

Colorado Department of Transportation

**Standard Specifications**  
for  
**Road And Bridge Construction**



No. \_\_\_\_\_



## PREFACE

These standard specifications are to be used 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 herein referred to (e.g. Form 605) are CDOT forms. Forms from other organizations or agencies are clearly identified (e.g. FHWA Form 1273).

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.

Copies of this book may be obtained from the Colorado Department of Transportation, Office of Bid Plans, 4201 E. Arkansas Avenue, Denver, CO 80222.

Addenda to these specifications may be issued by the Department to suit its needs. Addenda may be accessed on the CDOT web site and will be available for purchase at prices established by the Department.



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## SECTION 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 sex.

The titles or headings of the sections and subsections herein 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.**

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.
ARA	American Railway Association
AREA	American Railway Engineering Association
ARTBA	American Road and Transportation Builders Association
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

101.01

ATSSA	American Traffic Safety Services Association
AWG	American Wire Gauge
AWPA	American Wood Preservers' Association
AWS	American Welding Society
AWWA	American Water Works Association
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
EIA	Electronic Industries Association
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
ITE	Institute of Transportation Engineers
MIL	Military Specifications
MUTCD	Manual on Uniform Traffic Control Devices
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 (nSf)
OSHA	Occupational Health and Safety Administration
PCI	Prestressed Concrete Institute
ROW	Right of Way
SAE	Society of Automotive Engineers
UL	Underwriters Laboratories, Inc.

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

**101.03 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.

**101.04 Award.** The acceptance by the Department of a proposal.

**101.05 Basis of Payment.** The terms under which "work" is paid, as a designated "Pay Item" in accordance with the quantity measured and the "Pay Unit."

**101.06 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.

**101.07 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.

**101.08 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.

**101.09 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.

**101.10 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 in accordance with and meets the applicable specifications.

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

**101.12 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.

101.13

| **101.13 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.

| **101.14 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.

| **101.15 Construction Requirements.** Specifications covering performance of work required for proper completion and acceptance.

| **101.16 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.

| **101.17 Contract Item (Pay Item).** A specifically described unit of work for which a price is provided in the Contract.

| **101.18 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 105.13.

| **101.19 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.

| **101.20 Contract Performance Bond.** The security executed by the Contractor and Surety or Sureties and furnished to the Department to guarantee completion of the work in accordance with the Contract.

| **101.21 Contract Time.** The number of working days 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.

| **101.22 Contractor.** The individual, firm, or corporation contracting with the State of Colorado through the Department of Transportation for performance of prescribed work.

**101.23 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.

**101.24 County.** The county in which the work is to be done.

**101.25 Culvert.** Any structure not classified as a bridge which provides an opening under the roadway.

**101.26 Day.** See subsection 101.08

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

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

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

**101.30 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.

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

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

**101.33 Holidays.** Holidays recognized by the State of Colorado are:

- New Year's Day
- Dr. Martin Luther King, Jr.'s Birthday (observed)
- Washington-Lincoln Day
- Cesar Chavez Day
- Memorial Day
- Independence Day
- Labor Day
- Columbus Day
- Veterans' Day
- Thanksgiving Day
- Christmas Day

101.33

When New Year's Day, Cesar Chavez Day, 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.

Additional legal holidays, when designated by the Governor or the President of the United States will also be recognized by the State.

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

**101.35 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.

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

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

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

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

**101.40 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.

**101.41 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.

- (a) *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.
- (b) *Base Course.* The layer or layers of specified or selected material placed on a subbase or a subgrade to support a surface course.
- (c) *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."



**101.42 Planned Force Account.** Items of work, included on the plans, which will be paid for in accordance with subsection 109.04.

**101.43 Plans.** The drawings, or reproductions, provided by the Department which show the location, character, dimensions, and details of the work to be done.

**101.44 Preconstruction Conference.** A meeting of CDOT project personnel, Contractor project personnel and other stake holders held prior to the beginning of construction at which topics pertinent to the successful prosecution of the work are discussed.

**101.45 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 according to the context.

**101.46 Project.** The specific section of the highway on which construction is to be performed as described in the Contract.

**101.47 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 in accordance with 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.

**101.48 Project Special Provisions.** See definition for special provisions in subsection 101.66.

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

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

**101.51 Proposal Form.** The documents furnished by the Department on which the offer of a bidder is submitted. Also called bid proposal.

101.52

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

**101.53 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, which is signed and sealed by the Contractor's engineer in accordance with the Rules of Procedures of the State Board of Registration for Professional Engineers and Land Surveyors.

**101.54 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.

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

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

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

**101.58 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.

**101.59 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.

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

**101.61 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.

**101.62 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.

**101.63 Shop Drawings.** A general term that includes drawings, diagrams, illustrations, samples, schedules, calculations, and other data which 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 in accordance with subsection 105.02(c). Shop drawings include data which illustrates material, equipment, and items which are incorporated in and become part of the permanent work in accordance with the Contract.

**101.64 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.

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

**101.66 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 105.08.

- (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 which are intended for temporary use.

**101.67 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) for Road and Bridge Construction. The book is divided into three parts namely:
  - (1) General Provisions (Section 100)
  - (2) Construction Details (Section 200 thru 600)
  - (3) Material Details (Section 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

**101.68 Specified Completion Date.** The date on which the contract work is specified to be completed.

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**101.69 Standard Special Provisions.** See definition for Special Provisions, subsection 101.66.

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

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

**101.72 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 which may be encountered in the work and not otherwise classified.

**101.73 Subcontractor.** An individual, firm, corporation, or other legal entity to whom the Contractor sublets part of the Contract.

**101.74 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.

**101.75 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.

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

**101.77 Superstructure.** The entire structure except the substructure, as defined in subsection 101.75.

**101.78 Supplemental Specifications.** See definition for Specifications, subsection 101.67.

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

**101.80 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.

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

**101.82 Value Engineering Change Proposal (VECP).** A change to contract requirements proposed by the Contractor which 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.

**101.83 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.

**101.84 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.

**101.85 Working Day.** Any day, exclusive of Saturdays, Sundays and holidays, on which 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.

**101.86 Working Drawings.** A general term that includes drawings, diagrams, illustrations, samples, schedules, calculations, and other data which illustrate the construction of the work, material, equipment, methods, and items which are necessary to construct the work in accordance with 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.

**101.87 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.

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**SECTION 102  
BIDDING REQUIREMENTS  
AND CONDITIONS**

**102.01 Prequalification of Bidders.** The bidder shall follow the prequalification and bidding procedures contained in the Rules for Prequalification, Debarment, Bidding, and Work on Colorado Department of Highways' Road, Highway, and Bridge Public 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 ten days prior to 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.** Upon request, the Department will furnish the prospective bidder with a proposal form (bid proposal). This form 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 for which unit bid prices are invited. The proposal form will state the time in which the project must be completed, the amount of the proposal guaranty, and the date, time and place of the opening of proposals.

All papers bound with or attached to the proposal form are considered a part of the proposal and must not be detached or altered when the proposal is submitted.

The plans, specifications, and other documents designated in the proposal form, will be considered a part of the proposal whether attached or not.

The prospective bidder shall pay the Department the sum stated in the Invitation for Bids for each 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 in accordance with 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 change to proposal forms, plans, or specifications prior to the opening of proposals will be issued by the Department by certified mail to all holders of proposal forms. Certain individuals are named in the project specifications who have authority to provide information, clarification or interpretation to bidders prior to 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 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, and is not intended as a substitute for personal investigation, interpretation and judgment of the bidders.

The Department does not warrant the adequacy of boring logs 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 apply only to that particular boring and are not intended to be conclusive as to the character of any material between or around test borings. 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 prior to 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 in accordance with the "Rules" referenced in subsection 102.01.

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

- (a) 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.
- (b) If there are unauthorized additions, conditional or alternative proposals, or irregularities of any kind which may tend to make the proposal incomplete, indefinite, or ambiguous.
- (c) If the bidder fails to acknowledge in the proposal the receipt of all revisions current on the date of opening of proposals.
- (d) 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.
- (e) 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 which 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 which 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.
- (f) If the Contractor submitting the bid is affiliated with another bidder that has submitted a bid on the same public project.
- (g) If the bidder has been sent a notice of intent to revoke prequalification under Chapter Two of the "Rules."
- (h) If the bidder has been asked in writing to show why it should not be found in default on a Department contract.
- (i) 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 in accordance with 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 prior to 4:30 P.M. on the fifth calendar day after the bid opening. Failure to submit the Forms 605 and 621 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 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.

## 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 in accordance with 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 which 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

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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 prior to 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 in accordance with 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 in accordance with the TrafficControl 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 in accordance with subsection 105.01, the Contractor shall open to traffic the portions of the project as directed. Prior to 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

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control items as long as construction operations interfere with traffic. When construction operations which 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 which 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 in accordance with subsection 104.02 when contract unit prices exist, or as extra work, in accordance with 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 for which 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 which 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 the Department's original design either at lower cost, with improved quality, or both. 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 in accordance with the Contract at contract bid prices. The Contractor shall have no claim against the Department for compensable or noncompensable delay to the Contract based on the failure to respond to the proposal.

The Contractor may submit either a full VECP or a preliminary Conceptual VECP, followed by a full proposal. The Engineer will provide timely review of all proposals and advise the Contractor whether the Proposal is complete or incomplete. When the proposal is complete, the Engineer will advise the Contractor of either the approval of the proposal or the reasons for rejection of the proposal.

Cost savings generated to the Contract as a result of VECPs offered by the Contractor and accepted by the Engineer shall be shared equally between the Contractor and the Department.

If the Engineer determines that the time for response indicated in the submittal under item (c)5 below is insufficient for review, the Contractor will be promptly notified. Based on the additional time needed by the Engineer for review and the effect on the Contractor's schedule caused by the added time, the Engineer will evaluate the need for a noncompensable time adjustment to the Contract.

- (a) VECPs that will be considered are those that would produce savings to the Department or provide improved project quality without impairing essential functions and characteristics of the facility. Essential functions include but are not limited to: service life, economy of operation, ease of maintenance, desired appearance, safety, and impacts to the traveling public or to the environment during and after construction.
- (b) *Submittal of Conceptual Proposal.* For VECPs that require 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 and advise the Contractor 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 the Department to eventual approval of the full VECP. The following information shall be submitted for each Conceptual Proposal.
  1. A statement that the proposal is submitted as a Conceptual VECP.
  2. A general description of the difference between the existing Contract and the proposed change, and the advantages and disadvantages of each, including effects on cost, service life, economy of operation, ease of maintenance, desired appearance, safety, and impacts to the traveling public or to the environment during and after construction.
  3. A set of conceptual plans and a description of proposed changes to the Contract specifications.
  4. An estimate of the anticipated cost savings or increase.
  5. A statement specifying:

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- (1) when a response to the conceptual proposal from the Department is required to avoid delays to the existing contract prosecution,
- (2) the amount of time necessary to develop the full Proposal,
- (3) the date by which a Contract Modification Order must be executed to obtain maximum benefit from the Proposal, and
- (4) the Proposal's impact on time for completing the Contract.

(c) *Submittal of Full Value Engineering Change Proposal.* The following materials and information shall be submitted with each proposal.

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, economy of operation, ease of maintenance, desired appearance, safety, and impacts to the traveling public or to the environment during and after construction.
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 proposed plans and specifications shall be signed and sealed by the Contractor's engineer.
4. A complete analysis indicating the final estimated costs and quantities to be replaced by the Proposal compared to the new costs and quantities generated by the Proposal. All costs and proposed unit prices shall be documented by the Contractor.
5. A statement specifying the date by which a Contract Modification Order must be executed to obtain the maximum cost reduction during the remainder 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 Department project, the proposal shall indicate the date, Contract number, and the action taken by the Department.
8. An estimate of any effects the VECP will have on other costs to the Department.
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.



10. A statement specifying when a response from the Owner is required to avoid delays to the prosecution of the Contract.

(d) *Evaluation.* VECPs will be evaluated in accordance with the following:

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 investigations. The Engineer may reject proposals that are not consistent with the Department's design policies and criteria for the project.
2. The Engineer will reject all or any portion of 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.
3. VECPs, whether or not approved by the Department, apply only to the ongoing Contracts referenced in the Proposal and become the property of the Department. Proposals shall contain no restrictions imposed by the Contractor on their use or disclosure. The Department has the right to use, duplicate and disclose in whole or in part any data necessary for the utilization of the Proposal. The Department 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.
4. If the Department is already considering certain revisions to the Contract or has approved certain changes in the Contract for general use 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.
5. The Contractor shall have no claim against the Department 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.
6. Proposals will be rejected if equivalent options are already provided in the Contract.
7. Proposals that only reduce or eliminate contract pay items will be rejected.
8. The savings generated by the Proposal must be sufficient to warrant a review and processing, as determined by the Engineer.

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9. A Proposal changing the type or thickness of the pavement structure or changing the design of a bridge will be rejected.
  10. 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.
- (e) *Payment.* If the VECP is accepted, the changes and payment will be authorized by Contract Modification Order. 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, or both, as appropriate, under the Contract.
  2. The cost of the revised work as determined from the changes will be paid to the Contractor. The Department will pay the Contractor 50 percent of the savings to the Department upon completion of the value analysis work. The savings to the Department shall be the difference between the cost of the revised work and the cost of the related construction required by the original Contract computed at Contract bid prices.
  3. Costs incurred by the Contractor for development, design, and implementation of the VECPs will not be reimbursed.
  4. When work performed under an approved VECP is modified to fit field or other conditions, the maximum amount paid for the work will be limited to that which would have been paid if the work had been performed under the original contract provisions. The rejection or limitation of reimbursement shall not constitute the basis of any claim against the Department for delay or for other costs except as allowed under the original Contract.

## 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) when the Contractor fails to correct conditions unsafe for the workmen 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 prosecution 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 in accordance with 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 insure 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.

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The first sheet or page of each set of shop drawings, working drawings, and other submittals shall be stamped “Approved for Construction” and signed 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. 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 ½ 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.
2. 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.
3. Design notes, calculations, lists, reports, descriptions, catalog cuts, and other non-drawing submittals shall be submitted on 8½ inch by 11 inch sheets.
4. 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.
5. Unless otherwise specified, two sets of working drawings shall be submitted to the Engineer.
6. The shop drawings, working drawings, other submittals and all revisions shall be signed and 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 which summarizes the minimum required submittals is included at the end of this subsection. 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 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 prior to 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 which 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:

Reviewed, no exception taken	Shop drawings have been reviewed and do not require resubmittal
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 resubmittal.
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 drawing 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 108.07.

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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 Engineer ten 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 prior to final payment, the construction drawings shall be submitted to the Engineer.

- (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 for herein.

**Table 105-1  
SUMMARY OF CONTRACTOR SUBMITTALS**

<b>Section No.</b>	<b>Description</b>	<b>Type</b>	<b>Contractor P.E. Seal Required?</b>
504	MSE Walls (Contractor Alternative)	Shop Drawing	Yes
504	MSE Walls (Default Design)	Shop Drawing	No
508	Timber Structures	Shop Drawing	No
509	Steel Structures	Shop Drawing	No
512	Bearing Devices Type II	Shop Drawing	No
512	Bearing Devices Type III	Shop Drawing	Yes
514	Pedestrian and Bikeway Railing	Working Drawing	No
518	Expansion Devices: 0-4"	Working Drawing	No
518	Expansion Devices: 0-6", 9", 12"...	Shop Drawing	Yes
601 & 618	Precast Panel Deck Forms	Working Drawing	No
601	Permanent Steel Bridge Deck Forms	Working Drawing	Yes
601	Falsework	Working Drawing	Yes
602	Reinforcing Steel	Working Drawing	No
606	Bridge Railing	Working Drawing	No
607	Sound Barriers (Alternative)	Shop Drawing	Yes
607	Sound Barriers (Default Design)	Working Drawing	No
613	Light Standards (Low Mast)	Working Drawing	Yes
613	Light Standards (High Mast)	Working Drawing	Yes
614	Overhead Sign Structures	Shop Drawing	Yes*
614	Traffic Signal Pole (Mast Arm)	Shop Drawing	No
614	Traffic Signal Pedestal Pole	Working Drawing	No
614	Traffic Signal Equipment	Working Drawing	No
618	Prestressed Concrete (Pre-tensioned)	Shop Drawing	Yes*
618	Prestressed Concrete (Post-tensioned)	Shop Drawing	Yes*
618	Steel Diaphragms between Prestressed Girders	Working Drawing	No
628	Pre-fabricated Pedestrian Bridges	Shop Drawing	Yes

\*A 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.

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**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.

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 which 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 in accordance with 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 in accordance with 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 (a) and (b) below will be used only when the lot is represented by three to seven tests inclusive.

- (a) The formula,  $P = (X_n + aR - T_u)F$ , will be used if a maximum limit only is specified or; when the average of the several test values is above the mid point of the specification band or above the job-mix formula value.
- (b) The formula,  $P = (T_L + aR - X_n)F$ , will be used if a minimum limit only is specified or; when the average of the several test values is below the mid point of the specification band or below the job-mix formula value.
- (c) 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 which 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  $P = 0.76(T_o - T_u)F$  will be used. When a minimum limit only is specified or the test value is below the minimum specified limit, the formula  $P = 0.76(T_L - T_o)F$  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,  
 $X_n$  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,  
 $T_u$  is the upper or maximum tolerance limit permitted by the specifications,  
 $T_L$  is the lower or minimum tolerance limit permitted by the specifications, and  
 $T_o$  is the test value of the test which deviates from the specifications,  
 F is price reduction factor to be applied for each element as shown in the following table:

**TABLE OF PRICE REDUCTION FACTORS**

<b>Element</b>	<b>Factor "F"</b>
100 percent size sieve	1
12.5 mm (½") 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
Compaction, bituminous mixtures (Section 403)	7
Liquid Limit	3
Plasticity Index	10
Asphalt content, (all asphalt- aggregate mixtures)	20
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	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 or 304 is 3 or greater the reduction will apply to the contract price multiplied by the Multipliers (M) listed in the following table.

**Multiplier for Price Reductions for Miscellaneous Items**

<b>Item Number-Name</b>	<b>Element</b>	<b>Multiplier (M)</b>
206- Structural Backfill	Gradation	0.60
304-Aggregate Base Course	Gradation	0.60

If the P for gradation, asphalt cement content, or compaction for Items 301 or 403 is 3 or greater and asphalt cement is not paid for separately, the reduction will apply to the contract price multiplied by the following Multiplier (M) listed in the following table:

**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

\* 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 =  $(P/100) \cdot \text{Multiplier} \cdot \text{Price per Unit} \cdot \text{Quantity}$ .

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 which 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 which is obviously defective may be isolated and rejected without regard to sampling sequence or location within a lot.

**105.04 Conformity to the Contract of Superpave Performance Graded Binders.**

Superpave Performance Graded binders shall be price reduced according to the following if the requirements of subsection 702.01 are not met:

(1) High Service Temperature Requirements from Table 702-1

The Dynamic Shear ( $G^*/\sin\theta$ , kPa) of Rolling Thin Film Oven (RTFO) residue will be measured at the appropriate temperature for the binder type, as specified in Table 702-1. If the Dynamic Shear of the RTFO aged binder is less than 2.20 kPa, the temperature at which  $G^*/\sin\theta = 2.20$  kPa will be determined. A "P" of 3 shall be applied for each degree C the material temperature must be lowered below the specified temperature to achieve a Dynamic shear of 2.20 kPa. Price adjustments for high service temperature properties will be calculated as follows:

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$$P(\text{high}) = 3 \cdot [T_{\text{spec}} - T_{\text{DS}}],$$

Where  $T_{\text{DS}}$  = Temperature in °C where  $G^*/\sin\phi = 2.20$  kPa

$T_{\text{spec}}$  = Appropriate test temperature in °C for binder specified from Table 702-1

- (2) Low Service Temperature Requirements from Table 702-1:

The m-value of Pressure Aging Vessel (PAV) aged binder will be measured at the appropriate temperature ( $T_{\text{spec}}$ ) as specified in Table 702-1. If the m-value is less than 0.300, the test temperature at which the m-value = 0.300 will be determined. A “P” of 3 shall be applied for each degree C the material temperature must be raised above the specified test temperature to achieve an m-value of 0.300. Price adjustments for low service temperature properties will be calculated as follows:

$$P(\text{low}) = 3 \cdot [T_m - T_{\text{spec}}]$$

Where  $T_m$  = Temperature in °C where m-value = 0.300

$T_{\text{spec}}$  = Appropriate test temperature in °C for binder specified from Table 702-1

- (3) The price reductions will be cumulative. When the binder is included in the contract unit price for HMA, the total price reduction will be calculated as follows:

$$P(\text{total}) = P(\text{low}) + P(\text{high})$$

$$\text{Amount of Reduction} = [P(\text{total})] \cdot [(1/100) \cdot (\text{Invoice price for PG Binder})]$$

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

$$P(\text{total}) = P(\text{low}) + P(\text{high})$$

$$\text{Amount of Reduction} = [P(\text{total})] \cdot [(1/100) \cdot (\text{Contract Unit price for PG Binder})]$$

- (4) Price reductions based on the “F” factors in the Table of Price Reduction Factors will be added to the P (low) and P (high) price reductions described in 105.03. Other binder requirements listed in Table 702-1 will be tested, but will not be considered for price reduction calculations. However, the Contractor shall not be allowed to continue to produce mix with out of specification Superpave PG asphalt binder. If two consecutive samples fail to meet all requirements listed in 702-1, the Contractor shall take corrective action before being allowed to continue production of Hot Bituminous Pavement. 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 Table 702-1.

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 which 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 in accordance with 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 in accordance with 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 Section 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 prior to 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 in accordance with the requirements of this Section. Test results determined to have sampling or testing errors will not be used.

Except for density measurements taken within a compaction test section, any test result for an element greater than the distance 2 times V (see Table 105-2) outside the tolerance limits will be designated as a separate process and the pay factor will be

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calculated in accordance with subsection 105.05(a). A pay factor less than zero shall be zero. The calculated PF will be used to determine the Incentive or Disincentive Payment (I/DP) for the process.

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 105-2.  
T<sub>o</sub> = the individual test result.  
T<sub>u</sub> = upper specification limit.  
T<sub>L</sub> = 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) in accordance with Colorado Procedure 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 105-3 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 105-3. Where Pn is equal to or greater than 10 and less than 201, PF will be computed by formula (1):

$$PF = \frac{PF_1 + PF_2}{2} + \left[ \frac{PF_2 + PF_3}{2} - \frac{PF_1 + PF_2}{2} \right] \bullet \frac{(Pn_2 - Pn_x)}{(Pn_2 - Pn_3)} \text{ formula (1)}$$

Where, when referring to Table 105-3:

- PF<sub>1</sub>= PF determined at the next lowest Pn formula using process QL
- PF<sub>2</sub>= PF determined using the Pn formula shown for the process QL
- PF<sub>3</sub>= PF determined at the next highest Pn formula using process QL
- Pn<sub>2</sub>= the lowest Pn in the spread of values listed for the process Pn formula
- Pn<sub>3</sub>= the lowest Pn in the spread of values listed for the next highest Pn formula
- Pn<sub>x</sub>= 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 in accordance with Table 105-3.

As test results become available, they will be used to calculate QL and PF numbers for each process. The process I/DP's 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. When condition red, as described in subsection 106.05(g), exists for any element, resolution and correction will be in accordance with Section 106. Material which the Engineer determines is defective may be

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isolated and rejected without regard to sampling sequence or location within a process.

**Table 105-2  
“W”AND “V” FACTORS FOR VARIOUS ELEMENTS**

<b>Hot Mix Asphalt</b>		
<b>Element</b>	<b>V Factor</b>	<b>W Factor</b>
2.36 mm (No. 8) mesh and larger sieves	2.80	N/A
600 μm (No. 30) mesh sieve	1.80	N/A
75 μm (No. 200) mesh sieve	0.80	N/A
Gradation	N/A	15
Asphalt Content	0.20	25
In-place Density	1.10	45
Joint Density	1.60	15

**Table 105-3  
FORMULAS FOR CALCULATING PF BASED ON Pn**

<b>Pn</b>	<b>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:</b>	<b>Maximum PF</b>
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
≥ 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 105-2

When AC is paid for separately UP shall be:

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

Where: Ton <sub>HMA</sub>	=	Tons of Asphalt Mix
UP <sub>HMA</sub>	=	Unit Bid Price of Asphalt Mix
Ton <sub>AC</sub>	=	Tons of Asphalt Cement
UP <sub>AC</sub>	=	Unit Bid Price of Asphalt Cement

For the joint density element:

$$UP = UP_{HMA}$$

Where: UP<sub>HMA</sub> 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 <sub>HMA</sub>	=	Bid Tons of Asphalt Mix
BUP <sub>HMA</sub>	=	Unit Bid Price of Asphalt Mix
BTon <sub>AC</sub>	=	Bid Tons of Asphalt Cement
BUP <sub>AC</sub>	=	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

**105.06 Conformity to Contract of Portland Cement Concrete Pavement.**

Conformity to the Contract of all Portland Cement Concrete Pavement, Item 412, will be determined in accordance with the following:

When the Engineer finds that the materials furnished, the work performed, or the finished product does not conform with 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 in accordance with 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 three elements of compressive strength, sand equivalent, and pavement thickness (compressive strength criteria) or the two elements of flexural strength and pavement thickness (flexural strength criteria). The Contractor shall choose whether compressive strength or flexural strength criteria will be used and indicate the choice in writing to the Engineer when the initial proposed mix design is submitted to the Engineer. Once the selection of acceptance criteria is made, they shall remain the acceptance criteria for all processes for the duration of the project.

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

If the Contractor chooses compressive strength criteria then the QL will be calculated for the elements of compressive strength, sand equivalent and pavement thickness on a process basis. If the Contractor chooses flexural strength criteria, then the QL will be calculated for the elements of flexural strength and pavement thickness on a process basis. A separate process will be established for an element when a change in the process affects that element. 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. A change in process is defined as a change that affects the element involved. Changes in mix design, material source, design pavement thickness, or the method being utilized to place the pavement are considered changes in 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, providing there are no changes in process as described above.
  2. Construction of ramps, acceleration and deceleration lanes, shoulders placed separately and areas requiring hand work are considered separate processes.
  3. A change in the mix design is a process change for the compressive strength element or the flexural strength element, but is not a process change for the pavement thickness element.
- (b) When it is necessary to represent material by one or two tests, each individual test shall have a PF computed in accordance with 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 105-6 and 105-7.  
 $T_0$  = 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 in accordance with the following:

- A. For compressive strength and pavement thickness:

When  $3 \leq Pn \leq 5$

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

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

When  $6 \leq Pn \leq 9$

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

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

105.06

When  $10 \leq P_n \leq 25$

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

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

When  $P_n \geq 26$

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

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

B. For flexural strength:

When  $3 \leq P_n \leq 5$

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

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

When  $6 \leq P_n \leq 9$

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

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

When  $10 \leq P_n \leq 25$

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

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

When  $P_n \geq 26$

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

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

C. For sand equivalent:

When  $3 \leq P_n \leq 5$

If  $QL \geq 85$ , then  $PF = 1.00 + (QL - 85)0.000667$

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

When  $6 \leq P_n \leq 9$

If  $QL \geq 90$ , then  $PF = 1.00 + (QL - 90)0.001000$

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

When  $10 \leq P_n \leq 25$

If  $QL \geq 93$ , then  $PF = 1.00 + (QL - 93)0.001429$

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

When  $P_n \geq 26$

If  $QL \geq 95$ , then  $PF = 1.00 + (QL - 95)0.002000$

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 in accordance with 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 an I/DP is computed shall determine the formula to be used.

- (e) The Contractor will 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 which is obviously defective may be isolated and rejected without regard to sampling sequence or location within a process.

**Table 105-4**  
**“V” FACTORS AND INCENTIVE PAYMENTS**  
**COMPRESSIVE STRENGTH CRITERIA**

Element	V Factor	Maximum Incentive Payment	Lower Tolerance Limit, T <sub>L</sub>
Compressive Strength	400 psi	2.00%	28 day strength, Table 601-1
Pavement Thickness	0.4 inch	2.00%	Plan Thickness-0.4”
Sand Equivalent	4%	1.00%	80%

**Table 105-5**  
**“V” FACTORS AND INCENTIVE PAYMENTS**  
**FLEXURAL STRENGTH CRITERIA**

Element	V Factor	Maximum Incentive Payment	Lower Tolerance Limit, T <sub>L</sub>
Flexural Strength	50 psi	3.00%	570 psi
Pavement Thickness	0.4 inch	2.00%	Plan Thickness-0.4”

105.07

**105.07 Conformity to Roadway Smoothness Criteria.** Roadway smoothness shall be tested as described below. Roadway smoothness testing will not be measured and paid for separately, but shall be included in the work.

- (a) Transverse Pavement Surface Smoothness. The finished transverse surface elevation of the pavement will be measured using a 10 foot straightedge.

The Contractor shall furnish an approved 10 foot straightedge and depth gauge and provide an operator to aid the Engineer in testing the finished pavement surface. Areas to be measured shall be as directed by the Engineer. Areas showing high spots of more than  $\frac{3}{16}$  inch in ten feet shall be marked and diamond ground until the high spot does not exceed  $\frac{3}{16}$  inch in ten feet. Additional diamond grinding shall be performed as necessary to extend the area ground in each lateral direction so that the lateral limits of grinding are at a constant offset from and parallel to the nearest lane line or pavement edge, and in each longitudinal direction so that the grinding begins and ends at lines normal to the pavement centerline within the ground area. All ground areas shall be neat rectangular areas of uniform surface.

- (b) Longitudinal Pavement Surface Smoothness. Pavement surfaces shall be tested and evaluated for longitudinal smoothness as described herein.

1. Testing Procedure (General). The longitudinal surface smoothness of the pavement shall be tested using the profilograph method described below.

The Contractor shall determine a Profile Index (PI) in inches per mile for each section of finished pavement surface. A pavement section is defined as a continuous area of finished pavement 0.1 mile in length and one lane 12 feet in width. A partial section resulting from an interruption of the continuous pavement surface is subject to the same evaluation as a whole section.

Each profilograph shall be certified in accordance with CP 73 and have a certification sticker which includes the date of certification, the type of filter, and the filter setting used when the profilograph was certified.

The Project Engineer may require a profilograph to be recertified at any time. If the profilograph being recertified meets the criteria for certification on the first try the costs of recertification will be paid as extra work. If not, the cost of the recertification shall be borne by the Contractor.

The Contractor shall provide, operate, and maintain on the project, an approved profilograph that meets the following requirements:

The profilograph shall be equipped with:

- (1) A microcomputer capable of automatically reducing the recorded profilograph data and downloading it to a disk. The data on the disk shall be

formatted to permit evaluation of the data by the Engineer. If software is required for this evaluation, the Contractor shall provide copies of the software for the Engineer's use.

- (2) A printer compatible with the microcomputer that prints a profilogram with the required data.

The Contractor shall demonstrate to CDOT project personnel the calibration, operation and maintenance of the profilograph that will be used on the project. The demonstration shall be conducted on the project prior to measurement.

The profilograph shall be operated at a speed recommended by the Manufacturer. To ensure that these speeds are maintained, the profilograph may be propelled by a motorized vehicle which is capable of maintaining the correct speed. The motorized vehicle shall propel the profilograph in accordance with the Manufacturer's recommendations without interfering with traffic or the operation of the profilograph.

The profilograph shall be calibrated after transportation and before each day's use in accordance with the manufacturer's instructions.

As directed by the Engineer, additional profiles shall be taken to retest paved surfaces that have received corrective work, to check previously submitted data or to identify the limits of irregularities.

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 begin 25 feet from the joint. One sided joints shall be profiled to determine conformity to the bump specification.

The Contractor shall notify the Engineer prior to beginning each profilograph operation.

A Department employee or designated representative will:

- (1) Witness and document the calibration of the profilograph prior to each test.
- (2) Accompany the Contractor's operator during the entire profilograph testing procedure.
- (3) Immediately take possession of the profilogram and disk containing the results and document the inspection by signing the profilogram report.
- (4) Document that the testing has been completed in accordance with the specification.

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Each profilogram shall include the following information:

- (1) Project subaccount number.
- (2) Project number.
- (3) Project location.
- (4) Date.
- (5) Lane and wheel path profiled.
- (6) Operator's signature.
- (7) Profile Index in inches per mile for each 0.1 mile section.

Each profilogram trace shall be marked by the computer or the Contractor to indicate the following:

- (1) Beginning and ending stations.
- (2) Intermittent reference stations every 0.1 mile.
- (3) Beginning and ending reference points.
- (4) Horizontal equations stations.
- (5) Construction joints.
- (6) Location of bridge abutments.
- (7) Net total linear feet of each lane.
- (8) Net square yards of each lane.
- (9) Bumps: when the perpendicular distance from a 25 foot baseline to the profile exceeds 0.4 inch.

The Contractor shall determine a Profile Index for each 0.1 mile section of completed pavement. The Profile Index shall consist of two profiles taken 3 feet from and parallel to the edge of each lane. The two profiles for each section shall be averaged to determine the Profile Index.

The entire length of each through lane, climbing lane and passing lane including bridge approaches and bridge decks from the beginning to the end of the project shall be profiled. Shoulders, ramps, tapers, turn slots, acceleration lanes, deceleration lanes, and medians shall not be profiled and will not be subject to incentive/ disincentive adjustments. The profile of the entire length of a lane may be taken at one time or the lane may be profiled in increments. Profiles may be taken with or against stationing.

All other longitudinal pavement surfaces will be measured using a 10 foot straightedge. The Contractor shall furnish an approved 10 foot straightedge and depth gauge and provide an operator to aid the Engineer in testing the finished pavement surface. Areas to be measured shall be as directed by the Engineer. Areas showing high spots of more  $\frac{3}{16}$  inch in ten feet shall be marked and diamond ground until the high spot does not exceed  $\frac{3}{16}$  inch in ten feet. Additional diamond grinding shall be performed as necessary to extend the area ground in each lateral direction so that the lateral limits of grinding are at a constant offset from and parallel to the nearest lane line or pavement edge, and in each longitudinal direction so that the grinding begins



and ends at lines normal to the pavement centerline within the ground area. All ground areas shall be neat rectangular areas of uniform surface.

When both new pavement and a new bridge are being constructed on a project, the profile of the area 25 feet each side of every bridge expansion device (joint) shall be deleted from the profile before the Profile Index (PI) is determined. Incentive and disincentive payments will not be made for this area. All bumps that exceed 0.4 inch in 25 feet shall be diamond ground until the bump does not exceed 0.4 inch in 25 feet. Diamond grinding 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 every bridge expansion device (joint) shall be deleted from the profile before the Profile Index (PI) is determined. Incentive and disincentive payments will not be made for this area. If the Engineer determines that corrective work is required in this area, payment will be made in accordance with subsection 109.04.

2. Smoothness testing procedures. The Contractor shall profile the surface of the pavement placed on the second day of paving as soon as possible after completion of this paving. Production shall be suspended if:
  - (1) The Profile Index for any 0.1 mile section exceeds the Profile Index which requires corrective work on pavements subject to Inches/Mile requirements; or
  - (2) The Profile Index for any 0.1 mile section exceeds the original Profile Index on pavements subject to Percent Improvement (%I) requirements.

Production shall remain suspended until 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.

When production is resumed, the Contractor shall profile the pavement placed on the first day of paving after paving resumes and the conditions above for suspension of work shall apply.

The Contractor shall take sufficient profiles during construction to control the paving process.

The Contractor shall profile the finished pavement surface and determine a Profile Index using a 0.1 inch blanking band.

When incentive and disincentive payments are based on percent improvement, the Contractor shall also profile the original pavement surface and determine a Profile Index for each 0.1 mile section, before commencing work, using a 0.1 inch blanking band.

105.07

3. Bumps. All bumps that exceed 0.4 inch in 25 feet shall be diamond ground until the bump does not exceed 0.4 inch in 25 feet. Additional diamond grinding shall be performed as necessary to extend the area ground in each lateral direction so that the lateral limits of grinding are at a constant offset from and parallel to the nearest lane line or pavement edge, and in each longitudinal direction so that the grinding begins and ends at lines normal to the pavement centerline within the ground area. All ground areas shall be neat rectangular areas of uniform surface.

The exact location of each bump shall be determined with a profilograph and the location marked on the pavement before diamond grinding commences. The area that is diamond ground shall also be checked with a profilograph after grinding is complete to ensure that the area now meets specifications.

Diamond grinding of bumps, including all necessary traffic control, shall be completed at the Contractor's expense.

On asphalt pavements, the diamond grinding shall not reduce planned pavement thickness by more than 0.3 inches and the entire ground area shall be covered with a fog seal coat when grinding is complete.

When longitudinal tining is required on concrete pavement, the pavement shall be grooved to restore the longitudinal texture, whenever the length of the ground area exceeds 45 feet. It will not be necessary to groove ground areas that are less than 45 feet in length.

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

4. Corrective Work. When the Contract specifies pavement smoothness based on inches per mile or the criteria for determining if corrective work is required is specified in Table 105-6. For asphalt pavements, when the Contract specifies pavement smoothness based on percent improvement, the criteria for determining if corrective work is required is specified in Table 105-7.

If the first Profile Index for a 0.1 mile section taken on the finished pavement surface exceeds the specified limit for corrective work, the lane shall be reprofiled and another Profile Index determined after all bumps exceeding 0.4 inch in 25 feet have been diamond ground. Corrective work will be required if the Profile Index still exceeds the specified limit.

If corrective work is required, the Contractor shall submit a written corrective work proposal to the Engineer, which shall include the methods, and procedures that will be used. The Contractor shall not commence corrective work until the methods and procedures have been approved in writing by the Engineer.

The Engineer's approval shall not relieve the Contractor of the responsibility of producing work in conformity with the specifications.

When longitudinal tining is required on concrete pavement, the pavement shall be grooved to restore the longitudinal texture, whenever the length of the ground area exceeds 45 feet. It will not be necessary to groove ground areas that are less than 45 feet in length.

Use of a rotomill, diamond grinder, feathering, scab patching, or any combination thereof will not be permitted for corrective work on asphalt pavements.

Corrective work on asphalt pavements shall consist of an approved overlay or removal and replacement. Corrective work on asphalt pavements shall conform to the following conditions:

- A. Removal and replacement. The pavement in areas requiring corrective work shall be removed the full width of the lane and the full thickness of the course in accordance with subsection 202.09 Removal of Asphalt Mat (Planing).

The removal area shall begin and end with a transverse butt joint which shall be constructed with a transverse saw cut perpendicular to centerline. All replacement shall be made with approved hot bituminous mixtures that meet all contract requirements. Replacement material shall be placed in sufficient quantity so the finished surface will conform to grade and smoothness requirements. The corrective area shall be compacted to the specified density.

- B. 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 the finished surface will conform to grade and smoothness requirements. The overlaid area shall be compacted to the specified density. The overlay thickness shall be equivalent to that of the final pass made in accordance with the plans and specifications.

When the corrective work is complete, the Contractor shall profile the corrective work area and determine a Profile Index for each 0.1 mile section. Bumps which exceed 0.4 inch in 25 feet shall be diamond ground in the corrective work area.

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If the first Profile Index for a 0.1 mile section taken on the finished pavement surface in the corrective work area exceeds the specified limit for corrective work, the lane shall be reprofiled and another Profile Index for each 0.1 mile section determined after all bumps exceeding 0.4 inch in 25 feet have been diamond ground. Additional corrective work in accordance with this specification will be required if the Profile Index for a 0.1 mile section exceeds the specified limit.

Regardless of the corrective method used, the final product shall provide a pavement surface equal to adjacent sections not requiring corrective work.

All corrective work, including all necessary traffic control, shall be at the Contractor's expense.

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

- 5 Final acceptance and incentive and disincentive payments for pavement smoothness will be made on a square yard basis in accordance with the following:

- A. When the pavement is subject to an incentive/disincentive payment for pavement smoothness based on inches per mile the following applies:

Incentive payments will be based on the Profile Index (PI) for each 0.1 mile section using a 0.1 inch blanking band before diamond grinding of bumps or any corrective work has been done.

Disincentive payments will be based on the Profile Index (PI) for each 0.1 mile section using a 0.1 inch blanking band after the bumps that exceed 0.4 inch in 25 feet have been diamond ground and before any other corrective work has been completed.

Incentive and disincentive payments for Pavement Smoothness will be made in accordance with Table 105-6.

**Table 105-6  
PAVEMENT SMOOTHNESS  
(INCHES PER MILE)  
0.1 INCH BLANKING BAND**

Pavement Smoothness Category <sup>1</sup>	Incentive Payments <sup>2</sup>			Disincentive Payments <sup>3</sup>			Corrective Work Required <sup>4, 5</sup>
	PI (in./mi.)	Asphalt \$/Sq. Yd.	Concrete \$/Sq. Yd.	PI (in./mi.)	Asphalt \$/Sq. Yd.	Concrete \$/Sq. Yd.	
I RURAL INTERSTATE	8 or less	\$0.16	\$1.40	22.1-24	-\$0.16	-\$1.40	24.1 or more
	8.1-10	\$0.12	\$1.05	20.1-22	-\$0.12	-\$1.05	
	10.1-12	\$0.08	\$0.70	18.1-20	-\$0.08	-\$0.70	
	12.1-14	\$0.04	\$0.35	16.1-18	-\$0.04	-\$0.35	
	14.1-16	\$0.00	\$0.00				
II ALL OTHER HIGHWAYS WITH SPEED LIMITS EQUAL TO OR GREATER THAN 45 MPH	8 or less	\$0.16	\$1.40	25.6-28	-\$0.16	-\$1.40	28.1 or more
	8.1-10.6	\$0.12	\$1.05	23.1-25.5	-\$0.12	-\$1.05	
	10.7-13.3	\$0.08	\$0.70	20.6-23	-\$0.08	-\$0.70	
	13.4-16	\$0.04	\$0.35	18.1-20.5	-\$0.04	-\$0.35	
	16.1-18	\$0.00	\$0.00				
III <sup>6</sup> ALL HIGHWAYS WITH SPEED LIMITS LESS THAN 45 MPH	8 or less	\$0.16	\$1.40	29.1-34	-\$0.16	-\$1.40	34.1 or more
	8.1-11.7	\$0.12	\$1.05	26.1-29	-\$0.12	-\$1.05	
	11.8-15.4	\$0.08	\$0.70	23.1-26	-\$0.08	-\$0.70	
	15.5-18.0	\$0.04	\$0.35	20.1-23	-\$0.04	-\$0.35	
	18.1-20	\$0.00	\$0.00				

Footnotes on page 52

## Footnotes for Table 105-6

- <sup>1</sup>The pavement smoothness category will be shown on the plans.
- <sup>2</sup>Incentive Payments will be based on the Profile Index (PI) for each 0.1 mile section before diamond grinding of bumps or any corrective work has been done.
- <sup>3</sup>Disincentive payments will be based on the Profile Index (PI) for each 0.1 mile section after bumps have been diamond ground and before any other corrective work has been completed.
- <sup>4</sup>Asphalt pavement - A disincentive of \$0.16/sq. yd. will be applied in addition to the corrective work.
- <sup>5</sup>Concrete pavement - A disincentive of \$1.40/sq. yd. will be applied in addition to the corrective work
- <sup>6</sup>a. This category applies to the following asphalt pavement construction: (1) new construction; (2) complete reconstruction, including replacement of existing curb and gutter; (3) construction of more than one layer; (4) construction of one layer over an intermediate treatment; and (5) urban construction where smoothness is not affected by existing curb and gutter or numerous intersections. All other asphalt pavement construction where the speed limit is less than 45 mph is subject to percent improvement incentive or disincentive in accordance with Table 105-7. b. This category applies to the following concrete pavement construction: (1) new construction; and (2) complete reconstruction. All other concrete pavement construction where the speed limit is less than 45 mph is not subject to incentive or disincentive; however, all bumps that exceed 0.4 inch/25 feet must be diamond ground until they are less than 0.4 inch/25 feet in accordance with these specifications.

- B. When the pavement is subject to an incentive or disincentive payment for asphalt pavement smoothness based on the Percentage of Improvement (%I), the following applies:

Incentive payments will be based on the %I of the Profile Index (PI) for each 0.1 mile section on the final paved surface before diamond grinding of bumps or any corrective work has been done compared to the Profile Index (PI) for each 0.1 mile section of the original surface.

Disincentive payments will be based on the %I of the Profile Index (PI) for each 0.1 mile section on the final paved surface after the bumps that exceed 0.4 inch in 25 feet have been diamond ground and before any other corrective work has been completed compared to the Profile Index (PI) for each 0.1 mile section of the original surface.

The %I will be calculated as follows:

$$\%I = \frac{(\text{PI OF ORIGINAL SURFACE} - \text{PI OF FINAL SURFACE}) \cdot 100}{\text{PI OF ORIGINAL SURFACE}}$$

Incentive and disincentive payments for Pavement Smoothness will be made in accordance with Table 105-7.

Disincentives and corrective work will not be required for a 0.1 mile section if the final Profile Index (PI) after grinding bumps and before any other corrective action is equal to or less than the PI shown in Table 105-8.

**Table 105-7  
ASPHALT PAVEMENT SMOOTHNESS  
PERCENT IMPROVEMENT (%I)  
0.1 INCH BLANKING BAND**

Incentive Payments <sup>1</sup>		Disincentive Payments <sup>2</sup>		Corrective Work Required <sup>3</sup> %I
%I	\$/Sq.Yd.	%I	\$/Sq.Yd.	
More than 75.0	\$0.16	20.1-26.2	-\$0.16	20.0 OR LESS
70.1-75.0	\$0.12	26.3-32.5	-\$0.12	
65.1-70.0	\$0.08	32.6-38.8	-\$0.08	
55.1-65.0	\$0.04	38.9-45.0	-\$0.04	
45.1-55.0	\$0.00			

<sup>1</sup>Incentive payments will be based on the Profile Index (PI) for each 0.1 mile section before diamond grinding of bumps or any corrective work has been done.<sup>2</sup>Disincentive payments will be based on the Profile Index (PI) for each 0.1 mile section after bumps have been diamond ground and before any other corrective work has been completed.<sup>3</sup>A disincentive of \$0.16/sq. yd. will be applied in addition to the corrective work.

**Table 105-8  
PI FOR NO DISINCENTIVE OR CORRECTIVE WORK  
FOR PERCENT IMPROVEMENT (%I)**

Pavement Smoothness Category	Description	PI
<b>I</b>	Rural Interstate	16 inches/mile
<b>II</b>	All other highways with speed limits greater than or equal to 70 km/hour (45 MPH)	28 inches/mile
<b>III</b>	All highways with speed limits less than 70 km/hour (45 MPH)	20 inches/mile

- (c) Smoothness Requirements for the work items: Removal of Asphalt Mat (Planing), Heating and Scarifying, Cold Bituminous Pavement Recycle, Heating and Repaving, and Heater Remixing.

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1. Testing procedures. A Profile Index (PI) for each 0.1 mile section shall be determined on the original pavement surface prior to beginning the work, using a 0.2 inch blanking band in accordance with CP 64.

A Profile Index (PI) for each 0.1 mile section shall be determined on the pavement surface after the work is complete using a 0.2 inch blanking band.

2. Final pavement smoothness acceptance will be made as follows:

0.1 mile sections with a final Profile Index (PI) that is greater than the Profile Index prior to performing the work shall be corrected by a method approved in writing by the Engineer. Corrective work shall be such that the resulting final PI is equal to or less than the initial PI. All corrective work shall be at the Contractor's expense, and shall include traffic control, and all additional hot bituminous pavement required.

**105.08 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 PlansCalculated 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.

**105.09 Cooperation by Contractor.** The Contractor will be supplied with a minimum of six sets of contract documents.

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.

**105.10 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.

The Contract will indicate those utility items which are to be relocated or adjusted by the utility owner or which are 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 which are the responsibility of the Contractor will be considered nonexcusable delays. 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. Delays shall be dealt with in accordance with subsection 108.07.

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 in accordance with subsection 104.03. Consideration for delays shall be in accordance with subsection 108.07(d).

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

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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.

**105.11 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.

**105.12 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 bench marks as described in the Contract. The Contractor shall furnish and set construction stakes establishing lines and grades in accordance with the provisions of Section 625. The Engineer may order extra surveying which will be paid for at the established rate of \$100 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 prosecution 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 prosecution 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 be held responsible for the preservation of all stakes and marks, and if any 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 the rate of \$100 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 insure conformance with the Contract. A minimum of two working days will be required as advance notice to the Engineer to provide project control staking.

**105.13 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 claims for additional compensation or extension of contract time filed pursuant to subsection 105.21.

**105.14 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.

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**105.15 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 prior to the inspection pursuant to subsection 105.20(b) whether or not previous inspections or tests were conducted by the Engineer or authorized representative.

**105.16 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 prior to 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.

**105.17 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 which 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)	Overweight cont. (Pounds)	Price Reduction cont. (Dollars)
0 - 3000	20	8,001 - 9,000	582
3001 - 4000	40	9,001 - 10,000	842
4001 - 5,000	82	Over 10,000	\$870 plus \$164 for each 1,000 lbs over 10,000 lbs
5,001 - 6,000	130		
6,001 - 7,000	226		
7,001 - 8,000	376		

**105.18 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.

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In the case of a Contract involving 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.

**105.19 Failure to Maintain Roadway or Structure.** If the Contractor fails to comply with the provisions of subsection 105.18, the Engineer will immediately notify the Contractor of such noncompliance. If the Contractor fails to remedy unsatisfactory maintenance within 24 hours after receipt of such notice, the Engineer may immediately proceed to maintain the project, and the entire cost of this maintenance will be deducted from monies due or to become due the Contractor on the Contract.

**105.20 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 on which 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.

**105.21 Disputes and Claims for Contract Adjustments.** When the Project Engineer is a Consultant Project Engineer, actions, decisions, and determinations specified herein as made by the Project Engineer may be made by the Resident Engineer.

- (a) Disputes include, but are not limited to, any disagreement resulting from a change, 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. When a dispute occurs, the Contractor shall pursue resolution through the process set forth in this subsection. The Contractor shall:
1. Provide a written notice of protest to the Project Engineer before doing the work;
  2. Supplement the written protest within 15 calendar days with a written statement providing the following:
    - (1) The date of the protested order;
    - (2) The nature of the order and circumstances which caused the protest;
    - (3) The contract provisions supporting the protest;
    - (4) The estimated dollar cost, if any, of the protested work and documentation supporting the estimate; and
    - (5) An analysis of the progress schedule showing the schedule change or disruption if the Contractor is asserting a schedule change or disruption; and
  3. Supplement the information provided in 2. above as necessary during the time the dispute continues.

Throughout protested work, the Contractor shall keep complete records of extra costs and time incurred. The Contractor shall permit the Project Engineer access to these and all other records needed for evaluating the protest as determined by the Project Engineer.

The Project Engineer will evaluate all protests. If the Project Engineer determines that a protest is valid, the Project Engineer will adjust payment for work or time by an equitable adjustment in accordance with subsection 108.07, 109.04, or 109.10. If the Project Engineer fails to provide satisfactory resolution, the Contractor may pursue the more formalized method for submitting a claim, as outlined below.

- (b) All claims filed by the Contractor based upon: (1) work or materials not clearly defined in the Contract, (2) extra work not ordered by the Engineer in accordance with subsection 104.03, (3) extensions of time made pursuant to subsection 108.07, or (4) any other cause, resulting in requests for additional compensation or time, shall be governed by this subsection.

The Contractor and the Department agree that the dispute resolution process set forth in this subsection shall be exhausted in its entirety prior to initiation of litigation.

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Failure to comply with the requirements set forth in this subsection shall bar the Contractor from any further administrative, equitable, or legal remedy.

- (c) Upon discovery of any facts which formulate the basis of a potential claim, or upon unsatisfactory resolution of a dispute, the Contractor shall give written notice to the Project Engineer to enable the Department to obtain its independent evidence of these facts.

Within seven calendar days after the discovery of the facts giving rise to a claim, or after unsatisfactory resolution of a dispute, the Contractor shall notify the Project Engineer in writing of the intent to file a claim as described in subsection 105.21(b), unless written notice of protest was given in accordance with subsection 105.21(a). The Contractor's formal notification of intent to file a claim shall describe the contractual and legal basis of the claim and factual evidence supporting the claim.

If notice of protest or notice of intent to file claim are not properly given by the Contractor according to these specifications, the Contractor shall not be entitled to any additional compensation or extension of time for any cause related to the claim, including any act or failure to act by the Engineer. Any such claim based upon any cause will be considered invalid and will be denied by the Project Engineer on the basis that proper notifications, as required herein, were not given. The Contractor's prior and formal notifications of intent to file a claim and subsequent Department acknowledgment of those notifications shall not be construed as proving or substantiating the validity of the Contractor's claim as related to the contractual basis of the claim, factual information related to the claim, or cost, or amount of time extension related to the claim.

- (d) When the Contractor provides written notification of intent to file a claim pursuant to subsection 105.21(c), the claim will be reviewed by the Project Engineer who will render a written decision to the Contractor to either affirm the claim as valid or deny the claim, in whole or in part, in accordance with the following procedure:

- 1. Within 60 days after project acceptance, the Contractor shall submit to the Project Engineer a complete claim package which represents the final position the Contractor wishes to have considered by the Department. The submitted claim package shall include all documents supporting such claim, regardless of whether such documents have been provided previously to the Department. All claims filed by the Contractor shall be in writing and in sufficient detail to enable the Engineer to ascertain the basis and amount of claim. As a minimum, the following information must accompany each claim submitted:

- A. A claim certification containing the following language:



**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 herein for work on this contract is a true statement of the actual costs and time incurred, and is fully documented herein and supported under the contract between the parties.

This claim package contains all documents which support the claims made herein and I understand that no further data, other than data provided for clarification purposes, may be presented by me.

Dated \_\_\_\_\_/s/  
Subscribed and sworn before me this \_\_\_\_\_ day of

\_\_\_\_\_  
NOTARY PUBLIC  
My Commission Expires:

- B. 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.
- C. The date on which facts were discovered which gave rise to the claim.
- D. The name, title, and activity of all known CDOT, Consultant, and other individuals who may be knowledgeable about facts giving rise to such claim.
- E. 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.
- F. The specific provisions of the Contract which support the claim and a statement of the reasons why such provisions support the claim.
- G. If the claim relates to a decision of the Engineer which the Contract leaves to the Engineer’s discretion, the Contractor shall set out in detail all facts supporting its position relating to the decision of the Engineer.
- H. The identification of any documents and the substance of any oral communications that support the claim.
- I. Copies of all known documents that support the claim.

- J. If an extension of contract time is sought, the documents required by subsection 108.07(d).
- K. If additional compensation is sought, the exact amount sought and a breakdown of that amount into the following categories:
- (1) These categories represent the only costs that are recoverable by the Contractor. All other costs or categories of costs are not recoverable:
    - (i) Actual wages and benefits, including FICA, paid for additional non-salaried labor;
    - (ii) Costs for additional bond, insurance and tax;
    - (iii) Increased costs for materials;
    - (iv) Equipment costs calculated in accordance with subsection 109.04(c) for Contractor owned equipment and based on invoice costs for rented equipment;
    - (v) Costs of extended job site overhead;
    - (vi) Subcontractor's claims (the same level of detail as specified herein is required for all subcontractor's claims)
    - (vii) An additional 10 percent will be added to the total of items (i), (ii), (iii), (iv), (v), and (vi) as compensation for items for which no specific allowance is provided, including profit and home office overhead.
  - (2) In adjustment for the costs as allowed above, the Department will have no liability for the following items of damages or expense:
    - (i) Profit in excess of that provided in (1) above;
    - (ii) Loss of profit;
    - (iii) Additional cost of labor inefficiencies in excess of that provided in (1) above;
    - (iv) Home office overhead in excess of that provided in (1) above;
    - (v) Consequential damages, including but not limited to loss of bonding capacity, loss of bidding opportunities, and insolvency;
    - (vi) Indirect costs or expenses of any nature in excess of that provided in (1) above;
    - (vii) Attorneys fees, claim preparation fees, and expert fees.

The time period within which the Contractor is to provide such written documentation may be extended by the Project Engineer if requested by the Contractor and if the Project Engineer determines an extension would enhance the claim record and improve the potential for resolution of the claim. If the Contractor fails to provide such written documentation within 60 days after project acceptance, or within an extended time period authorized by the Project Engineer, the Project Engineer will base the decision upon the information previously submitted in the Contractor's

notification of intent to file a claim and pertinent specification and contract documents. Requests of time extension to submit documentation shall be submitted in writing prior to final acceptance of the project. The Engineer's approval or disapproval of the extension will be given to the Contractor in writing prior to final acceptance.

The Contractor shall keep full and complete records of the costs and additional time incurred for each claim. All Contractor's records and the records of all subcontractors on the Contract shall be open to inspection or audit by representatives of the Department during the life of the Contract and for a period of not less than three years after the date of final payment. The Contractor, subcontractors, and lower tier subcontractors shall provide adequate facilities, acceptable to the Engineer, for the 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 claim. The audit may be performed for any claim, and is mandatory for all claims with amounts greater than \$250,000.

2. The Project Engineer: (1) will review the information in the Contractor's written notification of intent to file a claim, (2) will review all written documents as submitted by the Contractor in support of the claim, and (3) may consider any other information available in rendering a decision. The Project Engineer will assemble and maintain a claim record comprised of all written documents submitted by the Contractor in support of the claim and all other written documents considered by the Project Engineer in reaching a decision. All documentation the Contractor wants considered shall be made available to the Project Engineer and will be made a part of the claim record during the review of the claim. Once the claim record has been assembled by the Project Engineer, the submission of additional information, other than clarification and data supporting previously submitted documentation, at any subsequent levels of review by anyone, will not be permitted. The Project Engineer will provide a copy of the complete claim record along with the written decision to the Contractor describing the contractual basis and factual information considered by the Project Engineer in reaching a decision.
3. The Project Engineer will render a written decision to the Contractor within 60 days from the receipt of the Contractor's submission of all written documentation supporting the claim. If more than one claim has been filed by the Contractor on the Project, the Project Engineer will have the right to consolidate all related claims and issue one decision on all such claims provided that consolidation of claims does not extend the time period within which the Project Engineer is to render a decision. Consolidation of unrelated claims will not be made. If the Project Engineer fails to render a written decision to the Contractor within the specified 60 day time period, or within any extended time period as agreed to by both, the Contractor must either: (1) accept this as a denial of the claim, or (2) appeal the claim to the

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Region Transportation Director, in the same manner as if the Project Engineer had denied the Contractor's claim, according to subsection 105.21(e).

- (e) If the Contractor disagrees with the written decision of the Project Engineer, the Contractor must either: (1) accept the Project Engineer's decision as final, (2) file a one-time written appeal to the Project Engineer with the submission of additional information, or (3) file a written appeal to the Region Transportation Director based upon all information previously submitted and made a part of the claim record. The Contractor's written appeal shall be made within 60 days from the receipt of the Project Engineer's written decision. The Contractor hereby agrees that if a written appeal is not properly filed within this specified 60 day time period, the claim shall be settled in the same manner as if the Contractor had accepted the Project Engineer's written decision as final. Failure by the Contractor to properly file a written appeal, according to these specifications, shall bar the Contractor from any further administrative equitable or legal remedy for said claim under the Contract.
- (f) When the Contractor properly files a written appeal to the Project Engineer pursuant to subsection 105.21(e), the Project Engineer will review all new submissions made by the Contractor and render a decision to the Contractor pursuant to subsection 105.21(d). When a written appeal to the Region Transportation Director is properly filed by the Contractor pursuant to subsection 105.21(e), the Project Engineer will provide the complete claim record, as defined by subsection 105.21(d), to the Region Transportation Director. The claim will be reviewed by the Region Transportation Director who will render a written decision to the Contractor to either affirm, overrule, or modify the Project Engineer's decision, in whole or in part, in accordance with the following procedure:
  - 1. For the purpose of this subsection, Region Transportation Director shall be understood to mean the Region Transportation Director or the Region Transportation Director's designated representative.
  - 2. The Region Transportation Director will maintain the claim record during the review of the claim. The Contractor's written appeal to the Region Transportation Director will be made a part of the claim record. Either the Contractor or the Department may request an oral hearing of the claim before the Region Transportation Director. When an oral hearing is requested by either party, both the Project Engineer and the Contractor's representative shall be present and the hearing shall be conducted at a time which is convenient to all parties. The Region Transportation Director will consider all written documents in the claim record and all oral presentations in support of that record made by the Contractor and the Project Engineer. The Region Transportation Director will not consider any written documents or oral arguments, which have not previously been made a part of the claim record, other than clarification and data supporting previously submitted documentation.

3. The Region Transportation Director will render a written decision to the Contractor within 60 days from the receipt of the Contractor's written appeal, unless both parties agree to an extension of time. If the Region Transportation Director fails to render a written decision to the Contractor within the specified 60 day time period, or within any extended time period as agreed by both parties, the Contractor must either: (1) accept this as a denial of the claim, or (2) appeal the claim to the Chief Engineer, in the same manner as if the Region Transportation Director had denied the Contractor's claim, according to subsection 105.21(g).
- (g) If the Contractor disagrees with the written decision of the Region Transportation Director, the Contractor must either: (1) accept the Region Transportation Director's decision as final, or (2) file a written appeal to the Chief Engineer within 60 days from the receipt of the Region Transportation Director's written decision. The Contractor hereby agrees that if a written appeal is not properly filed within this specified 60 day time period, the claim shall be settled in the same manner as if the Contractor had agreed with and accepted the Region Transportation Director's written decision as final. Failure by the Contractor to properly file a written appeal according to these specifications shall bar the Contractor from any further administrative, equitable, or legal remedy for said claim under the Contract.
- (h) When the Contractor properly files a written appeal to the Chief Engineer pursuant to subsection 105.21(g), the complete claim record as maintained by the Region Transportation Director will be provided to the Chief Engineer. The Chief Engineer or his duly authorized delegate will review said claim and will render a written decision to the Contractor to either affirm, overrule, or modify the Region Transportation Director's decision, in whole or in part, in accordance with the following procedure:
1. The Contractor's written appeal to the Chief Engineer will be made a part of the claim record. Either the Contractor or the Chief Engineer may request that arbitration be commenced to review the claim and provide a recommendation to the Chief Engineer. Arbitration will not be convened when the value of the claim is less than \$20,000. Arbitration shall be in accordance with subsection 105.21(i).
  2. When arbitration is not requested by either the Contractor or the Chief Engineer, the Chief Engineer will render a decision within 60 days after reviewing the information contained in the claim record. The Chief Engineer will not consider any written documents or oral arguments, which have not previously been made available to the Region Transportation Director and properly made a part of the claim record, other than clarification and data supporting previously submitted documentation.
  3. When arbitration is requested by either the Contractor or the Chief Engineer, it shall be convened pursuant to subsection 105.21(i). Either the Chief

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Engineer or his duly authorized delegate will attend the arbitration. The Chief Engineer or his duly authorized delegate will consider the entire administrative claim record, including the arbitrator's written recommendation. The Chief Engineer or his duly authorized delegate will not consider any written documents or oral arguments which have not been made available to arbitration and made a part of the claim record. The Chief Engineer or his duly authorized delegate will not be bound by the recommendation of the arbitration.

- (i) When requested by either the Contractor or the Chief Engineer, pursuant to subsection 105.21(h), arbitration shall consist of independent arbitrators who shall consider the claim in accordance with the following procedures:
1. The Chief Engineer shall contact an independent arbitration organization such as the American Arbitration Association (AAA) which shall appoint arbitrators according to their internal procedures. Arbitrators shall not be employed by, affiliated with, or have consultive or business connection with the claimant Contractor. Arbitrators shall not have assisted either in the evaluation, preparation, or presentation of the claim case either for the Contractor or the Department or have rendered an opinion on the merits of the claim for either party, and shall not do so during the proceedings of arbitration. The costs and reasonable expenses of arbitration shall be directly paid by the Department. The Department will subtract one-half of the cost of the arbitration from the Contractor's final payment.
  2. Once established, the arbitrators shall serve until the final recommendation is made to the Chief Engineer or his duly authorized delegate. The entire claim record will be made available to the arbitrators by the Chief Engineer.

The independent arbitrators shall administer the process pursuant to the CDOT modified version of AAA's Construction Industry Arbitration Rules, established for its construction claims, except to the extent that such rules conflict with the specifications, in which case the specifications shall control. A copy of the modified AAA rules is made a part of the Contract by special provision. Unless both parties agree otherwise one arbitrator shall be used for claims less than \$250,000 and three arbitrators shall be used for claims \$250,000 and greater. The arbitrators shall consider the facts of the claim and preside over an informal hearing on the claim. The hearing will be transcribed by a court recorder. Either party may have an attorney present at the arbitration hearing. Attorneys licensed in the State of Colorado may participate in the claim presentation. Unless both parties agree otherwise all hearings shall be held in Denver.

The arbitrators shall consider all written information available in the claim record and all oral presentations in support of that record by the Contractor and the Department. The arbitrators shall not consider any written documents or oral arguments which have not previously been made a part of the claim

record, other than clarification and data supporting previously submitted documentation. The arbitrators shall not consider an increase in the amount of the claim, or any new claims.

3. After complete review of the facts associated with the claim, the arbitrators shall render a written explanation of its recommendation, based upon its findings of fact, to the Chief Engineer or his authorized delegate who will retain authority over disposition of the claim. When three arbitrators are used, and only two arbitrators agree then the recommendation of the two arbitrators and the recommendation of the third arbitrator shall be given to the Chief Engineer or his authorized delegate. The arbitrator's recommendation shall include: (1) a summary of the issues and factual evidence presented by the Contractor and the Department concerning the claim, (2) recommendations concerning the validity of the claim, (3) recommendations concerning the value of the claim as to cost and time impacts if the claim is determined to be valid, (4) the contractual and factual bases supporting the recommendations made, (5) detailed and supportable calculations which support any recommendation made. The arbitrators shall act only in an advisory capacity to the Chief Engineer or his authorized delegate, with no direct authority for resolution of the claim. Recommendations which are not supported by the plans, the specifications or other portions of the Contract will not be considered by the Chief Engineer or his authorized delegate. The arbitrators shall not consider Contractor's claims for legal or consultant preparation fees or anticipated profit. Recommendations concerning the value of the claim as to cost and time impacts will not be considered by the Chief Engineer or his authorized delegate if not supported by the required documents from subsection 105.21(d).
4. Upon receipt of the recommendation of the arbitration, the Chief Engineer or his authorized delegate will render a final decision within 60 days pursuant to subsection 105.21(h).

The decision of the Chief Engineer, or the Chief Engineer's authorized delegate, shall constitute final agency action by the Department pursuant to C.R.S. § 24-4-106 and Colorado Rule of Civil Procedure 106(a)(4). In the Contractor disagrees with the Department's final agency action, Contractor's sole remedy is judicial review pursuant to C.R.S. § 24-4-106. The conclusions and recommendations of the arbitration panel shall not be admissible in any court of law. Any offer made by the Contractor or the Department at any stage of the claims process, other than the Department's final agency action, as set forth in this subsection shall be deemed an offer of settlement pursuant Colorado Rules of Evidence 408 and therefore inadmissible in any litigation.

106.01

## **SECTION 106 CONTROL OF MATERIAL**

**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 prior to delivery.

When alternative materials are permitted for an item in the Contract, the Contractor shall state at the preconstruction 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.

**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 which allows removal of material under certain conditions and for a stated price.

Conditions of this agreement which 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 Mined Land Reclamation Division 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 material from a contractor source must be approved by the Engineer prior to incorporation of the material into the project. The Contractor shall produce material which meets contract specifications throughout construction of the project.

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, 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. The Contractor shall submit such certification to the Engineer, signed and stamped (or sealed) by either a certified industrial hygienist (CIH), certified hazardous materials manager (CHMM), registered professional engineer (PE), Certified Safety Professional (CSP), or Registered Environmental Manager (REM) for each contractor source outside of the project limits.

If contractor source material for embankment or topsoil, originating outside of the project limits, is placed on the project and is at anytime 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 in accordance with 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 in which the materials are used, will be inspected and tested by the Engineer, or by

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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 in which 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 prior to the date of advertisement for bids.

Sampling and testing will be done in accordance with 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 in accordance with the Standard AASHTO Method which was current on the date of advertisement for bids.

Samples will be taken by the Department except that the Contractor shall take samples of asphalt cement, in accordance with AASHTO T 40; hot mix asphalt, in accordance with Colorado Procedure 41 and a composite of aggregates for hot bituminous mixtures, in accordance with Colorado Procedure 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 prior to 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 in which those tests are performed, shall be qualified in accordance with 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 in accordance with 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 quality control plan (QCP) in accordance with the following:
  1. Quality Control Plan. For each element listed in Table 106-1, the QCP must provide adequate details to ensure that the Contractor will perform process

control. The Contractor shall submit the QCP to the Engineer at the preconstruction conference. The Contractor shall not start any work on the project until the Engineer has approved the QCP in writing.

- A. Frequency of Tests or Measurements. The QCP 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. 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.
  - C. 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 in accordance with 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 QCP. 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 QCP.
  4. Testing Standards. The QCP 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.

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5. Testing Supervisor Qualifications. The person responsible for the process control sampling and testing shall be identified in the QCP 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 make provisions such that the Engineer can inspect process control work in progress, including 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 QCP. 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 in accordance with 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 in accordance with 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 in accordance with 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 QCP.

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, HMA 4.75 mm (#4) sieve, HMA 2.36 mm (#8) sieve, HMA 75 mm (#200) sieve, voids in the mineral aggregate, air voids, in-place density, and joint density in accordance with 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 test results 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 in accordance with 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 CP13 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 in accordance with 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.

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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 in accordance with 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 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 otherwise directed by the Engineer.

The test results will be evaluated and the Contractor shall make adjustments if required in accordance with 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 HMA 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.

4. Total Quality Level. Add the three individual QLs and divide by three to determine the Total Quality Level (TQL).
  - A. If TQL is 90 or greater, then no change is required and production can continue.
  - B. If TQL is 65 or greater and less than 90 and the QL for the test element of air voids is 70 or greater, then no change is required and production can continue.
  - C. If TQL is 65 or greater and less than 90 and the QL for the test element of air voids is less than 70 or the TQL 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. Production shall not resume until the Engineer has approved a revised mix design.

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.

- (1) If TQL is 90 or greater, then no change is required and production can continue.
- (2) If TQL is 65 or greater and less than 90 and the QL for the test element of air voids is 70 or greater, then no change is required and production can continue.
- (3) If TQL is 65 or greater and less than 90 and the QL for the test element of air voids is less than 70 or the TQL is less than 65, then production shall be halted until a new mix design has been completed in accordance with CP 52 or CP 54, a new Form 43 issued, and the Contractor demonstrates capability of producing a mixture meeting the verification requirements in accordance with (i) or (ii) below:
  - (i) The Contractor shall produce material that shall not be placed on CDOT projects. A minimum of 48 hours notice is required, along with the approval of the Engineer, prior to placement. Three samples will be tested for volumetric properties. If the TQL 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;
  - (ii) 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 and a new TQL are calculated. If the TQL 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. If the TQL is less than 65 or the QL for the elements of air voids or VMA is less than 70, the material shall be removed and replaced at the Contractor's expense. 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 in accordance with (i) or (ii), then production shall be halted until a new mix design has been completed in accordance with CP 52 or CP 54, a new Form 43 issued, and the Contractor demonstrates capability of producing a mixture meeting the verification requirements in accordance with (i) or (ii).

5. 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 in accordance with the above requirements. The test frequency shall be one per day unless altered by the Engineer.
  6. 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 per 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 in accordance with Table 106-1.
- (g) *Reference Conditions.* Three reference conditions can exist determined by the Moving Quality Level (MQL). The MQL will be calculated in accordance with 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 1250 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
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 <sup>3</sup>	1/2000 tons or 1/Day if less than 2000 tons	1/2000 tons	Not applicable
Percent Lime <sup>3 4</sup>	1/Day	Not applicable	Not applicable

Notes for Table 106-1:

1 The minimum number of acceptance tests will be: 5 asphalt content, 3 gradation, 10 in-place density, and 5 joint density for all projects.

2 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.

3 Not to be used for incentive or disincentive pay. Test according to CP 60B and report results from Form 106 or Form 565 on Form 6.

4 Verified per Contractor's QC Plan.

**106.06 Sampling and Testing of Portland Cement Concrete Paving.** All Portland Cement Concrete Paving, Item 412, shall be tested in accordance with 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. If the Contractor chooses flexural strength criteria, then the Quality Control testing for flexural strength shall be performed at the expense of the Contractor. The Contractor shall develop a quality control plan (QCP) in accordance with the following:

1. Quality Control Plan. For each element listed in Tables 106-2 or 106-3, the QCP must provide adequate details to ensure that the Contractor will perform process control. The Contractor shall submit the QCP to the Engineer at the preconstruction conference. The Contractor shall not start any work on the project until the Engineer has approved the QCP in writing.
  - A. Frequency of Tests or Measurements. The QCP shall indicate a random sampling frequency, which shall not be less 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 will be calculated in accordance with the procedure in CP 71 for Determining Quality Level. 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 area of material represented by the last test result shall correspond to the QL.
  - D. F-test and t-test Charts. If the Contractor chooses flexural strength criteria, then the results of F-test and t-test analysis between the Department's verification tests of flexural strength and the Contractor's quality control tests of flexural strength shall be shown on charts. The F-test and t-test will be calculated in accordance with standard statistical procedures using all verification tests and quality control tests completed to date. When a verification test is completed, the F-test and t-test calculations will 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 posted daily at a location convenient for viewing by the Engineer.
2. 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 QCP.
3. Testing Standards. The QCP 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. The trial mix proposed and conducted by the Contractor for mix design approval shall include compressive strength data including the curing time for compressive strength process control tests. CDOT may participate in the process control testing for compressive strength at a frequency determined by the Engineer.

4. Testing Supervisor Qualifications. The person in charge of and responsible for the process control testing shall be identified in the QCP. 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, if other than the person in responsible charge, 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 the Contractor chooses flexural strength criteria, 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 strength of concrete specimens. The machine shall be used only for flexural strength tests. 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 and the following: The machine and the flexural strength assembly shall be of a rigid construction. The applied vertical load shall be uniformly distributed to the third points and uniformly across the width of the beam (transverse distribution). Uniform distribution of the load is defined as less than a 3 percent variation in the load between each of the nine strain gages placed in the middle third section of the tension face for loads from 1,000 to 10,000 pounds. The Engineer must approve the firm prior to assessing the machine. The machine shall be ready for use and calibration two days before paving begins. After the machine has been calibrated and accepted by the Engineer it shall not be moved until all portland cement concrete paving and flexural strength acceptance tests have been completed.

- C. Beam molds for molding all test specimens required. This shall include all testing described in subsection 106.06.
7. Reporting and Record Keeping. The Contractor shall report the results of the tests to the Engineer in writing at least once per day. The Contractor shall make provisions such that the Engineer can inspect quality control work in progress, including sampling, testing, plants, documentation and the Contractor's testing facilities at any time.
- (b) *Acceptance Testing.* Acceptance testing frequencies shall be in accordance with Table 106-2 or Table 106-3. Except for flexural strength, acceptance tests will be conducted by and at the expense of the Department. Acceptance sampling and testing procedures will be in accordance with 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 quality control test. The Engineer shall designate the location where samples are to be taken. Samples shall be taken by the Contractor. 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.

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 prior to 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. Each set of three cylinders will be tested at 28 days after molding.

Acceptance tests for flexural strength shall be the Contractor's quality 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 T 23 with the following

106.06

additional requirements: Specimens shall be consolidated by internal vibration without the vibrator being inserted in the center six inches of the specimen's long dimension. After the initial curing, specimens shall be stored in a moist condition at  $73.4\text{ }^{\circ}\text{F} \pm 3\text{ }^{\circ}\text{F}$ . The flexural strength of each specimen shall be measured according to AASHTO T 97 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. Specimens shall be properly centered in the machine for each test. Leather shims shall be used in each test. The loading rate shall remain constant after the initial loading of a maximum of 1000 pounds has been applied.

- (c) *Verification Testing.* Verification testing will be used only when the Contractor chooses flexural strength criteria and is the responsibility of the Department. 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 shall be in accordance with Table 106-2. The location of sampling shall be based on a stratified random procedure.

Verification sampling and testing procedures will be in accordance with Sections 105, 106, 412 and the Schedule for Minimum Materials Sampling, Testing and Inspection in the Department's Field Materials Manual, and CP 13. Samples for verification and acceptance testing shall be taken by the Contractor in accordance with the designated method and shall be taken 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 using 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) prior to the placement of any concrete pavement. The check testing program will include a conference directed by the Region Materials Engineer of 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 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 the compressive strength criteria is chosen, 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 the process control 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 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 Tests (IAT) for flexural strength will be performed at a frequency of 1 per 50,000 sq. yds. The sample for the IAT will be a split sample of the Contractor's quality control test. The Department's representative performing verification tests shall also use a split sample of the Contractor's quality 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.
- (f) *Testing Schedule.* All samples used to determine Incentive or Disincentive payment by quality level formulas in accordance with Section 105, will be selected by a stratified random process.

**Table 106-2  
TESTING SCHEDULE -  
ITEM 412 PORTLAND CEMENT CONCRETE  
PAVEMENT, FLEXURAL STRENGTH CRITERIA**

<b>Element</b>	<b>Minimum Testing Frequency Contractor's Process Control</b>	<b>Minimum Testing Frequency CDOT Acceptance Testing</b>
Aggregate Gradation and Sand Equivalent	For the first five days, 1/10,000 sq. yds. or one/day if less than 10,000 sq. yds. are placed in a day. After 5 days, 1/40,000 sq. yds.	None
Slump	First three loads each day, then as needed for control.	Witness by the Engineer.
Water Cement Ratio	First three loads each day, then 1/500 cu. yds.	First three loads each day, then 1/2000 cu. yds.
Air Content and *Yield	1/2500 sq. yds. or one/day if less than 2500 sq. yds. are placed in a day. tests.	Minimum of 1/day. If the project total < 50,000 sq. yds. then a minimum of ten tests. If the project total ≥ 50,000 sq. yds. then 1/5000 sq. yds.
Flexural Strength	1/2500 sq. yds. or one/day if less than 2500 sq. yds. are placed in a day.	One verification test per four quality control tests performed by the Contractor. (Approximately 1/10,000 sq. yds.).
Compressive Strength	1/10,000 sq. yds.	None
Pavement Thickness	In accordance with subsection 412.21.	Minimum of 1/day. If the project total < 50,000 sq. yds. then a minimum of ten tests. If the project total ≥ 50,000 sq. yds. then 1/5000 sq. yds.
Pull Test Joints	Minimum of six transverse and six longitudinal joint locations in each 2500 linear feet.	Witness by the Engineer.
Load Transfer Dowel Bar Placement	Minimum of six transverse joint locations in each 2500 linear feet.	Witness by the Engineer.
Tining Depth	1 per 528 linear feet in each lane and shoulder wider than 8 feet.	Witness by the Engineer.
*Yield is for information only.		



**Table 106-3**  
**TESTING SCHEDULE -**  
**ITEM 412 PORTLAND CEMENT CONCRETE**  
**PAVEMENT, COMPRESSIVE STRENGTH CRITERIA**

Element	Minimum Testing Frequency Process Control	Minimum Testing Frequency CDOT Acceptance Testing
Aggregate Gradation and Fractured Faces	1/10,000 sq. yds. or one/day if less than 10,000 sq. yds. are placed in a day	None
Slump	First three loads each day, then as needed for control.	Witness by the Engineer.
Compressive Strength, Air Content, *Yield, and Sand Equivalent	1/2500 sq. yds. or one/day if less than 2500 sq. yds. are placed in a day.	Minimum of 1/day. If the project total < 50,000 sq. yds. then a minimum of ten tests. If the project total $\geq$ 50,000 sq. yds., then 1/5,000 sq. yds.
Pavement Thickness	In accordance with subsection 412.21.	Minimum of 1/day. If the project total < 50,000 sq. yds. then a minimum of ten tests. If the project total $\geq$ 50,000 sq. yds. then 1/5000 sq. yds.
Pull Test Joints	Minimum of six transverse and six longitudinal joint locations in each 2500 linear feet.	Witness by the Engineer.
Load Transfer Dowel Bar Placement	Minimum of six transverse joint locations in each 2500 linear feet.	Witness by the Engineer.
Tining Depth	1 per 528 linear feet in each lane and shoulder wider than 8 feet.	Witness by the Engineer.
*Yield is for information only.		

**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.

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The Department reserves the right to retest all materials which have been previously tested or inspected. The retesting may be prior to 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 in accordance with 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 prior to 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 in accordance with 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.** 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 are defined as "processes required to change the raw ore or scrap metal into the finished, in-place steel or iron product". This requirement will not prevent a minimal use of foreign steel or iron provided the total project delivered cost of all such steel and iron which includes the cost of delivering the steel and iron to the project, does not exceed one-tenth of one percent of the total contract cost or \$2,500, whichever is greater.

With every steel or iron product that requires pre-inspection, pretesting, certified test results, or certificate of compliance, the Contractor shall provide a certification by each supplier, distributor, fabricator, and manufacturer that has handled the steel or

iron product that every process, including the application of a coating, performed on the steel or iron product either has or has not been carried out in the United States of America. These certifications shall create a chain of custody trail that includes every supplier, distributor, fabricator, and manufacturer that handles the steel or iron product. The lack of these certifications will be justification for rejection of the steel or iron product. Upon completion of the project, the Contractor shall certify in writing of compliance with this requirement and provide evidence of the project delivered cost of all foreign steel or iron permanently incorporated into the project.

**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. Each certificate shall include:

- (1) The Department's project number
- (2) Manufacturer's name
- (3) Address of manufacturing facility
- (4) Laboratory name & address
- (5) Name of product or assembly
- (6) Complete description of the material
- (7) Model, catalog, stock no. (if applicable)
- (8) Lot, heat, or batch number identifying the material delivered
- (9) Date(s) of the laboratory testing
- (10) 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 in accordance with and meets the applicable specifications.
- (11) 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) of pay item \_\_\_\_\_ (pay item number and Description) for installation on project number \_\_\_\_\_.

\_\_\_\_\_  
Contractor

\_\_\_\_\_  
Date

The Certificate of Compliance shall be an original document, not a facsimile, with an original signature (including corporate title) by 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 tested, and the samples have passed all specified tests. One copy of the Certificate of Compliance shall be furnished to the Engineer at the time of material delivery. Failure to comply may result in delays to the project or rejection of the materials.

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.

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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. Each report shall include:

- (1) The Department's project number
- (2) Manufacturer's name
- (3) Address of manufacturing facility
- (4) Laboratory name & address
- (5) Name of product or assembly
- (6) Complete description of the material
- (7) Model, catalog, stock no. (if applicable)
- (8) Lot, heat, or batch number identifying the material delivered
- (9) Date(s) of the laboratory testing
- (10) 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.
- (11) 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) of pay item \_\_\_\_\_ (pay item number and Description) for installation on project number \_\_\_\_\_.

\_\_\_\_\_  
Contractor

\_\_\_\_\_  
Date

The Certified Test Report shall be an original document, not a facsimile, with an original signature (including corporate title) by 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 tested, and the samples have passed all specified tests. One copy of the Certified Test Report shall be furnished to the Engineer at the time of material delivery. Failure to comply may result in delays to the project or rejection of the materials.

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.

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.

**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.

**107.02 Permits, Licenses, and Taxes.** The Contractor shall procure all permits and licenses, pay all charges, fees, and taxes, and give all notices necessary and incidental to the due and lawful prosecution of the Contract.

Prior to 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.

Publicly owned vehicles and Contractor's vehicles operating within the confines of the project are exempted from the payment of ton-mile taxes under Section 42-3-127, CRS. The confines of the project as exempted under Section 42-3-127, CRS are defined as including all sources of earthen or mineral aggregates and water for use on the project, and the connecting roads or areas between the project and such sources.

**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 sub-division 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 which 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 in accordance with subsection 109.04.

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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 Sanitary, Health, and Safety Provisions.** The Contractor shall observe all rules and regulations of Federal, State and local health officials. The Contractor shall not require any worker to work in surroundings or under conditions which are unsanitary, hazardous or dangerous to health or safety.

**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 in accordance with 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, bikepath, or sidewalk. Signs shall be constructed, erected, and maintained in accordance with 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 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 in accordance with 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 nonexecution 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.

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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 in accordance with 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.** 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.



The Contractor shall procure and maintain, until final acceptance of the project, liability insurance for damages imposed by law, of the kinds and in the amounts specified, with insurance companies authorized to do business in the State of Colorado. The insurance shall cover all operations under the Contract, whether performed by the Contractor or by subcontractors. Before commencing the work, the Contractor shall furnish certificates of insurance in the form satisfactory to the Department certifying that the policies are in full force and effect and shall not be changed or canceled until 30 days after written notice thereof has been received by the Department. In the event such notice of change or cancellation is received by the Department, the Contractor, within 20 days of such receipt, shall submit a substitute policy which meets all of the requirements of the Contract. Such substitute policy must be effective no less than 48 hours prior to the date of the change or cancellation.

The types and coverage limits of insurance are as follows:

- (1) Workers' Compensation Insurance and employee liability in accordance with current State Statutes. Employer's Liability Insurance at a minimum of \$500,000 each accident, and \$500,000 each disease.
- (2) Commercial General Liability at a minimum of \$1,000,000 Each Occurrence; \$1,000,000 Personal Injury; \$2,000,000 Products/Completed Operations; \$2,000,000 General Aggregate. The Policy shall be endorsed for Annual Aggregate and be written on an Occurrence form. CDOT shall be endorsed as an Additional Insured by the Contractor and by all Subcontractors. Completed Operations coverage shall be provided for a minimum period of one year following final acceptance of work.
- (3) Commercial Automobile Liability shall cover all owned, non-owned, and hired vehicles with a minimum of \$1,000,000 combined single limit bodily injury and property damage. The Policy shall protect CDOT as an Additional Insured and be written on an Occurrence form.
- (4) Professional Liability Insurance (Errors & Omissions Insurance for Surveyors, Engineers or Architects). The Contractor shall procure and maintain, or shall ensure that all subcontractors meeting the following contract elements procure and maintain a minimum of \$1,000,000 Each Occurrence and \$1,000,000 Annual Aggregate when:
  - (1) Contract items 625, 629, or both are included in the Contract
  - (2) Plans, specifications, and submittals are required to be signed and sealed by the Contractor's Professional Engineer, including but not limited to:
    - (i) Shop drawings and working drawings as described in subsection 105.02
    - (ii) Mix Designs
    - (iii) Contractor performed design work as required by the plans and specifications
    - (iv) Change Orders

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(v) Approved Value Engineering Change Proposals

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 at a minimum of \$1,000,000. This policy shall contain a clause stating that it takes effect (drops down) in the event the primary limits are impaired or exhausted. The Policy shall be written on an Occurrence form.

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 on which 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 which 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 in accordance with 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 prior to 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 which 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 prior to 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 prior to 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

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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 in accordance with subsection 108.07. 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. *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. [25-8-103 (15), CRS]
2. *Pollution.* Man-made, man-induced, or natural alteration of the physical, chemical, biological, and radiological integrity of water. [25-8-103 (16), CRS]
3. *State Waters.* Based on 25-8-103 (19) CRS, state waters are defined to be any and all surface and subsurface waters which are contained in or flow through the state, including, streams, rivers, lakes, drainage ditches, storm drains, ground water, and wetlands, but not including waters in sewage systems, waters in treatment works or disposal systems, waters in potable water distribution systems, and all water withdrawn for use until use and treatment have been completed.

(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 anticipates, or if construction activities result in any change from or noncompliance with permits or certifications, then the

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Contractor shall detail the anticipated changes or noncompliance in a written report to the Engineer, and revise existing permits or certifications or obtain new permits or certifications as necessary. The report shall be submitted within two days from the time the Contractor becomes aware of the change or noncompliance. Within five days after receipt of the report, the Engineer will approve or reject the request for change in writing, or detail a course of action.

3. The Contractor may be legally required to obtain 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 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 minimizes pollution of any adjacent waters, including wetlands. Erosion control work shall be performed in accordance with Section 208 and this subsection.
5. At least ten days prior to the beginning of construction, the Contractor shall submit to the Engineer a written report describing the location of potential pollution sources, such as vehicle fueling, storage of fertilizers or chemicals, etc. The report shall include maps indicating areas that will be used for storage of building materials, soils, or wastes, and the location of any dedicated asphalt or concrete batch plants. The report shall also include a spill contingency plan for any petroleum product, chemicals, solvents, or other hazardous materials in use, or in storage, at the work site. Work shall not be started until the report, including the spill contingency plan, has been submitted to the Engineer.
6. Required dewatering of excavations shall be conducted in a manner that avoids pollution and erosion. Water from dewatering operations shall not be directly discharged into any state waters including wetlands, irrigation ditches, canals, or storm sewers, unless allowed by a permit. Discharge into sanitary sewers will not be allowed unless written permission is obtained from the owner or controlling authority and a copy of this approval submitted to the Engineer. Unless prohibited by law or otherwise specified in the Contract, the water from dewatering operations shall be contained in basins for dissipation by infiltration or evaporation, shall be hauled away from the project for disposal in accordance with applicable laws and regulations, or shall be land applied to approved non-wetland vegetated areas and allowed to soak into the soil. Depending upon the quality of the water, land application of water to vegetated areas may require a written concurrence or permit from the Colorado Department of Public Health and Environment (CDPHE). Based on guidelines and criteria from CDPHE, the Contractor shall determine the quality of the water,

obtain applicable concurrences or permits, and furnish copies of the concurrences or permits obtained to the Engineer.

7. At least 15 days prior to 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 5 miles downstream from the dredging or fill operations.
8. Upon completion of wetland or in stream construction activities, 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. Affected areas shall be returned to their pre-existing elevation unless otherwise specified in the Contract.
9. Construction operations in state waters, including wetlands, shall be restricted to:
  - (1) Channel change areas designated in the Contract.
  - (2) Areas designated in the Contract which must be entered to construct structures.
  - (3) Forging waters no more than four times per day. Whenever forging waters more than four times per day is necessary, a temporary bridge or other structure shall be used.
  - (4) Areas authorized by the Corps of Engineers.
10. Work in, or near, wetlands shall be performed in a manner that will minimize harm to the wetlands. Wetland areas outside of the right-of-way shall not be used for storage, parking, waste disposal, access, borrow material, or any other construction support activity.
11. Pollutant by-products of highway construction, 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. A minimum of ten days prior to the start of concrete operations, the Contractor shall submit in writing a method for containing concrete wastewater to the Engineer for approval.

12. The use of chemicals such as soil stabilizers dust palliatives, herbicides, growth inhibitors, fertilizers, deicing salts, etc., during construction shall

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be in accordance with the manufacturer's recommended application rates, frequency, and instructions. These chemicals shall not be used, stored, or stockpiled within 50 horizontal feet of the ordinary high water line of any state waters, including wetlands, except when otherwise specified in the Contract.

13. Construction waste or salvable material, excess excavated material, fill material, construction equipment, fuels, lubricants, and other petroleum distillates shall not be stored or stockpiled within 50 horizontal feet of any wetland, water impoundment area, or the ordinary high water line of any watercourse. Equipment fueling and servicing shall occur only within approved designated areas.
14. The quantity of materials stored on the project shall be limited, as much as practical, to that quantity required to perform the work in an orderly sequence. 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 a state water at any time.
15. Spill prevention and containment measures 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.
16. Use of heavy equipment in or around state waters, including wetlands, will not be allowed, except as specified in the Contract, permits, and subsection 107.25(b)10. above, unless otherwise directed by the Engineer. If any such work is allowed, the equipment shall be of such type that will produce minimal environmental damage. For allowed work in wetlands, the equipment shall be on fiber, wooden, earthen, or metallic mats to prevent undue disturbance and damage to the wetlands area. Where practical, equipment shall be operated from banks or shoulder above riparian and wetland areas.
17. The Contractor shall prevent grass or brush fires that will expose areas of soil to erosion.
18. The construction activity shall not block the movement of those species of aquatic life indigenous to the waterbody.
19. The construction activities shall not impair Indian tribal rights, including, but not limited to, water rights, and treaty fishing and hunting rights.



20. Discharges of pollutants into breeding areas of migratory waterfowl, or into fish spawning areas during spawning seasons shall not be permitted unless allowed by permits from appropriate regulatory agencies.

(c) *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 water quality controls.
4. In the event that a spill occurs as a direct result of the Contractor's actions or negligence, the clean-up 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 in accordance with Section 208 by the Contractor and at the Contractor's expense.

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## **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. Prior to beginning any work by subcontractor, the Contractor shall request permission from the Engineer by submitting a completed Sublet Permit Application, CDOT Form No. 205. The subcontract work shall not begin until the Contractor has received the Engineer's written permission. The Contractor shall make all project related written subcontracts 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 original total cost of bid items. 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 original total cost of bid items before computing the amount of work required to be performed by the Contractor's own organization.

The calculation of the percentage of subcontracted work shall be based on the prime contract unit prices rather than subcontract unit prices. Proportional value for a subcontracted partial contract item will be verified by the Engineer. For the purpose of calculating the value of subcontracted work, the cost of procuring materials and manufactured products can be included in either the prime contract or subcontract. However, 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.

Subcontracts, or transfer of Contract shall not release the Contractor of liability under the Contract and bonds.

**108.02 Notice to Proceed.** The Contractor shall not commence work prior to the issuance of a Notice to Proceed. The "Notice to Proceed" will stipulate the date on which contract time commences. When the Contractor proceeds with work prior to that date, contract time will commence on the date work actually begins. The Contractor shall commence work under the Contract on or prior to the fifth day following Contract execution or the twentieth day following the date of award, whichever comes later, or in accordance with the selected start date allowed in the special provisions.

**108.03 Schedule.** The Contractor shall be responsible for planning, scheduling, and reporting the progress of the work to ensure timely completion of the work as called for in the Contract. The Contractor shall prepare a Project Schedule that shall be used for coordination, for evaluation of progress, and for the evaluation of changes to the Contract. The Schedule shall include all activities, including those of subcontractors,

Contractor's engineers and surveyors, and suppliers. Seasonal and weather constraints, utility coordination, railroad restrictions, right of way restrictions, traffic constraints, environmental constraints, other project interfaces, expected job learning curves and other constraints shall be considered when preparing the Project Schedule. Days scheduled as no work days shall be indicated. A CPM schedule will be required unless the Commencement and Completion of work special provision allows a bar chart schedule. The Schedule shall show all work completed within the contract time.

The Contractor shall submit two copies of all required schedule information as described below. All schedules, diagrams, and reports shall include a title, project number, date of preparation, and the name of the Contractor. For CPM schedules, all required schedules and reports shall also be submitted electronically on floppy disk or compact disk.

The Bar Chart or Initial Schedule shall be submitted at least 10 working days prior to the start of the work. The Engineer's review of the Schedule will not exceed two working days. Work shall not begin until the Schedule is accepted in writing, unless otherwise approved by the Engineer.

- (a) *Methods Statement.* A Methods Statement shall be prepared for the salient features listed in the Commencement and Completion of Work special provision, and for any feature not listed in the Commencement and Completion of Work special provision that the Contractor considers a controlling factor for timely completion. The Methods Statement shall be a detailed narrative describing each feature and all work necessary to complete the feature. The Methods Statement shall be submitted with the Contractor's schedule. The following format is required.
- (1) *Feature:* name of the feature;
  - (2) *Responsibility:* Contractor, subcontractor, supplier, utility, etc. responsible for the feature;
  - (3) *Procedures:* procedures to be used to complete the work. The procedure to be used shall include general information regarding methods such as forming, excavation, pouring, heating and curing, backfill and embankment, trenching, protecting the work, etc. When separate or different procedures are to be employed by the Contractor due to seasonal or project phasing requirements, such differing procedures shall be described in the procedure statement;
  - (4) *Production Rates:* the planned quantity of work per day for each feature;
  - (5) *Labor Force:* the labor force planned to do the work;
  - (6) *Equipment:* the number, types, and capacities of equipment planned to do the work;
  - (7) *Work Times:* the planned time for the work to include:
    - A. number of work days per week
    - B. number of shifts per day
    - C. number of hours per shift.

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At the Engineer's request, the Contractor shall update the Methods Statement, or any part thereof, and submit it with the next monthly schedule update.

- (b) *Bar Chart.* The Bar Chart shall be time scaled and shall show the following:
- (1) The salient features, as listed in the Commencement and Completion of Work special provision.
  - (2) Any feature not listed in the Commencement and Completion of Work special provision that the Contractor considers a controlling factor for timely completion.
  - (3) The number of days required to complete each feature and its relationship in time to other features.
  - (4) Sufficient space for each feature to permit two additional plots parallel to the original time span plot.
  - (5) The anticipated delivery dates for equipment or materials in any feature that could affect timely completion of the project.
  - (6) Critical completion dates for any activity within any feature that could affect timely completion of the project.
  - (7) Connecting lines between features that show the intended progression of activities.

The Schedule shall be updated as of the cutoff date for the monthly progress pay estimate and submitted to the Engineer before the payment of the progress pay estimate is approved. The Contractor shall provide a copy of the original bar chart showing, for each feature, the days actually worked and the anticipated days required to complete.

- (c) *Critical Path Method.* CPM is a scheduling method which shows the interdependencies between work activities. The critical path is that path through the schedule which, if delayed, will cause a delay to project completion.

The Contractor shall use either Microsoft Project or Primavera Scheduling software to develop and manage the Critical Path Method Schedule. The Contractor shall notify the Project Engineer in writing, when submitting the first schedule which software, will be used. This choice cannot be changed after the first schedule submittal. When the Contractor uses Primavera-scheduling software, the Engineer may request an additional electronic copy of all required schedules and reports converted to the Microsoft Project format on floppy disk or compact disk, for information only. This additional information shall be submitted with all schedule submittals and updates. The Contractor shall perform all work required to ensure that the Microsoft schedule accurately reflects the planned schedule and progress.

The progress schedule shall include as a minimum the salient features of this project as listed in the Commencement and Completion of Work special provision. The progress schedule shall include all activities for all work on the project, including subcontracted work, delivery dates for critical material,

submittal and review periods, milestone requirements and no work periods. Where the project has specific phases, each phase shall be described separately for each applicable salient feature.

Construction activity duration shall not exceed 15 calendar days unless approved by the Engineer. Series of activities that have aggregate durations of five calendar days or less may be grouped in a single activity. For example, “form, reinforce, and pour pier” could be defined as a single activity rather than three.

Time Scaled Logic Diagram: This diagram shall show the logical progression of all activities required to complete the work defined in the Contract. Activity information shall include activity ID, description, duration, early start and finish dates, late start and finish dates, total float, and responsibility.

- (1) Initial Schedule. The Initial Schedule shall include all necessary detail for procurement, construction and submittal activities required during the first 90 days of contract time. In addition, the Initial Schedule shall include a very basic group of activities that describes the time period after the 90th day of contract time and through the completion of the project. Only salient features and other significant activities will be required for the period after the first 90 days of contract time. The 15-calendar day activity duration limit will not apply to the portion of the Initial Schedule beyond the first 90 days of contract time. This submittal shall include a Time Scaled Logic Diagram.
- (2) Project Schedule. The Project Schedule submittal shall consist of a Time Scaled Logic Diagram Schedule Report. It shall be prepared in full and submitted to the Engineer within 45 calendar days after the Engineer’s acceptance of the Initial Schedule. The Engineer’s review of the Project Schedule will not exceed seven calendar days. Revisions required as a result of the Engineer’s review shall be submitted within 7 calendar days. Work shall not continue beyond 90 calendar days after the start of Contract Time until the Project Schedule is accepted in writing, unless otherwise approved by the Engineer.

The Project Schedule shall cover the time from the Date of Notice to Proceed to the predicted completion date.

The Schedule Report shall tabulate for each activity the activity ID, description, duration, earliest start and finish date, latest start and finish date, total float time, predecessor and successor activities, and responsibility.

- (3) Schedule Updates. The Contractor shall update the Initial Schedule or the Project Schedule monthly to reflect actual construction progress of all work activities on the project. Updates shall show the previous month’s progress and a projection for all remaining work activities on the project.

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Schedules shall be updated as of the cutoff date for the monthly progress pay estimate and submitted to the Engineer before the payment of the progress pay estimate is approved.

Each of the diagrams, charts, and reports shall comply with the requirements for the Project Schedule above, except that they shall also include the actual completion dates and percentages of completion for the appropriate activities.

A Job Progress Narrative Report shall be submitted with all updates. It shall detail the description of job progress, problem areas, current and anticipated delaying factors and their anticipated effects, impacts to job milestones or project completion, any corrective action proposed or taken, and any minor revisions to the Schedule.

Revision of the Schedule may be required, as determined by the Engineer, for: a major revision in the schedule logic or methods of construction; the addition, deletion, or revision of activities required by contract modification; delays in milestones or the completion of the project; or for prosecution of work that revises the phasing or staging which is represented on the plans or on the progress schedule.

If it is determined that a revision to the Schedule is required, it shall be provided to the Engineer for review within 15 calendar days of written notification. The Engineer's review of the revised schedule will not exceed one week. Revisions required as a result of the Engineer's review shall be submitted within one week. When accepted by the Engineer in writing, the revised schedule shall become the Project Schedule.

The Contractor shall participate in the Engineer's review and evaluation of the submittals. Meetings will be held to review progress and planning when requested by the Engineer or Contractor.

The Contractor shall prosecute the work according to the Schedule. The Contractor ensure that its subcontractors, suppliers, and engineers, at any tier, also prosecute the work according to the Schedule. The Department shall be entitled to rely on the Contractor's Schedule for planning and coordination.

Acceptance of the Contractor's Schedule by the Engineer is not to be construed as relieving the Contractor of obligation to complete the contract work within the contract time allowed for the portion of the work or the entire Contract, or granting, rejecting or in any other way acting on the Contractor's request for extension of contract time, or claims for additional compensation.

All costs relating to the preparation, submittal, and acceptance of the Schedule, reports and revisions, and all requirements of this subsection will not be paid for separately, but shall be included in the work.

Failure of the Contractor to comply with the requirements of this subsection shall be grounds for a determination by the Engineer that no further progress payments are to be made until the Contractor is in full compliance.

**108.04 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.

**108.05 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

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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.

**108.06 Workplace Violence.** If a representative or employee of the Contractor, or a subcontractor, commits an act of workplace violence on the project, he 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.

**108.07 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 carry on construction operations on Saturdays, Sundays or holidays unless previously arranged and approved. The Contractor shall not perform work on any day of a three or four day holiday weekend when the holiday is New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, or Christmas 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 105.20, 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 on which the work can be effectively prosecuted during six hours or more of the day. One-half day will be assessed for each working day on which 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 working days 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 on which 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 on which 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 in accordance with subsection 108.07 (a) 2.

- (c) *Delay.* Delay is defined as any event, action or factor that extends the time for the performance of the work.
1. *Excusable Delay.* A delay that was beyond the Contractor's control and not caused by the Contractor's fault or negligence, and for which a contract time extension may be granted.
- A. *Compensable Delay.* An excusable delay caused by the Department for which the Contractor may be entitled to additional monetary compensation. Monetary compensation for such delays will be made in accordance with subsection 109.10.
- B. *Noncompensable Delay.* An excusable delay for which the Contractor may be entitled to an extension of contract time but no additional monetary compensation. Contract time allowed for the performance of the work may be extended for delays caused by acts of God, acts of the public enemy, fires, floods, area wide strikes, freight embargoes, unusually severe weather, or delays not caused by the Contractor's fault or negligence.

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2. *Nonexcusable Delay.* A delay that was reasonably foreseeable or within the control of the Contractor for which no monetary compensation or contract time extension will be granted.

Delays in delivery of materials or fabrication scheduling, resulting from late ordering, financial considerations, or other causes which 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 which prevent procurement of materials or fuel within the allowable contract time limits will be considered excusable delays.

- (d) *Extension of Contract Time.* The Contractor's claim that insufficient contract time was specified is not a valid reason for an extension of contract time.

If the Contractor finds it impossible for reasons beyond the Contractor's control to complete the work within the contract time, as specified or extended, a written request for extension of contract time shall be submitted to the Engineer in two parts. The first part shall be a written notice submitted within seven days of the occurrence of a delay to the prosecution of the work. The notice shall contain a description of the activity which is delayed and information with appropriate documentation concerning the nature and cause of the delay.

The second part shall be a formal request by the Contractor for an extension of contract time which shall be submitted within 30 days of the initial notice. This part of the request shall be accompanied by evidence supporting the request. Such evidence shall demonstrate the following:

- (1) The cause for the delay is allowable for consideration of a contract time extension under the terms of the Contract.
- (2) The cause for the delay is allowable for consideration of monetary compensation under the terms of the Contract (to be submitted only if the Contractor is seeking monetary compensation for the delay).
- (3) The delay has or will make it impossible for the Contractor to complete the work by the specified completion dates without taking steps to accelerate the work.
- (4) A schedule revision as defined in subsection 108.03 shall accompany the request. The Schedule as revised shall clearly indicate that the activity or activities delayed were critical or have become critical due to the delay. For the purpose of these specifications, an activity shall be considered critical if all previously available float time has been used, and this delay will directly delay the Contract Completion Date. Float time is the length of time that an activity can be delayed without affecting the Contract Completion Date.

The Engineer's determination as to the extension of contract time to be allowed will be based on the current Schedule in effect at the time of the alleged delay, the supporting evidence submitted by the Contractor and any other relevant information available to the Engineer. The impact of the delay shall be reflected in the Schedule by adding activities or extending the duration of the affected activities, and, if appropriate, adjusting the Contract Completion Date. Delays in activities which, according to the current Schedule, do not affect the final Contract Completion Date will not be the basis for a change in the Contract Completion Date. If the Engineer grants an extension of the contract time, the Contract Completion Date as extended shall be in effect as though it were the contract time originally specified in the Contract.

**108.08 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.

The schedule of liquidated damages will be:

Original Contract Amount		Liquidated Damages per Calendar Day (\$)
From More Than	To And Including	
0	150,000	67
150,000	250,000	174
250,000	500,000	430
500,000	1,000,000	1,086
1,000,000	2,000,000	1,778
2,000,000	4,000,000	2,363
4,000,000	10,000,000	3,240
10,000,000	-----	3,240 plus 583 Per Each Additional 1,000,000 Contract Amount or Part Thereof Over 10,000,000

Due account shall be taken of any adjustment of the contract time for completion of the work granted under the provisions of subsection 108.07.

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.

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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.

**108.09 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 ten 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 ten calendar days, makes an assignment for the benefit of creditors, or
- (6) Fails to comply with the Contract regarding minimum wage payments, DBE requirements, or 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 ten 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 stop work order 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 ten 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 which 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 ten 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 108.09(a) or 108.09(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 in accordance with Subsection 108.09. Damages for improper notice of default may be awarded accordingly.

#### **108.10 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

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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 108.10(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 which 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 which is in the Contractor's possession and in which 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 which are measured by linear foot, such as pipe culverts, guardrail, underdrains, etc., will be measured parallel to the base or foundation upon which 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 "gage," when used in connection with the measurement of plates, will mean the U.S. Standard Gage.

When the term "gage" refers to the measurement of wire, it will mean the wire gage specified in ASTM A510.

The term "ton" will mean the short ton consisting of 2000 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 sealed by the Measurement Standards Section of the Colorado Department of Agriculture 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 by weighers certified by the Measurement Standards Section of the Colorado Department of Agriculture. The certified weigher shall perform the



duties according to the Colorado Department of Agriculture's regulations. The cost of the certified weighers, scales, scale tickets, scale house, and verifying the scale's accuracy will not be paid for separately but shall be included in the contract price for the weighed material.

The operator of each vehicle weighed by a certified weigher shall obtain a scale ticket (certificate of correct weight) from the 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) Gross Weight.
- (6) Tare Weight.
- (7) Net Weight.
- (8) Material Type.
- (9) Certified Weigher's Name.

Vehicles used to haul material being paid for by weight shall be weighed empty daily at times directed by the Engineer and shall bear a plainly legible identification mark. The Contractor shall furnish to the Engineer, in writing, a list of identification marks, number of axles, and the distance between extreme axles of each delivery vehicle to be used on the project. This information shall be furnished prior to time of delivery of the material and at any subsequent time the Contractor changes vehicles, combination vehicles, or axle length relationships.

Materials to be measured by volume in the hauling vehicle shall be hauled in approved vehicles and measured therein 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 1000 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 either by volume or weight. Water meters shall be accurate within a range of  $\pm 3$  percent. When water is metered, the Contractor shall use an approved metering device and shall furnish the Engineer a certificate showing that 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

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Water meters shall be calibrated when the Engineer determines there is reason to believe the meters are not accurate within the allowable tolerance. In the event water meter accuracy is found acceptable, the cost involved in checking the water meter shall be at the Department's expense. Should the water meter accuracy be 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. The weight to volume factor shall be determined by Colorado Procedures 22 or 80 as described in the Department's Field Materials Manual. 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.

Bituminous 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 D 1250 for asphalts or ASTM D 633 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 bituminous material has been lost from the car or the distributor, wasted, or otherwise not incorporated in the work. When bituminous 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, pipe conduit, etc., and these items are identified by gage, unit weight, section dimensions, etc., 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 for which there are pay items and which 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 for which there are no 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 108.10, 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.

Should any such alteration directly cause 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 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.

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The Contractor will receive the actual costs paid to, or in 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 hereinafter 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 hereinafter 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 work day 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 work day.
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 \$2.00 per hour. Small tools are defined as any tool which 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 10%. Such parts not totally expended on the force account work will be prorated based on actual use.

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.

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(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 prior to 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 ten 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 in accordance with 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 prior to 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 in accordance with the Contract, and the value of the materials on hand in accordance with 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 1½ 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 which

109.06

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.

- (b) *Securities in Lieu of Standard Amount Retained.* When the original contract amount exceeds \$80,000, 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 which 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 which 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 fails to comply with this provision the Engineer will not authorize further progress estimates until the required payments have been made and the Contractor agrees to make payments as specified.

- (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 No. 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 ten working days 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 in accordance with 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.

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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 in accordance with Contract requirements and at unit bid prices.

For this subsection only, satisfactory completion of all work described on CDOT Form No. 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.

The Contractor shall be solely responsible for all additional costs involved in paying retainage to the subcontractors prior to 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 Department and 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

**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 for which 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 for which stockpile material payment is being requested.

Payment for stockpiled structural steel (unfabricated milled plate) may be made subject to the following additional conditions:

- (i) The plan quantity of structural steel shall exceed one million pounds.

- (ii) The structural steel shall have been delivered to the Contractor's fabrication plant.
  - (iii) The material conforms to the requirements of the Contract.
  - (iv) 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 must 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 which 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 which 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 105.20, 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 in accordance with subsection 109.06(f)6. will be subject to correction in the final estimate and payment.

109.10

**109.10 Compensation for Compensable Delays.** If the Engineer determines that a delay is compensable in accordance with either subsection 105.21 or 108.07, monetary compensation will be determined in accordance with 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 non-salaried labor;
  - (2) Costs for additional bond, insurance and tax;
  - (3) Increased costs for materials;
  - (4) Equipment costs calculated in accordance with subsection 109.04(c) for Contractor owned equipment and based on invoice costs for rented equipment;
  - (5) Costs of extended job site overhead;
  - (6) Subcontractor's claims (the same level of detail as specified herein is required for all subcontractors' claims)
  - (7) An additional 10 percent will be added to the total of items (1), (2), (3), (4), (5), and (6) as compensation for items for which 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) Attorneys fees, claim preparation fees, and expert fees.

All costs claimed must be documented and accompanied by a claim certification form obtained from the Department.

**CONSTRUCTION DETAILS**  
**SECTION 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, including mowing, as required. Undisturbed stumps, roots, and nonperishable solid objects located 2 feet or more below subgrade or embankment slope may remain in place. 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 in accordance with 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 in accordance with 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.

201.02

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 in accordance with good tree surgery practices.

The Contractor shall scalp the areas within the excavation or embankment grading limits. Mowed sod need not be removed where the embankment to be constructed is 4 feet or more in height. Scalping shall include the removal from the ground surface of brush, roots, sod, grass, residue of agricultural crops, sawdust, and other vegetable matter. See subsection 208.04(d) for disturbed area limits.

### METHOD OF MEASUREMENT

**201.03** Measurement will be by one of the following methods:

- (a) *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.
- (b) *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:

- (a) *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.
- (b) *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 in accordance with subsection 104.03.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Clearing	Acre, Lump Sum
Grubbing	Acre, Lump Sum
Clearing and Grubbing	Acre, Lump Sum

- (c) *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.

**CONSTRUCTION REQUIREMENTS**

**202.02 General.** The Contractor shall raze, remove, and dispose of all structures and obstructions which 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 in accordance with 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 prior to 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.

202.02

Removed concrete and asphalt material may be used to construct embankments in accordance with subsection 203.06.

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.

**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 which 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.

**202.04 Signs and Traffic Signals.** Removal of signs shall include removal of posts, footings, pedestals, sign panels, and brackets. Concrete adhering to salvable sign posts 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 preconstruction 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 as a result 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 prior to opening of new lanes to traffic.

The pavement surface area to be covered with pavement marking material shall be sandblasted, or blast cleaned by another approved method, prior to the application of pavement primer or prior to the placing of pavement marking material when used without a pavement primer. A dustless-abrasive shot blasting, power washing, or other approved cleaning method may be used to do the sandblasting work. The sandblast shall be applied to remove all dirt, laitance, and curing compound residue. After sandblasting, all loose dust and dirt shall be removed before application of pavement primer or pavement marking material.

**202.06 Detours.** The Contractor shall completely remove the detour and dispose of the materials in accordance with the Contract.

**202.07 Pavements, Sidewalks, Curbs.** All concrete pavement, sidewalks, structures, curbs, gutters, etc., designated for removal, shall be disposed of in accordance with 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, the substructures of existing structures shall be removed down to the natural stream bottom and those parts outside of the stream shall be removed down 1 foot below natural ground surface. Where such portions of existing structures lie wholly or in part within the limits of a new structure, they shall be removed 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.

202.08

Adequate measures shall be taken by the Contractor to protect the steel from contamination or corrosion. Reinforcing steel, contaminated as a result of the Contractor's failure to provide adequate protection, shall be resandblasted 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.

Prior to beginning planing operations, the Contractor shall submit a planing plan for approval by the Engineer. This plan shall include as a minimum:

- (1) The number and types of planers to be used.
- (2) The width and location of each planing pass.
- (3) 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 pick up 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 days 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 work day. 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.

The longitudinal surface smoothness of the roadway prior to and after planing shall be tested in accordance with subsection 105.07(c).

**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 in accordance with 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 for which the sandblasting is required.

Removal of temporary pavement markings will not be measured and paid for separately but shall be included in the work.

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.

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### **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 herein.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Removal of Structures and Obstructions	Lump Sum
Removal of	Each, Linear Foot, Square Yard Cubic Yard
Removal of Asphalt Mat (Planing)	Square Yard
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.

## 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 the excavation for ditches and channels, necessary for the construction of the roadway in accordance with the Contract. All excavation will be classified, "unclassified excavation", "stripping", "muck excavation", "rock excavation", "borrow", or "potholing" as hereafter described. All embankment will be classified "embankment material" or "rock fill" as hereafter described.

**203.02 Excavation.**

- (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.

Overhanging rock or other rock considered dangerous shall be removed when ordered, and will be classified "Unclassified Excavation".

- (b) *Stripping.* Stripping shall consist of removing overburden or other specified material from material 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) *Muck Excavation.* Muck excavation shall consist of the removal and disposal of mixtures of soils and organic matter not suitable for foundation or embankment material.
- (d) *Rock Excavation.* Rock excavation shall consist of igneous, metamorphic, and sedimentary rock which cannot be excavated without blasting or the use of rippers, including all boulders or other detached stones having a volume of  $\frac{1}{2}$  cubic yard or more, as determined by physical or visual measurement.
- (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 consists of exposing and verifying the location of existing utilities at locations as directed.

**203.03 Embankment.**

- (a) *Embankment Material.* Embankment material shall consist of approved material acquired from excavations, hauled and placed in embankments. Approval of the embankment material will be contingent on the material having a resistance value when tested by the Hveem Stabilometer, or equivalent resilient modulus value, of

203.03

at least that specified in the Contract, and a maximum dry density of not less than 90 pounds per cubic foot. The material must be stable when tested in accordance with Colorado Procedure L-3102.

1. *Soil Embankment.* Soil embankment shall consist predominantly of materials smaller than 4.75 mm (No. 4) sieve in diameter. Soil embankment shall be constructed with moisture density control in accordance with the requirements of subsection 203.07.
  2. *Rock Embankment.* Rock embankment shall consist of materials with 50 percent or more by weight, at field moisture content, of particles with least dimension diameters larger than 4.75 mm (No. 4) sieve and smaller than 6 inches. Rock embankments shall be constructed without moisture density control in accordance with the requirements of subsection 203.08.
- (b) *Rock Fill.* Rock fill shall consist of sound, durable stones, boulders, or broken rock not less than 6 inches in least dimension. At least 50 percent of the rock used shall have a volume of 2 cubic feet or more, as determined by physical or visual measurement.

Claystone or soil-like nondurable shale, as defined by Colorado Procedure 26, shall not be treated as sound rock and shall be pulverized, placed, and compacted as soil embankment. Claystone or soil-like non-durable shale particles greater than 12 inches in diameter shall not be placed in the embankment.

### **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 bituminous 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. Prior to beginning grading operations, all necessary clearing and grubbing in that area shall have been performed in accordance with Section 201.

The Contractor shall notify the Engineer not less than five working days prior to beginning excavation so the necessary cross sections may be taken. The Contractor shall not excavate beyond the dimensions and elevations established.

Archaeological and paleontological materials encountered during the work shall be dealt with in accordance with subsection 107.23.

**203.05 Excavation.**

- (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.

Any change to cut slopes by the Department will be made prior to the next drilling operations.

- (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 as approved.

Wherever 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 in accordance with 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) *Muck.* Unsuitable materials encountered in the subgrade shall be removed to the depth directed by the Engineer. The excavated area shall be backfilled to the finished graded section with approved material.

The Engineer will designate as unsuitable those soils that are detrimental to the roadway and they shall be removed to the depth as determined by the Engineer. All unsuitable material shall be disposed of as directed.

- (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 therein, 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 the working limits of the area being excavated.

203.05

- (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 in accordance with 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 Embankment.** Embankment construction shall include preparation of the areas upon which embankments are to be placed, construction of dikes, placing and compacting of 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.

Free running water shall be drained from the material before the material is placed on the roadway.

The type of relative compaction required shall be as provided in the Contract.

Broken concrete, broken asphalt, or other solid materials more than 6 inches in greatest dimension shall not be placed within embankment areas supporting the roadway shoulders and pavement structure. These embankment areas are defined as the cross-sectional areas of an embankment situated beneath the shoulders and pavement structure and inside the lines projected downward and outward on a 1:1 slope from the outside edges of the roadway shoulders to their intersection with the base of the embankment. Broken concrete, broken asphalt, or other solid materials more than 6 inches in greatest dimension removed on the project may be disposed of in embankment side slope areas not supporting the roadway shoulders and pavement structure, as defined above. These materials shall be placed in layers; the thickness of each layer shall be less than 1½ times the following maximum allowable dimensions. Rocks and concrete shall not have any single dimension greater than 2 feet and asphalt shall not have any single dimension greater than 12 inches. Each layer shall be separated by a minimum of 6 inches of compacted and approved embankment material. No layer shall be within the top 2 feet of the subgrade or final finished side slope surface. These materials shall be placed as the embankment is being constructed. Excavation of in-place embankment to accommodate disposal of materials shall not be permitted.

When embankment is placed on a slope that is steeper than 4:1, as measured in the steepest direction, the embankment shall be continuously benched as the work is brought up in layers. Benching shall be well keyed and, where practical, a minimum of



8 feet wide. Each horizontal cut shall begin at the intersection of the original ground and the vertical sides of the previous bench. Excavation from benching shall be compacted along with the new embankment material at the Contractor's expense.

Where embankment is to be placed and compacted and end dumping is permitted, the slopes of the original ground or embankment shall be deeply plowed or cut into before starting end dumping.

Where the base of embankment is within 4 feet of the subgrade, all sod, and vegetable and other organic matter shall be removed from the surface upon which the embankment is to be placed. The cleared surface shall be completely broken up by plowing or scarifying to a minimum depth of 6 inches, and compacted to the specified embankment density. Sod not requiring removal shall be thoroughly disked prior to embankment construction.

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 overturning of or placing excessive pressure against the structure. When noted on the plans, 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.

Embankment shall be placed in horizontal layers not to exceed 8 inches loose measurement and shall be compacted as specified before the next layer is placed. Spreading equipment shall be used to obtain uniform thickness prior to compaction. As the compaction progresses, continuous mixing, leveling, and manipulating shall be done to assure uniform moisture and density. Bridging across streams, ponds, and swampy ground may be placed in layers greater than 8 inches as directed.

When embankments are constructed using claystone or soil-like non-durable shale as identified in the plans or by the Engineer, the material shall be pulverized to a maximum dimension of 12 inches in diameter, placed in a maximum layer thickness of 12 inches and watered to promote slaking and breakdown of the nondurable material in conformance with subsection 203.07.

Excavated material containing particles greater than 6 inches in greatest dimension shall not be used as embankment material unless designated in the Contract or approved by the Engineer. When the excavated material consists predominately of rock too large to be placed in 8 inch layers, the Engineer may permit the material to be placed in thicknesses up to the average rock dimension, not to exceed 3 feet. Placing of occasional boulders of sizes larger than the maximum layer thickness may be authorized by the Engineer. Each layer shall be leveled and smoothed by distribution of finer material or approved embankment material. If the use of leveling equipment is not practicable 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

203.06

construct a compact, stable fill and to finish the slopes to a neat and smooth appearance. Each layer shall be compacted as specified in subsection 203.08.

Rock fill, or claystone or soil-like non-durable shale, or both shall not be constructed above an elevation 2 feet below the finished subgrade. The top 2 feet of the embankment shall be placed in layers not to exceed 8 inches loose thickness and compacted in accordance with subsections 203.07 and 203.08 as applicable.

When a rock fill is placed over any structure, the structure shall be covered with a minimum of 2 feet of compacted embankment material or other approved material before the rock is placed.

Cross hauling may be used to insure that the best available material is placed in the top 2 feet of all embankments. When directed by the Engineer, cross haul will be paid for in accordance with subsection 109.04.

Frozen materials shall not be used in construction of embankments.

During the construction of the roadway, the roadbed shall be maintained so that it is well drained at all times.

**203.07 Construction of Embankment and Treatment of Cut Areas with Moisture and Density Control.** Soil embankments shall be constructed with moisture and density control, and the soil upon which the embankments are to be constructed shall be scarified to a depth of 6 inches and compacted with moisture and density control. The moisture content of the soil at the time of compaction shall be as specified or directed.

The material shall be removed from the full width of roadbed in all cut sections to the designated depth. The soil below the designated depth shall be thoroughly scarified to a depth of 6 inches and the moisture content increased or reduced, as necessary, to obtain the moisture content specified. This scarified layer shall then be compacted to the relative compaction specified.

All embankment material shall also be compacted to the specified relative compaction.

Maximum dry density of all soil types encountered or used will be determined in accordance with AASHTO T 99, AASHTO T 180, or a modification thereof.

The amount of water to be used in compacting A-2-6, A-2-7, A-4, and A-6 through A-7 soils shall not deviate from optimum on the dry side by more than two percentage points as determined by AASHTO T 99, T 180, or a modification thereof, as designated in the Contract. A-4 soils which are unstable at the above moisture content shall be compacted at a lower moisture content to the specified density. The amount of water used in compacting all other soils shall be as required to obtain the percent relative compaction required.

Additional work involved in drying embankment material to the required moisture content shall be included in the contract price paid for excavating or furnishing the material with no additional compensation.

Density requirements will not apply to materials which cannot be tested in accordance with any of the above procedures for determining maximum dry density. Compaction for materials which cannot be tested shall be in accordance with subsection 203.08.

The percent of relative compaction specified shall be equal to or greater than minimum values as shown in the following table for the various classes of soil and type of compaction.

Claystone or soil-like non-durable shale shall be pulverized and compacted to the specified moisture and percent of relative compaction and 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 three or more coverages with the tamping foot roller to obtain density. One coverage consists of one pass over the entire surface designated. One pass consists of the passing of an acceptable tamping foot roller over a given spot. The roller shall be operated at a uniform speed not exceeding 3 miles per hour. No additional compensation will be made for additional roller coverages to achieve specified density requirements

<b>Soil Classification (AASHTO M 145)</b>	<b>AASHTO T 99 Minimum Relative Compaction (Percent)</b>	<b>AASHTO T 180 Minimum Relative Compaction (Percent)</b>
A-1	100	95
A-3	100	95
A-2-4	100	95
A-2-5	100	95
All Others	95	90

**203.08 Construction of Embankments without Moisture and Density Control.**

Rock embankment material shall be placed in layers in accordance with the requirements of subsection 203.06.

Each layer of rock embankment material shall be compacted by routing construction equipment, compactors, or both, uniformly over the entire surface of each layer before the next layer is placed. At least one compactor shall be in simultaneous operation with each separate rock embankment placement operation. Specific types of compactors shall be furnished and used when required by the Contract.

Each layer of rock embankment shall not be covered by another layer until the Engineer is satisfied that adequate compaction has been obtained. If the Engineer determines that the compactive effort is unsatisfactory, the Engineer may order the Contractor to compact the unsatisfactory area by two additional passes using approved compaction equipment.

203.09

**203.09 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 recompacted to the requirements for density and moisture at the Contractor's expense. After recompaction, these areas shall be proof rolled again and all failures again corrected at the Contractor's expense.

Upon approval of the proof rolling, the sub base, base course, or initial pavement course shall be placed within 48 hours. If the Contractor fails to place the sub base, 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.

**203.10 Presplitting.** When presplitting is designated in the Contract, the top of the rock slope will be established by the Engineer. The Contractor shall drill the bore holes along the slope line, maintain the drill holes at the angle designated in the Contract, and ensure that all drill holes are in the same plane. The diameter, spacing, and loading of presplit holes shall result in a neat break. The presplitting holes shall be drilled for the full depth of the ledge.

The initial presplitting of each geological formation shall be accomplished utilizing a 100 foot test section. After drilling, loading, and shooting this test section, the material shall be removed so the Engineer can determine if the diameter, spacing, and loading of the presplit holes are adequate to give an acceptable backslope. If the results are determined acceptable by the Engineer, the presplitting may continue throughout the geological formation using those methods and procedures. If the presplitting is determined unsatisfactory, the Contractor shall make adjustments in the spacing, diameter, loading, or a combination thereof of the presplit holes utilizing another test section.

Presplitting holes shall be loaded with explosives in accordance with the manufacturer's recommendations. The cost of presplitting shall be included in the contract unit price for rock excavation.

**203.11 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.

**203.12 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**

**203.13** Items paid for by volume will not be remeasured but will 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 on the plans in an amount of at least plus or minus two percent of the plan quantity.

- (a) *Excavation.* When payment is specified on a volume basis, all accepted excavation and borrow will be measured in its original position by cross-sectioning the area excavated. These measurements will include authorized excavation of rock, shale, muck, 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 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 on the plans.

Measurements will include over-breakage in rock excavation from the backslopes 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, only when the topsoil or wetland topsoil is designated to be removed within the roadway prism. When the topsoil source is not designated in the Contract, embankment will be measured from the original ground line.

203.13

- (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 under 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 which 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.

- (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. Additional proof rolling shall be at the Contractor's expense.

### **BASIS OF PAYMENT**

**203.14** 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Rock Excavation	Cubic Yard
Rock Fill	Cubic Yard
Unclassified Excavation	Cubic Yard
Unclassified Excavation (Complete in Place)	Cubic Yard

<b>Pay Item (cont.)</b>	<b>Pay Unit (cont.)</b>
Muck Excavation	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.

Excavated materials which, when specified, require more than one handling prior to final placement will be paid for at the contract unit price for unclassified excavation, rock excavation, stripping, muck excavation, or borrow as appropriate, for the first approved handling. Payment for the second approved handling will be made at the same unit price as the first handling, except that material used in conjunction with another pay item will be paid for in that pay item.

Payment for Unclassified Excavation (Complete in Place), Embankment Material (Complete in Place), and Borrow (Complete in Place) shall be full compensation for all work necessary to complete the item including construction of embankments, unclassified excavation, borrow, compaction, compaction of bases of cuts and fills, all work in available materials pits, and disposal of excess excavated material.

All costs associated with reducing the size of the claystone particles, removing the oversized particles, and disposal of the oversized particles will not be paid for separately but shall be included in the work.

Pavement replacement if required due to potholing, shall be accomplished, measured, and paid for in accordance with 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.

206.01

**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 in accordance with 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, sheeting, bracing, 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.* Class 1 and Class 2 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 (flow-fill) meeting the following requirements shall be used to backfill bridge abutments. The Contractor may substitute structure backfill (flow-fill) for structure backfill (class 1) or structure backfill (class 2) to backfill culverts and sewer pipes.

<b>Ingredients</b>	<b>Lbs./Cu.Yd.</b>
Cement	50
Coarse Aggregate (AASHTO No. 57 or 67)	1700
Fine Aggregate (AASHTO M 6)	1845
Water	325 (or as needed)

The amount of water shall be such that the structure backfill (flow-fill) flows into place properly without excessive segregation. Approximately 39 gallons of water per cubic yard of structure backfill (flow-fill) is normally needed.

The Contractor may use aggregate which does not meet the above specifications if the cement is increased to 100 pounds per cubic yard and the aggregate conforms to the following gradation:



Sieve Size	Percent Passing
25.0 mm (1 inch)	100
75 µm (No. 200)	0-10

The Contractor may substitute 30 pounds per cubic yard of cement and 30 pounds per cubic yard of fly ash for 50 pounds per cubic yard of cement or may substitute 60 pounds per cubic yard of cement and 60 pounds per cubic yard of fly ash for 100 pounds per cubic yard of cement.

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 prior to 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 which impacts the performance of the flowfill including all non-glass constituents.

- (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 which 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.

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 prior to 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 before compacting to the required density and before successive layers are placed.

206.03

Structure backfill (Class 1) shall be compacted to a density of not less than 95 percent of maximum density determined in accordance with AASHTO T 180.

Required density for structure backfill (Class 2) shall conform to subsection 203.07. The type of compaction shall be as specified in the contract for embankment construction. When there is no embankment in the Contract or the type of compaction for structure backfill (Class 2) is not designated, the type of compaction shall be AASHTO T 180.

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  $0.8f'_c$ .

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 prior to 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.

Compaction of structure backfill (flow-fill) will not be required.

The maximum layer thickness for structure backfill (flow-fill) shall be 3 feet. Additional layers shall not be placed until the structure backfill (flow-fill) has lost sufficient moisture to be walked on without indenting more than 2 inches. Damage resulting from placing structure backfill (flow-fill) in layers that are too thick or from not allowing sufficient time between placement of layers shall be repaired 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 in accordance with 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.

206.07

### **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:

<b>Pay Item</b>	<b>Pay Unit</b>
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.

## **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. It shall include the placing of topsoil upon constructed cut and fill slopes after grading operations are completed.

### **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 which 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 prior to 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 prior to 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.

207.04

### 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 203.13, 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 203.13, 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 203.13, 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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, erosion 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. This work includes constructing a stabilized construction entrance, as shown on the plans, or as directed by the Engineer.

The Contractor shall coordinate the construction of temporary erosion control measures with the construction of permanent erosion control measures to assure economical, effective, and continuous erosion control throughout the construction period.

### **MATERIALS**

**208.02** The material for erosion 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 one of the following:
- (1) One of the ties binding the bales shall consist of blue and orange twine, or
  - (2) One of the ties binding the bale shall consist of specially produced shiny galvanized wire, or
  - (3) The bale shall have a regional Forage Certification Program tag indicating the Regional Forage Certification Program Number.

Erosion bales 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 erosion bales or remove their identifying twine, wire or tags until the Engineer has inspected and accepted them.

The Contractor shall provide a certificate of compliance showing the transit certificate number or a copy of the transit certificate as supplied from the forage producer.

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, 700 Kipling Street, Suite 4000, Lakewood, CO 80215, (303) 239-4177.

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Bales shall be approximately 5 cubic feet of material and weigh not less than 35 pounds.

- (b) *Silt Fence.* Silt fence posts shall be metal or wood with a minimum length of 42 inches. Metal posts shall be “studded tee” or “U” type with minimum weight of 1.33 pounds per linear foot. Wood posts shall have a minimum diameter or cross section dimension of 2 inches. Silt fence geotextile shall conform to subsection 712.08(b). Geotextile shall be attached to posts with three or more staples per post.
- (c) *Temporary Berms.* Temporary berms, shall be constructed of compacted soil.
- (d) *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.
- (e) *Brush Barrier.* Brush barriers shall consist of brush, limbs, root mat, vines, soil, rock, or unmerchantable timber. The erosion control geotextile that covers the barrier shall conform to subsection 712.08(b).
- (f) *Check Dam.* Check dams shall be constructed of stone, logs, or wooden timbers. Stone shall meet the requirements of Section 506.
- (g) *Outlet Protection.* Outlet protection riprap shall conform to section 506. Erosion control geotextile shall conform to subsection 712.08(b).
- (h) *Sediment Trap and Basin.* In constructing an excavated Sediment Trap or Basin, excavated soil may be used to construct the dam embankment, provided the soil meets the requirements of Section 203.
- (i) *Erosion Logs.* Erosion logs shall be curled aspen wood excelsior with a consistent width of fibers evenly distributed throughout the log. The casing shall be seamless, photodegradable tube netting and shall have minimum dimensions as shown in Table 208-1, based on the diameter of the log called for in the plans. The curled aspen wood excelsior shall be fungus free, resin free and shall be free of growth or germination inhibiting substances.

**Table 208-1  
NOMINAL DIMENSIONS OF EROSION LOGS**

<b>Diameter</b>	<b>Length</b>	<b>Weight (minimum)</b>	<b>Stake Dimensions</b>
8 inch	7-10 feet	1.6 pounds/foot	1.5 by 1.5 by 20 inches
12 inch	7-10 feet	2.5 pounds/foot	1.5 by 1.5 by 24 inches
18 inch	7-10 feet	4 pounds/foot	1.5 by 1.5 by 30 inches



Stakes to secure erosion logs shall consist of pinewood or hardwood.

- (j) *Silt Dikes.* Silt dikes shall be pre-manufactured triangular shaped urethane foam covered with a woven geotextile fabric. The fabric aprons shall extend a minimum of two feet beyond each side of the triangle.

Each silt dike shall have the following dimensions:

Center height	8 to 10 inches
Base	16 to 21 inches
Section length	3 to 7 feet
Section width including fabric extensions	5.6 feet

- (k) *Concrete Washout Structure.* The Contractor shall design and construct a concrete washout structure that will contain washout from concrete placement and construction equipment cleaning operations. Embankment required for the concrete washout structure may be excavated material, provided that this material meets the requirements of Section 203 for embankment.
- (l) *Stabilized Construction Entrance.* Unless otherwise directed by the Engineer, aggregate for the construction entrance shall be coarse material that meets the following gradation requirements:

Sieve size	Percent by weight Passing Square Mesh Sieves
75 mm (3 inch)	100
50 mm (2 inch)	95-100
19.0 mm (¾ inch)	0-15

Geotextile shall conform to the requirements of subsection 420.02.

## CONSTRUCTION REQUIREMENTS

### 208.03 Project Review, Schedule, and Erosion Control Supervisor.

- (a) *Project Review.* The Contractor may submit modifications to the Contract's erosion control measures in a written proposal to the Engineer. Such proposed modifications shall be submitted at least ten working days prior to the beginning of any construction work. The written proposal shall include the following minimum information:
- (1) Reasons for changing the erosion 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.

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The Engineer will approve or reject the written proposal in writing within two weeks after the submittal. The Engineer may order additional control measures prior to approving the proposed modifications. The Contractor shall obtain amendments to permits or certifications required as a result of the approved changes. Modifications to the erosion control measures shall not be reason for extension of contract time.

- (b) *Schedules.* At least 10 working days prior to the beginning of any construction work, the Contractor shall submit for approval a schedule for accomplishment of temporary and permanent erosion control work. This schedule shall specifically indicate the sequence of clearing and grubbing, earthwork operations, and construction of temporary and permanent erosion control features. The schedule shall include erosion and sediment control work for all areas within the project boundaries, including but not limited to, haul roads, borrow pits, and storage and plant sites. Work shall not be started until the erosion and sediment control schedule has been approved in writing by the Engineer.

Once the work has started, and during the active construction period, the Contractor shall update the schedule for all erosion and sediment control work on a weekly basis, and submit the updated schedule to the Engineer. If during construction the Contractor proposes changes which would affect the Contract's erosion and sediment control measures, the Contractor shall propose revised erosion and sediment control measures to the Engineer for approval in writing. Revisions shall not be implemented until the proposed measures have been approved in writing by the Engineer.

- (c) *Erosion Control Supervisor.* When included in the Contract, the Contractor shall assign to the project an employee to serve in the capacity of the Erosion Control Supervisor (ECS). The ECS shall be a person other than the Superintendent, unless otherwise approved by the Engineer. The ECS shall be experienced in all aspects of construction and have satisfactorily completed an ECS training program authorized by the Department. Proof that this requirement has been met shall be submitted to the Engineer at least ten working days prior to the beginning of any construction work. A list of authorized ECS training programs will be provided by the Engineer upon request by the Contractor.

The ECS's responsibilities shall be as follows:

- (1) Ensure compliance with all water quality permits or certifications in effect during the construction work.
- (2) Directly supervise the installation, construction, and maintenance of all erosion control measures specified in the Contract and coordinate the construction of erosion control measures with all other construction operations.
- (3) Direct the implementation of suitable temporary erosion and sediment control features as necessary to correct unforeseen conditions or emergency

- situations. Direct the dismantling of those features when their purpose has been fulfilled unless the Engineer directs that the features be left in place.
- (4) Inspect, with the Engineer or designated representative, all erosion control features implemented for the project. The inspections shall take place at least once every 14 calendar days and after each storm event that causes surface runoff. A report shall be submitted to the Engineer after every inspection and shall become part of the Department's project records. The appropriate form for this report will be supplied by the Engineer. The inspections shall be made during the progress of the work, during work suspensions, and until final acceptance of the work. During project suspensions, inspections shall take place at least once every 30 calendar days, or as directed.
  - (5) Attend the Preconstruction Conference, all project scheduling meetings, and reviews by the Erosion Control Advisory Team (ECAT) and Regional Erosion Control Advisory Team (RECAT) as requested by the Engineer.
  - (6) Upon the Engineer's request, implement necessary actions to reduce anticipated or presently existing water quality or erosion problems resulting from construction activities. The criteria by which the Engineer initiates this action may be based on water quality data derived from monitoring operations or by any anticipated conditions (e.g., predicted storms) which the Engineer believes could lead to unsuitable water quality situations.
  - (7) Make available, upon the Engineer's request, all labor, material, and equipment judged appropriate by the Engineer to install and maintain suitable erosion and sediment control features.

#### **208.04 Erosion Control.**

- (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 prior to installation.
- (b) *Work Outside the Right of Way.* In areas outside the right-of-way that are used by the Contractor and which include, but are not limited to, borrow pits, haul roads, storage and disposal areas, maintenance, batching areas, etc., erosion and sediment control work shall be performed by the Contractor at the Contractor's expense.
- (c) *Construction Implementation.* The Contractor shall incorporate into the project all erosion and sediment control features as outlined in the accepted schedule.
- (d) *Stabilization.* Permanent stabilization is defined as the covering of disturbed areas with final seed and mulch as indicated on the plans. When required by the plans, an erosion control blanket shall be used in combination with the final seed

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and mulch. Temporary stabilization is defined as the covering of disturbed areas with seed, mulch, mulch with a tackifier, or a combination thereof. Other permanent or temporary soil stabilization techniques may be proposed, in writing, by the Contractor and used upon approval, in writing, by the Engineer.

The surface area of erodible earth material exposed at one time by clearing and grubbing, and earthwork operations shall not exceed 34 acres: 17 acres for clearing and grubbing plus 17 acres for earthwork operations. The Contractor shall permanently stabilize each 17 acre increment of the project immediately upon completion of the grading of that section. Once earthwork has begun on a section, it shall be pursued until completion. If approved by the Engineer, slopes from the edge of pavement to the point of slope selection may be left unseeded until paving has been completed.

The duration of the exposure of uncompleted construction to the elements shall be as short as practicable. Completed areas shall be permanently stabilized within seven calendar days after completion. Disturbed areas where work is temporarily halted shall be temporarily stabilized within seven days after the activity ceased unless work is to be resumed within 30 calendar days after the activity ceased. Payment for temporary stabilization will be made at the contract unit price if the work was interrupted due to no fault or negligence of the Contractor. Payment will not be made for temporary stabilization required by Contractor's negligence, by the lack of proper Contractor scheduling or for the convenience of the Contractor.

Clearing and grubbing operations shall be scheduled and performed so that grading operations and permanent stabilization measures can follow immediately thereafter if the project conditions permit. Otherwise temporary stabilization measures may be required between successive construction stages. No payment will be made for additional work required because the Contractor has failed to properly coordinate the entire erosion control schedule, thus causing previously seeded areas to be disturbed by operations that could have been performed prior to the seeding. Upon failure of the Contractor to coordinate the permanent stabilization measures with the grading operations in a manner to effectively control erosion and prevent water pollution, the Engineer will suspend the Contractor's grading operations and withhold monies due to the Contractor on current estimates until such time that all aspects of the work are coordinated in an acceptable manner.

- (e) *Maintenance.* The Contractor shall continuously maintain all erosion and sediment control features so that they function properly during construction and work suspensions until the project is accepted.

From the time seeding and mulching work begins until the date the project is declared complete, the Contractor shall keep all seeded areas in good condition at all times. Any damage to seeded areas or to mulch materials shall be promptly repaired as directed.

If the Contractor fails to maintain the erosion and sediment control features in accordance with the Contract, or as directed, the Engineer may at the expiration of a period of 48 hours, after having given the Contractor written notice, proceed to maintain the features as deemed necessary. The cost thereof will be deducted from any compensation due, or which may become due to the Contractor under this contract.

Temporary erosion and sediment control measures shall remain upon completion of the project unless otherwise directed by the Engineer. If removed, the area in which these features were constructed shall be returned to a condition similar to that which existed prior to its disturbance. At the completion of the Contract, removed salvageable temporary erosion control items shall become the property of the Contractor.

- (f) *Disposal of Sediment.* Sediment removed during maintenance of erosion control features shall be used in or on embankment provided it meets conditions of Section 203, or it shall be wasted in accordance with subsection 107.25.

**208.05 Construction of Erosion Control Measures.** Erosion control measures shall be constructed in accordance with the following.

- (a) *Seeding, Mulching, Sodding, Soil Retention Blanket.* Seeding, mulching, sodding, and soil retention blanket shall be performed in accordance with Sections 212, 213, and 216.
- (b) *Erosion Bales.* The bales shall be placed embedded into the soil and shall be anchored securely to the ground with wood stakes. Stakes shall have a minimum diameter or cross section dimension of 2 inches. Re-bars shall not be used. Gaps between bales shall be filled with Certified Weed Free mulch to obtain tight joints.
- (c) *Silt Fence.* Silt fence shall be installed in locations specified in the Contract prior to any grubbing or grading activity. Sediment shall be removed from behind the silt fence when it accumulates to one half the exposed geotextile height and shall be disposed of in accordance with subsection 208.04(f).
- (d) *Temporary Berms.* Berms shall be constructed to the dimensions shown in the Contract, graded to drain to a designated outlet, and compacted with a minimum of two passes of a rubber tire vehicle, preferably a grader wheel.
- (e) *Temporary Diversion.* Unless otherwise specified in the Contract or directed, the diversion's ridge and channel shall be stabilized within 14 calendar days of its installation. The diversion shall be installed prior to any up slope land disturbance.
- (f) *Temporary Slope Drains.* Temporary slope drains shall be installed prior to installation of permanent facilities or growth of adequate ground cover on the

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slopes. All 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) *Brush Barrier.* The barrier shall be constructed at the time of clearing and shall be covered by an erosion control geotextile.
- (h) *Check Dam.* Logs shall be obtained, if possible, from clearing operations on the project. Sediment shall be removed from behind the check dam when it has accumulated to one half of the original height of the dam and shall be disposed of in accordance with subsection 208.04(f).
- (i) *Outlet Protection.* Geotextile used shall be protected from cutting or tearing. Overlaps between two pieces of geotextile shall be 1 foot minimum.
- (j) *Storm Drain Inlet Protection.* Storm drain inlet protection measures shall be constructed in locations and with materials and techniques specified in the Contract. Construction shall be in a manner that will facilitate maintenance, and minimize interference with construction activities.

At excavated drop inlet sediment traps, sediment shall be removed when it has accumulated to one-half the design dept of the trap and shall be disposed of in accordance with subsection 208.04(f).

- (k) *Sediment Trap and Basin.* Sediment traps or basins shall be installed before any land disturbance takes place in the drainage area.

Area under the embankment shall be cleared, grubbed, and stripped of all vegetation and root mat. Embankment construction shall conform to Section 203.

Sediment shall be removed from the trap or basin when it has accumulated to one half of the wet storage depth of the trap or basin and shall be disposed of in accordance with subsection 208.04(f).

- (l) *Erosion Logs.* The Contractor shall maintain the erosion logs during construction to prevent sediment from passing over or under the logs or from sediment accumulation greater than two thirds of the original exposed height of each erosion log.

Stakes shall be embedded to a minimum depth of 12 inches. At the discretion of the Engineer, a shallower depth may be permitted if rock is encountered.

- (m) *Silt Dikes.* Prior to installation of silt dikes, the Contractor shall prepare the surface of the areas in which the dikes are to be installed such that they are free of materials greater than two inches in diameter and are suitably smooth for the installation of the silt dikes, as approved by the Engineer.

Dikes shall be secured with “U” staples, 8 inches in length and 11-gauge minimum, placed in two rows per apron along edges one foot on center. The staple pattern shall be as shown on the plans.

- (n) *Concrete Washout Structure Design.* The concrete washout structure shall be designed to meet or exceed the dimensions shown on the plans. At least ten days prior to start of paving operations, the Contractor shall submit in writing a *method* statement outlining the design, site location and installation of a concrete structure that will contain washout from concrete placement operations. Work on this structure shall not begin until written acceptance is provided by the Engineer.

The structure shall meet the following requirements:

- (1) 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 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) Each concrete truck driver and pumper operator shall be aware of site locations.
- (6) The site shall be accessible to appropriate vehicles.
- (7) The bottom of excavation shall be a minimum of five feet vertical above groundwater or, alternatively, excavation must be lined with an impermeable synthetic liner that is designed to control seepage to a maximum rate of  $10^{-6}$  centimeters per second.
- (8) Freeboard capacity shall be included into structure design to reasonably ensure the structure will not overtop during or because of a precipitation event.
- (9) The Contractor shall prevent tracking of washout material onto the roadway surface.
- (10) Solvents, flocculents, and acid shall not be added to wash water.

The structure shall be fenced with orange plastic construction fencing or equivalent fencing material to provide a barrier to construction equipment and to aid in identification of the concrete washout area.

The concrete washout structure shall be completed and ready for use prior to concrete placement operations.

Waste material from concrete washout operations shall be removed and disposed of in accordance with subsection 208.04 (f) when it has accumulated to two-thirds of the wet storage capacity of the structure.

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- (o) *Stabilized construction entrance.* Stabilized construction entrances shall be constructed to the minimum dimensions shown on the plans, unless otherwise directed by the Engineer. Construction of approved stabilized construction entrances shall be completed before any excavation or work is started between such entrances, as shown on the plans.

The Contractor shall maintain the stabilized construction entrance during the entire time that it is in use in the project. The stabilized construction entrance shall be removed at the completion of this project unless otherwise directed by the Engineer.

**208.06 Failure to Perform Erosion Control.** The Contractor will be subject to liquidated damages for incidents of failure to perform erosion control as required by the Contract. Incidents to which these liquidated damages may be applied include the following:

- (1) Failure to submit an initial schedule or failure to submit a weekly schedule update as specified in subsection 208.03(b).
- (2) Failure of the Erosion Control Supervisor to perform the inspections required by subsection 208.03(c)4.
- (3) Failure of the Erosion Control Supervisor to implement necessary actions requested by the Engineer as required by subsection 208.03(c)6.
- (4) Failure to design and implement erosion and sediment control measures for unforeseen conditions as required by subsection 208.04(a).
- (5) Failure to construct or implement erosion control or spill containment measures required by the Contract, or failure to construct or implement them in accordance with the Contractor's approved schedule as required by subsection 208.04(c).
- (6) Failure to limit the exposed surface area of erodible earth to 34 or fewer acres as required by subsection 208.04(d).
- (7) Failure to temporarily stabilize areas where work is temporarily halted within seven days as required by subsection 208.04(d).
- (8) Failure to perform maintenance of an erosion control feature within 48 hours after notice from the Engineer to perform maintenance as required by subsection 208.04(e).
- (9) Failure to remove and dispose of sediment from erosion control features as required by subsection 208.04(f) and subsections 208.05(c), (h), (j), and (k).
- (10) Failure to install and properly utilize a concrete washout structure for containing washout from concrete placement operations

The Engineer will notify the Contractor in writing of each incident of failure to perform erosion control, items (1) through (10) above. The Contractor will be allowed seven calendar days from the date of notification to correct the failure. The Contractor will be charged liquidated damages in the amount of \$500 for each calendar day after the seventh day that one or more of the incidents of failure, items (1) through (10) above, remains uncorrected. This deduction will not be considered a penalty, but will be considered liquidated damages based on estimated additional



construction engineering costs. The liquidated damages will accumulate, for each cumulative day that one or more of the incidents remains uncorrected. The number of days to which liquidated damages are assessed will be cumulative for the duration of the project; that is: the damages for a particular day will be added to the total number of days for which liquidated damages are accumulated on the project. The liquidated damages will be deducted from any monies due the Contractor.

### **METHOD OF MEASUREMENT**

**208.07** Erosion bales and check dams will be measured by the unit.

Silt fence, erosion logs, silt dikes, temporary berms, temporary diversions, temporary drains, and brush barriers will be measured by the actual number of linear feet that are installed and accepted. Stakes, anchors, connections and tie downs used for temporary slope drains will not be measured and paid for separately, but shall be included in the work.

Concrete washout structure will be measured by the actual number of structures that are installed and accepted, and will include excavation, embankment, concrete, liner, erosion bales, fencing, and containment and disposal of concrete washout and all other associated waste material.

Storm drain inlet protection will be measured by the unit as specified in the Contract.

Sediment trap and sediment basin quantities will be measured by the unit which shall include all excavation and embankment required to construct the item. Other materials used to provide for outlet and overflow will be measured and paid for separately.

The Erosion Control Supervisor will not be measured, but will be paid for on a lump sum basis. The lump sum price bid will be full compensation for all work required to complete the item.

Excavation required for 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 paid for on a lump sum basis.

Stabilized construction entrance will be measured by the actual number constructed and accepted.

### **BASIS OF PAYMENT**

**208.08** Work to furnish, install, maintain, remove, and dispose of erosion and sediment control features specified in the Contract will be paid for at the contract unit price.

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Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Erosion Bales (Weed Free)	Each
Silt Fence	Linear Foot
Temporary Berms	Linear Foot
Temporary Diversion	Linear Foot
Temporary Slope Drains	Linear Foot
Brush Barrier	Linear Foot
Check Dam	Each
Storm Drain Inlet Protection	Each
Sediment Trap	Each
Sediment Basin	Each
Sediment Removal and Disposal	Lump Sum
Erosion Control Supervisor	Lump Sum
Erosion Log ( ____ Inch)	Linear Foot
Silt Dike	Linear Foot
Concrete Washout Structure	Each
Stabilized Construction Entrance	Each

Payment for stabilized construction entrance 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.

Temporary erosion and pollution 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.

In the case of repeated failures on the part of the Contractor in controlling erosion, sedimentation, or water pollution, the Engineer reserves the right to employ outside assistance or to use Department forces to provide the necessary corrective measures. Such incurred direct costs, plus project engineering costs, will be charged to the Contractor, and appropriate deduction will be made from the Contractor's monthly progress estimate.

Accepted work performed to install measures for the control of erosion and sedimentation, and water pollution, not originally included in the Contract will be paid for as extra work in accordance with subsection 104.03.

Seeding, sod, mulching, soil retention blanket, and riprap will be measured and paid for in accordance with Sections 212, 213, 216, and 506.

## 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 shall also include 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, samples of the water shall be submitted for approval prior to 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:

Chemical Constituents	Percent by Weight
Magnesium Chloride (MgCl <sub>2</sub> )	28 to 35
Enhancing or Nondetrimental 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. Water for finishing operations shall be uniformly applied by spraying across the full width of the course.

**209.04 Prewetting.** Prewetting material in excavation areas prior to 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 prior to 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. Application of water shall be done with acceptable sprinkling equipment at an appropriate rate as approved by the Engineer.

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Magnesium Chloride dust palliative shall be applied 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.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
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 in accordance with 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 prior to 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 prior to 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 in accordance with 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 in accordance with 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 in accordance with Section 607. Wire in the old fence shall be salvaged and used in the reset fence.

Where snowfences 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.

210.04

Right of way fence shall be reset approximately 6 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 27 inches in accordance with Standard Plan M-606-1, and filling the resulting voids under the posts with a lean concrete mixture consisting of one part cement and ten 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 in accordance with 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 prior to 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 prior to 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 brick-work, 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  $\frac{1}{4}$  to  $\frac{1}{2}$  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” in accordance with Section 613.

Concrete footings for ground signs and overhead sign structures, if required, will be measured and paid for in accordance with Section 614.

Steel post extensions, if required, will be measured and paid for as “Steel Sign Post” in accordance with 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 relaid 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 in accordance with 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,

210.12

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:

<b>Pay Item</b>	<b>Pay Unit</b>
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 in accordance with 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 in accordance with 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 in accordance with 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 six months prior to the date of seeding. Seed which 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 in accordance with 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 • (%Purity • %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 which becomes caked or damaged will not be accepted.
  2. Soil conditioner: Soil conditioner shall consist of an organic amendment, biological nutrient, biological culture or humic acid based material.  
 Humic acid based material (Humate) shall include the following:

212.02

- (1) pH 3 to 5
- (2) Maximum 20 percent inert ingredient
- (3) Minimum 80 percent organic matter with 40 percent minimum humic acid.

Organic amendment shall be an organic product containing a mixture of composted cow or sheep manure and plant residue produced by aerobic (biological) decomposition. It shall be processed at a consistent temperature of 140 °F or greater to accomplish the following:

- (1) Compost the windrows of composted organic amendment (cow or sheep manure) for 90 to 120 days. Certification must be provided to prove the product has gone through this process.
- (2) Eradicate harmful pathogens including coliform bacteria.
- (3) Create a carbon to nitrogen ratio of 15:1 to 25:1.
- (4) Contain no solid particle greater than ½ inch diameter.
- (5) Have a non-offensive smell similar to fresh turned soil.
- (6) Contain no significant level of dirt, soil, or chemical preservatives and contain a maximum of 30 percent composted plant residue.
- (7) Have a pH after composting between 6 and 8 with an organic matter content of at least 20 percent.
- (8) Contain soluble salts not greater than 5mmhos/cm.

The Contractor shall submit a two pound sample of the soil conditioner product four weeks before its use on the project site for the Engineer's approval. A certificate of Compliance shall be provided to the Engineer to verify the organic matter content, pH, and carbon matter to nitrogen ratio, and salt levels (by electrical conductivity mmhos/cm).

- (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 ¾ 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 prior to 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 time table and specifications.

<b>Zone</b>	<b>Spring Seeding</b>	<b>Fall Seeding</b>
<b>Areas Other Than Western Slope</b>		
Below 6000'	Spring thaw to June 1	September 1 until consistent ground freeze
6000'to 7000'	Spring thaw to June 1	September 15 until consistent ground freeze
7000'to 8000'	Spring thaw to July 15	August 1 until consistent ground freeze
Above 8000'	Spring thaw to consistent ground freeze	
<b>Western Slope</b>		
Below 6000'	Spring thaw to May 1	August 1 until consistent ground freeze
6000'to 7000'	Spring thaw to June 1	September 1 until consistent ground freeze
Above 7000'	Spring thaw to consistent ground freeze	

- (1) "Spring thaw" shall be defined as the earliest date in a new calendar year in which seed can be buried ½ 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 in which the surface soil (topsoil), due to freeze conditions, prevents burying the seed ½ 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 which 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

212.03

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 prior to 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 prior to 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 ¼ 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 1/2 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.* Prior to 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 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.

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 in accordance with 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.* Prior to 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

212.06

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 surface. Organic amendments shall be applied uniformly over the soil surface and incorporated into the top 6 inches of soil.

- (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  $\frac{1}{4}$  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  $\frac{1}{4}$  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.

212.08

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.

The Contractor shall furnish the Engineer with seed certifications and analysis, fertilizer analysis, and bag weight tickets prior to 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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.

213.01

## **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, in accordance with 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.

### **MATERIALS**

**213.02** 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) One of the ties binding the bale shall consist of specially produced galvanized shiny wire, or
- (3) 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 which breaks in the crimping process will not be accepted.

The type and application rate of mulch material shall be as designated in the Contract.



The hydromulch material for hydraulic mulching 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 fiber mulch shall be dyed green to aid in visual metering during application. The dye shall be biodegradable and not inhibit plant growth. 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 specifications:

- |   |                   |
|---|-------------------|
| (1) Percent moisture content                          | 10.0% ± 3.0%      |
| (2) Percent Organic Matter*<br>(Wood Cellulose Fiber) | 99.3% ± 0.2%      |
| (3) Percent Ash Content*                              | 0.7% ± 0.2%       |
| (4) pH  | 4.9 ± 0.5         |
| (5) Water Holding Capacity*                           | **1200-1600 grams |

\*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.

Material for mulch tackifier shall consist of a free-flowing, noncorrosive powder produced from the natural plant gum of *Plantago insularis* (Desert Indianwheat), applied in a slurry with water and wood fiber. The powder shall possess the following properties:

- |                     |             |
|---------------------|-------------|
| (1) Protein content | 1.6% ± 0.2% |
| (2) Ash content     | 2.7% ± 0.2% |
| (3) Fiber           | 4.0% ± 0.4% |
| (4) pH 1% solution  | 6.5 - 8.0   |

The material used for mulch tackifier shall not contain any mineral filler, recycled cellulose fiber, clays, or other substances which may inhibit germination or growth of plants. Water shall conform to subsection 209.02.

Wood chip mulch shall consist of fresh, moist pole peelings material having approximate dimensions;

213.02

Width: ¼ to ½ inch; Length: 3 to 4 inches

The Contractor shall submit a sample to the Engineer for approval at least 30 days prior to placing on the project.

The metal landscape border shall consist of a strip of metal such as steel conforming to ASTM A 1011 or approved equal.

## 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 prior to precipitation or damaging winds on site shall be reseeded with the specified seed mix at the Contractor's expense, prior to mulching and crimping.

When tackifier is required in the Contract it shall be applied in the following order: (1)hydraulic mulching, (2)mulch tackifier.

(b) *Hydraulic Mulching.* Cellulose fiber mulch and 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.

1. Mixing procedure for the hydraulic mulch and tackifier mixture shall be as follows:

- (1) Fill tank with water approximately ¼ 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
2000 lbs./Acre	100 lbs./Acre

2. 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 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.
- (4) Spray onto mulch or soil 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.

Powder	Fiber	Water
200 lbs./Acre	300 lbs./Acre	1000 gal./Acre

- (c) *General.* Mulch shall be tacked simultaneously or immediately upon completion of mulching and crimping to avoid non-uniform 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.

- (d) *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.
- (e) *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 tiedowns at intervals of approximately 2 feet. Wire tiedowns shall be 9 gage 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.

### METHOD OF MEASUREMENT

**213.04** The quantity of hay and straw mulch, wood chip mulch, wood cellulose fiber hydromulch, and tackifier will not be measured but shall be the quantity designated in

213.04

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.

### **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:

<b>Pay Item</b>	<b>Pay Unit</b>
Mulching (___)	Acre
Mulching (Weed Free Hay)	Acre
Mulching (Weed Free Straw)	Acre
Mulching (Wood Chip)	Cubic Foot
Mulch Tackifier	Pound
Metal Landscape Border __x__ Inch	Linear Foot

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.

## SECTION 214 PLANTING

### DESCRIPTION

**214.01** This work consists of furnishing and planting trees, shrubs, wetland perennials, and other plant material, hereinafter referred to as “plants” and obtaining live brush layer cuttings from on-site willow species designated by the Engineer near the project site and planting them in moist areas as shown on the plans or as directed.

### MATERIALS

**214.02 General.** Plants shall be of the species or variety designated in the Contract, in healthy condition with normal well developed branch and root systems, and shall conform to the requirements of the current “American Standard for Nursery Stock.” The Contractor shall obtain certificates of inspection of plant materials that are required by Federal, State, or local laws, and submit the certificates to the Engineer.

All plants 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 minimum acceptable sizes of all plants, with branches in normal position, shall conform to the measurements specified in the Contract.

Plants hardy in hardiness zones 2, 3, 4, and 5 only will be accepted. Hardiness zones are defined in U.S. Department of Agriculture publications.

All container grown plants shall be those plants that have been growing in a nursery 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.

Trees and shrubs shall have been root-pruned during their growing period in the nursery in accordance with standard nursery practice.

If plants of acceptable quality and specified variety or size are not available locally, the Contractor may:

- (1) Substitute acceptable plants that are larger than specified at no change in contract price.
- (2) On written approval, substitute smaller plants than those specified in the Contract at the adjusted price stated in the written approval.
- (3) On written approval, substitute plants of a different genus, species, or variety at the adjusted price stated in the written approval.

214.02

Before any substitution of plants will be considered, the Contractor shall furnish to the Engineer written statements from three sources verifying that the plants designated on the plans are not available.

At the landscape pre-construction conference, the Contractor shall name the nursery stock supplier for all items. The Contractor shall tag all nursery stock for inspection by the Engineer. The Engineer will reject any nursery stock not meeting the Contract at any of the three following times and locations:

- (1) At the named supplier's location. The Engineer will notify the Contractor when nursery stock will be inspected at the supplier's location.
- (2) On the project site at the time of delivery, prior to planting.
- (3) At the time of installation. Final acceptance of all plant material will be made at the time of installation on the project site.

Deciduous plants, broadleaf evergreens, and conifers shall be balled and burlapped, or in containers used in standard nursery practice. Balling and burlapping shall conform to the recommended specifications in the "American Standard for Nursery Stock". The ball of the plant shall be natural, not made, and the plant shall be handled by the ball at all times. No balled and burlapped plant shall be accepted if the ball is broken or the trunk is loose in the ball.

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.

Plants for fall planting shall be furnished balled and burlapped or container-grown unless otherwise designated in the Contract or approved.

- (a) *Brush Layer Cuttings.* Brush layer cuttings taken from designated plants shall be at least 0.5 inch in diameter or larger. Brush layer cuttings shall be 24 to 36 inches long with the bottom end cut off at an angle and the top end with a straight cut. Cuttings shall be taken and installed while dormant in early spring. Cuttings shall not be planted when the ground is frozen. Brush layer cuttings shall be stored no longer than one week. The cuttings shall be stored by submerging them at least  $\frac{2}{3}$  of their length in containers of water, free from any harmful oil, chemical, sprays, or other materials. The containers shall be kept in the shade.
- (b) *Wetland Perennial Plants.* Perennial wetland plants shall be supplied in containers as designated in the Contract; no bare root material will be allowed. The original plant stock for the plants shall be from Colorado. Perennial plants shall have been growing at least one growing season in the nursery. Perennials shall not be shipped while in a dormant condition. Perennials shall be a minimum of 6 inches in height when applicable to the species. Water shall be applied to wetland perennial plants until soil is saturated. Wetland perennial plants shall be watered thoroughly every day for a period of one month.

- (c) *Stakes.* Wood stakes shall be 2 inches x 2 inches square, or 2 ½ inch diameter and 6 feet long free from bends. Metal stakes shall be 6 feet long standard T-bar steel fence 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. The bottom of wood stakes shall be pointed.
- (d) *Soil Conditioners and Fertilizer.* Soil conditioner shall consist of composted plant material, 90 percent ¼ inch or less with a carbon to nitrogen ratio of 15:1 to 25:1. A sample of the soil conditioner and certificate of compliance shall be provided to the Engineer to verify the organic matter content, and carbon matter to nitrogen ratio shall be submitted one month prior to planting for a approval.

Fertilizer for planting shall be used as specified in the Contract.

### CONSTRUCTION REQUIREMENTS

**214.03 General.** All plants shall be protected from drying out or other injury. Broken and damaged roots shall be pruned before planting.

- (a) *Planting Seasons.* Plants shall be planted in accordance with the Contract.

Areas to be planted shall be brought to the lines and grades designated or approved. The location of plants shown in the Contract is approximate to the degree that unsuitable planting locations shall be avoided. Trees shall be planted at least 30 feet from the edge of the traveled way, except when guardrail or vertical curb exists, this distance may be reduced to 20 feet. Locations and layouts shall be approved before preparatory work for planting is started. Shrubs shall not be planted closer than 6 feet from the edge of pavement.

All layout staking for planting shall be done by the Contractor and shall be approved by the Engineer before planting holes are prepared.

The Contractor shall place all plant material according to the approved planting plans, or as directed.

- (b) *Excavation.* Planting pits shall be circular in outline with vertical or sloped sides. Pits for trees and shrubsshubs shall be at least two times greater in diameter than the earth ball.
- (c) *Planting.* Planting shall be done in accordance with good horticultural practices. 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.

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 level with the final grade. The

214.03

tree rootball shall be set in the center of the planting pit on undisturbed soil. Trees shall be stabilized and then the wire basket, any twine or wire, and burlap shall be removed before the pit is backfilled. Shrubs shall be planted in the center of the pit. Plastic, metal, fabric, or peat containers shall be removed. Shallow scores  $\frac{1}{4}$  to  $\frac{1}{2}$  inch deep shall be made along the edges of the rootball.

Areas to be planted with ground cover shall be prepared by placing topsoil and a  $\frac{1}{2}$  inch layer of soil conditioner on the ground surface, and roto-tilling 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 mulch cover of the type specified on the plans.

- (d) *Backfilling.* When soil conditioner is specified, composted plant material shall be added and thoroughly mixed into the backfill material at the rate of 0.5 cubic foot per tree and 0.1 cubic foot per shrub.

Backfill shall be thoroughly worked and watered-in to eliminate air pockets. Watering shall be done immediately after the plant is placed. Backfilling of the planting pit shall be resumed after this water is absorbed. Roots and crown shall be covered with soil at this time. After the soil has settled, plants 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. When saucers are required they shall be covered with a 4 inch thick layer of fresh moist wood chip mulch conforming to Section 213. After completion of all planting and before acceptance of the work, the Contractor shall water plants installed under this Contract, as needed to maintain a moist root zone optimum for plant growth. Plants damaged 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) *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..

- (f) *Staking.* All deciduous trees 2 inch caliper and greater shall be staked with two stakes. Stakes shall conform to subsection 214.02(c). Stakes shall be driven 2



feet into the ground with one stake on the side of the prevailing wind (generally the west side) and the other stake on the opposite side. Stakes shall be driven at least 1 foot outside each edge of the planting pit. Trees shall be guyed with 1 to 2 inch wide strips of nylon webbing with metal grommets.

Coniferous trees 4 feet or taller shall be staked as designated in the Contract or directed.

Stakes shall be spaced equally around the tree.

Trees specified to be guyed with wire shall be secured with No. 12 gage annealed galvanized steel wire free of bends and kinks.

- (g) *Wrapping Materials.* Wrapping material shall be horticulturally approved waterproof wrapping paper. Wrapping shall be applied from the base of the tree upward to the second scaffold branch and secured with arbor tape. *Populus sp.* are 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.

- (h) *Brush Layer Cuttings.* Using a rock bar or other tool, holes at least 20 inches deep shall be made in the streambank or other areas. A cutting shall be placed in each hole. If in riprap, the hole shall be backfilled with soil to within 3 inches of the riprap surface. The top 3 inches of the void shall be filled with gravel from the streambank or streambed and compacted slightly. The remaining exposed length shall be cut off 2 to 3 inches above the ground line. The placement of these cuttings shall be in areas shown on the plans that remain damp or are seasonally inundated, as directed. Brush layer cuttings shall be planted at a density of one cutting per square yard on streambank or other designated areas that have been regraded, ripped, or disturbed. The strip that is most successful for brush layer cutting establishment is only several yards wide and approximately, plus or minus, 2 feet from the ordinary high water line.

Water shall be applied to the brush layer cuttings planted areas until the soil mass is saturated. Brush layer cuttings shall be watered thoroughly every day for a period of one month.

- (i) *Irrigation.* Plantings that are to be irrigated shall be planted so that the irrigation system is operating and supplying the designated amount of water as planting is occurring. Plants shall be watered within 15 minutes of planting.

214.04

**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.

- (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 replaced each month during the Landscape Establishment period as directed. Plant replacement stock shall be planted in accordance with the Contract and be 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 herein. The Contractor shall maintain all landscaped areas in the condition they were in when first installed and accepted.

Prior to 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 prior to 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 in accordance with 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.

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 plant 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 planting to be measured will be the number of plants, of the types and sizes designated in the Contract, that are actually planted and accepted.

The quantity of brush layer cuttings will be measured by the actual number planted, complete in place and accepted.

Landscape Maintenance will not be measured, but will be paid for on a lump sum basis.

214.06

**BASIS OF PAYMENT**

**214.06** The accepted quantities of planting, and brush layer cuttings will be paid for at the contract unit price for each of the various items listed below that appear in the bid schedule.

Payment for the total cost of the item will be made at the completion of planting.

Cost of the performance bond shall be included in the cost of the plant items.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
___ Tree ___ Inch Caliper	Each
___ Tree ___ Foot	Each
___ Shrub ( ___ Gallon Container)	Each
Perennials ( ___ Quart Container)	Each
Perennials ( ___ Gallon Container)	Each
Brush Layer Cuttings	Each
Landscape Maintenance	Lump Sum

Water required for all items of work will not be measured and paid for separately, but shall be included in the work.

Payment shall be full compensation for all work necessary to complete the item.

For each month that landscape maintenance is performed and accepted during the Landscape Maintenance period as specified in subsection 214.04, payment for Landscape maintenance will be made in installments as follows:

- (1) 10 percent of the lump sum amount will be paid for each of the eight growing season months, March through October.
- (2) 5 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.

Landscape Establishment, except for landscape maintenance, will not be paid for separately, but shall be included in the work.

**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, hereinafter referred to as “plants,” of the designated species in accordance with 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 which 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 in accordance with 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.

Prior to removal for transplanting, all coniferous trees shall be sprayed with an approved anti-desiccant.

The following table represents the minimum diameter of root balls for collected plants.

**Type 6 - Collected Pinon Pine**

<b>Caliper</b>	<b>Min. Ball Dia.</b>
1 to 1½ inch	15 inch
1½ to 2 inch	17 inch
2 to 2½ inch	20 inch
2½ to 3 inch	24 inch
3 to 3½ inch	26 inch
3½ to 4 inch	28 inch
4 to 4½ inch	30 inch
4½ to 5 inch	32 inch

215.03

**Type 7 - All Collected Plants Other than Pinon Pine**

<b>Caliper</b>	<b>Min. Ball Dia.</b>
1 to 1½ inch	14 inch
1½ to 2 inch	16 inch
2 to 2½ inch	20 inch
2½ to 3 inch	24 inch
3 to 3½ inch	28 inch
3½ to 4 inch	32 inch
4 to 4½ inch	36 inch
4½ 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 root-balls for machine transplanted plants.

<b>Caliper</b>	<b>Min. Spade Machine Size (Based upon root ball width)</b>
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 with which 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 prior to 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  $\frac{1}{4}$  to  $\frac{1}{2}$  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 in accordance with 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.

215.04

The quantity of transplanted trees to be measured will be the actual number of trees of the various caliper 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.

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:

<b>Pay Item</b>	<b>Pay Unit</b>
Transplant Tree __Inch	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 covering for erosion control on roadway ditches or slopes as designated in the Contract or as directed.

**MATERIALS**

**216.02**

(a) *Covering.* Covering shall consist of blankets with close weave mesh and nettings with open weave mesh made of various materials as specified herein.

Blankets and nettings shall be photodegradeable or biodegradable, non-toxic to vegetation or germination of seed, and shall not be toxic or injurious to humans.

1. *Excelsior.* Excelsior soil retention covering shall be either photodegradeable or biodegradable as follows.

A. The blanket shall consist of a machine produced mat of curled wood excelsior of 80 percent, 6 inch or longer fiber length with a consistent thickness of fibers evenly distributed over the entire area of the blanket. The top side of the blanket shall be covered with a photodegradable extruded plastic mesh and stitched on 2 inch centers the entire width of the blanket.

Dimensions: 48" by 180' or 96" by 90'  
Roll Weight: 0.9 to 1.1 pounds per sq. yd.

B. The blanket shall consist of a machine produced mat of curled wood excelsior of 80 percent, 6 inch or longer fiber length with a consistent thickness of fibers evenly distributed over the entire area of the blanket. The top side of the blanket shall be covered with a biodegradable netting, manufactured from a jute or other biodegradable material and stitched on 2 inch centers the entire width of the blanket.

Dimensions: 48" by 180' or 96" by 90'  
Roll Weight: 0.9 to 1.1 pounds per sq. yd.

2. *Soil Retention Blanket (Coconut).* Soil Retention Blanket (Coconut) shall be a machine produced mat consisting of 100 percent coconut fiber. The blanket shall be of consistent thickness with the coconut fiber evenly distributed over the entire area of the mat. The blanket shall be covered on the top and bottom side with polypropylene netting having ultraviolet additives to reduce breakdown and an approximate <sup>5</sup>/<sub>8</sub> inch x <sup>5</sup>/<sub>8</sub> inch mesh

216.02

size. The blanket shall be sewn together with polyester, biodegradable or photodegradable thread.

Material requirements:

Coconut Fiber Content:	100%, 0.50 to 0.60 lb. per sq. yd.
Netting:	Both sides, heavyweight nondegradable 3 lbs. per 1000 sq. ft.
Thread:	Polyester, biodegradable or photodegradable
Roll Width:	6.5 to 7.5 feet
Roll Length:	83.5 to 90 feet
Area Covered by One Roll:	60 to 75 sq. yds.

A sample of the soil retention blanket (coconut) shall be submitted at least 2 weeks in advance of its use on the project for approval by the Engineer.

3. *Soil Retention Blanket (Straw)*. Soil Retention Blanket (Straw) shall be a machine produced mat consisting of 100 percent agricultural straw. The blanket shall be of consistent thickness with the straw evenly distributed over the entire area of the mat. The blanket shall be covered on the top side with polypropylene netting having an approximate  $\frac{5}{8}$  inch x  $\frac{5}{8}$  inch to  $\frac{1}{2}$  inch x  $\frac{1}{2}$  inch mesh and on the bottom with polypropylene netting with an approximate  $\frac{1}{4}$  inch x  $\frac{1}{4}$  inch to  $\frac{1}{2}$  inch x  $\frac{1}{2}$  inch mesh. The blanket shall be sewn together with biodegradable or photodegradable thread.

Material requirements:

Straw Content:	100%, 0.50 lb. per sq. yd.
Netting:	Bottom side lightweight polypropylene photodegradable, 1 to 1.65 lbs. per 1000 sq. ft. Top side heavyweight or lightweight polypropylene photodegradable, 1.65 to 3 lbs. per 1000 sq. ft.
Thread:	Biodegradable or photodegradable
Roll Width:	6.5 to 7.5 feet
Roll Length:	83.5 to 90 feet
Area Covered by One Roll:	60 to 75 sq. yds

A sample of the soil retention blanket (straw) shall be submitted at least 2 weeks in advance of its use on the project for approval by the Engineer.

4. *Soil Retention Blanket (Straw and Coconut)*. Soil Retention Blanket (Straw/Coconut) shall be a machine produced mat consisting of 70 percent agricultural straw and 30 percent coconut fiber. The blanket shall be of consistent thickness with the straw and coconut fiber evenly distributed

over the entire area of the mat. The blanket shall be covered on the top side with polypropylene netting having an approximate  $\frac{5}{8}$  inch x  $\frac{5}{8}$  inch mesh and on the bottom with polypropylene netting with an approximate  $\frac{1}{4}$  inch x  $\frac{1}{4}$  inch to  $\frac{1}{2}$  inch x  $\frac{1}{2}$  inch mesh. The blanket shall be sewn together with cotton, biodegradable or photodegradable thread.

Material requirements:

Straw Content:	70%	0.35 lb. per sq. yd.
Coconut Fiber Content	30%	0.15 lb. per sq. yd.
Netting:	Bottom side lightweight polypropylene photodegradable, 1 to 1.65 lbs. per 1000 sq. ft.	
	Top side heavyweight or lightweight polypropylene photodegradable, 1.65 to 3 lbs. per 1000 sq. ft.	
Thread:	Cotton, biodegradable or photodegradable	
Roll Width:	6.5 to 7.5 feet	
Roll Length:	83.5 to 90 feet	
Area Covered by One Roll:	60 to 75 sq. yds	

A sample of the soil retention blanket (straw and coconut) shall be submitted at least 2 weeks in advance of its use on the project for approval by the Engineer.

- (b) *Pins and Staples.* Pins and staples shall be made of wire 0.162 inch or larger in diameter. "U" shaped staples shall have legs 8 inches long and a 1 inch crown. "T" shaped pins shall not be used.

## CONSTRUCTION REQUIREMENTS

### 216.03

- (a) *Excelsior.* The area to be covered shall be prepared, fertilized, and seeded in accordance with Section 212, before the blanket is placed. When the blanket is unrolled, the netting shall be on top and the fibers shall be in contact with the soil. In ditches, blankets shall be unrolled in the direction of the flow of water. The end of the upstream blanket shall overlap the buried end of the downstream blanket a maximum of 8 inches and a minimum of 4 inches, forming a junction slot. This junction slot shall be stapled across at 8 inch intervals. Adjoining blankets (side by side) shall be offset 8 inches from center of ditch and overlapped a minimum of 4 inches. Six staples shall be used across the start of each roll, at 4 foot intervals, alternating the center row so that the staples form an "X" pattern. A common row of staples shall be used on adjoining blankets.
- (b) *Soil Retention Blanket (Coconut), (Straw), and (Straw and Coconut).* The area to be covered with Soil Retention Blanket (Coconut), (Straw), and (Straw and Coconut) shall be properly prepared, fertilized, and seeded before the blanket is placed. When the blanket is unrolled, the heavyweight polypropylene netting shall be on top and the lightweight polypropylene netting shall be in contact with

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the soil. In ditches and on slopes, blankets shall be unrolled in the direction of the flow of water. Installation shall be in accordance with manufacturer's recommendations. A representative of the manufacturer shall be present to give instruction during the installation of the soil retention blanket.

The blanket shall be placed smoothly but loosely on the soil surface without stretching. The upslope end shall be buried in a trench 6 inches wide by 6 inches deep beyond the crest of the slope to avoid undercutting. For slope applications, there shall be a 6 inch overlap wherever one roll of blanket ends and another begins with the uphill blanket placed on top of the blanket on the downhill side. There shall be a 4 inch overlap wherever two widths of blanket are applied side by side. Insert staples in a pattern according to the manufacturer's recommendation at approximately two staples per square yard.

At terminal ends, and every 35 feet, Soil Retention Blanket (Coconut), (Straw), and (Straw/Coconut) placed in ditches shall be buried in a trench approximately 6 inches deep by 6 inches wide. Before backfilling, staples shall be placed across the width of the trench spaced at 6 inches on center in a zigzag pattern. The trench shall then be backfilled to grade and compacted by foot tamping.

- (c) *Maintenance.* The Contractor shall maintain the blanket, fabric, or netting areas 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 wind, fire, or other 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 prior to application of the covering and shall be refertilized, reseeded, and mulched as directed.

**METHOD OF MEASUREMENT**

**216.04** Soil retention covering, including staples, complete in place and accepted, will be measured by the square yard of finished surface. No allowance will be made for overlap.

**BASIS OF PAYMENT**

**216.05** The accepted quantities of soil retention covering will be paid for at the contract unit price per square yard.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Soil Retention Blanket (____)	Square Yard

Preparation of seedbed, fertilizing, and seeding will be measured and paid for in accordance with Section 212.

Mulching will be measured and paid for in accordance with Section 213.

## **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 prior to herbicide application. Herbicide mixing and application shall be done in accordance with instructions on the registered product label. The Engineer shall be furnished such label information prior to mixing and application.

The Contractor shall notify the Engineer at least 24 hours prior to 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 in accordance with 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.



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**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:

<b>Pay Item</b>	<b>Pay Unit</b>
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, and the management of solid, special and hazardous waste when encountered on the Project.

### MATERIALS AND EQUIPMENT

**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 in accordance with 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:

#### Instrument Detection

Constituent	Threshold Limit	Increments
Flammable Gas	1% LEL	1%
Oxygen	19%	0.1%
Toxic Gas	1 PPM	1 PPM

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, industrial area or other sites which 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 or industrial gases and hazardous substances which exist or migrate into the construction area.

Encountering suspected contaminated material, including groundwater, 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)4. shall be followed.

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Transportation of waste materials on public highways, streets and roadways shall be done in accordance with 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 a HSO, not the project superintendent, who shall have at least two years 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. 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 preconstruction conference, that the above requirements have been met.

The HSO shall be equipped with the following:



- (1) Communication equipment as required in subsection 250.03(d)2.A. 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 which 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 which 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. 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

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supervisory training required by OSHA and U.S. EPA rules and regulations which complies with the accreditation criteria under the provisions of the proposed 29 CFR 1910.121 is required prior to beginning work. The Contractor shall furnish documentation at the Preconstruction 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)2.A. 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) 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 Number 85-115, available from the Superintendent of Documents, U.S. Government Printing Office. The Contractor and the HSO shall review the environmental documents listed prior to preparation of the HASP.

Four signed copies of the HASP shall be furnished 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 signed and stamped (or sealed) copies of the accepted HASP to each emergency response agency servicing the project area, the HASP designated emergency hospital, and five copies to the Engineer. Earth or demolition work shall not occur until after the HASP is accepted and the HASP has been 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, and other appropriate agencies and officials as may be designated by the Engineer. The Engineer will distribute the accepted HASP to appropriate Department personnel. The HASP shall be kept current and shall be revised by the HSO 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 prior to their entry on site. A signature log of all briefing attendees shall be kept and furnished to the Engineer.

The Contractor shall provide, as required, eye wash 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 prior to 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 working days prior to 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

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acceptance; manifest (if required); etc. in accordance with 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 prior to the start of confined space entry, storage tank removal, drilling, excavation, trenching, or dewatering operations.
  - B. The HSO shall designate the on site 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 & photon radioactivity),
  - (6) Greater than 15 pCi/L (Gross alpha particle activity), or
  - (7) Other action levels as determined by the HSO.
- 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 prior to 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 1000 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

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recommendation to discontinue monitoring must be agreed to by the Engineer and the Contractor. Prior to 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, in accordance with 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 in accordance with 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 may be accomplished under the supervision of the HSO, if proposed by the HSO and approved by the Engineer. This investigation and study shall determine the extent of contamination and study the feasibility of 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. The Contractor shall prepare the Remediation Plan as directed. 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 produced was caused by Contractor action, 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 which 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 in accordance with OSHA Publication Number 3142, *Working with Lead in the Construction Industry*.

Paint Removal and Waste Disposal work shall be performed in accordance with 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 therein.

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 prior to 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

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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, herein 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. Prior to 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 which are not designated to be salvaged shall be recycled. Contractor possession of the steel for future use shall be considered a form of recycling. Prior to 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, this letter 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 which has been assumed to contain lead, chromium, other heavy metals, or a combination thereof the Contractor shall capture paint debris which 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 prior to 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 soils to be excavated for construction of the project which are suspected or known to be contaminated. This work also includes stockpiling or containerization, analytical sampling and testing, and final disposition of soils specially handled.

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 soils 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 soil, which has

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not been summarized in the plans or specifications, at unknown locations on the site. Suspected contaminated soil will be handled by one of three methods as follows:

- (a) *Materials Handling (Stockpile)*. When recommended by the HSO and authorized by the Engineer, material will be stockpiled 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.

Stockpiled 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 containing different contaminants shall be placed in separate stockpiles.
  4. The Contractor shall prevent the dispersion of materials or the dilution or mixing of stockpiles.
  5. The ground surface on which 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 in accordance with 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, or both as recommended by the HSO and approved by the Engineer. The Contractor shall haul this material to a solid waste disposal facility.
- (c) *Hazardous Waste Disposal*. Soils 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 hazardous waste disposal facility designated by the Engineer.

- (d) *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 soils, which have been identified as solid waste or hazardous waste, requiring disposal according to federal, state, and local regulations, shall be transported in accordance with 49 CFR by the Contractor to an appropriately permitted 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 prior to 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 in accordance with 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 in accordance with 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

250.06

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 Asbestos-Containing Material Management.** If known or suspected asbestos-containing material is encountered, the requirements of subsection 250.03(d)4. shall be followed. Management of asbestos-containing materials shall be by an Asbestos Inspector and Manager.

### **METHOD OF MEASUREMENT**

**250.08** 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:

Preparation and briefing of the initial HASP;  
Procedures and equipment specified in subsections 250.03 - 250.07;  
PPE (levels C and D) for Contractor's personnel for any contamination identified in the preconstruction investigations;  
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:

Field monitoring necessary to ensure the safety of workers on the site;  
Hours in excess of the items listed under Environmental Health and Safety Management;  
Hours that are necessary due to unforeseen site conditions; and  
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 & D) will not be measured and paid for separately, but shall be included in the hourly cost of the MT.

Materials stockpiled under the requirements of this specification will be measured by the cubic yard computed from cross sections by the average end area or other acceptable

250.09

method. Disposal of solid waste and 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 in accordance with subsection 109.04, unless such work is caused by the Contractor's action.

### **BASIS OF PAYMENT**

**250.09** 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 bid price.

The accepted quantity for Monitoring Technician will be the number of hours of on site 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 Materials 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 prior to disposal. This includes haul, stockpile, water collection, 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 Hazardous Waste Disposal will be made at the appropriate contract unit price for the disposal of material determined to be either solid waste or 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 off site. It does not include stockpiling required for analysis which is included in the item Materials Handling (Stockpile) paid for as described above.

250.09

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) on the project.

- (1) *Solid Waste Disposal.* Transport costs to the disposal facility and disposal fees will be included in the contract unit price for this work.
- (2) *Hazardous Waste Disposal.* Transport costs to the disposal facility and disposal fees will be paid for in accordance with subsection 109.04

The cost of shoring required to limit the removal of contaminated materials to the specified limits shall be included in the bid 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 in the plans, will be paid for in accordance with 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 construction operations 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.

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:

<b>Pay Item</b>	<b>Pay Unit</b>
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
Hazardous Waste Disposal	Cubic Yard

**SECTION 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 insure a thorough and homogenous mixture.

**304.06 Shaping and Compaction.** Compaction of each layer shall continue until a density of not less than 95 percent of the maximum density determined in accordance with AASHTO T 180 has been achieved. 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. Water shall be uniformly applied during compaction in the quantity necessary for proper consolidation.

The surface of the base course will be tested with a 10 foot straightedge, or other approved device. The surface shall be tested prior to 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  $\frac{1}{4}$  inch. All irregularities exceeding the specified tolerance shall be corrected to the satisfaction of the Engineer at no additional cost to the Department.

304.06

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:

<b>Pay Item</b>	<b>Pay Unit</b>
Aggregate Base Course (Class___)	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 in accordance with 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 prior to the application of any base course material. Where bituminous 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Reconditioning	Square Yard

Water will not be measured and paid for separately but shall be included in the work.

307.01

## **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 C 977 and rate of slaking test for moderate reactivity per ASTM C 110 and shall be the product of a high-calcium limestone as defined by ASTM C 51.

**307.03 Water.** Water used for mixing or curing shall be in accordance with 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, prior to 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.** Prior to 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  $\pm 0.1$  foot. The subgrade shall also be proof rolled in accordance with 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.** Prior to 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 in accordance with 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 prior to 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.

Prior to 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 prior to and after the lime treatment, the Contractor shall perform proof rolling in accordance with subsection 203.09, 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

307.08

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 herein. 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 prior to compacting. The specimens will be compacted and tested in accordance with AASHTO T 99, and the in-place field density will be determined in accordance with Colorado Procedure (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  $2 \pm 1$  percent above the optimum moisture

content. The optimum moisture content will be determined in accordance with AASHTO T 99.

- (b) The finished surface shall be smooth and uniform conforming to the typical sections specified. All irregularities, depressions, or weak spots, which 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 thereon 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 in accordance with 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 in accordance with 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

**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 Quality 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 in accordance with ASTM C 174. 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 of 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**

<b>Element and Procedure</b>	<b>Process Control</b>	<b>Acceptance</b>	<b>Remarks</b>
pH ASTM C 977 (App) (Design) ASTM G 51 (Field)	1/5,000 sq. yds. or fraction thereof	1/10,000 sq. yds. or fraction thereof	pH will be determined after % lime has been established based on unconfined compressive strength
Atterburg Limits AASHTO T 89, T 90	1/5,000 sq. yds. or fraction thereof	1/10,000 sq. yds. or fraction thereof	Reduce by ½ original PI
Swell Potential ASTM D 4546	1/5,000 sq. yds. or fraction thereof	1/10,000 sq. yds. or fraction thereof	½ % or less with 200 psf surcharge pressure Modified as per local practices
Unconfined Compressive Strength ASTM D 5102 (Procedure B)	1/5,000 sq. yds. or fraction thereof 1/soil type	1/10,000 sq. yds. or fraction thereof 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 C 174	A lot is defined as 1 core per 1,500 sq. yds. or fraction thereof	1/3,000 sq. yds. or fraction thereof	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 CP 31	1/5,000 sq. yds. or fraction thereof	1/10,000 sq. yds. or fraction thereof	1" – 100% passing; #4 – 60% passing, dry sieving after final mixing
Determining Percent Relative Compaction Soil-Aggregate by Nuclear Method CP 80	1/5,000 sq. yds. or fraction thereof	1/10,000 sq. yds. or fraction thereof	Minimum 95% of maximum dry density as 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 T 99	1/soil type	1/soil type	
Sulfate AASHTO T 290	1/soil type	1/soil type	Sulfate content shall be less than 0.2% by weight in a 10:1 water to soil solution.

307.13

### 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)<sub>2</sub>)

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:

<b>Pay Item</b>	<b>Pay Unit</b>
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 in accordance with Section 203.



## SECTION 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 bituminous mixture constructed on a prepared foundation in accordance with 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 bituminous 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 in accordance with 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 Section 703 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  $\mu$ m (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 2.2.1 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 Department will process one asphalt design mix for each pavement grading at no charge to the Contractor. The Contractor will be assessed a charge of \$3,000 for testing and evaluating each additional design mix submitted by the Contractor.

401.02

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.

- (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**

Asphalt Content	±0.3%
Asphalt Recycling Agent	±0.2%
Temperature of Mixture When Discharged from Mixer	±20 °F
<sup>1</sup> Hot Mix Asphalt - Item 403	
<sup>2</sup> Passing the 9.5 mm ( <sup>3</sup> / <sub>8</sub> inch) and larger sieves	± 6%
<sup>2</sup> Passing the 4.75 mm (No. 4) and 2.36 mm (No. 8 sieves)	± 5%
<sup>2</sup> Passing the 600 µm (No. 30) sieve	± 4%
<sup>2</sup> Passing the 75 µm (No. 200) sieve	± 2%
<sup>1</sup> 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.	
<sup>2</sup> These tolerances apply to the Contractor's Quality 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 in accordance with 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 2000 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 2000 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 2000 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 2000 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 8000 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 in accordance with QC/QA specifications.

**Table 401-2**

<b>Grading</b>	<b>Test Procedure</b>	<b>Minimum Test Result</b>	<b>Sampling Frequency</b>
All Gradings	CP L-5109 Method B	70	One per 10,000 tons or fraction thereof (minimum)

401.03

**401.03 Aggregates.** Aggregates shall meet the applicable requirements of Section 703 - Aggregates.

**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-Asphalt Cements.

### CONSTRUCTION REQUIREMENTS

**401.07 Weather Limitations and Placement Temperatures.** Hot mix asphalt shall be placed only on properly prepared unfrozen surfaces which 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	Layers Below Top Layer
<1½	60	50
1½ - <3	50	40
3 or more	45	35

Note: Air temperature is taken in the shade. Surface is defined as the existing base on which 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 than ten 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 can not be resurfaced in accordance with the above temperature requirements within ten 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 quality 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 which 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 During Which Planed or Recycled Surfaces Must be Overlaid within Ten 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 Bituminous Mixing Plant.** The bituminous 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 bituminous plant mix.

Dust, smoke, or other contaminants shall be controlled at the plant site to meet all air quality requirements in accordance with subsections 107.01 and 107.24.

Acceptable safety equipment shall be provided by the Contractor to accommodate sampling and testing.

Hot bituminous plant mix shall not be stored longer than nine hours, unless additional protective measures are used and approved.

When hot bituminous plant mix is obtained from a commercial plant, the Contractor shall make arrangements for approved laboratory facilities at the plant site for testing hot bituminous paving mixtures. The plant laboratory shall meet the requirements of subsection 620.04.

**401.09 Hauling Equipment.** Trucks used for hauling bituminous 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 Bituminous Pavers.** Self-propelled bituminous pavers shall be provided and equipped with an activated screed assembly, heated if necessary, capable of spreading and finishing the bituminous plant mix material in lane widths applicable to the typical

401.10

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 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 bituminous paver shall be equipped with a means of preventing the segregation of the coarse aggregate particles from the remainder of the bituminous 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 bituminous pavers:

- (1) Blaw-Knox bituminous pavers shall be equipped with the Blaw-Knox Materials Management Kit (MMK).
- (2) Cedarapids bituminous pavers shall be those that were manufactured in 1989 or later.
- (3) Caterpillar bituminous pavers shall be equipped with deflector plates as identified in the December 2000 Service Magazine entitled "New Asphalt Deflector Kit {6630, 6631, 6640}".

Prior to 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 bituminous paver segregation. Use of the paver shall not commence prior to receiving approval from the Engineer.

The Contractor shall supply a Certificate of Compliance that verifies that the approved means and methods used to prevent bituminous 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 in accordance with Section 407.

**401.12 Surface Conditioning.** Irregularities in the existing pavement or base shall be brought to uniform grade and cross section.

Prior to placing tack coat and beginning overlay work, the surface to be tack coated shall be swept to remove accumulations of loose gravel and debris.

Bituminous 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 prior to placing bituminous 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 in accordance with one of the following methods:

- (1) *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.

401.14

- (2) *Dry Lime Added to Wet Aggregate.* The dry hydrated lime shall be added to aggregate wetted a minimum of 2 percent above the surface saturated dry condition (SSD) of the blended aggregate as shown on the Form 43, and then thoroughly mixed in an approved pugmill. The Engineer will not require the Contractor to go above 5 percent total moisture, 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 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 QC 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**

<b>Asphalt Grade</b>	<b>Minimum Mix Discharge Temperature, °F*</b>	<b>Minimum Delivered Mix Temperature, °F**</b>
PG 58-28	275	235
PG 64-22	290	235
PG 76-28	320	280
PG 64-28	320	280
PG 58-34	300	280
* 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 in accordance with 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 bituminous 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.** Bituminous 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 joints shall not be constructed in the wheel paths. The Contractor shall submit a longitudinal joint and pavement marking plan three days prior to 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:

401.16

- (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:
  - (i) The entire joint shall be tapered 3:1 or flatter. A Taper steeper than 3:1 shall be considered vertical.
  - (ii) 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 bituminous 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, he 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. In accordance with 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 in accordance with 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 for Segregation Determination**

<b>Mix Grading</b>	<b>Key Sieves</b>	<b>Allowable Difference, %</b>
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 remove and replace 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, will 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 will be at the expense of the Contractor. If the area is determined to be non-segregated, the Engineer shall reimburse the Contractor \$2,000 for obtaining the ten cores.

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**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. If the mixture contains modified asphalt cement (PG 76-28 or PG 64-28) and the surface temperature falls below 230 °F, further compaction effort shall not be applied unless approved.

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.

Pavement shall be compacted to a density of 92 to 96 percent of the maximum theoretical density, determined according to CP 51. Field density determinations will be made in accordance with CP 44 or 81.

The longitudinal joints shall be compacted to a target density of 92 percent of the maximum specific gravity. The tolerance shall be  $\pm 4$  percent. Maximum specific gravity will be that shown on the Form 43 for the asphalt mix used in construction of the joint. If two Forms 43 apply to the joint material, the average of the maximum specific gravities shown on the Forms 43 will be used. Density (percent relative compaction) will be determined in accordance with Colorado Procedure 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 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 the expense of the Contractor. Coring locations shall be centered on the line where the joint between the two adjacent lifts abut at the surface. Core holes shall be repaired by the Contractor using materials and methods approved by the Engineer.

Incentive or disincentive payment determined for joint density in accordance with 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 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 with the surrounding area.

The Contractor shall construct a compaction pavement test section (CTS) for each job mix for which 2000 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 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 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 a minimum of seven random corings. The locations of these cores shall 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

401.17

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.

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 in accordance with 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 prior to determining density of the cores, meet the CTS density requirements, the Contractor may begin production paving and continue to place hot mix bituminous pavement under the following conditions:

- (1) The period during which the Contractor continues to pave without test results from cores shall not exceed one working day.
- (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 bituminous pavement placed subsequently will be subject to price reduction or removal and replacement.

After production paving work has begun, a new CTS shall be constructed when a change in the compaction process is implemented. A new CTS may be required for different layers of pavement. Each additional CTS shall be constructed as specified herein, and shall be sampled, tested and accepted or rejected as described herein.

All additional costs associated with construction of the CTS shall be at the Contractor's expense. The hot mix asphalt (HMA) placed in the CTS will be paid for in accordance with subsection 401.22, at the contract price for the HMA mixture.

**401.18 Joints.** Placing of the HMA paving 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 in accordance with 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 in accordance with subsection 105.07. If not specified otherwise on the plans, the roadway surface shall be subject to inches per mile requirements for Category I, Rural Interstate Highway, in accordance with Table 105-6.

When the Contract specifies that the smoothness of an asphalt pavement is to be based on the Percentage of Improvement, the Contractor may still choose to use pavement smoothness based on inches per mile. The Contractor shall notify the Engineer in writing at least three working days prior to commencing of paving operation regarding the decision to change from Percentage of Improvement to inches per mile.

#### **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, in accordance with 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 bituminous 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.

401.22

Coring for longitudinal joint density testing, 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 in accordance with 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.



## **SECTION 403 HOT MIX ASPHALT**

### **DESCRIPTION**

**403.01** This work consists of constructing one or more courses of hot mix asphalt (HMA) pavement on a prepared base in accordance with these specifications, and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established.

The HMA 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 & gutter forms, areas between the curb & gutter or sidewalk and the existing paved parking lots, and areas designated on the plans. These quantities will be restricted to small areas which require hand placement methods and where conventional paving equipment can not 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. Prior to 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 in accordance with subsection 401.22, at the contract unit price per ton for the bituminous mixture.

Payment will be made under:

403.05

<b>Pay Item</b>	<b>Pay Unit</b>
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 bituminous pavement as shown in the Contract, by cleaning, heating, scarifying, redistributing, re-leveling, compacting, and rejuvenating the existing bituminous material.

**MATERIALS**

**405.02** Asphalt rejuvenating agent shall meet the requirements of subsection 702.04.

**CONSTRUCTION REQUIREMENTS**

**405.03** Weather limitations shall be as provided in subsection 401.07. Prior to 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 bituminous 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 °F 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 bituminous 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 °F, no further compaction effort shall be

405.03

done unless approved. A minimum of 24 hours shall elapse before a bituminous pavement overlay is applied to the scarified pavement.

The weight per cubic foot of the existing bituminous surface shall be determined in accordance with 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 bituminous 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 prior to and after heating and scarifying shall be tested in accordance with subsection 105.07(c).

#### **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 bituminous surfacing.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Heating and Scarifying Treatment	Square Yard

Asphalt rejuvenating agent will be measured and paid for in accordance with Section 411.

**SECTION 406**  
**COLD BITUMINOUS PAVEMENT (RECYCLE)**

**DESCRIPTION**

**406.01** This work consists of pulverizing the existing bituminous 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 702.03.

The pulverized material shall meet the following gradation requirements:

Sieve Size	Percent Passing
31.5 mm (1¼ 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 °F and rising. Recycling operations shall be discontinued when the temperature is 60 °F 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 bituminous 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 which forms adjacent to a vertical face shall be removed prior to spreading the mixed material, except that such fillet adjacent to existing pavement which 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

**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 prior to 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 prior to 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 in accordance with 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 5000 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 that results 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 within ten 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, prior to placing any hot bituminous surfacing. Soft areas that are not caused by the Contractor or weather, shall also be repaired prior to placing the hot mix asphalt.

**406.08 Recycling Train.** The Contractor shall furnish a self-propelled machine capable of pulverizing the existing bituminous 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 prior to 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

406.08

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 bituminous 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 prior to and after cold recycling shall be tested in accordance with subsection 105.07(c).

### 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Cold Bituminous Pavement (Recycle)	Square Yard
Repair of Cold Bituminous Pavement (Recycle)	Square Yard

Bituminous materials will be measured and paid for in accordance with Section 411.



406.13

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.

407.01

**SECTION 407  
PRIME COAT, TACK COAT, AND  
REJUVENATING AGENT**

**DESCRIPTION**

**407.01** This work consists of preparing and treating an existing surface with bituminous material, and blotter material if required, in accordance with these specifications and in conformity with the lines shown on the plans or established.

**MATERIALS**

**407.02 Bituminous Material.** The type and grade of bituminous material for prime and tack coating will be specified in the Contract.

The bituminous material for all coatings shall meet the applicable requirements of Section 702. The bituminous 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 prior to 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 bituminous material and blotter material.

The distributor and equipment shall be capable of uniformly distributing bituminous 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 which are to be adjacent to new pavement shall be cleaned to permit the adhesion of bituminous materials.

**407.07 Application of Bituminous Material.** Bituminous 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 bituminous material at the junctions of spreads is not in excess of the specified quantity. Excess bituminous material shall be removed or distributed as directed. Skipped areas or deficiencies shall be corrected. Bituminous 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 prior to application of the coating.

**407.08 Application of Blotter Material.** If, after the application of the prime coat or rejuvenating agent the bituminous material fails to penetrate and the roadway must be used by traffic, blotter material shall be spread in the quantity required to absorb excess bituminous material.

## **METHOD OF MEASUREMENT AND BASIS OF PAYMENT**

**407.09** Bituminous material will be measured and paid for in accordance with 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.

408.01

## **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  $\frac{1}{8}$  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 702.06.

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 prior to 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  $\frac{1}{16}$  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  $\pm 5$  °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.

408.05

**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:

<b>Pay Item</b>	<b>Pay Unit</b>
Hot Poured Joint and Crack Sealant	Ton

All materials, equipment, and costs incidental to the preparation of the surface prior to application of the hot poured joint and crack sealant will not be paid for separately, but shall be included in the work.

409.01

## **SECTION 409 SEAL COAT**

### **DESCRIPTION**

**409.01** This work consists of furnishing and applying bituminous material and cover coat material on an existing surface, in accordance with 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 Bituminous Material.** Emulsified asphalt shall be polymerized rapid set emulsified asphalt conforming to the requirements of subsection 702.03 for either CRS-2P or HFRS-2P.

Rejuvenating agent shall conform to the requirements of subsection 702.04.

**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.** Bituminous material 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 seal coat.

**409.05 Equipment.** The following equipment or its equivalent shall be used:

- (1) Bituminous distributor and equipment shall be capable of uniformly distributing bituminous 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. The distributor's spreading capabilities shall be computer controlled or it shall be calibrated to conform to the distributor manufacturer's procedure prior to 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 bituminous material 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, which 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 bituminous material. 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 seal coat shall be cleaned of loose sand, dust, rock, mud, and all other debris that could prevent proper adhesion of the bituminous coating. The cleaning shall be accomplished by power broom, scraping, blading, or other approved measures. Seal coating operations shall not be started until the surface is approved.

**409.07 Applying Bituminous Material.** Bituminous material 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 prior to 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 bituminous material. The quantity of bituminous material 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 bituminous material shall not be in excess of the area which trucks loaded with cover coat material can immediately cover.

The spread of bituminous material 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 bituminous material will be allowed to chill, set up, dry, or otherwise impair retention of the cover coat.

The distributor shall be parked so that bituminous material will not drip on the surface of the traveled way.

**409.08 Application of Cover Coat Material.** Immediately following the application of the bituminous material, 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 bituminous material.

If directed, the cover coat material shall be moistened with water prior to spreading, to eliminate or reduce the dust coating of the aggregate. If cover coat material is lightweight aggregate it shall be moistened with water prior to spreading.

409.08

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 bituminous material 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 imbedded material. The Contractor shall conduct additional brooming if so directed.

A fog seal shall be applied at the rate of 0.1 gallon per square yard of diluted emulsion when directed. The emulsion shall be diluted with water at the rate of 50 percent water and 50 percent emulsion. The application rate and the dilution rate may be changed by the Engineer.

**METHOD OF MEASUREMENT**

**409.09** Seal coat will be measured by the number of tons or cubic yards of the designated type of cover coat aggregate.

**BASIS OF PAYMENT**

**409.10** The accepted quantities of seal coat will be paid for at the contract price per ton or cubic yard for cover coat material.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Cover Coat Material (Type___)	Ton
Cover Coat Material (Type__) (Lightweight)	Cubic Yard

Bituminous materials, including the bituminous material used for fog seal, will be measured and paid for in accordance with Section 411.



## **SECTION 411 BITUMINOUS MATERIALS**

### **DESCRIPTION**

**411.01** This work consists of furnishing bituminous materials of all types and the application of these materials in accordance with these specifications and details shown on the plans.

### **MATERIALS**

**411.02** All bituminous materials shall conform to the requirements of Section 702.

The type and grade of bituminous 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.

### **CONSTRUCTION REQUIREMENTS**

**411.03** Bituminous materials shall be fortified when required by the Contract with an additive of an approved type. Additive shall be uniformly blended with bituminous materials at the refinery, or through an approved in-line blender as specified in the Contract.

Asphaltic application methods which 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 bituminous material when it can be accomplished without pickup or tracking of the bituminous 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.

411.04

Concentrated asphalt rejuvenating agent will be measured by the gallon before any water is added.

**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:

<b>Pay Item</b>	<b>Pay Unit</b>
Asphalt Cement (___)	Ton
Emulsified Asphalt (___)	Gallon
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 Bituminous 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 in accordance with 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, unless it is fast track concrete pavement, which shall conform to the requirements for Class E concrete as specified in Section 601. When the Engineer has determined that the quantity of concrete pavement is too small to make the use of mechanical equipment practical, the Contractor will be permitted to use AASHTO M 43 Size 57 or 67 aggregate in lieu of the coarse aggregate specified in Section 601.

**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 Quality Control Plan (QCP) 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 QCP are met. This QCP shall be submitted to the Engineer at the Preconstruction Conference. Paving operations shall not begin until the Engineer has approved the

412.05

QCP. This QCP 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 regards 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 QCP 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 nonagitator equipment. Bodies of nonagitating 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.

Consolidation shall be accomplished by vibrators for the full width of the concrete paving slabs. The vibrators shall be the internal type meeting the following requirements:

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 hand held 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 1¾ 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 1200 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) *Tining Equipment.* When longitudinal tining is required, the concrete pavement shall be longitudinally tined with a metal device with a single row of tines. The tines shall be of such dimensions as to produce grooves parallel with the centerline of the road in accordance with the dimensions specified in subsection 412.12(d). The tining machine shall be mechanically operated and shall cover the full pavement width in a single pass at a uniform speed and depth. Longitudinal tining shall be accomplished by equipment with horizontal and vertical controls to ensure straight, uniform grooves. Hand tining will be allowed on irregular areas or areas inaccessible to the tining machine. Hand tining shall consist of creating uniform grooves placed parallel with the centerline of the road.
- (d) *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

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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 in accordance with subsection 107.25.

- (e) *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 such a manner as to require as little rehandling as possible. Concrete for areas which 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 2000 psi prior to commencing paving. Determination that the concrete has reached 2000 psi shall not relieve the Contractor of the responsibility for protecting the pavement.

Any concrete or foreign materials 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.

**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.

The Contractor shall not add water 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 or 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 finish machine to provide an acceptable surface finish, after corrective action, will be cause for requiring replacement of the finish machine.

Wastewater generated from concrete finishing operations shall be contained and disposed of in accordance with subsection 107.25.

- (a) *Hand Finishing.* Unless otherwise specified, hand finishing methods will be permitted only under the following conditions. In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade when the breakdown occurs. Narrow widths or areas of irregular dimensions, or where operation of the mechanical equipment is impractical, may be finished by hand methods.

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.

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- (b) *Floating.* Hand floating will be permitted only as specified in subsection 412.12(a) above. Floats made of aluminum shall not be used.
- (c) *Final Finish.* For the final finish a strip of plastic turf shall be dragged longitudinally over the full width of pavement after a strip of burlap or other approved fabric has been dragged longitudinally over the full width of pavement to produce a uniform surface of gritty texture.

The plastic turf drag shall be made of material at least 3 feet wide and be maintained in such a condition that the resultant surface finish is of uniform appearance and reasonably free from grooves over  $\frac{1}{16}$  inch in depth. Where more than one layer of burlap drag is used, 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.

- (d) *Tining and Stationing.* Where posted speeds are 40 mph or higher, the surface shall be given a longitudinal metal tine finish immediately following turf drag. Tining is not required where posted speeds are less than 40 mph. Tining shall produce grooves of  $\frac{1}{8}$  inch by  $\frac{1}{8}$  inch spaced  $\frac{3}{4}$  inch apart and parallel to the longitudinal joint. Longitudinal tining shall stop at the edge of travel lanes. Tining devices shall be maintained clean and free from encrusted mortar and debris to ensure uniform groove dimensions. The tining finish shall not be performed too early whereby the grooves may close up.

Before paving the Contractor shall provide in writing a tining plan showing tining locations and describing methods that will be used for hand tining. Paving shall not commence until the Engineer has approved the tining plan in writing.

The tining grooves shall be neat in appearance, parallel with the longitudinal joint, uniform in depth and in accordance with what is shown in the plans and these specifications. Any time that the tining grooves do not meet these requirements, the concrete paving operation shall be immediately stopped and shall not resume until the problem has been resolved.

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.

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 and sealing are complete.



After the proper curing period, the sawed joint shall be thoroughly cleaned and immediately sealed in accordance with 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  $\frac{1}{8}$  inch greater than the required bar diameter shall be drilled laterally into the hardened concrete slabs at one half the slab depth, 30 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  $\frac{1}{4}$  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 insure 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 average bar pullout resistance is at least 11,250 pounds with slippage of  $\frac{1}{16}$  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 be at least 2500 psi before testing. The procedure and apparatus for performing pullout testing shall be as approved.

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.

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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 prior to placement of concrete.

2. *Transverse Construction Joints.* Transverse construction joints shall be constructed as specified in the Contract. Transverse construction joints shall be constructed when the concrete placement is interrupted for more than 30 minutes and initial set is imminent. No transverse joint shall be constructed within 2 feet of another transverse joint. If sufficient concrete has not been mixed at the time of interruption to form a slab at least 2 feet long, the concrete back to the preceding joint shall be removed and the bulkhead placed in accordance with 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 prior to 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, when requested by the Engineer, expose the bars while the concrete is still plastic to verify the tie bar's final location. The cost and repair of the concrete will not be measured and paid for separately, but shall be included in the item of work. Should the tie bars be found to be closer than 1 inch to the bottom of the sawed joint, or closer than 2 inches to the bottom of the slab, or if the spacing between tie bars is found to be greater than 32 inches, the Contractor shall cease paving operations until it can be successfully demonstrated that the required tolerances can be met. The weakened plane joint shall then be made by sawing in hardened concrete in accordance with the plan details.

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. 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. Dowel bars shall be furnished in a rigid welded assembly or, when the Contractor demonstrates that the placement can be made within required tolerances, placed by a dowel insertion machine. Dowel insertion machine may be used only with written permission from the Engineer. The rigid assembly shall be fabricated from number 1/0 wire or heavier with vertical support wires every 1 foot. 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. See standard plan M-412-1 for schematic describing the measurement of each tolerance. Dowel placement tolerances are:

Horizontal = 1 inch,  
 Horizontal translation = 2 inches,  
 Horizontal Skew =  $\frac{3}{8}$  inch,  
 Vertical =  $\frac{1}{4}$  inch,  
 Vertical Skew =  $\frac{3}{8}$  inch.

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 in accordance with 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, including tined grooves and exposed sides of the newly placed concrete, shall be sprayed uniformly with an impervious membrane curing compound. The impervious membrane curing compound shall meet the requirements of AASHTO M 148, Type 2 and shall be volatile organic content (VOC) compliant. The concrete shall not be left exposed for more than 30 minutes before being covered with curing compound. Failure to cover the surface of the concrete within 30 minutes shall be cause for immediate suspension of the paving operations.

Curing compound shall be applied under pressure by mechanical sprayers at the rate of not less than 1 gallon per 150 square feet of pavement surface. Curing compound may be applied in two passes, one forward and one backward. The spraying equipment shall be fully atomized, 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

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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 application, the damaged portions shall be repaired immediately with additional compound.

The sides of pavement slabs shall be immediately sprayed with curing compound when the forms are removed.

In addition, for Class E concrete, 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.

**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. Three maturity meters shall be used 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 meters shall remain in place until the concrete has attained a compressive strength of 2000 psi. 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. Each maturity meter shall be capable of recording the time and temperature at three depths, ½ inch below the surface, mid slab and ½ inch above the bottom of the pavement.

The Contractor shall develop maturity relationships for each mix placed during the cold weather conditions described above in accordance with ASTM C 1074 with the following additions or modifications:

- (1) The cylinders used to establish the compressive strength vs. maturity relationship shall be cast and cured in the field in conditions similar to the project.
- (2) These cylinders shall be tested in pairs at times which yield compressive strengths where three sets are at or below 2000 psi and one is above 2000 psi.
- (3) Testing to determine datum temperature or activation energy will not be required.
- (4) A test slab shall be cast at the same time and location as the cylinders. The test slab shall have a length and width of 6 feet and a thickness equal to the

pavement design thickness. Slab maturity will be determined with two probes located in the slab approximately 1 foot and 2 feet from the edge. The test slab shall be cured and protected in the same manner as that being used on the project.

The development of the maturity relationship and maturity determination of the test slab is part of the trial mix and shall be submitted to the Engineer prior to 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 2000 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 in accordance with ASTM C 856.
- (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 prior to joint sealing and final smoothness measurement. Defective concrete pavement replaced after smoothness measurement shall be retested for final smoothness. The Contractor's corrective work plan shall be approved prior to performing the work.

When necessary, the extent of defects will be determined by the inspection of cores drilled at the Contractor's expense.

Pavement slabs with any of the following conditions shall be removed and replaced:

- (1) Pavement slabs in driving lanes containing one or more cracks through the full depth of the slab that separate the slab into two or more parts. If the Contractor can demonstrate that the crack was caused by factors beyond the Contractor's control, the Contractor will be reimbursed the costs to remove and replace the slab.
- (2) Pavement slabs containing honeycombed areas.
- (3) Pavement slabs containing an extreme void as defined below.
- (4) Pavement slabs containing more than one void greater in depth than half the pavement thickness.

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- (5) 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.
- (6) Pavement slabs containing 20 or more severe voids as defined below.

A void is a defect in a slab caused by air pockets, clay balls, clumps of sand, cement or reinforcing fibers caused by incomplete mixing or foreign materials such as cans, rags, bottles, etc. The defect will be considered a moderate void when the largest dimension, either height, width or length is at least ½ inch but no 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 penetrate partial depth may, with the written approval of the Engineer, be epoxy injected using materials from the Department's Approved Products List and methods approved by the Engineer.

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 2 inches 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 2 inches.
- (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 or crack. 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 which 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.

**412.17 Surface Smoothness.** The roadway surface smoothness shall be tested in accordance with subsection 105.07. If not specified otherwise on the plans, the

roadway surface shall be subject to inches per mile requirements for Category I, Rural Interstate Highway, in accordance with Table 105-6.

**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 in accordance with subsection 412.16.
- (2) Corrective work for tining.
- (3) Corrective work for pavement smoothness in accordance with 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 prior to 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 prior to 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 prior to 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 prior to expiration of the sealant manufacturer's recommended concrete pavement curing period, if any.

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| 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. Smearred 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 not less than  $\frac{7}{32}$  inch and shall be furnished in sections not less than 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 not less than  $\frac{2}{3}$  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 2000 square yards. The top face of the form shall not vary from a true plane by more than  $\frac{1}{8}$  inch in 10 feet, and the vertical leg shall not vary more than  $\frac{1}{4}$  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 in accordance with 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  $\frac{1}{2}$  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 ¼ 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 prior to 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 in accordance with subsection 412.14.

**412.20 Construction by Slip Form Method.** The subgrade shall be completed in accordance with 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 105-6 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.

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**412.21 Determining Pavement Thickness.** The Contractor shall perform the process control (PC) testing for pavement thickness. A process control testing plan shall be submitted and must be approved prior to 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 1250 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 1250 linear feet long, intersections, entrances, crossovers, ramps, etc., shall be grouped into units of 1000 square feet or remaining fraction thereof. 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 in accordance with AASHTO T 148. When the cores are removed from the pavement, the Engineer will take possession and determine their length in accordance with AASHTO T 148.

The lower tolerance limit ( $T_L$ ) for pavement thickness shall be Plan Thickness (PT) minus 0.4 inches. This  $T_L$  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.

Coring frequency shall be in accordance with subsection 106.06. 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 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 in accordance with 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 process control (PC) test that is less than  $T_L$  but greater than PT minus 1.0 inch. If the length of the additional core is greater than  $T_L$ , no additional actions will be taken and the original randomly selected acceptance test core will be used to compute I/DP for the process that includes this material.
- (2) If the additional core or any randomly selected core is less than  $T_L$  but greater 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. 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 in accordance with Section 105. Cores taken at locations not randomly determined, such as process control cores will not be used to compute I/DP.
- (3) When the measurement of any core is less than PT (Plan Thickness) minus 1.0 inch, whether randomly located or not, the area represented by this core shall become a separate process and this core will not be used to compute an I/DP. The actual thickness of the pavement in this area will be determined by taking exploratory cores. 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.

Pavement areas found to be less than PT minus 1.0 inch shall be removed and replaced at the Contractor's expense. Exploratory cores taken at the Contractor's expense will be used to determine the extent of deficient pavement for pavement removal.

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 in accordance with 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 non-shrink high strength grout.

**412.22 Opening to Traffic.** The Engineer will determine when the pavement shall be opened to traffic; otherwise the pavement shall not be opened to traffic until 14 days

412.22

after the concrete was placed or the concrete has achieved a compressive strength of 3000 psi. Prior to opening the pavement to traffic the roadway shall be cleaned, as approved.

Pavements placed with Class E concrete may be opened to traffic when the concrete has reached a maturity value that indicates the concrete has a compressive strength of at least 2500 psi as determined by ASTM C 1074 as modified in subsection 601.05.

### 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 ½ inch greater than the specified depth that continues for a length of 200 feet or more. Yield shall be determined in accordance with 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 in accordance with 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**

(a) *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:

<b>Pay Item</b>	<b>Pay Unit</b>
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 any dowels, tie bars, joint materials, tining, 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 in accordance with 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.

- (b) 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 in accordance with subsections 105.06 and 412.21. I/DP for other elements will be applied to the contract unit in accordance with Section 105.

Adjustments in payment because of deviations in air content will be in accordance with subsection 601.17 using \$100.00 per cu. yd. for the unit bid price.

420.01

## **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 subsection 712.08 for the use intended. Geotextiles for erosion control for drainage\_or for separators may be either Class A or Class B 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 conform to the requirements of Table 712-6 in subsection 712.08.

### **CONSTRUCTION REQUIREMENTS**

**420.03** Areas on which 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 which 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 in accordance with 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 prior to 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, in accordance with 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 prior to dumping into the asphalt paver.

Traffic shall be kept off all newly placed binder and geotextile material until the bituminous 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 in accordance with 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 in accordance with 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 prior to 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

420.07

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 in accordance with 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**

<b>Subgrade Strength_R-Value</b>	<b>Overlap Width (Unsewn Seam) Inches</b>
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 prior to geotextile application.

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 in accordance with the



manufacturer's recommendation. Where two or more widths of geotextile are applied side by side, they shall be overlapped in accordance with 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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.



420.10



## **SECTION 500 STRUCTURES**

### **SECTION 501 STEEL SHEET PILING**

#### **DESCRIPTION**

**501.01** This work consists of furnishing and driving corrugated steel sheeting or steel sheet piling in accordance with 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 nongalvanized interlocking type, at least 8 gage 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 A 857, Grade 36 for 7 gage or 8 gage steel, Grade 30 for heavier gages. 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 which 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.

501.05

The area of sheet piling cut-off to be measured will be those random areas of sheet piling which 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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 all types of piling shown in the Contract, other than sheet piling, in accordance with these specifications. Each pile shall be installed at the location and to the elevation, penetration, and bearing shown on the plans or established.

### MATERIALS

**502.02 Steel Piling.** Structural steel shapes used as piling shall conform to the requirements of AASHTO M 270 Grade 36.

Steel pipe shall conform to the requirements of ASTM A 252, Grade 2. Closure ends shall conform to the requirements of AASHTO M 270 Grade 36.

Steel shell piles shall conform to the requirements of AISI C 1010 or C 1015 steel.

Closure plates, driving points and their connecting welds shall not project beyond the perimeter of the pile tip for steel pipe and steel shell piles.

Commercial driving points may be used for end bearing piles. All steel pipe piles and steel shell piles shall be filled with Class B concrete conforming to subsection 601.02.

Steel piling may be ordered in plan lengths or in 30 to 60 foot lengths.

### CONSTRUCTION REQUIREMENTS

**502.03 Pile Driving Equipment.**

(a) *Pile Hammers.* Steam, air, diesel, or hydraulic impact hammers may be used to drive all types of piles. Vibratory or gravity hammers shall not be used to drive bearing piles.

1. For steam, air, and diesel hammers, a minimum manufacturer's rated energy as shown in Table 502-1 shall be used.

**Table 502-1**

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

502.03

The rated energy of the hammer shall not be greater than 2500 foot-pounds per square inch of unit area.

If more than one size of piling is designated in the Contract, the Contractor shall provide the necessary hammer or hammers to meet these requirements for all sizes of piles used.

2. Hydraulic hammers may be substituted for steam, air, and diesel hammers. The minimum energy requirement for hydraulic hammers shall be 40 percent of the value specified in Table 502-1. The maximum impact energy of hydraulic hammers shall be adjusted to not exceed 1000 foot-pounds per square inch of pile unit area.
  3. When designated in the Contract, a hammer with a rated energy determined by the Wave Equation Analysis Program (WEAP) shall be used. When the WEAP is used in the design phase of a project, a range of acceptable hammer energies will be included in the Contract.
- (b) *Hammer Cushion.* All impact pile driving equipment except hydraulic hammers shall be equipped with a suitable hammer cushion to prevent damage to the hammer or piles and to insure uniform driving behavior. Wood, wire rope, and asbestos cushion material shall not be used. A striker plate as recommended by the hammer manufacturer shall be used. The hammer cushion may be inspected by the Engineer at anytime during progress of the work. 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) *Pile Driving Head.* Appropriate driving heads, mandrels, or other devices shall be provided in accordance with the manufacturer's recommendations.
- (d) *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 insure 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.
- (e) *Followers.* Followers shall be used only when specified on the plans or approved in writing by the Engineer.

**502.04 Approval of Pile Driving Equipment.** All pile driving equipment discussed in subsection 502.03 shall be approved by the Engineer prior to delivery to the site. Approval will be based upon pile driving equipment data, such as rated energy, impact energy, or striking ram weight, which the Contractor shall submit. When the equipment is of questionable adequacy, the WEAP will be used to determine approval.

If the Contract includes hammers determined by subsection 502.03(a)3., the Contractor will be notified of the acceptance or rejection of the driving system within ten calendar days of the Engineer's receipt of the pile and driving equipment data. The

approval criteria for wave equation analysis will consist of (1) the pile stress at the required ultimate pile capacity and (2) pile driveability.

The driving stresses in the pile indicated by the Wave Equation Analysis shall not exceed 90 percent of the yield stress of the steel.

Once approved, changes in the pile driving equipment shall not be made without additional approval, and will be considered only after the Contractor has submitted the necessary information for a revised Wave Equation Analysis. The approval process outlined above shall be applied to the revised driving equipment.

All pile hammers delivered to the job site which the Engineer determines, either by observation or by pile driving analyzer, are not in good working condition will be rejected.

**502.05 Driving Piles.** Foundation piles shall not be driven until the excavation 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 with a variation of not more than  $\frac{1}{4}$  inch per foot from the vertical or from the batter shown in the Contract. Foundation piles shall not be out of the position shown in the Contract more than 6 inches after driving.

A minimum pile penetration of 10 feet 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 a minimum pile tip elevation is specified in the Contract, all piles shall be driven to or below this elevation unless otherwise approved in writing. If the pile cannot be driven to the minimum tip elevation, the Engineer will determine if predrilling is required. Any predrilling not required by the Contract and ordered by the Engineer will be paid for in accordance with subsection 109.04. The depth of the predrilling will be determined by the Engineer.

Piles shall be driven to virtual refusal in natural ground at or below the estimated tip elevations specified on the plans. Virtual refusal is defined as a penetration of 1 inch or less for the final ten blows unless modified by the Engineer based on the pile driving analyzer results as described below. If virtual refusal 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 Engineer may order the driving to be continued for 40 additional blows.

Water jets may be used in conjunction with the hammer to obtain the specified penetration only with approval. The last 3 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 will not modify any of the requirements of this section.

502.05

The Engineer may monitor the pile driving by using a Pile Driving Analyzer (PDA) to determine the condition of the pile, the efficiency of the hammer and the static bearing capacity of the piles, and to verify or modify the pile driving criteria specified in this Section. Modifications may include relaxing or stiffening the refusal criteria. The monitoring will be conducted by the Engineer. It is estimated that the Engineer will need approximately one hour per pile to install the PDA measurement equipment. Not more than two piles per project will be monitored unless specified in the Contract. All necessary work performed by the Contractor associated with the dynamic monitoring will not be paid for separately but shall be included in the work. If the Engineer requests additional piles to be monitored, or requests the Contractor to monitor the pile or piles, all necessary time required and work performed by the Contractor will be paid for in accordance with subsection 109.04.

**502.06 Drilling Holes to Facilitate Pile Driving.** Holes to facilitate pile driving shall be drilled at all locations shown on the plans and to elevations shown.

When test piles are shown on the plans they shall be used to determine if drilling holes to facilitate pile driving is required.

If the test pile or piles do not reach the estimated tip elevation as specified in subsection 502.05, holes shall be drilled to facilitate pile driving.

If the test pile or piles reach the estimated tip elevation shown on the plans and develop the required bearing capacity as determined in subsection 502.05, drilling holes will not be required and the remainder of the piles shall be driven in the normal manner.

The drilling of holes shall be done in such manner that the piling will stand accurately positioned as shown on the plans.

The diameter of the drilled holes and the material used to fill oversize holes shall be as stipulated herein unless otherwise designated on the plans.

The minimum diameter of the drilled holes shall be 1 inch larger than the outside diameter of steel pipe piles. The minimum diameter of the drilled holes shall be 2 inches larger than the web depth for H piles.

The maximum diameter of the drilled holes shall be 2 inches larger than the minimum diameter specified above. If the maximum diameter of the drilled hole is exceeded due to sloughing, drifting, over-drilling, or other causes, the void area between the driven pile and the edge of the hole shall be filled with sand or pea gravel 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.

**502.07 Capping Piles.** Steel pipe or shell piles will be inspected after all adjacent piles within a 5 foot radius have been driven. The Contractor shall supply suitable



lights for the inspection of the insides of these piles. Water or other foreign material shall be removed and the pipe or shell shall be filled with concrete.

The tops of all steel piles shall be cut off square and embedded in the concrete as shown on the plans.

**502.08 Extensions and Splices.** There will not be a limit placed on the number of splices allowed for steel piles; however, payment will be limited to two splices per pile.

Steel piling shall be spliced with a square-groove butt-joint weld using a  $\frac{1}{8}$  inch root opening. Weld deposition on pipe piles shall be made in two separate passes around the outside perimeter of the pile. Weld deposition on steel "H" piles shall be made in two passes. The first pass shall be made from one side of the part being welded and shall penetrate one-half the thickness of the member. The second pass shall be made on the side opposite from the first. For both types of piles, the slag left by the first pass shall be completely removed before making the second pass. All cuts at splices are to 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. Splices must be authorized.

Welding shall conform to the applicable requirements of ANSI/AWS D1.1.

Welders shall be prequalified in accordance with the standard qualification procedure of the American Welding Society. The Engineer may consider a welder qualified when the Welders' Certificate states that the welder has been doing satisfactory welding of the required type within a one year period previous to the subject work. A certification shall be submitted for each welder and for each project, stating the name of the welder, the name and title of the person who conducted the examination, the kind of specimens, the positions of welds, the results of the tests and the date of the examination. Such certification of pre-qualification may also be accepted as proof that a welder on field welding is qualified, if the Contractor who submits it is properly staffed and equipped to conduct such an examination or if the examining and testing is done by a recognized agency which is staffed and equipped for such purpose.

Approved commercial splices may be used as an alternate for welded splices.

**502.09 Defective Piling.** Piles damaged in driving by reasons of internal defects or improper driving; driven out of their proper location; or driven below the elevation specified on the plans without approval shall be corrected at the Contractor's expense 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.
- (3) The pile shall be spliced or built up.
- (4) A sufficient portion of the footing shall be extended to properly embed the pile.

All piles pushed up by the driving of adjacent piles shall be driven down again.

502.10

**502.10 Pile Tips.** Pile tips shall be placed on piles when shown on the plans. Pile tips and details for fastening tips to piles shall be in accordance with the plans or approved. If difficult driving conditions are encountered, the Engineer may order the Contractor to furnish and attach pile tips even though tips are not required by the plans. In that event, the tips will be paid for in accordance with subsection 109.04.

**502.11 Painting Steel Piles.** The exposed portion of steel piles not embedded in concrete, including 2 feet below the stream bed or ground line, shall be painted as described in Section 509.

### METHOD OF MEASUREMENT

**502.12** Piling will be measured by the linear foot in place. Measurement shall be from the tip to the cut-off elevation.

The length of pile cut-off to be measured will be those random lengths of piling which result from cutting off the tops of driven piles and which are not used in the work.

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, except when extra splices are ordered.

Splices for piles will be measured as additional length of pile. The additional length for each splice will be as follows: steel "H" piles, 3 linear feet; steel pipe piles, 3 linear feet.

Pile tips and end closure plates for steel pipe piles will be measured by the actual number used.

Drilled holes to facilitate pile driving will be measured by the linear foot, to the nearest foot.

### BASIS OF PAYMENT

**502.13** 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Steel Piling (size)	Linear Foot
Steel Pipe Piling (size)	Linear Foot
Steel Shell Piling (size)	Linear Foot
Drilling Hole to Facilitate Pile Driving	Linear Foot
End Plate	Each
Pile Tip	Each

502.13

Steel cut-offs 10 feet or less in length will be paid for at the contract unit price less 20 percent. These cut-offs shall become the property of the Contractor.

Pile 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 in accordance with subsection 104.03.

Concrete used to fill steel pipe will not be measured and paid for separately, but shall be included in the work.

503.01

## **SECTION 503 DRILLED CAISSONS**

### **DESCRIPTION**

**503.01** This work consists of drilling holes and placing reinforcing steel and concrete in the drilled holes in accordance with these specifications and in conformity with the lines and grades on the plans or established.

### **MATERIALS**

**503.02** Concrete shall be Class BZ or as specified in the Contract, and shall conform to the requirements of Section 601.

Reinforcing steel shall conform to the requirements of Section 602.

### **CONSTRUCTION REQUIREMENTS**

**503.03 Drilled Holes.** Caisson excavation shall be performed by heavy duty drilling rigs suitable for penetrating the cobbles, boulders, and bedrock to the required depths. Blasting will not be allowed.

The top of the caissons shall be the elevation shown on the plans. The elevations of the bottom of the caissons shown on the plans are approximate only and may be revised by the Engineer depending on the conditions encountered. The minimum embedment length into bedrock shall be as shown on the plans. Materials resulting from drilling shall be disposed of by the Contractor.

The maximum permissible variation of the center axis of any shaft at the top from its plan location shall be the greater of 3 inches or  $\frac{1}{24}$  of the shaft diameter. Caissons shall not be out of plumb more than three percent of their length. If a drilled hole does not meet these requirements, it shall be reamed or redrilled as required to bring it to the proper alignment, or drilled an additional distance, as approved by the Engineer. Additional concrete required as a result of these measures shall be provided at the Contractor's expense.

The excavation shall be protected with a suitable cover which will prevent persons or materials from falling into the hole.

When caving conditions are encountered, drilling shall be discontinued until the construction method used will prevent excessive caving.

**503.04 Cleaning and Inspection.** Holes shall be pumped free of water, cleaned of the loose material, and inspected by the Engineer. A drilled hole may be entered for inspection when deemed necessary by the Engineer, but only when a protective casing is in place. The Contractor shall provide fresh air ventilation, electric lights, suitable means of access, the protective casing, and shall assist the Engineer, as directed, in making the required inspection of the drilled excavation and foundation material.

**503.05 Reinforcing Steel.** After a hole has been inspected and approved, the reinforcing steel shall be installed and the concrete placed as soon as possible.

The required reinforcing steel cage for the drilled caisson shall be completely assembled and placed as a unit for the full length of the caisson immediately prior to the placing of any concrete. 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.

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. Approved spacers shall be provided at intervals not to exceed 10 feet along the cage to insure concentric positioning for the entire length of the cage; a minimum of three spacers shall be provided at each spacing interval. Additional reinforcement may be added to stiffen the cage at the Contractor's option and expense.

**503.06 Steel Casing.** If casings are used, they shall be steel of ample thickness and strength to withstand distortion due to handling, the internal pressure of fresh concrete, and the external pressure of the surrounding soil and ground water, and shall be watertight. The inside diameter of the casing shall be equal to or larger than the caisson dimensions shown on the plans. The use of casings larger than the diameter of the caissons shown on the plans must have prior approval from the Engineer. Additional concrete required due to the use of oversize casings shall be provided at the Contractor's expense.

Casings shall be removed unless otherwise designated on the plans. Casings shall be removed in a manner such that voids between the excavation and the casing will be completely filled with fresh concrete. The removal method shall prevent the intrusion of water, sloughing of the excavation, displacement of the reinforcing steel, and lifting of the concrete. The casing removal shall be performed in a manner that minimizes the displacement of the concrete from its initial placement point. If the casing is stuck and can't be removed without damaging the hole, it may be cut off and left in place with the Engineer's approval, or other remedial measures taken as approved. The top elevation of the reinforcing steel cage shall be checked before and after the casing removal. Upward movement in excess of 2 inches or downward movement in excess of 6 inches of the reinforcing steel cage will be cause for rejection of the caisson. Concrete settlement in the caisson will be determined by measuring the top surface of the concrete: (1) immediately after the casing is removed and additional concrete poured to the desired elevation; and, (2) at least four hours later. Concrete settlements in excess of  $\frac{1}{2}$  of the caisson diameter will also be cause for rejection of the caisson.

503.07

**503.07 Concrete.** For any portion of the caisson socketed in shale, if the concrete is not placed within four hours of drilling, the Contractor shall drill into the bedrock an additional  $\frac{1}{3}$  of the specified penetration prior to placing the concrete. The reinforcing cage shall extend to the new tip elevation.

Foundation piling shall not be driven nor excavation performed within a radius of 20 feet, nor additional caissons drilled within a clear distance of 3 feet, of concrete that has not attained a compressive strength of at least 1500 psi as determined by the Engineer.

Other construction methods, such as slurry displacement, may be used, if approved. The procedure for step-by-step construction shall be approved prior to beginning the work.

Concrete for each drilled caisson shall be placed in one continuous pour. Concrete may be placed in a dry hole by free-drop from the surface provided that a hopper or other approved device is used to force the concrete to drop straight down without hitting the sides of the hole or any reinforcing steel before striking the bottom. A drilled hole may be considered dry at the time of concrete placement if, without dewatering, the water depth at the bottom of the hole is not in excess of 2 inches.

Where an excavation cannot be practically dewatered for the placement of concrete, the Engineer may authorize a portion of the concrete to be placed under water in accordance with subsection 601.12(f). Concrete placed below water shall be limited to a height sufficient to seal the excavation and to withstand hydrostatic pressure. Immediately following the placement of this sealing concrete, the remaining portion of the hole shall be dewatered and the remainder of the concrete shall be placed. Concrete within the top 5 feet of the caisson shall be vibrated during placement. The layer of water-diluted concrete which has been floated to the top during placement shall be removed to the depth directed by the Engineer and wasted. The removed layer shall not be less than 4 inches thick. Only that concrete which meets specification requirements shall remain as part of the caisson.

Immediately following the concrete placement and the casing removal, the projecting reinforcing steel shall be thoroughly cleaned to remove accumulations of splashed mortar. This work shall be completed before the concrete takes its initial set. Care shall be taken when cleaning the reinforcing steel to prevent damage to or breakage of the concrete-steel bond.

#### **METHOD OF MEASUREMENT**

**503.08** Drilled caisson 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 caisson will be measured as  $\frac{1}{2}$  linear foot of additional length of drilled caisson.

**BASIS OF PAYMENT**

**503.09** The unit price of drilled caissons shall be full compensation for making all excavations; hauling and disposal of excavated material; performing all necessary pumping; furnishing and placing required concrete and reinforcement steel, including the reinforcement projecting above the tops of the caissons necessary for splicing; all backfilling; removing casings; and for furnishing all tools, labor, equipment, and incidentals necessary to complete the work. No extra payment will be made for casing left in place.

- (a) *Payment.* The accepted quantities for drilled caissons 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Drilled Caisson (___Inch)	Linear Foot

- (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:

<b>Additional Length</b>	<b>Compensation</b>
0 to 5 feet	Contract Unit Price
Over 5 feet to 15 feet	Contract Unit Price Plus 15%
Over 15 feet	As provided in subsection 109.04

Additional compensation will not be paid for the portions of a caisson that are extended due to the Contractor’s method of operation, as determined by the Engineer.

504.01

## **SECTION 504 CRIBBING**

### **DESCRIPTION**

**504.01** This work consists of the construction of steel, concrete or timber cribbing in accordance with these specifications, and in conformity with the design or type, lines and grades shown on the plans or established.

### **MATERIALS**

**504.02** Backfill shall be of the type designated on the plans and shall conform to Section 206. All cribbing members of the same type and size shall be interchangeable without any modification.

- (a) *Steel Cribbing.* Material used in steel cribbing shall conform to the requirements of AASHTO M 218.
- (b) *Concrete Cribbing.* Concrete shall be Class B and conform to the requirements of Section 601. Reinforcing steel shall conform to the requirements of Section 602.

Forms for concrete cribbing shall be true to line, and built of metal, plywood, or dressed lumber. A ¾ inch chamfer strip shall be used in all corners. Forms shall be watertight and shall remain in place at least 24 hours after the concrete has been placed.

The concrete placement shall be continuous. Acceptable methods of vibration or compaction of the concrete shall be used.

Backfilling around cribbing shall not be started until concrete test cylinders show a compressive strength of at least 80 percent of the required 28 day compressive strength. In lieu of test cylinders, the concrete shall be allowed to set for at least 14 days at a minimum temperature of 60 °F or 21 days at a minimum temperature of 40 °F.

- (c) *Timber Cribbing.* Timber cribbing shall meet the requirements of AASHTO LRFR Bridge Design Specifications, Section 8. When treatment with preservatives is required, it shall be done in accordance with subsection 508.03. The preservative shall be as noted on the plans and the treatment shall be for "Soil Contact." Inspection will be done in accordance with subsection 508.04.

### **CONSTRUCTION REQUIREMENTS**

**504.03** Construction requirements for timber cribbing shall conform to the applicable requirements of Section 508.

The foundation shall be firm and must be approved by the Engineer before construction of walls is commenced. Members that are damaged during installation shall be replaced at the Contractor's expense.



Filling of cribbing interior shall be placed in loose layers not exceeding 6 inches in thickness and shall be thoroughly tamped into place. Backfilling behind cribbing shall conform to Section 206 and shall progress with, but not ahead of, the filling of the interior of the cribbing. A layer of rock or stone spalls shall be laid against concrete or timber cribbing in advance of backfilling to prevent loss of backfill material through openings.

**METHOD OF MEASUREMENT**

**504.04** Crib walls of the various types and designs will be measured by the number of square feet of facial area.

**BASIS OF PAYMENT**

**504.05** The accepted quantities of cribbing will be paid for at the contract unit price per square foot of facial area for the items listed below that appear in the bid schedule.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Concrete Cribbing (Design__)	Square Foot
Steel Cribbing (Design__)	Square Foot
Timber Cribbing (Type__)	Square Foot

Structure excavation and structure backfill will be measured and paid for in accordance with Section 206.

Subsurface drains, if required, will be measured and paid for in accordance with Section 605 or subsection 104.03.

506.01

**SECTION 506  
RIPRAP**

**DESCRIPTION**

**506.01** This work consists of the construction of riprap in accordance with 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**

<b>Test Description</b>	<b>Test Method</b>	<b>Specification Requirement</b>
Abrasion Resistance by Los Angeles Machine	ASTM C 535	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**

Pay Item		% of Material Smaller Than Typical Stone <sup>2</sup>	Typical Stone Dimensions <sup>3</sup> (Inches)	Typical Stone Weight <sup>4</sup> (Pounds)
	Stone Size d50 <sup>1</sup> (Inches)			
Riprap	6	70-100	12	85
		50-70	9	35
		35-50	6	10
		2-10	2	0.4
Riprap	9	70-100	15	160
		50-70	12	85
		35-50	9	35
		2-10	3	1.3
Riprap	12	70-100	21	440
		50-70	18	275
		35-50	12	85
		2-10	4	3
Riprap	18	100	30	1280
		50-70	24	650
		35-50	18	275
		2-10	6	10
Riprap	24	100	42	3500
		0-70	33	1700
		35-50	24	650
		2-10	9	35

<sup>1</sup>d50 = nominal stone size  
<sup>2</sup>based on typical rock mass  
<sup>3</sup>equivalent spherical diameter  
<sup>4</sup>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 truck loads 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

506.03

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 gradall with multi-prong gapple 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Riprap (___ inch)	Cubic Yard or Ton

Structure excavation will be measured and paid for in accordance with 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 in accordance with 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 with 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 selvaged or bound so that the joints formed by tying the selvages 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 in accordance with 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:

506.10

<b>Pay Item</b>	<b>Pay Unit</b>
Riprap (Gabions)	Cubic Yard
Slope Mattress	Cubic Yard

Structure excavation and structure backfill will be measured and paid for in accordance with Section 206.

## SECTION 507 SLOPE AND DITCH PAVING

### DESCRIPTION

**507.01** This work consists of the construction of slope and ditch paving in accordance with 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 Class B or as shown on the plans. Reinforcement, when required, shall conform to the requirements of Section 602. Prefomed joint filler shall conform to AASHTO M 213.

**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:

Portland Cement	701.01
Fine Aggregate	703.01
Water	712.01

Mortar shall be used within 45 minutes after mixing and shall not be retempered. 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 with the following exceptions:

Field Compressive Strength (28 days) (Not a specification requirement)	2000 psi
Cement Content	560 lbs./cu. yd.
Air Content	6-9%
Slump, AASHTO Designation T-119	5-9 inches
Fine Aggregate, AASHTO M-6	70%
Coarse Aggregate, AASHTO M-43	30%, 2.36 mm (No. 8)
Polypropolyne Fibers (1" fiber length or equivalent)	1.5 lbs./cu. yd.

507.05

Riprap stone shall conform to the quality requirements of subsection 506.02 and the classification and gradation requirements specified in the following table:

**Table 507-1  
CLASSIFICATION AND GRADATION OF ROCK  
FOR GROUTED RIPRAP**

<b>Riprap Designation</b>	<b>Percent Smaller Than Given Size By Weight</b>	<b>Intermediate Rock Dimension, Inch</b>
d50 = 24" (Type HG)	100	30
	50 - 70	24
	0 - 5	18
d50 = 18" (Type MG)	70 - 100	21
	50 - 70	18
	0 - 5	12

**507.06 Bituminous Slope and Ditch Paving.** The mixture used shall conform to the requirements for the bituminous 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 which 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 in accordance with Section 601. Reinforcement, when required, shall be in accordance with Section 602.

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 1½ 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 1½ 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 in accordance with subsection 601.13(d).

**507.12 Bituminous Slope and Ditch Paving.** The bituminous mixture shall be properly shaped to the required cross section and thoroughly compacted.

A fog coat shall be placed on the exposed surfaces of the paving at the rate of approximately 0.1 gallon per square yard. Material for fog coat shall be Emulsified Asphalt (CSS-1) or as designated.

507.13

**METHOD OF MEASUREMENT**

**507.13** Bituminous 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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
Bituminous Slope and Ditch Paving (Asphalt)	Ton

Structure excavation will be measured and paid for in accordance with Section 206.

Fog coat and asphalt required for bituminous 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 in accordance with 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 1000 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 in accordance with 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.** Preservative treatment shall be by the empty cell method whenever practicable. 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. Treatment with chromated copper arsenate will not be permitted.

**508.04 Inspection.** All timber furnished shall be covered by a certificate of inspection issued by an approved inspection agency. Inspection approval shall be marked on each piece. The destination of the material and the project to which it is being shipped shall be shown on the certificate. The Department reserves the right to re-examine the timber at its destination and to reject any material not conforming to specification requirements.

Shop drawings shall be submitted in accordance with 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

**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 in accordance with AASHTO M 232 or cadmium plated in accordance with AASHTO M 299.

### 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 thoroughly brushed or treated with three coats of preservative applied at a temperature of between 180 and 190 °F.

Untreated stringer ends shall be separated at least ½ inch and shall be secured to the timber on which 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 ¼ inch of nominal depth before treatment and may be surfaced on the vertical grain face.

Before the timber capping is placed, a No. 20 gage galvanized sheet metal cap shall be placed on each pile in accordance with 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 ¼ 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 thoroughly treated with three coats of preservative applied at a temperature of between 180 and 190 °F. Holes drilled for drift bolts shall be  $\frac{1}{32}$  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 handrailing.

Parts specified herein, 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 wheelguards 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 in accordance with 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:

508.11

<b>Pay Item</b>	<b>Pay Unit</b>
Untreated Timber	MFBM
Treated Timber	MFBM

Structure excavation and structure backfill will be measured and paid for in accordance with Section 206.

Timber piling will be measured and paid for in accordance with Section 502.

## SECTION 509 STEEL STRUCTURES

### DESCRIPTION

**509.01.** This work consists of furnishing, fabricating, erecting, and painting structural steel in accordance with 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 M 270 (ASTM A 709) Grade 36. Material supplied for main members in tension as designated in the Contract shall meet a longitudinal Charpy V-notch (CVN) value of 15 foot-pounds at 40 °F. Testing shall be in accordance with AASHTO T 243 (ASTM A 673). 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 specifications:

High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality, Grade 50	AASHTO M 270 (ASTM A 709)
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High-Strength Low-Alloy Structural Steel with 50 ksi Minimum Yield Point to 4 inches thick	AASHTO M 270 (ASTM A 709)
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Steel conforming to AASHTO M 270 (ASTM A 709) 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 tests as specified for Zone 2 in AASHTO M 270.

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**509.05 Self Weathering Tubing.** Self weathering structural steel tubing shall conform to ASTM A 847, 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 section 5.2.1. 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 for Grade A Bolts of ASTM A 307. 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 AASHTO M 164. Type 1 bolts shall be used. Bolts for self weathering steels shall be Type 3, unless otherwise shown in the Contract.

Bolt and nut dimensions shall conform to AISC, section 4. 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. The length of the bolts shall be such that the point of the bolt will be flush with or outside of the face of the nut when completely installed. Sufficient thread must be provided to prevent the nut from encountering thread runout.

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, section 4.

**509.09 Pins and Rollers.** Steel for pins and rollers shall conform to ASTM A 668, 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 not less than 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 1½ 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 A 449 and shall be zinc plated.

**509.11 Galvanized and Metallized Steel.** When shown in the Contract, structural steel shall be galvanized in accordance with AASHTO M 111. Steel surfaces to be



metallized shall be coated in accordance with 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 A 108, grades 1010 through 1020, killed or semi-killed. In addition, studs shall conform to AWS D1.5, paragraphs 7.2 and 7.3, Type B studs, unless otherwise noted. Furnishing, testing, and qualifying of stud welding procedures shall be at the Contractor's expense. Manufacturer shall furnish the Engineer a certification as required by AWS D1.5 paragraph 7.3.3.

**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 prior to 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.

Material which 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) *Quality Control and Quality Assurance.* Quality control (QC) of structural steel fabrication is the responsibility of the Contractor. The QC inspector is the duly designated person who acts for and in behalf of the fabricator on inspection, testing, and quality matters within the scope of the contract documents. QC inspection and testing shall be performed at least to the extent specified in chapter 6 of AWS D1.5, and additionally as necessary to assure 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 in 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 in accordance with the provisions of the contract documents. The QA inspector shall have the authority to verify the qualifications of QC 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 prior notice to beginning of shop work, so that inspection may be provided.

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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.

**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.

**509.16 Shop Facilities for Fabrication.** Structural steel fabricators for all bridge structures other than rolled beams shall be certified under the AISC Quality Certification Program, Major Steel Bridges. 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 quality 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) *Quality Control Plan.* The fabricator shall submit a written quality control plan to the QA inspector prior to the beginning of fabrication. The quality control plan shall outline the quality control tasks to be performed by the fabricator to ensure that all work conforms to the Contract. The fabricator's personnel intended to be used for inspection and nondestructive testing shall be listed. The quality control plan shall be subject to approval by the QA inspector.
- (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 on site monitoring of all inspection activities on each shift on a daily basis.
- (c) *Supervision.* Adequate supervision and quality 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 quality 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 prior to resuming fabrication.

- (d) *Edge Discontinuities.* All plates and shapes shall be inspected at the edges and ends of plates for the presence of laminar discontinuities and inclusions prior to 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 ten working days. A calibrated tong ammeter and volt meter, external to the welding machine, shall be used. Records of these calibrations shall be available for review by the QA inspector.
- (f) *Reports.* The QC inspector shall submit the following reports to the QA inspector prior to 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 quality control and has been accepted as conforming to the contract requirements, but prior to 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 prior to acceptance. The QA inspector will mark approval of the member with the Department's stamp, when accepted. 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 reinspection prior to shipment. Reinspection will normally be made at the next regular inspection; however, if no regular inspection is scheduled, and reinspection 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 reinspection. A deduction shall be made from the bid item cost for the item requiring reinspection.

Materials will not be accepted at the project site if they do not bear the inspector's stamp of acceptance. Request for quality assurance inspection shall be given seven calendar 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.

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**509.18 Nondestructive Testing.**

- (a) *Written Practice and Records.* The fabricator's quality 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 in accordance with The American Society for Nondestructive Testing SNT-TC-1A. 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 prior to 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 prior to attaching to another member. Ultrasonic acceptance-rejection criteria shall be in accordance with either table 6.3 or table 6.26.3.2, of AWS D1.5 as determined by the category of stress of the main member to which the secondary member is attached. All flanges which connect at a splice, indicating a change from tension to compression, shall be tested in accordance with the tension criteria of table 6.3 of AWS D1.5.
    - D. *Sequence.* All flange and web splices shall be welded and tested prior to 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 QC 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**

<b>Element</b>	<b>(1) Tension- Compression</b>	<b>(2) Weld Orientation</b>	<b>(3) Percent Inspection</b>
Flange	Tension	Transverse	100
Flange	Tension	Longitudinal	25
Flange	Compression	Transverse	25
Flange	Compression	Longitudinal	10
	(4)		
Web	Tension	Transverse	100
Web	Tension	Longitudinal	25
Web	Compression	Transverse	25
Web	Compression	Longitudinal	10
Pier & End Diaphragms	Tension	Transverse	100
	Tension	Longitudinal	25
	Compression	Transverse	25
	Compression	Longitudinal	10

Note:

- (1) Tension areas shall be tested in accordance with AWS D1.5 Table 6.3. Compression areas shall be tested in accordance with Table 6.4 of AWS D1.5.
- (2) 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.
- (3) 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.
- (4) The tension area of webs and end or pier diaphragms is defined as  $\frac{1}{6}$  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 rewelding of the joint, or alternative nondestructive testing methods, as determined by the QA inspector. The testing procedures established in AWS D1.5, section 6.19 shall be amended as follows:
  - A. *Splices.* All materials spliced shall be tested prior to 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 in accordance with chapter 6, part C of AWS D1.5.

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- C. *Butt Joints.* All butt joints shall be ground flush and shall include mandatory scanning using pattern “D” (Figure 6.7 of AWS D1.5) longitudinal to their axis.
- D. *Scanning Procedure.* Table 6.2 of AWS D1.5 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 in which 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 (Form VII-9, AWS D1.5). 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 in accordance with chapter 6, part C of 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 which 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) Tables 6.3 and 6.4 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 search unit used to evaluate the flaw.
  - (5) Evaluation using reject may be used to evaluate flaws, only if calibration in accordance with AWS D1.5, 6.17.1 and the vertical linearity is within plus or minus 1 dB for a 60 dB range. Both AWS D1.5 forms VII-8 and VII-9 shall be recorded and submitted to the QA inspector prior to approval, whether or not reject is used.

- 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 in accordance with ASTM A 578. Plates greater than  $\frac{3}{4}$  inch thick shall be tested using 2.25 MHZ 1 inch diameter transducers. Plates less than and including  $\frac{3}{4}$  inch thick shall be tested with a 5 MHZ  $\frac{1}{2}$  inch diameter transducer. Supplementary requirement S2 shall be used as the acceptance standard.
- (c) *Dye Penetrant Testing.* Dye penetrant testing in accordance with ASTM E 165 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 in accordance with ASTM E 709 and AWS D1.5, except as amended herein. 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 E 709, 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 which are tacked or welded and subsequently cut apart and rewelded.
- (e) *Radiographic Testing.* When radiographic testing is specified, it shall be performed in accordance with chapter 6, part B of AWS D1.5, except that edge blocks shall be used. Radiographs shall be identified as follows:

1. *Contract Number.*

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2. *Weld Identification Number.* The fabrication number of the girder in which 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 in which 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 prior to 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 in accordance with ASTM E 18. 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 Quality 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 Quality control tests shall include the first production cut of the thickest fabricated flange. A minimum of 50 percent of production Quality 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 M 160. Pieces of steel which, prior to 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.

The Contractor shall furnish, if requested by the Engineer, an affidavit certifying that throughout the fabrication the identification of steel has been maintained in accordance with 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  $\frac{5}{8}$  inch thick and carrying calculated stress shall be milled or sawn to a depth of  $\frac{1}{4}$  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 in accordance with subsection 509.18(f).

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- (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 in accordance with 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.* Unwelded cold-bent steel plates shall conform to the following:
  1. *Rolling Direction.* The bendline will 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 as shown in Table 509-2.
  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  $\frac{1}{16}$  inch before bending throughout the portion of the plate at which the bending is to occur.

**TABLE 509-2**

Thickness (t) in inches	Up to $\frac{1}{2}$	Over $\frac{1}{2}$ to 1	Over 1 to $1\frac{1}{2}$	Over $1\frac{1}{2}$ to $2\frac{1}{2}$
Minimum Bend Radius	2t	$2\frac{1}{2}t$	3t	$3\frac{1}{2}t$

- (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.

$$R = \frac{14bD}{\sqrt{F_y} \Psi t}, \quad R = \frac{7500b}{F_y \Psi}, \text{ where}$$

- $F_y$  = specified minimum yield point in ksi of the member web.  
 $\psi$  = 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  $\frac{1}{4}$  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  $\frac{1}{8}$  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

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1¼ 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 QC 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 midlength 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 prior to 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 prior to 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 2½ 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 prior to welding to flanges. Girders shall be cambered prior to heat curving. Heat cambering procedures shall be in accordance with subsection 509.19(i) and shall be approved by the Engineer prior to 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  $\frac{1}{32}$  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  $\frac{1}{32}$  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.

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- (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  $\frac{1}{16}$  inch smaller than the nominal diameter of the fastener and reamed to  $\frac{1}{16}$  inch larger than the nominal diameter of the fastener, or drilled to  $\frac{1}{16}$  inch larger than the nominal diameter of the fastener. Sub-sized holes prior to reaming shall not be offset more than  $\frac{1}{16}$  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  $\frac{1}{32}$  inch 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  $\frac{1}{32}$  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.
- (l) *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  $\frac{1}{32}$  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  $\frac{1}{50}$  inch for pins 5 inches or less in diameter, or  $\frac{1}{32}$  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 herein. 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 core arc welding (FCAW) will be permitted on secondary to main member attachments when performed in the flat or horizontal positions. Vertical or overhead FCAW welding shall be limited to only that work approved by the QA inspector.

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 in accordance with Figure 5.8 of 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 in accordance with AWS D1.5, with the following exception: All mill scale and rust shall be removed from the surfaces of main members on which 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 in accordance with AWS D 1.5.
- (d) *Undercut.* Undercut in the stiffener, web or flange shall not exceed 0.01 inch in areas of tension as indicated in 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  $\frac{1}{32}$  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 in accordance with subsection 509.18(c).
- (f) *Gusset Plates.* Lateral gusset plates welded to girder flanges in tension shall be pre-heated to 250 °F.
- (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 QC inspector. Undercut may be prepared by contour grinding when approved by the Engineer. Areas repaired shall be recorded in accordance with AWS D 1.5, paragraph 6.5.8. Surfaces that are air carbon arc gouged shall be ground to bright metal prior to welding. Repair areas shall be preheated to a temperature of 200 to 300 °F prior to welding. Cracks removed prior to 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.

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2. *Groove Welds.* The number of repairs shall be limited to three or fewer heat cycles in any groove weld.
3. *Cut Edges.* Cavities resulting from the removal of cut edge discontinuities in plates shall be prepared prior to welding using a minimum ¼ inch radius and a minimum 40 degree angle. The base metal shall be ground to bright metal prior to welding.
4. *Mislocated Holes.* Misfit holes shall not be repaired, unless approved by the Engineer. When holes are repaired in accordance with an approved welding procedure, the soundness shall be established by ultrasonic testing. In addition, the hardness of the heat affected zone of the repair area shall be less than or equal to Rockwell C 30, when tested in accordance with ASTM E 110. Post weld heat shall be 400 °F per inch of thickness.

- (h) *Stud Welding.* Stud welding shall conform to AWS D1.5 section 7, as amended herein.

Studs shall not be welded to top flanges until after the formwork for the deck is in place in accordance with Occupational Safety and Health Administration (OSHA) regulations 29 CFR 1926 Subpart R.

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 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 in accordance with 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.**

- (a) The 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.
- (b) *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.
- (c) *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.
- (d) *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.
- (e) *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.
- (f) *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 in accordance with dimensional requirements prior to reaming or full size drilling of holes.

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- (g) *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.
- (h) *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.
- (i) *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.
- (j) *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  $\frac{1}{4}$  inch.
- (k) *Camber Tolerance.* Deviation from the design camber between any two supports (points of fixed elevations) shall be limited to:

$$+L/1200 \quad -L/2880$$

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 shop connections shall be made in accordance with 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 in accordance with AASHTO M 232 Class C or shall be zinc coated in accordance with AASHTO M 298.

Structural steel shall be galvanized in accordance with AASHTO M 111. 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, in accordance with ASTM A 780, if applied to correct areas less than 1 square inch.

**509.24 Shop Cleaning And Painting of Steel.** Graffiti shall be removed prior to painting, or in the case of ASTM A 709 Grade 50W steel, prior to shipping.

- (a) *Cleaning of Unpainted ASTM A 709 Grade 50W Steel.* The exterior surfaces of unpainted ASTM A 709 Grade 50W steel shall be blasted to remove mill scale and foreign material which would prohibit rusting to a uniform color.
- (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 top coat as described in subsection 708.03. The shop coat shall have a dry film thickness of 3.0 mils. The top coat 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 in accordance with 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 A 709 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 in accordance with "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.

## FIELD 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. All field welding and inspection shall be performed in accordance with this specification and AWS D1.5. Studs shall be free from rust, rust pits, scale, oil, moisture, paint, and other deleterious matter that would adversely affect the welding operation. Surfaces to which 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 in accordance with AWS D1.5 paragraph 7.5.4.1 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 -4 °F at the time of welding.

- (a) *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 Subsection 7.7.4. The base metal where the stud is to be welded shall be ground to bright metal immediately prior to the weld being made. Manual welding will not be allowed except to make repairs. Stud welding shall be in accordance with subsection 509.20 (h).
- (b) *Repairing Stud Welds.* Electrodes used to repair stud welds shall be kept in rod ovens in accordance with AWS D1.5 Subsection 12.6. The fillet weld size shall be a minimum of  $\frac{5}{16}$  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 in a manner that will provide safety to the Contractor's forces, inspectors and the traveling public. Structural steel members shall be erected in a manner to prevent damage to all elements of the structure. 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 designed to resist all loads imposed during each stage of construction until completion of the deck concrete.

At least four weeks prior to erection, the Contractor shall approve, sign and submit a proposed plan of erection to the Engineer for record purposes only. The Erection Plan shall be approved by, and contain the seal and signature of, the Contractor's Professional Engineer registered in the State of Colorado. The Erection Plan will not be approved by the Engineer. If falsework drawings are required, they shall be submitted in accordance with subsection 601.11.

The Erection Plan and procedure shall provide complete details of the erection process including but not limited to:

- (1) Temporary falsework support, bracing, guys, deadmen, connection details and attachments to other structure components or objects;
- (2) Procedure and sequence of operation including a detailed schedule that shall comply with the working hour limitations;
- (3) Cranes make and model, weight, geometry, lift capacity, outrigger size and reactions;
- (4) Girder weights, lift points, lifting devices, spreaders, and angle of lifting cables.
- (5) Assumed loads and girder stresses during progressive stages of lifting and erection to substantiate the structural integrity and stability of the girders prior to completion of the entire structure;
- (6) Girder launcher or trolley details and capacity (if intended for use); and
- (7) Locations of cranes, trucks delivering girders, and the location of cranes and outriggers relative to other structures, including retaining walls, wing walls and utilities.
- (8) Material properties and specifications for temporary works.
- (9) Drawings, notes, catalog data showing the manufacturer's recommendations or performance tests, and calculations clearly showing the above listed details, assumptions, and dimensions.

A Pre-Erection Conference will be held at least two weeks prior to the beginning of erection. The Contractor and the Contractor's Professional Engineer shall attend the meeting.

The Contractor's Professional Engineer shall inspect and provide written approval of each phase of the installation prior to allowing vehicles or pedestrians on or below the structure. The Contractor's Professional Engineer shall approve all changes to the Erection Plan. The Contractor shall submit all changes to the Erection Plan to the Engineer for record purposes only. The Contractor shall demonstrate his knowledge and familiarity with the location of the piece marks and the piece mark convention used by the girder fabricator at the Pre-Erection Conference. This is required to assure the structural components are assembled in accordance with the reviewed shop drawings.

The Contractor shall perform daily inspections of the erected girders until completion of the deck concrete. The Contractor shall provide the Engineer with written documentation of these inspections within 24 hours.

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.

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- (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 and to the following:

Falsework and forms shall be constructed so that any loads applied to girder webs will be applied within 6 inches of a flange or stiffener and will be distributed in a manner that will not produce local distortion of the web. 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.
- (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 which 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 evidences of fracture following the straightening procedures.
- (h) *Galvanizing.* Galvanized units on which 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-P-21035A. 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 which will damage or distort the members will not be permitted. Bearing surfaces and surfaces to be in permanent contact shall be

cleaned before the members are assembled. Splices and field connections of main stress carrying members shall have a minimum of one half of the holes filled with high strength bolts and cylindrical erection pins, with the bolts fully tightened before external support systems are removed and the connections completed by belting, unless otherwise specified.

Erection pins which are no less than  $\frac{1}{64}$  inch in diameter smaller than the drilled holes shall be used at the extreme corners of the pattern in main member connections. This requirement does not apply to diaphragms and lateral bracing in straight girder spans, provided the member is adequately supported prior to removal of the external support. Members that are assembled prior to being erected shall have all bolts installed and fully tightened. 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.* The correction of minor misfits involving minor reaming, cutting, and chipping will be considered a legitimate part of the erection. However, any error in shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the Engineer. The Engineer's approval shall be obtained for methods of correction 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 prior to assembly. All foreign material shall be removed prior to 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 done, and indicate the zinc thickness when galvanized bolts and nuts are used.
- (b) *Materials.* Washer type direct tension indicators shall conform to ASTM F 959.

Bolts shall be AASHTO M164 Type 1 for connections which are painted. Bolts for unpainted ASTM A 709 Grade 50W steel shall be AASHTO M 164 Type 3. The maximum tensile strength shall be 150 ksi for bolts 1 inch or less in diameter and 120 ksi for larger bolts.

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Nuts shall be AASHTO M 292 grade 2H or AASHTO M291 grade DH for plain or galvanized fasteners, except connections for unpainted ASTM A 709 Grade 50W steel, in which case nuts shall be AASHTO M 291 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. Plain bolts shall be "oily" to the touch when installed. Weathered or rusty items shall be cleaned and relubricated prior to installation.

(c) *Test Requirements.* All high strength fasteners, including black bolts and nuts, shall be subjected to a rotational-capacity test in accordance with AASHTO M 164, section 8.5 and shall meet the following requirements:

1. *Tension Procedure.* Fasteners shall be turned two times the required number of turns (from snug tight conditions) indicated in the AASHTO Standard Specifications for Highway Bridges, Table 10.17B, in a Skidmore-Wilhelm calibrator, or equivalent tension measuring device, 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, AASHTO Standard Specifications for Highway Bridges, Table 10.17A.
3. *Maximum Torque.* The measured torque to produce the required fastener tension shall not exceed the following equation:

$$\text{Torque} = 0.25 PD$$

Where:

Torque = Measured torque in foot-pounds

P = Measured bolt tension in pounds

D = Nominal diameter in feet

4. *Proof Load Tests.* Proof load tests (ASTM F 606 Method 1) are required for the bolts. Wedge tests of full size bolts are required in accordance with section 8.3 of AASHTO M 164. Galvanized bolts shall be wedge tested after galvanizing. Proof load tests in accordance with ASTM F 606 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.
5. *Snug Tight.* Installation of all high strength bolts shall be in accordance with AASHTO Standard Specifications for Highway Bridges, paragraph



10.17.4. The “snug tight” condition as defined in paragraph 10.17.4.3 or 10.17.4.6 shall be accomplished for any method of tightening.

- (d) *Field Connections.* Unless otherwise specified, all field connections shall be made with high-strength bolts which include direct tension indicators. Direct tension indicators shall be either washer type direct tension indicators or tension control bolts. Washer type indicators shall not be used with unpainted ASTM A 709 Grade 50W steel.
- (e) *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 inhibitor. Contact surfaces may be galvanized only when specified on the plans.
- (f) *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 prior to 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 tightened sufficiently 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.
1. *Impact Wrenches.* Impact wrenches, if used, shall be of adequate capacity to perform the required tightening of each bolt in approximately 10 seconds.
  2. *Washer Location.* In addition to load indicating washers, each fastener shall have a hardened washer under the turning element.
  3. *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.
  4. *Reusing Fasteners.* Bolts may be reused once, if approved. Direct tension indicators shall be tensioned only once and shall not be reused. Retightening of previously tightened bolts shall not be considered as reuse.

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- (g) *Locknuts and Lockwashers.* Subsections 509.28 (c), (e), and (f) shall not apply to bolts for which the plans specify lockwashers or locknuts. Fasteners with lockwashers or locknuts shall be snug tight only.
- (h) *Inspection.* The Contractor shall provide an acceptable platform from which the Engineer can inspect bolt tension and determine whether the work meets specification requirements. The following inspection procedure shall be used unless a more extensive or different inspection is specified.
1. *Quality Assurance.* The Engineer will inspect a sufficient number of fasteners to assure compliance with Table 509-3 using a method commensurate with the type of fastener used. All loose fasteners shall be brought into compliance.
  2. *Procedure Qualification.* The Contractor shall demonstrate that the bolt tightening method is providing tension in accordance with Table 509-3.
  3. *Frequency.* The demonstration shall be done daily on a minimum of three fasteners of each size and lot number using an accurate direct tension measuring device. (For short grip bolts, direct tension indicators with solid plates may be used to perform this test. The direct tension indicators shall be checked with a longer grip bolt in the tension measuring device first). There shall be a hardened washer under the nut or bolt head turned to tighten each bolt. The direct tension measurement device shall be furnished by the Contractor, and shall be certified by a testing laboratory at least once a year.

**Table 509-3**

Nominal Bolt Size	Required Minimum Bolt Tension lbs.
1/2	12,000
5/8	19,000
3/4	28,000
7/8	39,000
1	51,000
1 1/8	56,000
1 1/4	71,000
1 3/8	85,000
1 1/2	103,000

**509.29 Field Cleaning and Painting of Steel.**

- (a) *Self Weathering Steel.* Unpainted ASTM A 709 Grade 50W steel shall be cleaned of foreign material after erection to assure uniform weathering of the steel.

- (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 prior to application of top coats, all uncoated areas and areas with damaged shop primer shall receive one coat of shop primer. The shop primer shall be thoroughly cured prior to application of the top coat.
- (d) *Top Coat.* After retouching the shop coat, and field cleaning has been satisfactorily completed, all steel work shall be painted with the required top coat as specified in subsection 509.24. When the manufacturer of the top coat 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 fracture control plan (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 in accordance with this plan. The FCP shall be in accordance with AWS D1.5, Section 12. 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 in accordance with 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

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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**

<b>Nominal Bolt Size (In Inches)</b>	<b>Weight of 100 Bolts in Pounds</b>
$\frac{5}{8}$ - 11 UNC	32
$\frac{3}{4}$ - 10 UNC	53
$\frac{7}{8}$ - 9 UNC	81
1 - 8 UNC	117
$1\frac{1}{8}$ - 7 UNC	165
$1\frac{1}{4}$ - 7 UNC	212
$1\frac{3}{8}$ - 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, in accordance with 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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 implementing the Erection Plan will not be paid for separately but shall be included in the work.

510.01

## **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 in accordance with 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 prior to 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 preconstruction 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.

Unless otherwise specified, bolt holes along those edges of the plates that will form longitudinal seams in the finished structure shall be staggered in rows 2 inches apart, with one row in the valley and one in the crest of the corrugations.

Where the bolting plan used by the fabricator requires the longitudinal seams to have a minimum of six bolts per linear foot of seam, the holes shall be punched in rows 2 inches apart with two holes in the crest and one hole in the valley on both edges of the plates.

Where the bolting plan used by the fabricator requires the longitudinal seams to have a minimum of eight bolts per linear foot of seam, the holes shall be punched in rows 2 inches apart with two holes in the crest and two holes in the valley along both edges of each plate.

Plates for forming skewed or sloped ends shall be so cut as to give the angle of skew or slope specified. Units on which 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 in accordance with 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 which will damage the metal or metal coating will not be permitted.

Prior to backfilling operations, the full length of each round culvert shall be distorted from a true circle by preforming to an elliptical shape. This elongation shall

510.05

approximate five 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.

Damage to the pipe 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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 in accordance with Section 206.

Coating, when specified, will not be paid for separately but shall be included in the work.



## SECTION 512 BEARING DEVICE

### DESCRIPTION

**512.01** This work consists of furnishing and placing bearing devices in accordance with 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 shear 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 (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 A 709) Grade 36 unless otherwise required in the Contract. ASTM A 709 Grade 50W or ASTM A 709 Grade 50 may be substituted for ASTM A 709 Grade 36. Anchor bolts shall be ASTM A 449 zinc plated.

Structural steel elements of Type II bearing devices shall be painted in accordance with Section 509.

All metal surfaces of Type III bearing devices shall be completely zinc metallized in accordance with 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.

512.03

Welding shall conform to applicable requirements of ANSI/AWS D1.5 ancillary items.

Pads  $\frac{3}{4}$  inch or less in thickness may be either laminated or plain. Pads over  $\frac{3}{4}$  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  $\frac{1}{2}$  inch, plus or minus  $\frac{1}{8}$  inch in thickness. Unless otherwise noted on the plans, the top and bottom layers of metal shall be uniformly covered with a maximum of  $\frac{1}{8}$  inch of elastomer. The edges of the metal shall be uniformly covered with a minimum of  $\frac{1}{8}$  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  $\frac{1}{8}$  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 1000 psi, shall not exceed 0.06.

Pads less than  $\frac{3}{4}$  inch in thickness may be either laminated or plain. Pads  $\frac{3}{4}$  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  $\frac{3}{32}$  inch vulcanized to a stainless steel substrate. The stainless steel substrate shall be capable of resisting bending stresses to which 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 ¼ 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 3500 psi load, shall not exceed 0.03.

*Fixed Bearing.* A fixed bearing shall allow rotation but no longitudinal or transverse movement in the bearing plane.

*Guided Expansion Bearing.* A guided expansion bearing shall allow rotation and longitudinal movement and shall restrict transverse movement in the bearing plane.

*Nonguided Expansion Bearing.* A non-guided expansion bearing shall allow rotation and longitudinal and transverse movement in the bearing plane.

*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.

*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.

512.05

*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  $\frac{3}{16}$  inch and shall be recessed for  $\frac{1}{2}$  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 prior to bonding. Bonding shall be performed at the manufacturer's factory under controlled conditions and in accordance with 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  $\frac{3}{16}$  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 to which 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 in accordance with 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 which 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 section. Material tests shall be in accordance with Table 705-1 or 705-2 and as described herein. The manufacturer shall furnish facilities for the testing and inspection of the completed bearings in the plant or at an independent test facility. The Engineer or the Engineer's representative shall be allowed free access to the necessary parts of the manufacturer's plant and test facility.

(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, 1000 to 2999 kips, and 3000 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 prior to 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,

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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. *ShortDuration 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. *LongDuration 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 for which 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 nonparallelism 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 prior to 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 on which 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  $\frac{1}{16}$  inch for bearing seats up to 30 inches,  $\frac{3}{32}$  inch for bearing seats over 30 inches and under 45 inches, and  $\frac{1}{8}$  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  $\frac{1}{8}$  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

512.11

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 prior to beginning welding. Field welding to steel plates which 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 to which 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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.





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The presence of a manufacturer's representative will not be measured and paid for separately, but shall be included in the work.



514.01

## **SECTION 514 PEDESTRIAN AND BIKEWAY RAILING**

### **DESCRIPTION**

**514.01** This work consists of the construction of the designated type of railing in accordance with 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 A 53, 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 A 709 Grade 36.
- (3) Bolts shall conform to the requirements of ASTM A 307.
- (4) Zinc coating shall conform to the requirements of ASTM A 123, A 153, A 385 and A 386.
- (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 A 847 for structural steel tubing and ASTM A 709 Grade 50W for plates and shapes.

**514.04 Timber Railing.** Timber for posts and rails shall be pressure treated and shall be in accordance with 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 in accordance with Section 606.

## CONSTRUCTION REQUIREMENTS

**514.06** Prior to construction of any type of railing, the Contractor shall submit working drawings in accordance with Sections 101 and 105.

Posts shall be aligned and plumb within a tolerance of  $\frac{1}{4}$  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. Hand rails and rub rails shall not have projecting fasteners.

Welding shall be in accordance with 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. Bituminous 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 set screw in the fittings or by sufficient threads to develop its strength.

All steel railing shall be galvanized or painted in accordance with 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:

514.08

<b>Pay Item</b>	<b>Pay Unit</b>
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 in accordance with 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 prior to 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.

515.04

- (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 drain pipes, 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  $\frac{1}{2}$  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  $\frac{3}{8}$  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, in accordance with 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 prior to 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 in accordance with 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 a minimum rate of 1 gallon per 100 square feet of surface area. 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 prior to 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, prior to 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.

515.06

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:

<b>Pay Item</b>	<b>Pay Unit</b>
Waterproofing (Membrane)	Square Yard
Concrete Sealer	Square Yard

Hot mix asphalt will be measured and paid for in accordance with Section 403.



**SECTION 516  
DAMPPROOFING**

**DESCRIPTION**

**516.01** This work consists of dampproofing concrete surfaces in accordance with 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 which 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  $\frac{1}{8}$  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  $\frac{1}{10}$  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:

<b>Pay Item</b>	<b>Pay Unit</b>
Dampproofing (Asphalt)	Square Yard

517.01

## **SECTION 517 WATERPROOFING**

### **DESCRIPTION**

**517.01** This work consists of waterproofing concrete surfaces in accordance with these specifications and in conformity with the plans or as directed.

### **MATERIALS**

**517.02** Materials for waterproofing shall conform to the following:

<b>Item</b>	<b>ASTM Designation</b>	<b>Use</b>
Asphalt Primer	D 41	Primer under asphalt mop coats
*Asphalt Mop Coat	D 449	Mop coats with or without membrane
Woven Cotton Fabric	D 173	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 bituminous 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

517.05

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 not less than 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 not less than 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Waterproofing (Asphalt)	Square Yard

518.01

## **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 in accordance with these specifications and in conformity with the details shown on the plans, or as directed.

### **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 in accordance with 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 pretested 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 in accordance with 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 preconstruction conference the specific manufacturer and model number of the device the Contractor intends to furnish and install.

The device shall consist of a continuous premolded elastomeric expansion joint seal, embedded steel angles and steel extrusions as shown on the plans, required by the manufacturer, or specified herein 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 pretested 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 prior to the Engineer's approval.

Structural steel sections shall conform to the specifications of AASHTO M 270 (ASTM A709 Grade 36). Fabrication and welding of structural steel shall conform to the requirements of Section 509. The material designations for all steel components shall be shown on the Contractor's working drawings.

All structural steel not in contact with elastomers or embedded in concrete shall be painted or galvanized, in accordance with Section 509. Either painting or galvanizing may be used, unless noted otherwise on the plans. Portions of structural steel in contact with elastomeric seals or embedded in concrete shall not be painted, but may be galvanized. All paint coats shall be shop applied.

**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 in accordance with 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 preconstruction 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 24 inches.

The modular expansion joint device supplied shall be one of the approved devices as shown on the plans.

Only a continuous full length modular joint device supplied will be acceptable. 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 premolded elastomeric expansion joint seals, either box seals or 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 premolded elastomeric seals.

- (a) Center beams, support bars, and their connections shall satisfy the applicable design requirements of the AASHTO Standard Specifications for Highway Bridges. In addition, to help limit fatigue stresses at center beam to support bar connections, center beams and support bars shall satisfy the minimum criteria given in the following paragraph.

518.05

The maximum spacing of the support bars connected to a center beam shall not exceed 4 feet 0 inch along the center beam. The minimum area of a center beam shall be 4.9 square inches. The minimum section modulus about the horizontal axis for the bottom fiber of a center beam shall be 5.9 cubic inches. For the support bar, the minimum area (A) and minimum section modulus, about the horizontal axis for the top fiber (S), shall be as follows:

**Rated Movement**

	0-6"	0-9"	0-12"	0-15"	0-18"	0-21"	0-24"
A	5.1	6.2	7.0	7.7	8.5	9.1	9.7
S	2.9	4.2	5.5	6.7	8.0	9.3	10.4

The center beams and support bars shall be sufficiently detailed in the shop drawings so that the above minimum section properties can be independently verified using the information contained in the shop drawings.

(b) The following components shall meet the listed requirements:

Structural Steel (except center beams, edge beams and support bars)	AASHTO M 270 (ASTM A 709) Grade 36
Center Beams, Edge Beams and Support Bars	AASHTO M 270 (ASTM A 709) Grade 50
	or AASHTO M 270 (ASTM A 709) Grade 50W
Headed Studs	ASTM A108
Premolded Seals, Lubricant Adhesive, and Sliding Surfaces	Conforming to manufacturer's current literature
Stainless Steel Bearing Surfaces	Subsection 705.06

Structural steel shall conform to the requirements of Section 509 except the steel fabricator shall be certified under the AISC Quality Certification Program in Simple Steel Bridges, as a minimum.

All structural steel not in contact with elastomers or embedded in concrete shall be painted or galvanized, in accordance with Section 509. Either painting or galvanizing may be used, unless noted otherwise on the plans. Portions of structural steel in contact with elastomeric seals or embedded in concrete shall not be painted, but may be galvanized. All paint coats shall be shop applied.

The manufacturer shall furnish certification that the materials proposed for use on the project have been pretested 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 prior to 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 Elastomeric Concrete End Dam.** Elastomeric Concrete End Dam shall be an elastomeric concrete of either field vulcanized, fusion bonded synthetic elastomer and precision blended aggregates or an approved polyurethane binder and precision blended aggregates bonded to all adjacent surfaces of the existing structure.

The Contractor shall furnish a manufacturer's certification that the materials proposed for use on the project have been pretested and will meet the requirements as set forth in the manufacturer's current literature.

The material shall not be installed in the work prior to the Engineer's approval.

Two copies of the product literature containing pertinent materials and installation data for the elastomeric concrete supplied on this project shall be furnished to the Engineer at least two weeks prior to the installation of the elastomeric concrete end dam.

Material for this work will either be one of the approved products shown in the plans or approved by the Engineer. The Contractor shall state at the preconstruction conference the specific material the Contractor intends to furnish and install. No other material will be considered or allowed.

### 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.

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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 in accordance with manufacturer's recommended procedures and in accordance with 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 which 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 prior to 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 premolded 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 premolded elastomeric expansion seal and lubricant adhesive are placed against the metal surface. All cleaned metal surface on which rusting appears shall be recleaned 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. Water tightness 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 nonacceptance.

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 includes 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 in accordance with 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.

**518.10 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. Shop drawings shall include manufacturer's installation instructions.

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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 furnish facilities for testing and inspecting 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 Contractor shall notify the expansion device manufacturer of the scheduled installation a minimum of two weeks prior to the installation date.

The modular expansion joint device shall be installed in strict accordance with the manufacturer's written instructions, the advice of their technical representative, and these specifications. The permanently installed expansion joint device shall match exactly the finished roadway profile and grade.

Immediately prior to installation, the expansion joint device shall be inspected by the Engineer for proper alignment, and complete bond between the premolded elastomeric seals and the steel, and proper stud placement and effectiveness. Premolded 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 prior to shipment. Presetting shall be done in accordance with the joint opening at 70 °F 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.

Concrete 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 seal 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 and securely supported at the correct grade and elevation and the correct joint opening as shown on the plans and on the shop drawings. If the maximum time between setting the joint opening and placing concrete exceeds four hours, the opening shall be checked and adjusted as necessary.

- (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 ¼ 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 nongalvanized metal surfaces to come in contact with the premolded elastomeric seal shall be blast cleaned in accordance with the requirements of Steel Structures Painting Council Surface Preparation Specification No. 6 (SSPCSP6, 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 1.

The cleaned metal surfaces shall be protected from rusting until the premolded elastomeric seal and lubricant adhesive are placed against the metal surface. Any cleaned metal surface on which rusting appears shall be recleaned in accordance with 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 concrete Class D or S. Prior to concrete placement, all existing concrete surfaces shall be primed with a CDOT approved epoxy polysulfide grout. The grout shall be placed according to the manufacturer's instructions. 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 concrete Class D or S.

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- (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. Water tightness 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 nonacceptance.

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 includes 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 in accordance with 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 Elastomeric Concrete End Dam.** The material supplier shall supply a representative who is completely competent in all aspects of the work, including all material and all equipment necessary to install the elastomeric concrete end dam properly.

The representative shall remain on site until the job is completed. The representative shall be responsible for:

- (1) Advising the Engineer and the Contractor to insure that the correct installation method is being followed.
- (2) Training assigned personnel in the correct methods of installation.
- (3) Certifying to the Engineer that the material has been installed correctly.

All certifications from the supplier's representative to the Engineer shall be in writing and shall be signed and dated by the supplier's representative and the Contractor.

### **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.

Modular expansion device will be measured by the linear foot between faces of curbs, parallel to the expansion device, completely installed and accepted. Portions of devices required in faces of curbs, including cover plates and hardware, will not be measured for payment. The words “completely installed” shall be interpreted to mean the expansion joint device is in place with the following operations completed:

- (1) Concrete placed and finished.
- (2) Watertight integrity test performed.

Elastomeric Concrete End Dam will be measured by the cubic foot completed and accepted.

### **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, premolded 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 Elastomeric Concrete End Dam will be paid for at the contract unit price per cubic foot and shall include all work and materials necessary to

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complete the item including saw cutting existing bituminous pavement, removing bituminous pavement, light sandblasting of existing concrete and any existing steel, and all miscellaneous work required.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
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
Elastomeric Concrete End Dam	Cubic Foot

**SECTION 600  
MISCELLANEOUS CONSTRUCTION**

**SECTION 601  
STRUCTURAL CONCRETE**

**DESCRIPTION**

**601.01** This work consists of furnishing and placing portland cement concrete in accordance with 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 to them.

**601.02 Classification.** The classes of concrete shown in Table 601-1 shall be used when specified in the Contract.

**Table 601-1 CONCRETE TABLE**

Concrete Class	Required Field Compressive Strength	Cement Content: Minimum or Range	Air Content: Percent Range (Total)	Water Cement Ratio: Maximum or Range
B	3000 psi at 28 days	565 lbs./cu. yd.	5 – 8	N/A
BZ	4000 psi at 28 days	610 lbs./cu. yd.	N/A	N/A
D	4500 psi at 28 days	615 to 660 lbs./cu. yd.	5 – 8	0.44
DT	4500 psi at 28 days	700 lbs./cu. yd.	5 – 8	0.44
E	4200 psi at 28 days	660 lbs./cu. yd.	4 – 8	0.44
H	4500 psi at 56 days	580 to 640 lbs./cu. yd.	5 – 8	0.38 - 0.42
HT	4500 psi at 56 days	580 to 640 lbs./cu. yd.	5 – 8	0.38 - 0.42
P	4200 psi at 28 days	660 lbs./cu. yd.	4 – 8	0.44
S35	5000 psi at 28 days	615 to 720 lbs./cu. yd.	5 – 8	0.42
S40	5800 psi at 28 days	615 to 760 lbs./cu. yd.	5 – 8	0.40
S50	7250 psi at 28 days	615 to 800 lbs./cu. yd.	5 – 8	0.38

**Class B** concrete is an air entrained concrete for general use. Class D or H concrete may be substituted for Class B concrete. Additional requirements for Class B concrete are: Class B concrete shall have a nominal coarse aggregate size of 37.5 mm

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(1½ inches) or smaller. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

**Class BZ** concrete is concrete for drilled piers. Additional requirements for class BZ concrete are: Entrained air is not required unless specified in the Contract. High range water reducers may be added at the job site to obtain desired slump and retardation. Slump shall be a minimum of 5 inches and a maximum of 8 inches). Class BZ caisson concrete shall be made with 19.0 mm (¾ inch) nominal sized coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

**Class D** concrete is a dense medium strength structural concrete. Class H may be substituted for Class D concrete. Additional requirements for Class D concrete are: An approved water reducing admixture shall be incorporated in the mix. Class D concrete shall be made with 19.0 mm (¾ inch) nominal sized coarse aggregate. When placed in a bridge deck, Class D concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 67 coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

**Class DT** concrete may be used for deck resurfacing and repairs. Class HT may be substituted for Class DT concrete. Additional requirements for Class DT concrete are: An approved water reducing admixture shall be incorporated in the mix. Class DT concrete shall contain a minimum of 50 percent AASHTO M 43 size No. 7 or No. 8 coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

**Class E** concrete may be used for fast track pavements needing early strength in order to open a pavement to service soon after placement. Additional requirements for Class E concrete are: Type III cement may be used. Class E concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 357 or No. 467 coarse aggregate. If all transverse joints are doweled, then Class E concrete shall contain a minimum of 55 percent AASHTO M 43 sizes No. 57, No. 67, No. 357, or No. 467 coarse aggregate. In addition to the compressive strength requirements in Table 601-1 and unless stated otherwise on the plans, Class E concrete shall achieve a field compressive strength of 2500 psi within 12 hours. Laboratory trial mix for Class E concrete must produce an average 28 day flexural strength of at least 650 psi. Approved fly ash may be substituted for portland cement up to a maximum of 30 percent Class F by weight.

**Class H** concrete is used for bare concrete bridge decks that will not receive a waterproofing membrane. Additional requirements for Class H concrete are: An approved water reducing admixture shall be incorporated in the mix. Class H concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 67 coarse aggregate. Class H concrete shall contain cementitious materials in the following ranges: 450 to 500 pounds per cubic yard Type II portland cement, 90 to 125 pounds



per cubic yard flyash and 20 to 30 pounds per cubic yard silica fume. The total content of Type II portland cement, flyash and silica fume shall be 580 to 640 pounds per cubic yard. Laboratory trial mix for Class H concrete must not exceed permeability of 2000 coulombs at 56 days (ASTM C 1202). Laboratory trial mix for Class H concrete must not exhibit a crack at or before 14 days in the cracking tendency test (AASHTO PP 34).

**Class HT** concrete is used as the top layer for bare concrete bridge decks that will not receive a waterproofing membrane. Additional requirements for Class HT concrete are: An approved water reducing admixture shall be incorporated in the mix. Class HT concrete shall contain a minimum of 50 percent AASHTO M 43 size No. 7 or No. 8 coarse aggregate. Class HT concrete shall contain cementitious materials in the following ranges: 450 to 500 pounds per cubic yard Type II portland cement, 90 to 125 pounds per cubic yard flyash and 20 to 30 pounds per cubic yard silica fume. The total content of Type II portland cement, flyash and silica fume shall be 580 to 640 pounds per cubic yard. Laboratory trial mix for Class HT concrete must not exceed permeability of 2000 coulombs at 56 days (ASTM C 1202). Laboratory trial mix for Class HT concrete must not exhibit a crack at or before 14 days in the cracking tendency test (AASHTO PP 34).

**Class P** concrete is used in pavements. Additional requirements for Class P concrete are: Class P concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 357 or No. 467 coarse aggregate. If all transverse joints are doweled, then Class P concrete shall contain a minimum of 55 percent AASHTO M 43 sizes No. 57, No. 67, No. 357, or No. 467 coarse aggregate. Laboratory trial mix for Class P concrete must produce an average 28 day flexural strength of at least 650 psi. Class P concrete shall contain 70 percent to 80 percent portland cement and 20 percent to 30 percent Class F fly ash in the total weight of cement plus fly ash. Unless acceptance is based on flexural strength, the total weight of cement plus Class F fly ash shall not be less than 660 pounds per cubic yard. If acceptance is based on flexural strength, the total weight of cement plus Class F fly ash shall not be less than 520 pounds per cubic yard.

**Class S35** concrete is a dense high strength structural concrete. Additional requirements for Class S35 concrete are: An approved water reducing admixture shall be incorporated in the mix. Class S35 concrete shall be made with 19 mm ( $\frac{3}{4}$  inch) nominal sized coarse aggregate, i.e., 100 percent passing the 25.0 mm (1 inch) sieve and 90 percent to 100 percent passing the 19 mm ( $\frac{3}{4}$  inch) sieve. When placed in a bridge deck, Class S35 concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 67 coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

**Class S40** concrete is a dense high strength structural concrete. Additional requirements for Class S40 concrete are: An approved water reducing admixture shall be incorporated in the mix. Class S40 concrete shall be made with 19 mm

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(3/4 inch) nominal sized coarse aggregate. When placed in a bridge deck, Class S40 concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 67 coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

**Class S50** concrete is a dense high strength structural concrete. Additional requirements for Class S50 concrete are: An approved water reducing admixture shall be incorporated in the mix. Class S50 concrete shall be made with 19 mm (3/4 inch) nominal sized coarse aggregate. When placed in a bridge deck, Class S50 concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 67 coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight. Laboratory trial mix for Class S50 concrete must not exhibit a crack at or before 14 days in the cracking tendency test (AASHTO PP 34).

### 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
Water	712.01
Air Entraining Admixture	711.02
Chemical Admixtures	711.03
Curing Materials	711.01
Preformed Joint Material	705.01
Reinforcing Steel	709.01
Bearing Materials	705.06
Epoxy	712.10
Structural Concrete Coating	708.08

Type I or II cement shall be used unless high early strength concrete or sulfate resisting concrete is called for on the plans or as otherwise permitted.

Prestressing steel shall meet the requirements of subsection 714.01 except as noted on the plans.

Silica fume admixture shall conform to the requirements of subsection 701.03.

Calcium chloride shall not be used in any concrete unless otherwise specified.

**601.04 (unused)**

## CONSTRUCTION REQUIREMENTS

**601.05 Proportioning.** The Contractor shall submit a Concrete Mix Design Report consisting of design mix proportions, laboratory trial mix and aggregate data for each class of concrete being placed on the project. Concrete shall not be placed on the project before the Concrete Mix Design Report has been reviewed and approved by the Engineer. The Concrete Mix Design cannot be approved when the laboratory trial mix and aggregate data are the results from tests performed more than a year in the past. The design mix proportions shall show the weights and sources of all ingredients including cement, fly ash, aggregates, water, additives and the water cement ratio (w/c). When determining the w/c, cement (c) shall be the sum of the weight of the cement, the weight of the fly ash and the weight of silica fume.

The laboratory trial mix data shall include results of the following:

- (1) AASHTO T 119 Slump of Hydraulic Cement Concrete.
- (2) AASHTO T 121 Weight per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete. Air content from AASHTO T 152 Air Content of Freshly Mixed Concrete by the Pressure Method may be used in lieu of the air content by the gravimetric method in AASHTO T 121.
- (3) AASHTO T 22 Compressive Strength of Cylindrical Concrete Specimens shall be performed with at least two specimens at 7 days and three specimens at 28 days. Three additional specimens tested at 56 days shall be required for Class H and HT concrete.
- (4) Class H and HT concrete shall include a measurement of permeability by ASTM C 1202 Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration. The concrete test specimens shall be two 2 inch thick disks sawed from the centers of two molded 4 inch diameter cylinders cured no more than 56 days in accordance with ASTM C 192 Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
- (5) Class H, HT and S50 concrete shall include a measurement of cracking by AASHTO PP 34 Standard Practice for Estimating the Cracking Tendency of Concrete. The ring shall be cured in an indoor room with the temperature maintained 65°F to 75°F and relative humidity not exceeding 40 percent.
- (6) Class E and P concrete shall include AASHTO T 97 Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading) performed with two specimens at seven days and four specimens at 28 days.
- (7) Class E concrete shall include a report of maturity relationships in accordance with ASTM C 1074 with the following additions or modifications. 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.
  - (i) The cylinders used to establish the compressive strength vs. maturity relationship shall be cast and cured in the field in conditions similar to the project.

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- (ii) These cylinders shall be tested in pairs at times which yield compressive strengths three sets of which are at or below 2500 psi and one of which is above 2500 psi.
- (iii) Testing to determine datum temperature or activation energy will not be required.
- (iv) A test slab shall be cast at the same time and location as the cylinders. The test slab shall have a length and width of 6 feet x 6 feet and a thickness equal to the pavement design thickness. The maturity of the test slab, when used in the compressive strength vs. maturity relationship from the cylinders, shall indicate that a compressive strength of 2500 psi is achieved in the required time. Slab maturity will be determined with two probes located in the slab approximately 1 and 2 feet from the edge. The test slab shall be covered with a blanket similar to the one to be used on the pavement.

Except for class BZ concrete, the maximum slump of the delivered concrete shall be the slump of the approved concrete mix design plus 1½ inch. Except for class H and HT concrete, the laboratory trial mix must produce an average 28 day compressive strength at least 115 percent of the required 28 day field compressive strength. The laboratory trial mix for Class H or HT concrete must produce an average 56 day compressive strength at least 115 percent of the required 56 day field compressive strength.

The laboratory trial mix shall have a relative yield of 0.99 to 1.02. When Portland Cement Concrete Pavement is paid with a volumetric pay quantity, the relative yield of the concrete produced on the project shall be 0.99 to 1.02. If the relative yield of the produced concrete does not conform to this range for two consecutive yield determinations, concrete production shall cease and the Contractor shall present a plan to correct the relative yield to the Engineer.

Aggregate data shall include the results of the following:

- (1) AASHTO T 11 Materials Finer Than 75 um (No. 200) Sieve in Mineral Aggregates by Washing.
- (2) AASHTO T 19 Unit Weight and Voids in Aggregate.
- (3) AASHTO T 21 Organic Impurities in Fine Aggregate for Concrete.
- (4) AASHTO T 27 Sieve Analysis of Fine and Coarse Aggregates.
- (5) AASHTO T 84 Specific Gravity and Absorption of Fine Aggregate.
- (6) AASHTO T 85 Specific Gravity and Absorption of Coarse Aggregate.
- (7) AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
- (8) AASHTO T 104 Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
- (9) AASHTO T 176 Plastic Fines in Graded Aggregates and Soils by use of the Sand Equivalent Test
- (10) ASTM C 535 Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- (11) ASTM C 1260 Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)

Any aggregate with an expansion of 0.10 percent or more at 16 days after casting as determined by ASTM C 1260 shall not be used unless mitigative measures are included in the mix design and subsequent results of CPL 4202 with the design mix proportions show an expansion not exceeding 0.10 percent at 16 days after casting. The Concrete Mix Design Report shall state what mitigative measures were included in the concrete mix design and include results for ASTM C 1260 and CPL 4202.

The Concrete Mix Design Report shall include Certified Test Reports showing that the cement, flyash and silica fume admixture meet the specification requirements and supporting this statement with actual test results. The certification for silica fume shall state the solids content if the silica fume admixture is furnished as slurry.

Where the Contractor's use of fly ash results in any delay, necessary change in admixture quantities or source, or unsatisfactory work, the cost of such delays, changes or corrective actions shall be borne by the Contractor.

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, fly ash, or aggregate. Unless otherwise permitted by the Engineer, the product of only one type of portland cement from one mill of any one brand shall be used in a concrete mix design.

Review and 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.

**601.06 Batching.** Measuring and batching of materials shall be done at a batching plant in accordance with AASHTO M 157.

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) 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
- (9) Type, brand, and amount of cement and fly ash
- (10) Weights of fine and coarse aggregates

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- (11) Moisture of fine and coarse aggregate
- (12) Gallons of batch water (including ice)

The Contractor shall add the following information to the batch ticket at the placement site:

- (13) Gallons of water added by truck operator plus quantity of concrete in the truck each time water is added
- (14) Number of revolutions of drum at mixing speed (for truck mixed concrete)
- (15) Discharge time
- (16) Location of batch in placement
- (17) Water cement ratio (required for deck concrete only)

The drum on each truck mixer shall be reversed prior to charging to eliminate any wash water remaining in the mixer.

- (a) *Portland Cement and Fly Ash.* Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed.

All bulk cement shall be weighed on an approved weighing device. The bulk cement weighing hopper shall be sealed and vented to preclude dusting during operation. The discharge chute shall be so arranged that cement will not lodge in it or leak from it.

Separate storage and handling equipment shall be provided for the fly ash. The fly ash may be weighed in the cement hopper and discharged with the cement.

- (b) *Water.* Unless water is to be weighed, the water-measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. The measuring tank shall be equipped with an outside tap and valve to provide for checking the calibration unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank. In lieu of the volume method specified above, the Contractor will be permitted to use a water metering device that is accurate within the prescribed limits.
- (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 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.

- (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. If cement is used in bulk, a bin, hopper, and scale for cement shall be included. A single weighing hopper with an accumulative scale will be permitted, provided a separate scale is used for weighing cement.

Scales shall meet the requirements of subsection 109.01.

**601.07 Mixing.** Concrete may 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.

Silica fume, when specified, shall be added to the mix during initial batching.

- (a) *Mixing General.* The 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 mixer or agitating trucks may be extended to 120 minutes if:

- (1) No water is added after 90 minutes.
- (2) The concrete temperature prior to placement is less than 90 °F

The 90 minute time limit for mixer or agitating trucks may be extended to 180 minutes if:

- (1) No water is added after 90 minutes.
- (2) The concrete temperature prior to placement is less than 90 °F.
- (3) The approved concrete mix contains a water reducing and retarding admixture which conforms to AASHTO M 194, Type D.

- (b) *Stationary Mixing.* When mixed in a central mixing plant, the mixing time shall be between 50 and 90 seconds. Four seconds shall be added to the specified mixing time if timing starts the instant the skip reaches its maximum raised position. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein.

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, up to 10 per cent provided concrete test data for strength, segregation, and uniform consistency are satisfactory, and provided spillage of concrete does not occur.

The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be

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uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the free flow of materials into the drum.

The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the Contractor will be permitted to operate while it is being repaired, provided the Contractor furnishes an approved timepiece equipped with minute and second hands. If the timing device is not placed in good working order within 24 hours, further use of the mixer will be prohibited until repairs are made.

(c) *Truck Mixing.* Truck mixed concrete shall conform with one of the following:

1. Concrete mixed entirely in a truck mixer equipped with a mechanical counter shall be partially mixed at the plant or in transit for not less than 20 revolutions of the drum at mixing speed. The revolutions of the drum at charging speed shall not be counted as mixing revolutions. The concrete shall be mixed between 50 and 100 revolutions of the mixer drum at mixing speed at the delivery site before discharge of the concrete.
2. Concrete partially mixed in a stationary central mixing plant with mixing brought to completion in a truck mixer (known as shrink mixing) shall be mixed for a minimum of 30 seconds in the stationary mixer. Mixing shall be completed in the truck mixer for at least 20 but not more than 100 revolutions of the mixer drum at mixing speed at the delivery site before discharge of the concrete.
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 prior to discharge.

When water is added at the delivery site to control the consistency of the concrete as specified in subsection 601.02, the concrete shall be mixed for at least 20 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 water/cement ratio to exceed the requirements in subsection 601.02. Water from all sources shall be documented by the ready mix producer 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 the accuracy prescribed in AASHTO M 157.

- (d) *Self Contained Mobile Mixer.* Proportioning and mixing equipment shall be of the self-contained, mobile, continuous mixing type subject to the following:

The mixer shall be self-propelled and be capable of carrying sufficient unmixed dry, bulk cement, fine aggregate, coarse aggregate, admixtures and water to produce on the site not less than 6 cubic yards of concrete. The mixer shall have one bin for each size aggregate.

The mixer shall be capable of positive measurement of cement 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.

The mixer shall provide positive control of the flow of water into the mixing chamber. Water flow shall be indicated by flow meter and be readily adjustable to provide for minor variations in the aggregate moisture.

The mixer shall be capable of being calibrated 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.

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 whenever a change in the characteristics of the mixture is observed. The tolerances in proportioning the various ingredients shall be according to subsection 6.8 of AASHTO M 241.

**601.08 Air Content Adjustment.** When a batch of concrete delivered to the project does not conform to the minimum specified air content, an airentaining admixture conforming to subsection 711.02 may be added, one time only for the batch, at the Contractor's option prior to consideration for rejection or price adjustment. 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 will then be re-tested and if found acceptable may be placed in accordance with the specifications. A maximum of three batches per day may be adjusted by adding air entraining admixture at the delivery site.

**601.09 Forms.**

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- (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  $\frac{3}{32}$  inch between the center to center distance of studs, joists, form stiffeners, form fasteners or wales will be considered to be 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 herein 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.

- (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 which will later be removed shall be thoroughly coated with form oil prior to use. The form oil shall be a commercial quality form oil or other equivalent coating which 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 which can be placed in the dry without the use of cribs or coffer dams. 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.

- (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  $\frac{3}{4}$  inch by  $\frac{3}{4}$  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  $\frac{1}{2}$  inch from the face without injury to the concrete. When wire ties are used the wires shall be cut back at least  $\frac{1}{4}$  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.

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- (f) *Surface Treatment.* All forms shall be treated with oil prior to placing reinforcement except that an approved nonpetroleum base form release agent shall be used for surfaces which are to receive Class 5, Masonry Coating Finish. 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 which will adhere to or discolor the concrete shall not be used.

All concrete forms for surfaces to which Structural Concrete Coating is to be applied shall be treated with a water based concrete form release agent prior to 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 which 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 controlled by beam or cylinder tests, the following minimum periods of times, exclusive of days when the ambient temperature is below 40 °F, may be used as a guide for removal of forms and supports.

Forms and supports for cast-in-place concrete box culverts (CBCs) shall not be removed until the concrete compressive strength exceeds 1800 pounds per square inch for CBCs with spans up to and including 12 feet , and 2000 pounds per square inch for CBCs with spans exceeding 12 feet but not larger than 20 feet. Forms for CBCs with spans larger than 20 feet shall be removed in accordance with the second paragraph of subsection 601.11(e).

Portion of Structure	Type II Cement	Type V Cement
Centering under beams and girders	14 days	—
Sides of beams, walls or Sides of beams, walls or other forms that do not resist dead loading bending	12 hours	18 hours
Columns	24 hours	36 hours
Deck slabs	7 days	—

When field operations are controlled by beam or cylinder tests, 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.

If high-early-strength (Type III) cement or accelerating admixtures are used, the above periods may be reduced as approved.

Forms for 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 and loose material shall be removed, and the inside of box girders shall be cleaned with an industrial vacuum.

- (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 in accordance with subsection 618.07(a).

Concrete for precast panel deck forms shall be cured in accordance with 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  $\frac{1}{8}$  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 prior to 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 in

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accordance with 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 in accordance with 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 A 653 (Grades A through E) having a galvanized coating designation of Z600 (G 165) according to ASTM A 653.
- (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 in accordance with requirements of the American Iron and Steel Institute 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 in accordance with AWS D1.5 Section 3.10. 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 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 in accordance with fabrication and erection plans submitted to the Engineer in accordance with 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 ¼ 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.

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- (f) *Inspection.* If the Engineer determines that the procedures used during the placement of the concrete warrant inspection of the under-side 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 from which the above visual inspection can be made.

**601.11 Falsework.**

- (a) *General.* Falsework is defined as any temporary construction used to support vertical loads for a structure until it becomes self-supporting. Formwork is the temporary structure or mold used to retain plastic or fluid concrete in its designated shape until it hardens.

The Contractor shall be responsible for designing and constructing falsework which provides the necessary rigidity, supports the loads imposed, and produces in the finished structure the lines and grades indicated on the plans.

The Contractor shall have a Professional Engineer determine whether falsework drawings are or are not necessary. When falsework drawings are determined to be unnecessary, the Contractor shall submit a written statement signed by the Contractor's Professional Engineer so stating. All falsework drawings, including revisions, prepared by the Contractor's Professional Engineer shall meet the requirements of subsection 601.11 and shall be provided by the Contractor to the Engineer for record purposes only. The drawings shall be approved by, and contain the seal and signature of, a Professional Engineer registered in the State of Colorado. These drawings shall be approved and signed by the Contractor prior to providing them to the Engineer. The drawings will not be approved by the Engineer.

- (b) *Certification.* Prior to 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 which 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 not less than 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 prior to the placement of concrete.

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5. The entire bridge superstructure cross-section, except railing, shall be considered to be placed at one time except as provided herein. Girder stems and connected bottom slabs, if placed more than five days prior to 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, Standard Specifications for Highway Bridges.

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 in accordance with 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 shall be constructed so that any concentrated loads applied to steel girder webs shall be applied 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.

Temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girders and to prevent appreciable relative movement between the edge of deck forms and the adjacent steel girder. Where the deck overhang exceeds  $\frac{1}{3}$  of the distance between the girders, the exterior girder shall be braced to prevent rotation due to the weight of the overhang support falsework and concrete placement operation.

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  $\pm \frac{3}{8}$  inch from those indicated on the falsework drawings, which in the opinion of

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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 prior to 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.* Falsework supporting any span of a simple span bridge shall not be released until after the last concrete, excluding concrete above the bridge deck, has attained the compressive strength of at least 80 percent of the required 28 day strength,  $0.80f'_c$ , but in no instance prior to five days after the placement of the concrete.

Falsework supporting any span of a continuous or rigid frame bridge shall not be released until after the last concrete, excluding concrete above the bridge deck, has been placed in all spans and has attained the compressive strength of at least 80 percent of the required 28 day strength,  $0.80f'_c$ , but in no instance prior to five days after placement of the concrete.

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 before five days after the deck concrete has been placed.

Falsework for pier caps which will support steel or precast concrete girders shall not be released before five days after the cap concrete has been placed unless the compressive strength of at least 80 percent of the required 28 day strength,  $0.80f'_c$ , is obtained. Girders shall not be erected onto such pier caps until the concrete in the cap has attained the compressive strength of at least 80 percent of the required 28 day strength,  $0.80f'_c$ , shown on the plans.

If authorized, test hammer results may be used in lieu of test cylinders for form removal determinations only. The test hammer must be calibrated against similar concrete of known strength from the same aggregate source prior to use.

Falsework for cast-in-place prestressed portions of structures shall not be released until after the pre-stressing steel has been tensioned.

#### **601.12 Placing Concrete.**

- (a) *General.* A preplacement conference shall be held with selected Contractor and Department personnel prior to 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.

- (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 which has a temperature of 90 °F 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 °F 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 °F from batch to batch.

To avoid the possibility of flash set when the water is heated to a temperature in excess of 100 °F, the water and the aggregates shall be charged into the mixer before the cement is added.

Heating equipment or methods which 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 °F. 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 which will not be detrimental to the aggregates may be used. The use of live steam on or through binned aggregates will not be permitted.

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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 near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After 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.

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 imbedded 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.

- (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. If concrete, except for cofferdam seals, is deposited under water, the proportion of cement used shall be increased at least 25 percent at the Contractor's expense. Concrete deposited under water shall be carefully placed in a compact mass in its final position by means of a 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 which will insure 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 concrete placement 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 hereinafter 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 initial set. Each layer shall be so consolidated as to avoid the formation of a construction joint with a preceding layer which has not taken 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 under side 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 shotblasting  $\frac{1}{8}$  to  $\frac{3}{16}$  inch deep or rotomilling. If Class DT concrete is not placed within one week of the shotblasting 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.

- (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.

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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 in accordance with 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 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 where 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 on which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete.

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 non-shrink grout or epoxy grout and the dowel. Immediately prior to 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 in accordance with 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  $0.8f'_c$ .

The Contractor shall provide an as constructed survey of the abutments and piers prior to 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 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. The minimum compressive strength shall be determined from test cylinders made and cured at the structure site in accordance with AASHTO T 23 and tested in accordance with AASHTO T 22.

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.

**601.13 Curing Concrete Other Than Bridge Decks.** When the ambient temperature is below 35 °F the Contractor shall maintain the concrete temperature

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above 50 °F during the curing period. It shall be the Contractor's responsibility to determine for himself 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 cast information cylinders on the final portion of a placement and store as close to the structure as possible. The information cylinders shall receive similar thermal protection as the structure. The contractor shall protect the information cylinders from damage. In-place strength shall be determined by at least two cylinders. If the information cylinders are destroyed in the field, the minimum curing period shall be 120 hours.
- (3) 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 in accordance with ASTM C 1074. 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. The Contractor shall install the thermocouples at locations designated by the Engineer. The Contractor shall monitor the temperature at intervals acceptable to the Engineer.

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 of 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, which are to receive a Class I or Class 4 final finish. A volatile organic content (VOC) compliant curing compound conforming to AASHTO M 148, 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 in accordance with 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 ten 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 insure the concrete surface remains wet.
- (d) *Blanket Method.* Electrically heated curing blankets or insulation blankets may be used in cold weather to maintain specified curing temperature and to retain moisture in 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) *Potential Frost Damage.* 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.

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- (2) The Engineer will take immediate possession of the cores and submit the cores to a petrographer for examination in accordance with ASTM C 856.
- (3) All costs associated with coring, transmittal of cores, and petrographic examination shall be born 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 work day. 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) 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 from those which 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 sand blasted 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 incidental 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 prior to batching and application on the project. Approval of the final color of the coating will be determined by the Engineer as follows:

- (1) 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 to which the coating will be applied on the project. The sample coating shall be applied by the same methods to be used in field application.
- (2) At least three weeks prior to 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 on which 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.

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Concrete surfaces to which the structural concrete coating will be applied shall be prepared as follows:

- (1) Following curing of the concrete in accordance with 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 C 144), and an approved bonding agent shall be used to patch all holes produced by form ties, honeycombing, voids ½ 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 in accordance with 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 ¾ inch shall be filled in layers that do not exceed ¾ inch in thickness.
- (3) Within 24 hours prior to 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 bonding of the coating. If the surface is contaminated before application of the coating, it shall be recleaned as required prior to 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 Quality Control Plan (QCP) which defines the quality 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 QCP. It shall also identify the Contractor's method for ensuring that the provisions of the QCP are met. The Contractor shall submit the QCP 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 Class H, Class HT or Class S50 concrete. Representatives of the ready mix producer and the Contractor shall meet with the Engineer to discuss the following topics:

- (1) Concrete Mix Ingredients and Proportions (cement content, effect of admixtures, etc.)
  - (2) Work Schedule
  - (3) Applicable Specifications and Special Notes
  - (4) Delivery Details
  - (5) Planned Construction Joint Locations
  - (6) Role of All Personnel
  - (7) Construction Details - surface preparation, finish, joint locations, etc.
  - (8) Testing Requirements
  - (9) Acceptance Criteria
  - (10) Contingency Plans for Wind, Rain, Breakdown, etc.
  - (11) 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 prior to concrete placement. The proposed preheating method is subject to approval by the Engineer.

Prior to placement of a Class HT concrete overlay, the deck shall be prepared as follows:

1. Newly Placed Decks or Existing Decks That Have Been Used as the Final Driving Surface. The deck shall be shot blasted in preparation for a mechanically bonded surface. Shot blasting shall remove the upper surface of the deck down to the coarse aggregate, which requires removing approximately  $\frac{1}{8}$  to  $\frac{3}{16}$  inch of the concrete.

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2. Existing Decks Covered with One or More Layers of Bituminous Pavement. The deck shall be planed in accordance with subsection 202.09 to remove all overlying bituminous pavement, bridge deck membrane, and the upper  $\frac{1}{4}$  inch of the deck concrete.

If Class HT concrete is not placed within one week of shot blasting or planing, the area shall then be sandblasted and cleaned of all sand, concrete fragments, dirt, and other foreign material within one week before placement. The area shall be moistened at least two hours before placement in order that the substrate concrete is saturated. The substrate concrete shall be allowed to dry and shall be saturated surface dry and free of visible water at the time of placement.

- (b) *Test Slab.* At least seven days prior to initial placement of Class H, Class HT or Class S50 concrete on or in a deck, the Contractor shall have prepared, placed, and cured one test slab of at least 4 cubic yards to verify mix design, demonstrate the ability to perform placement, finishing & curing operations, and to check quality control. The test slab shall be approximately the same thickness as the concrete to be placed. Additional test slabs shall be placed as necessary to verify changes in design or procedures at the contractor's expense. Test slabs that are placed as acceptable work in segments of sidewalks, or as approach slabs, or other locations acceptable to the Engineer, will be paid for as the pay item for that element of the contract.
- (c) *Placing.* Concrete shall be placed in accordance with the requirements of subsection 601.12 except for the following:

Concrete shall be placed in such manner as to require as little rehandling 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.

Class H, Class HT and Class S50 concrete shall be placed only when the concrete mix temperature is between 50 °F and 80 °F at the time of delivery. Class H, Class HT and Class S50 concrete shall not be placed in or on bridge decks when the air temperature exceeds 80 °F or the wind velocity exceeds 10 mph as determined by a digital thermometer and anemometer provided on site by the Contractor. If the Engineer can determine from the Contractor's data that the evaporation rate is less than 0.20 pound per square foot per hour, in accordance with figure 2.1.5 in ACI 305, then Class H and HT concrete may be placed under these conditions.

Longitudinal joints for a Class HT concrete overlay will be allowed only at the locations of lane lines and must be approved by the Engineer.



Transverse joints may be utilized when the Engineer determines that the work is not progressing in a satisfactory manner, or when required by change in weather conditions. The Engineer may approve transverse joint locations to accommodate phased overlay construction.

- (d) *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.

- (e) *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 3000 to 4500 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 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.

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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  $\frac{1}{16}$  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 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 prior to 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 one foot from obstructions.

The grooving shall be rectangular and conform to the following:

Depth:  $\frac{1}{8}$  inch  $\pm$   $\frac{1}{32}$  inch  
Width:  $\frac{1}{8}$  inch  $\pm$   $\frac{1}{32}$  inch  
Spacing:  $\frac{3}{4}$  inch  $\pm$   $\frac{1}{32}$  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 curb or bridge rail on each side of the overlaid bridge deck.

Grooving to bridge joint system. For joint systems that are perpendicular to the roadway centerline, grooving shall extend to 9 inches  $\pm$  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 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.

(f) *Surface Smoothness.*

1. 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  $\frac{1}{8}$  inch but not exceeding  $\frac{1}{2}$  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  $\frac{1}{8}$  inch in 10 feet. Grinding shall not reduce the concrete cover on reinforcing steel to less than  $1\frac{3}{4}$  inches, ( $2\frac{3}{4}$  inches for bare decks without an overlay). Decks that require additional corrective action shall be corrected with a concrete overlay approved by the Engineer.
2. All Bridge Deck Final Riding Surfaces. Bare deck, or any concrete overlaid final surface is subject to an incentive payment. The Contractor shall provide the Engineer with the following for incentive payment only: The longitudinal finished surface smoothness of structures and approach slabs including concrete deck and any overlaid surface shall be tested with the profilograph method in accordance with subsection 105.07(b). Bridge Deck shall be subject to an incentive payment in accordance with the following Table 601-2. Incentive Payments will be based on the Lane Profile Index (LPI) before diamond grinding of bumps or any corrective work has been done.

**Table 601-2  
BRIDGE DECK SMOOTHNESS (INCHES/MILE)  
0.1 INCH BLANKING BAND**

Pavement Smoothness Category <sup>1</sup>	Incentive Payments		Corrective Work Required
	LPI (inches per mile)	Concrete \$ per square yard	
All Bridge Decks	0-12 or	1.20	In accordance with subsection 601.15(f)1.
	12.1-15	0.90	
	15.1-18	0.60	
	18.1-22	0.30	
	22.1-25	0.00	

<sup>1</sup> This category will be used only on new construction or complete reconstruction of bridge deck.

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- (g) *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.
- (h) *Concrete Bridge Sidewalks.* Bridge sidewalks shall receive a final transverse broom finish.
- (i) *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 a low viscosity, two part, methacrylate or an approved equal. The repair shall be in accordance with the recommendations of the manufacturer of the crack filling material.

**601.16 Curing Concrete Bridge Decks.** Except for Class H and HT concrete, 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.

For Class H and HT concrete the minimum curing period shall be 168 hours and from May 1 and until September 30 the water cure method as described below shall be used without the membrane forming curing compound.

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 AASHTO M 148, 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 gage 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 within ½ 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 and shall be continued for five days. The surface of the concrete, including bridge curbs and bridge sidewalks, shall be entirely covered with cotton, burlap, or combination polyethylene sheeting and burlap mats. Approved combinations of a barrier and a water retaining layer may be used. Prior to being placed, the mats shall be thoroughly saturated with water. The mats 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 mats shall remain in contact and be kept wet for a minimum of five days after concrete placement.
- (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 in accordance with subsection 601.16(a)1 above.
  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 in accordance with either subsection 601.16(a) or 601.16(b) above.
- (d) For decks placed 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) above.
- (e) Class H, Class HT and Class S50 concrete shall be cured as follows:
1. The concrete surface shall be kept moist at all times by fogging with approved atomizing nozzles until the surface has been covered by the final cure.
  2. At least two atomizing nozzles shall be in operation at all times.
  3. From October 1 and until April 30 continuous fogging will not be required if the evaporation rate is less than 0.10 pound per square foot per hour. Ambient temperatures during initial curing shall be warm

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enough that the water from fogging does not freeze before insulating blankets are applied. The internal concrete temperature shall be determined by using thermocouples and a continuous recording device. The Contractor shall provide the thermocouples and a continuous recording device and install the thermocouples at locations designated by the Engineer. The continuous recording device connected to the thermocouple shall be calibrated to provide accurate temperature readings. During the cure period the continuous recording device shall be visible, show visible readings, and the Contractor shall continuously monitor the concrete temperature and provide the recorded data to the Engineer after the monitoring of temperature for that placement is complete.

- (f) When the ambient temperature is below 35 °F, the Contractor shall maintain the internal concrete temperature above 50 °F during the curing period, except the last 48 hours of the curing period the internal concrete temperature may be kept above 40 °F.

Internal concrete temperature shall be determined by using thermocouples. Thermocouple wire, connectors, and hand held thermometer will be supplied by the Engineer. The Contractor shall install the thermocouples at locations designated by the Engineer.

During the curing period, the Contractor shall monitor the enclosure at intervals acceptable to the Engineer. The Contractor shall monitor concrete temperature, and 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.

During the curing period, for each day that the internal concrete temperature falls below the specified temperature, the protection shall remain in place and one extra day of curing time above 40 °F shall be added to the original days of protection.

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 C 856. 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, and petrographic examination shall be born by the Contractor regardless of the outcome of the petrographic examination.

At the end of the protection 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 of temperature shall be prevented.

**601.17 Acceptance and Pay Factors.** These provisions apply to all concrete.

- (a) *Air Content.* At any time during the placement of the concrete, when a batch deviates from the minimum or maximum percent of total air content specified, the following pro-cedure will be used to analyze the acceptability of the concrete.
1. A batch that deviates from the specified air content by more than one percent and all Class D concrete placed in bridge decks with air content exceeding eight percent will be rejected. Portions of loads incorporated into structures prior to determining test results which 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.
  2. A batch that deviates from the specified air content by one percent or less, may be incorporated into the project at a reduced price, calculated as follows: The first batch that deviates from the specified air content by  $\frac{1}{2}$  percent or less, will be accepted at full price. The first batch that deviates from the specified air content by more than  $\frac{1}{2}$  percent and up to 1 percent, which the Contractor elects to place, will be accepted at a reduced price. The second and third successive batches of a series that deviate from the specified air content by 1 percent or less, which the Contractor elects to place, will be accepted at a reduced price. The fourth and all other successive batches of a series that deviate from the specified air content will be rejected. The rejected batch count will stop with a batch that is within the specified air content, and deviation batch count will resume at one with the next batch that deviates from the specified air content.
- (b) *Slump.* Slump acceptance, but not rejection, may be visually determined by the Engineer. During the placement of the concrete, when a batch exceeds the maximum slump specified, the following procedure shall be used to analyze the acceptability of the concrete.
1. A batch that exceeds the maximum slump specified by more than 1 inch will be rejected. Portions of loads incorporated into structures prior to determining test results which 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.
  2. A batch that exceeds the maximum slump specified by 1 inch or less, may be incorporated into the project at a reduced price, calculated as follows: The first batch that exceeds the maximum slump specified by  $\frac{1}{2}$  inch or less, will be accepted at full price. The first batch that exceeds the maximum slump specified by more than  $\frac{1}{2}$  inch and up to 1 inch, which the Contractor elects to place, will be accepted at a reduced price. The second and third successive batches of a series that exceed the maximum slump specified by 1 inch or less, which the Contractor elects to place, will be accepted at a reduced

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price. The fourth and all other successive batches of a series that exceed the maximum slump specified shall be rejected. The rejected batch count will stop with a batch that has less than the maximum slump, and will resume at one with the next batch that exceeds the maximum slump.

- (c) *Strength (When Specified)*. The concrete will be considered acceptable when the running average of three consecutive strength tests 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 prior to 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 in accordance with 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 in accordance with 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 4500 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 specified strength of 4500 psi or greater, when the compressive strength test is below the specified strength by more than 500 psi but not more than 1000 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 1000 psi, the concrete represented will be rejected.

The Contractor may take cores at its own expense and in accordance with Colorado Procedure 65 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.

Class HT concrete overlays shall not be opened to traffic, including construction traffic, for at least 14 days after placement. At the Engineer's discretion, the overlay may be opened to construction traffic sooner than 14 days but not until after the curing period has elapsed and the average strength of two field cured cylinders has reached 4500 psi. The field cured cylinders shall be made in accordance with AASHTO T 23 Making and Curing Concrete Test Specimens in the Field.

- (d) *Pay Factors*. The pay factor for concrete which is allowed to remain in place at a reduced price shall be according to Table 601-3 and shall be applied to the unit price bid for Item 601, Structural Concrete.



If deviations occur in air content, slump, 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**

* Percent Total Air Deviations From Specified Air (Percent)	Slump		Strength							
	Pay Factor (Percent)	Maximum Slump Exceeded by (Inches)	Below Specified Strength (psi) [< 4500 psi Concrete]	Pay Factor (Percent)	Below Specified Strength (psi) [≥ 4500 psi Concrete]					
0.0-0.2	98	¼	1-100	98	1-100					
0.3-0.4	96	½	101-200	96	101-200					
0.5-0.6	92	¾	201-300	92	201-300					
0.7-0.8	84	1	301-400	84	301-400					
0.9-1.0	75	Over 1	401-500	75	401-500					
Over 1.0	Reject		Over 500	Reject						
*Class D bridge deck concrete with air content over 8% will be rejected.										
									65	501-600
									54	601-700
									42	701-800
									29	801-900
			15	901-1000						
			Reject	Reject	Over 1000					

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- (e) *Bonding of Bridge Deck Overlay.* After the curing period for Class DT and HT concrete has elapsed, the overlay shall be “sounded” by the Contractor in accordance with ASTM D 4580 Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding to determine if the Class DT and HT concrete has bonded to the bridge deck. In areas where the Class DT and HT concrete has not bonded to the bridge deck, it shall be removed and replaced at the Contractors expense.

**601.18** Unless otherwise stated in the plans or specifications, tolerances for concrete construction and materials shall be in accordance with ACI 117.

Cast in place bridge decks and bridge slabs shall be no more than ½ inch thicker nor more than ¼ 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 in accordance with 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 pre-stressing 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.

Class 5 finish will be measured by the square foot, without deduction for areas occupied by bridge rail base plates, other anchorages, or weep holes. Class 5 finish will not be remeasured 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 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 which 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 remeasured 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 in accordance with 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 remeasured, 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 in accordance with 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 remeasured, 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 in accordance with 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 remeasured but shall be the surface area quantity shown on the plans; except that measurements will 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:

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<b>Pay Item</b>	<b>Pay Unit</b>
Concrete, Class ____ (Bridge)	Cubic Yard
Concrete, Class ____ (Box Culvert)	Cubic Yard
Concrete, Class ____ (Wall)	Cubic Yard
Concrete, Class ____ (Miscellaneous)	Cubic Yard
Class 5 Finish	Square Foot
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 in accordance with subsection 109.02.

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 bond 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.

Preparation of designated surfaces for application of Class 5 finish will not be paid for separately but shall be included in the work. Concrete finish is included in the work unless a separate pay item is included in the bid schedule.

## SECTION 602 REINFORCING STEEL

### DESCRIPTION

**602.01** This work consists of furnishing and placing reinforcing steel in accordance with 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 which will highlight rusting of untreated bar areas.

Reinforcing steel that requires welding shall conform to ASTM A 706. Welding shall be done in accordance with ANSI/AWS D1.4.

All accessories, including reinforcing steel supports, ties, and splicers used in conjunction with epoxy coated reinforcing steel, shall be plastic or epoxy coated.

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. Length of lap splices for epoxy coated reinforcing steel shall be in accordance with *AASHTO Standard Specifications for Highway Bridges*, 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 in accordance with the details shown on the plans.

Bar lists and bending diagrams which 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 epoxy 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

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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 *Standard Specifications for Highway Bridges*.

Bars which are shown as “hooked” on the plans shall have “standard hooks” unless otherwise indicated. The term “standard hook” as used herein shall mean one of the following:

- (1) A 180 degree turn plus an extension of four bar diameters but not less than 2½ 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
  - (i) No. 5 bar and smaller, 90 degree turn plus an extension of six bar diameters at the free end of the bar.
  - (ii) No. 6, 7, and 8 bar, 90 degree turn plus an extension of 12 bar diameters at the free end of the bar.
  - (iii) 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:

<b>Bar Size</b>	<b>Grade60</b>
No. 3 thru No. 8	6 bar dia.
No. 9, No. 10, and No. 11	8 bar dia.
No. 14, and No. 18	10 bar dia.

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 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 2½ times the diameter of the bar. However, the clear distance between the bars shall not be less than 1½ times the maximum size of the coarse aggregate or 1½ 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 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 4 foot maximum spacing in each direction. Slab bolsters for the bottom mat and high chairs 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 in accordance with the plans and the latest edition of "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 where 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 size 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

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joined by butt welding in accordance with 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.

Epoxy coated bars shall be placed on plastic supports or steel supports fully coated with plastic or epoxy. Care shall be taken to prevent coated bars from coming into contact with other steel items.

### 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. 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.

Bar Size	Weight per Linear Foot in Pounds	Bar Size	Weight per Linear Foot in Pounds
¼ inch	0.167	No. 8	2.670
No. 3	0.376	No. 9	3.400
No. 4	0.668	No. 10	4.303
No. 5	1.043	No. 11	5.313
No. 6	1.502	No. 14	7.650
No. 7	2.044	No. 18	13.600

### 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



## SECTION 603 CULVERTS AND SEWERS

### DESCRIPTION

**603.01** This work consists of the construction of culverts, storm drains, and sanitary sewers hereinafter referred to as “conduit,” and nestable semicircular pipe for encasement in accordance with 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 Plan M-603-10 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 in accordance with 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 height of fill and supporting soil.

603.04

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 not less than 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 in accordance with details as shown on the plans. The bed shall consist of a layer of loose structure backfill not less than 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 center line 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 eye holes in which 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.**

- (a) *Concrete or Clay Conduit.* Conduit sections shall be joined in such 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 in accordance with 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  $\frac{3}{4}$  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.

**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 installed, it shall be inspected before any backfill is placed. 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 in accordance with Section 206.

Sanitary sewer lines, when completed, shall be tested for water-tightness before any backfill is placed. The installation shall not show infiltration or exfiltration in

603.09

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 in accordance with 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 Contractor's operations shall be repaired or replaced at the Contractor's expense.

Trenches in existing streets, except streets which 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.

**603.10 Repair of Damaged Culvert.** Coating on corrugated steel pipe and pipe arches, and corrugated steel pipe nestable shall be repaired in accordance with the provisions of subsection 707.09. Damaged pipe shall not be repaired. The Engineer will determine when the pipe is either acceptable or unacceptable in accordance with the provisions of subsection 105.03. Unacceptable pipe shall be removed and replaced.

#### **METHOD OF MEASUREMENT**

**603.11** 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 conduit measured along the bottom centerline. Extra length of 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 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 in accordance with Section 210.

#### **BASIS OF PAYMENT**

**603.12** 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. 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:

<b>Pay Item</b>	<b>Pay Unit</b>
___ 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

Structure excavation and structure backfill will be measured and paid for in accordance with 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.

604.01

**SECTION 604  
MANHOLES, INLETS,  
AND METER VAULTS**

**DESCRIPTION**

**604.01** This work consists of the construction of manholes, inlets, and meter vaults in accordance with 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.

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 in accordance with 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 ½ 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 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 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 insure 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 brick work 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 which 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.

604.06

<b>Measured Depth</b>	<b>Pay Depth</b>
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:

<b>Pay Item</b>	<b>Pay Unit</b>
Meter Vault	Each
Manhole _____ (_____)	Each
Inlet, Type _____ (_____Foot)	Each
Manhole Ring and Cover	Each
____ Inlet Grating and Frame	Each



## SECTION 605 SUBSURFACE DRAINS

### DESCRIPTION

**605.01** This work consists of constructing underdrains, edge drains, geocomposite drains, and french drains, in accordance with 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 B) 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

**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 in accordance with the manufacturer's recommendations.

The trench for geocomposite underdrain and geocomposite 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 so as 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 B) 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 in accordance with 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:

605.08

<b>Pay Item</b>	<b>Pay Unit</b>
___ 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.

606.01

## **SECTION 606 GUARDRAIL**

### **DESCRIPTION**

**606.01** This work consists of the construction of guardrail in accordance with 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 - W Beam
Type 6 Guardrail - Thrie Beam
Type 7 Guardrail - F-Shape Concrete Barrier

Use of Type 4 Precast Concrete Barrier is 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 conform to the requirements of Section 601. Reinforcing steel, unless otherwise noted, shall conform to the requirements of Section 602. During production of slipformed barrier and subsequent to mix design approval the Contractor may adjust the mix proportion requirements as follows:

The range for air content may be adjusted to be 5 percent to 9 percent

The weights of coarse and fine aggregates may each be adjusted up to 10 percent.

These adjustments may be made at the Contractor's discretion and do not require approval of a revised mix design before use. The Contractor shall inform the Engineer in writing of each adjustment of aggregate proportions before concrete with the adjusted mix design is placed.

The Contractor may furnish either wood or steel posts and wood or FHWA approved synthetic material blocks for guardrail as shown on the plans. Except as designated on the plans, only one type of posts and blocks shall be furnished for the project.

Components on which the spelter coating has been burned by welding or otherwise damaged shall be either regalvanized, recoated in accordance with AASHTO M 36, or painted with one full brush coat of zinc rich paint meeting Military Specification DOD-P-21035A.

## CONSTRUCTION REQUIREMENTS

### 606.03 Post and Rail Elements.

- (a) *Posts.* Posts shall be set firm and aligned with a tolerance of plus or minus  $\frac{1}{4}$  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 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 in which the rail installation is to advance and the number of posts installed ahead of rail installation. At the end of the Contractor's work day, the Contractor shall treat the ends of 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

606.03

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. Guardrail shall not be left in this configuration 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 acceptable 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 installed concrete guardrail at the end of the work day 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.* Permanent concrete barrier may be constructed by precast Type 7, 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 when tested according to AASHTO T 99. The compacted trench bottom shall be watered and approved before placing concrete. The 1 inch minimum deep keyway cut or formed in the pavement surface for the barrier base shall be cleaned and approved before placing concrete.

Concrete finish for all precast Type 7 barriers used as permanent installations, and all cast-in-place barriers shall be Class 1 in accordance with 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.

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 radius greater than 1000 feet: 0.25 inch from the edge of the straightedge.
- (2) On sharp vertical curves and horizontal curves with radius of 1000 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 radius greater than 1000 feet: 0.75 inch from the edge of the straightedge.
- (2) On sharp vertical curves and horizontal curves with radius of 1000 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 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 which 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) *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 in accordance with 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.

Connecting loops shall not be frayed, stretched, or deformed. Gaps between units shall not exceed the dimensions shown in 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 in accordance with Standard Plan M-606-14 to join the cast-in-place sections to the abutting precast sections. A ten foot transition section shall be provided when attaching barriers of differing shapes.

606.05

### 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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.



**SECTION 607  
FENCES**

**DESCRIPTION**

**607.01** This work consists of the construction of fence and gates, and removal of temporary plastic fence in accordance with 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 Sound 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 C 330 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.

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.

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 such time as 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.

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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 sound 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 (Sound 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,

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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:

<b>Pay Item</b>	<b>Pay Unit</b>
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 (Sound 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.

608.01

## SECTION 608 SIDEWALKS AND BIKEWAYS

### DESCRIPTION

**608.01** This work consists of the construction of bituminous or concrete sidewalks, bikeways, and curb ramps in accordance with 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 assure 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 in accordance with 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 slipform method may be used.
- (c) *Placing Concrete.* The foundation shall be thoroughly moistened immediately prior to the placing of the concrete. The proportioning, mixing and placing of the concrete shall be in accordance with 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 outside edges of the slab and all joints shall be edged with a  $\frac{1}{4}$  inch radius edging tool.

- (e) *Joints.* Expansion joints, at intervals of not more than 500 feet, shall be filled with  $\frac{1}{2}$  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  $\frac{1}{4}$  of the depth and shall be approximately  $\frac{1}{8}$  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, utility poles, etc., extending into and through the sidewalk. Preformed expansion joint filler  $\frac{1}{2}$  inch thick shall be installed in these joints. Expansion joint filler  $\frac{1}{2}$  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 so as 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 preconstruction conference what type of paving equipment will be used.

608.05

**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:

<b>Pay Item</b>	<b>Pay Unit</b>
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 in accordance with 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.

## SECTION 609 CURB AND GUTTER

### DESCRIPTION

**609.01** This work consists of the construction of curb, gutter or combination curb and gutter in accordance with 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
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Joint Filler	705.01
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Reinforcing Steel	709.01
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Concrete for curb shall be Class B, and meet the requirements of Section 601, except that when curb machines are used, a lesser slump will be permitted.

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.**

- (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 in accordance with the requirements for the class of concrete specified.

609.03

Compaction of concrete curb, gutters or combination curb and gutter, placed in forms shall have thorough consolidation which 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  $\frac{1}{8}$  inch wide except at expansion joints.
- (e) *Expansion Joints.* Expansion joints shall be formed at the intervals shown on the plans using a  $\frac{1}{2}$  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 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 radius greater than 1000 feet: 0.25 inch from the edge of the straightedge.



- (2) On sharp vertical curves and horizontal curves with radius of 1000 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 prior to placing of 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 use of a self-propelled curb machine or a paver with curb attachments.

The automatic curb machine shall meet the following requirements and shall be approved prior to its use:

- (1) The weight of the machine shall be such that compaction is obtained without the machine riding above the bed on which 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 which is clean and dry and which 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 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.

609.07

**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:

<b>Pay Item</b>	<b>Pay Unit</b>
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 in accordance with 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.

## 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, in accordance with 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 of the class designated 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 in accordance with 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 in accordance with Section 217 or as directed. Immediately after the placement of the herbicides, the plastic sheeting and stones shall be placed in accordance with 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.

610.04

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:

<b>Pay Item</b>	<b>Pay Unit</b>
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 in accordance with 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 in accordance with 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 in accordance with the details shown on the plans. All work shall be done in accordance with 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Cattle Guard	Each

612.01

## **SECTION 612 DELINEATORS AND REFLECTORS**

### **DESCRIPTION**

**612.01** This work consists of the installation and furnishing of delineators and reflectors in accordance with 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 subsection 713.07.
2. Flexible Posts. Flexible posts shall be manufactured from an impact resistant flexible material and shall conform to the following requirements:
  - A. 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.
  - B. Base Anchoring. The posts shall be designed to facilitate a permanent installation that resists overturning, twisting, and displacement from wind and impact forces. The post shall be designed for an anchoring depth of 18 to 24 inches. Detailed installation instructions shall be provided by the manufacturer.

The posts or below-ground anchors shall be capable of being driven into an earth shoulder or roadside 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. Reflective elements shall be 3 inches square for Type I, 3 inches by 6 inches for Type II, and 3 inches by 9 inches for Type III (hazard marker) delineators. Reflective material shall be Type III reflective sheeting meeting the requirements of subsection 713.10.

The top of the reflective element shall be mounted no more than 2 inches from the top of the post, with the reflective element facing in the direction of the oncoming traffic. The reflective element shall be mounted in accordance with the manufacturer's recommendations to prevent loss of the reflective element during the life of the post.

The reflective element shall be protected from scratches, abrasions, and other physical damage during shipping and driving by an easily removable “masking” sheet.

- D. Marking. The tops of the posts on the side away from traffic shall be date-stamped showing the month and year of fabrication. The numerals shall be at least  $\frac{1}{4}$  inch in height and shall be either die-stamped, or legibly stamped with permanent ink. In addition, each post shall be marked with a black horizontal stripe to denote an 18 inch embedment depth.
- E. Dimensions.
- (1) Width. The post shall have a minimum width of 3 inches and a maximum width of  $4\frac{1}{2}$  inches facing traffic.
  - (2) Length. The post shall be of such length to provide a height of 48 inches above the edge of the pavement and to provide the required anchoring depth.
- F. Physical Properties and Performance Requirements. Flexible posts shall conform to the following physical properties and performance requirements.
- (1) Heat Resistance: The post shall be conditioned a minimum of two hours in an oven at  $140\text{ }^{\circ}\text{F} \pm 3\text{ }^{\circ}\text{F}$ . The conditioned post shall be capable of straightening itself within five minutes when bent 90 degrees at the midpoint for each of four bends. The conditioning temperature shall be maintained while the test on each post is completed.
  - (2) Cold Resistance: The post shall be conditioned a minimum of two hours at  $-5\text{ }^{\circ}\text{F} \pm 3\text{ }^{\circ}\text{F}$  in an environmentally controlled test chamber. Testing shall be performed in the environmental chamber.
    - (i) The post shall not be adversely affected when a person, standing approximately at the center of the post, bends the free half of the post to a 90 degree angle with the remaining section being stood upon. The post shall return to its original shape within 60 seconds for each of four separate bends.
    - (ii) A steel ball weighing 2 pounds shall be dropped a distance of 5 feet through a virtually frictionless vertical guide to impact the surface of the post. The surface of the post being struck by the steel ball shall be in a horizontal position, with the post supported and held in position at both ends. The

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post shall be subjected to five impact tests concentrated near the middle of the post. Fracturing, cracking, or splitting of the post shall constitute failure.

- (3) Colorfastness: Post shall be exposed for 500 hours in a Carbon-Arc Type weatherometer (ASTM G23, Method 1). The post shall show no signs of delamination, distress, or discoloration, and the reflective sheeting shall not be removable from the post without damage.
  - (4) Impact Resistance: The post shall be manufactured from an impact resistant material and be so designed that an installed post is capable of self erecting and remaining serviceable after being subjected to a series of direct impacts by a typical passenger sedan at temperatures of 40 °F or above. The posts to be tested shall be installed in accordance with the recommendations of the manufacturer. The posts shall be furnished complete with attached reflectors proposed for use. Posts shall be capable of withstanding a series of ten impacts head on (90 degrees) into traffic face of the post at a speed of 35 mph. Posts shall also be capable of withstanding a series of five impacts at an angle of 75 degrees to the traffic face of the post at speeds of 55 mph. The impacting vehicle shall suffer little or no damage during the impact test series. After each impact, the post shall:
    - (i) Remain intact and securely anchored.
    - (ii) Return to its original vertical orientation within an angle of 10 degrees from vertical.
    - (iii) Show minimal signs of distress (cracking, loss of rigidity).
    - (iv) Retain a minimum of 50 percent of its original amount of reflective sheeting.
  - (5) Each post, prior to and after installation, shall be visibly free of bends or twists.
  - (6) The posts shall have a minimum tensile strength of 1,100 pounds per square inch, as determined in accordance with ASTM D 638.
  - (7) The color of the posts shall be Interstate Green in accordance with Federal Standard No. 595B, Color Number 14109, unless otherwise specified.
- G. Sampling and Acceptance. Prior to shipment of the posts, the manufacturer shall submit certified test reports and test data,



612.05

developed by an approved testing laboratory which attests to the fact that their marker post complies in all respects with requirements covered in the specifications.

- (b) *Median Barrier Reflector*: Details for the median barrier reflector 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.

**METHOD OF MEASUREMENT**

**612.04** Delineators and reflectors for median barrier 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Delineator (Type_____)	Each
Delineator (Flexible) (Type___)	Each
Reflector (Median Barrier)	Each

613.01

## **SECTION 613 LIGHTING**

### **DESCRIPTION**

**613.01** This work consists of furnishing and installing foundations, light standards, luminaires, lamps, conduit, cable, wiring and incidental materials for highway lighting and for traffic signal installations in accordance with these specifications and in conformance with the details, lines, grades and locations shown on the plans or established.

### **MATERIALS**

**613.02** Highway lighting materials shall conform to the requirements of Section 715, and shall be compatible with the requirements of the local utility company.

Electrical conduit for traffic signal installations shall conform to subsection 715.06.

At the preconstruction conference the Contractor shall submit three copies of a list of all materials and equipment to be incorporated into the work, to the Engineer for review and approval (including type of metal pole - either steel or aluminum). Also included shall be detail plans, drawings, photographs, photometric charts, templates, manufacturer's specifications and recommendations, and all other available information pertinent to this work. The Contractor shall not order materials or equipment until the Engineer approves the materials and equipment list. Approval of the above required submission shall not relieve the Contractor of responsibility for the proper functioning of the completed installation.

Materials shall conform to the applicable requirements of the National Electrical Code and shall be a type currently recommended and approved by Underwriters' Laboratories, Inc.

### **CONSTRUCTION REQUIREMENTS**

**613.03 General.** All installations shall be in accordance with these specifications and the National Electrical Code, and shall conform to subsection 107.01.

Each system shall conform as to voltage, cycles and type as shown on the plans or as designated. The Contractor shall furnish and install all incidentals necessary to provide a complete working unit or system, as called for on the plans.

Secondary service pedestal shall be constructed as shown on the plans.

**613.04 Foundation Pads.** Light standard foundations may be precast concrete, cast-in-place concrete, or screw-in galvanized steel foundations.

Screw-in foundations shall be of a type and manufacture previously approved by the Department. Screw-in foundations shall have a minimum auger helix pitch of 3 inches and be galvanized according to ASTM A 153. Screw-in foundations may be used only where soil testing shows aggregate sizes less than 3 inches in diameter. The

Contractor shall be responsible for testing and reporting soil conditions to the Engineer as necessary to ensure proper installation of screw-in foundations. The following minimum screw-in foundation sizes are required for 40-foot light standard:

No. of Mast Arms	Foundation Inside Diameter and Length	Outside Diameter of Helix
1	6 inch by 7 foot	12 inch
2	8 inch by 7 foot	14 inch

The cableway openings in the screw-in foundation shall be 2.5 inches by 12 inches. The openings shall have rounded ends and run vertically with the top 12 inches below the base plate. The baseplate shall have a pole mounting surface free from curvature or other deformity induced by the manufacturing process. The baseplate is to be machine smooth flame cut on the external edges and on the inner hole providing access to the foundation interior. The baseplate shall be of adequate size to provide actual contact support at outer corners and edges of the lighting structure or breakaway mounting device. The baseplate shall be permanently marked to indicate the locations of the cableway openings and shall have a thickness as required by the manufacturer's design based on shape of plate and number of mast arms. Bolt holes shall be provided through the baseplate to allow for the attachment of a breakaway device or light structure as specified in the plans. If tapped holes are used they shall be center tapped perpendicular to the baseplate plus or minus one degree, and the threads shall be fully cleaned after hot dip galvanizing so a bolt may be hand turned in the threads. Baseplate material shall conform to the requirements of ASTM A 709 Grade 36.

The screw-in foundation shaft shall be flame cut to length, 90 degrees square on top and true helical on the bottom. Cableway openings shall be smooth cut on both sides of the shaft 180 degrees apart unless otherwise specified. The sides of the cableway openings shall be parallel to the axis of the shaft plus or minus ½ degree as measured along their full length. Round shaft material shall be new, unused and mill traceable. The edges are to be mechanically cleaned before welding operation. The shaft shall be fabricated from standard weight pipe meeting the requirements of ASTM A 53, Type E or S, Grade B or ASTM 252, Grade 2.

The helix on screw-in foundations shall be of true helical form and shall be produced with a matching metal dye from formable weldable  $\frac{3}{8}$  inch thick steel meeting the requirements of ASTM A29, Grade M 1010. The preformed helix is to be tumbleblasted to remove scale and contaminants before welding.

Screw-in foundation pilot point shall be sheared on a 45 degree angle from 1.25 inch diameter round bar steel meeting the requirements of ASTM A 575. It shall project a minimum of 6 inches below the leading edge of the helix and shall be tumbleblasted prior to welding.

Screw-in foundations shall be supplied with lighting standard to base plate connection hardware consisting of 1 inch by 10 UNC, 4 inch long Grade 8 hex head bolts, nuts, and washers galvanized in accordance with ASTM A 153.

613.04

All welding for construction of screw-in foundations shall be in accordance with Sections 1 through 8 of AWS D1.1.

Completed screw-in foundations shall be hot dip galvanized in accordance with ASTM A 153 after fabrication. Minor damage to the coating may be field repaired by thoroughly cleaning the damaged area with a wire brush and removing all damaged and loose coating. The cleaned areas shall be painted with two coats of zinc rich paint meeting the requirements of Federal Specification TT-P-641 or MIL-P-21035.

The lot or piece number identifying each screw-in foundation shall be clearly stamped or painted on the foundation where not visible after installation. The foundation will be accepted on the basis of visual examination at the project site and the manufacturer's Certificate of Compliance. When requested by the Engineer, the Contractor shall furnish the manufacturer's Quality Control Inspection Reports and shall demonstrate the ability to provide certification with regard to:

- (1) Material Application
- (2) Welder Certification
- (3) Weld Quality
- (4) Coating Requirements

Screw-in foundation shall be installed according to the manufacturer's recommended procedures and accomplished by either a boom type or a bed-mounted type digger truck. The maximum torque used shall not exceed the manufacturer's recommended limits. In the case of extremely difficult soils that cause the torque capacity of the installation equipment or mechanical limit of the foundation to be exceeded, the foundation may be installed, as approved by the Engineer, in a predrilled hole that is not larger than the foundation shaft diameter. When the foundation is installed in a predrilled hole, minimum recommended torque requirements shall be followed. The installation torque may be measured by a torque-measuring device or by calibrating the hydraulic system of the installing equipment.

All anchor bolts shall be positioned by means of templates, the center of which shall coincide with the center of the base.

Conduits shall be properly positioned and anchored before placing concrete.

Ground wiring cast in the foundation shall have 3 foot minimum extension at both ends.

**613.05 Light Standards.** A light standard shall consist of a metal light pole, bracket arm or arms, transformer base or approved breakaway device, and connector bolts. In special cases, mountings may be made on the base flange, without transformer base, in which case the pole will require a handhole at the base.

- (a) Pole and bracket arm or arms shall be of the specified type and size shown on the plans.

Poles shall be set plumb on the foundation pad by means of non-corrosive metal shims and the mounting grouted with a non-shrinkable grout.

Defects or scratches on galvanized poles shall be given two coats of acceptable zinc-rich paint as directed.

- (b) Transformer base shall be of a frangible breakaway type as shown on the plans and shall accommodate the anchorage and base flange of the light pole supplied.

Each transformer base shall have a ½ inch bolt or lug fastened inside the base, visible from the door opening, for grounding purposes; also a wire hole for outside grounding, if required.

- (c) Connector bolts and anchor bolts shall accommodate the anchorage of the light pole from its base flange to the transformer base, and from the transformer base to the foundation pad.

**613.06 Luminaires and Lamps.** Luminaires shall be mounted on the mast arm by a slipfitter clamp or other approved method, and shall be adjusted vertically and horizontally to provide the required mounting height and maximum light distribution on the roadway.

Each luminaire shall be controlled by an individual photoelectric cell. The photoelectric control shall be positioned northward to minimize sun interference.

After installation and prior to acceptance, refractors shall be cleaned to provide maximum lumen output.

Lamps of the specified type and size shall be installed in the luminaires. Luminaire or pole shall be marked for the type and size of lamp. Tags will be furnished by the local utility company or the Department, if required.

Wall type luminaires for use under overpass structures shall be mounted as shown on the plans. Beam angle setting shall be adjusted to meet illumination requirements.

**613.07 Conduit and Direct Burial Cable.** Electrical conduit, including conduit for traffic signals, shall be installed in accordance with the applicable requirements described in the Department of Transportation's, "A Policy on the Accommodation of Utilities on Colorado Highways Rights-of-way," as amended, and to the following:

Conduit runs on structures or underground are shown on the plans only for information. Locations will be established during construction. Conduit and cable shall be so located as to avoid any interference with known present or known future construction installations. All underground conduit runs and conduit risers on poles shall be installed as needed even though they may not be shown on the plans.

All conduit, including conduit for traffic signals, installed under the roadway shall be 2 inch minimum diameter (ID), unless otherwise designated on the plans. The

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Contractor may, at no expense to the Department, use conduit of larger size than specified. If larger conduit is used, it shall be for the entire length of the run from outlet to outlet. Reducer couplings shall not be used. All conduit runs shall be sloped a minimum of 3 inches per 100 feet for drainage.

Existing underground conduit to be incorporated into a new system shall be cleaned with a mandrel or cylindrical wire brush 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 provided above. Both old and new 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 be sloped towards the handhole opening. Conduit, including conduit for traffic signals, entering pull boxes shall terminate 2 inches inside the box wall and 2 to 5 inches above the bottom, and shall be sloped toward top of 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. At all outlets, conduits shall enter from the direction of the 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 the full circumference thereof. Slip joints or running threads will not be permitted 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 all ferrous metal conduit, not previously treated with a corrosion preventative, shall be painted with rust preventive paint before couplings are made up. All couplings for metal type conduit shall be tightened until the ends of the conduit are brought together, providing a continuous electrical connection throughout the entire length of the conduit run. Where the coating on ferrous metal conduit has been damaged in handling or installing, such damaged places shall be painted with rust preventive paint. Non-metallic type conduit shall be cut with a hacksaw or other approved tool. Non-metallic type conduit connections shall be of the solvent weld type.

All metal type conduit ends shall be threaded and shall be capped until wiring is started. When caps are removed, the threaded ends shall be provided with conduit bushings. Non-metallic type conduit ends shall be capped until wiring is started.

Conduit connections at junction boxes shall be tightly secured and water proofed. Conduit entering controller cabinets shall be sealed by the use of paraffin or other sealing compound as approved by the Engineer.

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 will not be required. Jacking or drilling pits shall be kept a minimum of 2 feet clear of the edge of pavement whenever possible. Water will not be permitted as an aid in the jacking or drilling operations.

When trenching is specified to place conduit under existing pavement that is not to be removed, the trench shall not be wider than 4 inches for 2 inch conduit or 5 inches for 3 inch conduit. Trenches shall be filled to within 2 inches of the existing grade with Class B concrete, or as directed. The remaining 2 inches shall be filled to match existing grade and surfacing materials with concrete or hot asphalt mix within 48 hours after cutting roadway.

Underground conduit or cable shall be buried a minimum of 2 feet without sag between boxes. Conductor, regardless of type, shall be placed in conduit when crossing under roadway. Conduit placed under roadways shall be located at a depth of not less than 30 inches.

Rigid metallic conduits on bridges shall have an expansion fitting at every expansion joint of the bridge.

Pull boxes shall be constructed as shown on the plans. With either direct burial cable or wiring in conduit, pull boxes shall be installed at all wiring splices, all conduit ends, all conduit angle points, and at all other locations which are shown on the plans. Pull box locations which are shown on the plans are approximate.

It shall be the option of the Contractor, at no expense to the Department, to install additional pull boxes to facilitate the work.

Where practical, pull boxes shown in the vicinity of curbs shall be placed adjacent to the back of curb, and pull boxes adjacent to standards shall be placed along the side of foundations as shown on the plans.

Unless otherwise shown on the plans, pull boxes shall be installed so that the covers are level with curb or sidewalk grade or level with the surrounding ground when no grade is established. The bottoms of pull boxes installed in the ground or sidewalk areas shall be bedded in crushed rock.

Where a "stub out" is called for on the plans, a sweeping ell shall be installed in the direction indicated and properly capped. The locations of ends of all conduits in structures or terminating at curbs shall be marked by a "Y" at least 3 inches high cut into the face of curb, gutter or wall directly above the conduit.

**613.08 Wiring.** Unless otherwise authorized, the multiple system of electrical distribution shall be used. Conductors of the size and material required either single or in cable shall include but not be limited to: control wiring, luminaire wiring, main circuit wiring, ground wiring and service entrance wiring.

Each metal light standard shall be wired with a breakaway fused connector of proper capacity rating. The fused connector shall be located in the transformer base, or, if the pole has no transformer base, in the pole at the hand hole.

Luminaires may be selected which operate at either 120 volts 60 Hz or 240 volts 60

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Hz. Selection, however, must be consistent with utility company requirements. When 120 volt luminaires are utilized, 120/240 volts shall be brought to the base of each light standard and individual luminaires shall be connected to one leg or the other in such a manner as to minimize overall voltage drop.

A complete grounding system shall be provided for the entire lighting installation. Grounding shall consist of: ground cables, conduits, ground rods, wire or strap, and ground fittings, as required by the National Electrical Code.

**613.09 Testing.** Prior to final acceptance, the Contractor shall demonstrate to the Engineer's satisfaction that all electrical and lighting equipment installations are in proper condition. Temporary power and all required cable connections, for purpose of testing, shall be provided by the Contractor at no expense to the Department.

The Contractor shall operate the lighting system from sunset to sunrise for ten consecutive days. If lamps, ballast or photoelectric cells fail, they shall be replaced immediately. However, this will not require a restart of the test.

The records of all testing shall be submitted to the Engineer for approval.

### **METHOD OF MEASUREMENT**

**613.10** Light standard foundations including anchor bolts, whether concrete or screw-in type, will be measured by the actual number installed and accepted.

Light standards including pole, mast arm or arms, transformer base or approved breakaway device, and connector bolts will be measured by the number of light standards installed. Whenever Light Standard "Metal" is designated as a bid item, the Contractor will be permitted to furnish either steel or aluminum.

Luminaires including lamp, ballast and photoelectric cell will be measured by the number of installed luminaires of the specified wattage.

Secondary service pedestals will be measured by the number of units installed.

Conduit on structures or underground shall include junction boxes, pull boxes, 90 degree sweep ells, pull wire, weatherheads, adaptors, and condulets. Conduit will be measured by the linear foot in place and shall include all saw cutting, excavation, backfill, jacking and drilling pits. It shall also include removal of pavement, sidewalks, gutters, and curbs and their replacement in kind to match existing grade and all other work necessary to complete the item.

Direct burial cable, including junction boxes, will be measured by the linear foot along the cable.

Wiring will not be measured. The lump sum price bid for wiring shall include all the electrical circuitry necessary for the complete lighting installation as shown on the plans except for the conductors contained within the direct burial cable.



The Contractor may elect to use direct burial cable in conduit. However, all conductors in conduit, regardless of type, shall be considered as part of the wiring item and will not be measured and paid for separately.

**BASIS OF PAYMENT**

**613.11** 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Concrete Foundation Pad	Each
Light Standard Foundation	Each
Light Standard _____ (_____ Foot) (Furnish Only) (Install Only)	Each
Luminaire High Pressure Sodium (_____ Watt)	Each
Luminaire High Pressure Sodium (Wall Type) (_____ Watt)	Each
Luminaire (____) (____ Watt) (Furnish Only) (Install Only)	Each
Luminaire (Wall Type) (____)(____ Watt) (Furnish Only) (Install Only)	Each
Secondary Service Pedestal	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
Direct Burial Cable	Linear Foot
Wiring	Lump Sum

The Light Standard item, Luminaire Items and Electrical Conduit items will be furnish and install unless the Summary of Approximate Quantities indicates whether it is to be (Furnish Only) or (Install Only).

Soil testing for screw-in light standard foundations will not be measured and paid for separately, but shall be included in the work.

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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 sign posts and legends. This work shall be done in accordance with these specifications, the latest revision of the *Manual on Uniform Traffic Control Devices 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.

### **MATERIALS**

**614.02 Sign Posts and Sign Structures.** Concrete shall conform to the requirements of Section 601. Reinforcing steel shall conform to the requirements of Section 602. Steel for Sign Posts 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 sign posts 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

Prior to use all timber shall be stored, banded and kept dry.

All lumber shall be manufactured in accordance with 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.

Underground portions of timber sign posts, plus at least 6 inches above ground line, shall be painted with one of the preservatives listed in AASHTO M 133.

Timber sign posts 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.

Structure backfill around concrete footings shall be Class 2, in accordance with 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. Retroreflective sheeting shall be type III and shall conform to subsections 713.04 and 713.06 when applicable.

Retroreflective sheeting for all signs requiring a yellow background shall be fluorescent.

All exposed lockbolt fastener heads on the faces of sign panels shall be covered with material matching the background of the panel.

The Contractor shall provide sign panel legends for standard signs in accordance with the *Standard Highway Signs* published by the FHWA and the Colorado Supplement thereto, and sign panel legends for special signs in accordance with the detailed sign layouts provided by the Engineer.

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 ¼ 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 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 (unused)**

**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 III 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 in accordance with subsection 508.08 and the plan details.

**614.08 Traffic Signal Materials.**

- (a) *General.* At the preconstruction conference, the Contractor shall submit, for approval, a list of equipment and materials which 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, IEEE, UL, or EIA, wherever applicable. In addition to the requirements of the plans, these

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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 which 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 which is supplied shall be of models which 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 in accordance with 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 ¼ 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.

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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 back up 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 a 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 2 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 in accordance with 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 in accordance with 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:

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)

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<b>Quantity (cont.)</b>	<b>Item (cont.)</b>
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 to 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) which 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 2 and 4 channel devices available under the 170 and NEMA TS1 specification as well as the newer 2 and 4 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. TX0, DX0, and Ground0 serve the first eight slots; TX1, DX1 and Ground1 serve the next six slots. Back 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

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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 for which shall be as shown in the following table:

**Connector Circuitry  
For Magnetic Detector Amplifiers**

<b>MS Connector Circuit</b>	<b>18-8 Pin</b>
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, fuseholders, 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 in which 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 which 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 -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 AWG, and shall be of a length specified on the plans.

- (f) *Pedestrian Push Buttons.* Pedestrian push buttons shall be of the direct push button contact type. They shall operate on a voltage not to exceed 32 volts DC. They shall be of tamper-proof design and equipped with a push button instruction sign.

The assembly shall be weatherproof and so constructed that it will be impossible to receive any electrical shock under any weather conditions.

The housing shall be shaped to fit the curvature of the pole to which it is attached to provide a rigid installation. Saddles shall be provided to make a neat fit when required.

- (g) *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  $\frac{3}{4}$  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.

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- (h) *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 herein and as shown on the plans. They shall provide a light indication in one direction only and shall be adjustable through three hundred and sixty 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 in accordance with the manufacturer's instructions.

- (i) *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.
- (j) *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.

Prior to 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  $\frac{1}{2}$  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.

- (k) *Traffic Signal Electrical Conductors and Control Cable.* Conductors and cables shall conform to subsection 713.11.

A  $\frac{1}{8}$  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 loopwire encased in  $\frac{1}{4}$  inch OD,  $\frac{3}{16}$  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.

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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.

(l) *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/or 127 software programmable addresses in 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 in accordance with 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 which meet the requirements for NEMA TS2-1992 section 3.2, actuated Type 2 A2 operation and Type I AI 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 1000 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 2500 micro henries with a Q factor of five or greater, within four seconds after application of power.

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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 ( $\Delta L$ ). 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  $\Delta L$  threshold value of eight nanohenries while the lowest sensitivity setting shall have a  $\Delta L$  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 (100cc. 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  $118 \pm 5$  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.

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Detector units shall have optically-isolated FET outputs to provide fail-safe solid state operation.

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 in accordance with 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  $\geq 25$  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 micro henry loop/lead-in attached to each channel, shall for any negative inductive change which 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 which 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

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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 at least a Windows™ 95 or Windows™ NT 4.0 operating system.

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 back 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 & 2 and 3 & 4. With the paired channels connected to 6 foot by 6 foot loops that are overlapped by 3 feet, vehicles

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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 which 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 in accordance with 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 herein.

Fillet welds connecting tubular steel to a shape or plate shall be qualified in accordance with 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 prior to fabrication. CDOT acceptance of submitted PQRs, WPSs, and WQRs establishes prequalification to fabricate Traffic Control Devices.

All unguessed 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.

Prior to welding, base metal surfaces shall be blasted or ground to eliminate mill scale, visible rust, oil, or debris.

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Welding shall be performed prior to 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 in accordance with the American Society for Nondestructive Testing (ASNT) SNTTC1A 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 Nondestructive 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 (a.c.) yoke method shall be performed. The yoke spacing shall be 4 inches. The yoke shall be calibrated each day in accordance with 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 in accordance with ASTM A 123. Pole hardware shall be galvanized in accordance with ASTM A 153. All signs must be clean prior to erection. Installation shall be of such sequence as to result in maximum traffic safety. Signs shall be erected in conformity with the plans. Prior to 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 in accordance with the Contract. The tops of drilled caissons used for overhead sign structure footings shall be formed to at least 6 inches below ground line in accordance with Section 601.

Timber sign posts 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 prior to 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 110-115 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 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 Sign Posts. 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 Sign Posts. 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 respace existing legend; to furnish and install new legend and border as required.

**614.10 Traffic Signal Systems - Construction.**

- (a) *General.* The Contractor shall submit an "As Built" plan, showing in detail all construction changes including: wiring, cabling, locations and depth of conduit. The "As Built" 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 imbedded 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.

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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 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  $\frac{5}{8}$  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  $\frac{3}{16}$  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 in accordance with 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

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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 which 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  $\frac{3}{8}$  inch wide and a minimum of 3 inches deep. The slot shall be as straight as possible and shall not vary more than  $\frac{1}{2}$  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 prior to 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 in accordance with 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 prior to 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 painted aluminum, 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

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workmanlike 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 prior to any operational shutdown of a traffic signal.

The above does not apply to intersections which 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. In the event that 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 in accordance with these specifications.

Signal faces which are installed prior to turning on shall be covered or directed away from traffic to clearly indicate that the signal is not in operation.

- (j) *Field Tests and Turn On.* Prior to completion of the work, the Contractor shall make the following tests on all traffic signal circuits in the presence of the Engineer:
1. 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 in which it is demonstrated that each and every part of the system functions as specified or intended herein. The

functional test for each traffic signal system shall consist of not less than 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 working day 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. Prior to 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.

**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 in accordance with 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

614.13

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, sign posts 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 from which 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 sign post extensions, if required, will be measured and paid for as "Steel Sign Post" 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: e.g., all brackets, nuts, bolts, shims, hinge plates, and couplings will be paid for as Steel Sign Post of the appropriate size; anchors and concrete footings will be paid for as Concrete Footing of the appropriate size.

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.

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 in accordance with 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.



614.14

Loop detector wire will be measured by the linear foot and shall include loop wire, pavement sawing, slot sealant, lead-in conduit as shown on the plans, excavation, backfill and all other work necessary to complete the item.

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.

All costs for making electrical service connections from the power source to the service switch will be paid for in accordance with 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.

### **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:

<b>Pay Item</b>	<b>Pay Unit</b>
Sign Bridge Structure (_____) (size)	Each
Sign Bridge Structure (Install Only)	Each
Sign Bridge-Cantilever Structure (_____) (size)	Each
Cantilever Structure (_____) (size)	Each
Overpass Mounted Sign Bracket	Each
Concrete Footing (_____)	Each
Steel Sign Post (_____)	Linear Foot
Timber Sign Post (_____)	Linear Foot
Sign Panel (Class)	Square Foot
Mask Sign Legend	Each
Illuminated Sign	Each
Barricade (Type _____)	Each
Flashing Beacon	Each
Modification of Steel Sign Post	Each
Modification of Timber Sign Post	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

614.14

<b>Pay Item (continued)</b>	<b>Pay Unit (continued)</b>
Traffic Signal Controller Cabinet (Furnish Only) (Install Only)	Each
Traffic Signal Controller (Type _____) (Furnish Only) (Install Only)	Each
Loop Detector Wire (Furnish Only) (Install Only)	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
Rumble Strip	Linear Foot

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.

**SECTION 615  
WATER CONTROL DEVICES**

**DESCRIPTION**

**615.01** This work consists of the construction of water and erosion control devices in accordance with 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:

<b>Pay Item</b>	<b>Pay Unit</b>
____ 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.

616.01

## **SECTION 616 SIPHONS**

### **DESCRIPTION**

**616.01** This work consists of the construction of invert siphons in accordance with 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 insure 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 5½ inch minimum inside diameter. Drain valves and valve boxes shall be approved prior to use.

**616.05 Drain Pipe.** 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 A 53 (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 in accordance with subsection 707.09 both inside and outside the pipe.

### **CONSTRUCTION REQUIREMENTS**

**616.06** Siphon pipe including drains shall be installed in accordance with 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

616.08

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. Drain pipe will be measured and paid for in accordance with Section 605. Concrete will be measured and paid for in accordance with Section 601. Reinforcing steel will be measured and paid for in accordance with Section 602. Structure excavation and structure backfill will be measured and paid for in accordance with Section 206.

Drain valves shall include the pipe for connecting the valve to the siphon, together with all necessary fittings and gaskets used therewith.

**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:

<b>Pay Item</b>	<b>Pay Unit</b>
Inch Concrete Siphon Pipe	Linear Foot
Inch Trash Guard	Each
Inch Valve and Valve Box	Each

617.01

**SECTION 617  
CULVERT PIPE**

**DESCRIPTION**

**617.01** This work consists of furnishing and installing culvert pipe in accordance with these specifications and in conformity with the lines and grades shown on the plans or established.

**MATERIALS**

**617.02** Materials shall meet the requirements shown on the plans and specified in the following subsections for the type of culvert pipe furnished.

Corrugated Steel Pipe and Pipe Arches	707.02
Corrugated Aluminum Pipe	707.06
Reinforced Concrete Pipe	706.02
Plastic Pipe	712.13
Gaskets	705.03
Pipe Joint Sealing Compounds	705.04

Any type of culvert pipe meeting the above specifications may be used. The Contractor shall state, at the preconstruction conference, the type of culvert pipe to be furnished.

Plastic end sections shall not be used. When plastic pipe is to be installed with end sections, steel end sections conforming to Standard Plan M-603-10 shall be used.

**CONSTRUCTION REQUIREMENTS**

**617.03** Installation shall conform to the requirements of Section 603.

**METHOD OF MEASUREMENT**

**617.04** Culvert 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**

**617.05** The accepted quantities of culvert pipe will be paid for at the contract unit price per linear foot for the specified size.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Inch Culvert Pipe	Linear Foot

Structure excavation and structure backfill will be measured and paid for in accordance with Section 206.

## SECTION 618 PRESTRESSED CONCRETE

### DESCRIPTION

**618.01** This work consists of fabricating, furnishing and installing prestressed concrete members in accordance with 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 herein shall be considered to mean the concrete which is to be prestressed.

The term “tendon” as referenced herein shall be considered to mean the prestressing steel within a duct.

### 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) *Grout for Post-tensioned Ducts.*

1. Portland Cement. Portland cement shall conform to subsection 701.01. Cement used for grouting shall be fresh and shall not contain any lumps or other indication of hydration or “pack set.”
2. Water. The water used in the grout shall conform to subsection 712.01.
3. Admixtures. An expansive admixture, approved by the Engineer, shall be used.

Admixtures containing chlorides in excess of 0.005 percent by weight of admixture, fluorides, sulfites or nitrates shall not be used.

Chemical admixtures shall conform to the requirements of subsection 711.03. Admixtures shall be used in accordance with the manufacturer’s recommendations for proportioning and construction requirements.

618.02

- (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 shall keep Certified Mill Test Reports (CMTR's) on file for all steel and metal products used, and shall furnish copies of CMTR's when requested.

Galvanizing and metallizing of steel products shall be done in accordance with 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 A 615, or ASTM A 706; epoxy coated bars shall also meet ASTM D 3963. Reinforcing bars that require welding shall conform to ASTM A 706. Welding of A 706 bars shall be done in accordance with ANSI /AWS D.1.4.
  2. Welded Wire Fabric. Steel welded wire fabric for concrete reinforcement shall conform to ASTM A 185, or ASTM A 497.
  3. Plate Steel. All plate steel shall conform to ASTM A 709 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.
- (c) *Concrete for Pretensioned and Combination Tensioned Products.* Materials for Concrete class PS shall meet the requirements specified in the following subsections:

Portland 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 1½ 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.

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 endorsement 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 and Combination Tensioned Members.* The shop drawings shall include the following:
- (1) All unit dimensions.
  - (2) Location and arrangement of prestressing strands.
  - (3) Initial and final jacking forces.
  - (4) Location, description, and detail of structural reinforcing items, excluding minor items used for field erection.
  - (5) Location of all hold-down devices.
  - (6) Location and description of all plates.
  - (7) Provisions for diaphragm connections.
  - (8) Blockout and keyway dimensions, if any.
  - (9) Location and detail of debonded strands.
- (c) *Post-tensioned Members.* The shop drawings for post-tensioned members shall show the following:

618.04

- (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) 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.
- (5) The initial and final force at each anchorage. The initial force is defined as the largest force at each anchorage before anchor set. The final force is defined as the residual force remaining after anchor set and long term losses.
- (6) 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.
- (7) 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.
- (8) The minimum length of strand or bar projection at the live ends and accessible dead ends.
- (9) The preload force for each unique tendon. The preload force is defined as 20 percent of the jacking force.
- (10) The required total jacking force for each unique tendon.
- (11) 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.
- (12) The sequence of stressing.
- (13) Blockout or buildout concrete dimensions and reinforcement details.
- (14) If the Contractor elects to submit an alternative system, as defined in subsection 618.07(c), 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 in accordance with the plans and as provided for in the AASHTO *Standard Specifications for Highway Bridges*.

**618.05 Notification of Fabrication for Pretensioned and Combination Tensioned Members.**

- (a) *Start of Work.* Prior to beginning the work, the Contractor shall provide written 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 written notice shall be received at least seven days before fabrication begins.

The anticipated production schedule, including the start of work, phase work and shipment dates shall be submitted in writing to the QA Representative before any 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; or Resubmit, revise as noted in accordance with 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 written notification be provided to the Engineer and the QA Representative. The written 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 in writing, 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 and Combination Tensioned Members.**

- (a) *Quality Control and Quality Assurance.* Quality Control (QC) of prestressed

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concrete fabrication is the responsibility of the Contractor. The Contractor shall designate a QC Manager who shall be responsible for product quality requirements as defined in the specifications and the Contractor's approved QC plan (QCP). The QC 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 QC Manager shall not be supervised by the Contractor's production section.

Quality Assurance and product acceptance are the prerogatives of the Engineer. The QA Representative acts for and in 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.

Repeated out of tolerance work, including dimensional non-conformance, shall be considered as recurring deficiencies. Recurring deficiencies shall be considered as evidence that required QC is not being provided. When the QA Representative determines that fabrication operations are producing recurring defects that do not conform to the Contract and the QCP requirements, the Contractor will be notified that the present work is unacceptable. Work shall not continue until the QC 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) *Quality Control Plan (QCP)*. The Contractor shall submit a written QCP to the QA Representative prior to the beginning of fabrication. The QCP shall be reviewed and approved in writing by the Contractor's QC Manager. The QCP shall list all methods utilized by the Contractor to ensure that the work conforms to contract requirements. The QC section is responsible for establishing the QCP, as well as conformance to the QCP. Fabrication shall not begin until the QCP 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 QCP, 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 QCP shall address the following:

- (1) Names and qualifications of the QC Manager and personnel conducting inspection and testing. This list shall be updated when changes in personnel occur.
- (2) List of material suppliers 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) QC 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 detensioning strands.
  - (8) Written report format for materials sampling, testing, and inspection for all phases of the work.
  - (9) Copies of all concrete mix designs to be used, including mix design computations and test data.
  - (10) Provisions for fabrication operations during cold, windy, or hot weather conditions.
  - (11) Procedures for patching small production holes and holes left by strand hold-down devices.
  - (12) Procedures for identifying, evaluating and reporting defects, including dimensional non-conformance, discovered during QC/QA inspections and testing.
  - (13) Procedures for notifying the QA Representative of structural defects, and submittal of written proposal for repairs.
- (c) *Frequency.* QC inspection and testing at all intervals of forming, tensioning, steel and concrete placement, curing, and storage operations shall be performed in accordance with the accepted QCP. The QCP 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 QC Manager shall review and submit the following completed records and reports to the QA Representative before the product receives acceptance by the QC 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.
  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:
    - (1) date and time of casting
    - (2) bed and setup location
    - (3) ambient conditions
    - (4) total cubic yards placed
    - (5) girder mark and unique sub-mark identifications
    - (6) actual product curing temperature charts or graphs
    - (7) actual curing enclosure humidity charts or graphs
    - (8) average release strength in psi

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- (9) date and time of release strength
  - (10) 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 QCP.
  4. Post-pour Inspection Records shall include the items to be checked as listed in the QCP. These records shall include all discovered variances from product dimensional tolerances.
  5. Report of minor repairs made to each individual product.
  6. The following written records shall be submitted to the QA Representative before product shipment:
    - (1) Elastomeric Bearing Pads - Product manufacturer's certification and supplier's letter of compliance.
    - (2) Length measurement of beams within three days prior to shipping.
    - (3) Product camber measurement within seven days prior to shipping.
  7. Steel and Metal. For reinforcing bars, welded wire fabric, plate steel, and miscellaneous steel and metal products incorporated into the work, QC Manager shall review and maintain all certified mill test reports (CMTRs). QC Manager shall certify in writing that all steel and metal products comply with the Contract. When requested, QC Manager shall furnish copies of CMTRs to the QA Representative.

**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 in accordance with the approved sequence as indicated in the QCP. 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 QC 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  $\frac{1}{8}$  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 gages, dynamometers or load cells. If pressure gages 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 gage system is used, a current certified calibrated graph or table correlating actual loads with the master gage 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 in a 7-wire strand breaks, that strand shall be removed and replaced.
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 tension 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.

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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 prior to 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 a plus or minus 20 inch horizontal tolerance from the locations shown on the contract drawings; if minimum or maximum placement locations are shown on the contract drawings, the placement tolerances shall not encroach beyond these 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 stands 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 in accordance with subsection 618.07(a). All post-tensioning operations shall conform to subsection 618.07(c)

- (c) *Post-tensioning Method.*

1. 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 be in attendance at this meeting:

- (1) The Engineer.
- (2) The Contractor's Superintendent.
- (3) A responsible representative of the post-tensioning system supplier. This individual shall have the following qualifications:
  - (i) Professional Engineer Registered in the State of Colorado.
  - (ii) 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.
  - (iii) A holder of a current Grouting Training Certificate from the American Segmental Bridge Institute.
  - (iv) Able to be present during all tendon stressing and grouting to keep written records of these operations for submittal to the Engineer for review.
- (4) A grout manufacturer's field representative who will provide technical assistance to the grouting crew, and will be present during all grouting operations.
- (5) The Contractor's designee who will be in direct charge of the post-tensioning and grouting crews. This individual shall have the following qualifications:
  - (i) Be skilled in the use of the post-tensioning and grouting equipment.
  - (ii) Have at least three years experience on previous projects supervising the post-tensioning and grouting of structures of similar type and magnitude.
  - (iii) Present on the project during the installation of the post-tensioning system, stressing operations, and grouting operations.
- (6) Other individuals as deemed necessary by the Contractor or Engineer.

Ten days prior to 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 records of the person supervising the grouting operations.
- (2) Name of the grout material and the required certifications and test results.

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- (3) Manufacturer and type of grout mixer and pump to be used, including provisions for back-up equipment and spare parts.
  - (4) Grouting procedure and the role of each person on the crew.
  - (5) Theoretical grout volume calculations.
  - (6) Method for closing all duct orifices as grouting progresses.
  - (7) Grout mixing and pumping procedures.
  - (8) Location of grout inlet and direction of pumping.
  - (9) Procedures for handling blockages.
  - (10) Methods to inspect behind anchorages, grout inlets and outlets, and vents for voids.
  - (11) Procedures for post grouting repair of all grout voids detected.
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. Items considered as acceptable alternatives are:
- (1) Alternative anchorage systems.
  - (2) Alternative number or sizes of ducts. The duct pattern must conform to an acceptable pattern as indicated on the plans.
  - (3) Alternative jacking ends.
  - (4) Alternative number of strands, provided the minimum area of steel and the center of force matches that indicated on the plans.
  - (5) 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.

If the Contractor elects to submit alternative details, the alternative details shall conform to the following:

- (1) The final center of force shall match that as indicated on the plans.
- (2) 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.
- (3) If the plans call for a tendon to be composed of bars, the Contractor's alternative shall have that same tendon composed of bars.
- (4) 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.
- (5) 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.

- (6) 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  $\frac{1}{2}$  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.

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  $\frac{1}{4}$  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, secondary high point grout vents shall be located three feet beyond all high points in the direction that the grout will be pumped.

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 non-shrink grout and finished smooth.

Once installed, the ends of the ducts shall be covered as necessary to prevent the entry of water or debris.

Prior to installation of the prestressing steel, the Contractor shall show that the ducts are free from debris and water. For ducts which are internal

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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.

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, corrosion inhibitors, or a combination thereof in the ducts and flushing the ducts with water will not be allowed.

4. Post-tensioning Equipment and Procedure. 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, in accordance with 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 in accordance with the sequence as indicated on the reviewed shop drawings. If the Contractor chooses to deviate from the sequence, the Contractor shall resubmit the shop drawings for review. 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  $\pm 7$  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.

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:

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During jacking:

$$f_{cp} = 0.8 f'_{ci} \sqrt{\frac{A'_b}{A_b} - 0.2} \leq 1.25 f'_c$$

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  $0.90 f'_{ci}$ . 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  $0.70 f'_{ci}$ . 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.

When all ducts in a girder web have been stressed, the ducts shall be grouted within seven days. The exception to the seven day grouting requirement is during

cold weather when heating would be required to allow the ducts to be grouted in accordance with (e) below. If the Contractor chooses not to heat the structure, the ducts shall be grouted within 30 days after weather permits grouting in accordance with (e) below.

- (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, which will produce hydrogen gas, carbon dioxide, or oxygen. In addition, the grout shall not contain fluorides, sulphites, nitrates, calcium carbonate fillers, or acid-soluble chloride ions which 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 in accordance with the manufacturer's instructions:

**Table 618-1**

<b>Property</b>	<b>Test Value</b>	<b>Test Method</b>
Total Chloride Ions	Max. 0.08% by weight of Cementitious material	ASTM C 1152
Fine Aggregate (If utilized)	Max. Size: 300 $\mu$ m (No. 50 Sieve)	ASTM C 33
Volume Change at 24 hours and 28 days	0.0% to + 0.3%	ASTM C 1090 <sup>1</sup>
Expansion	2.0% for up to 3 hours	ASTM C 940
Compressive Strength at 28 days (Average of 3 cubes)	7,000 psi minimum	ASTM C 942
Initial set of the grout	3 hours minimum 12 hours maximum	ASTM C 953
Bleeding at 3 hours	Maximum 0.0 %	ASTM C 940 <sup>4</sup>
Permeability at 28 days	Maximum 2500 coulombs At 30 Volts for 6 hours	ASTM C 1202
<b>FLUIDITY TEST <sup>2</sup></b>		
	<b>Efflux Time from Flow Cone</b>	<b>ASTM Method</b>
(a) Immediately after mixing	20 Seconds Minimum 30 Seconds Maximum OR 9 Seconds Minimum 20 Seconds Maximum	ASTM C 939  ASTM C 939 <sup>3</sup>
(b) 30 minutes after mixing with remixing for 30 seconds	30 Seconds Maximum OR 30 Seconds Maximum	ASTM C939  ASTM C 939 <sup>3</sup>
<b>Footnotes for Table 618-1</b>		
<sup>1</sup> ASTM C 1090 shall be modified to include verification at both 24 hours and 28 days.		
<sup>2</sup> Adjustments to flow rates shall be achieved by strict compliance with the manufacturer's recommendations.		
<sup>3</sup> Grout fluidity shall meet either the Standard ASTM C 939 flow cone test or the Modified Test described herein. Modify the ASTM C 939 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.		
<sup>4</sup> ASTM C 940 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 A 416 seven wire 0.5 inch diameter strand. Wrap the strand with 2 inch wide duct or electrical tape at each end prior to 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.		



**Footnotes for Table 618-1(continued)**

- (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.
- (vii) Calculate the bleed water, if any, at the end of the three hour test period and the resulting expansion in accordance with the procedures outlined in ASTM C 940, 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.

Each lot of grout used on the project shall have been sampled and tested within the last six months in accordance with the above referenced test procedures. The Contractor shall provide certified test reports for each lot of grout from an independently certified Cement Concrete Research Laboratory (For a listing of facilities contact NIST, Gaithersburg, Maryland, 20899) with the plan for grouting the ducts. Lots which do not meet the above requirements will be rejected.

- (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 in accordance with 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 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 in accordance with the API Recommended Practice 13B-1 "Standard Procedure for Field Testing Water-Based Drilling Fluids".

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- (3) Minimum of one strength test per day per lot in accordance with ASTM C942 and the minimum 28 day compressive strength shall be 7000 psi.
- (4) Minimum of two fluidity tests (flow cone) – one at the mixer and one at the duct outlet in accordance with ASTM C939, “Standard Tests Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)”. The efflux time shall be between 11 and 30 seconds.

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 insure that the tendon remains filled with grout, the outlet shall be closed and the pumping pressure allowed to build to a minimum of 150 psi and held for one minute 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 removed.

For vertical internal tendons, if the grouting pressure exceeds the maximum recommended pumping pressure, the grout shall be injected at increasingly higher outlets (which 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 prior to 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, anchorage grout caps and 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 in accordance with 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.

**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, gage 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 gage 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 for 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.

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The batching system shall record the weights of all concrete mix ingredients for each batch. Ingredient weights shall meet the requirements of ASTM C 94, Section 8, Measuring Materials.

The batching system shall be equipped with a flow meter which 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 be calibrated at intervals no longer than 12 months, or whenever the machine ram, sensor, or indicator components are replaced or repaired. Machine error shall not exceed plus or minus 1 percent of the applied load.

The machine calibration shall be performed according to the requirements of subsection 618.10(a), second paragraph. Current calibration labels shall be visibly displayed on the test machine.

- (d) *Concrete Cylinder Molds.* 4 inch by 8 inch molds, (nominal diameter to length) shall be used to produce hardened test specimens free of deformation and distortion. The molds shall produce specimen diameters ranging from 3.96 to 4.04 inches ; with uniform lengths ranging from 7.92 to 8.08 inches. No diameter of an individual specimen shall differ from any other diameter on the same specimen by more than 2 percent. Molds shall be made of nonabsorptive materials that do not promote chemical reaction with cementitious products.
- (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 in the contract drawings, 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 QC 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 designated as class PS. The Contractor shall be responsible for the actual mix proportions and adjustments necessary to produce the specified strength. The specified strengths and air content shall be as stated on the plans. Fly ash material may be substituted for portland cement, up to a maximum of 25 percent by weight. If fly ash material is used in the mix, the total cementitious content shall be the sum of the weight of the portland cement and the weight of the fly ash material.

When voluntary use of fly ash by the Contractor results in delays, changes in mix quantities or materials sources, or unsatisfactory work, the costs of such delays, changes or corrective actions shall be borne by the Contractor.

- (b) *Concrete Mix Components.* Materials sources shall be listed in the Contractor's QCP. The QC Manager must notify the QA representative in writing before changing the sources as listed in the QCP. For new sources, the Contractor must submit certified data for review and acceptance by the Engineer, at least 30 days before the sources can be used for production. Materials shall conform to the requirements of subsection 618.02(c).
- (c) *Proportioning.* The minimum total cementitious content shall be 610 pounds per cubic yard of concrete. Fine aggregates shall not exceed 45 percent of the total aggregate volume. Aggregates from different sources and of different gradings shall not be stockpiled together.
- (d) *Batching and Mixing.* Concrete shall be batched and mixed according to ASTM C 94.
- (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 QCP, 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.

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2. Mixed concrete that has a temperature in excess of 90 °F shall not be placed.
  3. 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 40 °F 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 laitence brought to the surface through vibration shall be removed before the surface is final finished.

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 QC section shall make representative cylinder test specimens for QC/QA testing. 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 in accordance with the following requirements:
1. Test cylinder specimens shall be made in accordance with ASTM C 31, except that 4 inch by 8 inch size specimens shall be made and vibration consolidation shall not be allowed. Specimens shall be cured as listed in the accepted QCP.
  2. Cylinders shall be tested in accordance with ASTM C 39. The average strength of at least two test cylinders shall be greater than the minimum required strength. No individual strength test shall be more than 7 percent below the minimum required strength.
  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 prior to 28-day testing, additional test specimens shall be available to verify product strength prior to 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 in accordance with either ASTM C 173 or ASTM C 231. Air entrained mixes shall be tested a minimum of once per day to assure specified air entrainment.
6. Slump of fresh concrete shall be determined in accordance with ASTM C 143. The slump shall be tested whenever test cylinder sets are made.
7. Unit Weight of fresh concrete shall be determined in accordance with ASTM C 138. Unit weight shall be tested a minimum of once per day for each different concrete mix design used.
8. Temperature of fresh concrete shall be taken as needed, to assure compliance with the temperature requirements.

**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.
4. Concrete shall attain initial set prior to application of the accelerated curing cycle. If initial set was not determined in accordance with ASTM C 403, accelerated curing shall not be induced for 4 hours, or 6 hours if retarding admixtures are used.

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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, 3500 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 150 ° F.

**618.13 Repairs of Pretensioned and Combination Tensioned Members.**

Repairable product defects discovered during QC or QA inspection, shall be corrected at the Contractor's expense prior to 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 QC section shall examine and record all defects. The QC section shall submit a written proposal for minor repairs to the QA Representative for review and acceptance prior to 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 approve, or reject, the finished repair work in writing.

Small production holes that are less than ½ 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 QCP.



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 prior to correcting any defects. The proposal shall include a detailed description and sketch of the defects, detailed repair procedures, description of repair materials, and the methods the Contractor will 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 which 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 which 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.

Repair methods shall adequately restore structural integrity of the product. When repairs have been completed, the Contractor's Engineer shall examine and analyze the product for construction and service load ability, and certify in writing that the repair work is structurally adequate. Evaluation and test data shall be submitted along with the written certification. 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 which impair the ability of the product to adequately withstand construction or service loads, and which 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:

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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 concretious laitence shall be removed from the product before storage.

Each finished product shall clearly display legible identification markings that show the cast date, piece mark and unique sub-mark. The marking shall also identify the setup location where the product was cast.

Finishing operations shall also conform to the following requirements:

1. Excessive laitence and unsound rubble shall be removed from surfaces to be bonded.
2. Fins and irregular projections shall be removed from the formed surfaces.
3. Bulges or offsets on the formed surfaces greater than  $\frac{1}{4}$  inch shall be smoothed by stoning, sawing, or grinding.
4. Dented and inset surfaces greater than 4 square inches in area and deeper than  $\frac{1}{2}$  inch shall require a written repair proposal before repair or finish work begins.
5. Patches in areas of exposed steel or prestressing strand shall be bonded with an approved bonding agent and patched with an approved non-shrink grout.
6. If liquid membrane curing compounds are used on the concrete surfaces which are to be bonded, they shall be removed by sandblasting, prior to shipping the product.

- (b) *Product Dimensional Tolerances.* Tolerances for prestressed concrete products shall meet the unit tabulations listed in the PCI Manual MNL-116, 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 Division VI, I-Beams.
  - (2) G-Series Sections shall conform to Division VI, I-Beams.
  - (3) Box Girders shall conform to Division VI, Box Beams.
  - (4) Deck Panels shall conform to the dimensional tolerances as listed in the PCI Special Report JR-343-88, Chapter 4, or the updated published edition thereof.
- (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 QC section and repaired in accordance with 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 in a manner that will provide safety to the Contractor's forces, inspectors and the traveling public. Pre-cast concrete members shall be erected in a manner to prevent damage to all elements of the structure. 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 designed to resist all loads imposed during each stage of construction until completion of the deck concrete.

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At least four weeks prior to erection, the Contractor shall approve, sign and submit a proposed plan of erection to the Engineer for record purposes only. The Erection Plan shall be approved by, and contain the seal and signature of, the Contractor's Professional Engineer registered in the State of Colorado. The Erection Plan will not be approved by the Engineer. If falsework drawings are required, they shall be submitted in accordance with subsection 601.11.

The Erection Plan and procedure shall provide complete details of the erection process including but not limited to:

- (1) Temporary falsework support, bracing, guys, deadmen, connection details and attachments to other structure components or objects
- (2) Procedure and sequence of operation including a detailed schedule that shall comply with the working hour limitations
- (3) Cranes: make and model, weight, geometry, lift capacity, outrigger size and reactions
- (4) Girder weights, lift points, lifting devices, spreaders, and angle of lifting cables
- (5) Assumed loads and girder stresses during progressive stages of lifting and erection to substantiate the structural integrity and stability of the girders prior to completion of the entire structure
- (6) Girder launcher or trolley details and capacity (if intended for use);
- (7) Locations of cranes, trucks delivering girders, and the location of cranes and outriggers relative to other structures, including retaining walls, wing walls and utilities
- (8) Material properties and specifications for temporary works
- (9) Drawings, notes, catalog data showing the manufacturer's recommendations or performance tests, and calculations clearly showing the above listed details, assumptions, and dimensions

A Pre-Erection Conference will be held at least two weeks prior to the beginning of erection. The Contractor and the Contractor's Professional Engineer shall attend the meeting.

The Contractor's Professional Engineer shall inspect and provide written approval of each phase of the installation prior to allowing vehicles or pedestrians on or below the structure. The Contractor's Professional Engineer shall approve all changes to the Erection Plan. The Contractor shall submit all changes to the Erection Plan to the Engineer for record purposes only. The Contractor shall demonstrate his knowledge and familiarity with the location of the piece marks and the piece mark convention used by the girder fabricator at the Pre-Erection Conference. This is required to assure the structural components are assembled in accordance with the reviewed shop drawings.

The Contractor shall perform daily inspections of the erected girders until completion of the deck concrete. The Contractor shall provide the Engineer with written documentation of these inspections within 24 hours.

All temporary struts, bracing, tie cables, other devices and extra material required shall be removed upon completion of the structure.

**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  $0.95 f'_c$ . No individual specimen strength shall be more than 7 percent below  $0.95 f'_c$ . 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 QCP. 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 C 42 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 in accordance with ASTM C 617. 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, then wrapped with a double layer of wet, thick cloth or burlap. Compressive testing shall not be

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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 in accordance with 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 2 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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

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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.

Concrete quantities will not be reduced for the volume occupied by the ducts, prestressing steel, anchorages, blockouts for tensioning, etc., and will not include web flares, projections, warts, etc., required to accommodate the prestressing system used.

All costs associated with implementing 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.

619.01

## **SECTION 619 WATER LINES**

### **DESCRIPTION**

**619.01** This work consists of the construction of water lines in accordance with these specifications, the latest revision of the American Water Works Association Standards and in conformity with the lines and grades shown on the plans or established.

This work also includes furnishing welded steel 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 in accordance with 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 herein 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.

#### **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:

<b>Pay Item</b>	<b>Pay Unit</b>
_____ 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

619.05

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 in accordance with 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 minimum inside height for a field office shall be 7 feet if the facility is certified as having been manufactured prior to November 1, 1992.

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 ½ x 11 inch and 8 ½ 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 rollaround stand. Paper will be provided by the Department.
- (2) **Copy Machine.** The Contractor shall provide a self feeding plain paper photo copying machine, which is 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 ½ x 14 legal size and to 8 ½ 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 working days.
- (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.

620.03

| Each laboratory shall be qualified in accordance with CP 10.

The minimum inside height for a field laboratory shall be 7 feet if the facility is certified as having been manufactured prior to November 1, 1992.

**620.04 Commercial Plant Laboratory.** The plant laboratory at the site of the commercial hot mix plant shall consist of weatherproof, insulated, mobile housetype trailer or other approved structure having equipment meeting the following minimum requirements.

| Each laboratory shall be qualified in accordance with 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. 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) Sieve Shaker: One, motor-driven, standard portable, capable of handling a set of 8 inch US standard sieves, mounted 24 inches above floor in a sound-proof, insulated enclosure having hinged openings
- (11) Heating: Furnace, 200 BTU per square foot, minimum, forced air type
- (12) Telephone: Minimum flat rate service from nearest exchange
- (13) Air Conditioner: Adequate for laboratory size
- (14) Furniture: Desk with at least one drawer. One desk chair with rollers. One stool with height compatible with work bench

- (15) Balance: Balance or scale capable of weighing 20,000 grams to an accuracy of one gram
- (16) 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, shall conform to State law, shall 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 prior to the start of any operations. Facilities shall be for the exclusive use of Department personnel.

The Contractor shall provide replacement equipment due to breakdown, damage, or theft within five working days.

**620.07 Maintenance, Service and Utilities.** The Contractor shall furnish the following:

- |              |   |
|--------------|---|
| Fuel:        | Adequate supply for heating and testing operations.   |
| Electricity: | A 3000 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 service 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.

620.08

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
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.

## **SECTION 622 REST AREAS AND BUILDINGS**

### **DESCRIPTION**

**622.01** This work consists of the construction of various facilities in rest areas and other areas in accordance with 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 preconstruction 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 for which shop drawings or descriptive brochures are required must be performed in accordance with 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 which 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-built 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  $\frac{3}{8}$  inch in thickness. Blocks shall be placed in accordance with 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  $\frac{1}{4}$  inch in thickness. All joints shall be tooled.

The Contractor shall furnish cap courses, base courses, covings, bull-nosed corners and any special units which are 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  $\frac{3}{8}$  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  $\frac{5}{16}$  inch (measured in from edge) and corners,  $\frac{1}{2}$  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 himself that all joints are full. If he finds joints that are not completely filled, he can order brick removed until he is assured that the joints of all remaining brick are completely filled.

All face surfaces of the face brick work 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

622.10

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 in accordance with 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 door frames 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 herein. 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  $\frac{1}{16}$  inch.
  3. **Grouting.** All joints in ceramic floor tile shall be grouted full with a grout mixture and application as recommended by the tile manufacturer immediately after a suitable area of tile has been set. A  $\frac{1}{8}$  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 1½ inch beyond the first sheathing board. Spacing between adjacent shingles (joints) shall be ¼ inch. Joints in any one course shall be separated at least 1½ inches from joints in adjacent courses and joints in alternate courses shall not be in direct alignment. Exposure of shingles shall be 4½ 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 1½ inch diameter tin disks, 18 inch 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 pound per 100 square feet of specification asphalt. Felt sheets shall be lapped 24 inch over preceding sheet and solid-mopped full with 25 pound per 100 square feet of specification asphalt. All starter courses shall be

622.16

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 pound per 100 square feet. of clean gravel. Damp gravel is permissible. In cold weather, instead of applying roof three ply solid, the 15 pound 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 in accordance with the manufacturer's instructions. Each and every joint shall be concealed with colored aluminum mouldings. 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 insure 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.

622.21

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 in accordance with 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 herein 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 scheduled 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 prior to covering or concealment. The rough work shall be tested as a whole unit (that is: as a whole stack or riser).

Testing shall be conducted using water as the media under a hydrostatic head of not less than 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.

622.22

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  $\frac{3}{4}$  inch drop in water level or not more than  $\frac{1}{16}$  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 to which 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 of which 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 in accordance with 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 in accordance with the regulations of the Department of Public Health and Environment, State of Colorado and as follows: Prior to 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 prior to 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, sludge, etc., which 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, etc., 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 recirculated 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 recirculated 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

**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 hereinafter 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 preconstruction conference or within 14 days after award of Contract, submit to the Engineer a complete list of electrical materials he proposes to furnish and install on the Contract. Five copies of the list, including manufacturer and catalogue numbers of devices and fixtures, shall be furnished in accordance with subsection 622.03.

- (a) *Symbols.* Items of equipment and materials are indicated on the plans in accordance with 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/or temperature drop in the building to below a preset 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 in accordance with the National Electrical Code.
- (k) *Grounding.* All equipment and conduit shall be grounded in accordance with 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.

Switches	48 inches
Convenience outlets	48 inches
Panel to center	54 inches
Lighting fixtures -	as shown on the 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.

622.25

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 which 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 in accordance with 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 in accordance with 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:

<b>Pay Item</b>	<b>Pay Unit</b>
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

623.01

## **SECTION 623 IRRIGATION SYSTEM**

### **DESCRIPTION**

**623.01** This work consists of furnishing and constructing an irrigation system in accordance with 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  $\frac{5}{8}$  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:

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 spray head 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.

623.07

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 capabilities 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 in accordance with ASTM D 1784 and D 2466, 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 D 1784 and D 2466, cell classification 12454-B. Threaded nipples shall be schedule 80 PVC with molded threads conforming to ASTM D 2464. Threaded fittings shall be kept to a minimum. Cement and cleaner for solvent weld pipe and fittings shall conform to ASTM D 2564.
- (b) *Lateral Line Pipe.* Lateral line pipe shall be 80 pound NSF polyethylene manufactured from virgin material in conformance with ASTM D 2239 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 D 2609, cell classification 12454-B. Pipe shall be clamped onto the fitting using 100 percent stainless steel screw clamps (two clamps on 1½ 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 D 1784 and D 2466, 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.

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- (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  $\frac{3}{4}$  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 D 638 and D 648. 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 prior to start of construction. Contractor shall maintain and protect the approved staking layout. Prior to 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 prior to the start of irrigation work on the project a preconstruction 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 prior to 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:

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
Drip lines	8 inches below soil grade

All pipes under roadways shall be encased in a steel pipe sleeve which 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

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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.

Prior to 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.

Prior to 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 prior to 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 prior to 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 prior to 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 preconstruction meeting and 72-hour notice shall be given by the Contractor when a milestone event is approaching.

**623.25 Irrigation As-built 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-built 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-built plan shall be kept on the construction site at all times and available for prompt review by the Engineer or the Engineer's representative.

Provision of the final as-built 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-built plans.

The Contractor shall provide finalized as-built plans to the Engineer at the time of Final Landscape Acceptance.

**623.26 Maintenance Manuals and Training.** Prior to 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:

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- (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:
  - (i) Manufacturer's name
  - (ii) Make and model number
  - (iii) Name and address of manufacturer's local authorized distributor
  - (iv) Spare parts list in detail
  - (v) 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 blueline print of the as-built 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 which 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.

623.33

### 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Shrubbery Spray & 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.



623.33

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 hand held 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.

624.01

**SECTION 624  
CORROSION RESISTANT  
CULVERTS**

**DESCRIPTION**

**624.01** This work consists of furnishing and installing corrosion resistant culvert pipe in accordance with 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.

<b>Abbreviation</b>	<b>Description</b>	<b>Subsection</b>
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
RCP	Reinforced Concrete Pipe, Type I, II, or V Cement	706.02
NRCP	Nonreinforced Concrete Pipe, Type I, II, or V Cement	706.01
PVC	Polyvinyl Chloride	712.13
PE	Polyethylene	712.13

All precoated sheet steel for PCSP culvert shall be tested by the manufacturer for coating holidays and certified to be 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 with which they are used. Coatings conforming to the requirements of Sections 706 and 707 will be permitted as applicable. End sections, connecting bands, and pipe extensions shall be of similar metal, or of non-metallic material, to avoid galvanic corrosion.

When the plans specify culvert to resist a corrosive condition indicated by a corrosion resistance number, the Contractor will be permitted to furnish any pipe allowed under that specific corrosion resistance number in Table 624-1. The Contractor shall state at the preconstruction conference the type of culvert intended to be furnished.

**Table 624-1**

<b>Corrosion Resistance Number*</b>	<b>CR1</b>	<b>CR2</b>	<b>CR3</b>	<b>CR4</b>	<b>CR5</b>	<b>CR6</b>
Corrosion Condition Description*	Mild	Mild	Mild	Moderate	Severe	Extreme
Corrosion Condition Inside or Outside Pipe	Outside Only	Inside Only	Both	Both	Both	Both
<b>Type of Pipe</b>						
CSP	NO	NO	NO	NO	NO	NO
Bit. Co. CSP	YES <sup>1</sup>	NO	NO	NO	NO	NO
A.F. Bo. CSP	YES	YES	YES	YES	YES	YES
CAP	YES <sup>2</sup>	YES <sup>2</sup>	YES <sup>2</sup>	YES <sup>2</sup>	YES	NO
PCSP - both sides	YES	YES	YES	NO	NO	NO
RCP or NRCP, Type I Cement	YES	YES	YES	NO	NO	NO
RCP or NRCP, Type II Cement	YES	YES	YES	YES	NO <sup>3</sup>	NO
RCP or NRCP, Type V Cement	YES	YES	YES	YES	YES	YES
PVC	YES	YES	YES	YES	YES	YES
PE	YES	YES	YES	YES	YES	YES
<p>* As determined by the Department.</p> <p><sup>1</sup> 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.</p> <p><sup>2</sup> 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.</p> <p><sup>3</sup> RCP or NRCP made with Type II cement having maximums of 5 percent C<sub>3</sub>A and 25 percent (C<sub>4</sub>AF+2C<sub>3</sub>A) may be used for corrosion condition CR-5 if approved by the Engineer.</p>						

### CONSTRUCTION REQUIREMENTS

**624.03** Installation shall conform to the requirements of Section 603 or Section 510 as applicable.

Joining and installation of plastic pipe shall conform to ASTM D 2321 and the manufacturer's recommendations.

### METHOD OF MEASUREMENT

**624.04** Corrosion resistant culvert 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.

624.05

**BASIS OF PAYMENT**

**624.05** The accepted quantities of corrosion resistant culvert pipe will be paid for at the contract unit price per linear foot for the specified size and corrosion resistance number.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
<u>    </u> Inch Culvert Pipe (CR <u>  </u> )	Linear Foot

Structure excavation and structure backfill will be measured and paid for in accordance with Section 206.

## **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 in accordance with 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 or PE 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**

**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 Electronic Distance Meters (EDM), total stations, theodolites, levels, rods, tapes, tripods, tribrachs, and Global Positioning System (GPS) receivers and equipment, shall be checked and calibrated in accordance with the CDOT Survey Manual, Chapter 6, Section 6.1.10, and documented in the survey records prior to the start of work and every six months thereafter.

EDM and total stations shall be checked and calibrated on a National Oceanic and Atmospheric Administration/ National Geodetic Survey (NOAA / NGS) calibrated baseline in accordance with the CDOT Survey Manual, Chapter 2, Section 2.1 and 2.2, and documented in the survey records prior to the start of work and every six months thereafter.

GPS receivers and equipment shall be checked and calibrated on a NOAA / NGS calibrated baseline in accordance with the CDOT Survey Manual Chapter 3, Section 3.3, and documented in the survey records prior to the start of work and every six months thereafter.

625.02

Levels shall be checked and calibrated in accordance with the CDOT Survey Manual, Chapter 6, Section 6.4.5, and Chapter 5, Section 5.9.12, and documented in the survey records prior to 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 in accordance with 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 in accordance with the CDOT Survey Manual Chapter 6, Section 6.1.11 and 6.1.16, or is available from the Engineer.

A Presurvey Conference – Construction Survey shall be held in accordance with the CDOT Survey Manual Chapter 6, Section 6.1.6, prior to performing any surveying work under this section. The Engineer, Region Survey Coordinator (or designee), Contractor's Superintendent, Contractor's Surveyor (PLS or PE) and Party Chief shall attend. A Presurvey Conference – Construction Survey Form shall be included in accordance with the CDOT Survey Manual Chapter 6, Appendix 6.A.4. A surveying work schedule shall be submitted to the Engineer for review prior to the conference.

**625.04 Contractor Surveying.** The Contractor shall perform all construction surveying and staking that is necessary for construction of the project. Construction surveying and staking shall be based on the Primary Control established by the Department. Bid items which require stakes to be set by the Contractor's Surveyor (PLS or PE) are shown on the Survey Tabulation Sheet of the plans in accordance with the CDOT Survey Manual Chapter 6, Section 6.1.7.

The Contractor shall check all Department established Primary horizontal and vertical control points in accordance with the CDOT Survey manual Chapter 6, Section 6.1.13, and verify and document in the survey records their horizontal accuracy tolerance in accordance with the CDOT Survey Manual Chapter 5, Section 5.5, and their vertical accuracy tolerance in accordance with the CDOT Survey Manual Chapter 6, Section 6.4.3 and Chapter 5, Section 5.8.6, for a CDOT Class A - Primary Survey prior to 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, Section 5.5. Vertical accuracy tolerances for Primary Control surveys and monuments shall be as specified in the CDOT Survey Manual Chapter 6, Section 6.4, and Chapter 5, Section 5.8.6.

Horizontal accuracy tolerances for Secondary Control surveys and monuments shall be as specified in the CDOT Survey Manual Chapter 6, Section 6.2.4. Vertical accuracy tolerances for Secondary control surveys, monuments, and/or Secondary benchmarks shall be as specified in the CDOT Survey Manual Chapter 6, Section 6.2.7.

**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 reestablished at the Contractor's expense in accordance with the CDOT Survey Manual Chapter 6, Section 6.2.

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 in accordance with the CDOT Survey Manual Chapter 6, Section 6.2.3.

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, 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 in accordance with 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.

625.08

**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 6.1.15. Survey fieldbooks shall be indexed in accordance with the Survey Manual Chapter 2, Section 2.4.14.

All survey records generated shall be the property of the Department and shall be available to the Engineer for inspection or reproduction at all times. All survey records shall be transmitted to the Engineer for inclusion into the project records before final project acceptance. All survey records shall be stamped with the seal of, and signed by, the responsible PLS or PE identified in subsection 625.01.

If an electronic format is used it shall contain the same information and format as required in the Survey Manual Chapter 6, Section 6.1.15, for written documentation, a printout shall be signed and sealed by the PLS or PE in responsible charge identified in subsection 625.01, and shall be submitted to the Engineer on a CD ROM compact disc, or other acceptable medium which contains the stakeout data and the raw data from the actual placement of stakes.

Initial staking for major structures (overhead signs, concrete box culverts, bridges, and all other structures assigned a structure number) shall be done in accordance with the CDOT Survey Manual Chapter 6, Section 6.9, 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 prior to payment of the monthly estimate.

Before final payment is made, the following two items shall be completed, bear the seal and signature of the responsible PLS or PE identified in subsection 625.01, and have copies submitted to the Engineer for review:

- (1) All survey records
- (2) Supplemental or amended Project Control Diagram (a copy of which shall be submitted to the Region Survey Coordinator)

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Construction Surveying	Lump Sum

Traffic control for construction surveying will be measured and paid for in accordance with Section 630.

626.01

## **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 which must be performed prior to 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 2½ 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.

626.02

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Mobilization	Lump Sum

Nothing herein shall be construed to limit or preclude partial payments for other items as provided for by the Contract.

627.01

## SECTION 627 PAVEMENT MARKING

### DESCRIPTION

**627.01** This work consists of furnishing and applying pavement marking, and furnishing, installing, and removing temporary pavement marking in accordance with 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
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 in accordance with 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 pavement markings shall be in place on all roadways prior to opening to traffic.
- (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 and control points for the installation of those pavement markings for roadways that are being constructed under traffic shall be 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 pavement markings before they are open for traffic.

Markings applied to a final surface shall not leave a scar that conflicts with permanent markings.

2. The following criteria apply to all construction on roadways open to traffic other than (d)1. above.

Control points, 4 inch by 1 foot marks at 40 foot intervals, are guide markers for the installation of temporary markings, full compliance markings, or both and shall not be used as a substitute for temporary markings.

All temporary broken line pavement markings shall be installed daily and shall be at least 4 feet long with a maximum gap of 36 feet.

Temporary edge lines are not required unless specified on the plans. Control points for edge lines shall not be established unless full compliance final edge lines are to be placed the same day.

Temporary centerline pavement markings for no-passing zones shall be full compliance and shall be placed daily.

Temporary pavement stencils (school, railroad, etc.) are not required unless detailed on 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.

(e) Control points, temporary pavement markings and Contractor pavement marking plans will not be paid for separately but shall be included in the work unless otherwise noted on the plans.

627.04

**627.04 Pavement Marking with Paint.** Striping shall be done when the air and pavement temperatures are at least 40 °F. The pavement surface and weather conditions shall be conducive to satisfactory results.

Equipment shall be capable of painting a reasonably clean-edged stripe of the designated width  $\pm$  ¼ inch and shall have a bead dispenser directly behind, synchronized with the paint applicator. For centerlines and lane lines, an automatic skip control shall be used that will paint a stripe with a gap as shown on the plans. 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. Stripes shall be protected until dry.

Paint and beads shall be applied within the following limits:

	<b>Application Rate or Coverage Per Gallon of Paint</b>	
	<b>Minimum</b>	<b>Maximum</b>
Paint:	100 sq. ft.	110 sq. ft.
Beads:	5 lbs. 13 oz.	6 lbs. 3 oz.

**627.05 Epoxy Pavement Marking.** The 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 50 °F at the time of epoxy pavement marking application.

The surface areas of new portland cement concrete pavement and decks that are to receive markings shall be sandblasted prior to placement of the epoxy pavement marking. The amount of sandblasting 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 prior to placement of the epoxy pavement marking. Should any pavement become dirty, from tracked mud etc. as determined by the Engineer, it shall be cleaned prior to the placement of the epoxy pavement marking.

When recommended by the epoxy manufacturer, a high pressure water blast integrated into the gun carriage shall be used to clean the pavement surface prior to 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.

Epoxy pavement marking shall be applied to the road surface according to the epoxy manufacturer's recommended methods at 15 mils minimum thickness. Glass beads shall be applied into the epoxy pavement marking by means of a pressurized bead applicator at a rate of ¼ pound per square foot, 25 pounds per gallon minimum.

Epoxy pavement marking and beads shall be applied within the following limits:

	Application Rate or Coverage Per Gallon of Epoxy Pavement Marking	
	Minimum	Maximum
15 mil Marking:	100 sq. ft.	110 sq. ft.
Beads:	25 lbs.	

**627.06 Thermoplastic Pavement Marking.**

- (a) *Equipment-General.* The material shall be applied to the pavement by an extrusion method wherein 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 which 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 which 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.

627.06

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 prior to 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 cross-walk lines, stop bars, short lane lines and short center lines. 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 which will allow the Engineer to readily ascertain the rate of application.
  - B. The main storage tank shall be equipped with a heating device which 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 insure placement where needed.
4. **Cleaning Equipment.** Equipment must be provided to insure removal of laitance, dust, debris, paint and other foreign matter from the road surface immediately prior to the installation of the composition, or immediately prior to the application of primer.



- (c) *Application.* The stripe shall be applied to the pavement either to 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 prior to 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 insure 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  $\frac{3}{32}$  inch at the edges, or less than  $\frac{1}{8}$  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 at a rate of 10 pounds per 100 square feet, minimum.

**627.07 Methyl Methacrylate Pavement Marking.** Methyl methacrylate pavement marking shall be installed in accordance with 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.

627.07

Methyl methacrylate pavement marking and beads shall be applied within the following limits:

	<b>Application Rate or Coverage</b>	
	<b>Gallon of Methyl Methacrylate Pavement Marking</b>	
	<b>Minimum</b>	<b>Maximum</b>
Methyl Methacrylate Pavement Marking:	26 sq. ft.	28 sq. ft.
First Bead Applicator:	10 lbs	—
Second Bead Applicator:	6 lbs	—

**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 prior to 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 prior to application of the markings.

The surface areas of new portland cement concrete pavement and decks that are to receive marking shall be sandblasted prior to placement of primer and marking material. The amount of sandblasting shall be sufficient to remove all dirt, laitance and curing compound residue.

The air temperature shall be at least 60 °F.

When the marking strip is applied to newly overlaid hot mix asphalt, it shall be applied immediately after breakdown rolling. The rolling shall then continue to insure complete inlay of the marking strip and to obtain the required density of the pavement.

The marking strip as applied shall be in good appearance, free of cracks and the edges shall be true and straight.

**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 which 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 prior to 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 insures 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 to which 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 prior to opening of new lanes to traffic.

Pavement marking tape (removable) shall be installed in accordance with 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 center lines, 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 in accordance with the manufacturer's recommendations, and shall be maintained throughout the required construction phase at the Contractor's expense.

627.12

### METHOD OF MEASUREMENT

**627.12** The types of pavement marking described herein will be measured by the following units, complete in place and accepted.

- (a) Pavement marking paint, epoxy pavement marking, and methyl methacrylate pavement marking will be measured by the number of gallons used including glass beads. Material used in excess of coverage limit prescribed will not be measured.
- (b) 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.
- (c) 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.
- (d) 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.
- (e) 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:

<b>Pay Item</b>	<b>Pay Unit</b>
Pavement Marking Paint	Gallon
Epoxy Pavement Marking	Gallon
Methyl Methacrylate Pavement Marking	Gallon
Thermoplastic Pavement Marking	Square Foot
Preformed Plastic	
Pavement Marking (___ mils)	Square Foot
___ Inch Pavement Marking Tape	Linear Foot
Pavement Marking Tape (Removable)Linear	Linear Foot
Raised Pavement Marker (Temporary)	Each
Pavement Marking Paint (Word-Symbol)	Square Foot
Pavement Marking Paint (Xwalk-Stop Line)	Square Foot

<b>Pay Item (continued)</b>	<b>Pay Unit (continued)</b>
Thermoplastic Pavement Marking (Word-Symbol)	Square Foot
Thermoplastic Pavement Marking (Xwalk-Stop Line)	Square Foot
Preformed Thermoplastic Pavement Marking	Square Foot
Preformed Plastic Pavement Marking 60 mil (Word-Symbol)	Square Foot
Preformed Thermoplastic Pavement Marking (Word-Symbol)	Square Foot
Preformed Thermoplastic Pavement Marking (Xwalk-Stop Line)	Square Foot

Sandblasting will be measured and paid for in accordance with Section 202.

Glass beads and cleaning with high pressure water blast or air blast shall be included in the cost of the work.

629.01

**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), along with installing or adjusting Monument Boxes as listed on the Survey Tabulation Sheet or as shown on the plans.

All such monuments included in this section shall be established in accordance with 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, 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 Meters (EDM), total stations, theodolites, levels, rods, tapes, tripods, tribrachs, and Global Positioning System (GPS) receivers and equipment, shall be checked and calibrated in accordance with the Colorado Department of Transportation (CDOT) Survey Manual, Chapter 6,

Section 6.1.10, and documented in the survey records prior to the start of work and every six months thereafter.

EDM and total stations shall be checked and calibrated on a National Oceanic and Atmospheric Administration/ National Geodetic Survey (NOAA / NGS) calibrated baseline in accordance with the CDOT Survey Manual, Chapter 2, Section 2.1 and 2.2, and documented in the survey records prior to the start of work and every six months thereafter.

GPS receivers and equipment shall be checked and calibrated on a NOAA / NGS calibrated baseline in accordance with the CDOT Survey Manual, Chapter 3, Section 3.3, and documented in the survey records prior to the start of work and every six months thereafter.

Levels shall be checked and calibrated in accordance with the CDOT Survey Manual, Chapter 6, Section 6.4.5, and Chapter 5, Section 5.9.12, and documented in the survey records prior to 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 in accordance with 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 in accordance with the CDOT Survey Manual Chapter 6, Section 6.1.11 and 6.1.16, or is available from the Engineer.

A Presurvey Conference – Construction Survey shall be held in accordance with the CDOT Survey Manual Chapter 6, Section 6.1.6, prior to 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 in accordance with the CDOT Survey Manual Chapter 6, Appendix 6.A.4. A surveying work schedule shall be submitted to the Engineer for review prior to the presurvey conference.

The Contractor shall check all Department-established Primary horizontal and vertical control points in accordance with the CDOT Survey manual Chapter 6, Section 6.1.13, and verify and document in the survey records their horizontal accuracy tolerance in accordance with the CDOT Survey Manual Chapter 5, Section 5.5, and their vertical accuracy tolerance in accordance with the CDOT Survey Manual Chapter 6, Section 6.4.3 and Chapter 5, Section 5.8.6, for a CDOT Class A - Primary Survey prior to using them for monumentation surveying control.

629.03

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 6.1.15. Survey fieldbooks shall be indexed in accordance with the Survey Manual Chapter 2, Section 2.4.14.

All survey records generated shall be the property of the Department and shall be available to the Engineer for inspection or reproduction at all times. All survey records shall be transmitted to the Engineer for inclusion into the project records before final project acceptance. All survey records shall be stamped with the seal of, and signed by, the responsible PLS identified in subsection 629.01.

If an electronic format is used it shall contain the same information and format as required in the Survey Manual Chapter 6, Section 6.1.15, for written documentation, a printout shall be signed and sealed by the PLS in responsible charge of establishing the monuments as identified in subsection 629.01, and shall be submitted to the Engineer on a CD ROM compact disc, or other acceptable medium which contains the 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 5.11.9 and 5.11.10, 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 in accordance with the CDOT Survey Manual Chapter 6, Section 6.3.5, and Chapter 5, Section 5.11.9, shall be submitted to the Engineer prior to filing.

**629.04 Locating Monuments.** This work consists of field locating all survey monumentation which is in place as a result 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 in accordance with the CDOT Survey Manual Chapter 6, Section 6.3.

A diligent search of construction zones and project limits shall be performed by the PLS in accordance with the Survey Manual Chapter 5, Section 5.11.9, 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 in accordance with 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 which 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 in accordance with the Survey Manual Chapter 5, Section 5.11.9 and Section 5.11.10, 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 which 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 in accordance with 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 which 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 in accordance with the CDOT Survey Manual, Chapter 5, Section 5.11.9, and Section 5.11.10, 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 in accordance with 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 in accordance with Title 38 CRS.

Copies of all new Monument Records filed by the PLS with the State Board shall be submitted to the Engineer prior to filing.

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

629.05

Densification (HARND) monuments shall be referenced or replaced using Dual Frequency survey grade GPS equipment in accordance with 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 in accordance with 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 in accordance with the CDOT Survey manual Chapter 6, Section 6.2.9, and Chapter 5, Section 5.11.10. Prior to referencing, moving or replacing the monument the NGS State Geodetic Advisor and the CDOT Region Survey Coordinator is to be notified, contact information is available in the CDOT Survey Manual Chapter 1, Section 1.2.5.

Survey records for referencing, moving, or replacing a federal or local government agency monument shall include documentation of the work in accordance with subsection 629.03. The survey records shall be submitted to the Engineer, for review by the Region Survey Coordinator, 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 which control the work.

**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 in accordance with 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 in accordance with the CDOT Survey Manual Chapter 5, Section 5.10.

Vertical accuracy tolerances for Primary Control monuments and surveys shall be as specified in the CDOT Survey Manual Chapter 6, Section 6.4.3 and Chapter 5, Section 5.8.6.

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 in accordance with 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 0.2 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 in accordance with 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 in accordance with the CDOT Survey Manual Chapter 6, Section 6.2.3.

ROW monuments, property boundary monuments, and easement monuments shall be installed in accordance with the CDOT Survey Manual Chapter 6, Section 6.3, and Chapter 5, Section 5.11, 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 in accordance with 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 in accordance with the CDOT Survey Manual Chapter 5, Section 5.11.5 and Section 5.11.6. Survey records shall include documentation of the survey performed to establish the monuments in accordance with 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.

629.06

PLSS, GLO, BLM, or MS monuments shall be installed in accordance with the CDOT Survey Manual Chapter 6, Section 6.3 and Chapter 5, Section 5.11, 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 in accordance with the CDOT Survey Manual Chapter 5, Section 5.11.5 and Section 5.11.6. Survey records shall include documentation of the survey performed to establish the monuments in accordance with 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 Engineer prior to filing.

**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 in accordance with Title 38 CRS and State Board Rules and Policies, the work shall be done in accordance with 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 in accordance with 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 prior to being deposited with the county in accordance with Title 38 CRS, Property – Real and Personal, State Board Rules and Policies, MOU, and the CDOT Survey Manual:

- (1) All survey records
- (2) The ROW Plans
- (3) The Project Control Diagram (new, supplemental or amended)

The Presurvey Conference – Construction Surveys, equipment calibrations, and survey records will not be paid for separately but shall be included in the work.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
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 in accordance with Section 630.

630.01

## **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, masking and unmasking existing signs in construction zones, and concrete barriers as required by the Manual on Uniform Traffic Control Devices for Streets and Highways and the Colorado Supplement thereto, in accordance Contract. Devices shall comply with NCHRP 350 criteria requirement. When a device is not in use, the Contractor may remove it from the project for the period it is not needed. 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.

### **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. Material that the Engineer determines is inadequate to produce the desired results, shall not be used.

Reflective sheeting shall conform to the requirements of subsection 713.04.

Retroreflective sheeting shall be one of the types specified for the particular application in Table 630-1.

Retroreflective sheeting for all signs requiring an orange or yellow background shall be fluorescent.

**Table 630-1  
RETROREFLECTIVE SHEETING TYPES**

<b>Sheeting</b>	<b>Type III</b>	<b>Type VI</b>	<b>Fluorescent <sup>1</sup></b>
<b>Application</b>	<b>Work Zone</b>	<b>Work Zone</b>	<b>Work Zone</b>
All Orange Construction Signs (Including Roll-up Signs)			X
Barricades (Temporary)	X		
Vertical Panels	X		
Flaggers Stop/Slow (May include flashing light approved under SHRP product # 3016)	X		X
Drums <sup>2</sup>	X		
Non orange Fixed support signs with prefix "W"	X		X
Special warning signs			X
STOP sign (R 1-1)			
YIELD sign (R1-2)			
WRONG WAY sign (R5-1a)	X		
DO NOT ENTER sign (R5-1)			
EXIT sign (E5-1a)			
DETOUR sign (M4-9) or (M4-10)			X
All other fixed support signs <sup>3</sup>	X		X
All other signs which use is limited to working hours only	X	X	X

<sup>1</sup> Fluorescent sheeting shall be of a type that is on the Colorado Approved Products List.

<sup>2</sup> Drum sheeting shall be manufactured for flexible devices.

<sup>3</sup> Fixed support signs are defined as all signs that must remain in use outside of working hours. They shall be mounted in accordance with Standard Plan S-630-1, Note 12, unless otherwise approved.

The Contractor shall provide sign panel legend for standard signs in accordance with "Standard Highway Signs" published by the FHWA and the Colorado Supplement thereto, and sign panel legend for special signs in accordance with the detailed sign layouts provided by the Engineer.

**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:

630.03

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 which 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 night time, or when specified in the Contract, the minimum height shall be 36 inches.

When traffic cones are used during night time 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 ± 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  $\pm\frac{1}{2}$  inch in height and 3 to 3½ 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 to which traffic will pass. The striping shall start at the top and extend downward at least 32 inches. Reflective sheeting shall be Type III. 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 Concrete Barrier (Temporary).** Concrete Barrier (Temporary) shall conform to Precast Type 7 Concrete Barrier as detailed in Standard Plan M-606-14. Undamaged and unpainted sections of Concrete Barrier (Temporary) with stabilization pins as shown on the plans, may be used as Guard Rail Type 7 (Precast-Portable), when approved.

**630.08 General.** All traffic control devices shall be provided with all components necessary to comprise a complete installation.

Work zone devices that do not meet NCHRP 350 requirements shall not be used.

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.

Portable devices that requires weight to prevent overturning shall be weighted with appropriate sized sand bags.

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**

**630.09 Traffic Control Plan.** The Contractor shall control traffic in accordance with 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.

630.09

Any major revision to the Traffic Control Plan (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 preconstruction conference.

The proposed MHT shall include as a minimum the following:

- (1) A detailed diagram which 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) The Contractor shall furnish supporting references from documents such as the MUTCD, Standard Plans, etc. for any devices incorporated into the MHT which are not included in the TCP provided by the Contract.
- (4) 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.
- (5) A plan for maintaining and controlling pedestrian, bicycle, and other non-vehicular traffic.
- (6) A plan for emergency vehicle access.
- (7) 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 630-2. If the vertical clearance is less than what is shown for the particular condition in Table 630-2, 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 630-2, 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.
- (8) 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 630-2  
VERTICAL CLEARANCES TO STRUCTURES**

	<b>Highway Underpasses</b>	<b>Railway Underpasses</b>	<b>Overhead Wires</b>
Local Rural Roads	14 Feet	23 Feet <sup>2</sup>	3
Local Urban Streets			
Rural Collectors			
Urban Collectors	16 Feet <sup>1</sup>	23 Feet <sup>2</sup>	3
Rural Arterial			
Urban Arterial			

1 Vertical clearance to sign trusses and pedestrian overpasses shall be 17 feet  
 2 Measured from top of rail to bottom of highway structure. All railway clearances are subject to the individual railroad's approval.  
 3 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 ½ inch for each 1000 volts over 50,000.

**630.10 Traffic Control Management.** The Contractor shall designate an individual, other than the superintendent, to be the Traffic Control Supervisor. The Traffic Control Supervisor shall be certified as a worksite traffic supervisor by either the American Traffic Safety Services Association (ATSSA) or the Colorado Contractors Association (CCA), and shall have a current Department flaggers certificate. A copy of the Traffic Control Supervisor's certifications shall be provided to the Engineer at the preconstruction conference.

The Traffic Control Supervisor's duties shall include:

- (1) Preparing, revising, and implementing each required Method of Handling Traffic in accordance with the Traffic Control Plan.
- (2) Directly supervising project flaggers.
- (3) Coordinating all traffic control operations, including those of subcontractors and suppliers.
- (4) Coordinating project activities with appropriate police and fire control agencies.
- (5) Preparing a traffic control diary on every calendar day traffic control devices are in use. This diary shall be submitted to the Engineer daily and become a part of the Department's project records. The diary shall include the following information as a minimum:

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- (i) Date
  - (ii) For Traffic Control Inspection, the time of the inspection
  - (iii) Project number
  - (iv) Traffic Control Supervisor's name
  - (v) Description of traffic control operations (lane closures, shoulder closures, pilot car operations, detours, etc.) including location, setup and takedown time, and approved Method of Handling Traffic (MHT) number
  - (vi) Types and quantities of traffic control devices used in accordance with the approved MHT
  - (vii) List of flaggers and uniformed traffic control (UTC) used, including start time, stop time, and number of flagging hours and UTC hours used
  - (viii) Traffic control problems (traffic accidents; damaged, missing or dirty devices, etc.) and corrective action taken
- (6) Inspecting traffic control devices on every calendar day that traffic control devices are in use, masked, or turned away from traffic. These inspections shall include at least one night inspection per week. The TCS or another representative who is certified as a work site traffic supervisor shall perform these inspections.
  - (7) Insuring that traffic control devices are functioning as required.
  - (8) Overseeing all requirements covered by the Contract which contribute to the convenience, safety and orderly movement of traffic. Have an up-to-date copy of the MUTCD and applicable standards and specifications available at all times on the project.
  - (9) Attending all project scheduling meetings.
  - (10) Supervising the cleaning and maintenance of all traffic control devices.

A certified worksite traffic supervisor shall provide Traffic Control Management (TCM) on a 24-hour-per-day basis. The Traffic Control Supervisor (TCS) or another representative who is certified as a work site traffic supervisor shall be available and reasonably accessible to the job site on every working day, on call at all times, and available upon the Engineer's request at other than normal working hours. During non-work periods, the TCS or another representative shall respond to the job site within 45 minutes. When another representative responds, the TCS or another representative who is certified as a work site traffic supervisor shall arrive at the job site within two hours after notification. 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 time.

**630.11 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, or reinforced 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, and plywood at least  $\frac{3}{8}$  inch thick. Adhesives, glues, tapes, or mechanical fasteners that mar the face of the panel to be masked shall not be used.

**630.12 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. All storage areas shall be approved. When masking is used, it shall be done in accordance with subsection 630.11.

The construction traffic signs for reduced speed limit signs and double fines signs shall be placed, or unmasked, no sooner than four hours prior to 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 in accordance with the manufacturer's recommendations. Anchoring methods or devices which 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.

**630.13 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.

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All traffic control personnel shall wear safety apparel and hardhats meeting the requirements of the latest version of the ISEA “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.

Night time 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 through the project necessary to assure proper safety to traffic. All flagging personnel shall have completed the Department’s minimum training requirements for flaggers within two years prior to 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 project; except that 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 to traffic.
  - (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.

### METHOD OF MEASUREMENT

**630.14** Quantities to be measured for construction traffic control devices shall be the number of units of the various sizes and descriptions listed below.

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 drum channelizing devices will be measured by the unit. Concrete barriers 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.

The flashing beacon (portable) will be measured as a unit complete in place. Sign panel will be paid for under the appropriate item.

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 or another representative certified as a work site traffic 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 active TCM will be every calendar day on which active traffic control occurs in accordance with 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 or another representative certified as a work site traffic supervisor. An authorized 24-hour day of TCI shall be every 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.

Resetting, repairing, or replacing traffic control devices is considered maintenance of the devices. Cleaning and maintaining of traffic control devices are not considered traffic control activities subsidiary to the Traffic Control Management, Traffic Control Inspection or flagging pay items.

Payment will be made for either Traffic Control Management or Traffic Control Inspection for every calendar day that traffic control devices as shown in the MHT are in use, masked, or turned away from traffic on the project. Payment will not be made for both items for the same calendar day. Work on a night shift that begins before midnight and ends after midnight will be considered as occurring on the calendar day on which the shift ends.

The quantity to be measured for flagging will be the total number of actual flagging hours that are used as authorized in accordance with an approved MHT. Payment will not be made for time spent by flaggers to set up and take down construction traffic

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control devices. 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.

### BASIS OF PAYMENT

**630.15** 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 in accordance with subsection 105.20, exclusive of any maintenance periods.

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:

<b>Pay Item</b>	<b>Pay Unit</b>
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
Concrete 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
Traffic Control Management	Day
Traffic Control Inspection	Day



<b>Pay Item (continued)</b>	<b>Pay Unit (continued)</b>
Flagging	Hour
Pilot Car Operation	Hour

The Contractor shall agree to quantities for the following items on a weekly basis when signing the CDOT Form 7 – Weekly Report of Miscellaneous Pay Items:

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

**SECTION 700  
MATERIALS DETAILS**

**SECTION 701  
HYDRAULIC CEMENT**

**701.01 Portland Cement.** Portland cement shall conform to the requirements of the following specifications for the type specified or permitted:

<b>Type</b>	<b>Specification</b>
Masonry Cement	ASTM C 91
Portland Cement	ASTM C 150
Blended Hydraulic Cement	ASTM C 595
Hydraulic Cement	ASTM C 1157

In addition to the standard chemical requirements for portland cement in ASTM C 150, the maximum percent of equivalent alkalis ( $\text{Na}_2\text{O} + 0.658 \text{K}_2\text{O}$ ) shall not exceed 0.90 percent.

Where either Type I or Type II portland cement is required, blended hydraulic cement conforming to ASTM C 595 Type IP or Type IP(MS) may be used, except that the blended cement shall consist of no less than 70 percent portland cement. Where Type II portland cement is required, blended hydraulic cement conforming to ASTM C 595 Type IP(MS) may be used, except that the blended cement shall consist of no less than 70 percent portland cement. Where blended hydraulic cement is used the substitution of fly ash for the blended hydraulic cement is not allowed.

For concrete where Class F fly ash is required, blended hydraulic cement conforming to ASTM C 595 Type IP or Type IP(MS) may be used, except that the blended cement shall consist of no less than 70 percent portland cement and no less than 20 percent Class F fly ash by weight. The weight of blended hydraulic cement must equal the weight of portland cement plus fly ash.

Where either Type I or Type II portland cement is required, hydraulic cement conforming to ASTM C 1157 Type GU or Type MS may be used. Where Type II portland cement is required, hydraulic cement conforming to ASTM C 1157 Type MS may be used.

Where Type V portland cement is required one of the following may be used:

- (1) Type II portland cement with no more than 5.0 percent  $\text{C}_3\text{A}$  content and no more than 25.0 percent  $[\text{C}_4\text{AF} + 2(\text{C}_3\text{A})]$ .
- (2) Type II portland cement with no more than 0.040 percent expansion at 14 days when tested in accordance with ASTM C 452.
- (3) Type II portland cement with at least 15 percent of the cement replaced with an approved Type F fly ash.
- (4) ASTM C 595 Type IP(MS) blended hydraulic cement consisting of no less than 70 percent portland cement and at least 15 percent Type F fly ash.
- (5) ASTM C 1157 Type HS hydraulic cement.

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Cement shall be from a preapproved source listed on the Department's Approved Products List. The cement intended for use on the project shall have been tested and accepted prior to its use. Certified Test Reports showing that the cement meets the specification requirements and supporting this statement with actual test results shall be submitted to the Engineer.

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 insure that the material meets the specifications.

The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement which, for any reason, has become partially set or which 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 C 618, Class C or Class F. All chemical requirements of ASTM C 618 Table 1 shall apply with the following exceptions:

- (1) Footnote A shall not apply.
- (2) Loss on Ignition shall not exceed 3.0 percent.

Class C fly ash will not be permitted in concrete where Type V portland cement is required.

Fly ash shall be from a preapproved source listed on the Department's Approved Products List. The fly ash intended for use on the project shall have been tested and accepted prior to its use. Certified Test Reports showing that the fly ash meets the specification requirements and supporting this statement with actual test results shall be submitted to the Engineer.

Preapproval shall include submission of a report from the supplier documenting the results of testing the fly ash from that source in accordance with 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 insure that the material meets the specifications.

**701.03 Silica Fume.** Silica fume for concrete shall conform to the requirements of ASTM C 1240.

Silica Fume shall be from a preapproved source listed on the Department's Approved Products List. The silica fume intended for use on the project shall have been tested and accepted prior to its use. Certified Test Reports showing that the silica fume meets the specification requirements and supporting this statement with actual test results shall be submitted to the Engineer. The certification for silica fume shall state the solids content if the silica fume admixture is furnished as slurry.

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 insure that the material meets the specifications.

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**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 Provisional Standard MP1)

**Table 702-1  
SUPERPAVE PERFORMANCE GRADED BINDERS**

PROPERTY	REQUIREMENT FOR PG BINDER					AASHTO Test No.
	58-28	58-34	64-22	64-28	76-28	
<b>Original Binder Properties</b>						
Flash Point Temp., °C, minimum	230	230	230	230	230	T 48
Viscosity at 135 °C, Pa•s, maximum	3	3	3	3	3	TP 48
Dynamic Shear, Temp. °C, where G*/Sin δ @ 10 rad/s ≥ 1.00 kPa	58	58	64	64	76	TP 5
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	50	-	T 51
Toughness, joules (inch-lbs)	-	-	-	12.4 (110)	-	CPL-2210
Tenacity, joules (inch-lbs)	-	-	-	8.5 (75)	-	CPL-2210
Acid or Alkali Modification (pass-fail)						CPL-2214
<b>RTFO Residue Properties</b>						
Mass Loss, percent maximum	1.00	1.00	1.00	1.00	1.00	CP-L 2215
Dynamic Shear, Temp. °C, where G*/Sin δ @ 10 rad/s ≥ 2.20 kPa	58	58	64	64	76	TP 5
Elastic Recovery, 25 °C, percent min.	-	-	-	-	50	CPL-2211
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	20	-	T 51
<b>PAV Residue Properties, Aging Temperature 100 °C</b>						
Dynamic Shear, Temp. °C, where G*•Sin δ @ 10 rad/s ≤ 5000 kPa	19	16	25	22	28	TP 5
Creep Stiffness, @ 60 s, Test Temperature in °C	-18	-24	-12	-18	-18	
S, maximum, MPa	300	300	300	300	300	TP 1
m-value, minimum	0.300	0.300	0.300	0.300	0.300	TP 1
**Direct Tension, Temperature in °C, @ 1 mm/min., where failure strain ≥ 1.0 %	-18	-24	-12	-18	-18	TP 3
**Direct tension measurements are required when needed to show conformance to AASHTO MP 1.						

Samples of the PG binder for acceptance shall be sampled on the project as stated in the Schedule of 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 D 449, and the asphaltic primer shall conform to the requirements of ASTM D 41.

**702.02 Liquid Asphaltic Materials.** Liquid asphaltic materials shall conform to the requirements of AASHTO M 81, M 82, and ASTM D 2026 for the designated types and grades.

Primer for dampproofing shall meet the requirements of ASTM D 41.

RC-800 (Rubberized) shall be a blend of asphalt cement, rubber, and cutter stock. The asphalt cement shall be blended with a minimum of 1½ percent by weight of rubber prior to adding cutter stock. The final product shall meet the requirements of Table 702-2.

**Table 702-2**

Property	Requirement		AASHTO Test No.
	Min.	Max.	
Flash point °C (°F)	27 (80)		T 79
Kinematic viscosity, 60 °C, mm <sup>2</sup> /s (140 °F, centistokes)	800 (800)	1600 (1600)	T 201
Distillation test:			
Distillate, percent by volume of total distillate to 360 °C (680 °F)			
To 225 °C (437 °F)	15		
To 260 °C (500 °F)	45		
To 316 °C (600 °F)	75		
Residue from distillation to 360 °C (680 °F):			
Volume percent of sample by difference	75		T 78

**702.03 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 seal coats shall be sampled and will be tested for information only according to CP-L 2213, Chip Seal Compatibility.

- (a) Polymerized emulsions for seal coat shall conform to the following requirements for CRS-2P (Cationic, Polymerized) or HFRS-2P (Anionic,

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Polymerized, High Float). CRS-2P or HFRS-2P shall be an emulsified blend of polymerized asphalt, water, and emulsifiers. The asphalt cement shall be polymerized prior to emulsification and shall contain a minimum of 3.0 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. The emulsified blend shall conform to the requirements listed in Table 702-3.

**Table 702-3**

Property	CRS-2P	HHFRS-2P	AASHTO Test No.
<b>Tests on Emulsion:</b>			
Viscosity, at 50°C, Sabolt-Furol, s	min	50	
	max	450	T 59
Storage stability, 24 hr, % max	1.0	1.0	T 59
Particle charge test	Positive		T 59
Sieve test, % max	0.10	0.10	T 59
Demulsibility, % min	40	40	T 59
Oil Distillate by volume, % max or range	3.0	3.0	T-59
Residue by distillation/ evaporation <sup>2</sup> , % min	65 <sup>2</sup>	65 <sup>2</sup>	T 59/ CP-L 2212 <sup>1</sup>
<b>Tests on residue:</b>			
Penetration, 25 °C, 100g, 5s, min	70	70	T 49
Penetration, 25 °C, 100g, 5s, max	150	150	
Ductility, 25 °C, 5 cm/min, cm, min		75	T 51
Solubility, in trichloroethylene% min	97.5	97.5	T 44
Elastic Recovery, 25 °C min		58	CP-L 2211
Float Test, 60 °C, s min		1200	T 50
Toughness, in-lbs, min	70		CP-L 2210
Tenacity, in-lbs, min	45		CP-L 2210
<sup>1</sup> 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 accordance with AASHTO T-59 to determine acceptability. <sup>2</sup> For high float emulsions the distillation and evaporation tests will be in accordance with AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5°C (400 ± 10°F) maximum temperature to be held for 15 minutes.			

- (b) *Emulsion for Prime Coat.* Emulsion for prime coat shall conform to the following requirements for either Asphalt Emulsion Prime in Table 702-4, or Penetrating Priming Stabilizer in Table 702-5.

**Table 702-4  
FOR ASPHALT EMULSION PRIME**

Property	Requirement	AASHTO Test No.
Viscosity, Saybolt Furol, at 50 °C (122 °F), s	15-150	T 59
Settlement	1% max.	T 59
% Residue	65% min.	T 59 to 260 °C (500 °F)
Oil Distillate by Volume, %	7% max.	T 78
<b>Tests on Residue from Distillation:</b>		
Solubility in Trichloroethylene, %	97.5 min.	T 44
<b>Tests on Residue from Cutback Distillation to 360 °C (680 °F):</b>		
Viscosity, 60 °C, mm/s (140 °F, centistokes)	3,000 (3000) min.	T 202

**Table 702-5  
FOR PENETRATING PRIMING STABILIZER**

Property	Requirement		AASHTO Test No.
	Max.	Min.	
Flash (T.O.C.), °C (°F)	38 (100)		T 79
Saybolt Furol Viscosity at 50 °C (122 °F), s	30	100	T 72
Kinematic Viscosity at 60 °C, mm <sup>2</sup> /s (140 °F, centistokes)	60	212	T 201
Residue by evaporation, %	55		T 59
<b>Tests on residue:</b>			
Penetration, 25 °C (77 °F), 100 g, 5 sec, mm		25	T 49
Softening Point Ring & Ball, °C (°F)		71 (160)	T 53

- (c) *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 prior to emulsification, and shall contain a minimum of three 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.



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The emulsion shall be pumpable and suitable for application through a pressure distributor.

**Table 702-6  
HIGH FLOAT EMULSIFIED ASPHALT  
(POLYMERIZED) (HFMS-2sP)**

Property	Requirement		AASHTO Test No.
	Max.	Min.	
<b>Tests on Emulsion:</b>			
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
Asphalt Content, % Residue	65		T 59
Oil distillate by volume, %	1	7	T 59
<b>Tests on Residue:</b>			
Penetration, 25 °C (77 °F), 100g, 5 sec	150	300*	T 49
Float Test, 60 °C (140 °F), sec	1200		T 150
Solubility in TCE, %	97.5		T 44
Elastic Recovery, 4 °C (39.2 °F), %	50		CPL 2211
*When approved by the Engineer, Emulsified Asphalt (HFMS-2sP) with a residual penetration greater than 300 mm 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 mm 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**

Property	Requirement		Test
	Max.	Min.	
<b>Tests on Emulsion:</b>			
Viscosity @ 25 °C, SFS	15	85	ASTM D 244
Pumping Stability	Pass		GB Method <sup>1</sup>
Sieve Test, %w		0.1	ASTM D 244 <sup>2</sup>
Cement Mixing, %w		2.0	ASTM D 244
Particle Charge		Positive	ASTM D 244
Conc. of Oil Phase	60		ASTM D 244 <sup>3</sup>
<b>Tests on Residue:</b>			
Viscosity @ 60 °C , CST	1000	4000	ASTM D 2170
Flash Point, COC, °C (° F)	232		ASTM D 92
<b>Volatility</b>			
IBP, °C	163		ASTM D1160, 10mm
2%V, °C	204		”
5%V, °C	221		”
RTF-C Weight Change, %W		2	ASTM D 2872
Saturates, %w		28	ASTM D 2007
RTF-C Ratio		2.5	ASTM D 2872
Specific Gravity	0.98	1.02	ASTM D 70
<sup>1</sup> 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 (¼ inch) inlet and outlet. The emulsion passes if there is no significant separation after circulating ten minutes. <sup>2</sup> Test procedure identical with ASTM D 244 except that distilled water shall be used in place of two percent sodium oleate solution. <sup>3</sup> ASTM D 244 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.			

**702.04 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.

**Table 702-8**  
**ASPHALT REJUVENATING AGENT**

Property	Test Method	Requirement
Viscosity, S.F., @ 25 °C (77 °F), s	ASTM D244	15-40
<sup>1</sup> Residue, % min.	ASTM D244	60-65
<sup>2</sup> Miscibility Test	ASTM D244	No coagulation
<sup>3</sup> Sieve Test, % max.	ASTM D244	0.10
Particle Charge Test	ASTM D244	Positive
ASTM D244 (Mod):		
Viscosity, 60 °C (140 °F), mm <sup>2</sup> /s	ASTM D445	100-200
Asphaltenes, % max.	ASTM D4124	0.75
<sup>4</sup> Maltenes Dist. Ratio $\frac{PC+A_1}{S+A_2}$	ASTM D4124	0.3-0.5

<sup>1</sup> 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 cool immediately and calculate results.

<sup>2</sup> Test procedure identical with ASTM D244 except that .02 Normal Calcium Chloride solution shall be used in place of distilled water.

<sup>3</sup> Test procedure identical with ASTM D244 except that distilled water shall be used in place of 2% sodium oleate solution.

<sup>4</sup> In the Maltenes Distribution Ratio Test by ASTM Method D4124.

PC = Polar Compounds  
A<sub>1</sub> = First Acidaffin  
A<sub>2</sub> = Second Acidaffins  
S = Saturates

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 3.0 percent styrene-butadiene solution polymer. The finished product shall conform to the physical requirements listed in Table 702-8A below.

**Table 702-8A**  
**ARA 1P**

Test on Emulsion	Test Method	Min	Max
Viscosity, Saybolt-Furol @ 77 °F, s	ASTM D 244	15	100
Residue @ 350 °F, %	ASTM D244 Modified	60	
Sieve Test, %	ASTM D244		0.10
Oil distillate, %	ASTM D244		2.0
<b>Test on Residue</b>	Residue from D244 Modified		
Penetration @ 39.2 °F, 50g, 5s	ASTM D-5 Modified	300	
Asphaltenes, %	ASTM D4124		15
Rotational Viscosity @ 275 °F, #21 spindle, 150 rpm, cps	ASTM D4402	20	100

**702.05 Recycling Agents.** Asphalt recycling agents shall conform to the physical and chemical requirements of Table 702-9.

**Table 702-9**  
**APHALT RECYCLING AGENT**

Property	Test Method	Requirement
Viscosity @ 60 °C (140 °F), mm <sup>2</sup> /s (cSt)	ASTM D2170	200-800 (200-800)
Specific Gravity	ASTM D 70	Report
Flash Point C.O.C., °C (°F) min.	ASTM D 92	204 (400)
Oven Weight Change, 5 hrs. @ 163 °C (325 °F), % max.	ASTM D1754	4
*Viscosity Ratio, % max.	ASTM D2170	3
Saturates, % max.	ASTM D4124	30
*Viscosity Ratio = $\frac{\text{Viscosity after oven wt. change test, measured @ 60 °C (77°F)}}{\text{Original Viscosity @ 60 °C (77 °F)}}$		

**702.06 Hot Poured Joint and Crack Sealant.** Hot poured material for filling joints and cracks shall conform to the requirements of ASTM D 6690, Type I or II. ASTM D 1985 mortar blocks shall be used for concrete bond test. ASTM D 6690 material must pass asphalt compatibility test, Section 9, ASTM D 5329.

Sealant material shall be supplied preblended, prereacted, 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 pretested by the Department prior to use and subsequently placed on the Colorado Approved Products List.

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### SECTION 703 AGGREGATES

All sieve sizes and designations described in this section refer to laboratory sieves having square openings and conforming to ASTM E 11.

Where the Contract refers to a nominal size aggregate, the nominal size shall conform to the gradation in Table 703-1 below.

**Table 703-1  
DEFINITION OF NOMINAL AGGREGATES**

Nominal Size	Material passing the designated sieve by weight		
	100%	90% to 100%	No more than 90%
50 mm (2")	63 mm (2½")	50 mm (2")	37.5 mm (1½")
37.5 mm (1½")	50 mm (2")	37.5 mm (1½")	25.0 mm (1")
25.0 mm (1")	37.5 mm (1½")	25.0 mm (1")	19.0 mm (¾")
19.0 mm (¾")	25.0 mm (1")	19.0 mm (¾")	12.5 mm (½")
12.5 mm (½")	19.0 mm (¾")	12.5 mm (½")	9.5 mm (⅜")
9.5 mm (⅜")	12.5 mm (½")	9.5 mm (⅜")	4.75 mm (#4)

The grading and composition requirements for coarse and fine aggregates for concrete are set forth in Table 703-2.

**Table 703-2**  
**CONCRETE AGGREGATE GRADATION TABLE**  
 Percentage Passing Designated Sieves and Nominal Size Designation

Sieve Size	Coarse Aggregates (from AASHTO M 43)										Fine Aggregate
	No. 3	No. 357	No. 4	No. 467	No. 57	No. 6	No. 67	No. 7	No. 8	No. 8	
50 mm to 25.0 mm (2" to 1")	50 mm to 4.75 mm (2" to No. 4)	37.5 mm to 4.75 mm (1 1/2" to #4)	19.0 mm to 4.75 mm (1 1/2" to 3/4")	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 150µm (#4 to #100)	4.75 mm to 150µm (#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						
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	40-70	85-100			
4.75 mm (#4)	0-5	0-5	0-5	0-5	0-10	0-5	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		
600µm (#30)									25-60		
300µm (#50)									10-30		
150µm (#100)									2-10		

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**703.01 Fine Aggregate for Concrete.** Fine aggregate for concrete shall conform to the requirements of AASHTO M 6. The amount of material finer than 75 µm (No. 200) sieve shall not exceed three percent by dry weight of fine aggregate, when tested in accordance with AASHTO T 11 or Colorado Procedure 31, Method D, unless otherwise specified. The minimum sand equivalent, as tested in accordance with AASHTO T 176 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, except that the percentage of wear shall not exceed 45 when tested in accordance with AASHTO T 96. Coarse aggregate shall conform to the grading in Table 703-2. Sizes 357 and 467 shall each be furnished in two separate sizes and combined in the plant in the proportions necessary to conform to the grading requirements. Compliance with grading requirements will be based on the combination and not on each individual stockpile.

**703.03 Aggregate for Bases.** Aggregates for bases shall be crushed stone, crushed slag, crushed gravel, natural gravel, or crushed reclaimed concrete or asphalt material which conforms 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 No. 40 sieve fraction, stated in 2.2.2 of AASHTO M 147, shall not apply. The requirements for the Los Angeles wear test (AASHTO T 96) shall not apply to Class 1, 2, and 3. Aggregate for bases shall meet the grading requirements of Table 703-3 for the class specified for the project, unless otherwise specified.

The liquid limit shall be as shown in Table 703-3 and the plasticity index shall not exceed six when the aggregate is tested in accordance with AASHTO T89 and T 90 respectively.

**Table 703-3  
CLASSIFICATION FOR AGGREGATE BASE COURSE**

Sieve Size	Mass Percent Passing Square Mesh Sieves						
	LL not greater than 35			LL not greater than 30			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
100 mm (4")		100					
75 mm (3")		95-100					
60 mm (2½")	100						
50 mm (2")	95-100			100			
37.5 mm (1½")				90-100	100		
25 mm (1")					95-100		100
19 mm (¾")				50-90		100	
4.75 mm (#4)	30-65			30-50	30-70	30-65	
2.36 mm (#8)						25-55	20-85
75 µm (#200)	3-15	3-15	20 max.	3-12	3-15	3-12	5-15

NOTE: Class 3 material shall consist of bank or pit run material.

**703.04 Aggregates for Hot Mix Asphalt.** Aggregates for hot plant mix bituminous pavement (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. For Gradings S, SX, and SG, a percentage of the aggregate retained on the 4.75 mm (No. 4) sieve shall have at least two mechanically induced fractured faces when tested in accordance with 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. 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 in accordance with AASHTO T 90. The material shall not contain clay balls, vegetable matter, or other deleterious substances.

The aggregate for Gradings S, SX, and SG shall have a percentage of wear of 45 or less when tested in accordance with AASHTO T 96.

**Table 703-4  
MASTER RANGE TABLE FOR HOT MIX ASPHALT**

Sieve Size	Percent by Weight Passing Square Mesh Sieves		
	Grading SX	Grading S	Grading SG
37.5 mm (1½")			100
25.0 mm (1")		100	90 - 100
19.0 mm (¾")	100	90 - 100	
12.5 mm (½")	90 - 100	*	*
9.5 mm (⅜")	*	*	*
4.75 mm (#4)	*	*	*
2.36 mm (#8)	28 - 58	23 - 49	19 - 45
1.18 mm (#16)			
600 µm (#30)	*	*	*
300 µm (#50)			
150 µm (#100)			
75 µm (#200)	2 - 10	2 - 8	1 - 7

\* 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 in accordance with 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 (½ inch) and shall be non-plastic when tested in accordance with AASHTO T 90.



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Additionally, each source of aggregate for SMA shall meet the following requirements:

- (1) No more than 30 percent when tested in accordance with 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 in accordance with AASHTO T 104 Soundness of Aggregate by Use of Sodium Sulfate.

**Table 703-5  
MASTER RANGE TABLE FOR STONE MATRIX ASPHALT**

Sieve Size	Percent by Weight Passing Square Mesh Sieves		
	9.5 mm ( $\frac{3}{8}$ " nominal)	12.5 mm ( $\frac{1}{2}$ " nominal)	19.0 mm ( $\frac{3}{4}$ " nominal)
19.0 mm ( $\frac{3}{4}$ "			100
12.5 mm ( $\frac{1}{2}$ "	100	100	85 – 95
9.5 mm ( $\frac{3}{8}$ "	90 – 100	85 – 95	55 – 75
4.75 mm (#4)	30 – 55	24 – 32	24 – 32
2.36 mm (#8)	20 – 42	16 – 24	16 – 24
1.18 mm (#16)			
600 $\mu$ m (#30)	12 – 25	10 – 16	10 – 16
300 $\mu$ m (#50)			
150 $\mu$ m (#100)			
75 $\mu$ m (#200)	8 – 12	8 – 12	8 – 12

**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) Percentage of wear, Los Angeles Abrasion Test (AASHTO T 96), not more than 35.
- (2) When blast-furnace slag is used, weight per cubic foot shall be at least 70 pounds.
- (3) 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 in accordance with Colorado Procedure 45.
- (4) 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 in accordance with AASHTO T 19, Shoveling Procedure. The total mass of the test sample of lightweight aggregate used in AASHTO T 96 (Los Angeles Abrasion) shall be 2000 g.

**Table 703-6  
GRADATION SPECIFICATIONS FOR COVER COAT AGGREGATE**

Sieve Size	Percent by Weight Passing Square Mesh Sieve		
	9.5 mm (3/8") Type I	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	70-100	60-80
4.75 mm (#4)	0-15	0-4	
75 µm (#200)	0-1.0	0-1.0	0-1.0

\*Type IV shall be used only with light 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:

Sieve Size	Mass percent passing
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.

**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:

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

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**703.08 Structure Backfill Material.**

(a) Class I structure backfill shall meet the following gradation requirements:

Sieve Size	Mass Percent Passing Square Mesh Sieves
50 mm (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 of 35 or less and a plasticity index of 6 or less 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 I structure backfill, it will be paid for in accordance with subsection 104.03.

**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 703-7.

**Table 703-7  
GRADITION SPECIFICATIONS FOR FILTER MATERIAL**

Sieve Size	Mass Percent Passing Square Mesh Sieves		
	Class A	Class B	Class C
75 mm (3")	100		
37.5 mm (1½")		100	
19.0 mm (¾")	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 in accordance with AASHTO T 96, shall not be more than 70. The grading requirements shall be as follows:

<b>Sieve Size</b>	<b>Mass Percent Passing Square Mesh Sieves</b>
63 mm (2½ inch)	100
50 mm (2 inch)	95-100
19.0 mm (¾ inch)	0-15

704.01

**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 C 55.

**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 C 139, or, for hollow blocks, to ASTM C 90. 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 C 270.

**SECTION 705**  
**JOINT, WATERPROOFING,**  
**AND BEARING MATERIALS**

**705.01 Joint Fillers.**

- (a) *Joint Sealant with Backer Rod.* The joint sealant material shall be a silicone that is on the Department's Approved Products List. The silicone materials shall be stored and applied in accordance with 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 prior to joint sealant shall be constructed of closed cell polyethylene strand as approved.
- (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 where called for 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 (unused)**

**705.03 Gaskets.** Rubber gasketed joints shall conform to the requirements of AASHTO M 315 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 C 425.

**705.06 Bearing Materials**

**Table 705-1**  
**POLYISOPRENE (NATURAL RUBBER) ELASTOMER**

Specimen Properties	ASTM Test Procedure	Requirements		
		50 Duro	60 Duro	70 Duro
<b>Physical Properties</b>				
Hardness	D 2240	50 ± 5	60 ± 5	70 ± 5
Tensile Strength, MPa min (psi).	D 412	15.5 (2250)	15.5 (2250)	15.5 (2250)
Ultimate Elongation, % min.	D 412	450	400	300
<b>Heat Resistance, 70 Hr/70 °C (158 °F)</b>				
Change in Durometer Hardness, Max. Points		+10	+10	+10
Change in Tensile strength, % max.	D 573	-25	-25	-25
Change in Ultimate Elongation, % max.	D 573	-25	-25	-25
Compression Set, % max. 22 Hr./100 °C (212 °F)	D 395 Method B	25	25	25
Ozone Resistance, 20% strain 100 ppm Ozone in Air by Vol. 38 ± 1 °C (100 °F ± 2 °F)/48 Hr. Mounting Procedure ASTM D 518, Procedure A	D 1149	No Cracks	No Cracks	No Cracks
Adhesion Bond Made During Vulcanization, N/mm (Lb. Per Inch)	D 429, 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)	D 746 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)	D 1043	1 3	1 3	1 3
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)	ASTMD 4014 Quad Shear Test as described in Annex A	2 3	2 3	2 3
<sup>1</sup> Stiffness at test temperature shall not exceed 4 times the stiffness measured at 23 °C (73 °F). <sup>2</sup> 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 ¼ cycle of strain shall be discarded and the stiffness shall be determined by the slope of the force deflection curve for the next ½ cycle of loading. <sup>3</sup> ASTM D 1043 refers to the “Modulus of Rigidity” while ASTM D 4014 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	Requirements		
		50 Duro	60 Duro	70 Duro
<b>Physical Properties</b>				
Hardness	D 2240	50 ± 5	60 ± 5	70 ± 5
Tensile Strength, MPa min (psi).	D 412	17.2 (2500)	17.2 (2500)	17.2 (2500)
Ultimate Elongation, % min.	D 412	400	350	300
<b>Heat Resistance, 70 Hr/70 °C (158 °F)</b>				
Change in Durometer Hardness, Max. Points		+15	+15	+15
Change in Tensile strength, % max.	D 573	-15	-15	-15
Change in Ultimate Elongation, % max.	D 573	-40	-40	-40
Compression Set, % max. 22 Hr./100 °C (212 °F)	D 395 Method B	35	35	35
Ozone Resistance, 20% strain 100 ppm Ozone in Air by Vol. 38 ± 1 °C (100 °F ± 2 °F)/48 Hr. Mounting Procedure ASTM D 518, Procedure A	D 1149	No Cracks	No Cracks	No Cracks
Adhesion Bond Made During Vulcanization, N/mm (Lb. Per Inch)	D 429, 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)	D 746 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)	D 1043	1 3	1 3	1 3
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)	ASTMD4014 Quad Shear Test as described in Annex A	2 3	2 3	2 3
<sup>1</sup> Stiffness at test temperature shall not exceed 4 times the stiffness measured at 23 °C (73 °F). <sup>2</sup> 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 ¾ cycle of strain shall be discarded and the stiffness shall be determined by the slope of the force deflection curve for the next ½ cycle of loading. <sup>3</sup> ASTM D 1043 refers to the “Modulus of Rigidity” while ASTM D 4014 refers to the “Shear Modulus Stiffness”. The word “stiffness” is used to describe both terms.				



705.06

- (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 not less than 60 percent by volume of the total compound.

- (b) *Sheet Lead.* Sheet lead shall conform to the requirements of ASTM B 29 for common desilverized lead.

- (c) *Polytetrafluoroethylene (PTFE) Sheets.* PTFE resin shall be virgin material conforming to the requirements of ASTM D 4894 or D 4895. The specific gravity shall be 2.13 to 2.19 and the melting point shall be 623 °F ± 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 (min.)	ASTM D 4894 or D 4895	2800 psi
Elongation (min.)	ASTM D 4894 or D 4895	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:

<b>Mechanical</b>	<b>ASTM Method</b>	<b>15% Glass Fiber</b>	<b>25% Carbon</b>
Tensile Strength (min.)	D 4894 or D 4895	2000 psi	1300 psi
Elongation (min.)	D 4894 or D 4895	150%	75%
<b>Physical</b>	<b>ASTM Method</b>	<b>15% Glass Fiber</b>	<b>25% Carbon</b>
Specific Gravity (min.)	D 4894 or D 4895	2.20	2.10
Melting Point	D 4894 or D 4895	621 °F ± 18 °F	621 °F ± 18 °F

The maximum coefficient of friction for the PTFE shall be as follows:

Bearing Pressure	500 psi	2000 psi	3000 psi
Unfilled PTFE	0.08	0.06	0.04
Filled PTFE	0.12	0.10	0.08

The average bearing pressure on the PTFE sliding surface due to all loads shall not exceed:

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 gage minimum thickness and shall conform to ASTM A 240, 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 -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:

- (1) Overall Vertical Dimensions
 

Average Total Thickness 1/4 inches or less	-0, +1/8 inch
Average Total Thickness over 1/4 inches	-0, +1/4 inch

705.06

(2) Overall Horizontal Dimension	
36 inches and less	-0, +1/4 inch
Over 36 inches	-0, +1/2 inch
(3) Thickness of Individual Layers of Elastomer (Laminated Bearings Only)	±1/8 inch
(4) 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
(5) Position of Exposed Connection Members	±1/8 inch
(6) Edge Cover of Embedded Laminates or Connection Members	-0, +1/8 inch
(8) 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 either in 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 in accordance with Colorado Procedure L-2202:

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 lbs

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:

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 requirements of ASTM D 6690 Type 2, except that blocks for the bond test shall be as described in ASTM D 1985.

The membrane material shall be pretested by the Department prior to use. The batch or lot of the product will be placed on the Department's Approved Product List.

**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.

706.01

**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 prior to 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 8 feet apart. Joints for this pipe shall come equipped with steel rings and rubber gaskets conforming to ASTM C 361 and as described in Bureau of Reclamation Specifications for Type R-2 joints.

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 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.

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 prior to 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 prior to 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 prior to 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 in accordance with 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.

707.01

**SECTION 707**  
**METAL PIPE**

**707.01 Ductile Iron Pipe.** This pipe shall conform to the requirements of ASTM A 716 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 with 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 to which 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 ½ inch 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 prior to any handling or backfilling operations.

Special fittings and elbows for conduits shall be of the same gage as the conduit to which they are joined.

When aramid fiber bonded corrugated steel pipe is specified the pipe shall conform to ASTM A 885 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 therein 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.



707.05

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 prior to any handling or backfilling operations.

Special fittings and elbows for underdrains shall be of the same gage as the conduit to which 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 metal or alloy, unless otherwise shown on the plans.

**707.09 Repair of Damaged Coating.** Units on which 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 which 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.

## SECTION 708 PAINTS

**708.01 General.** This specification covers ready-mixed paint. Paint shall be easily mixed. The mixed paint shall be free from agglomerates, skins and foreign matter and shall be of suitable consistency for the method of application. Paint shall have satisfactory spreading qualities and give a smooth, continuous coating free from breaks or sags. Paint shall be able to withstand one year of storage without detrimental deterioration. In a  $\frac{3}{4}$  full, tightly closed container, paint shall show no skinning after 48 hours.

Color where designated by number refers to Federal Standard 595B. All proportions specified herein shall be by weight.

### 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 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 3 mils.

The manufacturer shall certify in writing to the Engineer that the SSPC-SP 6 steel cleaning is compatible with the primer used.

The top coat shall be an approved high-build polyurethane enamel with a minimum dry film thickness of 3 mils. To prevent bubbling, a mist coat shall be applied prior to application of the top coat.

**708.04 Aluminum Paint.** The paint shall be supplied ready-mixed in the proportion of (ASTM D 962, 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  $\frac{1}{2}$  to

708.04

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 Paint.** Pavement marking paint shall conform to the requirements listed in the table below. All proportions are by weight. Pigment composition and vehicle composition shall not vary by more than 1.0 percent of each amount specified.

Finished Paint Pigment (White and Yellow) ..... 49.0% to 52.0%

(a) <i>Pigment Composition.</i>	<b>White</b>	<b>Yellow</b>
Titanium Dioxide, ASTM D 476, Type III	27.0%	
Yellow Pigment		35.0%*
Calcium Carbonate, ASTM D 1199, Type GC-II	18.0%	53.3%
Magnesium Silicate ASTM D 605	54.3%	11.0%
Pigment Suspending Agents (see below)	0.7%	0.7%

\*The pigment for yellow paint shall consist of a blend of organic yellow pigment and other pigments and fillers as are necessary to result in a colorfast paint complying with all provisions of this specification. The paint shall contain no lead or other material such that the dry film could be considered a hazardous waste under EPA or Colorado Department of Health Regulations.

(b) <i>Vehicle Composition.</i>	<b>White &amp; Yellow</b>
Alkyd Resin Solution, AASHTO M 248, Type F	70.0%
VM&P Naphtha, Fed. Spec. TT-N-95, Type I	
Driers, ASTM D 600 cl. B, and Anti-Skinning Agent, Methanol	30.0%

(c) *Pigment Suspending Agent.*  
Organo-montmorillonite conforming to subsection 708.06(b) shall be added to achieve the desired storage and stability requirements.

(d) *Properties of Finished Paint.*  
The paint at the time of container filling shall be free of skins, pigment agglomerates and foreign matter and shall meet the following requirements:

- (1) Fineness of grind, Hegman, minimum 2
- (2) Consistency, Krebs-Stormer, K.U. @ 25 °C (77 °F) 70-80
- (3) Drying time, a wet film of paint 380 micrometers thick tested according to ASTM Method D 711, minutes maximum 30
- (4) Reflectance. The white paint shall have a daylight 45°, 0° luminous directional reflectance of not less than 80% when compared to magnesium oxide.
- (5) Color. The color of the yellow paint shall visually match color chip No. 33538 of Federal Standard 595B. In case of dispute, the color shall be within the green and red tolerance limits when compared with the standard color chips of the Standard Yellow for Highway Signs and Markings - U.S. Department of Transportation, Washington, D.C. The manufacturer shall

supply test data showing that the yellow pavement marking paint will retain the yellow color within these limits for a period of one year under outdoor sunlight exposure.

#### 708.06 Materials - Specifications

(a) *Paint Pigments.*

Chromium Oxide, (Green)	ASTM D 263
Magnesium Silicate	ASTM D 605
Titanium Dioxide	ASTM D 476, Class IV
Red Iron Oxide	ASTM D 3721
Black Iron Oxide	ASTM D 769
Yellow Iron Oxide	ASTM D 768

- (b) *Organo-montmorillonite.* Organo-montmorillonite shall be an organo 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 D 12
Mineral Spirits	ASTM D 235
Driers - Cobalt and/or manganese	ASTM D 600
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 hrs.
Dry Hard	18 hrs. 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.

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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, prior to 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 on the basis of 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.

**MINIMUM PHYSICAL PROPERTIES**

Solids by Weight	48 percent (Without texturing agent)
Solids by Volume	36 percent (Without texturing agent)
Weight per gallon	8.3 lbs./gal. (Without texturing agent)
Texturing Agent	3.2 to 3.8 lbs./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 in accordance with 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 therein, 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 A 615
Axle-steel Deformed and Plain Bars for Concrete Reinforcement	ASTM A 996
Low-Alloy Steel Deformed Bars for Concrete Reinforcement [to be Welded]	ASTM A 706
Fabricated Deformed Steel Bar Mats for Concrete Reinforcement	ASTM A 184
Steel Welded Wire Fabric, Plain, for Concrete Reinforcement	AASHTO M 55
Steel Welded Wire Fabric, Deformed for Concrete Reinforcement	AASHTO M 221
Epoxy Coated Reinforcing Bars	AASHTO M 284

Unless otherwise designated, bars conforming to ASTM A 615 & ASTM A 996 shall be furnished in Grade 60 for # 5 bars and larger and Grade 40 or 60 for bars smaller than # 5.

In ASTM A 184, bar material conforming to ASTM A 616 will not be permitted.

**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 M 284 and shall be grade 40, epoxy-coated, and deformed. Bar size shall be as designated on the Standard Plan M-412-1.

Dowel bars for transverse joints shall conform to AASHTO M 254 for the coating and to ASTM A 615, grade 60 for the core material and shall be epoxy-coated, smooth, and lightly greased, pre-coated 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 A 121, Class I. Aluminum barbed wire shall be manufactured in accordance with ASTM B 211 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 A 116, coating Class I.

Aluminum coated steel woven wire shall conform to the requirements of ASTM A 116, 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 A 392, Class I; and aluminum coating for steel fabric to ASTM A 491, Class I.

**710.04 Snow Fence.** Wire-bound picket fence shall conform to the requirements of ASTM F 537. Posts shall conform to the requirements of AASHTO M 281.

**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 be either 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 damaged either 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 Sound 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 American Wood Preserver’s Association (AWPA) standards, Sections C1 and C2 (Soil contact for posts, above ground for balance of fence). A treatment report is required from the treatment plant.
- (5) Preservative. Section P5 of AWPA standards.

All lumber shall be manufactured in accordance with 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 in accordance with



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AASHTO M 133 and AWPA C14. 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 in accordance with 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 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.
- (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 in accordance with AASHTO M 232, Class C, or AASHTO M 298, Class 50, Type 1. All other fittings shall be galvanized in accordance with AASHTO M 111. Bolts, nuts, and washers for corrosion resistant guard rail shall be of corrosion resistant material and conform to or exceed the requirements of ASTM A 307.

Where high strength bolts are required, they shall conform to the requirements of ASTM A 325.

**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	AASHTO M 148
Sheet Materials for Curing Concrete	AASHTO M 171

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 which 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 which have been frozen will be rejected in accordance with subsections 106.08 and 106.09.

**711.03 Chemical Admixtures.** Chemical admixtures for concrete shall conform to the requirements of AASHTO M 194.

Admixtures which have been frozen will be rejected.

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## **SECTION 712 MISCELLANEOUS**

**712.01 Water.** Water used in mixing or curing shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substance injurious to the finished product. Water will be tested in accordance with, and shall meet the suggested requirements of AASHTO T 26. Water known to be of potable quality may be used without test. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

**712.02 Calcium Chloride.** Calcium chloride shall conform to the requirements of AASHTO M 144.

**712.03 Hydrated Lime.** Hydrated lime for aggregate pretreatment shall conform to the requirements of ASTM C 207, Type N. In addition, the residue retained on a 75  $\mu\text{m}$  (No. 200) sieve shall not exceed 10 percent when determined in accordance with ASTM C 110. (Drying of the residue in an atmosphere free from carbon dioxide will not be required.)

**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 in accordance with 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 in accordance with 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 A 536. 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 A 47. 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 (unused)**

**712.08 Geosynthetics.** Geosynthetic rolls shall be furnished with suitable wrapping to protect against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled to provide product identification sufficient for inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. The Contractor shall furnish to the Engineer a certified test report from the producer, containing all data required to verify compliance with the specifications listed in the appropriate table.

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 for various applications are given in Tables 712-1 through 712-8. Unless otherwise stated, all property values represent minimum average roll values (MARV) in the weakest principle direction (i.e., average test results from any sampled roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the minimum values in the Tables). Stated values are for non-critical, non-severe conditions. Lots shall be sampled in accordance with ASTM D 4354.

- (a) *Geomembrane.* Geomembrane shall be manufactured for stopping seepage loss. The lining shall consist of virgin polyvinyl chloride (PVC) resins, plasticizers, stabilizers, and such materials that, when compounded, will meet the physical requirements for the thickness specified as listed 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 ½ 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	Thickness			Test Method
	0.25 mm (10 mil)	0.51 mm (20 mil)	0.76 mm (30 mil)	
Thickness, % Tolerance	±7	±5	±5	ASTM D 1593
Tensile Strength, kN/m (lbs./in.) width	3.50 (20)	8.75 (50)	12.25 (70)	ASTM D 882, Method B
Modulus @ 100% Elongation, kN/m (lbs./in.)	1.58 (9)	3.50 (20)	5.25 (30)	ASTM D 882, Method B
Ultimate Elongation, %	350	350	350	ASTM D 882, Method A
Tear Resistance: N (lbs)	18 (3.2)	29 (6.5)	38 (8.5)	ASTM D 1004
Low Temperature Impact, °C (°F)	-23 (-13)	-26 (-15)	-29 (-20)	ASTM D 1790
Volatile loss, % max.	1.5	0.9	0.7	ASTM D 1203, Method A
Pinholes, No. Per 8 m <sup>2</sup> (No. Per 10 sq. Yds.) max.	1	1	1	
Bonded Seam Strength, % of tensile strength	80	80	80	

- (b) *Geotextiles for Erosion Control, Drainage, and Silt Fence.* Fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long chain synthetic polymers composed of at least 95 percent by weight polyolefins, polyesters, or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages.

Geotextiles for erosion control shall conform to the physical requirements of Table 712-2 for the appropriate class.

Geotextiles for drainage applications shall be nonwoven and shall conform to the physical requirements of Table 712-3.

Geotextiles for silt fence applications shall conform to the physical requirements of Table 712-4.

**Table 712-2  
PHYSICAL REQUIREMENTS FOR  
EROSION CONTROL GEOTEXTILES**

<b>Property</b>	<b>Class A<sup>1</sup></b>	<b>Class B<sup>2</sup></b>	<b>Test Method</b>
Grab Strength, N (lbs)	900 (200)	400 (90)	ASTM D 4632
Elongation, % min.	15	15	ASTM D 4632
Seam Strength, N (lbs) <sup>3</sup>	800 (180)	360 (80)	ASTM D 4632
Puncture Strength, N (lbs)	360 (80)	180 (40)	ASTM D 4833
Trapezoid Tear, N (lbs)	225 (50)	135 (30)	ASTM D 4533
Apparent Opening Size (AOS) US Std Sieve	AOS less than 0.297 mm (greater than No. 50 sieve)		CW 002215 ASTM D 4751
Permeability, cm/s <sup>4</sup>	k fabric >k soil for all classes		ASTM D 4491
Ultraviolet Degradation at 500 hours	50% strength retained for all classes		ASTM D 4355

<sup>1</sup> Class A erosion control geotextiles are used where installation stresses are more severe than for Class B applications.

<sup>2</sup> Class B erosion control geotextiles are used in structures or under conditions where the fabric is protected by a sand cushion or by “zero drop height” placement of stone. Stone placement depth should be less than 3 feet and stone weights should not exceed 250 pounds.

<sup>3</sup> Values apply to both field and manufactured seams, if required.

<sup>4</sup> A nominal coefficient of permeability may be determined by multiplying permittivity value by nominal thickness. The k value of the fabric should be greater than the k value of the soil.

**Table 712-3**  
**PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILES**

<b>Property</b>	<b>Class A<sup>1</sup></b>	<b>Class B<sup>2</sup></b>	<b>Test Method</b>
Grab Strength, N (lbs)	800 (180)	360 (80)	ASTM D 4632
Seam Strength, N (lbs) <sup>3</sup>	710 (160)	310 (70)	ASTM D 4632
Puncture Strength, N (lbs)	360 (80)	110 (25)	ASTM D 4833
Trapezoid Tear, N (lbs)	225 (50)	110 (25)	ASTM D 4533
Apparent Opening Size (AOS) US Std Sieve	AOS less than 0.297 mm (greater than No. 50 sieve)		ASTM D 4651
Permeability, cm/s <sup>4</sup>	k fabric >k soil for all classes		ASTM D 4491
Ultraviolet Degradation at 500 hours	50% strength retained for all classes		ASTM D 4355
<p><sup>1</sup> Class A drainage geotextiles are used where installation stresses are more severe than for Class B applications, i.e. very coarse sharp angular aggregate is used, a heavy degree of compaction (95% AASHTO T 99) is specified or depth of trench is greater than 10 feet)</p> <p><sup>2</sup> Class B drainage geotextiles are used with smooth graded surface having no sharp angular projections and sharp angular aggregate is not used; compaction requirements are light (&gt;95% AASHTO T 99), and trenches are less than 10 feet) in depth</p> <p><sup>3</sup> Values apply to both field and manufactured seams, if required.</p> <p><sup>4</sup> A nominal coefficient of permeability may be determined by multiplying permittivity value by nominal thickness. The k value of the fabric should be greater than the k value of the soil.</p>			

**Table 712-4  
PHYSICAL REQUIREMENTS FOR  
TEMPORARY SILT FENCE GEOTEXTILES**

<b>Property</b>	<b>Wire Fence Supported Requirements</b>	<b>Self Supported Requirements</b>	<b>Test Method</b>
Tensile strength, N (lbs)	400 (90) minimum	400 (90) minimum	ASTM D 4632
Elongation at 50% minimum tensile strength	N/A	50 maximum	ASTM D 4632
Permittivity <sup>1</sup> s-1	0.01 minimum	0.01 minimum	ASTM D 4491
Apparent Opening Size (AOS), mm <sup>1</sup>	0.84 maximum	0.84 maximum	ASTM D 4751
Ultraviolet Degradation at 500 hours	minimum 70% Strength Retained	minimum 70% Strength Retained	ASTM D 4355
<sup>1</sup> Permittivity and AOS do not relate directly to filtration performance of silt fence fabrics. Values presented reflect minimum criteria of products currently used. Performance tests such as VTM-51 (from Virginia Highway Research Council) may be used to evaluate silt fence performance if deemed necessary by the engineer.			

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 712-5A and B may be used as a guide for Comparing the permeability coefficient of the fabric with that of the in-place soil.

**Table 712-5A  
TYPICAL VALUES OF PERMEABILITY COEFFICIENTS<sup>1</sup>  
(TURBULENT FLOW)**

<b>Type of Material</b>	<b>Particle Size Range Millimeters (Inches)</b>		<b>Effective Size</b>	<b>Permeability Coefficient-k cm/s</b>
	<b>D max</b>	<b>D min</b>	<b>D 20 mm (Inches)</b>	
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
<sup>1</sup> Basic Soils Engineering, R.K. Hough, 2nd Edition, Ronald Pess Co.; 1969, Page 76.				



**Table 712-5B TYPICAL VALUES OF PERMEABILITY  
COEFFICIENTS<sup>1</sup> (LAMINAR FLOW)**

Type of Material	Particle Size Range Millimeters (Inches)		Effective Size	Permeability Coefficient-k cm/s
	D max	D min	D 10 mm	
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 & GRAVEL	10	0.05	0.1	0.01
Uniform, fine SAND	0.25	0.05	0.06	40 x 10 <sup>-4</sup>
Well-graded, silty SAND & GRAVEL	5	0.01	0.02	4 x 10 <sup>-4</sup>
Silty SAND	2	0.005	0.01	1.0 x 10 <sup>-4</sup>
Uniform SILT	0.05	0.005	0.006	0.5 x 10 <sup>-4</sup>
Sandy CLAY	1.0	0.001	0.002	0.05 x 10 <sup>-4</sup>
Silty CLAY	0.05	0.001	0.0015	0.01 x 10 <sup>-4</sup>
CLAY (30% to 50% clay sizes)	0.05	0.0005	0.0008	0.001 x 10 <sup>-4</sup>
Colloidal CLAY (-2 μm 50%)	0.01	10	40	10 <sup>-9</sup>

<sup>1</sup> Basic Soils Engineering, R.K. Hough, 2nd Edition, Ronald Pess Co.; 1969, Page 76.

- (c) *Paving Geotextile*. The paving geotextile shall be constructed of nonwoven synthetic fibers; resistant to chemical attack, mildew, and rot; and shall conform to the physical requirements of Table 712-6.

**Table 712-6  
PHYSICAL REQUIREMENTS FOR PAVING GEOTEXTILES**

Property	Requirements	Test Method
Tensile Strength, N (lbs.)	450 (100)	ASTM D 4632
Mass per Area, g/m <sup>2</sup> (oz./sq. yd..)	140 (4)	ASTM D 3776
Elongation-at-Break, %, min.	50	ASTM D 4632
Asphalt Retention, L/m <sup>2</sup> (gal./sq. yd.)	0.9 (0.2)	Texas DOT Item 3099
Melting Point, °C (°F)	149 (300)	ASTM D 276

- (d) *Weed Barrier Geotextile*. Geotextile for weed barrier shall be a nonwoven, spunbound polypropylene polyester or polyolefin extruded in such a manner as to form a mat and shall conform to the physical requirements of Table 712-7.

**Table 712-7**  
**PHYSICAL REQUIREMENTS FOR WEED BARRIER**

Property	Requirements	Test Method
Grab Strength, N (lbs.)	310 (70)	ASTM D 4632
Puncture Strength, N (lbs.)	135 (30)	ASTM D 4833
Trapezoid Tear, N (lbs.)	110 (25)	ASTM D 4533
Water Flow Rate, L/s/m <sup>2</sup> (gal./sq. yd./min.)	110 (160)	ASTM D 4491
Ultraviolet Degradation at 150 hours	45% strength retained	ASTM D 4355

- (e) *Separator Geotextile.* Geotextile separator material shall consist of permeable sheets of polymeric yarn or fiber oriented into a woven or non-woven stable network which retains its relative structure during handling, placement and long-term service. The geotextile shall meet or exceed the properties shown in Table 712-8.

**Table 712-8**  
**PHYSICAL REQUIREMENTS FOR SEPARATOR<sup>1</sup>**

Property	Class A		Class B		Test Method
	Elongation < 50% <sup>2</sup>	Elongation > 50% <sup>2</sup>	Elongation < 50% <sup>2</sup>	Elongation > 50% <sup>2</sup>	
Grab Strength, N (lbs.)	1200 (270)	800 (180)	800 (180)	510 (115)	ASTM D 4632
Puncture Resistance, N (lbs.)	445 (100)	310 (70)	310 (70)	180 (40)	ASTM D 4833
Trapezoidal Tear Strength, N (lbs)	445 (100)	335 (75)	310 (70)	180 (40)	ASTM D 4533
Apparent Opening Size, mm (US Sieve Size) Permittivity, sec <sup>-1</sup>	AOS < 0.3 mm (US Sieve Size No. 50) 0.02 default value, must also be greater than that of soil				ASTM D 4751
Permeability, cm/sec	k fabric > k soil for all classes				ASTM D 4491
Ultraviolet Degradation at 500 hours	50% strength retained for all classes				ASTM D 4355

<sup>1</sup> Strength values are in the weaker principle direction  
<sup>2</sup> As measured in accordance with ASTM D 4632

**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 gage (U.S.), soft temper.

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Wire mesh for Slope Mattress (cage thickness up to 10 inches) shall be 14 gage (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  $\frac{1}{2}$  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 gages lighter.

All wire used, including tie and connecting wire, shall be certified by mill test reports showing compliance with specification requirements.

- (a) *Mesh Openings.* 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 prior to the date of letting.
- (c) *Non-raveling.* The mesh for both gabions and slope mattresses shall show no raveling beyond the mesh opening in which 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 gages 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 FOR MINIMUM STRENGTH  
TESTS FOR GABION BASKETS ONLY**

<b>Part</b>	<b>Minimum Strength (pounds per foot)</b>
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:

	<b>Stone Size</b>
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, min. 40 pounds per yard.
  - (2) Size 2 inch steel pipe conforming to ASTM A 53 either black or galvanized.
  - (3) Size 3 inch x 3 inch x  $\frac{3}{8}$  inch structural steel angles conforming to ASTM A 709 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.

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**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 C 881.

**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.

The drainage geotextile shall conform to the physical requirements of subsection 712.08, Table 712-3, for the Geotextile (Drainage) (Class B). 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 712-9.

**Table 712-9  
PHYSICAL REQUIREMENTS FOR DRAINAGE CORE**

Property	Value	Test Method
Compressive Strength, kPa (lbs./sq. in.)	140 (20)	ASTM D 1621
In-Plane Flow Capacity L/s/m (gal./min./ft.), minimum	2.12 (10)	ASTM D 4716
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:

*Ribbed Type:* AASHTO Interim Specifications Bridges, Section 18, Soil Thermoplastic Pipe Interaction Systems; material specifications are ASTM F 894 for polyethylene pipe, and ASTM F 794 for poly (vinyl) chloride pipe. Couplings shall be as recommended by the manufacturer.

*Corrugated Type:* AASHTO M 294.

*Smooth Type:* ASTM F 679. Couplings shall be as recommended by the manufacturer.

**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**

Application	Aluminum		Steel
	ASTM Designation	Alloy NO. Temper	ASTM Designation
Sign panels	B 209	6061-T6 5052-H36 5052-H38	*A 653
Traffic controller cabinets	B 209	6061-T6	709 Grade 36
Clip bolts	B 211	2024-T4	
Locknuts or steel nuts and bolts	B 211	2017-T4	*A 307
Clips and backing angles	B 221	6061-T6	
* Steel sheets shall have a Z600 zinc coating in accordance with ASTM A 653 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  $\frac{1}{3}$  inch, and the dimensions of the opposing sides shall be within  $\frac{1}{16}$  inch.

Aluminum sign panel shall be subject to the requirements of the first paragraph of subsection 713.09.

**713.03 (unused)**

**713.04 Sign Panel Backgrounds.** Reflective sheeting background material used shall be of the type as specified on the plans and shall conform to the requirements specified in subsection 713.10.

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All reflective sheeting shall be sealed at the seams and edges as recommended by the manufacturer.

The aluminum sign blanks shall receive a chemical treatment conforming to ASTM B 449, Class 2 prior to placement of reflective sheeting.

**713.05 Hardware.** All hardware shall be compatible with sign material and shall not cause discoloration due to weather.

**713.06 Messages.** Letter design shall be in accordance with the following:

Letter design for commercial legend shall be Series “E” for capitals, and Series “E Modified” for upper and lower case letters and numbers. The “E Modified” legend shall have an increased stroke width of 20 percent of the required legend height. The Inter-letter spacing shall be “Colorado Improved” in accordance with the Colorado Supplement to the Standard Highway Signs.

Silk screen process figures shall be in accordance with the plans and series figures described in the current editions of “Standard Alphabets for Highway Signs” and “Standard Highway Signs”, published by the FHWA, and the “Colorado Supplement to Standard Highway Signs”.

For overhead signs, the legend and borders shall be VIP sheeting or equivalent. The background retroreflective sheeting shall be Type III.

**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 grommetted mounting hole. The delineator unit shall withstand the combined corrosion test described in ASTM B 117.

**713.08 Glass Beads for Traffic Markings.** Glass beads for Traffic Paint shall conform to AASHTO M 247, Type 1 or Type 2, non-flotation grade.

Glass beads for Thermoplastic Pavement Marking shall conform to AASHTO M 247, Type 1.

Glass beads for epoxy pavement marking shall conform to AASHTO M 247, Type 1. The beads shall be silicon treated to meet the requirements of Section 4.4.2 of AASHTO M 247.

Glass beads shall be furnished in fully identified containers and shall be free of extraneous material or clumps.

Glass beads for methyl methacrylate pavement marking shall conform to AASHTO M 247, type 1 non-floatation and shall be applied by the first bead applicator. Glass beads applied by the second bead applicator shall be AASHTO M 247, type 1 silane coated (AC-02) floatation beads.

**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 which 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 in accordance with AASHTO T 257, with an observation angle of 0.1 degrees.

Entrance Angle Degrees	Specific IntensityCandlepower per Foot-Candle			
	Crystal	Yellow	Red	Green
0	110	50	33	22
20	60	30	18	12



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- 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.

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 D 788, Grade 8. The reflectors shall meet test requirements of Colorado Procedure L-2115, Sec. 3.2 and 3.3.

- (b) *Retroreflective Sheeting*. Reflective sheeting for traffic control devices shall conform to the requirements of ASTM D 4956.

**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 IMSA.

Direct-burial cable shall be copper and conform to Specification 19-5 of the IMSA except that conductors shall be seven, wire, stranded.

Pull rope shall be  $\frac{1}{8}$  inch nylon.

Messenger cable (span wire) shall be  $\frac{3}{8}$  inch diameter (minimum), seven wire stranded, common galvanized, utilities grade, rated at 11,500 pounds, in accordance with ASTM A 475.

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

Max. 35 watts,  $\pm 5$  watts for 12 inch ball

Max. 30 watts,  $\pm 5$  watts for 8 inch ball

Max. 15 watts,  $\pm 5$  watts for 12 inch arrow

Max. 15 watts,  $\pm 5$  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 assure 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  $-40$  °F and  $+165$  °F

(6) Lens

Shall be replaceable, polycarbonate (UV stabilized "Lexan") convex lens; meet ITE color standards; minimum of  $\frac{1}{8}$  inch thickness; and minimum light

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transmittance of 92 percent, free from bubbles, flaws and other imperfections. Non-polycarbonate tinted lenses will be accepted provided that these meet ITE color standards. Chromacity shall be measured uniform across the face of the lens. Non-polycarbonate lenses shall also meet 3½ 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 D 4505, Type I, Class B, C, D or E, and shall have a minimum thickness of 60 mils.

**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 insure a color similar to Federal Highway White, Color Number 17886, conforming to Federal Standard 595. Yellow - Sufficient yellow pigment shall be used to insure a color similar to Federal Highway Yellow, Color Number 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 E 303.
  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

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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 in accordance with 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.

Color	White		Yellow	
	0.2°	0.5°	0.2°	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 in accordance with 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 in accordance with 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 D 4592, Type I, and shall be 4 ± 0.1 inches wide.

**713.17 Epoxy Pavement Marking Material.** Only 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 certified test report (CTR). The CTR shall confirm that the material meets all CDOT requirements and is the same material that was preapproved in the product evaluation process.

- (a) *Formulation.* 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:

	<b>White:</b>	<b>Yellow:</b>
<b>Pigments</b>	Min % by weight 18% Titanium Dioxide, (ASTM D 476, Type II)	% by weight 21-27%
<b>Epoxy Resin</b>	75-82%	73-79%

The pigment for yellow 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) *Epoxy Number.* The epoxy number of the epoxy resin shall be 0.38 ± 0.05 as determined by ASTM D 1652 for white and yellow component A on pigment free basis.
- (d) *Amine Number.* The amine number on the curing agent (component B) shall be 410 ± 50 per ASTM D 2071.
- (e) *Toxicity.* Upon heating to application temperature, the material shall not produce fumes which are toxic or injurious to persons or property.
- (f) *Color and Weather Resistance.* The mixed epoxy compound, both white and yellow, when applied to 3 inch x 6 inch aluminum panels at 15 ± ½ mils of thickness with no glass beads and exposed in the Q.U.V. Environmental Testing

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Chamber as described in ASTM G 154, shall conform to the following minimum requirements. (The test shall be conducted for 75 hours at 122 °F, 4 hours humidity, and 4 hours U.V., in alternating cycles. The prepared panels shall be cured at 77 ° F for 72 hours prior to exposure.) The color of the white epoxy system shall not be darker than Federal Standard No. 595B-17778. The color of the yellow epoxy system shall conform to Federal Standard No. 595B-13538. The gloss values of both samples shall not be less than 70° after the test.

- (g) *Drying Time.* The 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 epoxy material shall be capable of fully curing under the constant surface temperature condition of 25 °F and above.
- (i) *Adhesion to Concrete.* The catalyzed epoxy pavement marking material, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified (4000 psi minimum) concrete surface that there shall be a 100 percent concrete failure in the performance of this test.
- (j) *Hardness.* The epoxy pavement marking materials, when tested according to ASTM D 2240, shall have a Shore D Hardness between 75 and 100. Samples shall be allowed to cure at room temperature,  $75 \pm 2$  °F for a minimum of 12 hours and a maximum of 48 hours prior to performing the indicated test.
- (k) *Abrasion Resistance.* The abrasion resistance shall be evaluated on Taber Abrader with a 1000 gram load and CS-17 wheels. The duration of the test shall be 1000 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 70. The tests shall be run on cured samples of material which have been applied at film thickness of  $15 \pm \frac{1}{2}$  mils to code S-16 stainless steel plates. The samples shall be allowed to cure at  $75 \pm 2$  °F for a minimum of 48 hours prior to performing the indicated tests.
- (l) *Tensile Strength.* When tested according to ASTM D 638, the epoxy pavement marking materials shall have a tensile strength of not less than 6000 psi. The Type IV Specimens shall be cast in a suitable mold and pulled at the rate of  $\frac{1}{4}$  inch per minute by a suitable dynamic testing machine. The samples shall be allowed to cure at room temperature ( $75 \pm 2$  °F) for a minimum of 12 hours and a maximum of 48 hours prior to performing the indicated tests.
- (m) *Compressive Strength.* When tested according to ASTM D 695, the catalyzed epoxy pavement marking materials shall have a compressive strength of not less than 12,000 psi. The cast sample shall be conditioned at room temperature,  $75 \pm 2$  °F, for a minimum of 12 hours and a maximum of 48 hours prior to performing the tests. The rate of compression of these samples shall be no more than  $\frac{1}{4}$  inch per minute.

**713.18 Raised Pavement Marker.** Raised pavement marker shall be not less than 3.5 inches nor 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 not less than 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:

Observation AngleDegrees	Entrance AngleDegrees	Specific Intensity Candela per Lux	
		White	Yellow
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.



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**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' in accordance with 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 prior to 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 Anchorages 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.

## SECTION 715 LIGHTING MATERIALS

**715.01 General.** Materials shall be of a standard line from a name brand manufacturer, or must be approved. Electrical material shall be approved by the Underwriters' Laboratories, Inc., and shall conform to the recommendations and requirements of the National Electrical Code.

Material shall be the same as, or compatible with, that used by the local utility, provided it meets the above requirements.

All lighting materials and all electrical materials shall be subject to inspection and approval and may be rejected as unsuitable at the project site. Samples may be taken or manufacturer's certification may be accepted in lieu of samples.

**715.02 Concrete Foundation Pads.** Concrete shall be Class "B" conforming to Section 601.

Anchor bolts shall be designed by the Contractor's Engineer and shown on the working drawings. The threaded ends of the anchor bolts and the nuts and washers shall be galvanized in accordance with ASTM A 153. Galvanizing for anchor bolts shall extend from 2 to 4 inches beyond the threads.

Reinforcing steel shall conform to the requirements of Section 602.

Grounding wire cast in the foundation shall be No. 6 AWG, soft drawn bare copper or better.

**715.03 Light Standards.**

- (a) *General.* All 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 90 MPH wind velocity, in accordance with AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals," unless otherwise shown on the plans.

All breakaway bases and couplers shall meet the breakaway requirements as specified in AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, Section 7.1.7.2. 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, or as specified.

All standards shall have cable-entrance holes located in conformity with the type of arm mounting used. Metal surfaces shall be free of any imperfections marring the appearance and of any burrs or sharp edges that might damage the cable.

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All metal poles shall be tapered and shall be supplied with pole caps.

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	Alloy No.
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 conforming to ASTM B 313 (excluding pressure and burst tests) alloy 5086-H34.

Aluminum mast arms shall be tapered and trussed as shown on the plans.

Steel mast arms and trusses shall be made of Schedule 40 standard steel pipe conforming to ASTM A 53.

All steel poles, mast arms and base flanges shall be hot-dip galvanized in accordance with ASTM A 123. Units on which 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 herein.

Base flanges for aluminum poles and transformer bases shall be aluminum castings of material conforming to ASTM B 26 alloy SG70A-T6 or an acceptable equivalent.

All transformer bases shall have vandal resistant, removable access doors.

- (c) Hardware used with steel standards shall be either cadmium plated, hot dip galvanized 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.

**715.04 Luminaires and Lamps.** A luminaire shall be a complete pre-wired lighting device specifically manufactured for the purpose of roadway lighting. A luminaire unit shall consist of housing, lens, reflector, ballast, lamp holder,

photoelectric control, mounting slip-fitter, and all necessary internal wiring. Luminaires shall be adaptable to the type of power distribution system to be used. Luminaires shall have a noncorrosive housing, a portion of which, by means of a hinge with a safety catch and a latch, may be opened to provide access to all internal components. Lamp holder shall be glazed porcelain. Screw shell shall be nickel plated or equal. Luminaires shall also conform to the following requirements:

- (a) Roadway luminaires shall be of the high pressure sodium type. Units for the project shall all be of the same type and design.

The luminaire light distribution shall be IES Type II, unless otherwise specified on the plans.

When luminaires are furnished for continuous roadway lighting, the manufacturer's photometric charts showing utilization curves and isolux lines shall be furnished to the Engineer to verify:

1. The average initial illumination on the traveled way will be at least 0.8 foot-candle.
2. The initial foot-candle value at the point of least illumination on the pavement area will be at least one fourth the average initial illumination.

- (b) Wall type luminaires for use under overpass structures shall be complete pre-wired lighting devices. Each luminaire shall be weatherproof, corrosion resistant and shall consist of a housing, reflector, shrouded porcelain socket, refractor, door, integral ballast and lamp.

Detail requirements are as follows:

1. The housing shall be cast aluminum.
2. The door shall be a cast aluminum frame with stainless steel hinges and latch containing a thermal shock resistant prismatic refractor.
3. Reflector shall be aluminum and shall be asymmetric.
4. Socket shall be for horizontal lamp position.
5. Integral ballast shall be rated to the circuit voltage and size of lamp specified.
6. Main beam angle setting shall be adjustable from 60° to 70°.
7. Manufacturer's photometric charts corresponding to the luminaire be installed shall be furnished to the Engineer upon request. The charts will be

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used to verify that the luminaire will meet the following illumination requirements:

- A. The average initial illumination on the traveled way will be at least 0.8 foot-candle.
- B. The initial foot-candle value at the point of least illumination on the traveled way will be at least 0.05.

For the purpose of making the above calculations:

- (1) Traveled way is defined as the portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes; and limited to a 70 foot length of roadway measured 35 feet each way from the luminaire station.
  - (2) The luminaire is considered to be located 15 feet from the nearest edge of the traveled way and mounted 15 feet above the roadway surface. The luminaire shall be designed to permit either wall or pendant mounting as required.
- (c) *Lamps.* Lamps for roadway lighting shall be high pressure sodium of the wattage shown on the plans. Minimum lumens for each specific wattage shall be as follows:

Watts	Min. Lumens
100	8 500
150	12 000
250	25 000
400	50 000
1000	130 000

**715.05 Ballasts.** Ballasts shall be of the magnetic regulator type specifically manufactured for use with high pressure sodium lamps, and shall operate at a minimum of 90 percent power factor. Operation shall be suitable with a line voltage variation of  $\pm 10$  percent. Satisfactory starting operation shall be obtained with an ambient temperature of  $-20$  °F.

**715.06 Conduit.** Unless otherwise specified, conduit shall be rigid metallic or semirigid plastic electrical conduit. Metallic conduit shall be clean, free of burrs, and shall be galvanized.

Conduit threads, when used in damp or wet locations, or when buried in the earth, or buried in concrete which is in contact with the earth, shall be completely covered with a coating of white lead. Coatings having insulating qualities will not be permitted.

Plastic conduit shall be a semirigid type currently recommended and approved by Underwriters' Laboratories, Inc. for the proposed usage. Underground plastic conduit for traffic signals shall conform to the requirements of ASTM F 441 schedule 80.

Fittings shall be of the type used outside the conduit and shall be secured to the conduit in such manner that the joints are watertight.

Concrete and plastic pull boxes shall be as shown on the plans.

Junction boxes used in structures shall be galvanized steel, 6 inches square by 4 inches deep with weatherproof covers.

Pull boxes shall be a minimum of 16 inches by 12 inches and 6 inches deep, or as shown on the plans, and shall have weatherproof covers.

**715.07 Direct Burial Cable.** Direct burial cables shall consist of 7-strand concentric Class B stranding. If not otherwise specified in the Contract, the conductors shall be a minimum of No. 6 AWG copper.

The cables shall have conductors insulated with 60 mils of cross-linked polyethylene.

Compact stranding will not be permitted. A separator shall be applied on conductors to provide free stripping. The void areas between conductors may or may not be filled with a non-hygroscopic material. Cables shall be bound with binding tape. The bound conductors shall be covered with interlocked galvanized (inside and outside) steel tape armor and covered with 50 mils of polyvinyl chloride (PVC), or the armor may be a 10 mil thick corrugated bronze tape, helically applied with a minimum overlap of 12.5 percent or three corrugations, whichever is greater. The completed cable shall be marked "Type USE or RHH or RHW". The outside diameter of the completed cable shall not be more than 1.10 inches.

Cable assembly in polyethylene pipe will be allowed as an alternative to direct burial cable. Conductor size as shown in the Contract shall be in appropriate size polyethylene pipe as shown in the following table.

Conductor Size	Pipe Size (Inch)
#6	1
#4	1¼
#2	1¼
#1	1½

Polyethylene pipe shall be medium or high density and shall meet all provisions of NEMA standard publication No. TC7.

The requirements for conductors shall be the same as those specified for buried cable.

When crossing under roadway, all conductors, regardless of type, shall be run in rigid metal conduit or schedule 80 plastic conduit.

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**715.08 Lighting Circuitry and Wiring.** Lighting systems shall be photoelectrically controlled. Photo cells shall be of the hermetically sealed, cadmium sulfide type and shall be preaged. Photoelectric units shall have a turn-on setting of 2.0 foot-candles, maximum. The ratio of the turn-off to turn-on setting shall be 3:1, maximum.

All electrical apparatus used in the lighting system shall be of ratings adequate to handle the necessary loads and shall conform to power source requirements.

Unless otherwise shown on the plans, copper wires and copper conductors shall be used and shall meet the minimum specifications and sizes as required by the National Electrical Code.

**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 A 1011, Grade 33 or 36, plates conforming to ASTM A 283 Grade C or D, or ASTM A 572 Grade 42; or it shall be manufactured to meet the requirements of ASTM A 53, Grade B or ASTM A 139 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, in accordance with subsection 509.24(b). Pipe that is cement mortar lined in accordance with 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, in accordance with AWWA Standards

<b>BURIED PIPE</b>		<b>EXPOSED PIPE</b>	
<b>INTERIOR</b>	<b>EXTERIOR</b>	<b>INTERIOR</b>	<b>EXTERIOR</b>
Lined with cement mortar in accordance with AWWA Standard C 205	80 mil thickness tape coating systems for the exterior of steel water pipelines in accordance with AWWA Standard C 214	Lined with cement mortar in accordance with AWWA Standard C 205 or coal tar epoxy in accordance with Corps of Engineers C 200	Subsections 509.24 and 509.29

**FOR PIPES CARRYING NON-POTABLE WATER AND FOR SEWERS**

<b>BURIED PIPE</b>		<b>EXPOSED PIPE</b>	
<b>INTERIOR</b>	<b>EXTERIOR</b>	<b>INTERIOR</b>	<b>EXTERIOR</b>
Lined with cement mortar in accordance with AWWA Standard C 205 or coal tar epoxy in accordance with Corps of Engineers C 200	80 mil thickness tape coating systems for the exterior of steel water pipelines in accordance with AWWA Standard C 214	Lined with cement mortar in accordance with AWWA Standard C 205 or coal tar epoxy in accordance with 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.



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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 A 53.

**716.04 Copper Pipe.** Copper pipe shall conform to the requirements of ASTM B 88, 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 D 2104 when size, type, and schedule or series are designated or ASTM D 2239 when size and pressure ratings are designated. Polyvinyl Chloride pipe (PVC) shall conform to the requirements of ASTM D 1785 when size and schedule are designated or ASTM D 2241 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 herein.

(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 with 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 to which 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, center-piece and other cast parts shall be cast bronze meeting the requirements of ASTM B 62. All packing shall have each ring cut to fit, with staggered joints. Continuous (spiralled) 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 with 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 light-weight aggregate concrete blocks conforming to ASTM C 129, 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  $2\frac{1}{4}$  inch x  $3\frac{5}{8}$  inch x  $7\frac{5}{8}$  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 C 216, 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  $\frac{3}{16}$  inch x 6 inch galvanized rod.

Corrugated wall ties shall be  $\frac{7}{8}$  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  $\frac{1}{4}$  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, ½ inch or 5/8 inch integral stops and 5 ½ inch or 5 ¾ 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 ½ inches x 4 ½ 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 herein.

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, Sec. 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 C 126.

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.

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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 D 312, 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 D 226.

Roofing aggregate shall meet the quality requirements of subsection 703.02 and shall be graded uniformly with 100 percent passing the 19.0 mm ( $\frac{3}{4}$  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 not less than 36 pounds per bundle.

All membrane roofing shall be 4 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 A 116.1, 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 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 fiber glass, thickness as shown on the plans with a density of  $\frac{3}{4}$  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,  $\frac{1}{4}$ " 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 not less than the following average weights per 5 foot of length:

2 inches	20 pounds
3 inches	30 pounds
4 inches	40 pounds
6 inches	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

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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 B 88, 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. 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.

- (a) *Grills.* Grill location, model, style and sizes shall be as shown on the plans.
- (b) *Thermostat.* Thermostats shall be as specified under electrical work in subsection 717.16.
- (c) *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.
- (d) *Duct Work.* Duct work shall be fabricated from galvanized steel sheets in accordance with 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:

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"

\*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'-10". All vertical riser ducts shall be supported at floor and ceiling with angle iron rests secured to the ducts.

- (e) *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. 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 trade mark of the manufacturer and shall bear the Underwriter's Laboratories, Inc. label.

Thinwall electrical metallic tubing conduit will be permitted above grade, unless otherwise noted on the plans.

- (a) *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.
- (b) *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 3 conductor, Type USE; three single conductors, Type USE, placed in the same trench; or 2 conductor Type UF, with ground wire. The wire size shall be as shown on the plans with no splices below ground.



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Cable serving outdoor lighting may be one cable of 2 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 D 4227. 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.

- (c) *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.

- (d) *Emergency Light.* The emergency light shall be weatherproof, with guard, red glass globe, gasket and 6 volt, 25 watt, medium base extended service lamp.
- (e) *Device Plates.* Device plates in Utility room shall be pressed steel to suit the device to be covered. Device plate in Men and Women's rooms shall be stainless steel type 430.
- (f) *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 milliammeter, 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 gage minimum steel cabinet, adequately ventilated by louvers.
- (g) *Disconnect Switches.* All safety switches shall be S/N, fused, and Type "ND" construction as prescribed by the National Electrical Code. Weather-proofhousing for exterior switches shall be provided.
- (h) *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.
- (i) *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 ½ 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 or crushed or natural gravel meeting the following grading requirements:

Passing 25.0 mm (1 inch) Sieve	100%
Passing 19.0 mm (¾ inch) Sieve	95%-100%
Passing 4.75 mm (No. 4) Sieve	0%-5%



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