral line. The ends of the capillary tubing shall be installed on 6-inch plastic stakes with debris caps on the end of the tubing.

623.10 Plastic Pipe and Fittings. All pipe shall be identified with the following indelible markings: manufacturer's name, nominal pipe size, schedule or class of pipe, pressure rating in pounds per square inch, date of extrusion, and NSF seal of approval.

(a) Mainline Pipe. Mainline pipe shall be Class 200 PVC manufactured from virgin polyvinyl chloride (PVC) compound per ASTM D1784 and D2241, cell classification 12454-B, Type I, Grade I. Pipe sizes 3 inches and smaller shall be of the solvent weld type, and sizes larger than 3 inches shall have rubber gasketed fittings. Fittings shall be standard weight schedule 40 injection molded PVC conforming to ASTM D1784 and D2466, cell classification 12454-B. Threaded nipples shall be schedule 80 PVC with molded threads conforming to ASTM D2464. Threaded fittings shall be kept to a minimum. Cement and cleaner for solvent weld pipe and fittings shall conform to ASTM D2564.

(b) Lateral Line Pipe. Lateral line pipe shall be 80-pound NSF polyethylene manufactured from virgin material in conformance with ASTM D2239 and designated as PE 2306 or PE 3408. Pipe size shall not exceed 2 inches. Fittings shall be *injected*-molded schedule 40 PVC conforming to ASTM D2609, cell classification 12454-B. Pipe shall be clamped onto the fitting using 100 percent stainless-steel screw clamps (two clamps on 1 1/2 inch and 2-inch pipe).

(c) Drip Lateral Line Pipe and Capillary Tubing. Drip lateral line pipe and capillary tubing shall be made of linear low density, UV resistant polyethylene with a pressure rating of 50 psi.

(d) Swing Joint Assembly. Swing joints shall be premanufactured with full rotation capacity. Swing joints shall consist of threaded fittings combined with elastomer seals and solvent weld or threaded fittings when attaching to supply line, valve, or sprinkler head. The swing joint assembly shall consist of injection-molded schedule 40 PVC conforming to ASTM D1784 and D2466, cell classification 12454-B, Type I, Grade I.

(e) Detectable Underground Marking Tape. The Contractor shall provide utility line marking tape for installation above all mainline pipe, which does not have control wire placed in the same trench.

623.11 Valves.

(a) Automatic Control Valves. The automatic control valve shall be a normally closed 24-volt AC, 60-cycle solenoid actuated globe or angle pattern, diaphragm type valve. The valve body and bonnet shall be heavy duty glass filled nylon or brass and internal components (not including diaphragm and seat disc) shall be non-corrosive brass, bronze, stainless-steel, or a combination thereof. Control valve diaphragms shall be of a one-piece molded reinforced fabric. Control valve shall have a non-shock cold-water rating of at least 150 psi.

Control valves shall function manually (without electrical power) by means of an internal bleeder device on the bonnet assembly. Control valves 1 inch or greater shall have manual flow control capacity. Control valves shall be constructed so that the bonnet assembly and all operating parts can be removed without disturbing the valve body. Valve closure time (measured in actual seat disc movement time) shall be at least 0.5 second.

(b) *Quick-Coupler Valves.* The quick-coupler valve shall have a two-piece brass body, a non-shock cold water rating of at least 150 psi, and 1-inch female pipe threads at the base. The quick-coupler valve shall be designed to permit operation with a special connecting device (lug type coupler) designed for this purpose. The quick-coupler shall be provided with a rubber-like vinyl hinged locking cover. Quick-coupler keys and hose swivels shall be compatible with the quick-coupler valves furnished. Hose swivels shall be of all brass construction designed to rotate freely.

(c) *Drip Pressure Reducing Valve*. The drip pressure-reducing valve shall be of the non-adjustable, pre-set type, consisting of a two-piece body molded from sturdy long lasting plastic. The internal spring shall be of stainless-steel. Each pressure-reducing valve shall have a minimum flow range of 0.5 gallons per minute with a regulated outlet pressure of 20 to 35 psi, with an inlet pressure range of 35 to 100 psi.

(d) *Mainline Pressure Reducing Valve.* Valves 2 inches or smaller shall be of the diaphragm spring cage construction type with a bronze body, renewable stainless-steel seat, and stainless-steel integral strainer. Valves larger than 2 inches shall be the balanced piston type with a ductile-iron or cast-iron body.

(e) *Manual Drain Valves.* The manual drain valve shall be constructed of heavy-duty cast bronze and machined brass. The drain valve shall be a rising stem globe valve with a non-shock cold water rating of at least 150 psi. The drain valve shall have a reverse flow capability, removable bonnet, and cast bronze cross handle.

(f) *Mainline Isolation Valves.* Mainline isolation valves 3/4 inch through 3 inches shall be full port ball valves with a bronze body and have a stainless-steel ball and Teflon seat. The valves shall have a blow-out proof stem and be rated at a minimum of 400 psi, WOG. Mainline isolation valves larger than 3 inches in size shall be resilient seated gate valves with a cast iron body and have a 2-inch square nut operator. All isolation valves shall be rated at 200-psi differential pressure.

623.12 Valve Box. The valve box, cover and necessary extensions shall be as shown on the plans, and shall be manufactured or molded, virgin plastic materials conforming to ASTM D638 and D648. Box extensions shall be used as necessary to completely expose the remote-control valve and shall seat in place under the valve box. Valve box lids shall be imprinted "Irrigation Control Valve."

623.13 Strainer. Strainer shall be a wye pattern type with a polypropylene body. The strainer shall contain a 150 mesh stainless-steel screen accessed by removing a threaded non-corrosive cap. Strainer shall be flushed via a ball valve located on the strainer.

CONSTRUCTION REQUIREMENTS

623.14 General. Irrigation systems shall be installed in conformity with applicable local codes. Information on the plans shows general locations only. The Contractor shall establish exact locations of all irrigation equipment to fit field conditions, and locations will be approved by the Engineer before start of construction. Contractor shall maintain and protect the approved staking layout. Before purchase of any irrigation equipment, the Contractor shall submit a list of suppliers and specification sheets for all irrigation components. This submittal must be approved by the Engineer before any equipment purchase is made. At the submittal stage, all changes in equipment shall be brought to the attention of the Engineer.

623.15 Site Review. At least 14 days before the start of irrigation work on the project, a Pre-construction Conference shall be held. During irrigation installation, monthly meetings shall be held. Those in attendance shall be a representative of the Contractor's staff, the Landscape and Irrigation Subcontractors, the Engineer, and a CDOT Landscape Architect. A written description of work methods, and time schedules and milestone dates shall be presented. The Contractor shall notify the Engineer before mainline pressure testing, coverage tests, and final review. The Contractor shall provide two radio transceivers with necessary personnel or remote-control devices to operate automatic controllers during coverage tests and final review.

623.16 Excavation and Backfill. Excavation and backfill shall conform to the requirements of Section 206 and subsection 703.08(b) (Class 2 Structure Backfill), except that compaction of backfill outside of the roadway prism may be done by water flooding, with the approval of the Engineer. The Contractor shall maintain bottoms of trenches flat to permit all piping to be supported on an even grade. Where lines occur under paved areas, dimensions shall be considered to be below the subgrade. All mainline pipe shall be bedded in sand to allow a minimum of 2 inches of sand on all sides. Rock larger than 1 inch shall not be placed in the backfill material.

Where it is necessary to excavate adjacent to existing trees or shrubs, the Contractor shall use all possible care to avoid injury to the plant root system.

623.17 Pipe Installation. Minimum cover for irrigation pipe shall be as follows:

Table 623-2

MINIMUM COVER FOR IRRIGATION PIPE

Mainline Pipes	24 inches below finished grade
Lateral Pipes	18 inches below finished grade
Pipe under roadways	30 inches below subgrade finished grade
Irrigation sleeving	30 inches below finished grade

All pipes under roadways shall be encased in a steel pipe sleeve that shall be jacked or placed in a hole bored under present roadways, or in a steel or plastic pipe sleeve placed by trenching on new construction. At least 4 inches of clearance shall be provided between lines and at least 4 feet of clearance between lines of other trades. Parallel pipes shall not be installed directly over any other line. Manual drain valves shall be installed at all low points in the mainline. Minimum grade of pipe to drains shall be 3 inches per 100 feet. Plastic threaded fittings shall be assembled using teflon tape applied to male pipe threads only. Threaded fittings shall be kept to a minimum. The Contractor shall tape all open ends of the pipe during installation to prevent entry of any foreign matter into the system.

623.18 Kick Blocks. Concrete kick blocks shall be installed when the following conditions occur on 4 inch or greater mainline pressure pipe:

(1) 22 degree or greater change in pipe direction.

(2) Change in pipe size.

(3) Dead ends in pipes.

623.19 Wiring. All 24-volt wire to automatic control valves and flow sensor wiring shall be installed at a minimum depth of 28 inches below finished grade. Power source wire shall conform to subsection 715.07.

Wiring shall be installed at the side of and under mainline whenever possible. When more than one wire is placed in a trench, the Contractor shall tape wires together with electrical tape at intervals of 15 feet or less. A 24-inch coiled expansion loop shall be provided every 300 feet along wire run, before controller enclosure, at each connection, and at directional changes. Each automatic controller shall have its own separate ground wire, colored green. Wiring between automatic controller and automatic control valves or sensors shall be continuous. At locations where splicing is approved by the Engineer, moisture proof splices shall be made in a valve box. Two extra wires shall be installed along the entire mainline pipe from each automatic controller to the last automatic control valve. Wire splices shall be compatible in effectiveness to wire coating. All wire under roadways shall be encased in a separate steel or plastic conduit.

Wires not following the mainline shall be installed using open trench excavation. Wiring shall not be installed using a vibratory plow.

Tubing shall be installed to an even grade in an open trench. Flush valve assemblies shall be installed at all ends of the drip lateral lines.

Before backfilling, all capillary drip lines shall be staked with an approved staple, 6 feet on center.

623.20 Drip Systems. Drip lateral lines and capillary tubing shall be installed after 5 gallon and larger plant materials are in place and finished grade is established. The Contractor shall tape all open ends of pipe during installation to prevent entry of debris into the system. All pipe shall be cut with a knife or blade type pipe cutter to prevent entry of pipe debris into the system; a saw shall not be used.

Tubing shall be installed to an even grade in an open trench. Flush valve assemblies shall be installed at all ends of the drip lateral lines.

Before backfilling, all drip lines shall be staked with an approved staple, 6 feet on centers.

623.21 Valve Boxes. All valve boxes shall be installed flush with the finished grade. A "branding iron" type of tool shall be used to imprint the automatic control valve number (letters and numbers 2 inches high) on the valve box lid. Valve numbering system shall be as indicated on the plans. Geotextile filter fabric shall be placed under valve box and extend a minimum of 4 inches beyond bottom rim of valve box. Valves shall be grouped so that three or four valves are located together. Valves shall not be installed in low areas subject to standing water.

623.22 System Flushing. After all irrigation pipelines and valves are in place and connected, and before installation of irrigation sprinklers, rotary heads, etc., the Contractor shall thoroughly flush all lines with water at system operating pressure.

623.23 Pressure and Coverage Tests, and Adjustments. After installation of valves, pipe, and fittings, mainlines shall be inspected for leaks after a minimum 90 psi static pressure (or point-of-connection static pressure if higher) has been maintained for four hours in a hydro static test. Mainline pipes shall not be buried until completion of the test. If the system does not pass the test, the Contractor shall detect and correct problems until the system reaches the acceptable test standard. This test shall be passed before payment for the pipe.

Gasketed pipe shall be tested using a volumetric (make up water) test and leak rates supplied by the pipe manufacturer and commonly accepted in the industry.

The Contractor shall perform coverage tests in the presence of the Engineer, after the irrigation system is completed and before any planting, seeding or sodding to assure that all irrigated areas are watered completely and uniformly. The Contractor shall make all necessary adjustments to provide required coverage as directed.

Drip lateral and emitter coverage tests shall be performed after planting and before backfilling of lateral lines and emitters.

623.24 Inspections. Inspections by the Engineer or the Engineer's representative can be made at any point during construction. Milestone progress dates shall be established at the Pre-construction Conference and 72-hour notice shall be given by the Contractor when a milestone event is approaching.

623.25 Irrigation As-Constructed Plans. The Contractor shall dimension from two permanent reference points, building corners, sidewalk corners, road intersections or any permanent structures, the location of the following items:

(1) Routing of irrigation mainline.

(2) All drip and sprinkler automatic control valves.

(3) Quick coupling valves, isolation gate valves, and manual drain valves.

(4) Other related equipment as directed.

The Contractor shall provide an accurately detailed irrigation as-constructed layout of the irrigation system at the same scale as the design plans and on 24-inch by 36-inch waterproof medium within 90 days after installation is complete and before notice of substantial landscape completion as defined in subsection 214.04. An in-progress as-constructed plan shall be kept on the construction site at all times and available for impromptu review by the Engineer or the Engineer's representative.

Provision of the final as-constructed plan is a condition for final acceptance and release of retainage.

All changes in the irrigation system layout, including lateral layout, shall also be indicated on irrigation as-constructed plans.

The Contractor shall provide finalized as-constructed plans to the Engineer at the time of Final Landscape Acceptance.

623.26 Maintenance Manuals and Training. Before Final Landscape Acceptance, the Contractor shall provide two individually bound maintenance manuals to the Department for the irrigation system, and shall train the owner's maintenance personnel in the proper operation of all irrigation equipment, including winterization procedures. Each manual shall contain the following:

1. Index sheet, stating irrigation contractor's name, address, telephone number and name of person to contact.
2. Duration of equipment or component warranty and warranty form.
3. Equipment list providing the following for each item:
   A. Manufacturer's name
   B. Make and model number.
   C. Name and address of manufacturer's local authorized distributor
   D. Spare parts list in detail
   E. Detailed operating and maintenance instructions for major equipment
4. Descriptions of all installed materials and systems in sufficient detail to permit maintenance personnel to understand, operate, and maintain the equipment.

   A printout of the as-constructed plans shall be provided, showing the area covered by that automatic controller. The area of coverage of each automatic control valve shall be identified using a distinctly different pastel color, drawn over the entire area of coverage.

   Following approval of charts by the Engineer, they shall be hermetically sealed between two layers of plastic sheet, each 20 mils thick.

623.27 Warranty. The Contractor shall warranty the irrigation system for the duration of the Landscape Establishment period specified in subsection 214.04. To ensure proper operation of the system, the Contractor shall perform, as required, warranty activities including, but not limited to the following:

1. Inspection of the system and correction of system leaks, improperly operating valves, clogged emitters, malfunctioning automatic controllers and other components.
2. Maintaining optimum sprinkler coverage.
3. Adjusting sprinkler head elevations relative to finish grade.

In an emergency the Contractor shall correct all deficiencies within 24 hours of notification by the Engineer. The Contractor shall perform irrigation system inspections at least once per week and after each mowing. The Contractor shall make corrections as necessary to ensure proper operation. The Contractor shall document each inspection in writing and submit it to the Engineer.

623.28 Final Landscape Acceptance. Before final landscape acceptance is granted, the Contractor shall perform an overall operation and pressure test and confirm the irrigation system is correctly functioning. This includes two weeks on "Flow" to be verified by the CDOT "Central Computer". The Contractor shall inspect every sprinkler and as necessary, raise or lower those sprinklers that are no longer at the proper elevation relative to the finish grade as shown in the plans. The Contractor shall complete Spring start-up (pressurization) and repair all damage to the irrigation system.

623.29 Cleanup. Upon completion of the work, the Contractor shall restore ground surfaces to required elevations and remove excess materials, debris, and equipment from the site.

623.30 Keys and Repair Components. Three keys shall be furnished for manual operation of valves. When valves require different kinds of keys, three keys of each kind shall be furnished. Keys shall be of adequate length and made of non-corrosive metal.

The following sprinkler components shall be furnished for system repair:

1. Two Automatic Control Valves.
2. Two Manual Drain Valves.
3. Four of Each Type of Sprinkler Specified.
4. Two Valve Boxes.
5. Two Mainline Isolation Valves.
6. Two Quick Coupler Valves.

623.31 Irrigation Scheduling. The Contractor shall submit recommendations for the project's initial irrigation operating schedule for optimum plant establishment to the Engineer.

METHOD OF MEASUREMENT

623.32 Automatic controller will be measured by the number of units of each size installed and accepted, including concrete pad, conduit, bolts, enclosure, ground wire, and all other items necessary to complete the work as shown on the plans.

Drip emitters will be measured by the number of multi-outlet emitters and shall include the capillary tubing, tubing stakes, enclosure box, and debris caps. Each drip emitter shall have six outlets.

Emitter valve assemblies will be measured by the number of units of each size installed.

Vacuum breakers, backflow preventers, strainers, and all other valves of the various types and sizes, including fittings, valve boxes, copper risers, and sleeves, will be measured by the number of units installed and accepted.

Quick couplers, sprinkler of the various types and sizes including risers, check valves, swing joints and fittings, will be measured by the number of units installed and accepted.

Plastic and copper pipe will be measured by the linear foot installed and will include the cost of the detectable underground marking tape.

Power source wire and 24-volt wire will be measured by the linear foot installed.

Water meter pay item includes all appurtenant fittings, valves, meter pit, and related equipment.

BASIS OF PAYMENT

623.33 The accepted quantities will be paid for at the contract unit price for the various items below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Shrubbery Spray and Flood Irrigator	Each
_____Inch Pop-up Spray Sprinkler	Each
_____Inch Pop-up Rotary Sprinkler	Each
_____Inch Above Ground Rotary Sprinkler	Each
_____Inch Above Ground Spray	Each
Hose Swivel	Each
Hose Bib	Each
_____Inch Copper Pipe	Linear Foot
_____Inch Plastic Pipe	Linear Foot
_____Inch Hose	Linear Foot
_____Inch Valve Box	Each
_____Inch Backflow Preventer	Each
_____Inch Pressure Reducing Valve	Each
_____Inch Drain Valve	Each
_____Inch Automatic Drain Valve	Each
_____Inch Manual Control Valve	Each
_____Inch Automatic Control Valve	Each
Power Source Wire	Linear Foot
_____Inch Quick-Coupler Valve	Each
_____Inch Gate Valve	Each
_____Inch Mainline Isolation Valve	Each
_____Inch Water Meter	Each
_____Inch Station Automatic Controller	Each
_____Inch Station Satellite Controller	Each
Control Wire, 24 Volt	Linear Foot
_____Inch Strainer	Each
Automatic Controller Transmitter/Receiver	Unit Each
Drip Emitter	Each
Emitter Valve Assembly	Each
_____Inch Flush Unit	Each

Water lines will be paid for as provided in Section 619.

Kick blocks, unions, fittings, filter fabric, valve access sleeves, valve boxes, piping and wire inside boxes, keys, and aggregate for valves will not be paid for separately but shall be included in the work.

Structure excavation and backfill including compaction and water will not be paid for separately but shall be included in the work.

Concrete pad, bolts, enclosure, ground wire, and all other items necessary to complete the work shall be included in the price of the automatic controller.

Capillary tubing, tubing stakes, enclosure box and debris caps shall be included in the price of the drip emitter.

System flushing and adjustment, pressure and coverage tests, maintenance manuals, and training will not be paid for separately but shall be included in the price of the work.

The backflow preventer enclosure and pad will not be paid for separately but shall be included in the work.

Detectable Underground Marking Tape will not be paid for separately but shall be included in the work.

Advisor Message Receiver pagers and handheld two-way radios will not be paid for separately but shall be included in the work.

Warranty work will not be measured and paid for separately but shall be included in the work.

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SECTION 624
DRAINAGE PIPE

DESCRIPTION

624.01 This work consists of furnishing and installing pipe defined by class for culverts (cross drains), side drains, and storm sewers per these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

624.02 Materials shall meet the requirements in the Contract and in the following subsections.

Abbreviation	Description	Subsection
CSP	Corrugated Steel Pipe	707.02
Bit. Co. CSP	Bituminous Coated Corrugated Steel Pipe	707.03
A.F. Bo. CSP	Aramid Fiber Bonded Corrugated Steel Pipe	707.03
CAP	Corrugated Aluminum Pipe	707.06
PCSP- both sides	Precoated Corrugated Steel Pipe coated on both sides with 10 mils minimum	707.10
ALT2 CSP	Aluminized Corrugated Steel Pipe Type 2	707.11
RCP	Reinforced Concrete Pipe, Type I, II, or V Cement	706.02
NRCP	Nonreinforced Concrete Pipe, Type I, II, or V Cement	706.01
Plastic	Polyvinyl Chloride (PVC), Polyethylene (PE), Steel Reinforced Polyethylene (SRPE), and Polypropylene (PP)	712.13

All precoated sheet steel for PCSP culvert shall be tested by the manufacturer for coating holidays and certified free of defects. The coating will be visually inspected by the Engineer during construction and all damage found shall be repaired in an approved manner.

Connecting bands shall receive the same corrosion protection as the pipe where they are used. Coatings conforming to the requirements of Sections 706 and 707 will be permitted as applicable. Connecting bands and pipe extensions shall be of similar metal, or of non-metallic material, to avoid galvanic corrosion.

End sections for concrete or metal pipe shall be the same material as the pipe and meet the requirements for the same class as that specified for the pipe per Table 624-1.

Plastic end sections shall not be used. When plastic pipe is to be installed with end sections, steel or concrete end sections meeting the same class as that specified for the pipe per Table 624-1 shall be used.

The Contractor may furnish any pipe material allowed in Table 624-1 for the class of pipe specified in the Contract except for storm drains. The Contractor may furnish RCP, PVC, SRPE or PP allowed in Table 624-1 for the class of pipe specified in the Contract for storm drains. The Contractor shall state at the Pre-construction Conference the pipe materials intended to be furnished.

Table 624-1
MATERIALS ALLOWED FOR CLASS OF PIPE

Material Allowed**	Class of Pipe*										
	0	1	2	3	4	5	6 ▸	7	8	9	10 ▸
CSP	Y	N	N	N	N	N	N	N	N	N	N
ALT2 CSP	Y	Y	Y	Y	Y	N	N	N	N	N	N
Bit. Co. CSP	Y	Y^	N	N	N	N	N	N	N	N	N
A.F. Bo. CSP	Y	Y	Y	Y	Y	Y	Y	N	N	N	N
CAP	Y	Y#	Y#	Y#	Y#	Y	N	N	N	N	N
PCSP - both sides	Y	Y	Y	Y	Y	Y	Y	N	N	N	N
PVC ▾	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
PE ▾	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
PP ▾	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SRPE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
RCP (SP0) ◂ , ▲	Y	Y	N	N	N	N	N	Y	N	N	N
RCP (SP1) ◂ , ▲	Y	Y	Y	N	N	N	N	Y	Y	N	N
RCP (SP2) ◂ , ▲	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N
RCP (SP3) ◂ , ▲	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 624-1 Notes: *As determined by the Department per the CDOT *Pipe Selection Guide*. Determination is based on abrasion and corrosion resistance.

**Y=Yes; N=No.

^Coated Steel Structural Plate Pipe of equal or greater diameter, conforming to Section 510, may be substituted for Bit. Co. CSP at no additional cost to the project.

#Aluminum Alloy Structural Plate Pipe of equal or greater diameter, conforming to Section 510, may be substituted for CAP at no additional cost to the project.

◂ SP= Class of Sulfate Protection required per subsection 601.04 as revised for this project. RCP shall be manufactured using the cementitious material required to meet the SP class specified.

▸ For pipe classes 6 and 10, the RCP shall be coated per subsection 706.07 when the pH of either the soil or water is less than 5. The Contract will specify when RCP is to be coated.

▲ Concrete shall have a compressive strength of 4500 psi or greater.

▾ Per subsection 712.13.

Where class of pipe specified allows the use of metal pipe, its use will be limited per the resistivity requirements in Table 624-2. The Contract will state whether the resistivity requirements apply.

Table 624-2
RESISTIVITY REQUIREMENTS FOR METAL PIPES

Soil Side Resistivity, R (Ohm – cm)	Soil Side pH	MINIMUM REQUIRED GAUGE THICKNESS FOR METAL PIPE MATERIAL
≥1500	5.0-9.0	16 Gauge Aluminized Type 2
≥250	3.0-12.0	16 Gauge Polymer Coated

The minimum wall thickness for metal pipe shall be the gauge shown on Standard Plan M-603-1 unless otherwise specified in the Contract.

Joint systems for siphons, irrigation systems, and storm drains shall be watertight. Watertight joint systems for plastic pipe shall conform to subsection 705.02.

CONSTRUCTION REQUIREMENTS

624.03 Installation shall conform to the requirements of Section 603 or Section 510 as applicable.

Installation for Aluminized Corrugated Steel Pipe Type 2 shall conform to all requirements for Corrugated Steel Pipe (CSP) including the fill height tables and requirements in Standard Plan M-603-1.

Joining and installation of plastic pipe shall conform to ASTM D2321 and the manufacturer's recommendations.

METHOD OF MEASUREMENT

624.04 Drainage pipe will not be measured but will be the net length of pipe called for on the plans, except when field changes are ordered or when there are errors on the plans. In case of exceptions, the quantity to be measured shall be the actual net length of conduit measured along the bottom centerline of the installed pipe. The net length shall include end sections when required.

BASIS OF PAYMENT

624.05 The accepted quantities of drainage pipe will be paid for at the contract unit price per linear foot for the specified size and class.

Payment will be made under:

Pay Item	Pay Unit
_____Inch Drainage Pipe (Class__)	Linear Foot

Structure excavation and structure backfill will be measured and paid for per Section 206.

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SECTION 625
CONSTRUCTION SURVEYING

DESCRIPTION

625.01 This work consists of the construction surveying, calculating, and staking necessary for the construction of all elements of the project. The work shall be done under the supervision of a Professional Land Surveyor (PLS) or Professional Engineer (PE) who is experienced and competent in road and bridge construction surveying and licensed in the State of Colorado.

Locating, preserving, referencing, installing and restoring land monuments such as Primary Control monuments from which the right of way or any land boundary will be calculated, described or monumented, Public Land Survey System (PLSS) monuments, General Land Office (GLO) monuments, Bureau of Land Management (BLM) monuments, Mineral Survey (MS) monuments, Right-of-way (ROW) monuments, property boundary monuments, easement monuments, and other monuments that are required by law or regulation to be established by a PLS, and the determination of any land boundary, shall be done per Section 629, under the supervision of a Professional Land Surveyor (PLS) who is experienced and competent in Right of Way and boundary surveying and licensed in the State of Colorado.

The PLS shall be available to review work, resolve problems, and make decisions in a timely manner.

Unless specified otherwise in the Contract, all survey procedures shall be in conformance with the CDOT Survey Manual.

If the Revision of Section 102 Project Plans and Other Data states 3D modeling data is available, the Contractor may choose to perform 3D Engineered Construction Surveying (3DECS).

3DECS is the use of global positioning and or robotic instruments to guide construction equipment operations by comparing 3D model information in real time. For 3DECS, either the construction equipment is fed modeling information and makes automatic adjustments (machine control), or the equipment operator is fed the information and makes physical adjustments.

Adobe Sign software shall be used for electronic seals by the Contractor’s Engineer, a Professional Engineer, or a Professional Land Surveyor. Electronic signatures and seals shall comply with the requirements of the Architects, Professional Engineers, and Professional Land Surveyors Rules and Regulations, 4 CCR 730-1.

MATERIALS AND EQUIPMENT

625.02 The Contractor shall furnish all personnel, survey equipment, safety equipment, materials, and traffic control necessary to perform the required construction surveying and staking. All surveying equipment, including:

Total stations, LiDAR scanners, levels, rods, tapes, tripods, tribrachs, and Global Positioning System (GPS) receivers and equipment, shall be checked and calibrated per the CDOT Survey Manual, Chapter 6, Section 6.1.10, and documented in the survey records before the start of work and every six months thereafter.

Electronic Distance Measuring Instruments (EDMI) and total stations shall be checked and calibrated on a National Oceanic and Atmospheric Administration/ National Geodetic Survey

(NOAA / NGS) calibrated baseline per the CDOT Survey Manual, Chapter 2, Section 2.1 and 2.2, and documented in the survey records before the start of work and every six months thereafter.

GPS receivers and equipment shall be checked and calibrated on a NOAA / NGS calibrated baseline per the CDOT Survey Manual Chapter 3 and documented in the survey records before the start of work and every six months thereafter.

Levels shall be checked and calibrated per the CDOT Survey Manual, Chapters 5 and 6, and documented in the survey records before the start of any level circuit.

If any survey equipment is found to be functioning outside the manufacturer's specified tolerance, certification from an approved repair facility showing that the instruments have been repaired, properly adjusted, or both if necessary shall be included in the survey records and submitted to the Engineer before being used.

Traffic control shall be per Section 630.

CONSTRUCTION REQUIREMENTS

625.03 General. The Department will establish Primary horizontal and vertical control for the project. All available information defining the extent of that control is provided on the plans per the CDOT Survey Manual Chapter 6 or is available from the Engineer.

A Presurvey Conference – Construction Survey shall be held per the CDOT Survey Manual Chapter 6, before performing any surveying work under this section. The Engineer, Region Survey Coordinator (or designee), Contractor's Superintendent, Contractor's Surveyor (PLS) and Party Chief shall attend. A Presurvey Conference – Construction Survey Form shall be included per the CDOT Survey Manual Chapter 6. A surveying work schedule shall be submitted to the Engineer for review before the conference.

625.04 Contractor Surveying. The Contractor shall perform all construction surveying and staking necessary for construction of the project. Construction surveying and staking shall be based on the Primary Horizontal and Vertical Control established by the Department. Bid items that require stakes to be set by the Contractor's Surveyor are shown on the Surveyor Tabulation Sheet of the plans and shall be per the CDOT Survey Manual Chapter 6.

If the Contractor uses 3D Engineered Surveying the following shall apply:

1. All surveying shall be based on the Primary Horizontal and Vertical Control established by the Department.
2. The Contractor shall provide construction stakes for the control points of the project centerline or Engineer approved offset line (i.e., POT, POC, PCC, PC, PT, TS, ST, SC, CS per the Survey Manual) and angle points, all of which shall be established from primary control monuments and their assigned coordinates as shown on the plans.
3. Staking for the project centerline or offset, shall be established from the project centerline control points as shown on the plans in order to provide a method of machine control equipment checks, inspection, and field verification.
4. The maximum staking interval for the project centerline shall be 500 feet on tangents and 100 feet on curves or as specified on the survey tabulation sheet. All project centerline control points as shown on the plans shall be staked.

5. Within the first week of the Contractor utilizing 3DECS, the Contractor shall check their 3DECS system and verify on writing to CDOT that the accuracy of the system complies with the contract requirements.
6. The Contractor shall conduct an as-constructed survey of the following items: Installed or relocated utility lines as shown on the utility plans, including those installed or relocated by the Contractor or by others.

   A. Installed or relocated culverts, conduit, inlets, or other drainage features.

   B. Traffic signal heads, poles, pushbutton assemblies, and controller cabinets.

   C. ITS fiber vaults, splice points, interfaces, nodes and other assets.

   D. Lighting including pull boxes, meters and light standards.

   The as-constructed survey shall be completed per the *CDOT Survey Manual*, Chapter 6, Section 6.14.

At no cost to the Department, the Contractor shall revert to traditional surveying and disband using 3DECS should the Engineer determine the existence of contractor quality or accuracy issues related to 3DECS.

The Contractor shall check all Department established Primary horizontal and vertical control points per the CDOT Survey Manual Chapter 6~~,~~ and verify and document in the survey records their horizontal accuracy tolerance per the CDOT Survey Manual Chapter 5, and their vertical accuracy tolerance per the CDOT Survey Manual Chapter 6, for a CDOT Class A, Primary Survey before using them for construction surveying control.

625.05 Staking. Acceptable staking placement intervals for the various construction survey items are described in the CDOT Survey Manual Chapter 6. Staking placement intervals specified on the Survey Tabulation Sheet have precedence over those in the CDOT Survey Manual. Stationing shall be established in the field on centerline or an approved offset.

625.06 Accuracy and Tolerances. Horizontal and vertical accuracy tolerances for Secondary Control surveys and monuments, and for each construction item being staked shall be as specified in the Contract or in the CDOT Survey Manual Chapter 6. If a discrepancy should occur, the higher degree of accuracy or the more restrictive tolerance shall apply.

Horizontal accuracy tolerances for Primary Control surveys and monuments shall be as specified in the CDOT Survey Manual Chapter 5. Vertical accuracy tolerances for Primary Control surveys and monuments shall be as specified in the CDOT Survey Manual Chapters 5 and 6.

Horizontal accuracy tolerances for Secondary Control surveys and monuments shall be as specified in the CDOT Survey Manual Chapter 6. Vertical accuracy tolerances for Secondary control surveys, monuments, and Secondary benchmarks shall be as specified in the CDOT Survey Manual Chapter 6.

3D Engineered surveying accuracy and tolerances shall be the same as the staking accuracy and tolerances stated in the CDOT Survey Manual.

625.07 Responsibility and Inspection. Supervision and coordination of construction surveying and staking is the Contractor's responsibility. The Engineer may inspect the Contractor's surveying; however, such inspection will not relieve the Contractor of any responsibility for accuracy or completeness of work. The Contractor shall check the work to verify the accuracy

and include documentation of this check in the Survey Records. All Contractor surveying inaccuracies, errors, or omissions shall be corrected at the Contractor's expense. Engineer's inspection or the Contractor's corrections shall not entitle the Contractor to additional payment or contract time extension.

625.08 Reset Monuments and Stakes. Primary and Secondary Control monuments, benchmarks, and other significant stakes that are damaged, destroyed, or made inaccessible by the progress of construction shall be replaced, transferred or re-established at the Contractor's expense per the CDOT Survey Manual Chapter 6.
A supplemental or amended Project Control Diagram shall be submitted to the Engineer and the Region Survey Coordinator for any replaced, transferred or re-established Primary Control monuments per the CDOT Survey Manual Chapter 6.

Locating, preserving, referencing, installing and restoring land monuments such as Primary Control monuments that the right of way or any land boundary will be calculated, described or monumented, PLSS monuments, GLO monuments, BLM monuments, MS monuments, ROW monuments, property boundary monuments, easement monuments, and other monuments that are required by law or regulation to be established by a PLS, shall be done per Section 629, under the supervision of a PLS who is experienced and competent in Right of Way and boundary surveying and licensed in the State of Colorado.

625.09 Changes. All changes in lines and grades required by field conditions and all discrepancies in grades, alignment, location or dimensions detected by the Contractor shall be immediately submitted to the Engineer in writing. No changes in given data or plans will be allowed unless approved by the Engineer in writing. All changes shall be documented in the survey records.

625.10 Pay Quantities Measurements. The Engineer will perform all interim and final measurements deemed necessary by the Department to determine contract pay quantities. The Contractor shall establish and maintain Primary and Secondary Control points and stationing as required for these measurements.

625.11 Survey Records. Survey records shall be completed as the work is done. Field survey notes for construction surveying and checking by the Contractor shall be recorded in survey records in conformance with the format given in the CDOT Survey Manual Chapter 6, Section 6.1.16. Survey fieldbooks shall be indexed per the Survey Manual Chapter 2.

The Contractor shall make all survey records generated available to the Engineer for inspection or reproduction at all times. The Contractor shall submit all survey records to the Engineer before final project acceptance. All survey records are considered property of the Department. The responsible PLS or PE identified in subsection 625.01 shall electronically seal all survey records.

The electronic format shall contain the information and format as required in the Survey Manual Chapter 2 and Chapter 6, including stakeout data and the raw data from the actual placement of stakes. The records shall be electronically sealed by the PLS in responsible charge identified in subsection 625.01.

Initial staking for major structures (overhead signs, concrete box culverts, bridges, and all other structures assigned a structure number) shall be done per the CDOT Survey Manual Chapter 6, from two independent setups. An independent check shall be made by the Contractor and shown in the survey records for all bridge structures.

METHOD OF MEASUREMENT

625.12 Construction surveying will not be measured but will be paid for on a lump sum basis.

BASIS OF PAYMENT

625.13 Payment for construction surveying will be the contract lump sum bid and will be full compensation for all surveying work necessary to complete the project as shown on the plans, to include all resetting of stakes, marks, monuments Secondary and Primary Control points, and preparing supplemental or amended Project Control Diagrams.

Construction surveying required by plan force account or by additional work beyond the scope of the original Contract will be paid for at a negotiated rate not to exceed the rate established in Section 105. That rate shall also apply to reductions in construction surveying as impacted by reductions or deletions to the original contract work. Any survey work not performed to the contract requirements shall be subject to price reduction or rejection.

Partial payment for construction surveying, as determined by the Engineer, will be made as the work progresses. The Contractor shall submit a schedule of estimated contractor construction surveying time as required on the Survey Tabulation Sheet before the first partial payment is made. Copies of the Survey Records for all completed survey work shall be submitted to the Engineer before payment of the monthly estimate.

Before final payment is made, the Contractor's responsible P.L.S. shall complete and electronically seal all survey records and the Project Control Diagram (supplemental or amended). Submit the survey records and the supplement or amended Project Control Diagram to the Engineer and the Region Survey Coordinator for review.

Payment will be made under:

Pay Item	Pay Unit
Construction Surveying	Lump Sum

Traffic control for construction surveying will be measured and paid for per Section 630.

All costs associated with 3DECS surveying will not be measured and paid for separately but shall be included in the work.

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SECTION 626
MOBILIZATION

DESCRIPTION

626.01 This work consists of the mobilization of personnel, equipment and supplies at the project site in preparation for work on the project. This item shall also include the establishment of the Contractor's offices, buildings and other necessary facilities, and all other costs incurred or labor and operations that must be performed before beginning the other items under the Contract.

BASIS OF PAYMENT

626.02 Partial payments for mobilization will be made once each month as the work progresses. These partial payments will be made as follows:

(1) When 5 percent of the original contract amount is earned, 25 percent of the amount bid for mobilization, or 2 1/2 percent of the original contract amount, whichever is less, will be paid.

(2) When 10 percent of the original contract amount is earned, 50 percent of the amount bid for mobilization, or 5 percent of the original contract amount, whichever is less, will be paid.

(3) When 25 percent of the original contract amount is earned, 60 percent of the amount bid for mobilization, or 6 percent of the original contract amount, whichever is less, will be paid.

(4) When 50 percent of the original contract amount is earned, 100 percent of the amount bid for mobilization, or 10 percent of the original contract amount, whichever is less, will be paid.

(5) Upon completion of all work on the project, payment on any amount bid for mobilization in excess of 10 percent of the original contract amount will be paid.

(6) The total sum of all payments shall not exceed the original contract amount bid for the item, regardless of the fact that the Contractor may have, for any reason, shut down the work on the project or moved equipment away from the project and then back again.

For the purpose of this Section the term “original contract amount” as used above shall mean the amount bid for the construction items in the Contract not including the amount bid for mobilization. Payments for materials on hand, as described in subsection 109.07, will not be included as a percent of original contract amount earned until said materials on hand have been incorporated into the work and accepted and paid for as contract items.

These payments shall be independent of partial payments as defined in subsection 109.06. Payment will be full compensation for all work necessary to complete the item.

Payment will be made under:

Pay Item	Pay Unit
Mobilization	Lump Sum

Nothing shall be construed to limit or preclude partial payments for other items as provided for by the Contract.

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SECTION 627
PAVEMENT MARKING

DESCRIPTION

627.01 This work consists of furnishing and applying pavement marking, and furnishing, installing, and removing temporary pavement marking per these specifications, the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), the Colorado supplement thereto, and in conformity to the lines, dimensions, patterns, locations and details shown on the plans or established.

MATERIALS

627.02 Materials shall conform to the requirements of the following subsections:

Paint	708.05
Glass Beads	713.08
Modified Epoxy Pavement Marking Material	713.17
Thermoplastic Marking Material	713.12
Pavement Primer	708.07
Preformed Plastic Pavement Marking Material	713.13
Pavement Marking Tape	713.15
Pavement Marking Tape (Removable)	713.16
Raised Pavement Marker	713.18
Preformed Thermoplastic Pavement Marking Material	713.14
Methyl Methacrylate Pavement Marking Material	713.19

CONSTRUCTION REQUIREMENTS

627.03 General. All pavement markings shall be placed per the following requirements. When the term “full compliance” is used, it means the pavement markings shall meet the requirements of Standard Plan S-627-1.

(a) Pavement Marking Plan. When pavement-marking location details are not provided in the Contract, the Contractor shall submit a layout of existing conditions to the Engineer for approval or modification. This layout is to be used as the final pavement-marking plan.

(b) Roadways Closed to Traffic During Construction. Full-compliance final markings shall be in place before opening the roadway to traffic.

Pavement markings on detour routes shall be full-compliance markings.

(c) Roadways Constructed Under Traffic. Full compliance final pavement markings shall be placed within two weeks after final surfacing is completed. Full compliance pavement markings shall also be placed on any roadways opened to traffic when the project pavement work is discontinued for more than two weeks.

(d) Temporary Pavement Markings. Temporary pavement markings and control points for the installation of those pavement markings for roadways that are being constructed under traffic shall be installed as follows:

1. When one roadway of a normally physically divided highway is closed, and a crossover is constructed, full-compliance pavement markings shall be placed along the tapers and through the median crossovers to the two-way traffic section. Pavement markings through the two-way traffic section shall be as shown on the plans.

   All temporary paved roadways shall have full-compliance centerline, lane line, and edge line markings before they are open for traffic.

   Upon removal, markings applied to a final surface shall not leave a scar that conflict with permanent markings.

2. The following criteria apply to all construction on roadways open to traffic other than (d)1. above:

   Full-compliance centerline, lane line, and edge line temporary markings shall be in place at the end of each workday.

   No-passing zone restrictions shall be identified by full compliance no-passing zone markings. No-passing zone markings shall be in place daily.

   Temporary pavement stencils (SCHOOL, RR Xing, etc.) are not required unless specified in the plans.

   Temporary pavement markings shall be installed according to the manufacturer's recommendations in such a way that the markings adequately follow the desired alignment.

3. Control Points consisting of 4-inch by 1-foot marks at 40-foot intervals may be placed as guide markers for the installation of temporary or final pavement markings. Raised flexible pavement markers may be substituted for these marks. Control points shall not be used as a substitute for any required marking.

(e) Pavement Marking for Seal Coats (Section 409).

1. Raised flexible pavement markers, suitable for use on seal coats, shall be installed as follows:

   No-passing zones shall be marked with two markers placed side-by-side at 40-foot intervals throughout the zone.

   Passing zones shall be marked with one marker at 40-foot centers. Closer spacing shall be used on curves, as deemed appropriate.

   Raised flexible pavement markers, installed on 40-foot centers, may also be used to mark lane lines through multi-lane roadway sections. Auxiliary lanes and shoulder lines may be marked with flexible markers on 80-foot centers or as appropriate.

2. Full-compliance final pavement markings shall be placed within one week of completion of the seal coat project.

627.04 Pavement Marking with Low Temperature Acrylic Paint and High Build Acrylic Paint. Striping shall be applied on asphalt or portland cement concrete pavements when the air and pavement temperatures are as follows: for high-build waterborne paint, at least 45 °F and expected to remain 45 °F or above for at least 24 hours; for low temperature waterborne paint, at least 35 °F and expected to remain 35 °F or above for at least 24 hours. The pavement surface shall be dry and clean, and free of all latent materials, per the manufacturer's recommendations. Weather conditions shall be conducive to satisfactory results.

Glass beads shall be applied into the paint by means of a low pressure, gravity drop bead applicator.

The Contractor shall use equipment that meets the following requirements, as approved:

(1) Equipment shall permit traffic to pass safely within the limits of the roadway surface and shoulder while operating.

(2) Equipment shall be designed for placement of both solid and broken line stripes with a reasonably clean-edged stripe of the width and location as shown on the contract and no overspray on the road surface.

(3) Equipment shall have a glass bead dispenser directly behind and synchronized with the paint applicator. Each applicator shall have individual control and automatic skip control that will paint a strip with a gap as shown in the Contract.

(4) The equipment may be equipped with a heat exchanger to heat the paint to reduce drying time.

(5) The operation shall include a trailing vehicle equipped with a flashing arrow board.

The Contractor shall prevent traffic from crossing a wet stripe. Stripes that have been marred or picked up by traffic before they have dried shall be repaired at the Contractor's expense. Removal of paint from vehicles that crossed wet paint shall be at the Contractor's expense. The water-based paint and stripes shall fall within the following minimum and maximum ranges:

Table 627-1
MINIMUM AND MAXIMUM RANGES OF PAINT AND STRIPES

Description	Units	Pavement Marking Paint Low Temp	Pavement Marking Paint High Build	Pavement Marking Paint High Build (Temporary)
Alignment	Lateral Deviation	2.0 inch per 200 feet Max	2.0 inch per 200 feet Max	2.0 inch per 200 feet Max
Coverage Rate	Sq Ft per Gallon	89-94	67-70	100-105
Thickness	Mil	17-18	23-24	15-16
Width	Inches	Per Plans ± 0.25	Per Plans ± 0.25	Per Plans ± 0.25
Dry Time	Minutes	5-10	7-12	5-10
Beads	Application Rate, lbs./gal	7-8	9-10	7-8

(6) High Build (Temporary) shall only be used for temporary pavement marking applications.

Equipment shall have a bead dispenser directly behind, synchronized with the paint applicator and shall be capable of painting a clean-edged stripe of the designated width plus or minus 1/4 inch with no overspray on the road surface. For centerlines and lane lines, an automatic skip control shall be used. Machines having multiple applicators shall be used for centerlines with "no passing zones." In areas where machines are not practical, suitable hand-operated equipment shall be used as directed by the Engineer. Stripes shall be protected until dry.

627.05 Modified Epoxy Pavement Marking. The modified epoxy pavement-marking compound shall be applied with equipment that will precisely meter the two components in the ratio given in subsection 713.17(a). The equipment shall automatically shut off or warn the operator if one component is not being mixed. The equipment shall produce the required amount of heat at the mixing head and gun tip to provide and maintain the temperatures specified.

Before mixing, the individual components A and B shall each be heated to a temperature of 80 to 140 °F. After mixing, the application temperature for the combined material at the gun tip shall be 80 to 140 °F. The 140 °F upper limit is the maximum temperature under any circumstances.

Both pavement and air temperatures shall be at least 35 °F at the time of modified epoxy pavement marking application.

The surface areas of new portland cement concrete pavement and decks that are to receive markings shall be waterblasted before placement of the modified epoxy pavement marking. The amount of waterblasting shall be sufficient to remove all dirt, laitance, and curing compound residue.

The surface areas of new asphalt pavement, existing asphalt pavement, and existing concrete pavement that are to receive markings shall be cleaned with a high-pressure air blast to remove loose material before placement of the modified epoxy pavement marking. Should any pavement become dirty, from tracked mud etc. as determined by the Engineer, it shall be cleaned before the placement of the modified epoxy pavement marking.

When recommended by the modified epoxy manufacturer, a high-pressure water blast integrated into the gun carriage shall be used to clean the pavement surface before modified epoxy pavement marking application. The water blast shall be followed by a high-pressure air blast to remove all residual water, leaving only a damp surface.

Modified epoxy pavement marking shall be applied to the road surface according to the modified epoxy manufacturer's recommended methods at the application rate or coverage shown below. Glass beads shall be applied into the modified epoxy pavement marking by means of a low pressure, gravity drop bead applicator.

Modified epoxy pavement marking and beads shall be applied within the following limits:

Table 627-2

APPLICATION RATE OR COVERAGE
PER GALLON OF MODIFIED EPOXY PAVEMENT MARKING

Rate	Minimum	Maximum
18 mil Marking	85 sq. ft.	90 sq. ft.
Beads	23 lbs.	

627.06 Thermoplastic Pavement Marking.

(a) Equipment-General. The material shall be applied to the pavement by an extrusion method where one side of the shaping die is the pavement and the other three sides are contained by or are part of suitable equipment for heating, mixing, and controlling the flow of the material.

The equipment shall be constructed to provide continuous mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the shaping die shall be so constructed as to prevent accumulation and clogging. All parts of the equipment that come in contact with the material shall be easily accessible and exposable for cleaning and maintenance.

All mixing and conveying parts up to and including the shaping die, shall maintain the material at the plastic temperature.

The equipment shall be so constructed as to assure continuous uniformity in the dimensions of the stripe. The applicator shall provide a means for cleanly cutting off square stripe ends and shall provide a method of applying "skip" lines. The use of pans, aprons or similar appliances that the die overruns will not be permitted under this specification.

Beads for the surface of the completed stripe shall be applied by an automatic bead dispenser attached to the applicator in such manner that the beads are dispensed almost instantly upon the completed line. The bead dispenser shall be equipped with an automatic cutoff control synchronized with the cutoff of the thermoplastic material.

The equipment shall be so constructed as to provide for varying die widths to produce varying widths of traffic markings.

The equipment shall be so designed to permit agitation of the material to prevent scorching, discoloration or excessive high temperatures of any part of the material.

A special kettle shall be provided for melting and heating the composition. The kettle shall be equipped with an automatic thermostatic control device so that heating can be done by controlled heat transfer liquid rather than direct flame.

The applicator and kettle shall be so equipped and arranged as to satisfy the requirements of the National Fire Underwriters.

The equipment shall be so equipped as to permit preheating of the pavement immediately before application of the material.

The applicator shall be mobile and maneuverable to the extent that straight lines can be followed, and normal curves can be made in a true arc.

(b) Types of Equipment.

1. Portable Applicator. The portable applicator shall be a device typically used for painting crosswalk lines, stop bars, short lane lines and short centerlines. The applicator shall be easily maneuverable and capable of being propelled by the operator.

2. Mobile Applicator. The mobile applicator shall contain equipment to provide for automatic installation of skip lines in any combination of line and skip up to 40 feet. The mobile applicator shall be moved in conjunction with the melting and heating kettles in such a manner as to provide continuous highway operation of the kettles and the mobile applicator as an integral unit.

3. Epoxy Primer Equipment. The epoxy primer application shall be accomplished using equipment having the following features:

A. The main storage tank shall be equipped with a visible gauge that will allow the Engineer to readily ascertain the rate of application.

B. The main storage tank shall be equipped with a heating device that will maintain the epoxy at a constant efficient temperature.

C. The spray nozzle and epoxy spray shall be protected from the action of wind to ensure placement where needed.

4. Cleaning Equipment. Equipment must be provided to ensure removal of laitance, dust, debris, paint and other foreign matter from the road surface immediately before the installation of the composition, or immediately before the application of primer.

(c) Application. The stripe shall be applied to the pavement to either the right or left of the application unit, dependent upon roadway lane being used. The unit shall not occupy more than one lane of roadway while operating.

The finished lines shall have well defined edges and be free of waviness. All of the equipment necessary to the preheating and application of the material shall be so designed that the temperature of the material can be controlled within the limits necessary to its pourability for good application.

At the time of installation of thermoplastic materials, the pavement shall be clean, dry, and free of laitance, oil, dirt, grease, paint or other foreign contaminants. Pavement and ambient temperatures shall be at least 50 °F.

An epoxy resin primer conforming to subsection 708.07 shall be applied to all pavement surfaces before the application of the thermoplastic pavement marking.

The marking material shall not be applied until the epoxy resin primer reaches the tacky stage, approximately 15 minutes under normal conditions. An infrared heating device may be employed to shorten the curing time of the epoxy.

To ensure the best possible adhesion, the marking material as specified, shall be installed at the manufacturer's recommended temperature.

The minimum thickness of thermoplastic lines as viewed from a lateral cross section shall not be less than 3/32 inch at the edges, or less than 1/8 inch at the center. Measurements shall be taken as an average throughout any 36-inch section of the line. The material, when formed into traffic stripes, must be readily renewable by placing an overlay of new material directly over an old line of compatible material. Such new material shall bond itself to the old line in such a manner that no splitting or separation takes place.

Glass beads shall be applied to the thermoplastic pavement marking by means of a low pressure, gravity drop bead applicator at a rate of 10 pounds per 100 square feet, minimum.

627.07 Methyl Methacrylate Pavement Marking. Methyl methacrylate pavement marking shall be installed per manufacturer’s recommendations. The Contractor shall use installation equipment, materials, equipment technicians and operators recommended by the manufacturer.

Methyl methacrylate pavement markings shall be applied to the road surface according to the manufacturer's recommended methods at 60-mil minimum thickness. Glass beads shall be applied using a double drop bead application system. The first bead applicator shall apply glass beads at the rate of 3.2 pounds per square yard (10 pounds per gallon) minimum, and 1.9 pounds per square yard (6 pounds per gallon) minimum for the second bead applicator.

Methyl methacrylate pavement marking, and beads shall be applied within the following limits:

Table 627-3
APPLICATION RATE OR COVERAGE
PER GALLON OF METHYL
METHACRYLATE PAVEMENT MARKING

Rate	Minimum	Maximum
Methyl Methacrylate Pavement Marking	26 sq ft	28 sq ft
First Bead Applicator	10 lb	--
Second Bead Applicator	6 lb	--

627.08 Preformed Plastic Pavement Marking. This retroreflective preformed plastic strip shall be suitable for application on asphaltic or portland cement concrete pavement. The strip shall be applied at the locations called for on the plans or as directed.

If recommended by the manufacturer, an epoxy resin primer conforming to subsection 708.07 shall be applied to all pavement surfaces before the application of the preformed plastic pavement marking.

The surface of the pavement shall be clean, free of loose foreign material, dry and have no moisture for a minimum of 48 hours before application of the markings.

The air and surface temperature shall be a minimum 40 °F or as recommended by the manufacturer.

The marking strip as applied shall be in good appearance, free of cracks and the edges shall be true and straight.

The preformed plastic pavement marking shall be Type I, Type II, or Type III as shown on the plans.

Before beginning installation operations, the Contractor shall submit to the Engineer instructions from the performed plastic pavement manufacturer detailing surface preparation, grooving requirements and material application. The instructions shall include the following:

(1) Equipment Requirements.

(2) Approved Work Methods and Procedures.

(3) Material Application Temperature Requirements.

(4) Ambient Air and Surface temperature Requirements.

(5) Weather Limitations.

(6) Special Precautions.

(7) Any other requirements necessary for successful installation and satisfactory performance of the material.

The Contractor shall secure from the manufacturer all warranties and guarantees with respect to materials, workmanship, performance, or combination thereof, and shall include these warranties and guarantees with the Certification of Compliance.

Materials supplied without installation instructions or with incomplete instructions will not be accepted for use.

Unless otherwise shown on the plans, typical pavement markings shall conform to the shapes and sizes as shown on Standard Plan S-627-1.

The Contractor shall make all arrangements to have a manufacturer-trained installer of the manufacturer's products on-site during the placement of preformed plastic pavement marking to ensure proper installation. A minimum of two weeks before the placement of the preformed plastic pavement marking, the Contractor shall submit written documentation of the installer's qualifications and training in the installation of preformed plastic pavement marking. Upon completion of the work, the Contractor shall obtain and submit to the Engineer written documentation from the manufacturer-trained installer certifying that the product was installed in full compliance with this specification and manufacturer's recommendations.

The preformed plastic pavement marking shall be inlaid on new and existing pavements as shown in the Contract. The material shall be usable for patching worn areas of the same type according to the manufacturer's recommendations.

The Contractor shall not perform wet cutting of pavement unless otherwise directed. Application and removal of temporary pavement marking associated with wet cutting of pavement shall be at the Contractor's expense.

The preformed plastic pavement marking shall conform to pavement contours by the action of traffic, and shall be applicable on new, dense, and open graded asphalt wearing courses during the paving operations according to the manufacturer's recommendations. After application, the markings shall be immediately ready for traffic.

(a) Inlaid Preformed Plastic Pavement Marking. The grooved width for inlaid preformed plastic pavement marking is called for in the Contract. The grooved width shall be the pavement marking width plus 1 inch, with a tolerance of plus or minus 1/4 inch. The depth of the grooves shall be 130 mils plus or minus 5 mils. Groove position shall be a minimum of 2 inches from the edge of the pavement marking to the longitudinal pavement joint.

Grooving shall not be performed on bridge decks with Polyester Polymer Concrete Overlays.

The bottom of the groove shall have a smooth, flat finished surface. The spacers between blade cuts shall be such that there will be less than a 10-mil rise in the finished groove between the blades.

Grooves shall be clean, dry and free of laitance, oil, dirt, grease, paint or other foreign contaminants. The Contractor shall prevent traffic from traversing the grooves, and re-clean grooves, as necessary, before application of the preformed plastic pavement markings.

(b) Reserved.

627.09 Preformed Thermoplastic Pavement Marking. The markings shall consist of a resilient white or yellow thermoplastic product with glass beads uniformly distributed throughout the entire cross-sectional area. Legends and symbols shall be capable of being affixed to bituminous pavements by heating.

The markings shall conform to pavement contours, breaks and faults through the action of traffic at normal pavement temperatures. The material shall have resealing characteristics with the capability of fusing with itself and previously applied thermoplastic markings under normal use.

The preformed thermoplastic markings shall be packaged in a protective plastic film with cardboard stiffeners where necessary to prevent damage in transit. The carton in that the material is packed shall be clearly labeled for ease of identification.

(a) Application. Application temperature shall be as recommended by the manufacturer. The pavement and air temperature shall be as recommended by the manufacturer at the time of application. The materials shall be applied using a heating method recommended by the manufacturer. The Contractor shall provide the Engineer a copy of the manufacturer's installation recommendations before beginning the work. The pavement shall be clean, dry and free from debris. The preformed thermoplastic markings may be installed on top of existing thermoplastic markings after all loose material has been removed. The preformed thermoplastic markings shall not be installed on top of existing preformed plastic pavement markings without first removing the existing markings to a depth that ensures removal of the adhesive backing of the preformed plastic. It shall not be installed on top of pavement marking paint without first removing the paint.

(b) Equipment. The Contractor shall use a heating method specifically recommended by the manufacturer for the installation of preformed thermoplastic markings.

627.10 Pavement Marking Tape. Retroreflective tape shall be suitable for temporary use on asphaltic or portland cement concrete pavements. The tape shall be applied at the locations shown on the plans or as directed. The tape shall conform to subsection 713.15.

The surface that the tape is applied shall be clean, dry and free of dirt, oils and grease. The tape shall be pressed down immediately after application, until it adheres properly and conforms to the surface. Temporary marking tape sections longer than 1 foot shall be removed before placement of the final pavement course. All tape shall be removed on sections where tape conflicts with revised traffic lanes before opening of new lanes to traffic.

Pavement marking tape (removable) shall be installed per the manufacturer's recommendations and maintained throughout the required construction phase at no additional cost to the Department.

627.11 Raised Pavement Markers. Raised pavement markers (temporary) shall be installed on centerlines, edge lines, and lane lines where specified in the Contract. Single markers shall be installed at 5-foot intervals for solid lines. A group of four markers at 3-foot spacings and at 40-foot intervals shall be installed for skip lines.

Markers supplementing lines shall be installed at the spacing shown on the plans. Raised pavement markers (temporary) shall be installed per the manufacturer's recommendations and shall be maintained throughout the required construction phase at the Contractor’s expense.

METHOD OF MEASUREMENT

627.12 The types of pavement marking described will be measured by the following units, complete-in-place and accepted.

Pavement marking paint will be measured by the number of gallons used including glass beads. Material used in excess of coverage limit prescribed will not be measured.

Modified epoxy pavement marking, polyurea, and methyl methacrylate pavement marking will be measured by the total number of gallons of components A and B used including glass beads. Material used in excess of coverage limit prescribed will not be measured.

Thermoplastic pavement marking, preformed thermoplastic pavement marking, and preformed plastic pavement marking will be measured by the square foot. The unmarked spaces between markings will not be included in the overall measurement.

The amount of pavement marking tape to be measured will be the linear feet of the specified width tape applied. Gaps in marking will not be measured for payment.

Raised pavement marker (temporary) will be measured as a unit in place and shall include all adhesive necessary for installation. Removal of the raised pavement marker shall be included in the work.

Pavement word and symbol markings, transverse and longitudinal crosswalk lines, and stop lines will not be measured, but shall be the quantities, in square feet, designated in the Contract; except measurements will be made for revisions requested by the Engineer. The unmarked spaces within these markings will not be included in the measurement.

BASIS OF PAYMENT

627.13 The accepted quantities will be paid for at the contract price per unit of measurement for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Pavement Marking Paint	Gallon
Pavement Marking Paint (High Build)	Gallon
Pavement Marking Paint (High Build)(Temporary)	Gallon
Pavement Marking Paint (Low Temperature)	Gallon
Modified Epoxy Pavement Marking	Gallon
Methyl Methacrylate Pavement Marking	Gallon
Thermoplastic Pavement Marking	Square Foot
Preformed Plastic Pavement Marking (Type __) (Inlaid)	Square Foot
Preformed Plastic Pavement Marking (Word-Symbol) (Type I) (Inlaid)	Square Foot
Preformed Plastic Pavement Marking (Xwalk-Stop Line) (Type I) (Inlaid)	Square Foot
____Inch Pavement Marking Tape	Linear Foot
Pavement Marking Tape (Removable)	Linear Foot
Raised Pavement Marker (Temporary)	Each

Pavement Marking Paint (Word-Symbol)	Square Foot
Pavement Marking Paint (Xwalk-Stop Line)	Square Foot
Thermoplastic Pavement Marking (Word-Symbol)	Square Foot
Thermoplastic Pavement Marking (Xwalk-Stop Line)	Square Foot
Preformed Thermoplastic Pavement Marking	Square Foot
Preformed Thermoplastic Pavement Marking (Word-Symbol)	Square Foot
Preformed Thermoplastic Pavement Marking (Xwalk-Stop Line)	Square Foot

Waterblasting will not be measured and paid for separately but shall be included in the work.

Glass beads and cleaning with high-pressure water blast or air blast shall be included in the cost of the work.

Each authorized application of temporary pavement marking will be measured and paid for at the contract unit price for the type of material used.

Control points and Contractor pavement marking plans will not be measured and paid for separately but shall be included in the work.

All costs associated with having the Preformed Plastic Pavement Marking manufacturer-trained installer on-site and providing the documentation will not be measured and paid for separately but shall be included in the work.

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SECTION 629

SURVEY MONUMENTATION

DESCRIPTION

629.01 This work consists of locating, preserving, referencing, installing and restoring land monuments, such as Primary Control monuments from which the right of way or any land boundary will be calculated, described or monumented, Public Land Survey System (PLSS) monuments, General Land Office (GLO) monuments, Bureau of Land Management (BLM) monuments, Mineral Survey (MS) monuments, Right-of-way (ROW) monuments, property boundary monuments, easement monuments, and other monuments that are required by law or regulation to be established and recorded by a Professional Land Surveyor (PLS), and the determination of any land boundary, shall be done per Section 629, under the supervision of a PLS who is experienced and competent in Right of Way and boundary surveying and licensed in the State of Colorado.

All such monuments included in this section shall be established per the applicable and most recent editions of the Department of Interior's Manual of Surveying Instructions (BLM Manual), Colorado Revised Statutes (CRS), Colorado State Board of Licensure for Professional Engineers and Land Surveyors (State Board) Rules and Policies, the Memorandum of Understanding (MOU) with the State Board and CDOT, and the CDOT Survey Manual, under the supervision of a PLS who is experienced and competent in Right of Way and boundary surveying and licensed in the State of Colorado.

The PLS shall be available to review work, resolve problems, and make decisions in a timely manner.

Unless specified otherwise in the contract, all survey procedures shall be in conformance with the CDOT Survey Manual.

MATERIALS AND EQUIPMENT

629.02 The Contractor shall furnish all personnel, survey equipment, safety equipment, materials, and traffic control necessary to perform the required monumentation and related surveying.

Monuments and monument boxes will be furnished by the Department. The various types of monuments and monument boxes shall be constructed according to the details shown on Standard Plan M-629-1. The Contractor shall furnish all labor, survey tools, equipment, and incidental materials such as but not limited to concrete, grout, asphalt caulk, glue, epoxy, nails, stakes, lath, and replacement monuments of the variety not included on the Standard Plan M-629-1.

All surveying equipment, including Electronic Distance Measuring Instruments (EDMI), total stations, levels, rods, tapes, tripods, tribrachs, and Global Positioning System (GPS) receivers and equipment, shall be checked and calibrated per the Colorado Department of Transportation (CDOT) Survey Manual, Chapter 6, Section 6.1.10, and documented in the survey records before the start of work and every six months thereafter.

EDMI and total stations shall be checked and calibrated on a National Oceanic and Atmospheric Administration/ National Geodetic Survey (NOAA / NGS) calibrated baseline per the CDOT Survey Manual, Chapter 2, Section 2.1 and 2.2, and documented in the survey records before the start of work and every six months thereafter.

GPS receivers and equipment shall be checked and calibrated on a NOAA / NGS calibrated baseline per the CDOT Survey Manual, Chapter 3, Section 3.3, and documented in the survey records before the start of work and every six months thereafter.

Levels shall be checked and calibrated per the CDOT Survey Manual, Chapter 6, and Chapter 5, and documented in the survey records before the start of any level circuit.

If any survey equipment is found to be functioning outside the manufacturer's specified tolerance, certification from an approved repair facility showing that the instruments have been repaired, properly adjusted, or both if needed shall be included in the survey records and submitted to the Engineer before being used.

Traffic control shall be per Section 630.

CONSTRUCTION REQUIREMENTS

629.03 General. The Department will establish Primary horizontal and vertical control for the project. All available information defining the extent of that control is provided on the plans per the CDOT Survey Manual Chapter 6, or is available from the Engineer and CDOT PLS Coordinator or Project Engineer.

A Presurvey Conference – Construction Survey meeting be held per the CDOT Survey Manual Chapter 6, Section 6.1.6, before performing any surveying work under this section. The Engineer, Region Survey Coordinator and Plans Coordinator (or designee), Contractor's Superintendent, Contractor's Surveyor (PLS) and Party Chief shall attend. A Presurvey Conference – Construction Survey Form shall be included per the CDOT Survey Manual Chapter 6. A surveying work schedule shall be submitted to the Engineer for review before the Presurvey Conference.

The Contractor shall check all Department established Primary horizontal and vertical control points per the CDOT Survey manual Chapter 6, Section 6.2, and verify and document in the survey records their horizontal accuracy tolerance per the CDOT Survey Manual Chapter 5, Section 5.5, and their vertical accuracy tolerance per the CDOT Survey Manual Chapter 6.2, and Chapter 5.9, for a CDOT Class A, Primary Survey before using them for monumentation and surveying control.

Survey records shall be completed as the work is done. Field survey notes for monumentation, surveying and checking by the Contractor shall be recorded in survey records in conformance with the format given in the CDOT Survey Manual Chapter 6, Section 6.1. Survey field books shall be indexed per the Survey Manual Chapter 2, Section 2.4.

The Contractor shall make all survey records generated available to the Engineer for inspection or reproduction at all times. The Contractor shall submit all survey records to the Engineer before Final Acceptance. All survey records are considered property of the Department. The responsible PLS or PE identified in subsection 629.01, shall electronically seal all survey records.

The electronic format shall contain the information and format as required in the Survey Manual Chapter 6, Section 6.1 including stakeout data and the raw data from the actual placement of the monuments.

Survey records shall include the requirements specified in the CDOT Survey Manual Chapter 6, Section 6.3, and Chapter 5, Section 5.12, for any PLSS monument, GLO monument, BLM monument, or MS monument on the project.

Copies of any new Monument Records filed by the PLS with the State Board of Registration per the CDOT Survey Manual Chapter 6, Section 6.3, and Chapter 5, Section 5.12, shall be submitted to the PLS Coordinator and Engineer, after filing with the State Board.

629.04 Locating Monuments. This work consists of field locating all survey monumentation that is in place because of a Government (Federal, State, County or Municipal) survey or resurvey as shown on original PLSS, GLO, BLM, or MS plats, notes, or other survey monumentation documented in the public record per the CDOT Survey Manual Chapter 6, Section 6.3.

A diligent search of construction zones and project limits shall be performed by the PLS per the Survey Manual Chapter 5, Section 5.12, to locate any survey monumentation of the public record. An electronic magnetic field sensor or locator shall be used in this search. The responsible PLS shall document the search, and time spent searching, in the survey records using a narrative form. The survey records shall include the procedures used to make the diligent search, a description of each monument searched for, and the actions taken to reference and preserve the location of the monument per subsection 629.05.

629.05 Preserving and Referencing Monuments. This work consists of field surveying, establishing, installing, and making measurements to reference monuments that will facilitate the installation of a replacement monument in the event the construction activity disturbs a monument of the public record as listed in subsection 629.04.

Referencing of monuments for possible replacement requires the use of correct replacement methods so the stated precision of the monument in question is not degraded.

When a construction activity is planned that will disturb an existing PLSS, GLO, B.L.M., or MS monument, the monument shall be referenced and the survey records shall include the information required in subsection 629.03, and the monument shall be upgraded by the PLS and a new Monument Record filed with the State Board per the Survey Manual Chapter 5, Section 5.12, when the following conditions are met:

(1) No boundary survey was done for the project.

(2) A Monument Record has been filed with the State Board and there are no Monument Records that indicate conflicting locations.

(3) The existing monument does not meet the physical standards set by the State Board.

A new monument record shall be filed with the State Board per Title 38 CRS and State Board Rules and Polices, a disclaimer should be written on the new Monument Record stating, “the new monument was set in the same location as described by the previous monument record”.

When conflicting evidence of the location of an existing PLSS, GLO, BLM, or MS monument is encountered and construction activity is planned that will alter the evidence, the monument shall be referenced, and the survey records shall include the information required in subsection 629.03. A minimum of two CDOT permanent reference monuments shall be established per the CDOT Survey Manual, Chapter 5, to reference the location of all existing found monuments. Reference monuments must meet the required physical standards of the actual monument for the type of monument being referenced. These references shall be set when all of the following conditions are met:

(1) No boundary survey was done for the project.

(2) No monument record or conflicting monument records are filed with the State Board.

The reference monuments shall be set and stamped per Title 38 CRS and State Board Rules and Polices, a new monument record should be marked “Other” for “Type of Monument” and a full explanation given on the monument record as to why the presumed monument was not upgraded, the monument record shall be filed with the State Board per Title 38 CRS.

Copies of all new Monument Records filed by the PLS with the State Board shall be submitted to the CDOT PLS Coordinator and Project Engineer, after filing with the State Board.

The equipment used in referencing or replacing the monument shall be able to produce the stated accuracies as specified by the owner of the monument. For example, the Colorado High Accuracy Reference Network (HARN) and CDOT HARN Densification (HARND) monuments shall be referenced or replaced using Dual Frequency survey grade GPS equipment per the procedures set forth under the most recent Policy of the National Ocean Service Regarding the Incorporation of Geodetic Data of Other Organizations into the National Geodetic Survey Data Base, standards of accuracy are given in the Standards and Specifications for Geodetic Control Networks and Geometric Geodetic Accuracy Standards and Specifications for using GPS Relative Positioning Techniques (as amended).

National Geodetic Survey (NGS), U.S. Coast and Geodetic (USCG), and U.S. Geological Survey (USGS) benchmarks shall be referenced by setting a minimum of 3 temporary benchmarks per the procedures set forth under the most recent edition of the NGS Benchmark Reset Procedures. The temporary benchmarks shall be set outside the construction area so a permanent monument can be reset upon completion of the construction.

Referencing, moving, or replacing a federal or local government agency monument shall be done per the CDOT Survey Manual Chapter 6, Section 6.1, and Chapter 5, Section 5.12. Before referencing, moving or replacing the monument the NGS Western Region State Geodetic Advisor and the CDOT Region Survey Coordinator is to be notified, contact information is available in the CDOT Survey Manual Chapter 5, Section 5.3.6.

Survey records for referencing, moving, or replacing a federal or local government agency monument shall include documentation of the work per subsection 629.03. The survey records shall be submitted to the CDOT PLS Coordinator or Project Engineer, for review, before payment is made and shall include the following:

(1) Description of the original monument and two sets of close-up photographs.
(2) Two sets of labeled color photographs showing a close-up of the replaced monument, and a view of the monument looking toward the horizon in each of the cardinal directions.
(3) A complete description of the reference monuments and replacement monument with a “to-reach” description.
(4) A signed and sealed statement by the responsible PLS that states the replacement monument’s positional tolerance has not been degraded. The documentation shall conform to the owner of the monument’s specifications that control the work.
Before Survey Monumentation payment is made, the Contractor’s surveyor shall submit legible electronically sealed copies of the survey records per subsection 629.03.
Before final Survey Monumentation payment and before depositing with the county, per Title 38 CRS, Property – Real and Personal, State Board Rules and Policies, MOU, and the CDOT Survey Manual, the Contractor shall complete and electronically seal all survey records, the Right of Way (ROW) Plans, and the Project Control Diagram (new, supplemental or amended) and submit copies the Engineer.

629.06 Installing Monuments. This survey work consists of installing Primary Control monuments, benchmarks, ROW monuments, property boundary monuments, easement monuments, PLSS, GLO, BLM, or MS monuments, and other monuments included on the plans. The work shall include determining the location of the monuments, installing the monuments, and verifying the positional accuracy of the monument is correct.

A Primary Control survey, when not furnished by the Department, shall be performed per the CDOT Survey Manual Chapter 5, meeting the horizontal and vertical accuracy tolerances for a CDOT Class A, Primary Survey. A Project Control Diagram shall be submitted to the Engineer and the Region Survey Coordinator for all new Primary Control monuments and surveys per the CDOT Survey Manual Chapter 5, Section 5.11.

Vertical accuracy tolerances for Primary Control monuments and surveys shall be as specified in the CDOT Survey Manual Chapter 6, Section 6.4 and Chapter 5, Section 5.9.

Unless stated otherwise in the contract, if construction activity disturbs a Primary Control monument (or benchmark) a new Primary Control monument (or benchmark) shall be installed by the Contractor per the CDOT Survey Manual, Chapter 6, Section 6.2. Primary Control monuments shall be set so they are intervisible from at least two adjacent Primary Control monuments and shall not exceed 0.6 mile between adjacent intervisible Primary Control monuments. Primary Control monuments set by the Contractor shall not conflict with construction activities. The Primary Control survey shall consist of a closed loop network and have adequate redundancy, precision, and accuracy to prove that all the monuments included in the network are within the horizontal and vertical accuracy tolerance as specified in the CDOT Survey Manual Chapter 5, Section 5.5 for a CDOT Class A , Primary Survey.

Survey records shall include documentation of Primary Control monuments and survey per subsection 629.03. A supplemental or amended Project Control Diagram shall be submitted to the Engineer and the Region Survey Coordinator for all replaced, transferred or re-established Primary Control monuments per the CDOT Survey Manual Chapter 6, Section 6.2.

ROW monuments, property boundary monuments, and easement monuments shall be installed per the CDOT Survey Manual Chapter 6, Section 6.3, and Chapter 5, Section 5.12, meeting the horizontal accuracy tolerances as specified in the CDOT Survey Manual Chapter 5, Section 5.5 for a CDOT Class B, Secondary Survey using the Primary Control monuments and the data on the Control and Monumentation sheet of the ROW plans.

Additional Secondary Control monuments may be required to be set per the CDOT Survey Manual Chapter 5, Section 5.6.8, meeting the horizontal accuracy tolerance specified in the CDOT Survey Manual Chapter 5, Section 5.5 for a CDOT Class B Secondary Survey, before the ROW monuments are installed.

The procedures used to set ROW monuments shall include an independent check of the installation per the CDOT Survey Manual Chapter 5, Section 5.12. Survey records shall include documentation of the survey preformed to establish the monuments per subsection 629.03. The independent check shall be documented in the survey records and the field measured differences calculated or reduced to show the work is within the specified horizontal accuracy tolerance.

PLSS, GLO, BLM, or MS monuments shall be installed per the CDOT Survey Manual Chapter 6, Section 6.3 and Chapter 5, Section 5.12, meeting the horizontal accuracy tolerance specified in the CDOT Survey Manual Chapter 5, Section 5.5 for a CDOT Class B Secondary Survey using the Primary Control monuments and the data on the Control and Monumentation sheet of the ROW plans. The procedures used to set PLSS, GLO, BLM, or MS monuments shall include an independent check of the installation per the CDOT Survey Manual Chapter 5, Section 5.12. Survey records shall include documentation of the survey preformed to establish the monuments per subsection 629.03. The independent check shall be documented in the survey records and the field measured differences calculated or reduced to show the work is within the specified horizontal accuracy tolerance.

The installation of ROW, property boundary, easement, PLSS, GLO, BLM, or MS monuments installed at a different location than the data shown on the Monumentation sheet of the ROW plans shall be submitted to the Engineer and the Region Survey Coordinator along with the monuments description and horizontal data in order that the new monument can be revised on the Land Survey Control Diagram and ROW plan sheets.

Copies of all new Monument Records filed by the PLS with the State Board for the installation of new PLSS, GLO, BLM, or MS monuments shall be submitted to the CDOT PLS Coordinator and the Engineer, after filing with the State Board.

629.07 Monument Box. This survey work shall consist of installing or adjusting monument boxes included on the plans. When it is necessary to set a monument within a monument box per Title 38 CRS and State Board Rules and Policies, the work shall be done per Standard Plan M-629-1. If the monument meets the physical standard as stated by the State Board and is situated within the finished roadway, a monument box shall be installed as shown on Standard Plan M-629-1. When an existing monument box, due to construction, will no longer meet the physical standard set by the State Board, the box shall be replaced or adjusted to meet those standards.

METHOD OF MEASUREMENT

629.08 Survey Monuments, Monument Boxes, and Adjust Monument Boxes will be measured by the actual number of the various types installed and accepted by the Engineer. Measurement for locating survey monuments will be by the hour as approved by the Engineer.

BASIS OF PAYMENT

629.09 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

No payments will be made before the proposed work schedule is submitted.

Legible signed and sealed copies of survey records per subsection 629.03 shall be submitted on a monthly basis to the Engineer for completed work before payment is made for that pay item.

Before final payment is made, the following three items shall be completed, bear the seal and signature of the responsible PLS identified in subsection 629.01, and have copies submitted to the Engineer for review before being deposited with the county per Title 38 CRS, Property – Real and Personal, State Board Rules and Policies, MOU, and the CDOT Survey Manual:

(1) All survey records.

(2) The Right of Way Plans.

(3) The Project Control Diagram (new, supplemental or amended).

The Presurvey Conference – Construction Surveys meeting, equipment calibrations, and survey records will not be paid for separately but shall be included in the work.

Payment will be made under:

Pay Item	Pay Unit
Locate Monuments	Hour
Survey Monument (Type)	Each
Monument Box	Each
Adjust Monument Box	Each

Traffic control for monumentation and related surveying will be measured and paid for per Section 630.

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SECTION 630
CONSTRUCTION ZONE TRAFFIC CONTROL

DESCRIPTION

630.01 This work consists of furnishing, installing, moving, maintaining, and removing temporary traffic signs, advance warning arrow panels, flashing beacon (portable), barricades, channelizing devices, delineators, temporary traffic signals, temporary portable rumble strips, mobile pavement marking zones, temporary emergency pull-off areas, masking and unmasking existing signs in construction zones, concrete barriers, and Automated Flagging Assistance Devices (AFAD) as required by the Manual on Uniform Traffic Control Devices for Streets and Highways and the Colorado Supplement thereto, per the Contract. Devices shall comply with the performance criteria contained in NCHRP Report 350 (only applicable for devices developed before 2011) or Manual for Assessing Safety Hardware (MASH) (acceptable for all devices). Devices temporarily not in use shall, as a minimum, be removed from the shoulder area. Moving will include devices removed from the project and later returned to use.

This work also includes Traffic Control Management, flagging, and pilot car operation.

This work consists of providing traffic pacing operation to motorists within the project area, as shown on the plans. It includes locating traffic related incidents, providing roadside assistance, and clearing the traffic related incidents. The use of law enforcement officers shall be integrated into the Rolling Roadblock operations.

MATERIALS

630.02 Signs and Barricades. Construction traffic sign and barricade materials shall conform to the applicable portions of Section 614 with the following exception: Sign panels may be fabricated from plywood, aluminum, steel, or other suitable materials provided they are stable and durable enough to meet the other requirements of Section 614. Traffic control devices deemed inadequate by the Engineer shall not be used and shall be removed from the project site.

Temporary sign support assembly shall be timber, perforated square metal tubing inserted into a larger base post or slip base, or perforated metal U-channel with a slip base. The temporary sign support assembly shall conform to NCHRP (only applicable for sign support assemblies developed before 2011) or MASH (acceptable for all sign support assemblies), and AASHTO requirements regarding temporary sign supports during construction.

If U-Channel posts with a slip base are selected, they shall be used only in multi-post applications, as shown on Standard Plan S-630-4.

Retro-reflective sheeting shall conform to the requirements of subsection 713.04.

Retro-reflective sheeting types shall be as defined in the *CDOT Retroreflective Sheeting Materials Guide*.

Retro-reflective sheeting shall be one of the types specified for the particular application in Table 630-1.

Retro-reflective sheeting for all signs requiring an orange background shall be Fluorescent.

Table 630-1
RETROREFLECTIVE SHEETING TYPES

Sheeting	Type IV	Type VI (Roll-up sign material)	Type Fluorescent *
Application	Work Zone	Work Zone	Work Zone
All Orange Construction Signs			X
Orange Construction Signs that are used only during daytime hours for short term or mobile operations		X ▸	X
Barricades (Temporary)	X		X
Vertical Panels	X		X
Flaggers Stop/Slow Paddle	X		X
Drums and Tubular Markers#	X ▾		X
Non-orange Fixed Support signs with prefix "W"	X		
Special Warning Signs			X
STOP sign (R1-1) YIELD sign (R1-2) WRONG WAY sign (R5-1a) DO NOT ENTER sign (R5-1) EXIT sign (E5-1a)	X		
DETOUR sign (M4-9) or (M4-10)			X
All other fixed support signs ◂	X		X
All other signs used only during working hours	X		X
All other signs that are used only during daytime hours for short term or mobile operations	X	X ▴	X

Table 630-1 Notes:
* Fluorescent Sheeting shall be of a brand that is on the CDOT Approved Products List.
# Drum and Tubular Marker sheeting shall be manufactured for flexible devices, and sheeting materials shall conform to Section 713.
◂ Fixed support signs are defined as all signs that must remain in use outside of working hours. They shall be mounted per Standard Plan S-630-1.
▸ RS 24 only.
▴ White only.
▾ For projects advertised before September 1, 2017, Type IV or Fluorescent sheeting will be permitted. For projects advertised on or after September 1, 2017, only Fluorescent sheeting will be permitted.

The Contractor shall provide sign panel legend for standard signs per “Standard Highway Signs” published by the FHWA and the Colorado Supplement thereto, and sign panel legend for special signs per the detailed sign layouts provided by the Engineer.

Variable Message Signs (Portable) shall conform to the requirements of the Project Special Provision, Revision of Section 630, Portable Message Sign Panel.

630.03 Electronic Advance Warning Signs. Advance warning flashing or sequencing arrow panels shall be furnished of a size as required by project conditions and shall meet the following requirements:

Table 630-2
REQUIREMENTS FOR
ELECTRONIC ADVANCE WARNING SIGNS

Type	Minimum Size	Minimum Number of Panel Lamps	Minimum Legibility Distance
A	24"x48"	12	1/2 mile
B	30"x60"	13	3/4 mile
C	48"x96"	15	1 mile

The panel face shall be rectangular in shape, solid construction and shall be finished nonreflective black. The panels shall be mounted on a vehicle, trailer, or other suitable support. Vehicle-mounted panels shall be provided with remote controls.

Arrow panels shall have the capability of the following mode selection: left arrow or chevron, right arrow or chevron, left and right arrow, and caution. The caution mode consists of four or more lamps, arranged in a pattern that will not indicate a direction.

Arrow panels shall include an automatic photocell sensor type signal lamp dimmer with manual override and shall be capable of minimum 50 percent dimming from rated lamp voltage.

630.04 Temporary Traffic Signals. Temporary traffic signals must meet the physical display and operational requirements of conventional traffic signals. A minimum of two signal faces shall be provided for each approach and each signal face shall consist of three 12-inch sections. At railroad grade crossing locations, one signal face with three 8-inch sections shall be visible from each rail approach. The traffic signal controllers shall conform to the requirements of subsection 614.08(b) and shall be capable of two-phase operation, or more if specified on the plans, with all-red timing intervals.

The Contractor shall submit a list of equipment proposed to be used. The equipment shall be identified by trade name, size and number. Material deemed inadequate by the Engineer shall not be used.

630.05 Traffic Cones. Traffic cones shall not be used outside of working hours unattended. The minimum cone height shall be 28 inches. However, when they are used on freeways, at nighttime, or when specified in the Contract, the minimum height shall be 36 inches.

When traffic cones are used during nighttime, they shall be reflectorized. The reflectorized material shall be selected from the Colorado Approved Products List and shall have a smooth, sealed outer surface that will display the same approximate color day and night. Reflectorization of cones shall be provided by a white band at least 6 inches wide placed no more than 3 to 4 inches from the top, and an additional white band, 4 inches wide, placed a minimum of 2 inches below the 6-inch band.

Tubular markers shall be 3 to 3 1/2 inches in diameter, shall be 36 inches plus or minus 1/2 inch in height, predominantly orange in color, and shall be reflectorized.

630.06 Channelizing Device (Fixed). Channelizing Device (Fixed) shall be 36 inches plus or minus 1/2 inch in height and 3 to 3 1/2 inches in width for the surface facing traffic. The shape of the device is immaterial as long as it can accommodate the striping pattern and functions as described below. Reflectorization shall be alternating 4 to 6 inches wide orange and white stripes slanting downward at a 45-degree angle toward the side where traffic will pass. The striping shall start at the top and extend downward at least 32 inches. Reflective sheeting shall be Type IV. These devices shall be manufactured of flexible high-impact resistant material, shall be physically attached to the pavement, and shall be capable of returning to a vertical position after impact by a vehicle.

The brand name and model of the Channelizing Device (Fixed) shall be submitted to the Engineer for approval before use.

630.07 Temporary Channelizing Devices.

(a) Stackable Vertical Panels. Stackable vertical panels shall comply with the crash test requirements contained in NCHRP Report 350 (only applicable for vertical panels developed before 2011) or MASH (acceptable for all vertical panels) and shall meet MUTCD requirements for vertical panels. Vertical panels shall be retroreflectorized with Type IV sheeting, per subsection 630.02. The stackable vertical panels shall have the following properties:

Table 630-3

REQUIREMENTS FOR STACKABLE VERTICAL PANELS

Property	Specification
Panel Material	Low density polyethylene
Color	Orange and white stripes with orange or white frame and black ballast
Vertical Panel Height	24, 36, 42 in
Ballast Type*	Rectangular or Square
Ballast Weight*	9 - 30 lb

Table 630-3 Notes:
*The ballast type and weight shall be as shown in the contract or as approved by the Engineer.

Markings for vertical panels shall be alternating orange and white retro-reflective stripes, sloping downward at an angle of 45 degrees in the direction of vehicular traffic. The width of the stripes shall conform to the requirements of the MUTCD.

Vertical panels shall be retroreflectorized with Type IV Sheeting. The stackable vertical panels shall be selected from the Department's Approved Products List and shall have a smooth, sealed outer surface that will display the same approximate color day and night.

(b) Stackable Tubular Markers. Stackable tubular markers shall comply with the crash test requirements contained in NCHRP Report 350 (only applicable for stackable tubular markers developed before 2011) or MASH (acceptable for all stackable tubular markers) and shall conform to MUTCD requirements for tubular markers. The stackable tubular markers shall have the following properties:

Table 630-4

REQUIREMENTS FOR STACKABLE TUBULAR MARKERS

Property	Specification
Tubular Section	Low density polyethylene
Color	Orange Tubular Marker with Black Base
Height (min.)	42 in
Ballast Type*	Rectangular, Octagonal or Square
Ballast Weight*	15 - 40 lb

Table 630-4 Notes: *The ballast type and weight shall be as shown in the contract or as approved by the Engineer.

Tubular Markers shall be retroreflectorized as shown in Table 630-1. The stackable tubular markers shall be selected from the Department's Approved Products List and shall have a smooth, sealed outer surface that will display the same approximate color day and night.

(c) Temporary Portable Rumble Strips. Temporary portable rumble strips shall be made of thermoset cast urethane, and shall operate in temperatures ranging from 0 to 180 °F. The Contractor shall submit documentation from the manufacturer showing that the product meets all American Traffic Safety Services Association (ATSSA) and FHWA criteria for temporary portable rumble strips. The rumble strip shall be capable of being installed without adhesives or bolts and shall have a minimum weight of 105 pounds. The face of the rumble strip shall be a non-slip textured surface.

630.08 Temporary Barrier Temporary Barrier shall comply with the crash test requirements contained in NCHRP Report 350 (for devices manufactured before 2020) or MASH (acceptable for all temporary barrier). Retroreflectorization is required on all temporary barrier according to Standard Plans S-612-1 and M-606-14 and shall meet material qualities per Section 713. All barrier types shall be designed to accommodate appropriate end treatments, transitions and delineation devices. Previously damaged barrier shall not be installed, and barrier damaged after installation shall be removed and replaced or repaired (for minor damage not affecting design intent) per manufacturer.

(a) Concrete Barrier. Temporary concrete barrier shall conform to precast Type 7 Concrete Barrier as detailed in Standard Plan M-606-14.

(b) Non-Concrete Barrier. Temporary non-concrete barrier shall be on the Department's Approved Product List. If used, metal barrier shall be made of galvanized steel. All non-concrete barrier types shall be designed to allow for proper drainage runoff. Barrier shall be installed and maintained according to manufacturer requirements and include all necessary components for installation. Product specific documentation pertaining to installation, maintenance, repair, removal, and inspection shall be provided by the Contractor before installation.

630.09 General. All traffic control devices shall be provided with all components necessary to comprise a complete installation. Traffic control devices deemed inadequate by the Engineer shall not be used and shall be removed from the project site.

Work zone devices designated by FHWA as Category I, II, or III, shall comply with the performance criteria contained in NCHRP Report 350 (only applicable for devices developed before 2011) or MASH (acceptable for all devices). Devices designated as Category IV, including but not limited to portable or trailer-mounted devices such as flashing arrow panels, temporary traffic signals, area lighting supports, and changeable message signs are not required to meet NCHRP 350 or MASH requirements.

Except for Category IV devices, the Contractor shall obtain and present to the Engineer the manufacturer's written NCHRP 350 (only applicable for devices developed before 2011) or MASH (acceptable for all devices) certification for each work zone device before it is first used on the project.

The Flashing Beacon (Portable) shall include all work and material necessary to complete the item. The beacon head, lens, signal lamp, flasher and electrical boxes and fittings shall conform to permanent flashing beacon requirements. The post or mounting method shall conform to construction traffic control materials. The flashing beacon shall be per subsection 614.06.

Portable devices that require weight to prevent overturning shall be weighted with appropriately sized sandbags.

Traffic control devices that are damaged, weathered, worn, or otherwise determined to be unacceptable, shall be replaced at the Contractor's expense.

Delineator (Type) (Temporary) shall conform to Delineator (Type) described in Section 612. Undamaged Delineator (Type) (Temporary), when approved, may be used as Delineator (Type).

CONSTRUCTION REQUIREMENTS

630.10 Transportation Management Plan. The Contractor shall prepare a Transportation Management Plan for each phase of the project. The Contractor shall manage the work zone impacts of the Project per the Transportation Management Plan (TMP). For significant projects, the TMP shall consist of the Traffic Control Plan (TCP) included in the Contract, a Transportation Operations (TO) component, and Public Information (PI) requirements. The TCP addresses traffic safety and control through the work zone; the TO component shall address sustained operations and management of the work zone impact area; and the PI component requirements shall address communication with the public and concerned stakeholders. For non-significant projects, TMP shall consist of the TCP and other components as specified in the Contract. The proposed TMP shall be approved in writing by

the Engineer before the Contractor begins the corresponding phase of construction. The initial TMP shall be submitted at the Pre-construction Conference.

The project will be considered a significant project unless otherwise specified in the Contract.

The Contractor's superintendent shall implement the TMP.

(a) Traffic Control Plan. The Contractor shall control traffic per the Traffic Control Plan (TCP), as shown in the Contract. To implement the TCP, the Contractor shall develop and submit a Method for Handling Traffic (MHT) for each different phase of construction, which shows the Contractor's proposed construction phasing and proposed traffic control devices consistent with the TCP. If at any time the Contractor desires to change the MHT, it shall be considered a different phase requiring a new MHT.

Any major revisions to the TCP as determined by the Engineer must be authorized by a Contract Modification Order.

Each proposed MHT shall be approved in writing by the Engineer before the corresponding phase of construction will be allowed to begin. The initial MHT shall be submitted at the Pre-construction Conference.

The proposed MHT shall include as a minimum the following:

1. A detailed diagram that shows the location of all traffic control devices, including advance construction signs and speed limit signs; method, length and time duration for lane closures; and location of flaggers and time duration of the flagging operation. Lane closures shall be kept to a minimum in both length and duration and cause a minimum of interference to the traveling public, consistent with the work being performed.
2. A tabulation of all traffic control devices shown in the detailed diagram including, but not limited to: construction signs; vertical panels; vertical panels with light; Type 1 and Type 2 barricades; Type 3 barricades; cones, drum channelizing devices; concrete barrier (temporary); advance warning flashing or sequencing arrow panels. Traffic control devices may be used for more than one operation or phase. However, all devices required for any particular phase must be detailed and tabulated for each phase.
3. When required by the Contract, the Contractor's Method of Handling Traffic (MHT) shall include details of a mobile pavement-marking zone. The mobile pavement marking zone shall include, as a minimum, three operations groups as follows:
   A. The application group composed of the pavement marking application truck and at least one cone installation truck.
   B. The pick-up group composed of at least one truck for warning and one truck for cone pickup.
   C. The signing group composed of one or more trucks installing signs. At a minimum, the following signs shall be used:

0

Table 630-5

MINIMUM SIGN REQUIREMENTS

FOR MOBILE PAVEMENT-MARKING ZONE

HIGHWAY/PAINTING/NEXT __ MILES	60 inch by 36 inch
HIGHWAY/PAINTING/AHEAD	48-inch Diamond
SPEED/LIMIT	48 inch by 60 inch

Truck mounted message boards may be used in lieu of temporary signs.

Groups 1 and 2 shall each be equipped with a truck-mounted Advance Warning Flashing or Sequencing Arrow Panel (C Type). Group 2 shall be equipped with a truck mounted impact attenuator. The impact attenuator shall be located on the rearmost vehicle of the group. A separate vehicle for this attenuator may be used. Each truck-mounted impact attenuator shall be certified by the manufacturer to be able to withstand a 62 MPH impact per NCHRP 350, Test Level 3(applicable only for truck-mounted impact attenuators developed before 2011) or MASH, Test Level 3 (acceptable for all truck-mounted impact attenuators). The cone setting truck and the cone pickup truck shall not be the same vehicle. Group 2 shall also be equipped with a truck mounted NO/PASSING/THRU/PAINTING/ZONE 48 inch by 60-inch sign.

Group 3 shall place HIGHWAY/PAINTING/AHEAD signs on intersecting crossroads and interchange entrance ramps as the pavement marking operation approaches. If required, for spot locations, this group shall also provide flagging.

All groups shall maintain radio communications to ensure appropriate advance warning and buffer distances are maintained for traffic.

All groups shall clear the roadway every 15 minutes or as deemed necessary by the Engineer to allow traffic queues to pass.

Traffic cone spacing shall be determined as required by the standard plans' calculations based on current speed limits. Cone spacing shall not exceed 120 feet. Cones shall be placed a distance of 2 miles on the centerline. The distance and spacing may be adjusted, depending on traffic conditions and terrain, as determined by the Engineer.

4. The Contractor shall furnish supporting references from documents such as the MUTCD, Standard Plans, etc. for any devices incorporated into the MHT that are not included in the TCP provided by the Contract.

5. An access maintenance plan for all properties requiring access during construction. This plan shall also indicate the areas where equipment will be stored, vehicles parked, and construction signs and materials stored, if within the project limits. The Contractor shall ingress and egress the project at existing access points, including median crossings, shown on the plans, unless otherwise approved.

6. A plan for maintaining and controlling pedestrian, bicycle, and other non-vehicular traffic.

7. A plan for emergency vehicle access.

8. The Contractor shall provide verification by field survey that the vertical clearances for structures in all areas covered by a proposed MHT meet or exceed the minimum clearances shown in Table 630-6. If the vertical clearance is less than what is shown for the particular condition in Table 630-6, the Contractor shall identify the location where this clearance cannot be met and provide an appropriate signing plan. If the existing vertical clearance is already less than what is shown in Table 630-6, the Contractor shall identify the location, but a signing plan will be required only if the clearance is to be reduced further. This information shall be included in the MHT and shall be submitted to the Engineer for approval a minimum of five days before the MHT is implemented.

9. The Contractor shall provide verification by field survey that the total driving lane plus shoulder in all areas covered by a proposed MHT is at least 17 feet. If this width cannot be maintained, the Contractor shall identify the location where this clearance cannot be met and provide an appropriate signing plan. If the existing width is already less than 17 feet, the Contractor shall identify the location, but a signing plan will be required only if the width is to be reduced further. This information shall be included in the MHT and shall be submitted to the Engineer for approval a minimum of five days before the MHT is implemented.

Table 630-6
VERTICAL CLEARANCES TO STRUCTURES

Between	Highway Underpasses	Railway Underpasses	Overhead Wires
Local Rural Roads	14 Feet	23 Feet[2]	[3]
Local Urban Streets	14 Feet	23 Feet[2]	[3]
Urban and Rural Collectors	14 Feet	23 Feet[2]	[3]
Freeways	16 Feet*	23 Feet[2]	[3]
Rural Arterial	16 Feet*	23 Feet[2]	[3]
Urban Arterial	16 Feet*	23 Feet[2]	[3]

Table 630-6 Notes:

*Vertical clearance to sign trusses and pedestrian overpasses shall be 17 feet.
Measured from top of rail to bottom of highway structure. All railway clearances are subject to the individual railroad's approval.

◂ Communication and power lines of:

0 to 750 volts	18 Feet
750 to 22,000 volts	20 Feet
22,000 to 50,000 volts	22 Feet

For voltages over 50,000 volts, increase clearance 1/2 inch for each 1000 volts over 50,000.

(b) Transportation Operations Plan. The Contractor shall provide weekly written verification that the TO requirements are enforced throughout the work. The TO shall provide the following:

1. Procedures to respond to traffic incidents that may occur in the work zone and restore normal project operations
2. Details of the process to review incidents for the purpose of modifying the TCP to reduce the frequency and severity of such incidents.
3. Other procedures the Contractor deems necessary to maintain traffic operations.
4. A post-closure evaluation report shall be completed by the Contractor and submitted at project acceptance. The report shall include cause and impact of delays, actions taken to mitigate incidents, why expected delays were exceeded, and how the situation can be avoided in the future.

(c) Public Information. Public information requirements will be specified in a Project Special Provision titled Revision of Section 626 – Public Information Services.

630.11 Traffic Control Management. The contractor shall designate an individual, other than the superintendent, to be the Traffic Control Supervisor (TCS). The Traffic Control Supervisor shall be certified as a worksite traffic supervisor by an authorized entity and shall have a current flagger certification from an authorized entity.

A copy of the Traffic Control Supervisor's certifications shall be provided to the engineer at the pre-construction conference and shall be available at all times on the worksite.

The contractor’s superintendent, and all others serving in a similar supervisory capacity, shall have completed an approved traffic control supervisor training as offered by the authorized entities. The certifications of completion or certifications of achievement for all appropriate staff shall be submitted to the engineer at the pre-construction conference.

The Traffic Control Supervisor’s duties shall include:

(1) Preparing, revising, and implementing each required Method of Handling Traffic (MHT) per the traffic control plan.

(2) Directly supervising project flaggers.

(3) Managing work zones at the direction of the prime contractor for all traffic control operations, including those of subcontractors and suppliers that required traffic control operations.

(4) Working with the prime contractor to ensure proper notification of traffic control activities with appropriate police, fire, and emergency responder agencies.

(5) Preparing a daily traffic control diary and submitting it to the engineer within 24 hours of the work date. Work may be suspended pursuant to subsection 105.01 when diaries have not been submitted as required. The diary shall include the following information as a minimum:

- Date.
- The time of the traffic control inspection.

- Project number.
- Traffic control supervisor's name and signature.
- Description of all traffic control operations currently in place (lane closures, shoulder closures, pilot car operations, detours, etc.), including location, setup, and takedown time, and approved MHT number.
- Types and quantities of traffic control devices used per the approved MHT.
- List of flaggers and Uniformed Traffic Control (UTC) used, including the flaggers name, start time, stop time, flagger locations, and the number of flagging hours and UTC hours used.
- Traffic control problems (traffic accidents, damaged, missing, or dirty devices) and corrective action taken.
- Non-work time inspection notes, including non-work time designation, time of inspection, and corrective actions taken.

(6) Inspect all traffic control devices daily, whether in use, masked, or turned away from traffic. These inspections shall include at least one non-work time inspection (daytime inspection for primarily night work or nighttime inspection for primarily day work) per week *if traffic control devices are present on the roadway.* The TCS or another representative who is certified as a worksite traffic supervisor shall perform these inspections. The engineer may initiate a safety standdown for failure to complete any daily or nighttime inspections.

(7) Ensuring that traffic control devices are functioning as required.

(8) Overseeing all requirements covered by the contract that contribute to the convenience, safety, and orderly movement of traffic. Have an up-to-date copy of the MUTCD, in-use fully signed copies of MHTs, and applicable standards and specifications available at all times on the project.

(9) Attending the weekly safety, scheduling, and/or project meetings. If an additional TCS is required to perform TCM during these meetings, the cost of the additional TCS will be incidental to the work.

(10) Supervising the cleaning and maintenance of all traffic control devices.

A certified worksite traffic supervisor shall be responsible for traffic control management (TCM) on a 24-hour-per-day basis. The TCS or authorized designee shall be on the work site at all times when TCM is performed. The TCS shall be on call at all times. Upon request of the engineer, the TCS may be required to be on the project site at times other than normal working hours. During non-work periods, the TCS shall respond to the job site within 45 minutes of notification. The TCS may appoint a qualified representative to serve as the TCS for periods of time as approved by the engineer. The qualified representative shall be certified as a TCS and shall assume all duties and responsibilities of the TCS. The contractor shall maintain a 24-hour telephone number at which the TCS can be contacted. The TCS shall not act as a flagger except in an emergency or in relief for short periods of no more than 15 minutes per hour for scheduled flagger breaks.

Each designated TCS shall have a flagger assigned to them to assist in their duties at all times as a TCS/TCS trainee (flagger) pair. The TCS trainee shall have a current flagger certification from an authorized entity. The TCS trainee shall not be allowed to give breaks to other flaggers, unless approved by the Engineer.

- The duties assisting a TCS shall include:
- Assisting in TCS duties 5f, 5g, 5.h, 5.i, 6, 7, and 10 above.
- Assisting in revising and implementing each required MHT, per the traffic control plan.
- Performing as a spotter for the TCS.

The flagger cannot perform any other TCS duties and cannot assist without a TCS present.

630.12 Temporary Masking Signs. Sign legend or portions thereof that conflict with the construction signing or Traffic Control Plan shall be completely covered by the Contractor so that none of the covered sign or legend is visible to traffic.

If the whole sign is to be covered, it shall be covered with a nontransparent material that covers the entire face of the sign.

If partial legend is to be covered, it shall be with a material furnished with reflective sheeting conforming to Section 713 and shall be the same color as the masked panel.

All covering materials shall be plywood, hard-board, sheet metal, aluminum, corrugated polypropylene or rigid plastic, and shall be durable enough to resist deterioration due to weathering and atmospheric conditions for the duration of the project. Examples are aluminum at least 0.040 inch thick, corrugated polypropylene board, and plywood at least 3/8 inch thick. Adhesives, glues, tapes, or mechanical fasteners that mar the face of the panel to be masked shall not be used.

630.13 General. Portable construction traffic signs shall be removed when not required. Permanently mounted construction traffic signs shall be masked or turned away from traffic when not required. When work is suspended, or the project is in free time, and there is no condition requiring traffic control devices or construction traffic signs, all of the construction traffic signs shall be masked or turned away from traffic. If this condition is to exist for more than 30 days, all construction traffic signs shall be removed. When storing portable signs or supports within the project they shall be removed beyond the clear zone and shall not be visible to traffic. The minimum clear zone distance shall be 18 feet, measured from the edge of traveled way. If the signs cannot be stored at least 18 feet from the traveled way, they shall be removed. Signs shall not be stored on the paved surface. All storage areas shall be approved. When masking is used, it shall be done per subsection 630.12.

Perforated square metal tubing or U-channel shall be installed for temporary sign supports according to the manufacturer's recommendations and as shown on the Plans.

The Contractor shall be responsible for all maintenance of the signs and posts. If a sign or post is damaged during construction, the contractor shall be responsible for replacing and maintaining the sign and posts at no additional cost to the Project.

The construction traffic signs for reduced speed limit signs and double fines signs shall be placed, or unmasked, no sooner than four hours before the start of work activities. The time when the double fine signing is to be placed or unmasked and location of the reduced speed limit signs and double fine signs shall be as shown on the plans or as directed by the Engineer.

Double fine signing shall be removed or masked as soon as work activities are completed. Work activities are defined as all construction and maintenance activities where workers are present in the clear zone, or there are existing hazards in the travel way, shoulders, or clear zones. Hazards include but are not limited to workers, equipment, drop offs, lane closures,

temporary guardrail, and other objects, both in the roadway and the adjacent roadside, that may affect the traveling public.

The retroreflective surfaces of all signs and other traffic control devices shall be cleaned as frequently as necessary to preserve their legibility and retroreflectivity. However, all devices shall be cleaned a minimum of once every two weeks.

Vertical panels fabricated with vehicle wheel rims, and steel drum channelizing devices shall not be used.

Channelizing Device (Fixed) shall be attached to the pavement per the manufacturer's recommendations. Anchoring methods or devices that penetrate the surface of the permanent pavement will not be permitted. Upon removal of the device, the roadway surface shall be cleaned, patched, or both as approved by the Engineer.

The flashing beacon shall be installed per subsection 614.09. For solar powered flashing beacons, batteries may be placed in a lockable container attached to a supplemental pole supporting the solar panels that is installed outside the clear zone, or behind guardrail. If it is not possible to place this assembly outside the clear zone or behind guardrail, the batteries shall be placed in a lockable pull box and buried at the base of the pole. Other installations shall be as approved.

The Contractor shall ensure the proper operation of the flashing beacon throughout the duration of the project. If the beacon fails to operate properly, it shall be repaired or replaced at the Contractor’s expense. The Contractor may propose an alternate method by submitting a revised MHT per subsection 630.10 for approval by the Engineer. All additional traffic control devices required during the time that the beacon is being repaired or the MHT is being prepared and reviewed shall be at the Contractor’s expense.

630.14 Flagging and Pilot Car Operation. Flagging and pilot car operation shall be performed as described in the latest edition of part VI of the MUTCD as adopted by CDOT.

All traffic control personnel shall wear all appropriate Personal Protective Equipment (PPE), including safety apparel and hardhats meeting the requirements of the latest version of the International Safety Equipment Association (ISEA)’s “American National Standard for High-Visibility Safety Apparel and Headwear”. Safety apparel shall be labeled as meeting the standard performance for Class 2 or Class 3 risk exposure. The apparel and hardhat background material color shall be either fluorescent orange-red or fluorescent yellow-green as defined in the standard. The retroreflective material shall be either orange, yellow, white, silver, yellow-green, or a fluorescent version of these colors, and shall be visible at a minimum distance of 1,000 feet.

Nighttime flagging stations shall be illuminated with flood lights unless otherwise approved and shall not be paid for separately.

(a) The Contractor shall provide all flagging throughout the project, necessary to assure proper safety to traffic. All flagging personnel shall have completed the Department's minimum training requirements as per the CDOT Flagger Program for flaggers before starting work on the project.

(b) Reimbursement for flagging shall be limited to the following areas:

1. The entire construction area under contract and for a distance of 500 feet outside the project limits or approach to the project; except if the project consists of two or more sections, the limits will apply to each section individually.
2. Those areas beyond the above-described limits where the Engineer determines the use of flaggers are necessary to provide adequate warning for traffic and the protection of the work zone.
3. A detour provided on the plans or approved by the Engineer for by-passing all or any portion of the construction, irrespective of whether the detour termini are within the project limits.

(c) The cost of all flagging for haul routes from the Contractor's materials sources to the limits of the project shall be at the Contractor's expense.

(d) The authorized duties of flaggers consist of directing the traveling public and the construction traffic that affects the traveling public within the project limits.

When Automated Flagger Assistance Devices (AFAD) are used, one of two methods are approved. Method 1 consists of an AFAD at each end of the Temporary Traffic Control (TTC) zone and method 2 consists of an AFAD at one end of the TTC zone and a flagger at the opposite end. A flagger may simultaneously operate two AFADs only if the Flagger has an unobstructed view of both the AFADs and the approaching traffic in both directions. AFADs shall only be operated by Flaggers who have received training and shall not leave the AFAD unattended at any time while in use.

630.15 Emergency Pull-Off Area (Temporary). The specific locations where emergency pull-off areas will be allowed shall be clearly detailed in the traffic control plans (TCP). The emergency pull-off areas shall be spaced one-half to one mile apart, unless otherwise shown on the TCP.

If the Engineer determines that law enforcement is required, the pull off area shall be extended as shown on the plans.

Temporary pavement material for the pull-off area shall be a minimum of 3 inches thick unless otherwise shown on the plans and may be either PCCP or HMA. If the materials used require that the Contractor provide thickness greater than the minimum to serve the life of the pull-off area, these shall be provided at no additional cost to the project.

Upon completion of the project, the Contractor shall remove the pull-off area and return the shoulder, signing, and earthwork to its original condition, unless otherwise shown on the plans. Materials removed and not designated in the Contract to be salvaged or incorporated into the work shall become property of the Contractor.

All damaged portions of the shoulder, earthwork, landscaping, signing, culverts, and end sections shall be repaired or replaced at the Contractor’s expense.

630.16 Temporary Portable Rumble Strip. Temporary portable rumble strips shall be placed in locations shown on the traffic control plans and shall be removed at the end of each workday, or as approved by the Engineer.

Before placement of the rumble strip, the roadway shall be cleaned to be free of dust, sand, and other materials that may cause slippage. The minimum roadway temperature at the time of installation shall be per the manufacturer’s recommendations.

If the strip slides, it shall be thoroughly cleaned on both sides, and reset onto a clean roadway surface.

A minimum of two temporary portable rumble strips shall be arranged in an array, as shown on the plans. An additional temporary portable rumble strip may be added, as approved by the Engineer.

Damaged or missing rumble strips shall be replaced at the Contractor's expense.

Temporary portable rumble strips shall be used only on roadways with posted speed limits of 75 MPH or less.

Rolling Roadblock.

(a) Rolling Roadblock Plan. The Contractor's Traffic Control Plan (TCP) shall include a roadblock operation plan (Pacing Plan). The Pacing Plan shall outline the Contractor's expected equipment and personnel, law enforcement personnel, an outline of the operation, and include a contingency plan should any of the Contractor's critical equipment break down. The Pacing Plan shall also include the times of the days of the week that Rolling Roadblock activities will be performed, and specific activities and locations for each aspect of the Rolling Roadblock. If there are certain work activities that need to be completed before start of the work anticipated during the rolling roadblock operation, the activities shall be clearly detailed in the Pacing Plan.

Rolling Roadblock operations shall not take place during holidays or special events, as described in the Traffic Control Plan – General, or as directed by the Engineer.

A minimum of two weeks before start of rolling roadblock operations, the Contractor shall provide the date and times that rolling roadblock operations are to begin to the Engineer, the CDOT Region Traffic Engineer, the CDOT Public Information Office, and the Colorado State Patrol. Portable VMS signs shall be displayed one week before work with the messages shown on the plans.

(b) Design Considerations. Contractor design of the Rolling Roadblock shall evaluate the actual distance required for the rolling roadblock operation, based on site-specific features, such as: roadway geometrics, pacing speeds, regulatory speeds, interchange spacing, work duration, availability of law enforcement officers, traffic volumes, and maximum queue length. On-ramps and entrances between the beginning point of the pacing area and the work area shall be blocked using flaggers and traffic control devices until the pilot vehicle has passed. Two-way radios shall be used to provide constant communication to pilot vehicles, contractor's workers, flaggers stationed at on-ramps, and the Engineer.
The starting point of a rolling roadblock operation shall consider the following factors: the speed of the pacing vehicles, the location of entrance ramps, and horizontal and vertical alignment of the facility.

The minimum speed allowed for a rolling roadblock operation shall be 10 mph.

(c) Rolling Roadblock Operation. Before start of the rolling roadblock, the Contractor shall move all equipment not required for this operation to a safe distance away from the pertinent section of roadway.

The TCS shall be present throughout the rolling roadblock operation. Two-way radios shall be provided for constant communication between the Engineer, the TCS, and law enforcement personnel.

METHOD OF MEASUREMENT

630.17 Quantities to be measured for construction traffic control devices shall be the number of units of the various sizes and descriptions listed below.

Table 630-7
SIZING FOR CONSTRUCTION TRAFFIC SIGNS

Panel Size A	Up to 9 Square Feet including Type 1 and Type 2 Barricades
Panel Size B	Over 9 to 16 Square Feet
Panel Size C	Over 16 Square Feet
Special	As shown on the plans

The total number of traffic control devices of each type on the schedule and approved subsequent modified schedules shall be the maximum number approved for payment. Traffic channelizing devices consisting of vertical panels, traffic cones, or drums will be measured by the unit.

Traffic channelizing devices consisting of vertical panels, traffic cones, or drums will be measured by the unit. Barrier (Temporary) will be measured by the linear foot. Barricades will be measured by the number used. Barricade warning lights shall be furnished as a part of this item when required by the Traffic Control Plan (TCP). Advance Warning Flashing or Sequencing Arrow Panels will be measured by the unit according to size.

Temporary Portable Rumble Strips will be measured by the actual number of strips that are used on the project.

The Flashing Beacon (Portable) will be measured as a unit complete in place. Each sign panel will be paid for under the appropriate item. The solar power system for Flashing Beacon (Portable), poles, and lockable container will not be measured and paid for separately but shall be included in the work.

The quantity to be measured for Traffic Control Management will be the number of authorized 24-hour days of active TCM performed by the TCS/TCS Trainee (Flagger) pair or another representative certified as a work site traffic control supervisor. Payment will be made for one day of Traffic Control Management regardless of the number of TCSs required to adequately control the work. An authorized 24-hour day of TCM is each calendar day active traffic control occurs per an approved MHT. This includes activities such as flagging operations, pilot car operations, and setting up or removal of construction zones, shoulder closures, lane closures or detours.

Traffic control devices that are left in place during non-working hours, including configurations such as lane closures, temporary channelization or detours, are not considered active traffic control.

The quantity to be measured for Traffic Control Inspection will be the number of authorized 24-hour days of traffic control inspection (TCI) performed by the TCS/TCS Trainee (Flagger) pair or another representative certified as a worksite traffic control supervisor. An authorized 24- hour day of TCI is each calendar day that traffic control devices, as shown in the MHT are in use, masked, or turned away from traffic on the project, and the only traffic control activity is the inspection of traffic control devices.

Cleaning and maintaining of traffic control devices are not considered traffic control activities subsidiary to the TCM, TCI, or flagging pay items. Cleaning and maintaining devices are included in the Basis of Payment section.

Payment will be made for either Traffic Control Management or Traffic Control Inspection for each calendar day as defined above in 630.18. Payment will not be made for both pay items for the same calendar day.

Work on a night shift that begins before midnight and ends after midnight will be measured by the calendar day that the shift ends.

The quantity to be measured for flagging will be the total number of actual flagging hours that are used as authorized per an approved MHT. Payment will not be made for time spent by flaggers to set up and take down construction traffic control devices. Payment will not be made for additional flaggers necessary to cover flagger break times and shall be included in the cost of the work.

The quantity to be measured for pilot car operation will be the total number of hours that pilot car operation is used as authorized. Hours of flagging and hours of pilot car operation in excess of those authorized shall be at the Contractor's expense.

Emergency Pull-Off Area (Temporary) will be measured by the actual number of pull-off areas that are constructed, maintained, and removed.

When the Contract provides payment for Mobile Pavement Marking Zone on a lump sum basis, it will not be measured but will be paid for as a single lump sum upon satisfactory completion of the work associated with this item.

When the Contract provides payment for Mobile Pavement Marking Zone by the day, it will be measured as the actual number of days that Mobile Pavement Marking Zone is utilized in the project.

AFADs will be measured per device. While an AFAD is in operation, the operating flagger shall not perform other flagging duties except as outlined in Method 2 as defined in Subsection 630.14 and MUTCD Chapter 6. The operator flagger for the AFAD is not paid for separately but included in the cost of the work.

Rolling Roadblock Operation will be measured as the actual number of hours that this operation is used. If measured by the day, Rolling Roadblock Operation will be measured as the actual number of days, or part of, that this operation is used.

Temporary VMS signing will be measured and paid for per Section 630.02.

Emergency Pull-Off Area (Temporary) will be measured by the actual number of pull-off areas that are constructed, maintained, and removed.
When the Contract provides payment for Mobile Pavement Marking Zone on a lump sum basis, it will not be measured but will be paid for as a single lump sum upon satisfactory completion of the work associated with this item. When the Contract provides payment for Mobile Pavement Marking Zone by the day, it will be measured as the actual number of days that Mobile Pavement Marking Zone is utilized in this project.

AFADs will be measured per device. While an AFAD is in operation, the operating Flagger shall not perform other flagging duties except as outlined in Method 1 as defined in Subsection 630.14 and MUTCD Chapter 6.

Rolling Roadblock Operation will be measured as the actual number of hours that this operation is used. If measured by the day, Rolling Roadblock Operation will be measured as the actual number of days, or part of, that this operation is used.

Temporary VMS signing will be measured and paid for per Section 630.

BASIS OF PAYMENT

630.18 Payment for the individual traffic control devices necessary to complete the work shall be full compensation for furnishing, erecting, cleaning, maintaining, resetting, repairing, replacing, moving, removing, and disposing of the construction traffic control devices. All construction traffic control devices that are not permanently incorporated into the project will remain the property of the Contractor.
Construction traffic control devices, as determined by the project Traffic Control Plan (TCP), will be paid for as follows: 50 percent of the accepted amount upon first utilization, an additional 40 percent of the accepted amount when 75 percent of the original contract amount has been earned, and the final 10 percent when the project has been completed per subsection 105.21, exclusive of any maintenance periods. The percent of original contract amount earned will be determined by comparing the amount earned for bid items, other than traffic control devices and mobilization, with the original contract amount minus the amounts bid for traffic control devices and mobilization.

The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Construction Traffic Sign (Panel Size___)	Each
Construction Traffic Sign (Special)	Square Foot
Vertical Panel	Each
Vertical Panel (With Light) (Flashing)	Each
Vertical Panel (With Light) (Steady Burn)	Each
Advance Warning Flashing or Sequencing	
Arrow Panel (____Type)	Each
Drum Channelizing Device	Each
Traffic Cone	Each
Tubular Marker	Each
Channelizing Device (Fixed)	Each
Barrier (Temporary)	Linear Foot
Delineator (Type___) (Temporary)	Each
Barricade (Type___) (Temporary)	Each
Traffic Control Management	Day
Traffic Control Inspection	Day
Flagging	Hour
Pilot Car Operation	Hour
Flashing Beacon (Portable)	Each
Traffic Signal (Temporary)	Lump Sum
Mobile Pavement Marking Zone	Lump Sum
Emergency Pull Off Area (Temporary)	Each
Mobile Pavement Marking Zone	Day
Stackable Vertical Panel	Each
Stackable Tubular Marker	Each
Temporary Portable Rumble Strips	Each
Automated Flagging Assistance Device	Each
Automated Flagging Assistance Device	Day
Rolling Roadblock	Day
Rolling Roadblock	Hour

Construction Traffic Sign (Special) is a project specific sign indicated on the Schedule of Construction Traffic Control Devices.

When Traffic Control Management and Traffic Control Inspection are not pay items, Traffic Control Management will not be paid for separately, but shall be included in the work.

Flagger hand devices will not be measured and paid for separately but shall be included in the work.

Cost of electrical power, including batteries, for all temporary lighting or warning devices shown on the TCP will not be paid for separately but will be considered subsidiary to the item.

Temporary masking signs, including the covering materials and fastening devices, will not be measured and paid for separately but shall be included in the work.

The Contractor may provide larger construction traffic signs than those shown on the plans, if approved; however, payment will be made for the panel size designated.

If the Contractor fails to complete construction within the approved contract time, Payment will not be made for the use of Section 630 pay items for the period of time after expiration of the approved contract time. These items shall be provided at the Contractor's expense.

Cleaning and patching of the roadway after removal of the Channelizing Device (Fixed) will not be paid for separately but shall be included in the work.

Placement, unmasking, removal and masking of reduced speed limit signs and double fines signs, will not be measured and paid for separately but shall be included in the work.

Preparation and implementation of the Traffic Management Plan will not be measured and paid for separately, but shall be included in the work, except for public information services that will be measured and paid for per Section 626 as revised for this project.

Traffic Control Management, vehicles, traffic control devices, and all other work, materials and equipment necessary for the mobile pavement marking zone will not be measured and paid for separately but shall be included in the work.

Flagging required for the mobile pavement marking zone will be measured and paid for separately.

Payment for Emergency Pull-off Area (Temporary) will be full compensation for all work, materials, and equipment necessary to construct, maintain and remove the emergency pull-off area including: HMA or PCCP required for constructing the temporary pull-off area; temporary concrete barriers, impact attenuators and other traffic control devices; construction signing; and maintaining the temporary pavement.

Payment for Temporary Portable Rumble Strips will be full compensation for all work and material required to complete the item including: cleaning the roadway surface, installing the rumble strip, maintaining the strip through the duration of each day's use (including cleaning and resetting of the strip if it slides), removal at the end of each workday, and final removal. Signing required for the rumble strip will be measured and paid for under the construction signing items.

Construction signing will be measured and paid for under the appropriate construction signing items.

Portable Variable Message Signs (VMS) will be measured and paid for per the project special provision, Revision of Section 630, Portable Message Sign Panel.

Traffic control officers and vehicles will be paid for per the project special provision, Revision of Section 630, Uniformed Traffic Control.

Flaggers will be paid for under Pay Item 630, Flagging.

Two-way radios will not be measured and paid for separately but shall be included in the work.

Temporary concrete barrier walls, if required, will not be measured and paid for separately but shall be included in the work.

SECTION 641

SHOTCRETE

DESCRIPTION

641.01 This work consists of constructing pneumatically applied concrete onto designated surfaces at locations and thicknesses with the lines and dimensions shown on the plans or as designated by the Engineer.

MATERIALS

641.02 Shotcrete proportioning and placement shall comply with the requirements of ACI 506.2, "Specifications for Materials, Proportioning and Application of Shotcrete," and the requirements of Section 601 (Class Shotcrete)

Pre-packaged material shall meet the requirements of ASTM C1480 and meet the sulfate resistance requirements listed in the general notes.

The maximum aggregate size in shotcrete shall be 1/2 inch.

When specified, steel fibers shall be incorporated into the mixture. Steel fibers shall conform to the requirements of ASTM C1116, Type I, Section 4.1.1.

When specified, polypropylene fibers shall be incorporated into the mixture. Polypropylene fibers shall have a nominal length of 3/4 inch and shall conform to the requirements of ASTM C1116, Type III, Section 4.1.3.

641.03 Submittals. The following documents and shop drawings shall be submitted per subsection 105.02. Shotcrete shall not be placed on the project before the submittals have been reviewed and approved by the Engineer.

(a) Mix Design. A shotcrete mix design meeting the requirements of subsection 601.05.

(b) Shotcrete Application Method Statement. The Shotcrete Application Method Statement shall indicate dry-mix process or wet-mix process and shall include drawings and notes describing equipment, procedures and sequences for shotcrete production, application, curing plan, and applicable manufacturer's literature and recommendations.

The Shotcrete Application Method Statement shall also include written documentation that verifies the qualifications of the nozzlemen that will be performing the work. All nozzlemen shall have had at least one year of experience in the application of shotcrete and hold a current certification for ACI Shotcrete Nozzleman for the methods and orientations to be used.

(c) Process Control (PC) Plan. The PC Plan shall address the following:

1. Procedures for identifying the strength of the placed shotcrete.
2. Procedures for determining the thickness of the placed shotcrete.
3. Plan for pre-construction testing as described in the plans.
4. Surface preparation.
5. Curing method.

6. Cold and hot weather placement procedures.
7. PC testing and inspection personnel.
8. PC testing frequency.
9. PC testing criteria.
10. Excavation plan addressing minimum compressive strength required before continuing with excavation.
11. Procedures to control excavation, and a plan for filling voids in over-excavated areas.
12. Plan for multiple shotcrete layers and applications where applicable.

(d) Architectural Application. When an architectural application is specified, the Contractor shall submit the following for approval by the Engineer before full production:

1. A test panel of the shotcrete application with the date of application.
2. Where a coloring process is required, a sample color concrete chip and appropriate technical information on the proposed pigment, colorants, or photo-reactive stains.

CONSTRUCTION REQUIREMENTS

641.04 General. Shotcrete shall be applied at the locations and to the thicknesses shown on the plans. The thickness of shotcrete shall not be less than the dimensions shown on the plans.

Acceptable shotcrete shall consist of a dense and uniform mixture without rebound, inclusions, segregation, or discernible weakness of bond between the rock or structure and the shotcrete. Acceptance will be based on the requirements of subsection 641.06 and the visual inspection and sounding of the shotcrete. Shotcrete that exhibits movement or settlement after placement while still in the plastic state shall be repaired or replaced at the Contractor's expense. Applications that are deemed by the Engineer to be unacceptable shall also be repaired or replaced at the Contractor's expense.

For rock and soil cuts, surfaces shall be prepared to the line and grade shown on the plans. The Contractor shall provide documentation, including survey data, to show that the excavated face conforms to the plans so that the minimum thickness is achieved. If the Engineer determines that irregularities are excessive, additional reinforcing may be required. All costs associated with additional shotcrete required to bring an over excavated cut to the proper line and grade shall be borne by the Contractor. The Contractor shall fill all voids, holes, or pits created during the excavation process. Where additional shotcrete in excess of the plan thickness is required to make the final shotcrete face conform to the plans, the Contractor shall provide a plan and method statement for applying the additional shotcrete. The work shall not proceed until the proposed plan and methods have been reviewed and approved by the Engineer.

A light application of water may be used to clean the surface of all dry soil or rock surfaces before application of the shotcrete.

Shotcrete shall not be applied to frozen surfaces. De-icing compounds shall not be used to thaw ice, snow, or frost.

Before patching concrete structures, loose material shall be removed, and surfaces shall be dampened to a saturated surface dry condition. Before the placement of new shotcrete, the Contractor shall sandblast exposed reinforcing steel clean.

Rebound shall be removed and disposed of by the Contractor. Rebound shall not be worked back into the surface and shall not be salvaged and included in later batches.

Weep holes and the drainage system shall be installed as shown on the plans.

Where reinforcement fibers are required, the fibers shall be uniformly dispersed in the shotcrete. Production shall be suspended when visible fiber clumps are observed.

When multiple layers of shotcrete are to be applied, each layer of shotcrete shall be cleaned. If curing compound is used the curing compound shall be removed by sandblasting or a method approved by the Engineer.

641.05 Curing Shotcrete. Curing shall be per subsection 601.13 and shall include the following:

Film curing with polyethylene sheeting may be used to supplement water curing. The Contractor shall spray the shotcrete surface with water immediately before installation of the polyethylene sheeting. Polyethylene sheeting shall completely cover the surfaces and the Contractor shall overlap the sheeting edges. Joints between sheets shall be sealed. The Contractor shall promptly repair any tears, holes, and other damage. Anchor sheeting shall be installed as necessary to prevent billowing.

The minimum curing period shall be determined by one of the following methods.

(1) The minimum curing period shall be seven days.

(2) The minimum curing period shall be from the time the shotcrete has been placed until the shotcrete has met a compressive strength of 80 percent of the required field compressive strength. Compressive strength shall be determined by coring information panels. Information panels shall be constructed by the Contractor on the final portion of a placement and stored as close to the structure as possible. If the information panels are lost, mislabeled, damaged or destroyed in the field, the minimum curing period shall be seven days.

(3) The minimum curing period shall be from the time the shotcrete has been placed until the shotcrete has met a compressive strength of 80 percent of the required field compressive strength. The Contractor shall develop a maturity relationship for the shotcrete mix design per CP 69. The Contractor shall provide the maturity meter and all necessary thermocouples, thermometers, wires and connectors. The Contractor shall be responsible for the placement, protection and maintenance of the maturity meters and associated equipment. Locations where the maturity meters are placed shall be protected in the same manner as the rest of the shotcrete. The Contractor shall install the thermocouples at locations designated by the Engineer. The Contractor shall monitor the temperature at intervals acceptable to the Engineer. If the maturity meter malfunctions, the minimum curing period shall be seven days.

All costs associated with curing shall be at the Contractor's expense. The curing period may be stopped when succeeding layers of shotcrete are to be placed.

When the ambient temperature is expected to fall below 35 °F during the curing period the Contractor shall maintain the shotcrete internal temperature above 50 °F during the curing period. The Contractor shall monitor the internal shotcrete temperature by the use of maturity meters or high/low thermocouples. Maturity meter probes or thermocouples shall be located 2 feet from the edge of the final portion of shotcrete placed for the day and be located at mid-depth of the layer.

The Contractor shall determine the necessity for undertaking protective measures. Maturity meters, thermocouples and information panels will not be measured or paid for separately but shall be included in the work.

Enclosures with artificial heat sources will be permitted. If enclosures are used the Contractor shall monitor the structural integrity of the enclosure. Artificial heat sources shall not be placed in such a manner as to expose any area of shotcrete to drying due to excessive temperatures. At the end of the curing period, the protection shall remain in place until it can be removed without allowing the shotcrete temperature to fall more than 50 °F in a 24-hour period. Sudden changes of shotcrete temperature shall be prevented.

The following procedures shall be followed if the temperature of the shotcrete structure falls below 32 °F before the minimum curing period is complete:

(1) The Contractor shall take cores following the procedures of ASTM C1604 at locations designated by the Engineer.

(2) The Engineer will take immediate possession of the cores and submit the cores for a petrographic examination per ASTM C856.

(3) All costs associated with coring, transmittal of cores, and petrographic examination shall be borne by the Contractor regardless of the outcome of the petrographic examination.

(4) Shotcrete damaged by frost as determined by the petrographic examination shall be removed and replaced at the Contractor's expense.

(5) The Contractor shall patch areas used for sampling and testing immediately after samples have been removed.

641.06 Acceptance.

(a) Test Panels. A test panel shall be produced for each mix and each workday. When more than 50 cubic yards of a shotcrete mixture has been placed in a day, a test panel shall be produced for every 50 cubic yards or fraction thereof. Test panels shall be produced per ASTM C1140 Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels. Test panels shall be constructed in the same manner as that being used on the project, including distance from nozzle, angle and orientation. Test panels shall be cured in similar conditions to what is anticipated in the field and shall be field cured until test specimens are taken.

(b) Field Compressive Strength. The field compressive strength shall be determined from at least three test specimens from each test panel per ASTM C1140 and tested at 28 days. The Contractor shall remove test specimens and immediately give them to the Engineer. The Contractor shall remove the test specimens between 25 and 27 days of age. The test specimens shall be stored in watertight plastic bags and labeled with the project number, test panel number and date of placement. If the 28-day compressive strength does not meet the required strength, the Contractor may take additional cores from the test panel to be tested at 56 days. The Contractor shall remove the 56-day test specimens between

53 and 55 days of age. Shotcrete will be evaluated for acceptance and price reduction per subsection 601.17.

(c) Noted Deficiencies. When shotcrete exhibits segregation, honeycombing, delamination, or excessive cracking, the following procedures shall be applied:

1. The Contractor shall take cores following the procedures of ASTM C1604 at locations designated by the Engineer. The shotcrete shall be at least 28 days old. A set of three cores will be taken for each 100 square feet of shotcrete. Cores containing reinforcing steel shall not be tested.
2. The Engineer will take immediate possession of the cores and test the cores for compressive strength. A core that breaks during coring operations such that it cannot be tested per ASTM C1604 will be assigned a compressive strength of 0 psi.
3. If a set of cores does not produce an average strength of 4,500 psi, the shotcrete represented by the cores shall be removed and replaced at the Contractor's expense.
4. All costs associated with coring shall be at the Contractor's expense, regardless of the outcome.
5. The Contractor shall patch areas used for sampling and testing immediately after samples have been removed.

METHOD OF MEASUREMENT

641.07 Shotcrete will be measured by the actual number of square yards applied and accepted. The quantity will be determined by the Engineer. There will be no increase of pay if the thickness exceeds the required minimums shown on the plans.

Initial Shotcrete Facing for soil nail wall, including the shotcrete steel and mesh reinforcement used for the temporary facing, will be measured by the actual square feet of shotcrete that is applied to the depth shown on the plans. Square feet of wall will be determined using the height measured at 20-foot maximum intervals along the wall layout line.

BASIS OF PAYMENT

641.08 The accepted quantities will be paid for at the contract unit price per square yard for each of the items listed below that appear in the bid schedule: Pay ItemPay Unit

Shotcrete	Square Yard
Shotcrete Sculpting	Square Yard
Initial Shotcrete Facing	Square Foot

Payment will be full compensation for all work, materials, and equipment required to complete the item including submittals, test panels, test specimens, samples, pigment, fiber, drainage system and maturity meters.

Shotcrete that is sculpted will be measured and paid for as Shotcrete Sculpting. The architectural surface treatment shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in providing architectural surface treatment complete in place, including the test panels, line layout and all supporting metal bracing and support as specified in the Contract.

Test panels for shotcrete sculpting will not be measured and paid for separately but shall be included in the work.

Line layout and metal bracing for shotcrete sculpting will not be measured and paid for separately but shall be included in the work.

DIVISION 700
MATERIALS DETAILS

SECTION 701
HYDRAULIC CEMENT

701.01 Hydraulic Cement. Hydraulic cement shall conform to the requirements of the following specifications for the type specified or permitted:

Portland Cement	ASTM C150
Blended Hydraulic Cement	ASTM C595

All concrete, including precast, prestressed and pipe shall be constructed with one of the following hydraulic cements unless permitted otherwise.

ASTM C150 Type I
ASTM C150 Type II
ASTM C150 Type V
ASTM C595 Type IL(MS)
ASTM C595 Type IL(HS)
ASTM C595 Type IP
ASTM C595 Type IP(MS)
ASTM C595 Type IP(HS)
ASTM C595 Type IT(MS)
ASTM C595 Type IT(HS)

Cement shall be from a preapproved source listed on the Department's Approved Products List.

The cement shall be subject to sampling and testing by the Department. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of the cement until the corrections necessary have been taken to ensure that the material meets the specifications.
The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement that has become partially set or that contains lumps of caked cement shall not be used.

Cement salvaged from discarded or used bags shall not be used.

701.02 Fly Ash.

Fly ash for concrete shall conform to the requirements of ASTM C618, Class C or Class F with the following exceptions:

(1) The loss on ignition shall not exceed 3.0 percent.

(2) The CaO in Class F fly ash shall not exceed 18 percent.

Blending of pozzolans according to ASTM D5370 is permitted to meet the requirements of ASTM C618.

Fly ash shall be from a preapproved source listed on the Department's Approved Products List.

Preapproval shall include submission of a report from the supplier documenting the results of testing the fly ash from that source per the Toxicity Characteristic Leaching Procedure (TCLP) described in 40 CFR 261, Appendix II. The report shall include the results of TCLP testing for heavy metals and other contaminants found in the fly ash. The report shall list the contaminants tested, and the allowable levels for each contaminant tested. A new report shall be submitted for each preapproved source annually. Additional TCLP testing may be required when the Department suspects that the fly ash source may have been contaminated.

The fly ash shall be subject to sampling and testing by the Department. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of fly ash until the corrections necessary have been taken to ensure that the material meets the specifications.

701.03 Silica Fume. Silica fume for concrete shall conform to the requirements of ASTM C1240.

Silica Fume shall be from a preapproved source listed on the Department's Approved Products List.

The silica fume shall be subject to sampling and testing by the Department. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of the silica fume until the corrections necessary have been taken to ensure that the material meets the specifications.

701.04 High-Reactivity Pozzolans. High-Reactivity Pozzolans (HRP) shall conform to the requirements of AASHTO M 321. HRPs include but are not limited to metakaolin, rice hull ash, zirconium fume, ultra-fine fly ash, and fume from the production of 50 percent ferrosilicon (with SiO_2 less than 85 percent).

HRPs shall meet the following optional requirement of AASHTO M 321: The sulfate expansion at 14 days shall not exceed 0.045 percent.

HRP shall be from a preapproved source listed on the Department's Approved Products List.

The HRP shall be subject to sampling and testing by the Department. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of HRP until the necessary corrections have been taken to ensure that the material conforms to the specifications.

701.05 Slag Cement. Slag cement shall conform to the requirements of ASTM C989. Slag cement shall be Grade 100 or Grade 120. Slag cement shall have a maximum Aluminum Oxide content of 11.0 percent.

Slag cement shall be from a pre-approved source listed on the Department's Approved Products List.

Slag Cement shall be subject to sampling and testing by the Department. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of Slag Cement until the necessary corrections have been taken to ensure that the material conforms to the specifications.

SECTION 702
BITUMINOUS MATERIALS

702.01 Asphalt Cements.

(a) Superpave Performance Graded Binders. Superpave Performance Graded Binders shall conform to the requirements listed in Table 702-1. (Taken from AASHTO M 320)

Asphalt cement shall not be acid modified or alkaline modified.

Asphalt cement shall not contain any used oils that have not been rerefined. Modifiers that do not comply with environmental rules and regulations including 40 CFR Part 261.6(a) (3) (IV), and part 266/Subpart C shall not be added. Modifiers shall not be carcinogenic.

The supplier of the PG binder shall be certified per CP 11.

Table 702-1
SUPERPAVE PERFORMANCE GRADED BINDERS

Requirement For PG Binder - Original Binder Properties

Property	58-28	58-34	64-22	64-28	70-28	76-28	AASHTO Test No.
Flash Point Temp., °C, minimum	230	230	230	230	230	230	T 48
Viscosity at 135 °C, Pa●s, maximum	3	3	3	3	3	3	T 316
Dynamic Shear, Temp. °C, where G*/Sin δ @ 10 rad/s ≥ 1.00 kPa	58	58	64	64	70	76	T 315
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	50		-	T 51
Toughness, joules (inch-lb)	-	-	-	12.4 (110)		-	CP-L 2210
Tenacity, joules (inch-lb)	-	-	-	8.5 (75)		-	CP-L 2210
Acid or Alkali Modification (pass-fail)	Pass	Pass	Pass	Pass	Pass	Pass	CP-L 2214

Table 702-1
SUPERPAVE PERFORMANCE GRADED BINDERS (continued)

Requirement For PG Binder - RTFO Residue Properties, CPL-L 2215

Property	58-28	58-34	64-22	64-28	70-28	76-28	AASHTO Test No.
Mass Loss, percent maximum	1	1	1	1	1	1	CP-L 2215
Dynamic Shear, Temp. °C, where G*/Sin δ @ 10 rad/s ≥ 2.20 kPa	58	58	64	64	70	76	T 315
Elastic Recovery, 25 °C, percent min.	-	-	-	-	50	50	T 301
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	20	-	-	T 51

Requirement For PG Binder - PAV Residue Properties, Aging Temperature 100°C, R 28

Property	58-28	58-34	64-22	64-28	70-28	76-28	AASHTO Test No.
Dynamic Shear, Temp. °C, where G*●Sin δ @ 10 rad/s ≤ 6000 kPa	19	16	25	22	25	28	T 315
Creep Stiffness, @ 60 s, Test Temperature in °C	-18	-24	-12	-18	-18	-18	T 315
S, maximum, MPa	300	300	300	300	300	300	T 313
m-value, minimum	0.3	0.3	0.3	0.3	0.3	0.3	T 313

Acceptance Samples of the PG binder will be taken on the project per the Schedule in the *Field Materials Manual*.

The Department will test for acid modification and alkaline modification during the binder certification process. Thereafter, the Department will randomly test for acid modification and alkaline modification.

(b) Dampproofing. Asphalt for dampproofing shall conform to the requirements of ASTM D449, and the asphaltic primer shall conform to the requirements of ASTM D41.

702.02 Emulsified Asphalts. Emulsified asphalts shall conform to AASHTO M 140 or M 208 for the designated types and grades. Emulsified asphalt and aggregate used for surface seals shall be sampled and will be tested for information only per CP-L 2213.

Emulsified asphalt (HFMS-2S) with a residual penetration greater than 300 dmm (0.1 mm) shall conform to all properties listed in AASHTO M 140, Table 1 except that ductility shall be reported for information only.

(a) Emulsion for Tack and Fog Coats. Emulsions for tack and fog coats shall conform to the requirements listed in Table 702-2 or 702-3, before dilution.

Table 702-2
TACK AND FOG COAT EMULSIONS

Tests on Emulsion

Property	CSS-1h	SS-1h	AASHTO Test No.
Minimum Viscosity, at 25 ºC, Saybolt-Furol, s	Min. 20, max. 100	20	T 59
Maximum Viscosity, at 25 ºC, Saybolt-Furol, s	100	100	T 59
Storage stability, 24 hr, % max.*	1	1	T 59
Particle charge test	Positive		T 59
Sieve test, % max.	0.1	0.1	T 59
Oil Distillate by volume, % max.	3	3	T-59
Residue by distillation/ evaporation, % min. ◂	573	573	T 59/ CP-L 2212#

Tests on Residue

Property	CSS-1h	SS-1h	AASHTO Test No.
Penetration, 25 ºC, 100g, 5s, min., dmm	40	40	T 49
Penetration, 25 ºC, 100g, 5s, max., dmm	120	120	T 49
Ductility, 25 ºC, 5 cm/min, cm, min.	40	40	T 51
Solubility, in trichloroethylene% min.	97.5	97.5	T 44

*If successful application is achieved in the field, the Engineer may waive this requirement.

CP-L 2212 is a rapid evaporation test for determining percent residue of an emulsion and providing material for tests on residue. CP-L 2212 is for acceptance only. If the percent residue or any test on the residue fails to meet specifications, the tests will be repeated using the distillation test per AASHTO T-59 to determine acceptability.

◂ For polymerized emulsions the distillation and evaporation tests will be performed per AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5 ºC (400 ± 10 ºF) maximum temperature to be held for 15 minutes.

(b) Emulsion for Chip Seals. Polymerized emulsions for chip seals shall conform to the requirements listed in Table 702-3. Emulsion for chip seals shall be an emulsified blend of polymerized asphalt, water, and emulsifiers. The asphalt cement shall be polymerized before emulsification and shall contain at least 3 percent polymer by weight of asphalt cement. The emulsion standing undisturbed for a minimum of 24 hours shall show no white, milky separation but shall be smooth and homogeneous throughout. The emulsion shall be pumpable and suitable for application through a distributor.

Table 702-3
POLYMERIZED EMULSIONS FOR CHIP SEALS

Tests On Emulsion

Property	CRS-2	CRS-2P	CRS-2R	HFMS-2P	AASHTO Test No.
Min. Viscosity, at 50 °C, Saybolt-Furol, s	50	50	50	50	T 59
Max. Viscosity, at 50 °C, Saybolt-Furol, s	450	450	450	450	T 59
Storage stability, 24 hr, % max.	1	1	1	1	T 59
Particle charge test	Positive	Positive	Positive		T 59
Sieve test, % max.	0.1	0.1	0.1	0.1	T 59
Demulsibility*, % min.	40	40	40		T 59
Oil Distillate by volume, % max. or range	3	3	3	3	T-59
Residue by distillation/ evaporation, % min ◂	653	653	653	653	T 59/ CP-L 2212#

Tests on Residue

Property	CRS-2	CRS-2P	CRS-2R	HFMS-2P	AASHTO Test No.
Penetration, 25 °C, 100g, 5s, min., dmm	70	70	70	70	T 49
Penetration, 25 °C, 100g, 5s, max., dmm	150	150	150	150	T 49
Ductility, 25 °C, 5 cm/min, cm, min.	40			75	T 51
Ductility, 4 °C, 5 cm/min, cm, min.			40		
Solubility, in trichloroethylene, % min. ▸	97.54	97.54	97.54	97.54	T 44
Elastic Recovery, 25 °C min.				58	T 301
Float Test, 60 °C, s min.				1200	T 50
Toughness, in-lb, min.		70	90		CP-L 2210
Tenacity, in-lb, min.		45	45		CP-L 2210

Notes for Table 702-3

*If successful application is achieved in the field, the Engineer may waive this requirement.

#CP-L 2212 is a rapid evaporation test for determining percent residue of an emulsion and providing material for tests on residue. CP-L 2212 is for acceptance only. If the percent residue or any test on the residue fails to meet specifications, the tests will be repeated using the distillation test in acccordance with AASHTO T-59 to determine acceptability.

◂ For polymerized emulsions the distillation and evaporation tests will be performed per AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5 ºC (400 ± 10 ºF) maximum temperature to be held for 15 minutes.

▸ Solubility may be determined on the base asphalt cement before polymer modification.

(c) Emulsion for Slurry Seals and Micro-Surfacing. Emulsions for slurry seals and micro-surfacing shall conform to the requirements listed in Table 702-4. The modified emulsion shall contain a minimum of 3 percent polymer, SBR latex, or natural latex by weight.

Table 702-4
SLURRY SEAL AND MICRO-SURFACING EMULSIONS

Tests on Emulsion

Property	CQS-1hL	CQS-1hP	AASHTO Test No.
Min. Viscosity, at 25 ºC, Saybolt-Furol, s	15	15	T 59
Max. Viscosity, at 25 ºC, Saybolt-Furol, s	100	100	T 59
Storage stability, 24 hr, % max.*	1.0	1.0	T 59
Particle charge test	Positive	Positive	T 59
Sieve test, % max.	0.10	0.10	T 59
Oil Distillate by volume, % max.	0.5	0.5	T-59
Residue by distillation/ evaporation, % min. ◂	62 ◂	62 ◂	T 59/CP-L 2212#

Tests on Residue

Property	CQS-1hL	CQS-1hP	AASHTO Test No.
Penetration, 25 ºC, 100g, 5s, min., dmm	40	40	T 49
Penetration, 25 ºC, 100g, 5s, max., dmm	150	150	T 49
Ductility, 25 ºC, 5 cm/min, cm, min.	50	50	T 51
Solubility, in trichloroethylene% min.	97.5	97.5	T 44

Table 702-4 Notes:
*If successful application is achieved in the field, the Engineer may wave this requirement.

CP-L 2212 is a rapid evaporation test for determining percent residue of an emulsion and providing material for tests on residue. CP-L 2212 is for acceptance only. If the percent residue or any test on the residue fails to meet specifications, the tests will be repeated using the distillation test per AASHTO T-59 to determine acceptability.

◂ For polymerized emulsions the distillation and evaporation tests will be performed per AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5 ºC (400 ± 10 ºF) maximum temperature to be held for 15 minutes.

(d) Emulsion for Prime Coat. Emulsion for prime coat shall conform to the requirements of Table 702-5. Circulate before use if not used within 24 hours.

Table 702-5
ASPHALT EMULSION FOR PRIME COAT (AEP)

Property	Requirement	AASHTO Test No.
Viscosity, Saybolt-Furol, at 50 °C (122 °F), s	20-150	T 59
% Residue	65% min.	T 59, to 260 °C, (500 °F)
Oil Distillate by Volume, %	7% max.	T59

Tests on Residue from Distillation

Property	Requirement	AASHTO Test No.
Solubility in Trichloroethylene, %	97.5 min.	T 44

(e) Recycling Agent. Recycling Agent for Item 406, Cold Bituminous Pavement (Recycle), shall be either a high float emulsified asphalt (polymerized) or an emulsified recycling agent as follows:

1. High Float Emulsified Asphalt (Polymerized). High Float Emulsified Asphalt (Polymerized) for Cold Bituminous Pavement (Recycle) shall be an emulsified blend of polymer-modified asphalt, water, and emulsifiers conforming to Table 702-6 for HFMS-2sP. The asphalt cement shall be polymerized before emulsification and shall contain at least 3 percent polymer.

   The emulsion standing undisturbed for a minimum of 24 hours shall show no white, milky separation, and shall be smooth and homogeneous throughout.

   The emulsion shall be pumpable and suitable for application through a pressure distributor.

Table 702-6
HIGH FLOAT EMULSIFIED ASPHALT
(POLYMERIZED) (HFMS-2sP)

Tests on Emulsion

Property	Minimum Requirement	Maximum Requirement	AASHTO Test No.
Viscosity, Saybolt-Furol at 50 °C (122 °F), sec	50	450	T 59
Storage Stability test, 24 hours, %		1	T 59
Sieve test, %		0.10	T 59
Residue, %*	65		T 59
Oil distillate by volume, %	1	7	T 59

Tests on Residue

Property	Minimum Requirement	Maximum Requirement	AASHTO Test No.
Penetration, 25 °C (77 °F), 100g, 5 sec	150	300#	T 49
Float Test, 60 °C (140 °F), sec	1200		T 50
Solubility in TCE, %	97.5		T 44
Elastic Recovery, 4 °C (39.2 °F), %	50		T 301

Table 702-6 Notes:
*400 ± 10 °F maximum temperature to be held for 15 minutes.

#When approved by the Engineer, Emulsified Asphalt (HFMS-2sP) with a residual penetration greater than 300 dmm may be used with Cold Bituminous Pavement (Recycle) to address problems with cool weather or extremely aged existing pavement. Emulsified Asphalt (HFMS-2sP) with a residual penetration greater than 300 dmm shall meet all properties listed in Table 702-6 except that Elastic Recovery shall be reported for information only.

2. Emulsified Recycling Agent. Emulsified Recycling Agent for use in Cold Bituminous Pavement (Recycle) shall conform to the requirements in Table 702-7.

Table 702-7
EMULSIFIED RECYCLING AGENT

Tests on Emulsion

Property	Minimum Requirement	Maximum Requirement	Test
Viscosity @ 25 °C, SFS	20	200	ASTM D244
Pumping Stability	Pass		GB Method*
Sieve Test, %w		0.1	ASTM D244#
Cement Mixing, %w		2.0	ASTM D244
Particle Charge	Positive		ASTM D244
Conc. Of Oil Phase	64		ASTM D244 ◂

Tests on Residue

Property	Minimum Requirement	Maximum Requirement	Test
Viscosity @ 60 °C, CST	2000	4000	ASTM D2170
Flash Point, COC, °C (° F)	232		ASTM D92
Maltenes Dist. Ratio ▸ $\frac{PC+A_1}{S+A_2}$	0.3	0.6	ASTM D2006
PC/S Ratio	0.4		ASTM D2006
Asphaltenes, % max.		11.0	ASTM D2006

Table 702-7 Notes:

*Pumping stability is determined by charging 450 ml of emulsion into a one-liter beaker and circulating the emulsion through a gear pump (Roper 29.B22621) having a 6.3 mm (1/4 inch) inlet and outlet. The emulsion passes if there is no significant separation after circulating10 minutes.

#Test procedure identical with ASTM D244 except that distilled water shall be used in place of 2 percent sodium oleate solution.

◂ ASTM D244 Evaporation Test for percent of residue is modified by heating 50-gram sample to 149°C (300 °F) until foaming ceases, then cooling immediately and calculating results.

▸ In the Maltenes Distribution Ratio Test by ASTM Method D2006.

PC = Polar Compounds S = Saturates

A_1 = First Acidaffin A_2 = Second Acidaffins

(f) Asphalt Rejuvenating Agents. Asphalt rejuvenating agents (ARA) shall be composed of a petroleum resin-oil base uniformly emulsified with water and shall conform to the physical and chemical requirements of Table 702-8 or ASTM D4552.

Table 702-8
ASPHALT REJUVENATING AGENT

Property	Test Method	Requirement
Viscosity, S.F., @ 25 °C (77 °F), s	ASTM D244	20-40
*Residue, % min.	ASTM D244	60-65
#Miscibility Test	ASTM D244	No coagulation
◂ Sieve Test, % max.	ASTM D244	0.10
Particle Charge Test	ASTM D244	Positive

ASTM D244 (Mod)

Property	Test Method	Requirement
Viscosity, 60 °C (140 °F), mm^2/s	ASTM D445	100 - 200
Flash Point, COC, °C, min.	ASTM D92	196
Asphaltenes, % max.	ASTM D2006	1.0
▸ Maltenes Dist. Ratio $\frac{PC+A_1}{S+A_2}$	ASTM D2006	0.3-0.6
Saturated Hydrocarbons, %	ASTM D2006	21-28

Table 702-8 Notes:
*ASTM D244 Modified Evaporation Test for percent of residue is made by heating 50-gram sample to 149 °C (300 °F) until foaming ceases, then cooling immediately and calculating results.
#Test procedure identical with ASTM D244 except that 0.02 Normal Calcium Chloride solution shall be used in place of distilled water.
◂ Test procedure identical with ASTM D244 except that distilled water shall be used in place of 2% sodium oleate solution.
▸ In the Maltenes Distribution Ratio Test by ASTM Method D4124:
PC = Polar Compounds S = Saturates
A_1 = First Acidaffin A_2 = Second Acidaffins

For hot-in-place recycling ARA-1P is an acceptable alternative to ARA. ARA-1P shall meet the requirements below:

Emulsified Polymer Modified Asphalt Rejuvenating Agent (ARA-1P) for use in hot-in-place recycling of bituminous pavements shall be modified with a minimum of 1.5 percent styrene-butadiene solution polymer. The finished product shall conform to the physical requirements listed in Table 702-9 below.

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Table 702-9
ARA 1P

Test on Emulsion

Property	Test Method	Min	Max
Viscosity, Saybolt-Furol @ 77 ºF, s	ASTM D244		100
Residue @ 350 ºF, %	ASTM D244 Mod	60	
Sieve Test, %	ASTM D244		0.10
Oil distillate, %	ASTM D244		2.0

Test on Residue

Property	Test Method	Min	Max
Penetration @ 39.2 ºF, 100g, 5s, dmm	ASTM D5 Modified	150	250
Asphaltenes, %	ASTM D4124		15

702.03 (unused)

702.04 Hot Poured Joint and Crack Sealant. Hot poured material for filling joints and cracks shall conform to the requirements of ASTM D6690, Type II or Type IV. The concrete blocks used in the Bond Test shall be prepared per CP-L 4101.

Sealant material shall be supplied pre-blended, pre-reacted, and prepackaged. If supplied in solid form the sealant material shall be cast in a plastic or other dissolvable liner having the capability of becoming part of the crack sealing liquid. The sealant shall be delivered in the manufacturer's original sealed container.

Each container shall be legibly marked with the manufacturer's name, the trade name of the sealer, the manufacturer's batch or lot number, the application temperature range, the recommended application temperature, and the safe heating temperature.

The sealant shall be listed in CDOT’s Approved Products List before use.

SECTION 703
AGGREGATES

703.00 General All sieve sizes and designations described in this section refer to laboratory sieves having square openings and conforming to ASTM E11.

The grading and composition requirements for coarse and fine aggregates for concrete are set forth in Table 703-1.

Table 703-1
CONCRETE AGGREGATE GRADATION TABLE
Percentage Passing Designated Sieves and Nominal Size Designation

***Coarse Aggregates (from AASHTO M43)**

Sieve Size	*No. 3	*No. 357	*No. 4	*No. 467	*No. 57	*No. 6	*No. 67	*No. 7	*No. 8	Fine Aggregate
	50 mm to 25.0 mm (2" to 1")	50 mm to 4.75 mm (2" to No. 4)	37.5 mm to 19.0 mm (1 1/2" to 3/4")	37.5 mm to 4.75 mm (1 1/2" to #4)	25.0 mm to 4.75 mm (1" to #4)	19.0 mm to 9.5 mm (3/4" to 3/8")	19.0 mm to 4.75 mm (3/4" to #4)	12.5 mm to 4.75 mm (1/2" to #4)	9.5 mm to 2.36 mm (3/8" to #8)	4.75 mm to 150 µm (#4 to #100)
63 mm (2 1/2")	100	100								
50 mm (2")	90-100	95-100	100	100						
37.5 mm (1 1/2")	35-70		90-100	95-100	100					
25.0 mm (1")	0-15	35-70	20-55		95-100	100	100			
19.0 mm (3/4")			0-15	35 - 70		90-100	90-100	100		
12.5 mm (1/2")	0-5	10-30			25-60	20-55		90-100	100	
9.5 mm (3/8")			0-5	10-30		0-15	20-55	40-70	85-100	100
4.75 mm (#4)		0-5		0-5	0-10	0-5	0-10	0-15	10-30	95-100
2.36 mm (#8)					0-5		0-5	0-5	0-10	80-100
1.18 mm (#16)									0-5	50-85
600 µm (#30)										25-60
300 µm (#50)										10-30
150 µm (#100)										2-10

703.01 Fine Aggregate for Concrete. Fine aggregate for concrete shall conform to the requirements of AASHTO M 6, Class A. The minimum sand equivalent, as tested per Colorado Procedure 37 shall be 80 unless otherwise specified. The fineness modulus, as determined by AASHTO T 27, shall not be less than 2.50 or greater than 3.50 unless otherwise approved.

703.02 Coarse Aggregate for Concrete. Coarse aggregate for concrete shall conform to the requirements of AASHTO M 80, Class A, except that the percentage of wear shall not exceed 45 when tested per AASHTO T 96.

703.03Aggregate for Bases. Aggregates for bases except Aggregate Base Course (RAP) shall be crushed stone, crushed slag, crushed gravel, natural gravel, or crushed reclaimed concrete. Aggregate Base Course (RAP) shall be 100 percent crushed recycled asphalt pavement material. All materials except Aggregate Base Course (RAP) shall conform to the quality requirements of AASHTO M 147 except that the requirements for the ratio of minus 75 µm (No. 200) sieve fraction to the minus 425 µm (No. 40) sieve fraction, stated in 3.2.2 of AASHTO M 147, shall not apply

The requirements for the Los Angeles wear test (AASHTO T 96 and ASTM C535) shall not apply to Class 1, 2, and 3. Aggregates for bases shall meet the grading requirements of Table 703-2 for the class specified for the project, unless otherwise specified.

The liquid limit shall be as shown in Table 703-2 and the plasticity index shall not exceed six when the aggregate is tested per AASHTO T 89 and T 90 respectively.

Table 703-2
CLASSIFICATION FOR AGGREGATE BASE COURSE

Mass Percent Passing Square Mesh Sieves

LL not greater than 35

Sieve Size	Class 1	Class 2	Class 3
150 mm (6")			100
100 mm (4")		100	
75 mm (3")		95-100	
60 mm (2 1/2")	100		
50 mm (2")	95-100		
37.5 mm (1 1/2")			
25 mm (1")			
19 mm (3/4")			
4.75 mm (#4)	30-65		
2.36 mm (#8)			
75 μm (#200)	3-15	3-15	20 max.

NOTE: Class 3 material shall consist of bank or pit run material.

LL not greater than 30

Sieve Size	Class 4	Class 5	Class 6	Class 7
150 mm (6")				
100 mm (4")				
75 mm (3")				
60 mm (2 1/2")				
50 mm (2")	100			
37.5 mm (1 1/2")	90-100	100		
25 mm (1")		95-100	100	100
19 mm (3/4")	50-90		95-100	
4.75 mm (#4)	30-50	30-70	30-65	
2.36 mm (#8)			25-55	20-85
75 μm (#200)	3-12	3-15	3-12	5-15

Aggregate Base Course (RAP) shall be 100 percent reclaimed asphalt pavement material conforming to the requirements of Table 703-3

Table 703-3
CLASSIFICATION FOR RECLAIMED ASPHALT PAVEMENT
AGGREGATE BASE COURSE

Mass Percent Passing Square Mesh Sieves

Sieve Size	ABC (RAP)
50 mm (2")	100
25 mm (1")	85-100
19 mm (3/4")	75-100
12.5 mm (1/2")	55-90
9.5 mm (3/8")	45-80
4.75 mm (#4)	25-55
1.18 mm (#16)	5-25
75 µm (#200)	0-5

703.04 Aggregates for Hot Mix Asphalt. Aggregates for hot mix asphalt (HMA) shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, natural gravel, or crushed slag. Excess of fine material shall be wasted before crushing. A percentage of the aggregate retained on the 4.75 mm (No. 4) sieve for Gradings S, SX and SG— and on the 2.36 mm (No. 8) sieve for Gradings SF and ST—shall have at least two mechanically induced fractured faces when tested per Colorado Procedure 45. This percentage will be specified in Table 403-1, as revised for the project in Section 403. The angularity of the fine aggregate shall be a minimum of 45.0 percent when determined according to AASHTO T 304. Grading SF mixes, when determined by the Region Materials Engineer, may not require fine aggregate angularity of 45.0 percent. Aggregate samples representing each aggregate stockpile shall be non-plastic if the percent of aggregate passing the 2.36 mm (No. 8) sieve is greater than or equal to 10 percent by weight of the individual aggregate sample. Plasticity will be determined per AASHTO T 90. The material shall not contain clay balls, vegetable matter, or other deleterious substances.

The aggregate for Gradings ST, S, SX, and SG shall have a percentage of wear of 45 or less when tested per AASHTO T 96.

Table 703-4
MASTER RANGE TABLE FOR HOT MIX ASPHALT

Percent by Weight Passing Square Mesh Sieves

Sieve Size	Grading SF	Grading ST	Grading SX	Grading S	Grading SG
37.5 mm (11/2″)					100
25.0 mm (1″)				100	90 – 100
19.0 mm (3/4″)			100	90 – 100	
12.5 mm (1/2″)		100	90 – 100	*	*
9.5 mm (3/8″)	100	90 – 100	*	*	*
4.75 mm (#4)	90 – 100	*	*	*	*
2.36 mm (#8)	*	28 – 58	28 – 58	23 – 49	19 – 45
1.18 mm (#16)	30 – 54				
600 μm (#30)	*	*	*	*	*
300 μm (#50)					
150 μm (#100)					
75 μm (#200)	2 – 12	2 – 10	2 – 10	2 – 8	1 – 7

Table 703-4 Notes: * These additional Form 43 Specification Screens will initially be established using values from the As Used Gradation shown on the Design Mix.

Aggregates for stone matrix asphalt (SMA) shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, or crushed slag. A minimum of 90 percent of the particles retained on the 4.75 mm (No. 4) sieve shall have at least two mechanically induced fractured faces when tested per Colorado Procedure 45. The particles passing the 4.75 mm (No. 4) sieve shall be the product of crushing rock larger than 12.5 mm (1/2 inch) and shall be non-plastic when tested per AASHTO T 90.

Additionally, each source of aggregate for SMA shall meet the following requirements:

(1) No more than 30 percent when tested per AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

(2) No more than 12 percent when tested per AASHTO T 104 Soundness of Aggregate by Use of Sodium Sulfate.

Table 703-5
MASTER RANGE TABLE FOR STONE MATRIX ASPHALT

Percent by Weight Passing Square Mesh Sieves

Sieve Size	4.75 mm (#4) nominal	9.5 mm (3/8″) nominal	12.5 mm (1/2″) nominal	19.0 mm (3/4″) nominal
25 mm (1")				100
19.0 mm (3/4")			100	90-100
12.5 mm (1/2")	100	100	90-100	50-88
9.5 mm (3/8")	100	90-100	50-80	25-60
4.75 mm (#4)	90-100	26-60	20-35	20-28
2.36 mm (#8)	28-65	20-28	16-24	16-24
1.18mm (#16)	22-36			
600 µm (#30)	18-28	12-18	12-18	12-18
300 µm (#50)	15-22	10-15		
150 µm (#100)				
75 µm (#200)	12-15	8-12	8-11	8-11

The aggregates for hot mix asphalt (HMA) and stone matrix asphalt (SMA) shall meet the requirements of Table 703-6 when tested per CP-L 4211 Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus. The Contractor shall be assessed a price reduction of $1,000 for each production sample of the combined aggregate with a value greater than 20 according to CP-L 4211.

Table 703-6
AGGREGATE DEGRADATION BY ABRASION
IN THE MICRO-DEVAL CP-L 4211

	Not to exceed
Combined Aggregate (Mix Design)	18
Combined Aggregate (1/10,000 tons, or fraction thereof during production)	20

703.05 Aggregate for Cover Coat Material. Aggregates for cover coat material shall be crushed stone, crushed slag, crushed gravel, or natural gravel. Aggregates shall be composed of clean, tough, durable fragments free from an excess of flat, elongated, soft, or disintegrated pieces and free from fragments coated with dirt or other objectionable matter. Slag shall be air-cooled blast-furnace slag reasonably uniform in density.

The aggregate shall conform to the following requirements:

(1) The percentage of wear, Los Angeles Abrasion Test (AASHTO T 96), shall not be more than 35.

(2) The maximum amount of flat and elongated aggregate with a ratio of 3:1 shall not exceed 12 percent as determined by ASTM D4791.

(3) When blast-furnace slag is used, the weight per cubic foot shall be at least 70 pounds.

(4) For Type I, II, or IV cover coat material, 90 percent by weight of the particles retained on the 4.75 mm (No. 4) sieve shall have at least two fractured faces when tested per Colorado Procedure 45.

(5) Lightweight aggregate used for cover coat material shall be an aggregate prepared by expanding shale, clay, or slate in a rotary fired kiln. Lightweight aggregate shall have a dry loose unit weight of 35 to 55 pounds per cubic foot determined per AASHTO T 19, Shoveling Procedure. The total mass of the test sample of lightweight aggregate used in AASHTO T 96 (Los Angles Abrasion) shall be 2,000 g.

Table 703-7
GRADATION SPECIFICATIONS FOR COVER COAT AGGREGATE

Percent by Weight Passing Square Mesh Sieves

SIEVE SIZE	9.5 mm (3/8") Type 1	12.5 mm (1/2") Type II	19.0 mm (3/4")* Type IV
19.0 mm (3/4")			100
12.5 mm (1/2")		100	95-100
9.5 mm (3/8")	100	65-85	60-80
4.75 mm (#4)	0-15	0-10	0-10
75 µm (#200)	0-1.5	0-1.5	0-1.5

Table 703-7 Notes: *Type IV shall be used only with lightweight aggregates.

703.06 Mineral Filler. Mineral filler shall conform to the requirements of AASHTO M 17 and shall consist of rock dust, slag dust, hydrated lime, hydraulic cement, fly ash, or other suitable mineral matter. It shall be free of organic impurities and agglomerations. When used, it shall be dry enough to flow freely.

Mineral filler shall be graded within the following limits:

Table 703-8
MINERAL FILLER GRADATION

Sieve Size	Mass Percent Passing Square Mesh Sieves
600 µm (No. 30)	100
300 µm (No. 50)	95-100
75 µm (No. 200)	70-100

Mineral filler shall have a plasticity index not greater than four excluding hydrated lime and hydraulic cement.

If mineral filler other than limestone dust is used in stone matrix asphalt (SMA) it shall consist of mineral matter that meets the requirements of Tables 703-8, 703-9 and the following:

Alternative mineral filler shall consist of finely divided mineral matter such as rock dust, slag dust, fly ash, loess, or other suitable mineral matter. Calcium oxide content of any mineral filler shall not exceed 22 percent.

Alternative mineral filler test data shall be provided as part of the SMA mix design submittal and as required in Table 703-10 during production.

The Contractor shall sample and test alternative mineral filler at the frequencies listed in Table 703-9. Production will be suspended if alternative mineral filler test results fail to meet requirements. The Contractor shall submit written plans to correct the mineral filler operation to the Engineer for approval before commencing paving.

Table 703-9
REQUIRED TESTING FOR ALTERNATIVE
SMA MINERAL FILLERS

Type of Test	Contractor Testing Frequency	Specification Limit	Remarks
Plasticity Index AASHTO T90	One per 10,000 tons of SMA placed♦	4% Maximum	▲
Hydrometer Analysis AASHTO T88	One at Mix Design submittal	Report	
Gradation AASHTO T37	One per 10,000 tons of SMA placed♦	Table 703-10	▲
Calcium Oxide Content ASTM C25	One at Mix Design submittal	22% Maximum	
Modified Rigden Voids – NAPA Publication IS-101	One per 10,000 tons of SMA placed♦	Shall not exceed 50	▲

Table 703-9 Notes:

♦ The minimum frequency shall be twice per project.

▲ Sampling of alternative mineral fillers shall be at the point of introduction to the SMA and a split sample shall be submitted to the Engineer.

Table 703-10
ALTERNATIVE SMA MINERAL GRADATION

(AASHTO M17/ASTM D242-95)

Sieve	Percent Passing
600 µm (#30)	100
300 µm (#50)	95 – 100
75 µm (#200)	70 – 100

703.07 Bed Course Material.

(a) Bed course material for sidewalks, curbing, and bikeways shall consist of cinders, sand, slag, gravel, crushed stone, or other approved material of such gradation that all particles shall pass through a sieve having 19.0 mm (3/4 inch) square openings.

(b) Bed course material for slope protection, or riprap filter blanket shall be a porous, free draining material consisting of sand, gravel, cinders, slag, crushed stone, or other approved free draining material. This material shall meet the following gradation requirements:

Table 703-11
BED COURSE MATERIAL GRADATION

Sieve Size	Mass Percent Passing Square Mesh Sieves
75 mm (3 inch)	100
4.75 mm (No. 4)	20-65
75 µm (No. 200)	0-10

703.08 Structure Backfill Material.

(a) Class 1 structure backfill shall meet the following gradation requirements:

Table 703-12
STRUCTURE BACKFILL MATERIAL CLASS 1 GRADATION

Sieve Size	Mass Percent Passing Square Mesh Sieves
50 µm (2 inch)	100
4.75 mm (No. 4)	30-100
300 µm (No. 50)	10-60
75 µm (No. 200)	5-20

In addition, this material shall have a liquid limit not exceeding 35 and a plasticity index of not over six when determined in conformity with AASHTO T 89 and T 90 respectively.

(b) Class 2 structure backfill shall be composed of suitable materials developed on the project. To be suitable for use under this classification, backfill shall be free of frozen lumps, wood, or other organic material. If the material contains rock fragments that, in the opinion of the Engineer, will be injurious to the structure, the native material shall not be used for backfilling and the Contractor shall furnish Class 1 structure backfill material at the contract unit price. If contract unit price does not exist for Class 1 structure backfill, it will be paid for per subsection 104.03.

(c) Class 3 structure backfill shall be a sandy gravel and meet the following gradation:

Table 703-13
STRUCTURE BACKFILL MATERIAL CLASS 3 GRADATION

Sieve Size	Mass Percent Passing Square Mesh Sieves
9.5 mm (3/8 inch)	90-100
4.75 mm (No. 4)	45-80
75 µm (No. 200)	5-12

703.09 Filter Material. Filter material shall consist of free draining sand, gravel, slag, or crushed stone. The grading requirements are set forth in Table 703-14.

Table 703-14
GRADATION SPECIFICATIONS FOR FILTER MATERIAL

Percent by Weight Passing Square Mesh Sieves

Sieve Size	Class A	Class B	Class C
75 mm (3")	100		
37.5 mm (1 1/2")		100	
19.0 mm (3/4")	20-90		100
4.75 mm (No. 4)	0-20	20-60	60-100
1.18 µm (No. 16)		10-30	
300 µm (No. 50)		0-10	10-30
150 µm (No. 100)			0-10
75 µm (No. 200)	0-3	0-3	0-3

703.10 Aggregate for Median Cover. Aggregate for median cover shall consist of clean crushed stone, crushed gravel, or natural gravel. The percentage of wear, when tested per AASHTO T 96, shall not be more than 70. The grading requirements shall be as follows:

Table 703-15
GRADATION SPECIFICATIONS
FOR MEDIAN COVER AGGREGATE

Sieve Size	Mass Percent Passing Square Mesh Sieves
63 mm (2 1/2 inch)	100
50 mm (2 inch)	95-100
19.0 mm (3/4 inch)	0-15

SECTION 704
MASONRY UNITS

704.01 Clay or Shale Brick. Brick shall conform to the requirements of one of the following specifications:

Sewer and Manhole Brick-AASHTO M 91. Building Brick-AASHTO M 114.

704.02 Concrete Brick. Concrete brick shall conform to the requirements of ASTM C55.

704.03 Concrete Masonry Blocks. Concrete masonry blocks may be rectangular or segmented and, when specified, shall have ends shaped to provide interlock at vertical joints. The blocks shall conform to the requirements of ASTM C139, or, for hollow blocks, to ASTM C90. Dimensions and tolerances shall conform to the above applicable requirements or those specified on the plans.

704.04 Masonry Mortar. Masonry mortar shall be Type S conforming to ASTM C270.

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SECTION 705
JOINT, WATERPROOFING, AND BEARING MATERIAL

705.01 Joint Fillers.

(a) Joint Sealant with Backer Rod. The joint sealant material shall be an approved ASTM D5893 silicone sealant or ASTM D6690 Type II hot applied sealant on the Department's Approved Products List. The materials shall be stored and applied per manufacturer's recommendations, but they shall not be exposed to ambient temperatures in excess of 125 °F or stored in direct sunlight. The backer rod placed before joint sealant shall be an approved ASTM D5249 backer rod compatible with the joint sealant material chosen by the Contractor.

(b) Preformed Joint Fillers. Preformed fillers for joints shall conform to the requirements of AASHTO M 213 and shall be punched to admit the dowels as shown on the plans. The filler for each joint shall be furnished in a single piece for the full depth and thickness required for the joint unless otherwise authorized by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely, and held accurately to shape, by stapling or other positive fastening satisfactory to the Engineer.

705.02 Watertight Joint Systems. Watertight joint systems for plastic pipe shall conform to the requirements of ASTM D3212.

705.03 Gaskets. Rubber gasketed joints shall conform to the requirements of ASTM C443 and shall be flexible and able to withstand expansion, contraction, and settlement.

All rubber gaskets shall be stored in as cool a place as practicable, preferably at 70 °F or less. Rubber gaskets shall not be exposed to the direct rays of the sun for more than 72 hours.

Rubber gaskets, of the type requiring lubrication, shall be lubricated with the lubricant recommended and supplied by the manufacturer of the pipe.

705.04 Pipe Joint Sealing Compounds. Joint sealing compounds for concrete pipe shall conform to the requirements of AASHTO M 198.

Joint sealants for metal pipe shall conform to the pipe manufacturer's recommendations.

705.05 Compression Ring. Compression ring jointing connections for clay pipe, made of resilient material, shall conform to the requirements of ASTM C425.

705.06 Bearing Materials

Table 705-1
POLYISOPRENE (NATURAL RUBBER) ELASTOMER

Specimen Properties	ASTM Test Procedure	50 Duro Reqmts	60 Duro Reqmts	70 Duro Reqmts
Physical Properties				
Hardness	D2240	50 ± 5	60 ± 5	70 ± 5
Tensile Strength, MPa Minimum (psi)	D412	15.5 (2250)	15.5 (2250)	15.5 (2250)
Ultimate Elongation, % Minimum	D412	450	400	300
Heat Resistance, 70 Hr./70 ˚C (158 ˚F)				
Change in Durometer Hardness, Maximum Points		+10	+10	+10
Change in Tensile Strength, % Maximum	D573	-25	-25	-25
Change in Ultimate Elongation, % Maximum	D573	-25	-25	-25
Compression Set % Maximum, 22 Hr/70 ˚C (158 ˚F)	D395 Method B	25	25	25
Ozone Resistance, 20% Strain 25 ppm Ozone in Air by Volume 38 ± 1 ˚C (100 ± 2 ˚F)/48 Hr. Mounting Procedure ASTM D518, Procedure A	D1149	No Cracks	No Cracks	No Cracks
Adhesion Bond Made during Vulcanization, N per mm (Lb. per Inch)	D429, B	7 (40)	7 (40)	7 (40)
Low Temperature Brittleness: Grade 3 at -40 ˚C (-40 ˚F) Grade 4 at -48 ˚C (-55 ˚F) Grade 5 at -57 ˚C (-70 ˚F)	D746 Procedure B	No Failure	No Failure	No Failure
Instantaneous Thermal Stiffening: Grade 3 at -40 ˚C (-40 ˚F) Grade 4 at -46 ˚C (-50 ˚F) Grade 5 at -54 ˚C (-65 ˚F)	D1043	* ◂	* ◂	* ◂
Low Temperature Crystallization: Grade 3, 14 Days at -26 ˚C (-15 ˚F) Grade 4, 21 Days at -37 ˚C (-35 ˚F) Grade 5, 28 Days at -37 ˚C (-35 ˚F)	D4014 Quad Shear Test as described in Annex A	# ◂	# ◂	# ◂

Table 705-1 Notes:

*Stiffness at test temperature shall not exceed 4 times the stiffness measured at 23 ˚C (73 ˚F).

#Stiffness at test time and temperature shall not exceed 4 times the stiffness measured at 23 ˚C (73 ˚F) with no time delay. The stiffness shall be measured with a quad shear test rig in an enclosed freezer unit. The test specimens shall be taken from a randomly selected bearing. A ± 25˚ strain cycle shall be used, and a complete cycle of strain shall be applied with a period of 100 seconds. The first 3/4 cycle of strain shall be discarded, and the stiffness shall be determined by the slope of the force deflection curve for the next 1/2 cycle of loading.

◂ ASTM D1043 refers to the “Modulus of Rigidity” while ASTM D4014 refers to the “Shear Modulus Stiffness”. The word “stiffness” is used to describe both terms.

Table 705-2
CHLOROPRENE (NEOPRENE) ELASTOMER

Specimen Properties	ASTM Test Procedure	50 Duro Reqmts	60 Duro Reqmts	70 Duro Reqmts
Physical Properties				
Hardness	D240	50 ± 5	60 ± 5	70 ± 5
Tensile Strength, MPa Minimum (psi).	D412	17.2 (2500)	17.2 (2500)	17.2 (2500)
Ultimate Elongation, % Minimum	D412	400	350	300
Heat Resistance, 70 Hr/ 70 ˚C (158 ˚F)				
Change in Durometer Hardness, Maximum Points		+15	+15	+15
Change in Tensile Strength, % Maximum	D573	-15	-15	-15
Change in Ultimate Elongation, % Maximum	D573	-40	-40	-40
Compression Set % Maximum, 22 Hr/100 ˚C (212 ˚F)	D395 Method B	35	35	35
Ozone Resistance, 20% Strain 100 ppm Ozone in Air by Volume 38 ± 1 ˚C (100 ± 2 ˚F)/ 100 Hr Mounting Procedure ASTM D518, Procedure A	D1149	No Cracks	No Cracks	No Cracks
Adhesion Bond Made during Vulcanization, N per mm (Lb per Inch)	D429, B	7 (40)	7 (40)	7 (40)
Low Temperature Brittleness: Grade 3 at -40 ˚C (-40 ˚F) Grade 4 at -48 ˚C (-55 ˚F) Grade 5 at -57 ˚C (-70 ˚F)	D746 Procedure B	No Failure	No Failure	No Failure
Instantaneous Thermal Stiffening: Grade 3 at -40 ˚C (-40 ˚F) Grade 4 at -46 ˚C (-50 ˚F) Grade 5 at -54 ˚C (-65 ˚F)	D1043	* ◂	* ◂	* ◂
Low Temperature Crystallization: Grade 3, 14 Days at -26 ˚C (-15 ˚F) Grade 4, 21 Days at -37 ˚C (-35 ˚F) Grade 5, 28 Days at -37 ˚C (-35 ˚F)	D4014 Quad Shear Test as described in Annex A	# ◂	# ◂	# ◂

Table 705-2 Notes:

*Stiffness at test temperature shall not exceed 4 times the stiffness measured at 23 ˚C (73 ˚F).

#Stiffness at test time and temperature shall not exceed 4 times the stiffness measured at 23 ˚C (73 ˚F) with no time delay. The stiffness shall be measured with a quad shear test rig in an enclosed freezer unit. The test specimens shall be taken from a randomly selected bearing. A ± 25˚ strain cycle shall be used, and a complete cycle of strain shall be applied with a period of 100 seconds. The first 3/4 cycle of strain shall be discarded, and the stiffness shall be determined by the slope of the force deflection curve for the next 1/2 cycle of loading.

◂ ASTM D1043 refers to the “Modulus of Rigidity” while ASTM D4014 refers to the “Shear Modulus Stiffness”. The word “stiffness” is used to describe both terms.

(a) *Elastomeric Bearing Pads.* Laminates shall be rolled mild steel sheets conforming to AASHTO M 270 Grade 36 unless otherwise specified.

A Durometer hardness of 60 shall be used unless otherwise shown on the plans.

The elastomer portion of the elastomeric compound shall be 100 percent virgin natural polyisoprene (natural rubber) or 100 percent virgin chloroprene (neoprene) and shall be at least 60 percent by volume of the total compound.

(b) *Sheet Lead.* Sheet lead shall conform to the requirements of ASTM B29 for common desilverized lead.

(c) *Polytetrafluoroethylene* (PTFE) Sheets. PTFE resin shall be virgin material conforming to the requirements of ASTM D 4894 or D4895. The specific gravity shall be 2.13 to 2.19 and the melting point shall be 623 °F plus or minus 2°F.

Filler material shall be milled glass fibers, carbon, or other approved inert filler materials.

Finished unfilled PTFE sheet shall be made from PTFE resin and shall conform to the following requirements:

Tensile strength (minimum)ASTM D4894 or D4895 2,800 psi

Elongation (minimum)ASTM D4894 or D4895 200 percent

Filled PTFE sheet shall be made from PTFE resin uniformly blended with inert filler material. Finished filled PTFE sheet containing glass fiber or carbon shall conform to the following requirements:

Table 705-3
FINISHED FILLED PTFE REQUIREMENTS

Mechanical	ASTM Method	15% Glass Fiber	25% Carbon
Tensile Strength (min.)	D4894 or D4895	2000 psi	1300 psi
Elongation (min.)	D4894 or D4895	150%	75%

Physical	ASTM Method	15% Glass Fiber	25% Carbon
Specific Gravity (min.)	D4894 or D4895	2.20	2.10
Melting Point	D4894 or D4895	621 °F ± 18 °F	621 °F ± 18 °F

The maximum coefficient of friction for the PTFE shall be as follows:

Table 705-4

PTFE MAXIMUM COEFFICIENT OF FRICTION

Bearing Pressure	500 psi	2000 psi	3000 psi
Unfilled PTFE	0.08	0.06	0.04
Filled PTFE	0.12	0.1	0.08

The average bearing pressure on the PTFE sliding surface due to all loads shall not exceed:

Table 705-5
PTFE MAXIMUM AVERAGE BEARING PRESSURE
ON SLIDING SURFACE

Type II Bearing Device Unfilled and Filled PTFE	2000 psi
Type III Bearing Device Filled PTFE	3500 psi
Unfilled PTFE (Recessed)	3500 psi
Unfilled PTFE (Not Recessed)	2000 psi

The edge load pressure due to all loads and rotations shall not exceed:

Unfilled and filled PTFE (Type II and III Bearing Device) 5000 psi.

(d) Stainless-steel Sheets. The stainless-steel sheet shall be 16-gauge minimum thickness and shall conform to ASTM A240, Type 304.

(e) Adhesive Material. Adhesive material shall be an epoxy resin meeting the requirements of Federal Specification MMM-A-134, FEP film or approved equal.

(f) Certification and Testing. The Contractor shall furnish a manufacturer's certification that the material proposed for use on the project meets the requirements set forth in the tables above. The Department also reserves the right to test random samples of full-size bearings proposed for use on the project. The following values shall be met under laboratory testing of full-size bearings.

1. Compressive strain of any layer of an elastomeric bearing shall not exceed 7 percent at 800-psi average unit pressure, or at the design dead load plus live load pressure when so shown on the plans.

2. The shear resistance of the bearing shall not exceed 30 psi for 50 durometer, 40 psi for 60 durometer, or 50 psi for 70 durometer, polyisoprene compounds, nor 50 psi for 50 durometer, 75 psi for 60 durometer, or 110 psi for 70 durometer, chloroprene compounds. Shear resistance shall be measured at 25 percent strain of the total effective rubber thickness after an extended four-day ambient temperature of minus 20 °F.

   Components of nominal hardness between values shown may be used and test requirements interpolated. When test specimens are cut from the finished product a 10 percent variation in “physical properties” will be permitted.

(g) Tolerances. Flash tolerance, finish and appearance shall meet the requirements of the latest edition of the Rubber Handbook as published by the Rubber Manufacturers Association, Inc., RMA F3 and T.063 for molded bearings and RMA F2 for extruded bearings.

For both plain and laminated bearings, the permissible variation from the dimensions and configuration required by the plans and these specifications shall be as follows:

Table 705-6

DIMENSIONAL TOLERANCES FOR BEARINGS

Overall Vertical Dimensions:	
Average Total Thickness 1 1/4 inches or less	-0, +1/8 inch
Average Total Thickness over 1 1/4 inches	-0, +1/4 inch
Overall Horizontal Dimension:	
36 inches and less	-0, +1/4 inch
Over 36 inches	-0, +1/2 inch
Thickness of Individual Layers of:	
Elastomer (Laminated Bearings Only)	±1/8 inch
Variation from a Plane parallel to the Theoretical Surface (as determined by measurements at the edges of the bearings):	
Top	±1/8 inch
Sides	±1/4 inch
Individual Non-Elastic Laminates	±1/8 inch
Position of Exposed Connection Members:	±1/8 inch
Edge Cover of Embedded Laminates or Connection Members:	-0, +1/8 inch
Size of Holes, Slots or Inserts:	±1/8 inch
Position of Holes, Slots or Inserts:	±1/8 inch

705.07 Protective Covering for Bridge Deck Waterproofing Membrane. The protective covering shall be composed of one or more layers of felt thoroughly bonded together and saturated with asphalt. Both exposed sides shall be asphalt-coated. The density shall be 55 pounds per 100 square feet. The surfaces shall be coated with suitable mineral matter to prevent the material from sticking to itself.

The covering may be furnished in either rolls or sheets.

The covering shall be free of visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances, and indentations.

The covering furnished in rolls shall not crack nor be so sticky as to cause material damage upon being unrolled at atmospheric temperatures as low as 50 °F.

The covering shall conform to the following requirements when tested per Colorado Procedure L-2202:

Table 705-7
PROTECTIVE COVERING REQUIREMENTS
FOR BRIDGE DECK WATERPROOFING MEMBRANE

Property Determined	Specification
Width	Min. 35 1/2", Max. 60 1/2"
Pliability at 25 °C (77 °F)	At least 4 of 5 strips shall not crack when bent 90° over a rounded corner of 13 mm (1/2") radius.
Behavior on heating to 80 °C (176 °F)	Max. 1.5 percent volatile loss. No flowing, sagging or blistering.
Weight per square foot	0.5 lb

Protective covering may be conditionally accepted in the field based on visual inspection for appearance, workmanship, and weight per square foot of a representative specimen.

705.08 Prefabricated, Reinforced Membrane and Primer. The membrane shall be a factory-laminated sheet composed of either rubberized asphalt, bituminous mastic, or similar compounds reinforced with synthetic or fiberglass fabric. It shall be uniformly manufactured free from blemishes, discontinuities, and other defects. The membrane shall be supplied in rolls, having a minimum width of 30 inches and shall conform to the following requirements:

Table 705-8
PREFABRICATED, REINFORCED MEMBRANE REQUIREMENTS

Property Determined	Test Procedure	Specification
Thickness		70 mils minimum
Pliability	CP L-2203	No cracks

The primer used to bond membrane to the deck and to seal seams and patches shall be a water-resistant adhesive compatible with the membrane. The primer shall be of suitable consistency for application by brush, roller, or spray without further dilution.

705.09 Single Component, Hot Applied, Elastomeric Membrane. The membrane shall be capable of being sprayed or spread to a uniform thickness at the application temperature recommended by the manufacturer. After cooling, it shall form a tough resilient membrane, well bonded to the concrete surface and shall conform to the requirement of ASTM D6690 Type 2, except blocks for the bond test shall be prepared per CP-L 4101.

The sealant shall be listed in CDOT's Approved Products List before use.

705.10 Waterstop. Neoprene waterstop shall be made of suitable synthetic rubber. Neoprene waterstop shall conform to the applicable requirements designated in the latest edition of the Corp of Engineers Specifications for Rubber Waterstops CRD-C513.

Plastic waterstop shall be made of polyvinyl chloride (PVC) plastic. Plastic waterstop shall conform to the requirements designated in the latest edition of the Corp of Engineers Specifications for Polyvinyl chloride Waterstops CRD-C572.

SECTION 706
CONCRETE AND CLAY PIPE

706.01 Nonreinforced Concrete Pipe. This pipe shall conform to the requirements of AASHTO M 86 for the specified diameters and strength classes.

Pipe shall be obtained from a manufacturer that is a current plant quality certified member of the American Concrete Pipe Association (ACPA), meeting all current ACPA requirements for this certification.

A copy of the ACPA certification shall be submitted to the Engineer before delivery of the pipe.

706.02 Reinforced Concrete Pipe. This pipe shall conform to the requirements of AASHTO M 170 for the specified diameters and strength classes. Unless otherwise specified, pipe wall design and use of elliptical reinforcement in circular pipe are optional. Reinforced concrete pipe being jacked shall be Class V and shall be furnished with grouting nipples spaced not more than eight feet apart. Joints for this pipe shall come equipped with steel rings and rubber gaskets conforming to ASTM C361.

Elliptical pipe conforming to AASHTO M 207 shall be furnished when required on the plans. Arch pipe conforming to AASHTO M 206 shall be furnished when required on the plans.

Precast reinforced concrete end sections shall have one of the following:

(1) At least one line of reinforcement conforming to the requirements of AASHTO M 170 equivalent to the square inches per linear foot for elliptical reinforcement in circular pipe, Class II, Wall B, or

(2) Macro fiber at 5.0 lb/cy.

Pipe shall be obtained from a manufacturer that is a current plant quality certified member of the American Concrete Pipe Association (ACPA), meeting all current ACPA requirements for this certification.

A copy of the ACPA certification shall be submitted to the Engineer before delivery of the pipe.

706.03 Perforated Concrete Pipe. This pipe shall conform to the requirements of AASHTO M 175 for the specified diameters and strength classes. Unless otherwise specified, perforations shall be Type 1.

Pipe shall be obtained from a manufacturer that is a current plant quality certified member of the American Concrete Pipe Association (ACPA), meeting all current ACPA requirements for this certification.

A copy of the ACPA certification shall be submitted to the Engineer before delivery of the pipe.

706.04 Drain Tile. This pipe shall conform to the requirements of AASHTO M 178 or M 179 for the specified material, diameters and quality classes.

706.05 Porous Concrete Pipe. This pipe shall conform to the requirements of AASHTO M 176 for the specified diameters.

Pipe shall be obtained from a manufacturer that is a current plant quality certified member of the American Concrete Pipe Association (ACPA), meeting all current ACPA requirements for this certification.

A copy of the ACPA certification shall be submitted to the Engineer before delivery of the pipe.

706.06 Vitrified Clay Pipe. This pipe shall conform to the requirements of AASHTO M 65 for the specified diameter and strength class.

706.07 Coated Concrete Pipe. This pipe may be reinforced or nonreinforced per the requirements shown on the plans for the designated diameters and strength classes, and in addition, shall be coated with asphalt mastic conforming to the requirements of AASHTO M 243.

Asphalt mastic shall be uniformly applied in two coats by spray or brush to the entire designated surface to be coated, to a total thickness of 50 mils. Asphalt mastic may also be applied by trowel in one coat provided the required thickness is obtained. The first coat shall be dry to touch before the second coat is applied. The second coat shall be dry to touch before any handling or backfilling operations.

The finished coat shall cover the surface to be protected evenly, without running, and without any visible holidays, bubbles, or bare spots.

SECTION 707
METAL PIPE

707.01 Ductile Iron Pipe. This pipe shall conform to the requirements of ASTM A716 for the specified diameters and strength classes. Unless otherwise specified either smooth, corrugated or ribbed pipe may be furnished.

707.02 Corrugated Steel Pipe and Pipe Arches. These conduits and coupling bands shall conform to the requirements of AASHTO M 36, except for the following:

Sawed ends and butt-welded joints will be permitted for pipe with helical corrugations formed with continuous lock or welded seams provided all burrs are removed from sawed ends and provided the welds are acceptable.

Pipe fabricated with resistance spot welds shall also conform to the following additional requirement: Where double welding is necessary, adjacent welds shall not be closer than two spot-weld nugget diameters from center to center.

Shop formed elliptical pipe shall be furnished where specified. Field elongation will be accepted as an alternate to shop elongation when done in a neat workmanlike manner.

Special fittings and elbows for these conduits shall be the same metal thickness as the conduit where they are joined and shall conform to the applicable requirements of AASHTO M 36.

Semicircular corrugated steel pipe for encasement, along with required fastening devices, shall conform to the requirements of this subsection and the requirements of Military Specification MIL-P-236, Type I or II, Class 1.

Coupling bands shall conform to the requirements of AASHTO M 36 with the following exceptions:

(1) The use of channel bands as described in 9.1 of AASHTO M 36 will not be allowed.

(2) Connecting bands shall be at least 10 1/2 inches wide.

707.03 Bituminous Coated Corrugated Steel Pipe and Pipe Arches. Conduit, fittings, elbows, end sections and coupling bands shall be fully coated with bituminous material conforming to the requirements of AASHTO M 190, Type A coating or materials conforming to the requirements of AASHTO M 243, except that the use of tar base material will not be permitted. Coatings shall be shop applied. The finished coat shall uniformly cover the surface to be protected. The coating shall not contain any visible holidays, bubbles or bare spots. Minimum thickness shall be 1.3 mm (50 mils) measured on the crest of the corrugations.

In complying with AASHTO M 190, each section shall be given a double dip application. In the first immersion, the section shall remain submerged until the metal has reached a temperature that will allow the hot bituminous material to penetrate and seal each joint.

Other coatings meeting the requirements of AASHTO M 190 or M 243 will be acceptable upon written approval by the Engineer.

Materials meeting the requirements of AASHTO M 243 shall be uniformly applied by spray, trowel, or brush to the entire designated surface to be coated, to a minimum thickness of 1.3 mm (50 mils). The coating shall be dry to the touch before any handling or backfilling operations.

Special fittings and elbows for conduits shall be of the same gauge as the conduit where they are joined.

When aramid fiber bonded corrugated steel pipe is specified the pipe shall conform to ASTM A885 and the bituminous coating shall conform to the requirements of AASHTO M 190, Type A.

707.04 Corrugated Steel Pipe for Underdrains. This pipe shall conform to the requirements of AASHTO M 36, Type I, except that all reference to "sleeve type coupler" or "coupling" as described in 9.1 and 9.2 shall be disregarded. Sleeve type couplers or couplings will not be permitted.

Perforated pipe shall have Class 1 perforations.

707.05 Bituminous Coated Corrugated Steel Pipe for Underdrains. This pipe shall conform to the requirements of AASHTO M 36, Type I.

Perforated pipe shall have Class 1 perforations.

Underdrain, fittings, elbows, end sections, and coupling bands shall be fully coated with bituminous material conforming to the requirements of AASHTO M 190, Type A coating or materials conforming to the requirements of AASHTO M 243, except that the use of tar base material will not be permitted. Coatings shall be shop applied. The finished coat shall uniformly cover the surface to be protected. The coating shall not contain any visible holidays, bubbles or bare spots. Minimum thickness shall be 1.3 mm (50 mils) measured on the crest of the corrugations.

In complying with AASHTO M 190, each section shall be given a double dip application. In the first immersion, the section shall remain submerged until the metal has reached a temperature that will allow the hot bituminous material to penetrate and seal each joint.

Other coatings meeting the requirements of AASHTO M 190 or M 243 will be acceptable upon written approval by the Engineer.

Materials meeting the requirements of AASHTO M 243 shall be uniformly applied by spray, trowel, or brush to the entire designated surface to be coated, to a minimum thickness of 1.3 mm (50 mils). The coating shall be dry to the touch before any handling or backfilling operations.

Special fittings and elbows for underdrains shall be of the same gauge as the conduit where they are joined.

The specified minimum size of perforations shall apply after coating.

707.06 Corrugated Aluminum Pipe. This pipe and coupling bands shall conform to the requirements of AASHTO M196, Type 1 pipe.

707.07 Corrugated Aluminum Pipe for Underdrains. This pipe shall conform to the requirements of AASHTO M196. Non-perforated pipe shall be Type 1. Perforated pipe shall be Type III, with Class I perforations.

707.08 Extensions. Connecting bands and extensions to existing culverts shall be of the same type of metal or alloy, unless otherwise shown on the plans.

707.09 Repair of Damaged Coating. Units where the spelter coating has been damaged shall be either regalvanized as provided under AASHTO M 36 or painted with one full brush coat of a zinc rich paint meeting Military Specification DOD-P-21035A, or by other approved process on properly cleaned surface, as determined by the Engineer.

Bituminous coated material that has been damaged shall be repaired with field-applied asphalt mastic conforming to AASHTO M 243. Other coating material may be used when approved by the Engineer.

707.10 Polymer Precoated Corrugated Steel Pipe. Polymer precoated corrugated steel pipe shall conform to the requirements of AASHTO M 245.

707.11 Aluminized Corrugated Steel Pipe Type 2. Aluminized Corrugated Steel Pipe Type 2 shall conform to the requirements of AASHTO M 274.

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SECTION 708
PAINTS

708.01 General. This specification covers ready-mixed paints and coatings. Paints and coatings shall be manufactured eight weeks or less before delivery to the project. Each paint container shall be labeled with the name and address of the manufacturer, trade name or trademark, type of paint, number of gallons, batch number, and date of manufacture.

Paints shall be free of foreign material that is capable of clogging screens, valves, pumps, and other parts of the application equipment. Paint shall not contain the following:

(1) Benzene.

(2) Chlorinated solvents.

(3) Ethylene glycol ethers.

(4) Ethylene glycol acetates.

(5) Lead.

(6) Mercury.

(7) Chromium.

(8) Cadmium.

(9) Petroleum products.

The Contractor shall obtain certification in writing from the manufacturer showing that the product is free of the materials described above and that it meets or exceeds the requirements of 29 CFR 1910.1200.

Paints shall not form a surface skin within 48 hours in three-quarter filled, tightly closed containers. Paint and coating pigments shall be lead free, and shall not thicken, become granular, or curdle in their containers.

Volatile Organic Compound (VOC) levels for paints and coatings shall comply with the most current EPA regulations. All product compositional proportions are specified by weight. Material Safety Data Sheets and manufacturer's recommended application instruction sheets representing each paint and coating shall be submitted to the Engineer for the project records before use.

708.02 List of Paints.

PAINTS	SPECIFICATION
Structural Steel Bridge Paint	Subsection 708.03
White Wood Primer	TT-P-25
Outside White Paint	TT-P-102, Class A
Exterior Black Paint	TT-P-61
Black or White Baking Enamel	TT-E-489, Class B
Federal Yellow Enamel	TT-E-489, Class A
Aluminum Paint	Subsection 708.04
Pavement Marking Paint	Subsection 708.05

708.03 Structural Steel Bridge Paint. All structural steel shall be painted using an Inorganic Zinc-Rich Polyurethane System.

The primer shall be an approved inorganic zinc-rich primer conforming to the requirements of Table 1 of the STEEL STRUCTURES PAINTING COUNCIL SPECIFICATION NO. 20 (SSPC-PAINT 20). The vehicle of this primer shall be SSPC-Paint 20, Type 1-C.

The primer shall be applied according to the manufacturer's recommendations with a minimum dry film thickness of three mils.

The manufacturer shall certify in writing to the Engineer that the SSPC-SP 6 steel cleaning is compatible with the primer used.

The topcoat shall be an approved high-build polyurethane enamel with a minimum dry film thickness of three mils. To prevent bubbling, a mist coat shall be applied before application of the topcoat.

708.04 Aluminum Paint. The paint shall be supplied ready-mixed in the proportion of (ASTM D962, Type II, Class B) 2 pounds of aluminum paste per 1 gallon of mixing varnish (see subsection 708.06 (c)). Aluminum paint shall dry to touch in 1/2 to 4 hours and dry hard in 18 hours, maximum. Material will be inspected for leafing on a vertical primed steel surface at a spreading rate of 400 square feet per gallon.

708.05 Pavement Marking Materials. All pavement-marking materials shall be selected from the Department's Approved Products List (APL). Before start of work, a Certificate of Compliance (COC) for all pavement marking materials shall be submitted per subsection 106.12.

(a) Color. The pavement marking paint, without drop-on beads, shall meet the following requirements:

White – Federal Standard No. 595B-17925. The Yellowness Index (YI) of white shall not exceed 8.0 per ASTM E313 initially. The color after drying shall be a flat white, free from tint, and shall provide the maximum amount of opacity and visibility under both daylight and artificial light.

Yellow – Materials for pavement markings shall meet the initial daytime chromaticity that falls within the box created by the following corner points:

Table 708-1

INITIAL DAYTIME CHROMATICITY

COORDINATES (CORNER POINTS)

	1	2	3	4
x	0.530	0.510	0.455	0.472
y	0.456	0.485	0.444	0.400

(b) Low Temperature Acrylic Waterborne Paint. Low temperature acrylic waterborne paint binder (nonvolatile portion of vehicle) shall be 100 percent FASTRACK XSR acrylic polymer, by weight, as determined by infrared analysis or other chemical analysis available to the Department.

The paint shall meet the requirements of Table 708-2.

(c) *High Build Acrylic Waterborne Paint*. High build acrylic waterborne paint binder (nonvolatile portion of vehicle) shall be 100 percent FASTRACK HD 21A acrylic cross-linking polymer, by weight, as determined by infrared analysis or other chemical analysis available to the Department.

The paint shall meet the requirements of Table 708-3.

(d) *Performance Requirements*. The Low Temperature Acrylic Waterborne Paint and High Build Acrylic Waterborne paint shall be water resistant and shall show no softening or blistering.

Table 708-2
LOW TEMPERATURE ACRYLIC WATERBORNE PAINT

Property	White	Yellow	Test Method
Nonvolatile portion of vehicle (white and yellow), %	41.0 (min.)	41.0 (min.)	ASTM D2205
Pigment Composition			
Percent by weight♦	58-62	58-62	ASTM D4451 ASTM D3723
Paint			
Titanium Dioxide Content, lb/gal	1.0 (min.)		ASTM D5381
Properties of the Finished Paint			
Total Non-volatiles, (solids) % by weight	75.0 (min.)	75.0 (min.)	FTMS 141C - Method 4053.1, ASTM D2369, or ASTM D4758
Density, lb/gal	13.3-13.9	13.1-14.0	ASTM D2205
Consistency (Viscosity) White and Yellow, Krebs-Stormer Units	75-85	75-85	ASTM D562
Freeze Thaw Stability	Shall complete 5 or more test cycles successfully		ASTM D2243
Fineness of Grind, Cleanliness Rating B, minimum	3	3	ASTM D1210
Scrub Resistance	800	800	ASTM D2486
Directional Reflectance: [15 mil Wet Film]	88 (min.)	50 (min.)	ASTM E1347
Dry Opacity (Contrast Ratio): [15 mil Wet Film]	0.98 (min.)	0.98 (min.)	ASTM D2805

Table 708-2 Notes: ♦Percent by weight shall include percent of organic yellow pigment.

Table 708-3
HIGH BUILD ACRYLIC WATERBORNE PAINT

Property	White	Yellow	Test Method
Nonvolatile portion of vehicle (white and yellow), %	43.0 (min.)	43.0 (min.)	ASTM D2205
Pigment Composition			
Percent by weight♦	60-62	60-62	ASTM D4451 ASTM D3723
Paint			
Titanium Dioxide Content, lb/gal	1.0 (min.)		ASTM D5381
Properties of the Finished Paint			
Total Non-volatiles, (solids) % by weight	77.0 (min.)	77.0 (min.)	FTMS 141C - Method 4053.1, ASTM D2369, or ASTM D4758
Density, lb/gal	14.0-14.6	13.7-14.3	ASTM D2205
Consistency (Viscosity) White and Yellow, Krebs-Stormer Units	85-95	85-95	ASTM D562
Freeze Thaw Stability	Shall complete 5 or more test cycles successfully		ASTM D2243
Fineness of Grind, Cleanliness Rating B, minimum	3	3	ASTM D1210
Scrub Resistance	800	800	ASTM D2486
Directional Reflectance: [15 mil Wet Film]	88 (min.)	50 (min.)	ASTM E1347
Dry Opacity (Contrast Ratio): [15 mil Wet Film]	0.98 (min.)	0.98 (min.)	ASTM D2805

Table 708-3 Notes: ♦Percent by weight shall include percent of organic yellow pigment.

708.06 Materials - Specifications

(a) Paint Pigment.

Chrominum Oxide, (Green)	ASTM D263
Magnesium Silicate	ASTM D605
Titanium Dioxide	ASTM D476, Class IV
Red Iron Oxide	ASTM D3721
Black Iron Oxide	ASTM D769
Yellow Iron Oxide	ASTM D768

(b) Organo-montmorillonite. Organo-montmorillonite shall be an organic ammonium compound of montmorillonite with a high gelling efficiency in a wide range of organic liquids. It shall be a fine, creamy, white powder with maximum water content of 3.0 percent and a maximum of 5.0 percent retained on the 75 µm (No. 200) sieve. Organo-montmorillonite shall be prewetted with methanol or ethanol as recommended by the manufacturer.

(c) Varnish for Aluminum Paint.

MATERIAL	SPECIFICATION
Resin- 100% Phenol Formaldehyde	MIL-R-15189A
Oil-Tung	ASTM D12
Mineral Spirits	ASTM D235
Driers - Cobalt and/or manganese	ASTM D600

PROPERTIES OF VARNISH	
Viscosity (G-H)	A-C
Oil Length 275 liters per 100 kilograms of resin (33 gal)	
Nonvolatile	55% min.
Proportion of Thinners 90% Mineral Spirits, 10% Xylene	
Color (Hellige)	12 max.
Zinc Reactivity	None
Kauri Reduction	140% min.
Rosin and Rosin Derivatives	None
Appearance	Clear and Transparent
Drying Time: Set to Touch	1 to 3 hr.
Dry Hard	18 hr max.

Alkali Resistance. No visible attack to film dried 72 hours after 8 hours in 5% sodium hydroxide solution at 21 °C (70 °F).

708.07 Pavement Primers. The type and application rate of epoxy resin primer shall be as recommended by the thermoplastic or preformed plastic pavement-marking manufacturer.

A primer application rate of zero will not be accepted, except for thermoplastic marking and inlaid preformed plastic pavement marking placed on new asphalt surfaces as recommended by the manufacturer and approved in writing by the Engineer. However, if the Engineer determines that a new asphalt surface has become soiled, before placement of the pavement markings, pavement primer will be required and shall be applied as approved.

The epoxy resin primer material may be accepted at the job site based on a manufacturer's certification, or a sample may be sent to the Laboratory for testing, in which case three weeks shall be allowed between sampling and intended use.

708.08 Structural Concrete Coating. The Coating shall be a one-component, high-build, non-vapor barrier, 100 percent acrylic emulsion in water, and a texturing agent.

Table 708-4

MINIMUM PHYSICAL PROPERTIES

Solids by Weight	48 percent (Without texturing agent)
Solids by Volume	36 percent (Without texturing agent)
Weight per gallon	8.3 lb/gal (Without texturing agent)
Texturing Agent	3.2 to 3.8 lb/gal), No. 40 to 60 Ottawa sand or equivalent

All coating material shall be delivered to the project site in sealed containers bearing the manufacturer’s original labels.

A material safety data sheet (MSDS) prepared per Federal Standard 313 and a complete set of manufacturer's mixing and application instructions shall be submitted to the Engineer before the Contractor begins applying the coating.

708.09 Inspection and Testing. The manufacturer shall notify the Engineer well in advance of actual paint manufacture in order to arrange for sampling and testing of raw materials and inspection of paint production.

Test methods shall be according to ASTM or, if not covered, Federal Test Method Standard No. 141.

All paint shall have been approved before delivery.

SECTION 709
REINFORCING STEEL AND WIRE ROPE

709.01 Reinforcing Steel. Reinforcing steel shall conform to the requirements of the following specifications:

Deformed and Plain Billet-Steel Bars for Concrete Reinforcement	ASTM A615
Axle-steel Deformed and Plain Bars for Concrete Reinforcement	ASTM A996
Low-Alloy Steel Deformed Bars for Concrete Reinforcement [to be Welded]	ASTM A706
Fabricated Deformed Steel Bar Mats for Concrete Reinforcement	ASTM A184
Steel Welded Wire Fabric, Plain for Concrete Reinforcement	AASHTO M55
Steel Welded Wire Fabric, Deformed for Concrete Reinforcement	AASHTO M221
Epoxy Coated Reinforcing Bars	ASTM A775
Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement	ASTM A767
Deformed and Plain Stainless-steel Bars for Concrete Reinforcement	ASTM A955
Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement	ASTM A1035
Continuous Hot-Dip Galvanized Steel Bars for Concrete Reinforcement	ASTM A1094

Unless otherwise designated, bars conforming to ASTM A615 and ASTM A996 shall be furnished in Grade 60.

In ASTM A184, bar material conforming to ASTM A616 will not be permitted.

In ASTM A955, bar material shall be furnished in Grade 75 unless otherwise designated.

In ASTM A1035, bar material of Type CL will not be permitted unless designated in the plans or otherwise approved by the Engineer.

709.02 Wire Rope. The wire rope shall conform to the requirements of AASHTO M 30 for the specified diameter and strength class.

709.03 Dowel Bars and Tie Bars. Tie bars for longitudinal and transverse joints shall conform to AASHTO A775 and shall be grade 40, epoxy-coated, and deformed. Bar size shall be as designated on Standard Plan M-412-1.

Dowel bars for transverse joints shall conform to AASHTO M 254 for the coating and to ASTM A615, grade 60 for the core material and shall be epoxy-coated, smooth, and lightly greased, precoated with wax or asphalt emulsion, or sprayed with an approved material for their full length. Bar size shall be as designated on the Standard Plan M-412-1.

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SECTION 710
FENCE AND GUARDRAIL

710.01 Barbed Wire. Steel barbed wire shall conform to the requirements of ASTM A121, Class I. Aluminum barbed wire shall be manufactured per ASTM B211 with alloy 5052-O for the line wire and alloy 5052-H38 for the barbs.

710.02 Woven Wire. Woven wire shall conform to the details and requirements shown on the plans and to the following:

Zinc coated steel woven wire shall conform to the requirements of ASTM A116, coating Class I.

Aluminum coated steel woven wire shall conform to the requirements of ASTM A116, Type A.

Fittings and attachments shall be zinc coated to conform to the requirements of AASHTO M 232.

710.03 Chain Link Fabric. Chain link fabric and required fittings and hardware shall conform to the requirements of AASHTO M 181 for the kind of metal, sizes of wire and mesh specified.

Zinc coating for steel fabric shall conform to ASTM A392, Class I; and aluminum coating for steel fabric to ASTM A491, Class I.

710.04 Snow Fence. Wire-bound picket fence shall conform to the requirements of ASTM F537. Posts shall conform to the requirements of AASHTO M281.

710.05 "W" Beam Rail. The rail elements shall be corrugated sheet steel beams conforming to the requirements of AASHTO M 180 of the designated class and type. The beams shall be galvanized, shop painted or corrosion resistant as may be specified. The same requirements shall apply to metal offset devices.

Corrosion resistant steel for rail elements and terminals shall not be painted or galvanized.

Corrosion resistant beam rails shall consist of corrugated sheet steel conforming to the requirements of AASHTO M 180, Type IV and shall have a corrosion resistance of at least 4 times that of carbon steel without copper (0.02 Max), or twice that of carbon steel with copper. The sheet steel may either be in coils or cut lengths when processed for corrugation.

All corrosion resistant material shall be sandblasted to provide a uniform weathered appearance.

All corrosion resistant steel parts shall be handled with care to avoid gouges, scratches, or dents. Care shall be exercised to keep foreign material such as paint, grease, oil, or crayon, from contact with the surface. Steel parts either damaged physically or by contact with foreign substances, will not be accepted.

During shipment or site storage, corrosion resistant steel parts must be positioned to allow free drainage and air circulation on the surfaces. Natural oxide formation on the steel may occur and will not be considered objectionable.

The Contractor shall furnish three copies of a certified mill test report to the Engineer. This report shall show the results of physical and chemical tests of the metal and its coating.

710.06 Timber for Wood Noise Barrier. Timber shall be any of the timber species given in subsection 508.02 including all species defined as "Native." Throughout the project, posts shall be of one species; boards may be of another species; and rails may be a mix of any permissible species, except where single sided fence is built, the rails shall be of one species. The exposed board surfaces shall be of one finish throughout the entire fence and may be rough sawn, SIS, S1S2E, or S48; posts and rails may have any of the finishes. Species selected for posts, rails, and boards shall conform to the grading rules of the Western Wood Products Association (WWPA), the Southern Pine Inspection Bureau (SPIB), or the West Coast Lumber Inspection Bureau (WCLIB) for grading and strength.

(1) Posts. WWPA or WCLIB posts and timbers, No. 1 or better; or SPIB timbers No. 2SR or better.

(2) Rails. WWPA, WCLIB, or SPIB: Light framing, standard or better; or structural joists and planks, No. 2 or better.

(3) Boards. WWPA No. 2 common or better; or SPIB No. 1 or better.

(4) Treatment. The selected species shall be pressure treated lumber conforming in all respects to the AWPA Standard U1, Commodity Specification A: Sawn Products and AWPA Commodity Standard B: Posts (Ground contact for posts, above ground for balance of fence). A treatment report is required from the treatment plant.

(5) Preservative. AASHTO M-133.

All lumber shall be manufactured per Product Standard 20-70 as published by the Department of Commerce and shall be grade marked by a grading agency or have an accompanying certificate from the grading agency. The grading agency shall be certified by the Board of Review of the American Lumber Standards Committee.

All posts, rails, and fence board materials shall be dried after treatment to a maximum of 19 percent moisture content.

710.07 Fence Posts. Wood posts shall conform to the details and dimensions indicated on the plans. Wood posts shall be straight, sound, and seasoned with ends sawed off square or as indicated. All knots shall be trimmed flush with the surface. Wood posts shall be peeled and shall be treated with preservative per AASHTO M 133 or AWPA Standards. When native cedar posts are called for on the plans, the requirements for peeling and for treating may be omitted.

All dimension timber and lumber required for fences or gates shall be sound, straight, and free from knots, splits, and shakes. It shall be of the species and grades indicated on the plans.

Concrete posts shall be made of concrete of the class specified and shall contain steel reinforcement as shown on the plans.

Steel posts shall be galvanized per AASHTO M 111. Fittings, hardware and other appurtenances not specifically covered by the Contract shall be standard commercial grade, and in accord with current standard practice. Pipe or roll-formed steel material for fence posts shall conform to the requirements shown on the plans and to the requirements of Class 1 Pipe, Grade A and Grade B or Class 3 Formed Steel Sections, of Federal Specification RR-F-191/3E. Pipe material for fence posts shall conform to the requirements shown on the plans and to the requirements of Class 1 Pipe, Grade A or Grade B, of Federal Specification RR-F-191/3C.

710.08 Guardrail Posts. Posts shall be of either wood or steel. When the choice of post is at the option of the Contractor, there shall be only one kind furnished on the project unless otherwise specified in the Contract.

(a) Wood posts shall be fabricated from an approved or specified timber species and shall be of the quality, diameter or section, and length as specified or as shown in the Contract. Treated posts shall be fabricated or framed before treatment and shall conform to the requirements of AASHTO M 133 or AWPA Standards.

(b) Steel posts shall be of the section and length as specified or as shown in the Contract. Steel shall conform to the requirements of AASHTO M 183 for the grade specified.

The posts shall be galvanized or corrosion resistant as may be specified.

All corrosion resistant material shall conform to the requirements of AASHTO M 222.

(c) Concrete deadmen for end anchorages shall be as specified or as shown in the Contract.

710.09 Guardrail Hardware. Splices, end connections, end anchor rods, and accessories shall be as specified or as shown in the Contract.

Bolts, nuts, and washers shall be galvanized per AASHTO M 232, Class C, or AASHTO M 298, Class 50, Type 1. All other fittings shall be galvanized per AASHTO M 111. Bolts, nuts, and washers for corrosion resistant guardrail shall be of corrosion resistant material and conform to or exceed the requirements of ASTM A307.

Where high strength bolts are required, they shall conform to the requirements of ASTM F3125 Grade A325.

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SECTION 711
CONCRETE CURING MATERIALS AND ADMIXTURES

711.01 Curing Materials. Curing materials shall conform to the following requirements:

Burlap Cloth made from Jute or Kenaf	AASHTO M 182
Liquid Membrane-Forming Compounds for Curing Concrete	ASTM C309
Sheet Materials for Curing Concrete	AASHTO M 171*

*Only the performance requirements of AASHTO M171 shall apply.

Straw used for curing shall consist of threshed straw of oats, barley, wheat, or rye. Clean field or marsh hay may be substituted for straw when approved by the Engineer. Old dry straw or hay that breaks readily in the spreading process will not be accepted.

711.02 Air-Entraining Admixtures. Air-entraining admixtures shall conform to the requirements of AASHTO M 154.

Admixtures that have been frozen will be rejected per subsections 106.08 and 106.09.

711.03 Chemical Admixtures. Chemical admixtures for concrete shall conform to the requirements of AASHTO M 194.

Admixtures that have been frozen will be rejected.

Corrosion inhibiting admixtures shall conform to the requirements of ASTM C1582.

Pigments for integrally coloring concrete shall conform to the requirements of ASTM C979.

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SECTION 712
MISCELLANEOUS

712.01 Water. Water used in mixing or curing concrete shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetation, or other substance injurious to the finished product. Concrete mixing water shall meet the requirements of ASTM C1602. The Contractor shall perform and submit tests to the Engineer at the frequencies listed in ASTM C1602. Potable water may be used without testing. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, and other foreign materials.

712.02 Calcium Chloride. Calcium chloride shall conform to the requirements of AASHTO M 144.

712.03 Hydrated Lime. The hydrated lime for hot mix asphalt (HMA) shall conform to the requirements of AASHTO M 303, Type I. In addition, the particle size requirements shall conform to AASHTO M 303 when tested per CP-L 4209 Physical Testing of Quicklime, Hydrated Lime, and Limestone.

712.04 (unused)

712.05 Precast Concrete Units. Precast concrete manhole base sections, riser sections, and grade rings shall conform to AASHTO M 199. All other precast units shall be cast in substantial forms. Structural concrete used shall attain a minimum 28-day compressive strength of 3000 psi as determined per AASHTO T 22. When air-entrained concrete is specified, it shall have an air content of 5 to 8 percent by volume. The precast units shall be cured per AASHTO M 170. Additional reinforcement shall be provided as necessary to provide for handling of the precast units.

A sufficient number of cylinders shall be cast, and field cured from each batch, or truck-mixer load, of concrete to permit compression tests at 7, 14, and 28 days, and to allow for at least two cylinders for each test. When the strength requirement is met, the units will be certified for use.

Cracks in units, honeycombed or patched areas in excess of 30 square inches, excessive water absorption, or failure to meet strength requirements will be cause for rejection.

712.06 Frames, Grates, Covers, and Steps. Metal units shall conform to the plan dimensions and to the following specification requirements for the designated materials.

Gray iron castings shall conform to the requirements of AASHTO M 306 and AASHTO M 105, Class 35B.

Carbon-steel castings shall conform to the requirements of AASHTO M 103, grade 415-205, Class 2.

Ductile iron castings shall conform to the requirements of ASTM A536. Grade shall be optional unless otherwise designated.

Structural steel shall conform to the requirements of AASHTO M 270.

Malleable iron castings shall conform to the requirements of ASTM A47. Grade shall be optional unless otherwise designated.

Steps shall conform to the requirements of AASHTO M 199.

Galvanizing, where specified for these units shall conform to the requirements of AASHTO M 111.

712.07 Geosynthetics. Geosynthetic rolls shall be furnished with suitable wrapping to protect against moisture and extended ultraviolet exposure before placement. Each roll shall be labeled to provide product identification sufficient for inventory and process control purposes. Rolls shall be stored in a manner that protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. The Contractor shall submit a certified test report from the manufacturer per subsection 106.13 including all data necessary to verify compliance with this specification.

Securing pins shall be made from galvanized steel wire or other approved wire material, 0.091 inch or larger in diameter. They shall be U-shaped, with legs 6 inches long and a 1-inch crown.

Physical requirements of geosynthetics shall meet or exceed what is shown in Table 712-1. Unless otherwise stated, all property values represent minimum average roll values (MARV) in the weakest principal direction. Stated values are for non-critical, non-severe conditions. Lots shall be sampled per ASTM D4354.

(a) Geomembrane. Geomembrane shall be manufactured for stopping seepage loss. The lining shall consist of virgin polyvinyl chloride (PVC) resins, plasticizers, stabilizers, and other necessary materials that, when compounded, shall meet or exceed the physical requirements for the thickness specified in Table 712-1.

Individual widths of PVC materials shall be fabricated into large sections by dielectric sealing into a single piece, or into a minimum number of panels, up to 100 feet wide, as required to fit the facility. Lap joints with a minimum joint width of 1/2 inch shall be used. After fabrication, the lining shall be accordion folded in both directions and packaged for minimum handling in the field. Shipping boxes shall be substantial enough to prevent damage to contents.

Table 712-1
PHYSICAL REQUIREMENTS FOR GEOMEMBRANE

Property	0.25 mm (10 mil) Thickness	0.51 mm (20 mil) Thickness	0.76 mm (30 mil) Thickness	Test Method
Thickness, % Tolerance	±7	±5	±5	ASTM D1593
Tensile Strength, kN/m (lb/in) width	3.50 (20)	8.75 (50)	12.25 (70)	ASTM D882, Method B
Modulus @ 100% Elongation, kN/m (lb/in)	1.58 (9)	3.50 (20)	5.25 (30)	ASTM D882, Method B
Ultimate Elongation, %	350	350	350	ASTM D882, Method A
Tear Resistance: N (lb)	18 (3.2)	29 (6.5)	38 (8.5)	ASTM D1004
Low Temperature Impact, ˚C (˚F)	-23 (-13)	-26 (-15)	-29 (-20)	ASTM D1790
Volatile loss, % max.	1.5	0.9	0.7	ASTM D1203, Method A
Pinholes, No. /8 m^2 (No. Per 10 sq yd) max.	1	1	1	
Bonded Seam Strength, % of tensile strength	80	80	80	

(b) Reserved.

712.08 Geotextiles. Geotextile rolls shall be furnished with suitable wrapping to protect against moisture and extended ultraviolet exposure before placement. Each roll shall be labeled to provide product identification sufficient for inventory and process control purposes. Rolls shall be stored in a manner that protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. The Contractor shall submit a certified test report from the manufacturer per subsection 106.13 including all data necessary to verify compliance with this specification.

Securing pins shall be made from galvanized steel wire or other approved wire material, 0.091 inch or larger in diameter. They shall be U-shaped, with legs 6 inches long and a 1-inch crown.

Physical requirements for all geotextiles shall conform to the requirements of AASHTO M-288. Materials shall be selected from the New York Department of Transportation's Approved Products List of Geosynthetic materials that meet the National Transportation Product Evaluation Program (NTPEP) and AASHTO M-288 testing requirements.

Table 712-2
TYPICAL VALUES OF PERMEABILITY COEFFICIENTS*

Turbulent Flow	D max Particle Size Range Millimeters (inches)	D min Particle Size Range Millimeters (inches)	D 20 mm (inches) Effective Size	Permeability Coefficient k cm/s Turbulent Flow
Derrick STONE	3000 (120)	900 (36)	1200 (48)	100
One-man STONE	300 (12)	100 (4)	150 (6)	30
Clean, fine to coarse GRAVEL	80 (3)	10 (1/4)	13 (1/2)	10
Fine, uniform GRAVEL	8 (3/8)	1.5 (1/16)	3 (1/8)	5
Very coarse, clean, uniform SAND	3 (1/8)	0.8 (1/32)	1.5 (1/16)	3

Laminar Flow	D max Particle Size Range Millimeters (inches)	D min Particle Size Range Millimeters (inches)	D 20 mm (inches) Effective Size	Permeability Coefficient k cm/s Turbulent Flow
Uniform, coarse SAND	2 (1/8)	0.5 (1/64)	0.6	0.4
Uniform, medium SAND	0.5	0.25	0.3	0.1
Clean, well-graded SAND and GRAVEL	10	0.05	0.1	0.01
Uniform, fine SAND	0.25	0.05	0.06	40×10^{-4}
Well-graded, silty SAND and GRAVEL	5	0.01	0.02	4×10^{-4}
Silty SAND	2	0.005	0.01	1.0×10^{-4}
Uniform SILT	0.05	0.005	0.006	0.5×10^{-4}
Sandy CLAY	1.0	0.001	0.002	0.05×10^{-4}
Silty CLAY	0.05	0.001	0.0015	0.01×10^{-4}
CLAY (30% to 50% clay sizes)	0.05	0.0005	0.0008	0.001×10^{-4}
Colloidal CLAY (-2 µm 50%)	0.01	10	40	10^{-9}

Table 712-2 Notes:
*Basic Soils Engineering, R.K. Hough, 2nd Edition, Ronald Pess Co.; 1969, Page 76.
Note:Since the permeability coefficient of the soil will be unknown in most non-critical, non-severe applications for erosion control and drainage, the soil-permeability coefficients listed in Table 712-2 may be used as a guide for comparing the permeability coefficient of the fabric with that of the in-place soil.

712.09 Gabions and Slope Mattresses. All wire used in the manufacture and assembly of the mesh shall conform to Federal Specification QQ-W-461H, finish 5, class 3.

Wire mesh for gabions (cage thickness 12 inches and greater) shall be 11 gauge (U.S.), soft temper.

Wire mesh for slope mattress (cage thickness up to 10 inches) shall be 14 gauge (U.S.), soft temper.

Samples for testing shall include at least one sample of each component of the mesh.

Tie and connecting wire shall be supplied for securely fastening all edges of the gabions and diaphragms. Gabions shall be provided with four cross connecting wires in each cell 1/2 unit high and eight in each cell one unit high. Gabions shall also have inner tie wires connecting the front face to the rear face at approximate spacing of 12 inches in both vertical and horizontal dimensions. Tie wire shall meet the same specifications for wire used in the mesh except that tie wire for gabion cages shall not be more than two gauges lighter.

All wire used, including tie and connecting wire, shall be certified by mill test reports showing compliance with specification requirements.

(a) Mesh Opening. The longer dimension of the mesh openings for gabions and slope *mattresses* shall be as shown on the plans.

(b) Wire Mesh. Wire mesh shall be woven in such a manner as to be non-raveling and have elasticity. Tests for compliance with these and the following properties shall be performed by the Contractor. A certified test report, showing these required results and information shall be supplied with each project. Tests are to be run on cages of the same specification, made within a year before the date of letting.

(c) Non-raveling. The mesh for both gabions and slope mattresses shall show no raveling beyond the mesh opening where the break occurred when the loading is continued after the first break in the test conducted with the pull parallel to the axis of the wire twist.

(d) Elasticity. For gabions, when pulled parallel to the axis of the wire twist and deformation is controlled by spreader bars, no wire shall break until the mesh has been stretched at least 4.5 percent. The pull test shall be performed both parallel and perpendicular to the axis of the wire twist and in either case, the first wire break shall not occur until the loading on the table below has been reached.

(e) Edge Wire Connection. The edge wire connection for both gabions and slope mattresses shall be strong enough so that when tested the first wire break shall occur in the wire mesh.

(f) Selvedge. The selvedge on each sheet of mesh for both gabions and slope mattresses shall be galvanized steel wire (as described above) two gauges heavier than that used in the body of the mesh. For gabions, it shall be attached to the wire mesh strong enough so that when tested, no wire shall break until the loading on the table below has been reached. For slope mattresses, the first wire break shall be in the wire mesh.

(g) Field Connections. The field connections between adjacent wire baskets shall be made as recommended by the manufacturer and shall develop a connection strong enough that the failure under test shall occur in the mesh rather than in the lacing.

Table 712-3
MINIMUM STRENGTH
TESTS FOR GABION BASKETS ONLY

Part	Minimum Strength (pounds per foot)
Wire Mesh	
Pulled parallel to wire twist	3400
Pulled perpendicular to wire twist	1000
Connection of Selvedge wire to mesh	2200

(h) Dimensions. Gabions and slope mattresses shall be supplied in the various sizes shown on the plans. Cages and mattresses furnished by a manufacturer shall be of uniform size.

(i) Tolerances. All gabion and slope mattress dimensions are subject to a tolerance limit of 3 percent of manufacturer's stated sizes.

(j) Riprap. Riprap shall consist of hard, dense, sound, rough fractured stone or local sandstone, as nearly cubical as practicable. Thin slab type stones and flaking rock shall not be used.

Stone shall have a specific gravity of at least 2.25 and shall be resistant to the action of air and water. Flaking or fragmental rock will not be permitted.

The sizes of riprap stone for gabions and slope mattresses shall conform to the following:

	Stone Size
Gabions (cage thickness 12 inch or greater)	4 to 8 inch
Slope Mattress	3 to 6 inch

(k) Soil Anchor Stakes for Wire Mesh Slope Mattresses. Soil anchor stakes shall be steel and may be:

(1) Crane rails of a convenient size, minimum 40 pounds per yard.

(2) Size 2-inch steel pipe conforming to ASTM A53 either black or galvanized.

(3) Size 3-inch x 3-inch x 3/8-inch structural steel angles conforming to ASTM A709 Grade 36 or better.

(4) Used rails, pipe or angles may be used provided the material is not rusted or damaged to such an extent that the strength of the stakes is affected.

Soil anchor stakes shall be of the lengths called for on the plans.

712.10 Epoxy. Epoxy used for bonding new, or wet concrete, to old concrete shall be an approved product and shall be of the type specifically intended for bonding wet concrete to existing concrete. Each container of epoxy shall conform to ASTM C881.

712.11 Plastic Pipe for Underdrains. Polyethylene perforated or nonperforated corrugated pipe shall conform to AASHTO M 252.

Perforated or nonperforated Polyvinyl Chloride Pipe-Smooth Interior, Smooth or Ribbed Exterior, shall conform to AASHTO M 304.

712.12 Geocomposite Drains. Geocomposite drains, underdrains, and edge drains for subsurface drainage shall be constructed of a drainage geotextile and a semi-rigid drainage core. A drainage pipe collector may also be included in the drain system.

Drainage geotextile shall be a minimum Class 3, conforming to AASHTO M 288. The drainage pipe collector, when used, shall conform to the requirements designated in subsection 605.02 for the type of pipe used.

The semi-rigid drainage core shall be constructed of material that will not deteriorate in subsurface conditions and shall conform to the physical requirements of Table 712-4.

Table 712-4
PHYSICAL REQUIREMENTS FOR DRAINAGE CORE

Property	Value	Test Method
Compressive Strength, kPa (lb/sq in)	140 (20)	ASTM D1621
In-Plane Flow Capacity L/s/m (gal/min/ft), minimum	2.12 (10)	ASTM D4716
Minimum Core Thickness, mm (inch)	6 (0.25)	

712.13 Plastic Pipe. Plastic pipe shall conform to the following requirements for the type of pipe used:

(a) Polyethylene (PE) Pipe. Polyethylene (PE) pipe shall conform to the following requirements for the type of culvert pipe used:

1. AASHTO M 252 (Corrugated Pipe) for nominal pipe sizes of 3 to 10 inches (75 to 250 mm) with the following additions or exceptions:
   A. Type S, and Type SP are acceptable. (Type C, Type CP and Type D will not be accepted.)
   B. Rotational Molded Pipe will not be accepted.
2. AASHTO M 294 (Corrugated Pipe) for nominal pipe sizes of 12 to 60 inches (300 to 1,500 mm) with the following additions or exceptions:
   A. Type S, and Type SP are acceptable. (Type C, Type CP and Type D will not be accepted.)
   B. Rotational Molded Pipe will not be accepted.
3. ASTM F894 (Ribbed, Profile) with the following additions or exceptions:
   A. AASHTO LRFD Bridge Design Specifications, SECTION 12, 50-year life requirements.
   B. Minimum Cell Class per ASTM D3350 of 334433C or 335434C.
   C. Minimum section properties as noted in SECTION 12.
4. ASTM F 714 (Smooth Wall) with the following additions or exceptions:
   A. A DR of 21 or less will be required.
   B. AASHTO LRFD Bridge Design Specification, SECTION 12, 50-year life requirements.
   C. Minimum Cell Class per ASTM D3350 of 335434C.

The Contractor shall provide a polyethylene (PE) pipe product that is prequalified under the AASHTO National Transportation Product Evaluation Program (NTPEP). Only products from suppliers whose manufacturing plant and PE pipe products comply with this specification shall be placed by the Contractor. The current list of plants and PE pipe products that meet these requirements is located at: www.ntpep.org . The Contractor shall use plants listed as compliant and a size listed in the NTPEP reports on PE Thermoplastic Pipe. Every Certificate of Compliance (COC) on each diameter PE pipe product delivered to the project shall include a statement that the product has been manufactured at a NTPEP inspected plant, has been tested by NTPEP, has a NTPEP product number, and is currently on the NTPEP website. The COC shall confirm that the supplied pipe meets the applicable specification limits in subsection 712.13. Manufacturers shall remain acceptable to CDOT as long as the results of verification samples and performance in the field are satisfactory. Any changes in the PE pipe formulation will require re-submittal for prequalification testing by NTPEP.

(b) Polyvinyl Chloride (PVC) Pipe

(1) AASHTO M 304 (Profile) for nominal pipe sizes of 4 to 36 inches.

(2) ASTM F794 (Profile) for nominal pipe sizes 4 to 36 inches with 46 psi minimum pipe stiffness.

(3) ASTM F949 (Profile) for nominal pipe sizes 4 to 36 inches with 46 psi minimum pipe stiffness.

(c) Polypropylene (PP) Pipe. AASHTO M 330 for nominal pipe sizes of 12 to 60 inches with the following exceptions: Type S and Type SP are acceptable; Type C, Type CP and Type D will not be accepted.

The Contractor shall provide a polypropylene (PP) pipe product that is prequalified under the AASHTO National Transportation Product Evaluation Program (NTPEP). Only products from suppliers whose manufacturing plant and PP pipe products comply with this specification shall be placed by the Contractor. The current list of plants and PP pipe products that meet these requirements is located at: www.ntpep.org. The Contractor shall use plants listed as compliant and a size listed in the NTPEP reports on PP Thermoplastic Pipe. Every Certificate of Compliance (COC) on each diameter PP pipe product delivered to the project shall include a statement that the product has been manufactured at a NTPEP inspected plant, has been tested by NTPEP, has a NTPEP product number, and is currently on the NTPEP website. The COC shall confirm that the supplied pipe meets the applicable specification limits in subsection 712.13. Manufacturers shall remain acceptable to CDOT as long as the results of verification samples and performance in the field are satisfactory. Any changes in the PP pipe formulation will require re-submittal for prequalification testing by NTPEP.

(d) Steel Reinforced Polyethylene (SRPE). SRPE pipe shall be AASHTO MP 20 ribbed pipe for nominal pipe sizes 12 to 60 inches with the following exceptions:

Nominal pipe sizes 30 to 60 inches are acceptable; nominal pipe sizes 12 to 27 inches will not be accepted.

SECTION 713
TRAFFIC CONTROL MATERIALS

713.01 Signs – General. Aluminum or steel used for traffic control shall conform to Table 713-1.

Table 713-1
REQUIREMENTS FOR ALUMINUM OR STEEL
USED IN TRAFFIC CONTROL

Application	Aluminum ASTM Designation	Aluminum Alloy No. Temper	Steel ASTM Designation
Sign panels	B209 B449* B921*	6061-T6 5052-H36 5052-H38	A653#
Traffic controller cabinets	B209	6061-T6	A709 Grade 36
Clip bolts	B211	2024-T4	
Locknuts or steel nuts and bolts	B211	2014-T4	A307
Clips and backing angles	B221	6061-T6	

Table 713-1 Notes:
*In lieu of ASTM treatment, aluminum sign blanks shall receive a Class 2 anodized coating before the placement of retroreflective sheeting.
#Steel sheets shall have a Z600 zinc coating per ASTM A653 and a light phosphate coating. Phosphate coating of 3.5 oz./sq. ft. will be required for application with reflective sheeting. Nuts and bolts shall be galvanized, or cadmium plated.

713.02 Aluminum Sign Panel Tolerances. Aluminum sign panel sheet dimensional tolerances shall conform to the applicable requirements of the American National Standards Institute Dimensional Tolerances for Aluminum Products, ANSI-H35.2(M), with the following exceptions:

The flatness tolerances shall be one-half the values listed in Table 3.12 and shall apply to all aluminum alloy grades permitted for sign panels.

Sign blanks are to be tensile leveled for sheet thickness less than 0.09 inch, and stretcher leveled for thickness equal to or greater than 0.09 inch.

The individual sign blank bow tolerance (deviation of a side edge from a straight line) shall not exceed 1/3 inch, and the dimensions of the opposing sides shall be within 1/16 inch.

Aluminum sign panel shall be subject to the requirements of the first paragraph of subsection 713.09.

713.03 (unused)

713.04 Sign Message Materials. The legend, border, and overlay shall be used per the sheeting manufacturer's recommendation. Retroreflective sheeting background material shall be on the Department's Approved Product List; and the retroreflective sheeting background material shall be the type specified on the plans. At a minimum, ASTM D4956 Type IV shall be used for ground mount signs. ASTM D4956 Type XI shall be used for Class III overhead signs.

For Class III overhead signs, the legend and borders shall be ASTM D4956 Type XI sheeting.

All reflective sheeting shall be sealed at the seams and edges as recommended by the manufacturer.

713.05 Hardware. All hardware shall be compatible with sign material and shall not cause discoloration due to weather.

713.06 Flexible Delineators

(a) Physical Properties

1. Material. The post shall be manufactured from an impact resistant flexible material, and resistant to the following: U.V. exposure, cold weather temperatures, temperature fluctuation, and de-icing materials. The post shall be permanently sealed at the top and shall be date-stamped showing the month and year of fabrication. The date-stamp shall be on top of the post on the side facing away from traffic. The numerals shall be at least 1/4 inch in height and shall be die-stamped or legibly stamped with permanent ink.
2. Color. The post shall be Interstate Green in accordance with AMS-STD-595, Color Number 14109, unless otherwise specified. The post shall show no signs of delamination, distress, or discoloration.
3. Dimensions.
   A. Length. The post shall provide a height of 48 inches above the edge of pavement and provide the required anchoring depth for Drivable Method of installation. The post length shall conform to requirements outlined in S-612-01 for all other methods of installation.
   B. Width. The post shall have a minimum width of 2 3/8 inches and a maximum width of 4 1/8 inches facing traffic.

(b) Base Anchoring. The post shall be designed to facilitate a permanent installation resistant to overturning, twisting, and displacement from wind and impact forces. A metal anchor base shall be installed per CDOT Standard Plan S-612-01 or manufacturer's recommendation. A concrete foundation shall be used for delineator support in soft soils per the plans or as directed by the Engineer.

The base anchor shall be capable of being driven into an earth shoulder with or without a pilot hole. Installation shall be accomplished with typical maintenance equipment.

(c) Reflective Elements. Posts shall be shaped to accommodate the installation of reflective elements. Each reflective element shall be a 3 x 3 inch squared, Type IV or Type V reflective sheeting material meeting the requirements of subsection 713.10.

A Type I delineator shall have one (3 x 3 inch) reflective element on one side, a Type II delineator shall have two (3 x 3 inch) reflective elements on one side, and a Type III delineator shall have three (3 x 3 inch) reflective elements on one side.

Reflective elements shall be placed in a straight vertical column starting one inch from the top edge of the delineator. Type II and III delineators shall have reflective elements separated by one inch vertically in the column.

All reflective elements shall be placed at the factory by the manufacturer prior to on-site delivery of delineators. The texture of the projected surface shall be smooth and suitable for the adherence of reflective elements without preparation other than wiping with a clean cloth damped with mineral spirits to remove oil-type contaminants.
Reflective elements shall be protected from scratches, abrasions, and other physical damage during shipping and base anchor driving by an easily removable “masking” sheet.

(d) Workmanship. The posts shall exhibit good workmanship and shall be free of burrs, discoloration, contamination, and other objectionable marks or defects which affect appearance or serviceability. Each post shall be visibly free of bends or twists, prior to and after installation.

(e) Performance Requirements. Posts shall be tested in accordance with NTPEP's Evaluation of Temporary Traffic Control Devices: Flexible Delineators. Posts shall be designed such that an installed post is capable of self-erecting and remain serviceable after being subjected to a series of direct impacts by a typical passenger sedan. Posts installed in ground mount, side of roadway configurations shall be capable of withstanding a series of ten impacts into the traffic face of the post at a speed of 55 mph. Posts installed in surface mount, head-on and/or channelizing configurations shall be capable of withstanding a series of 125 impacts into the traffic face of the post at a speed of 55 mph. CDOT reserves the right to require additional testing to best meet the performance of Colorado’s environment.

(f) Sampling and Acceptance. Prior to shipment of posts, the manufacturer shall submit a MASH self-certification letter to the Project Engineer.

713.07 Reflectors. Reflectors shall consist of a clear and transparent acrylic plastic prismatic reflex lens with a smooth front face, except for the legibly molded manufacturer's trademark, and a back hermetically sealed surface with prismatic configuration effecting total internal reflection of light. Firmly fused to the back surface shall be a backing material. The backing material shall be white opaque plastic of the same type as the lens and delineator reflectors may be backed with a plastic-coated metallic foil. Delineator reflectors shall be housed in embossed aluminum and provided with a single grommeted mounting hole. The delineator unit shall withstand the combined corrosion test described in ASTM B117.

713.08 Glass Beads for Traffic Markings. Glass beads for pavement marking shall conform to AASHTO M 247, except for the following:

1. Gradation:

Table 713-2
GRADATION OF GLASS BEADS

U.S, Mesh	Microns	Modified Epoxy and Methyl Methacrylate % Passing	Acrylic Waterborne: Low Temperature and High Build % Passing
16	1180	90-100	100
18	1000	65-80	97-100
20	850		85-100
30	600	30-50	50-70
40	425		10-35
50	300	0-5	0-10
80	180		0-5

2. Roundness: All beads shall meet a minimum of 80 percent true spheres per the Office of Federal Lands Highways FLH T520 or a computerized optical testing method.
3. Color / Clarity: Beads shall be colorless, clear, and free of carbon residues.
4. Refractive Index: Minimum 1.51 by oil immersion method.
5. Air Inclusions: Less than 5 percent by visual count.
6. Coatings: According to the manufacturer's recommendation for optimum adhesion and embedment.
7. Chemical Resistance: Beads shall be resistant to hydrochloric acid, water, calcium chloride, and sodium sulfide as tested using the methods outlined in sections 4.3.6 to 4.3.9 of the TT-B Federal Spec.1325D.
8. For modified epoxy pavement marking, a minimum of 50 percent of the total weight shall be manufactured using a molten kiln direct melt method. For acrylic waterborne paint, a minimum of 15 percent of the total weight shall be manufactured using a molten kiln direct melt method. All molten kiln direct melt glass beads shall be above the 600 µm (#30) sieve.
9. Glass beads used for any type of pavement marking shall not contain more than 75 parts per million (ppm) arsenic, 75 ppm antimony and 100 ppm lead, as tested per EPA methods 3052 and 6010C, or other approved testing method.

   Glass beads shall be furnished in fully identified containers and shall be free of extraneous material or clumps.

   Glass beads for thermoplastic pavement marking shall conform to AASHTO M 247, Type 1.

713.09 Sampling and Inspection. The Engineer shall be notified well in advance of beginning of shop work so that adequate arrangements may be made for sampling and inspection. Shop inspection may be waived, and complete inspection made when the fabricated sign panels are delivered to the site of the work.

The following samples shall be submitted to the Engineer for approval:

(1) A 12-inch x12-inch sample of finished material for figure frames.

(2) A 12-inch x12-inch sample of reflective sheeting representing each lot used on the project.

(3) Two reflectors for each 100, or part thereof, of each size and color, with a limit of 53 samples for any one size or color. When reflective buttons are so affixed to the cutout frames that their removal for testing will cause breakage, it shall be the responsibility of the sign fabricator to furnish a representative sample of reflective buttons.

(4) 2 pounds of glass beads, representing each lot used on the project.

(5) 1 pint of paint of each color, representing each lot used on the project.

(6) 1 pound of thermoplastic marking material and one liter of each primer component.

(7) 36-inch strip of preformed plastic pavement marking.

(8) 36-inch strip of pavement marking tape.

(9) 1 square foot of preformed thermoplastic pavement marking material.

713.10 Quality Requirements of Reflective Materials. Reflective devices and reflective sheeting shall be materials that are on the Department's Approved Products List.
(a) Reflective Devices.

1. Reflective Quality Requirements.

   A. Delineator and Median Barrier Reflectors. The specific intensity of each delineator and median barrier reflector shall be at least equal to the following minimum values when tested per AASHTO T257, with an observation angle of 0.1 degrees.

TABLE 713-3
QUALITY REQUIREMENTS OF
DELINEATOR AND MEDIAN BARRIER REFLECTORS
Specific Intensity Candlepower per Foot-Candle

Entrance Angle Degrees	Crystal	Yellow	Blue	Red	Green
0	115	70	48	25	62
20	45	25	26	10	34

   B. Cut-out Figure Reflectors. The specific brightness of crystal reflectors used in cut-out figures shall be at least equal to the following minimum values.

Table 713-4
QUALITY REQUIREMENTS OF
CUT-OUT FIGURE REFLECTORS

Observation Angle Degrees	Entrance Angle Degrees	Specific Brightness: Candlepower per Sq In per Foot-Candle
0.1	0	14.0
0.1	20	5.6

2. Material and Component Requirements. Plastic for delineator and cutout figure reflectors shall be poly methyl methacrylate conforming to requirements of ASTM D788, Grade 8. The reflectors shall meet test requirements of CP L-2115, Section 3.2 and 3.3.

(b) Retroreflective Sheeting. Reflective sheeting for traffic control devices shall be listed on the CDOT Approved Products List and conform to the requirements of ASTM D4956.

1. Retroreflective Quality Requirements.

   Drums and Tubular Markers. Retroreflective sheeting shall conform to ASTM D4956 Type IV, with the following modifications:

   The Minimum Coefficient of Retroreflection (RA) shall conform to the following minimum values.

Table 713-5

MINIMUM COEFFICIENT OF RETROREFLECTION (RA)

Minimum Coefficient of Retroreflection (R_A) [cd/fc/ft^2 (cd/lx.m^2)]

Observation Angle	Entrance Angle	White	Fluorescent Orange
0.2°	-4°	500	200
0.2°	30°	200	80
0.5°	-4°	225	90
0.5°	30°	85	34

2. Daytime Color.

   Drums and Tubular Markers. All fluorescent orange sheeting shall meet the color requirements of ASTM D4956, with the following modifications:

   The chromaticity coordinates and total luminance factor shall conform to the requirements as described in 23 CFR Part 655 Appendix to Subpart F.

   The Fluorescence Luminance Factor (YF) shall conform to the following minimum values.

Table 713-6

MINIMUM FLUORESCENCE LUMINANCE FACTOR (YF)

Color	Y_F Initial Requirement	Y_F Minimum Requirement
Fluorescent Orange	20	15

713.11 Traffic Signals. Electrical conduit, pull boxes and junction boxes shall conform to the requirements of Section 613 and subsection 715.06, and to the details shown on the plans.

Conductors shall be nineteen strand or seven stranded, tinned copper wire, rated at 600 volts and individually insulated with heat-stabilized polyethylene. Conductors and cables shall be copper and conform to Specification 19-1 of the International Municipal Signal Association (IMSA).

Direct-burial cable shall be copper and conform to Specification 19-5 of the IMSA except that conductors x shall be seven, wire, stranded.

Pull rope shall be 1/8-inch nylon.

Messenger cable (span wire) shall be 3/8-inch diameter (minimum), seven wire stranded, common galvanized, utilities grade, rated at 11,500 pounds, per ASTM A475.

Grounding and bonding wires, straps and electrodes shall be copper and conform to NEC Article 250.

Adjustable face vehicle traffic control signal heads and associated equipment shall conform to the general specifications and definitions contained in the latest issue of Technical Report No. 1, prepared by the ITE, and as shown on the plans.

Adjustable face pedestrian signal heads and associated equipment shall conform to the general specifications and definitions contained in the latest issue of Technical Report No. 5, prepared by the Institute of Traffic Engineers, and as shown on the plans.

Traffic signal lamps shall conform to the general specifications and definitions contained in the latest issue of Technical Report No. 6, prepared by the Institute of Traffic Engineers. Lamps shall be rated for operation at 120 volts AC. Lamp wattages shall be 60-69 Watts for all 8-inch traffic signals, 150 Watts for all 12-inch traffic signals, 116 Watts for all 16-inch pedestrian signals, or as otherwise specified by the manufacturer.

LED Traffic Signal Section optical units shall meet or exceed ITE Adjustable Face Vehicular Traffic Control and Pedestrian Signal Head Standards. In addition to this, LED optical units shall conform to the following requirements:

(1) Wattage

Table 713-7

WATTAGE FOR TRAFFIC CONTROL SIGNAL HEADS

Max. 35 watts, ±5 watts for 12-inch ball
Max. 30 watts, ±5 watts for 8-inch ball
Max. 15 watts, ±5 watts for 12-inch arrow
Max. 15 watts, ±5 watts for PED hand symbol

Maximum total harmonic current distortion (THD) shall be < 20 percent.

Power factor shall be > 90 percent.

Load balance requirement: load in one phase shall not exceed the load in any other phase by 15 percent.

Note: THD and power factor requirements shall be waived for products designed to operate at less than 14 watts.

(2) Voltage

Operating shall be between 85 and 130 VAC. Electronic circuitry shall ensure proper operation of the load switch and monitor in the control cabinet.

(3) Circuit Configuration

The LEDs shall be connected to form multiple series circuits. All series circuits shall be interconnected at intervals, forming subcircuits not exceeding 15 LEDs for the ball and arrow signals, and 10 LEDS for the pedestrian hand symbol. In the event of an LED failure, these subcircuits shall limit the number of extinguished LEDs to no more than 4 percent of the total on the ball and pedestrian hand signal lamps, and 6 percent of the total on the arrow lamp.

(4) Enclosure

Shall be dust and water resistant.

(5) Operating Temperature

Between minus 40 °F and plus 165 °F

(6) Lens

Shall be replaceable, polycarbonate (UV stabilized "Lexan") convex lens; meet ITE color standards; minimum of 1/8 inch thickness; and minimum light transmittance of 92 percent, free from bubbles, flaws and other imperfections. Non-polycarbonate tinted lenses will be accepted if they meet ITE color standards. Chromacity shall be measured uniform across the face of the lens. Non-polycarbonate lenses shall also meet 3 1/2-foot drop tests. The outside face of the lens shall be smooth. Grooves, ridges, or both that may be used to enhance optical characteristics of the LED optical unit shall be located on the inside face of the lens.

(7) Candlepower Distribution

Shall meet minimum ITE specifications. Intensity shall be measured uniform across the face of the lens. Brightness shall be maintained in the event of voltage fluctuations or voltage drops.

(8) Beam Spread

30 degrees both horizontally and vertically.

(9) Manufacturer’s Warranty

Repair or replacement guarantee of five years covering all but accidental damage.

Foundations for poles, pedestals, posts, and cabinets shall conform to the requirements of Section 601.

Bonding and grounding jumpers shall be copper wire or copper strap of the same cross-sectional area; the wire size shall be No. 6 AWG for all systems except the ground terminal of controllers, which shall be No. 8 AWG.

All exterior parts of the signal heads requiring paint shall be painted Federal Yellow 595B No. 13538 unless otherwise specified.

Traffic signal faces, which are rigidly supported on the top and bottom, may be of an approved polycarbonate type unless otherwise shown on the plans.

713.12 Thermoplastic Marking Material. Thermoplastic marking material shall conform to AASHTO M 249 except for the following:

(1) In paragraph 3.1.2 of the AASHTO specifications, delete the first two sentences and replace with the following:

The material manufacturer shall have the option of formulating the material according to its own specifications. However, the binder shall be composed of alkyd resins wherein a minimum of 70 percent (by weight) of the binder shall be maleic modified glycerol ester of rosin. The physical and chemical properties contained in this specification shall apply regardless of the type of formulation used.

(2) In paragraph 4.3 of the AASHTO specifications, add the following physical characteristics: The infra-red spectra of the extracted binder will be compared to the characteristic absorption bands of maleic modified glycerol ester of rosin.

(3) In paragraph 6.1 of the AASHTO specifications, delete the second sentence and replace with the following: The containers of thermoplastic material shall weigh approximately 50 pounds.

713.13 Preformed Plastic Material. Preformed plastic pavement marking material shall conform to ASTM D4505 for one of the following requirements:

(1) Class 1 tape will not be permitted.

(2) Class 2: for lane lines, crosswalks, stop lines and edge lines.

(3) Class 3: for legends and symbols.

Preformed plastic pavement marking color shall conform to the requirements of ASTM D6628.

Preformed plastic pavement markings shall meet the dimensional requirements of ASTM D4505.

Skid resistance will not be considered a factor for acceptance.

The edges of the preformed plastic pavement marking shall be straight and uniform, and consistently adhere to the pavement.

Unless otherwise stated in the Contract, preformed plastic pavement marking shall conform to the following material requirements for the Type shown on the plans:

Table 713-8
PREFORMED PLASTIC PAVEMENT MARKING

Property	Type I	Type II*	Type III
Minimum thickness (mils)	75	75	60
Minimum Width (in)	4	7	4
Initial Retroreflectivity	Retroreflectivity level I per ASTM D4505	Retroreflectivity level I per ASTM D4505	Retroreflectivity level II per ASTM D4505
Adhesion (°F)#	Roadway surface temperature range of 50 °F - 115 °F ◂ per ASTM Test Method 1000	Roadway surface temperature range of 50 °F - 115 °F ◂ per ASTM Test Method 1000	Roadway surface temperature range of 50 °F - 115 °F per ASTM Test Method 1000
Beads	Ceramic or combination of glass and ceramic	Ceramic or combination of glass and ceramic	Glass
Minimum refractive index	1.7	1.7	1.5
Surface pattern	Minimum of 31 mils and per ASTM D4505	Minimum of 31 mils and per ASTM D4505	N/A

Table 713-8 Notes:
* Contrast pavement marking to be used for skip lines, lane lines and gore markings.
#The adhesion temperature is identical to both the application and test temperatures.
◂ Application at a lower temperature may be permitted as approved by the Engineer.

713.14 Preformed Thermoplastic Material.

(a) General. Preformed thermoplastic markings shall be composed of aggregates, pigments, binders and glass beads, and shall conform to AASHTO designation M 249 with the exception of the relevant differences due to the fact that the material is supplied in a preformed state. The material shall be either alkyd or hydrocarbon based. Only preformed thermoplastic pavement marking material listed on the Department's approved products list may be used.

(b) Physical Requirements.

1. Graded Glass Beads. The material shall contain a minimum of 30 percent graded glass beads by weight. The beads shall be clear and transparent. Twenty percent or less shall consist of irregular, fused spheroids, or silica. The refractive index shall be at least 1.50.

2. Pigments. White - Sufficient titanium dioxide pigment shall be used to ensure a color similar to Federal Highway White, Color No. 17886, conforming to Federal Standard 595. Yellow - Sufficient yellow pigment shall be used to ensure a color similar to Federal Highway Yellow, Color No. 13655, conforming to Federal Standard 595. The yellow pigment shall be organic and contain no lead chromate.

3. Skid Resistance. The surface of the preformed thermoplastic markings shall provide a minimum resistance value of 45 BPN when tested according to ASTM E303.

4. Thickness. The material shall be supplied at a minimum thickness of 125 mils.

5. Environmental Resistance. The preformed thermoplastic material shall be resistant to deterioration due to exposure to sunlight, water, oil, gasoline, salt and adverse weather conditions.

713.15 Pavement Marking Tape.

(a) Description. The marking tape shall consist of weather and traffic resistant yellow or white colored reflective material. The material shall consist of conformable (metal foil) backing with a pressure sensitive adhesive designed for adhesion to asphalt or concrete surfaces.

(b) Requirements.

1. Color. The color of the visible or outer surface shall closely match the white or yellow traffic marking paint specified for highway delineation. Glass beads shall be strongly adhered to the tape.

2. Reflectance. The white and yellow tapes shall have the following initial minimum reflectance values at 0.20° and 0.50° observation angles and 86.00° entrance angle as measured per the testing procedures of Federal Test Method Standard 370. The photometric quantity measured is specific luminance (SL) and is expressed as millicandelas per square meter per lux.

TABLE 713-9

SPECIFIC LUMINANCE (SL)

Observation Angle	White 0.2°	White 0.5°	Yellow 0.2°	Yellow 0.5°
Specific Luminance	1360	760	820	510

3. Adhesive. The striping tape shall be supplied in rolls ready for application and have a precoated pressure sensitive adhesive, which shall not have a protective liner or require a solvent activator.

4. Adhesion. The material shall adhere to asphalt and concrete surfaces when applied at surface temperatures of 35 °F and above. Once applied, the tape shall adhere to the pavement at subfreezing temperatures.

5. Conformability. The material shall be thin, flexible, conformable, and show no cracking, flaking, or bead loss. Following application, the tape shall remain conformed to the texture of the pavement surface. The thickness of the material shall not be less than 17 mils.

6. Removability. The tape shall be removable by following manufacturers' recommendations so long as the material is substantially intact. Removal shall not require sandblast, solvents, or grinding methods.

7. Durability. The striping material applied per manufacturers' recommended procedures shall be weather resistant and show no appreciable fading, lifting, or shrinkage during the useful life of the line.

8. Packaging and Delivery. The striping material as supplied shall be of good appearance and free from cracks. The edges shall be true, straight, and unbroken. The material shall be supplied in rolls with no more than one splice per 50 yards of length.

The striping material shall be packaged per accepted commercial standards to prevent damage during shipment and storage. The tape as supplied shall be suitable for use for a period of at least one year following delivery when stored at temperatures of 100 °F or below.

713.16 Pavement Marking Tape (Removable). Pavement marking tape designated in the pay item as removable shall conform to ASTM D4592, Type I, and shall be four plus or minus 0.1 inches wide.

713.17 Modified Epoxy Pavement Marking Material. Only modified epoxy pavement marking material that is on the Department's Approved Products List may be used. Batches or lots of approved products will be accepted on the project by Certificate of Compliance (COC) per subsection 106.12. The

COC shall confirm that the material meets all CDOT requirements and is the same material that was preapproved in the product evaluation process.

(a) Formulation. Modified epoxy pavement marking material shall be a two component, 100 percent solids, material formulated to provide simple volumetric mixing ratio of two volumes of component A and one volume of component B unless otherwise recommended by the material manufacturer.

(b) Composition. The component A of both white and yellow shall be within the following limits:

Table 713-10

RESIN / PIGMENT COMPONENTS (% BY WEIGHT)

Pigment	WHITE	YELLOW
TiO_2, ASTM D476, Type II	18-25	10-17
Organic Yellow		6-10
Epoxy Resin	75-82	73-84

The pigment for yellow modified epoxy shall contain no lead or other material such that the cured epoxy could be considered a hazardous waste under EPA or CDPHE regulations. The Contractor shall submit to the Engineer a manufacturer's certification of compliance with this requirement.

(c) Epoxide Number. The epoxide number of the modified epoxy's resin shall be the manufacturer's target value plus or minus 50 as determined by ASTM D1652 for white and yellow component A on pigment free basis.

(d) Amine Number. The amine number on the curing agent (component B) shall be the manufacturers target value plus or minus 50 per ASTM D2071.

(e) Toxicity. Upon heating to application temperature, the material shall not produce fumes that are toxic or injurious to persons or property.

(f) Color. The modified epoxy material, without drop-on beads, shall correspond following requirements:

White – Federal Standard No. 595B-17925. The Yellowness Index (YI) of white shall not exceed 8.0 per ASTM E313-10 initially.

After 72 QUV exposure per ASTM G154 with a UVA-340 Lamp at an irradiance of 0.89 W/m2/nm with alternating cycles of 4 hours U.V @ 140 ºF, and 4 hours' humidity @ 122 ºF the YI shall not exceed 15 when measured per ASTM E313.

The YI, after 500-hour QUV testing as above, shall not exceed 27.

Yellow – Materials for pavement markings shall meet the initial daytime chromaticity that fall within the box created by the following corner points:

Table 713-11

INITIAL DAYTIME CHROMATICITY

COORDINATES (CORNER POINTS)

	1	2	3	4
x	0.530	0.510	0.455	0.472
y	0.456	0.485	0.444	0.400

After 72-hour QUV exposure per ASTM G154 with a UVA-340 Lamp at an irradiance of 0.89 W/m2/nm with alternating cycles of 4 hours U.V @ 140 ºF, and 4 hours' humidity @ 122 ºF the Yellow shall fall within the initial chromaticity coordinates stated above.

(g) Drying Time. The modified epoxy pavement marking material shall have a setting time to a no-tracking condition of not more than 25 minutes at a temperature of 73 °F and above.

(h) Curing. The modified epoxy material shall be capable of fully curing under the constant surface temperature condition of 35 °F and above.

(i) Adhesion to Concrete. The catalyzed modified epoxy pavement marking material, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified (4,000 psi minimum) concrete surface that there shall be a 100 percent concrete failure in the performance of this test.

(j) Hardness. The modified epoxy pavement marking materials, when tested according to ASTM D2240, shall have a minimum Shore D Hardness value of 80. Samples shall be allowed to cure at room temperature, 75 plus or minus 2 °F, for a minimum of 72 hours and a maximum of 168 hours before performing the indicated test.

(k) Abrasion Resistance. The abrasion resistance shall be evaluated on a Taber Abrader with a 1,000-gram load and CS-17 wheels. The duration of the test shall be 1,000 cycles. The wear index shall be calculated based on ASTM test method C-501 and the wear index for the catalyzed material shall not be more than 60. The tests shall be run on cured samples of material that have been applied at film thickness of 15 plus or minus 1/2 mils to code S-16 stainless-steel plates. The samples shall be allowed to cure at 75 plus or minus 2 °F for a minimum of 72 hours before performing the indicated tests.

(l) Tensile Strength. When tested according to ASTM D638, the modified epoxy pavement marking materials shall have a tensile strength of at least 6,000 psi. The Type IV Specimens shall be cast in a suitable mold and pulled at the rate of 1/4 inch per minute by a suitable dynamic testing machine. The samples shall be allowed to cure at room temperature, 75 plus or minus 2 °F, for a minimum of 72 hours and a maximum of 168 hours before performing the indicated tests.

(m)Compressive Strength. When tested according to ASTM D695, the catalyzed modified epoxy pavement marking materials shall have a compressive strength of at least 12,000 psi. The cast sample shall be conditioned at room temperature, 75 plus or minus 2 °F, for a minimum of 72 hours and a maximum of 168 hours before performing the tests. The rate of compression of these samples shall be no more than 1/4 inch per minute.

713.18 Raised Pavement Marker. Raised pavement marker shall not be less than 3.5 inches or more than 4.5 inches in the major dimension and not more than 0.75 inch in height. The marker shall contain a retroreflective element at least 0.38 square inch in area. The color of the marker and the retroreflective element shall match the color of the pavement marking line. The reflective quality requirements shall be at least equal to the following minimum values:

Table 713-12
RAISED PAVEMENT MARKER
REFLECTIVE QUALITY REQUIREMENTS

Observation Angle Degrees	Entrance Angle Degrees	White Specific Intensity Candela per Lux	Yellow Specific Intensity Candela per Lux
0.1	0	0.09	0.06
0.1	20	0.04	0.02

The marker shall be ceramic or plastic and shall be secured to old or new pavement using an adhesive approved by the marker manufacturer.

713.19 Methyl Methacrylate Pavement Marking. The Methyl Methacrylate material shall be preapproved by the Department.

SECTION 714
PRESTRESSED UNIT MATERIALS

714.01 Prestressing Steel. Prestressing reinforcement shall be manufactured from high tensile strength steel or alloyed steel. Reinforcement size and grade shall be designated in the Contract. Prestressing steel materials shall meet the appropriate following requirements:

(1) Seven wire steel strand shall meet the requirements of AASHTO M 203. All furnished strand shall be "weldless" per AASHTO M 203, subsection 8.1.4. The Contractor shall furnish one test specimen per coil. Each test specimen shall be 5 to 6 feet long.

(2) High tensile alloy bars shall meet the requirements of AASHTO M 275. Unless otherwise approved by the Engineer, the Contractor shall furnish two test bars per diameter size, per heat number. Each test bar shall be 5 feet in length.

All testing specimens shall be furnished free of cost. If test specimens are not delivered in time for tests to be performed before time of use, the Contractor may elect to incorporate materials into the work at the Contractor's own risk. All test specimens shall be representative of the furnished material lot. If ordered by the Engineer, selection of test samples shall be witnessed by the Engineer's representative, at any location chosen by the Engineer.

All prestressing unit materials shall be subject to interim inspection and testing, before, during and after incorporation into the work, as ordered by the Engineer.

714.02 Anchorage Assemblies. If the anchorage assemblies are not attached to the reinforcement samples, the Contractor shall furnish two anchorage assemblies, complete with distribution plates, for each size or type to be used when requested by the Engineer.

714.03 Post-tensioning Products. The following lengths of materials shall be furnished by the Contractor:

(1) For strand to be furnished with fittings; 5 feet between near ends of fittings.

(2) For bars to be furnished with threaded ends and nuts; 5 feet threads at ends.

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SECTION 715
LIGHTING AND ELECTRICAL MATERIALS

715.01 General. Materials shall be of a standard line from a manufacturer that has at least three installations of the same type that have been installed and active for a minimum of one year. Electrical material shall be listed by the Underwriters' Laboratories, Inc. (UL), and shall conform to the current edition of the National Electrical Code (NEC).

Material shall be the same as, or compatible with, that used and accepted by the agency responsible for maintenance. The Contractor shall coordinate and conduct a final inspection with the Engineer and each Owner upon completion of construction. This inspection shall assure that all lighting and electrical materials comply with these requirements. The Engineer will obtain the Owner's written approval before accepting the work.

The Engineer may inspect all lighting and electrical materials and accept or reject them at the project site. Samples may be taken, or manufacturer's certifications may be accepted in lieu of samples.

715.02 Light Standard Foundations and Concrete Foundation Pads. Concrete shall be Class BZ for cast-in-place concrete foundations. All concrete shall conform to Section 601.

Anchor bolts shall be designed by the Contractor's Engineer and shown on the working drawings, or as provided by the pole manufacturer. The threaded ends of the anchor bolts, the nuts, and the washers shall be galvanized per ASTM A153. Galvanizing on anchor bolts shall extend 2 to 4 inches beyond the threads.

Reinforcing steel shall conform to Section 602.

715.03 Light Standards.

(a) General. Structural components of light standards, bases, couplers, anchor bolts, luminaires, and other attachments to be used for lighting shall be designed for a minimum of 120 MPH wind speed, per AASHTO's LRFD Specifications for Structural Supports for Highway signs, Luminaires, and Traffic Signals, Figure 3.8.2. For special wind regions, the wind speed shall be per AASHTO's Section 3.8.3. The CDOT Bridge Design Manual, Section 32.3 shall be used for Owner approved wind speeds.

Breakaway bases and couplers shall meet the breakaway requirements specified in AASHTO's LRFD Bridge Design Specifications Section 12. Conformance shall be verified by crash tests reviewed and accepted by FHWA. A certificate of compliance shall be provided.

(b) Metal Light Standards. Metal light standards shall be fabricated of either steel or aluminum, unless otherwise specified. Whenever the light standard metal is not specified, the Contractor may furnish either steel or aluminum. Material type and shape of light standards shall be the same throughout the project, unless otherwise shown in the Contract.

Metal poles shall be tapered and shall be supplied with pole caps.

Standards shall have cable-entrance holes located in conformity with the type of arm mounting used. Metal surfaces shall be free of imperfections marring the appearance and of burrs or sharp edges that might damage the cable.

Aluminum alloys shall have a minimum yield strength of 25,000 psi. Aluminum poles, arms, and fittings shall be made of aluminum alloy conforming to the following for the material form required:

ASTM Standard	Alloy Number
B 209	6061-T6
B 211	6061-T6
B 221	6061-T6 6063-T6 6005-T5
B 241	6061-T6 6063-T6

Aluminum poles may also be made of aluminum alloy 5086-H34 conforming to ASTM B313 (excluding pressure and burst tests).

Aluminum mast arms shall be tapered unless otherwise shown on the plans.

Steel mast arms shall be made of Schedule 40 standard steel pipe conforming to ASTM A53.

Steel poles, mast arms and base flanges shall be hot-dip galvanized per ASTM A123. Units where the spelter coating has been damaged shall be repaired as provided in AASHTO M 36, or other approved method.

Base flanges for both aluminum and steel poles shall have continuous welds both inside and outside, unless otherwise permitted. Base flanges inserted into the pole and bonded shall meet the requirements for materials and strength stated.

Base flanges for aluminum poles and transformer bases shall be aluminum castings of alloy ANSI 356.0-T6 or UNS A03560 T6 conforming to ASTM B26 or an acceptable equivalent.

Each metal light standard shall be wired with a breakaway, submersible fused connector of proper capacity rating. The fused connector shall be located in the transformer base. If the light standard has no transformer base, the fused connector shall be located in the pole at the hand hole.

Transformer bases shall have vandal resistant, removable access doors.
The transformer base shall be a frangible breakaway type as shown in CDOT standard S-613-1 and shall accommodate the anchorage and base flange of the light pole supplied. Each transformer base shall have a 1/2 inch bolt or lug fastened inside the base for grounding; the lug or bolt shall be visible from the door opening.

(c) Hardware. Hardware used with steel standards shall be either cadmium plated steel, hot dip galvanized steel, or stainless-steel. All hardware used with aluminum standards shall be anodized aluminum or stainless-steel. Bolts to be inserted in aluminum threads shall be stainless-steel with an anti-seize compound.

715.04 Luminaires and Lamps. Luminaires shall be UL or Intertek Testing Services (ETL) listed for use in wet locations with a minimum IP66 rating. Luminaires shall be adaptable to the type of power distribution system to be used.

(a) General. Luminaires shall conform to the following requirements:

1. Housing. The luminaire enclosure shall be an injection-molded or die-cast opaque housing. The housing shall have a powder-coated, corrosion-resistant finish. The color shall be gray or as specified per the project.

   The housing shall have a door that provides access to all internal components. The door shall be equipped with a safety catch and a latch. The housing shall have an inner rolled flange to support the door frame. The door frame shall be an aluminum casting, hinged to the housing. The door frame shall be sealed to the housing with a molded silicone gasket and shall be secured with a minimum of four captive screws.

2. Optical Chamber. The luminaire distribution shall be equal to or less than an Illuminating Engineering Society (IES) TM-15-11 Backlight, Uplight, and Glare (BUG) ratings listed below in Table 715-1 based on initial luminaire lumens or Light Loss Factor (LLF) = 1.0. Roadway luminaires with a U value greater than U0 shall not be accepted. The optical chamber shall be completely sealed from the housing, or the housing shall be completely sealed. A seamless one-piece memory-retentive gasket shall seal the optical chamber or housing against the luminaire lens door. All wires entering the optical chamber shall be gasketed at their point of entry. Socket mountings, rivets used in the construction or support of the reflector system, and all other penetrations into the optical chamber shall be completely sealed. The optical chamber shall be watertight when the luminaire door is closed.

Table 715-1
BACKLIGHT, UPLIGHT AND GLARE (BUG) VALUES

Luminaire Mounting Location	Minimum Initial Luminaire Lumen Range	Backlight (B) Rating Maximum	Uplight (U) Rating Maximum	Glare (G) Rating Maximum
Non median-mounted	Less than 6,000	B1	U0	G1
	6,000 – 14,000	B2	U0	G2
	14,000 – 24,000	B3	U0	G3
	Above 24,000*	B3	U0	G4
Median-mounted	Less than 6,000	B2	U0	G1
	6,000 – 14,000	B3	U0	G2
	14,000 – 24, 000	B4	U0	G3
	Above 24,000*	B4	U0	G4

Table 715-1 Notes: *By special application only.

3. Lens and Lens Door. The lens shall be either micro-lens fully sealed to maintain an IP66 rating; or shall be constructed of clear, flat (for lamps over 3,200 lumens), tempered glass. The glass shall be thermal-resistant and impact-resistant. The lens shall be sealed to the door frame with continuous silicone gasketing. The door shall have an easy-access, quick-release safety latch. The door shall have aluminum or stainless-steel quick-release hinge pins for tool-less or one-hand easy and secure opening. When the door is closed, the electrical component compartment and the optical chamber shall be completely sealed.

4. Electrical Components. All components shall be listed for wet locations by Underwriters Laboratory (UL), ETL or by an Occupational Safety and Health Administration Nationally Recognized Testing Laboratory (OSHA NRTL). Luminaires shall operate from 120 to 277 VAC or be adaptable to the type of power distribution system to be used. All internal wiring and quick disconnects shall be rated for at least 600 VAC and insulated for 302°F. The dimmable driver shall be easily removed from the luminaire housing without the use of tools. The following components shall be per corresponding sections of ANSI C136.37:

   A. Wiring and grounding electrodes.

   B. Terminal blocks for incoming AC lines.

   C. 7-pin Photocontrol receptacle; and

   D. Latching and hinging.

(b) Roadway Luminaires. Roadway luminaires shall be Light Emitting Diode (LED) type with integral driver, flat lens, aluminum housing, and be UL or ETL listed for wet locations. All luminaires for the project shall be the same type and design unless the plans specify otherwise.

1. The luminaire and all components shall be UL or ETL listed for wet location and shall have minimum ingress protection rating of IP66.
2. The light source shall be composed of LED modules connected to a non-integrated driver and be ready for connection to a production line luminaire. Luminaires utilizing integrated driver LED light sources, screw-based products, or panel retrofit products shall not be used.
3. The luminaire shall have a Type II, III, or IV distribution for non-median mounted luminaires, and Type II, III, IV or V distribution for median mounted luminaires.
4. Transmissive optical components shall be applied per LED manufacturer's Original Equipment Manufacturer (OEM) design guidelines to ensure suitability for the environment where the luminaire is installed.
5. Luminaires shall utilize an adjustable slipfitter-type mounting system for installation on 1.25-inch (1.66-inch outer diameter (o.d.)) to 2-inch (2.375-inch o.d.) diameter pipe tenons. Slipfitter shall consist of a two-piece clamp and four 9/16-inch hex bolts. Slipfitter shall allow for a vertical tilt adjustment of plus or minus 5 percent in order to mount luminaire plumb to foundation for a U0 rating (no uplight). Luminaires shall be equipped with integrated leveling bubble.
6. Access to all internal parts requiring replacement shall not require tools ("tool-less entry").
7. The luminaire housing shall be constructed of aluminum alloy.

8. The power supply and driver shall be provided in compliance with subsection 715.05. The dimming driver shall be internal and thermally separated from the LED compartment.

9. The dimming 7-pin photocell receptacle shall conform to subsection 715.04(d) below.

10. The luminaire finish shall be corrosion resistant super triglycidyl isocyanurate (TGIC) polyester powdercoat. The color shall be gray or as specified per the project.

    A. Powder coat: super TGIC polyester powder coat 2.5 mil nominal thickness.

    B. Finish shall exceed a rating of 6 per ASTM D1654 after 1,000 hours of testing per ASTM B117.

    C. The coating shall exhibit no greater than 30 percent reduction of gloss per ASTM D523, after 500 hours of ultraviolet (UV) testing at ASTM G154.

11. The effective projected area (EPA) for wind-loading calculations shall be no greater than 1.2 square feet.

12. The luminaire weight shall not exceed 45 pounds.

13. The luminaire shall be tested per IES LM-79 and TM-21 certifying photometric performance and rated life, respectively. IES LM-79 (performance) and TM-21 (predicted life at 55°C) testing shall both be for the same luminaire's operating drive current.

14. The luminaire shall have a maximum Backlight rating as shown in Table 715-1, an Uplight rating of U0, and a maximum Glare rating as shown in Table 715-1.

15. The luminaire system efficacy shall not be less than 85 luminaire lumens per input watt.

16. The luminaire shall have an external label per ANSI C136.15 and internal label per ANSI C136.22.

(c) Light Sources. LED luminaires shall not be retrofit to existing luminaire housing; the Contractor shall replace the housing along with the luminaire as a single unit. Light sources shall be compatible with dimmable drivers supplied with the luminaires where they are to be installed. The same manufacturer shall provide all light sources of a similar type.

LED light sources shall meet or exceed the following requirements:

1. CCT, CRI and Flux:

    A. Correlated Color Temperature (CCT) – All LED light sources shall emit white light and have a CCT no greater than 3,400K nominal per ANSI C78.277.

    B. Color Rendering Index (CRI) – All LED light sources shall have a minimum Color Rendering Index (CRI) of 70 per the IES LM-79 test results.

    C. Luminous Flux – LED light sources shall not exceed the junction temperature recommended by the LED manufacturer. Luminous flux differences between LEDs shall not exceed 10 percent.

2. LEDs shall have a minimum rated life of 70,000 hours per IES TM-21 at 55 °C at the normal operating driver current for the specific luminaire. The lumen output shall be maintained at 70 percent of initial rated lumens (L70) or greater at the rated life of the luminaire.

3. LEDs shall be temperature rated for operation and storage within the range of -40 °C to +50 °C and shall withstand low and high frequency vibration (ANSI C136.31 Vibration Level 3G) over the rated life of the light source.

4. Cooling System

A. Mechanical design of protruding external surfaces (heat sink fins) shall facilitate hose-down cleaning and discourage debris accumulation.

B. The cooling system must be passive utilizing heat sinks, convection or conduction.

C. Fans, diaphragms, pumps, or liquids shall not be used.

(d) Photocontrol Receptacle. Each roadway luminaire shall be furnished with a 7-pin multi-contact twist-lock outdoor lighting dimming receptacle per ANSI C136.41.

715.05 LED Drivers. LED drivers shall conform to the following:

(a) Dimming signal protocols are 0-10V direct current (DC) or Digital Addressable Lighting Interface (DALI).

(b) The operating voltage shall be 120/277-volt at 50/60 Hz, and the driver shall operate normally with input voltage fluctuations of plus or minus 10 percent, consistent with NEMA SSL-1, Electronic Drivers for LED Devices, Arrays or Systems.

(c) The minimum power factor (PF) shall be 0.90 at full input power and across specified voltage range.

(d) The maximum total harmonic distortion (THD) shall be 20 percent at full input power and across specified voltage range.

(e) The factory-set drive current shall be 700A or less unless approved by the Project Engineer. If higher drive currents are proposed, the submittal must be accompanied with IES LM-79 and TM-21 test results for higher operating drive current.

(f) Drivers shall be at a minimum Restriction of Hazardous Substances (RoHS) 1 compliant.

(g) The rated case temperature for operation and storage shall be rated for up to plus 85 °C. The LED driver shall be rated for an ambient operating temperature within the range of minus 40 °C to plus 50 °C.

(h) All electronics of the power supply shall be protected from all electrical surges with an elevated(10kV) electrical immunity rating including, but not limited to, lightning strikes and stray current in rebar and concrete. Surge protection shall be integral to the LED power supply.

(i) The luminaire, including driver, shall consume no more than 4 watts in the off state power.

1. Electrical immunity (including surge protection): The luminaire shall meet the “Elevated” 10kV/5kA requirements per IEEE/ANSI C136.2. The manufacturer shall indicate whether failure of the electrical immunity system can possibly result in disconnection of power from the luminaire.

2. Electromagnetic interference: The driver shall comply with Federal Communications Commission (FCC) 47 Code of Federal Regulations (CFR) part 15 non-consumer radio frequency interference (RFI) and electromagnetic interference (EMI) standards.

715.06 Alternative Power Sources. Electrical power systems not connected to an electrical power grid shall be one of the following:

(a) General. Alternative power source systems shall conform to the following:

1. The assembly shall be UL or ETL listed for wet location and shall have a minimum ingress protection rating of IP66.
2. The assembly shall withstand low and high frequency vibration (ANSI C136.31 Vibration Level 3G) over the rated life the assembly.

(b) Battery. All batteries shall conform to the following and shall be approved by the Project Engineer:

1. General
   A. The battery shall have an extended operating temperature rated for operation and storage within the range of minus 40 °C to plus 85 °C.
   B. The nominal voltage shall be 12V.
   C. Shall have no less than 80 percent capacity after 12 months of storage at 25 °C.
   D. Batteries used for roadway luminaires shall have a minimum rated capacity for three days autonomy without charge, at full light output for the three-day duration.
   E. Batteries shall be rated for a 5-year design life.

(c) Solar Panel. Solar panels shall be n-type, mono crystalline silicon, with greater than or equal to 20 percent efficiency at 25 °C. All solar panels shall be approved by the project Engineer.

(d) Wind Turbine. All wind turbines shall conform to the following and be approved by the Project Engineer.

1. Shall consist of an axial flux coreless permanent magnet synchronous generator.

2. Blade materials shall be reinforced polyamide.

3. Shall include anti-vibration mounts.

4. Shall include regulation to stop turbine from rotating when system is fully charged, or wind gusts are above design speeds.

5. The noise generated by the entire assembly shall be less than 55dBA at the adjacent edge of right of way.

715.07 Conduit. Unless otherwise specified, conduit shall be rigid metallic or semi-rigid plastic electrical conduit. Metallic conduit shall be clean, free of burrs, and galvanized.

Plastic conduit shall be a semi-rigid type currently recommended and UL listed for the proposed use. Underground plastic conduit for street lighting shall conform to ASTM F441 schedule 80. Fittings shall be the type used outside the conduit. Fittings shall connect the conduit in a manner that makes the joints watertight.

Junction boxes used in structures shall be galvanized steel, 6 inches square by 4 inches deep, with weatherproof covers.

Pull boxes and splice boxes shall be a minimum of 13 inches by 24 inches and 12 inches deep, sized per NEC 314 and CDOT Standard S-613-43. Pull and splice boxes shall have heavy-duty weatherproof covers rated for roadway applications. The housing shall be resistant to sunlight exposure, weathering, and chemicals; it shall be unaffected by freeze/thaw cycles. Covers shall fit flush to the sidewalk, turf area, or roadway surface. Hardware and inserts shall be stainless-steel. The cover for street lighting circuits shall be marked “ELECTRICAL” or “STREET LIGHTING”. The cover shall list the minimum HS load rating of 22,500 psi.

715.08 Lighting Circuitry and Wiring. All wiring shall be copper with 600-volt insulation, rated for outdoor use. Wire sizes #14 AWG through #10 AWG shall be solid copper. Wire sizes #8 AWG and larger shall be stranded copper; except, service ground conductors to grounding electrodes shall be #4 stranded, insulated copper. All conductor sizes shall be, at minimum, sized to the breaker amperage feeding the circuit per NEC Table 310.16.

A breakaway submersible, in-line fuse holder and fuse for each hot conductor and breakaway submersible connector shall be installed on the neutral if a neutral is required. The grounding wires shall not be fused or breakaway.

Fuse connectors shall be installed in the phase wires of their respective circuits at the junction box located as a back box to the luminaire or within the pole base or transformer base. The Contractor shall provide sufficient excess conductor length to allow withdrawal of the connected fuse holder from the hand hole. Fuses and fuse holders shall be UL listed and shall be installed in such a manner that the fuse stays with the load side when holder is separated. The Contractor shall form loops in the leads on each side of the fuse holders and so position the fuse holders that they may be easily removed or inserted through the opening of hand hole. All electrical apparatus used in the lighting system shall be rated to adequately handle the necessary loads and shall conform to power source requirements.

Bonding and grounding electrodes shall conform to the requirements of subsection 613.08.

715.09 Secondary Service Pedestals, Lighting Control Centers, and Meter Power Pedestal. Secondary Service Pedestals, Lighting Control Centers, and Meter Power Pedestals shall be metal conforming to ANSI C47.12.28, Pad Mounted Enclosure Integrity Standard and shall be the nominal size and dimensions shown in the Contract.

The cabinets shall be constructed of 12-gauge corrosion-resistant steel with hoods and covers constructed of 14-gauge corrosion-resistant steel. Cabinets shall be MEMA 3R or NEMA 4 construction and shall be UL listed as “Enclosed Industrial Control Equipment” (UL508A). Cabinets shall be vandal resistant dead-front enclosures.

The cabinet’s external finish shall be polyurethane industrial grade powder paint of 1.7 mil minimum thickness. The cabinet's internal finish shall be polyurethane industrial grade powder paint of 1.7 mil minimum thickness or bare aluminum.

All external fasteners, rivets, screws and bolts shall be stainless-steel. Fasteners, except sealing screws, shall not be removable by external access. Hinges shall be stainless-steel continuous piano hinge type hinges.

External nameplates shall be permanently attached to the cabinet. A stainless-steel handle shall be provided on the front exterior of each cabinet door or hood. Cabinet shall be equipped with a three-point latch. All handles shall be pad lockable per CDOT Maintenance requirements.

The cabinet shall have separate isolated sections for metering equipment (if required), utility termination, and CDOT equipment. All sections must be sealed and pad lockable. The metering section shall have a hinged swing back hood with an integral hinged polycarbonate sealable window for visual access to meters. The utility termination section shall be sealed and securable with a padlock. The section shall have a lift off cover with a stainless-steel handle. Sufficient clearance shall be provided for a 4-inch diameter conduit for utility cables. Utility landing lugs shall be UL listed and shall accommodate 6, #350 kcmil conductors. An optional meter fusible disconnect ahead of the meter shall be provided for utility companies that require them.

The CDOT compartment door shall be sealed and securable with a padlock. The compartment door shall be anchorable in an open position. There shall be a print pocket on the inside of the door. The print pocket shall hold all wiring schematics and instructions in a clear weatherproof sleeve with a side opening. Required UL labeling shall be located on the inside of the CDOT door. Distribution and control equipment shall be behind an internal dead-front door with a quarter-turn securing latch and be hinged to open more than 90 degrees. The dead-front door shall be hinged on the same side as the CDOT section door.

Pedestal mounting bolts shall not be visible or accessible externally. Pedestal mounting shall include pedestal mounting base and hardware. Pad mounting shall include concrete pad mounting base, anchor bolt kit and hardware.

Secondary service pedestals, lighting control centers, and meter power pedestals shall be rated for 600 VAC, installed with protection against damage from greater currents. The pedestals and centers shall be grounded with grounding electrodes in conformance with the current edition of the National Electric Code (NEC). The following equipment is for a typical installation and may or may not be required as shown on the plans:

(1) Fusible meter disconnect ahead of meter (optional per utility company requirements).

(2) Service meter pedestal or a meter socket. The Project Engineer per the CDOT region requirements shall confirm location of meter. The meter shall confirm to the utility company requirements.

(3) Service main circuit breaker that is installed in a circuit load center as sized on the plans.

(4) Circuit load center with an all-copper bus for CDOT loads.

(5) Circuit breakers.

(6) Ground fault circuit interrupter receptacle (GFCI) (20 amp, 120 VAC NEMA 5-20R).

(7) Multiple pole light contactors.

(8) Test switch.

(9) Photoelectronic control with exterior mounted 3-prong twist-lock receptacle.

(10) Mounting pans or false backs for circuit breakers, contactors, relays, switches, transformers, and other types of electrical equipment mounted inside the cabinet.

(11) 18” snow skirt (floor stand kit), optional per the Project Engineer’s requirements.

(12) Cabinet style HVAC unit (heating, ventilation, and air-conditioning), optional per the Project Engineer’s requirements.

The internal wiring of cabinets shall be assembled by a UL listed facility or by a licensed master electrician, using UL listed components. Cabinets shall conform to one or more of the following standards where appropriate: UL 50, Cabinets and Boxes; UL 67, Panel Boards; UL 869A, Service Equipment; and UL 508A Standard for Industrial Control Panels.

Circuit breakers and equipment shall be labeled with an engraved permanent label on the dead-front panel to indicate the circuit controlled.

Multiple Pole Light Contactors shall be “lighting” type, specifically rated for the type of lighting load specified. The contactors shall have a 600-Volt rating. All multiple pole light contactors shall be unenclosed, single phase with the number of poles specified on plans; they shall be open type lighting contactors with the rating shown or specified. Contactors shall be constructed for surface mounting on a false back or bracket within a weatherproof cabinet. The contactor coil shall operate on 120 Volt for 120/240 Volt circuits and 277 Volt for 277/480 Volt circuits. Contact material shall be designed for LED driver loads and require no maintenance such as filing, burnishing, or dressing at any time the contactor is in service.

A 277 VAC rated test switch or hand-off auto (HOA) switch shall be installed in the control cabinets if shown. The test switch shall be a heavy-duty single pole switch or circuit breaker rated at 20 amps and shall be installed in the control cabinet as a roadway lighting test switch. The switch shall be wired to shunt the photoelectric control relay power contactor and energize the lighting circuit contactors. The HOA switch shall be single or double pole, double throw, center off with 15A contacts. The HOA switch shall be wired to the photocell control when switch is in the Auto position, lighting contactor(s) shall close when photocell in in low light closure. HOA shall be wired to energize the lighting contactor(s) closure when the HOA is in the Hand position. The HOA’s off position will turn off the control circuit.

All components of the photoelectric control relays shall be housed in a weatherproof, locking, non-rusting container. The photoelectric control relay shall be rated for long life LED loads and attach to a three-prong locking receptacle by a twisting motion.

The photoelectric control relay shall meet or exceed the requirements of ANSI C136.10. The photoelectric control shall be factory set to turn on lights when ambient lighting levels fall to 1.4 foot-candles plus or minus 0.2 foot-candles when operated at 120 VAC. When operated at 250 VAC, turn on shall not change more than plus or minus 0.3 foot-candles from the 120 VAC value. The maximum off to on ratio shall be 1.5:1. The photoelectric control shall be a cadmium sulfide photoelectric control encapsulated for humidity protection, or a silicon junction type phototransistor. The photoelectric control shall be designed for normal operation at a dual voltage of 105 V and 285 V. Power consumption shall be less than 1 watt. At the designated voltage, the photoelectric control shall be capable of controlling a minimum load of 1000 watts. Minimum operating temperature range shall be from minus 40 °C to plus 65°C. A time delay control circuit shall prevent false turn offs by transient lighting conditions. The unit shall include a failsafe circuit for the lighting load such that the lighting systems remain energized if any functional failure of the photoelectric control circuit occurs.

715.10 Heavy Duty Safety Switch. All switches shall be heavy duty rated. Switchblades and jaws shall be fixable and plated copper. Switches shall have a pad lockable handle. Switches shall have defeatable door interlocks that prevent the door from opening when the handle is in the ON position (except for double-throw switches). Defeater mechanism shall be front accessible. Switches shall have deionizing arc chutes. Switch assembly and operating handle shall be an integral part of the enclosure base.

Switches rated 30 A to 600 A shall have reinforced, rejection type fuse clips. Switchblades shall be readily visible in the “ON” and “OFF” position. Switch operating mechanism shall be non-teasible, positive quick-make/quick-break type. Bail type mechanisms are not acceptable. Fusible switches shall be suitable for service entrance equipment (except for 4-pole switches and 1200 A when used on 480Y/277 wye systems). Switches shall have line terminal shields (except for non-fusible double throw switches).

Switches shall be suitable for systems capable of 200 kA at 480 V with Class J, L, R, or T fusing as applicable for single-throw switches; 100 kA at 600 V for double-throw switches. Embossed or engraved ON-OFF indication shall be provided. Double-make, double-break switchblade feature shall be provided. Fuse pullers shall be provided on all NEMA 3R, 4X and 12 switches through 200 A. Renewal parts data shall be shown on the inside of the door.

All enclosures shall be NEMA 3R unless otherwise noted. Other types, where noted, shall be NEMA 4X watertight corrosion-resistant 316 stainless-steel or NEMA 12 dust-tight and oil-tight special industry (dual NEMA 12/3R rating through 800 A). All enclosures shall have a factory installed ground terminal block. Nameplate shall be front cover mounted, containing a permanent record of switch type, ampere rating, and maximum voltage rating. 30 A to 100 A, NEMA 4X or NEMA 12 enclosures shall be provided with draw-pull latches.

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SECTION 716
WATER LINE MATERIALS

716.01 Cast Iron Pipe. Cast iron pipe shall conform to the requirements of Federal Specification WW-P-421, Class 150 with Type III mechanical joints.

716.02 Welded Steel Pipe. Welded steel pipe shall be of the length, diameter and metal thickness shown on the plans and shall conform to the following:

(1) Pipe shall conform to the applicable requirements of AWWA Standard C 200, Section 3, manufactured from steel sheets conforming to ASTM A1011, Grade 33 or 36, plates conforming to ASTM A283 Grade C or D, or ASTM A572 Grade 42; or it shall be manufactured to meet the requirements of ASTM A53, Grade B or ASTM A139 Grade B or C.

(2) Surface Preparation and Coating. Inside and outside surfaces shall be blast cleaned with sand, steel grit, steel Shot or a combination of steel grit and steel shot to remove mill scale and rust, per subsection 509.24(b). Pipe that is cement mortar lined per AWWA Standard C205 shall not be blast cleaned. Paint and coating schedule for pipe larger than 10 inch shall conform to Table 716-1.

TABLE 716-1
FOR PIPES CARRYING POTABLE WATER

Pipes to be disinfected after installation, per AWWA Standards

Interior Buried Pipe	Exterior Buried Pipe	Interior Exposed Pipe	Exterior Exposed Pipe
Lined with cement mortar per AWWA Standard C 205	80 mil thickness tape coating systems for the exterior of steel water pipelines per AWWA Standard C 214	Lined with cement mortar per AWWA Standard C 205 or coal tar epoxy per Corps of Engineers C 200	Subsections 509.24 and 509.29

TABLE 716-2

FOR PIPES CARRYING NON-POTABLE WATER AND FOR SEWERS

Interior Buried Pipe	Exterior Buried Pipe	Interior Exposed Pipe	Exterior Exposed Pipe
Lined with cement mortar per AWWA Standard C 205 or coal tar epoxy per Corps of Engineers C 200	80 mil thickness tape coating systems for the exterior of steel water pipelines per AWWA Standard C 214	Lined with cement mortar per AWWA Standard C 205 or coal tar epoxy per Corps of Engineers C 200	Subsections 509.24 and 509.29

Type of pipe and its coating for pipe 10 inch and smaller shall be as shown on the plans.

Bell and spigot ends with rubber gaskets, flanges, mechanical couplings, or field-welded joints may be used, as conditions require to join the pipe.

All field welds shall conform to Section 509 and shall have linings and coatings replaced equal to the original coating. Wire brushing shall be used where necessary to clean the pipe.

Where cement mortar lining is used with welded joints or bell and spigot ends with rubber gaskets, the joint cut back shall be mortared after the pipe has been laid. This cement mortar lining and application shall conform to AWWA Standard C 205.

On buried pipe coated with a tape coating system conforming to AWWA Standard C 214, the field joints shall be cleaned, primed, and wrapped with two thicknesses of 35-mil cold applied elastomeric joint tape conforming to AWWA Standard C 209, Type 11.

Damage to the pipe lining or coating due to the Contractor's operation shall be repaired at the Contractor’s expense.

716.03 Galvanized Pipe. Galvanized pipe and fittings shall conform to the requirements of ASTM A53.

716.04 Copper Pipe. Copper pipe shall conform to the requirements of ASTM B88, Type “K” and shall be annealed. Pipe shall be supplied with solder type fittings.

716.05 Plastic Pipe. Polyethylene pipe (PE) shall conform to the requirements of ASTM D2104 when size, type, and schedule or series are designated or ASTM D2239 when size and pressure ratings are designated. Polyvinyl Chloride pipe (PVC) shall conform to the requirements of ASTM D1785 when size and schedule are designated or ASTM D2241 when size and pressure ratings are designated.

All plastic pipe used as water pipe must bear the National Sanitation Foundation (NSF) seal of approval.

716.06 (unused)

716.07 Valves and Valve Boxes. Valves shall be designed to exceed the required working pressure of the water line but shall not be less than the values.

(a) Gate Valves.

1. General. Valves shall have non-rising stems, unless otherwise specified, with inside screw and shall open to the left or counterclockwise. Valves shall be equipped with double O-ring stem seals conforming to AWWA C500. All valves shall have the manufacturer's names, catalog number and working pressure molded or stamped thereon. Valves shall be painted as specified in AWWA C500, Section 27, and shall be furnished complete with all accessories. Ends of valve shall fit the pipe or fitting where attached (push-on, mechanical, bell-and-spigot or flanged).

   Gate valves shall be for buried service; however, they shall be protected against freezing above the frost line.

2. Valves Smaller than 3 Inch. Valves shall be of the wedge-disc type with non-rising stem, screw ends and bronze body. Metal composition of the body, centerpiece and other cast parts shall be cast bronze meeting the requirements of ASTM B62. All packing shall have each ring cut to fit, with staggered joints. Continuous (spiraled) packing shall not be used. Valves shall be provided with handwheels and stuffing box glands. Unless otherwise specified, valves shall be for 200-pound water service.

3. Valves 3 Inch and Larger. Valves 3 inch and larger shall conform to AWWA C500, except that they may be furnished with 2-inch square operating nuts or hand-wheels.

   Bypasses, when required, shall conform to the details shown on the plans or established.

   The intended position of the valve in the water line (either horizontal or vertical) shall be as shown on the plans.

(b) Other Valves. Butterfly valves, globe valves, air relief valves, check valves, tapping valve and sleeve and other appurtenances shall be as shown on the plans.

(c) Valve Boxes. Unless otherwise specified or shown on the plans, valve boxes shall be of the adjustable screw type, complete with drop cover.

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SECTION 717
REST AREA AND BUILDING MATERIALS

717.01 General. All materials and equipment shall be new and shall be of recognized standard quality.

717.02 Masonry and Masonry Wall Reinforcement.

(a) Masonry. Concrete blocks or concrete ornamental blocks shall be lightweight aggregate concrete blocks conforming to ASTM C129, Type 1. Corner block shall be installed at all wall openings. All block shall be uniform in color and be smooth textured. Ornamental block shall be of the type as scheduled on the plans.

Structural glazed tile shall be of the types, color, and sizes shown on the plans.

Face brick shall be 2 1/4 inch x 3 5/8 inch x 7 5/8 inch (nominal 8 inch) modular size brick. Brick required at ends of rowlock shall be solid brick (no holes). All face brick shall conform to ASTM C216, Grade SW Type FBS (rough). The style of brick to be used shall be as scheduled on the plans.

(b) Masonry Wall Reinforcement. Masonry wall reinforcement for curtain walls, shelter wall panels and information center wall panels shall be ladder type for 6-inch wall, 9 gauge, galvanized, with deformed side rods.

"Z" ties for cavity walls of building shall be 3/16 inch x 6-inch galvanized rod.

Corrugated wall ties shall be 7/8 inch x 7-inch x 20 gauge galvanized steel.

717.03 Mortar for Masonry and Structural Glazed Tile. Mortar shall conform to subsection 704.04. Coloring shall be added to the mortar for the face brick to yield a mortar compatible with or approximating the color of the face brick.

Remixing or retempering of mortar will not be permitted.

Waterproofing compound shall be used in all mortar. Mixing waterproofing compound with mortar shall be in strict accordance with the manufacturer's instructions.

717.04 Metal Specialties.

(a) Metal Toilet Stalls. Metal compartments for toilet rooms shall be of the type and style as scheduled on the plans.

Each toilet compartment shall be furnished with a cast alloy chrome plated Combination Coat Hook and Bumper and a chrome plated, single-fold type toilet paper dispenser.

(b) Mirrors. Mirrors shall have clear anodized aluminum or stainless-steel vandal-proof frames with finish similar to #44 satin stainless-steel. Corners shall be mitered and reinforced. Mirror glass shall be 1/4 inch thick, #1 quality polished plate, 18-inch-wide x 24-inch-high, of the type and style as scheduled on the plans.

717.05 Sanitary Napkin Disposal. Sanitary napkin disposal shall be of the type and style as scheduled on the plans.

717.06 Doors, Frames and Windows. General. All steel doors, door frames and windows shall be as scheduled on the plans.

All doors shall be full flush type, with no exposed seams.

(a) Frame and Window Construction. All frames shall be No. 16-gauge steel, with 2-inch face, 1/2 inch or 5/8 inch integral stops and 5 1/2 inch or 5 3/4 inch depth.

Window frames and door frames shall be shipped as “set up,” when welded units are used, with all comers and intersections welded and ground smooth. Frames may be knocked-down when units with steel tabs are furnished. Window frames shall have bottom panels of heights shown on the plans.

Hinge jambs shall be mortised for 4 1/2 inches x 4 1/2 inches template hinges and prepared for the ANSI Universal lock strike or approved equal.

(b) Door Hardware. Hardware shall be reinforced and completely prepared for field attachment into drilled and tapped holes.

All hardware, whether specifically mentioned or not, required to fully complete the work as shown on the plans and in the specifications, shall be included and of the same type and quality as that specified.

All hardware shall be as scheduled on the plans. Lockset shall conform to Federal Specification FF-H-00106b, Series 86C-4 where applicable and shall be mortise type. Finish of all hardware shall be U.S. 10 as identified in Fed. Spec. FF-H-00106b, Section 6.8, Table II.

(c) Hardware Sets. For hardware locations refer to the door schedule on the plans.

(d) Keying. All doors shall be keyed alike. Three keys shall be furnished per building.

717.07 Ceramic Tile. Unless otherwise specified, all tile shall conform to ASTM C126.

All floor tile shall be delivered to the job in unopened, sealed containers. They shall be accompanied with a certificate of grade signed by the manufacturer and the Contractor, together with adequate identification of the containers.

Ceramic floor tile shall be of unglazed tile of the style and pattern as scheduled on the plans. Ceramic tile for the Mosaic shall be 1-inch x 1-inch squares and part squares. The colors and placement shall be as shown on the plans.

The Contractor shall submit samples to the Engineer for approval, in duplicate, of each kind of tile proposed for use. When approved, one sample shall be retained for comparison with the finished work.

717.08 Roofing, Flashing and Roof Insulation. General. All roofing materials shall bear the manufacturer's label on sealed packages. All insulation shall be marked for proper identification.

Asphalt for applying roofing shall conform to ASTM D312, Types I, and III.

Felt for roofing shall be Type II (30-pound type) (not perforated) for the base sheet, and Type I (15-pound type) (perforated) for additional layers. Felt shall conform to ASTM D226.

Roofing aggregate shall meet the quality requirements of subsection 703.02 and shall be graded uniformly with 100 percent passing the 19.0 mm (3/4 inch) screen and 100 percent retained on the 4.75 mm (No. 4) screen.

Lumber shall be construction grade or better, Douglas Fir, Larch or Hemlock.

Shingles shall be good grade (No. 2) cedar shingles, with a weight of at least 36 pounds per bundle.

All membrane roofing shall be four ply. Lumber roofing shall be as shown on the plans.

All joints shall be sealed with a two-component type, polysulfide-base synthetic rubber sealant or an approved equal. Sealant shall meet the requirements of ANSI A116.1, Class B. Primer shall conform to the requirements of the manufacturer of the sealant used.

Joint filler used as back up for sealant shall be plastic foam joint filler.

Care shall be taken to ensure that back-up material shall not contain any asphalt. (Asphalt is incompatible with this type of sealant).

717.09 Carpentry. Ceiling panels, adhesive for panels, moldings to conceal joints, corners and intersections of panels and walls, color and style of panels shall be as scheduled on the plans.

717.10 Interior Insulation. All insulation, except that required for roof or in frame walls, shall be expanded polystyrene having a “K” factor of 0.26 (average) at a mean temperature of 70 ˚F and a Perm rating of 1.2 or less, with thicknesses as shown on the plans. Adhesive for bonding the insulation to the masonry walls shall be an asphalt emulsion material that is acceptable to the manufacturer of the insulation. Insulation required for underside of roof or in-frame walls shall be blanket-type fiberglass, thickness as shown on the plans with a density of 3/4 pound per cubic foot and shall have a vapor barrier of the embossed vinyl, scrim reinforced, aluminum foil type.

717.11 Glass and Glazing. All glass shall be obscure type, 1/4 inch thick, rough one side and polished one side or as called for on the plans.

All glass shall bear the identifying label of the manufacturer.

717.12 Trash Receptacles. The trash receptacles shall be of the type and style as scheduled on the plans. Each receptacle shall be furnished with 25 disposable polyethylene liners.

Receptacles shall be painted with baked enamel finish, Metallic Gray bottom and Sea Mist top.

717.13 Paint and Special Coating. The special makes of prepared paints, sealant or special coatings that may be specified or otherwise required must be delivered in the original package with the seals unbroken and labels attached.

717.14 Plumbing. The sanitary drainage system within the building and to the septic tank or sanitary hookup shall be made of standard weight cast iron soil pipe. The pipe shall be furnished in standard lengths with inner and outer surfaces concentric, smooth inside and free from defects. Any pipe cracked in cutting shall be removed.

Cast iron pipe, including bell, shall weigh at least the following average weights per 5-foot of length:

Table 717-1

PIPE WEIGHT PER 5-FOOT LENGTH

2-inch	20 pounds
3-inch	30 pounds
4-inch	40 pounds
6-inch	65 pounds

Fittings for cast iron pipe shall be standard design fittings of the same inside diameter as the pipe with which they are used, and of equal quality and weight in all parts.

Cast iron pipe and fittings shall conform to Commercial Standard CS 188 for Standard Weight Cast Iron Soil Pipe and Fittings.

Lead for caulking joints in cast iron pipe shall be soft pig. All oakum shall be pitched. Use 12 ounces of lead for each 4-inch diameter of pipe used.

All hot and cold-water piping and supply lines above grade shall be Type L, copper pipe with sweated and brazed fittings. Pipe, valves and fittings shall be of Bridgeport, Case or Mueller, or an approved equal. Connections involving different metals shall require a dielectric union. Solder shall be 95.5 tin and antimony and shall be applied as per manufacturer's instructions.

Underground water lines under concrete slab of the building shall be ASTM B88, Type “K” hard drawn copper pipe with brazed fittings. Brazing material shall be silver solder.

Pipe for sewage vent lines shall conform to the Colorado Plumbing Code. A suitable vent screen shall be provided for each vent line.

Underground water line to building, sanitary station and trailer pad shall be 100-psi pressure rated, virgin polyethylene pipe.

Fittings shall be of polyethylene or nylon with stainless-steel clamps. All pipe and fittings shall be approved by the National Sanitation Foundation and shall bear that mark.

717.15 Heating and Ventilating.

(a) Heaters. The wall heaters shall be of the make and model scheduled on the plans.

The forced air furnace shall be of the make and model scheduled on the plans with adjustable pulley type belt drive blower. Motor shall be 120 V/60 cycle single phase. Furnace shall be complete with cabinet, electric heating section, blower, filters, motor, belt drive, adjustable pulley on motor, safety controls, relays, and all other items as may be incidentally required for a complete and ready to operate installation. Capacity shall be as indicated on the plans.

(b) Grills. Grill location, model, style and sizes shall be as shown on the plans.

(c) Thermostat. Thermostats shall be as specified under electrical work in subsection 717.16.

(d) Exhaust Fan and Curb. Exhaust fan shall be of the make and model scheduled on the plans. Fan shall be mounted on a prefabricated curb equipped with automatic back draft damper. Fan shall be operated by a timer. Fasten curb directly on top of sheathing.

(e) Duct Work. Duct work shall be fabricated from galvanized steel sheets per recommended practice as outlined in the current edition of the American Society of Heating, Refrigeration and Air Conditioning Engineering Guide. Aluminum may be used at the Contractor's option and shall conform to gauge shown in the table below. All duct work shall be fabricated from the one material selected by the Contractor.

The following sheet gauges and thicknesses shall be used throughout:

Table 717-2

DUCT WORK SHEET GAUGES AND THICKNESS

Maximum Side (Inch)	Steel U.S. Gauge	Aluminum Thickness (Inch)	Type Of Transverse Joint*	Bracing
Up to 12	26	.020	S, Drive Pocket or Bar Slips, on 7"-10" centers	None
13 to 18	24	.025		None
19 to 30	24	.025		1" x 1" x 1/8" at 60"

Table 717-2 Notes: *Other joint connections of equivalent mechanical strength and air tightness may be used.

The flat side of all ducts shall be cross broken.

All horizontal ducts are to be supported with angle iron hangers secured to the construction above, at intervals not to exceed 7 feet 10 inches. All vertical riser ducts shall be supported at floor and ceiling with angle iron rests secured to the ducts.

(f) Outlets, Inlets and Vents. All outlets, inlets and vents shall be of the type and style called for on the plans, or an approved equal.

717.16 Electrical.

(a) Conduit. Conduit below grade, finish floor elevation, or embedded in concrete shall be rigid steel, hot dipped, sherardized or galvanized, unless otherwise specified. Each length of conduit shall be stamped with the name or trademark of the manufacturer and shall bear the Underwriter's Laboratories, Inc. label.

Thin wall electrical metallic tubing conduit will be permitted above grade, unless otherwise noted on the plans.

(b) Conduit Fittings. Conduit fittings shall be compatible with the conduit furnished, with cast covers and where installed exposed to the elements, shall have vellum or fiber gaskets.

(c) Conductors. All 120 and 220-volt wire and cable shall be single conductor, soft drawn, copper wire with 600-volt insulation. Type TW shall be used for overhead runs. Type THW shall be used in runs under floor slab inside building.

Cable serving water wells may be one cable of three conductors, Type USE; three single conductors, Type USE, placed in the same trench; or two conductors Type UF, with ground wire. The wire size shall be as shown on the plans with no splices below ground.

Cable serving outdoor lighting may be one cable of two conductors Type USE or two single conductors, Type USE placed in the same trench. The wire size shall be as shown on the plans with no splices below ground.

Main service cables shall be Type USE. Wire size shall be as shown on the plans for direct burial type. Cable sheathing and insulation shall conform to ASTM D4227. Splices will not be allowed between the utility pole and the main circuit breakers at building.

All wire smaller than #10 AWG, shall be solid copper and all wire #10 AWG and larger shall be stranded copper wire.

Aluminum wire will not be allowed. Wire size not shown on the plans shall be sized according to the requirements of the National Electric Code.

(d) Thermostat. Thermostat for controlling furnace or wall heaters shall be of the low voltage type.

Thermostat for operating emergency light shall be 32-90 ˚F range, heavy duty, line voltage type, to make contact on temperature drop.

(e) Emergency Light. The emergency light shall be weatherproof, with guard, red glass globe, gasket and 6 volt, 25 watt, medium base extended service lamp.

(f) Device Plates. Device plates in Utility room shall be pressed steel to suit the device to be covered. Device plate in restrooms shall be stainless-steel type 430.

(g) Emergency Battery Charger. The charger shall be 6 volt, 50-amp hour rated, operating on 110-120-volt AC, 60 cycle, without lights, mounted on a bracket supplied by the manufacturer, complete with fast charge ammeter, trickle charge millimeter, test switch and pilot lights. The battery shall be 6-volt plastic or glass jar lead acid type. All shall be mounted in a 20-gauge minimum steel cabinet, adequately ventilated by louvers.

(h) Disconnect Switches. All safety switches shall be S/N, fused, and Type “ND” construction as prescribed by the National Electrical Code. Weather-proof housing for exterior switches shall be provided.

(i) Timer. Timer for exhaust fan shall be 10 ampere, SPDT, 120 V for intermittent operation. A 24-hour dial with 96 tabs to permit 15-minute switching changes shall be provided.

(j) Miscellaneous. Lighting switches, receptacles, hand dryers, photoelectric cells, contactors, switches, panels, lighting fixtures, area luminaires and poles shall be the style, type and color as scheduled on the plans. Note: The Contractor shall furnish the Engineer three portfolios (bound copies) containing names of manufacturers, cuts and curves of all lighting fixtures to be used on the project within 30 days after approval of all materials has been made. The portfolios shall be made on 8 1/2 inch x 11 inch sheets, with cuts glued on and fixtures identified by number as per specifications. These portfolios will not be returned and will become the property of the Department.

717.17 Sewer, Septic Tank, Leaching Field, Sanitary Station and Sewer Lift Station. Concrete reinforcing steel, concrete pipe and sewer piping (vitrified clay, plastic, and cast iron) and associated construction methods shall be as specified under the appropriate subsections of Section 600 or 700.

Cast iron manholes and waterstops for septic tanks and water tower and hatch for trailer sanitary station shall be the type and size as scheduled on the plans.

The gravel material used for leaching fields shall be crushed stone, crushed or natural gravel meeting the following grading requirements:

Table 717-3

LEACH FIELD GRAVEL MATERIAL GRADATION

Sieve Size	Mass Percent Passing Square Mesh Sieves
25.0 mm (1 inch)	100
19.0 mm (3/4 inch)	95-100
4.75 mm (No. 4)	0-5

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INDEX

Page **Page**

INDEX

Page

INDEX

INDEX

Page

INDEX

INDEX

Page

INDEX

INDEX

Page

INDEX

INDEX

Page

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

Page

INDEX

NOTES

NOTES