# 15.0 STRUCTURES

The Contractor shall design and construct all of the Structures required to meet the Project criteria and make the Project fully functional in accordance with the Contract requirements.

To advance longer-lasting Highways, the Colorado Department of Transportation (CDOT) encourages using innovative technologies and practices to accomplish the fast construction of efficient and safe Highways and Bridges. Consideration by the Contractor of state-of-the-art technologies and elevated performance standards that result in improved safety, faster construction, reduced congestion from construction, improved quality, and user satisfaction are encouraged.

Refer to Table 15-1 and this Section for the work required at the existing Bridges on the Project.

**Table 15-1 Action for Existing Bridge Structures**

| Structure No. | Structure Description | Work |
|---|---|---|
| C-17-DD & C-17-DG | Interstate 25 (I-25) over State Highway (SH) 402 | Removal and reconstruction |
| C-17-BL & C-17-BM | I-25 over Big Thompson River | Widening, replace concrete overlay, approach slab, bridge deck rehabilitation and scour mitigation as needed. |
| C-17-F | I-25 Frontage Road over Big Thompson River | Scour mitigation as needed. |
| C-17-EK | Larmier County Road (LCR) 20E over I-25 | Abutment slope protection rehabilitation |
| C-17-EJ | Great Western Railway (GWRR) over I-25 | Abutment slope protection rehabilitation |
| C-17-FK | SH 392 over I-25 | East abutment wall construction |
| B-17-DI & B-17-DI | I-25 over Cache La Poudre River | Removal and reconstruction |
| B-17-BC & B-17-BD | I-25 over GWRR | Widening, replace asphalt, waterproofing membrane, approach slab, and bridge deck rehabilitation as needed. |
| B-16-AM | Prospect Road over I-25 | Removal and reconstruction |

New Structures shall be constructed for the Project at the following locations (General Layout Drawings provided in Reference Documents):

- I-25 over SH 402
- I-25 over Union Pacific Railroad (UPRR) and Kendall Parkway
- I-25 over Cache la Poudre River
- Prospect Road over I-25

The Contractor shall evaluate all existing concrete box culverts within the Project for condition, and performance and provide recommendations on adequacy to CDOT for Approval. All concrete box culverts shall be clean prior to Final Acceptance:

- Hillsboro Irrigation Ditch
- Lake Pond Road Underpass
- Farmers Ditch
- Greeley-Loveland Ditch
- Lake Canal
- Timnath Ditch
- Boxelder Creek

The Contractor shall repair the cracks in the slab and walls of the existing concrete box culverts listed above. Crack widths less than or equal to 0.006 inch shall be sealed with Concrete Sealer as described in CDOT *Standard Specifications*. Crack widths greater than 0.006 inch shall be repaired using an approved epoxy injection.

Resetting of Major Sign Structures shall be allowed if they comply with the latest provisions contained in CDOT M-Standard S-614-50 and S-614-60. As an alternative, the Contractor may submit a detailed analysis performed in conformance with the latest American Association of State Highway and Transportation Officials (AASHTO) *LRFD Bridge Design Specifications* for Structural Supports for Highway Signs, Luminaires, and Traffic Signals to confirm the structure satisfies the AASHTO design requirements. The following table identifies the major sign structures that are to be relocated as shown on the plans.

**Table 15-2 Major Sign Structure Resetting**

| Mile Post | Structure No. | Description |
|---|---|---|
| 256.11 | C-17-ED | NBND ML-VMS |
| 256.11 | C-17-EV | SBND ML-VMS |
| 257.18 | C-17-FC | NBND ML |
| 257.45 | C-17-FD | SBND ML |
| 263.29 | B-17-DY | NBND ML-VMS |
| 264.34 | B-17-ZD | SBND ML-VMS |
| 268.14 | B-16-GC | NBND ML+RAMP |
| 269.15 | B-16-GF | NBND ML+RAMP |

New concrete box culverts are required at the Louden Ditch. No Project Structure shall preclude anything required as part of the National Environmental Policy Act (NEPA) approval documents as further defined in Book 2, Section 1.

The Contractor shall obtain Structure numbers for all new Structures from CDOT during preliminary design. If any additional major Structures are required during the final design process, the Contractor shall obtain additional Structure numbers from CDOT.

# 15.1 Administrative Requirements

## 15.1.1. Standards

The versions of the referenced software, standards, data, and reports, which are current at the time of the Proposal Due Date, including all interim revisions and updates, shall be used unless specified otherwise in this Section.

Definitions of terms used herein are set forth in Exhibit A of Book 1 of the Contract Documents.

## 15.1.2. Software

The following software shall be used to load rate all major and minor Structures on this Project:

1. AASHTOWare Bridge Rating (BrR). Confirm with CDOT for version to be used.
2. If a Bridge type is selected that cannot be rated using the above software packages, the Contractor shall submit to CDOT the proposed rating software for Approval.

# 15.2 Design and Construction Requirements

## 15.2.1. Materials

### 15.2.1.1 Concrete

Cement types recommended in the Foundation Design Report shall be used for cast-in-place concrete in contact with soils. High sulfate content soils shall require Type V cement. Type III cement may be used for precast concrete. Class D concrete shall be used for noise wall panels, abutments, piers, and walls. Class BZ concrete shall be used for drilled caissons and filling post holes. Class B concrete shall be used for slope paving. Class D concrete shall be used for all conventionally reinforced Bridge decks, diaphragms, approach slabs, and Bridge rails. Class D, PS, or S40 concrete shall be used for all pretensioned or post- tensioned concrete. Contractor shall use a standard Class D mix for the Bridge deck. Concrete mix classes may be substituted per the CDOT *Standard Specifications*. The proposed concrete mix design and procedures shall meet the above requirements and shall be submitted for Acceptance by CDOT at least 3 weeks prior to the anticipated concrete placement date.

The use of lightweight concrete will not be allowed.

Minimum design concrete strengths shall meet the requirements of Section 601 of the CDOT *Standard Specifications*.

Maximum design concrete strengths used for design shall be (unless otherwise Approved by CDOT):

- Cast-in-place: f'c = 4.5 kilopound per square inch (ksi)
- Precast: f'c = 9.0 ksi

### 15.2.1.2 Pretensioning Steel

The minimum center-to-center strand spacing shall be 1 3/4 inches for 0.5-inch diameter strand and 2 inches for 0.6-inch diameter strand. Strands shall conform to American Society for Testing and Materials (ASTM) A 416 (AASHTO M 203), Grade 270, Low Relaxation Strands.

#### 15.2.1.3 Post-Tensioning Steel Systems

The Contractor shall provide corrosion protection for the strands consisting of grout filled galvanized or non-metallic ducts. Grout shall meet the requirements of Section 618 of the CDOT *Standard Specifications*. Installers of prestressing, post-tensioning systems shall be Post-Tensioning Institute (PTI) certified. The diameter for strands shall be 0.6 inches or 0.5 inches. Strands shall conform to ASTM A 416 (AASHTO M 203), Grade 270, Low Relaxation Strands.

#### 15.2.1.4 Reinforcing Steel

The use of epoxy coated reinforcing steel for all Bridges, walls, tunnels, noise walls, and box culverts shall be as defined in Table 1, subsection no. 8.1 of the CDOT *Bridge Design Manua*l and CDOT *Bridge Design Technical Memorandums*. The design category for anticipated level of de-icing salt application shall be "High". Abutments and pier columns exposed to splash from the adjacent Roadway shall use epoxy coated reinforcing steel. The splash zone is defined as anything within 10 feet radially of the outside edge of a Roadway shoulder. All reinforcing steel shall conform to the requirements of the CDOT *Standard Specifications* and consist of deformed bars conforming to ASTM A 615 except reinforcing to-be-welded shall conform to ASTM A 706 (unless Approved by CDOT). Epoxy coated reinforcing shall also conform to ASTM D 3963.

#### 15.2.1.5 Structural Steel

Structural steel shall conform to AASHTO M 270, Grades 36, 36W, 50, 50W, 70 or 70W. Structural steel supplied for main load-carrying members or components in tension, which are non-redundant, shall be designated as fracture-critical, meeting the Charpy V-notch Tests for Zone 2 in AASHTO M 222/M 222M and AASHTO M 223/M 223M. All structural steel shall be painted per Section 509 of the Standard Specifications. Weathering steel may be used as Approved by CDOT.

### 15.2.2. Design Parameters

#### 15.2.2.1 General

The Contractor shall complete the design in accordance with AASHTO Load Resistance Factor Design (LRFD) Bridge Design Specifications, Seventh Edition, with current interim revisions (hereinafter referred to as AASHTO LRFD Bridge Design Specifications), except as otherwise noted in this Section 15. All design calculations and plans shall be performed in English (Standard) units. Horizontally curved steel Bridges shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications.

Bridges shall be designed in accordance with the CDOT Bridge Design Manual in effect as of the proposal due date.

Bridge Superstructure types that would require temporary falsework or shoring for construction are allowed and shall meet all required vertical and horizontal clearances for both temporary conditions (construction) and final conditions. All falsework shall be designed in accordance with the AASHTO Guide Design Specifications for Bridge Temporary Works, First Edition with current interim revisions. See Section 15.2.10.3 for additional requirements.

All grade separated crossing of Railroad facilities shall be designed and constructed in accordance with the most current – Union Pacific Railroad - BNSF Guidelines for Railroad Grade Separation Projects and the American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering.

For Bridges, structural concrete stain (or paint for steel Structures) shall be applied to surfaces for each particular Structure in accordance with the I-25 Corridor Common Structural Element and Design Criteria

for the Preparation of Site Specific Structural Selection Reports (I-25 CCSE). All other visible, exposed, and accessible concrete surfaces shall have a surface treatment of structural concrete coating. Retaining walls, noise walls, and slope paving shall receive structural concrete coating unless noted otherwise. The existing slope paving, bridge piers, and abutments of widened bridges shall also be coated to provide a consistent color and texture between the existing and widened portions of the bridge.

The Bridges shown in Table 15-1 that require widening shall satisfy the minimum vertical clearance requirements shown in Section 15.2.3.1 Geometry. The Bridges shall be designed to accommodate the ultimate typical section. At some locations, the new girder depth for the widening must be shallower than the existing girders in order to satisfy the vertical clearance requirement. The Contractor must obtain Approval from CDOT to use girders for Bridge widening that are shallower than the existing Bridge girders.

### 15.2.2.2 Loads and Forces

The Contractor shall design all Structures, except as otherwise noted in this Section 15, for loads and forces in accordance with the AASHTO *LRFD* Bridge Design Specifications, or as stated herein.

Architectural elements and components to be constructed as part of Bridges, retaining walls, noise walls, and sign Structures shall be designed using the appropriate AASHTO specification.

#### 15.2.2.2.1 Live Loads

The Contractor shall design new Highway Bridges, box culverts, retaining walls, and Highway Bridge widenings using the live loads defined in the AASHTO LRFD Bridge Design Specifications. All Highway Bridges shall also be designed for the Colorado Permit Truck. Impact loads (dynamic load allowance) for Highway Bridges shall be as per the AASHTO LRFD Bridge Design Specifications.

#### 15.2.2.2.2 Dead Loads

The Contractor shall design all Highway Bridges for an initial 3-inch asphalt overlay (36 psf) wearing surface and waterproofing membrane.

#### 15.2.2.2.3 Uplift

The Contractor shall proportion Bridge spans to avoid uplift at supports due to non-seismic loads.

#### 15.2.2.2.4 Thermal Forces

The Contractor shall use temperature ranges for moderate climates per the AASHTO LRFD Bridge Design Specifications.

#### 15.2.2.2.5 Seismic

The Contractor shall design all Structures for seismic requirements in accordance with the AASHTO LRFD Bridge Design Specifications.

#### 15.2.2.2.6 Load Rating

The Contractor shall load rate all new Highway Bridges, box culverts, and Bridge widenings in accordance with the AASHTO *Manual for Bridge Evaluation*, Second Edition with current interim revisions and the CDOT Bridge Rating Manual. New Structures designed in accordance with the LRFD Design Specification shall be rated by the Load and Resistance Factor Rating (LRFR) method. Structures that are not designed in accordance with the AASHTO LRFD Bridge Design Specification shall also be rated using LRFR. However, should the LRFR rating be insufficient, the Structure shall be rated by the Load Factor Rating (LFR) method. Both the LRFR rating and the LFR ratings shall be submitted to CDOT. Load ratings shall

be provided electronically to CDOT prior to the commencement of any Bridge construction activities. Bridge widenings shall be rated as one system that includes both the portion of the remaining existing Bridge and the new widening.

Any temporary Bridges shall be load rated for HL93 and CDOT Permit Structures.

15.2.2.2.7 Wind Loads

The Contractor shall design all Highway Bridges for the wind loads specified in the AASHTO LRFD Bridge Design Specifications.

15.2.2.2.8 Collision Loads

The Contractor shall design Bridges and sound walls for the collision loads specified in AASHTO LRFD Bridge Design Specifications unless specified otherwise in this Section 15.

### 15.2.2.3 Geotechnical Data and Investigation

Geotechnical investigations conducted in the area of the Structures are included in "Preliminary Subsurface Investigation" in Book 3. The Contractor shall determine the additional geotechnical information required and conduct supplemental investigations as necessary to complete the final design. When planning and conducting additional investigations, the Contractor shall refer to the referenced Book 3 geotechnical documents completed for this Project. Additional boring logs and Laboratory Test results shall be presented in similar format as those Book 3 documents.

The referenced Book 3 soil and rock samples collected as part of this geotechnical engineering exploration are available at the geotechnical firm:

Yeh and Associates, Inc.
2000 Clay Street, Ste 200
Denver, CO 80211
Phone: 303-781-9590
Contact: www.yeh-eng.com

RockSol
12076 Grant St
Thornton, Co 80241
Phone: 303-962-9300

The Contractor shall have 90 days from NTP 1 to take possession of these geotechnical samples. If the Contractor has not taken possession within this timeframe, the above geotechnical firm will dispose of these materials accordingly. If the Contractor does take possession of these samples, the Contractor shall assume full responsibility for both their storage and disposal.

If groundwater observation wells are necessary to monitor water level or water quality, it shall be the Contractor's responsibility to properly abandon, permit, or renew the permits of these wells in accordance with State Engineer's Office requirements.

Contractor shall provide a soil vertical subgrade modulus for the concrete box culverts that are to be extended.

Geotechnical investigations shall comply with the requirements of the *2017 CDOT Field Materials Manual*; Chapter 10 of the AASHTO *LRFD Bridge Design Specifications*; Table 10-1 of Book 2, Section 10; and any other applicable standards necessary to perform the Work. All supplemental investigations made by the

Contractor shall be documented in geotechnical investigation reports of similar format as those referenced geotechnical documents and submitted to CDOT for review and comment prior to Acceptance within 30 days following completion of the fieldwork. All supplemental investigations made by the Contractor for non-CDOT Roadways shall be documented in separate Geotechnical Investigation Reports according to the maintaining entity and submitted to CDOT for Acceptance. No additional compensation will be provided for any additional costs for subsurface exploration work within areas of Contaminated Soil or Groundwater.

#### 15.2.2.4 Structure Foundation Analysis and Design Recommendations

The Contractor shall perform geotechnical analysis as required for the design of foundations for retaining walls, Bridges and other Structures. Design recommendations and substantiating analysis shall be documented in a draft form for the Preliminary Design Plans submittal and in final form for the Released for Construction (RFC) Documents submittal.

#### 15.2.2.5 Structure Aesthetics

The Contractor shall adhere to the I-25 CCSE in Book 3 for general structural Aesthetic guidelines unless otherwise stated in the agreements listed in Section 6, Third Party Agreements. Any further refinements shall be submitted to CDOT for Acceptance prior to any associated structural submittals, which includes the following:

Treatment concepts and details for all Structures (Bridges, retaining walls, noise walls, etc.) shall meet the requirements of this Section 15, shall be consistent with and complement the existing corridor Aesthetic treatments, and shall provide (as a minimum) the baseline Aesthetic treatments, approach, and commitments included in the I-25 CCSE. Contractor shall coordinate with local agencies in order to obtain acceptance of formliner pattern used on retaining walls and noise walls for the Project. Formliner pattern selection shall be Approved by CDOT in advance.

### 15.2.3. Bridges

#### 15.2.3.1 Geometry

All fill and cut slopes along the longitudinal axis of Bridges with spill-through abutments shall not be steeper than 2:1 (H:V) perpendicular to abutment. There shall be a 2-foot minimum width berm at the top of the slopes at the front face of abutments and a 2-foot minimum vertical dimension from the top of this berm to the bottom of girder. Minimum vertical clearance of 16 feet, 6 inches (from Traveled Way and outside edge of Shoulder including the Ultimate edge of shoulder) shall be provided for all grade separations. The Contractor shall also maintain the existing minimum vertical clearance, or better, over the Traveled Way and outside edge of Shoulders at existing and proposed Bridges during construction of the Project. I-25 Bridges over the Poudre River Trail shall maintain a minimum of 10’ vertical clearance.

For Bridge widenings, the concrete slope paving shall also be widened and should match the existing concrete slope paving layout.

#### 15.2.3.2 Type

Bridge and retaining wall types will be used as identified in the I-25 CCSE unless otherwise specified in this Section 15. Other types will be allowed, but only if they have been accepted for general use by other state or federal transportation authorities and Approved by CDOT. The Contractor must also demonstrate that the design of the Bridge and retaining wall types and components will meet the Project criteria and perform well under the Project’s environmental conditions, including frequent freeze-thaw cycles, anti-icing, and de-icing. Experimental Bridge and retaining wall types, timber Bridges, masonry Bridges, and structural-plate arches will not be allowed. Bridges shall incorporate as few joints and bearings as possible, be continuous over supports, not use intermediate hinges, and use integral or semi-integral

abutments wherever possible. Bridge types selected shall allow for and facilitate future Bridge widening unless Approved by CDOT. Avoid the use of fracture critical bridges. The Contractor shall submit, for Approval, all proposed Bridge and retaining wall types historically not used by CDOT in the Structural Concept Plans/Report.

### 15.2.3.3 Inspection Access

All Bridge Superstructures, joints, and steel reinforced elastomeric bearing pads with sliding surfaces and high load multi-rotational (HLMR) bearings shall be made accessible for long-term inspections and maintenance and shall be designed and detailed for ease of replacement. Jack locations and required jack sizes shall be shown on the Released for Construction Documents. The Bridge shall be designed to withstand anticipated applied loads and forces with the Superstructure jacked at the locations shown on the Released for Construction Documents.

Superstructures consisting of I-girders with exposed cross frames shall be made accessible for Inspection either with walkways (see CDOT Bridge Design Manual) or by use of an A-40 inspection truck. All concrete or steel box girders with an inside depth of 5 feet or more shall be made accessible for interior Inspection. All-pretensioned precast concrete box or tub girders with access shall be provided with low-point drainage through the bottom slab.

Access doors shall be placed at locations that do not impact traffic under the bridge, and shall be located to be readily accessible from bridge inspection trucks. All access holes shall be accessible with ladders from the ground and shall not require access by use of a CDOT A-40 inspection truck. Where access doors are provided above slope paving, cleats to support a ladder shall be provided in the slope paving and on steel girders. Location of access doors shall be submitted, no later than 30 days prior to fabrication, for Approval by CDOT. CDOT Standard Structural Worksheet B-618-2 shows typical bottom-slab access-door details. The doors shall swing into the box girder. Box girders shall be protected from access by vermin. The minimum opening for access doors shall be 2 feet by 3 feet and door shall be secured by a single padlock. Access holes through diaphragms shall be 2 feet, 6 inches in diameter, minimum. Access doors shall include lock protectors.

### 15.2.3.4 Components

#### 15.2.3.4.1 Bridge rails and pedestrian fencing

The Contractor shall design and construct bridge rails and pedestrian fencing (on bridges with Sidewalks) that match the face, color, and overall shape of barriers as defined in the I-25 CCSE and according to this Section 15. The Contractor shall use bridge rails on approach slabs. The Contractor shall design and construct pedestrian fencing/railing in accordance with AASHTO LRFD Bridge Design Specifications. Bridge rails subject to vehicular impact shall be designed to meet TL-4 loading in accordance with AASHTO LRFD Bridge Design Specifications. Current CDOT Bridge rails that meet the above criteria, such as Type 7 and Type 10M Bridge rails, are acceptable and do not have to be designed and crash tested. Alternate railing proposed shall be required to meet these requirements and be crash tested. Only Type 7 and 10M Bridge Rails will be used on this Project unless Approved by CDOT. Unless otherwise shown on the plans, all bridge rail on existing Bridges to be widened and identified in Table 15-1 shall be replaced with Type 10M Bridge Rail on both sides of each bridge deck (both directions) regardless whether or not the Bridge is widened.

Structures over railroads shall include Fence Chain Link (Special) (120-Inch) attached to the Type 10M Bridge rail posts. See Book 4 drawing Chain Link Fence (Special)(120-Inch),

Pedestrian railing attached to bridge rails shall be installed behind the bridge rail face, or back side of the bridge rail. All pedestrian fencing mounted on Bridge Structures shall meet fencing and screening

requirements in the AASHTO LRFD Bridge Design Specifications. Cover plates shall be used over the face of joints on the interior and exterior concrete bridge rails, and on curbs and Sidewalks to provide structural and safety shape continuity across the joint.

Place 1 extra 2 inch diameter conduit in bridge rails along outside Shoulders. The extra conduit shall extend 2 feet beyond end of sleeper beam at both ends of Bridge and terminate in a junction box. The Contractor shall coordinate final location of conduit with Roadway typical section beyond the sleeper beam.

#### 15.2.3.4.2 Approach Slabs

The Contractor shall provide an approach slab at each end of each Bridge. Provide an overlay on the approach slab as required in Section 15.2.3.4.5. All approach slabs shall be a minimum of 20 feet in length measured along the centerline of the Bridge, except when other physical features of the Project preclude this minimum length. For existing Bridges that are widened, completely replace the existing approach slabs, Backfill, and expansion joints on the remaining portion of the existing bridge. For bridges that are less than 50 feet wide (i.e., edge of deck to edge of deck), the end of the approach slab (i.e., adjacent to pavement), including expansion joint, shall be placed normal to centerline of Roadway. Approach slabs shall be separate from, and fit between, cantilevered wingwalls or retaining wall wingwalls so that the approach slab can freely rotate about the abutment. Bridge rails shall be connected to approach slabs. The Bridge rails shall be designed to function as a barrier to keep water out of the joint between wingwall/retaining wall and the edge of approach slab. The approach slab for Highway Bridges shall be at least the same width as the Bridge deck, and provide for expansion and contraction at the approach pavement interface where required. Approach slabs shall be anchored to the abutment. The Contractor shall design and construct a new underdrain system beneath the entire approach slab to remove water at Bridge abutments. Backfill behind the abutments shall be as shown in the CDOT Bridge Structural Worksheets Backfill Drawings B-206-F1 or B-206-M1. Bridge approach slab drains shall be located so as to minimize the amount of water flowing across all joints.

Approach slabs shall not settle more than 1/2 –inch within one (1) year after Final Acceptance. The Contractor shall implement ground improvement techniques to the approach embankment Subgrade if necessary to meet this requirement.

#### 15.2.3.4.3 Decks

The Contractor shall provide a minimum concrete deck thickness of 8 inches, except that decks and toppings for prefabricated pedestrian truss Bridges or adjacent precast prestressed box Bridges shall be 5 inches minimum. Open or filled grating decks and orthotropic decks will not be permitted. Concrete decks designed to the simplified “Ontario”, or any empirical methods, will not be permitted. Full depth precast deck slabs shall require cast-in-place joint closures, post-tensioning across joints and an overlay. Pretensioned, precast concrete deck forms shall be a minimum of 3 inches thick and have a full grout or concrete bearing. Full grout is defined as a 1 inch minimum thickness by 2 inch wide grout pad. Stay-in-place metal deck forms are permitted. If stay-in-place metal forms are used, the Superstructure, Substructure, and foundation shall be designed for an extra 5 pounds per square foot (psf) minimum dead load applied to the Superstructure. Parallel Bridges shall either have a minimum 2-inch (4-inch preferred) longitudinal gap between decks or parapets or shall be tied together to make one Bridge. Permanent deck forms will not be allowed for cast-in-place post-tensioned box girders, T-girder deck slabs, or cantilevered portions of decks. Cast-in-place concrete placed on top of a precast double tee or precast box girders shall be considered composite with the precast top flange if the minimum total laminated deck thickness is 8 inches, the minimum cast-in-place thickness is 5 inches and the top surface of the precast top flange is roughened. Precast double tees or precast box girders without a cast-in-place deck placed on top will not be allowed. Minimum longitudinal steel in the top mat of cast-in-place decks shall be #4s at 6-inch spacing spliced to the negative-moment steel reinforcing over piers.

#### 15.2.3.4.4 Deck Joints

The Contactor shall avoid or minimize joints wherever possible. Bridges in length up to 640 feet (steel) or 790 feet (precast or cast-in-place concrete) shall be jointless, wherever possible, according to guidelines given in CDOT Bridge Design Manual. A minimum 0 to 4-inch joint shall be placed at the end of approach slabs. Only strip seals for joints as reflected in CDOT Bridge Structural Worksheet - Bridge Expansion Device (0-4 inch) B-518-1, or CDOT Approved equal, with expected maximum 4-inch movement or modular joints for expected movements of 4-inches or greater shall be allowed. Design and location of joints shall provide for maintenance accessibility and future replacement. Aluminum joints will not be permitted. Modular joints shall be designed by LRFD and shall include LRFD fatigue requirements. Modular joints shall be tested for fatigue loading according to National Cooperative Highway Research Program (NCHRP) *Report 402, Fatigue Design of Modular Bridge Expansion Joints* (1997) Appendix A and Appendix B. All expansion devices shall be set to provide a smooth surface between the final grade into the device and the final grade out from the device. A smooth surface is defined as a maximum grade break, at or 30 feet either side of the device, of 0.2 percent. To facilitate the proper placement of expansion devices, the tabular Bridge geometry shall include a bent line for the expansion devices on a Bridge or approach slab. Asphaltic expansion devices and asphaltic plug joints shall not be used for any new construction.

End dam on approach slab shall be designed to accommodate a 3-inch wearing surface.

#### 15.2.3.4.5 Overlays

The Contractor shall provide an initial overlay system for all new Bridge decks. Bridge overlays shall be a minimum ¾" thin-bonded overlay (polyester concrete) on the bridge deck and approach slabs. The overlay shall be used on both the Bridge deck and associated approach slabs.

On existing bridges to be widened, Contractor shall remove existing asphalt and waterproofing membrane on bridge decks and replace with a minimum ¾" thin-bonded overlay (polyester concrete); unless noted otherwise on the plans. Prior to placement of the new overlay, the bridge deck shall be rehabilitated as described in Section 15.2.3.5 Bridge Deck Rehabilitation and the Project Special Provisions at the end of this Section.

#### 15.2.3.4.6 Superstructures

The Contractor shall ensure that all Superstructure elements meet the requirements for redundancy, fatigue, crack control, and deflection in the AASHTO *LRFD Bridge Design Specifications*.

Utilities to be supported by Structures shall be submitted to CDOT for Approval no later than 30 days prior to construction. Utility supports and other details shall be designed by a Professional Engineer licensed in the State of Colorado. Utilities shall be hidden from view in Superstructure elevation. Bridge deck drainage or anti-icing pipes shall not be allowed inside of box girders or embedded within concrete structural members.

For structural steel Superstructures, redundant-member Structures are preferred. For cast-in-place concrete box girder Superstructures, the Contractor shall consider the effects of a temperature gradient. The design of cast-in-place concrete box girders shall include the weight of the deck formwork left in place in the design of the Superstructure, Substructure, and foundation.

The maximum shear reinforcement spacing for cast-in-place mildly reinforced or post-tensioned concrete Bridges shall be 18 inches. The minimum amount of shear reinforcing per web for prestressed concrete girders shall be at least Av=135 x b'/fy, with b' the web width in inches, and fy the yield strength of the shear reinforcing in psi. Webs shall have at least double this minimum reinforcement for a distance d in front of anchorages. Minimum side-face steel shall be 1.5 times the minimum shear steel for areas more

than the depth of girder from the supports and shall be spaced at 12 inches maximum. All reinforcing steel shall have a minimum 2 inch clearance between parallel bars including spirals.

Under full dead load, without live load and after all losses, no part of the top or bottom girder fiber which resists moments using prestressing shall be in tension. Under full loads, after losses, tension due to live load will not be permitted if well distributed fully bonded reinforcing is not provided in these areas.

Girder camber for pre-tensioned, precast concrete box girders and BT girders shall be designed in accordance with the CDOT Bridge Design Technical Memorandum (2015-09). Negative camber is prohibited in precast concrete members.

The minimum concrete strength (f'c) shall be 4.5 ksi for any cast-in-place concrete member which forms part of a deck.

When utilizing continuity for design of precast prestressed girders, the effects of differential shrinkage, differential temperature, and any redistribution of moments due to creep shall be investigated. The transverse steel area in precast box girder flanges shall, at a minimum, be equal to the minimum required shear reinforcing steel for one web.

Precast girders used in segmental construction shall be bonded with epoxy or concrete closure pours. The top surface of precast deck panels shall be roughened perpendicular to the longitudinal axis of the Bridge to ensure composite action between the precast and cast-in-place slab. The minimum amount of non-prestressed longitudinal steel required in the cast-in-place portion of the slab shall be 0.2 square inch per foot width of slab.

All steel girders shall be designed to be fully composite with the deck along the entire length of the Structure. All shear studs on steel girders shall be field welded. The minimum flange thickness (excluding the bottom flange of box girders) shall be 5/8-inch, and the minimum thickness of steel to which shear studs are to be connected shall be at least 0.33 times the stud diameter. The minimum flange width shall be 12 inches. The minimum thickness of the bottom flange of a box girder shall be 3/8- inch. The minimum thickness of any stiffener or web plate of a girder shall be 3/8-inch. The thickness of any web or flange plate shall not change by more than a factor or two at any splice (see CDOT Bridge Detail Manual, Chapter 13.2, for welded plate girder detail guidelines). Cover plates shall not be used. Longitudinal flange stiffeners shall not be used except for spans exceeding 165 feet between points of zero dead-load moment. Transverse stiffeners shall be normal to the top flange and placed on the non-visible side (inside) of exterior girders. Shop splices of stiffeners, if any, shall be made with full penetration groove welds. These welds shall be completed before the stiffeners are welded to the girder. Stiffeners with diaphragms connected to them shall be welded with fillet welds to the top and bottom flange. The skew angle between bearing stiffeners and web shall not be less than 60 degrees.

All splices shall be normal to the top flange and normal to the longitudinal axis of the girder. Field splices shall preferably be located at or near points of dead load contraflexure. The full penetration welds at girder shop splices shall be made without backing.

Field connections shall not be welded, but shall be made with high strength bolts. All full penetration welds shall be ground flush for testing. Slip critical connections shall be made with 3/4 inch, 7/8 inch, or 1 inch diameter ASTM A325 bolts.

Shear connectors shall penetrate at least three inches above the bottom of the slab. The minimum cover from top of deck to top of stud for bare decks shall be 3 inches and for decks with an overlay and membrane shall be 2 inches.

The use of pins and hangers will not be allowed. The Contractor shall avoid Category D or poorer weld details in tension zones subject to fatigue stress ranges. The design life of the Structure for fatigue calculations shall be 75 years.

The location of all Fracture Critical Members (FCMs) shall be clearly delineated on the drawings. The Bridge design notes shall contain the supporting calculations and evaluations as to which members are designated FCMs and why they are so designated. CDOT shall be notified of any new Bridge containing FCMs. The Bridge designer shall provide the half-size copies of the Bridge drawings showing the FCMs and their details. These members and their details shall be highlighted. In addition, the fracture critical form that will be posted in the structure folder shall be obtained from CDOT and filled out with the correct information. This form and the highlighted drawings shall be submitted to CDOT with the rating package for the Bridge.

The Contractor shall follow the Shop Detail Drawing Review/Approval Guidelines developed by the AASHTO/NSBA Steel Bridge Collaboration G1.1-2000 for preparation of steel Shop Drawings.

#### 15.2.3.4.7 Bearings

The Contractor shall design and locate bearings to allow Inspection, maintenance accessibility, and future replacement. Substructure drawings shall show locations for lifting when removing bearings. Elastomeric pads and steel reinforced elastomeric bearings, with or without sliding surfaces, are the preferred bearing types. Sliding surfaces shall be polytetrafloroethylene (PTFE) with a stainless steel mating surface. Bearings shall be either elastomeric pads (CDOT Type I), steel reinforced elastomeric bearings with or without PTFE and stainless steel sliding surfaces (CDOT Type I or Type II), or HLMR bearings (CDOT Type III). The thickness of Type II bearings shall be designed so that the acceptable shear deflection limits of the pad are not exceeded if slip does not occur. The design of elastomeric pads and steel reinforced elastomeric bearings shall be such that pad walk-out will not occur by including pad-walkout restraints. Sole plates shall have a 3/4 inch minimum thickness. At expansion bearings, the edge of the sole plate shall not slide past the edge of the elastomeric pad by the use of a positive stop. The Contactor shall provide at least 3 inches of cover between anchor bolt centerlines and the edge of the concrete pedestal. The Contactor shall provide reinforcement for pedestals greater than 3 inches high. Suppliers of bearings devices shall only be those on CDOT's pre-approved product list. Only one bearing type shall be used across the width of the Bridge at any given Substructure location. Elastomeric pads and steel reinforced elastomeric bearing devices shall not be mixed with HLMR bearings at any one particular Bridge. The maximum bearing height for Type 1 bearings shall be 7 inches. Thermal movements shall be calculated using AASHTO LRFD Bridge Specifications Procedure B. Design of leveling pads for integral Bridges are excluded.

#### 15.2.3.4.8 Piers and Pier Caps

The Contractor shall design a type of pier and pier cap that will be consistent with the I-25 CCSE and according to this Section 15. Drop caps or integral caps are acceptable. Integral caps are preferred with cast-in-place concrete box Superstructures. The Contractor shall minimize the use of integral steel pier caps. Inspection access for integral steel pier caps shall be provided. Aesthetic treatments on piers shall extend below existing grade and be considered for ultimate template as necessary to accommodate future construction. Concrete guardrails shall not be cast monolithically with integral pier caps.

#### 15.2.3.4.9 Abutments

The Contractor shall provide integral, or semi-integral, end diaphragm-type abutments for Bridges whenever possible. The bottom of the abutment cap shall extend a minimum of 18 inches below the bottom of rip rap or slope protection. See CDOT Bridge Design Manual, Section 7.2-Mechanically Stabilized Earth (MSE) walls, which may serve as abutment support for Bridge Superstructure loads and as meeting the requirements of the “Retaining Walls” subsection in this Section 15. Retaining wall

wingwalls may be used in lieu of cantilevered wingwalls at abutments for all categories of Bridges and according to the I-25 CCSE related to Aesthetics and this Section 15. Cantilevered wingwalls and/or retaining walls shall extend 4 feet beyond the point of intersection of the embankment slope with the Roadway finished grade. Bridge monuments shall be supported on separate foundations.

#### 15.2.3.4.10 Slope Protection

The Contractor shall provide slope protection for all slopes under Bridges, and on slopes between tiered walls in accordance with I-25 CCSE. Slope paving only allowed with the Approval of CDOT.

#### 15.2.3.4.11 Foundations

The Contractor shall ensure that differential settlement shall not exceed 1/2 inch within a bent or abutment. Differential settlements between adjacent bents or abutments shall not exceed span length (in feet)/400. The Contractor shall design for down-drag where required. Spread footings are not acceptable at water crossings. Spread footings are acceptable if the bottom of the footing is located below frost heave, scour elevation, and are an Accepted foundation type in the Foundation Design Report to be prepared by the Contractor. Foundations of integral abutments with skews between the axis of the abutment and the direction of allowed movement shall be designed to resist the unbalanced earth pressures behind the abutments.

The Contractor's Quality Management Plan (QMP) shall include Inspection and testing of all drilled caisson operations. Non-destructive testing for non-redundant (single shaft) drilled caissons is required. Cross Sonic Log (CSL) and/or impact echo are acceptable methods of non- destructive testing for drilled caissons; however, CSL testing is required for drill caissons equal or greater than 4-ft in diameter, at single shaft locations, and at river crossings. Additional methods for non-destructive testing, that are in accordance with the AASHTO, ASTM, and FHWA guidelines, may be considered for use on this Project subject review and/or Acceptance of CDOT and incorporation into the Approved QMP.

Dynamic monitoring of driven-pile foundations using the Pile Driving Analyzer (PDA) Tests shall be performed at a minimum of two piles per Structure, each at a separate foundation element (abutment or pier foundation), and at a minimum of 2 percent of driven piles for the Project to Verify pile capacity with appropriate resistance factor meets or exceeds the design factored load per pile. The PDA Tests shall cover pile size, hammer type, and geology condition changes for Structures. The PDA Tests shall include the measurements for initial driving and restrike. The Contractor may replace or supplement PDA Tests with static load Tests for piles. Static load Tests shall be in accordance with ASTM D-1143 or ASTM D-3996. The exact number, type, layout and location of static and PDA Tests will be per the Contractor's QMP, subject to incorporation into the Approved QMP. Static axial load Tests or PDA on driven piles shall be performed in locations where driven piles will be used and the vertical loads will control the depth of the driven piles.

#### 15.2.3.4.12 Drainage and Scour

Bridge deck drainage systems shall be designed in accordance with the FHWA HEC-21, Bridge Deck Drainage Systems. Bridge deck drainage systems are required for Highway Bridges when the flow across expansion joints exceeds 1.0 cubic foot per second (cfs) for the 10-year frequency peak discharge. Spread limits (defined as to the edge of travelled lane) shall be designed to the lesser intensity of the 10-year frequency or four inches per hour. Gutter flow at both ends of Bridges shall be intercepted. Stormwater flowing toward the bridge shall be intercepted prior to the approach slab. Stormwater flowing away from the bridge shall be intercepted prior to leaving the approach slab. This stormwater shall be directed to an appropriate outfall.

All bridge deck drain inlets shall be grated. The bridge deck drainage system shall be compatible with the structural reinforcement, components, and Aesthetics of the Bridge. Outfalls shall be positioned to avoid

corrosion of structural members, and splash on vehicular traffic and pedestrian areas below the bridge. Adequate erosion protection shall be constructed at all outfalls. Downspouts for bridge drains shall be minimum 10-inch diameter hot-dipped galvanized steel pipe, and shall meet the requirements of ASTM A53, Grade B, and Standard Weight Schedule 40. See Book 2, Section 15.2.3.4.12 for more information on Bridge Deck Drainage.

Bridge deck drains shall be located so that downspouts can be taken immediately down pier columns. Bridge drain systems with "horizontal" runs shall not be used. The Bridge deck system shall also comply with requirements listed in Book 2, Section 12.

The Bridge deck drain system shall be designed and constructed to be easily modified to accommodate future changes to the width on the Bridge.

Scour analyses shall be based on the procedures in the FHWA HEC-18, Scour at Bridges, and HEC-20, Stream Stability at Highways. Scour countermeasures shall be designed in accordance with the FHWA HEC-23, Design of Countermeasures.

Approach slab inlets are preferred and should allow for thermal expansion.

#### 15.2.3.4.13 Utilities

The Contractor shall identify, maintain, and coordinate all Utility locations on Structures. Hanging of electrical conduits, telephone conduits, or other Utilities shall not be permitted under deck overhangs or on Bridge rail. Protection of conduits from the settlement of the abutment Backfill shall be provided. Utility placement on Structures shall be by the Approval of CDOT according to requirements of this Section 15. Utilities shall be hidden from view in Superstructure elevation.

#### 15.2.3.4.14 Median

Concrete median barrier supported on the Bridge deck and approach slabs shall be constructed to allow for removal and modification in the future without causing damage to the Bridge deck or approach slab concrete or reinforcement.

#### 15.2.3.4.15 Maintenance Plan

The Contractor shall submit to CDOT, for Acceptance with the final plans and specifications submittal, a maintenance plan for each new and existing Bridge describing Routine Maintenance Activity and items specific to each component of the Bridge. It shall also include a detailed list of all maintenance and rehabilitation Work and the number of times each procedure is anticipated to be performed over the 75-year Bridge life itemized by the year performed. This list shall be the same as that used for life cycle cost analysis provided in accordance with the Contract.

### 15.2.3.5 Bridge Deck Rehabilitation

The existing bridge decks that remain as part of a bridge widening shall be rehabilitated. The Contractor shall remove and dispose of existing deteriorated bridge deck concrete in accordance with Project Special Provisions at the end of this Section.

All Bridge decks and approach slabs shall be protected with an overlay as described in Section 15.2.3.4.5 Overlays. Prior to removal of concrete and placement of the new overlay, the bridge deck shall be sounded by the Contractor in the presence of the Contractor's ICQC Team, Contractor's Engineer, and CDOT for delamination according to ASTM D-4580. All unsound concrete shall be marked, measured, and removed at locations mutually agreed on between the Contractor's Engineer and CDOT. Class 1 removals are permitted only when the thin-bonded overlay (polyester concrete) is used. All damaged or corroded

reinforcing shall be replaced with reinforcing steel (epoxy coated). Removal areas shall be repaired with Concrete Class D, polymer polyester concrete, or approved equal as defined in the Project Specifications. When using polymer polyester concrete for overlay, use Deck Repair worksheet in Reference Drawings. Quantities for the bridge deck rehabilitation have been determined by CDOT and are shown in Table 15-3. Refer to Book 4 drawing Deck Repair Details for additional information. All Bridge deck rehabilitation quantities are to be included in the Work and are to be approved by the Engineer as described in the Project Specifications. Should the actual quantities for bridge deck rehabilitation vary by more than 5% of the quantities shown in Table 15-3, the Contractor shall request a Change Order as defined in Book 1, Section 13. No Change Order will be allowed for any overlay quantities, regardless of type.

**Table 15-3 Bridge Deck Rehabilitation Estimated Quantities**

| Item No. | Description | Unit | Quantity when using Polymer Polyester Concrete as overlay |
|---|---|---|---|
| 202-00450 | Removal of Portions of Present Structure (Class 1) | Square Yard | 156 |
| 202-00453 | Removal of Portions of Present Structure (Class 2) | Square Yard | 35 |
| 202-00460 | Removal of Portions of Present Structure (Class 3) | Square Yard | 5 |
| 601-03040 | Concrete Class D (Bridge) | Cubic Yard | 8 |
| 601-51005 | Galvanic Anodes | Each | 32 |
| 602-00020 | Reinforcing Steel (Epoxy Coated) | Pounds | 800 |

### 15.2.3.6 Removal of Bridges or Structures

A removal report/plan for each Bridge or Structure to be removed, or partially removed, shall be submitted to CDOT for review, a minimum of fourteen (14) days before removal operations begin. The report/plan shall describe methods of removal, Equipment to be used, and sequence of removal. The report/plan shall document any structural analysis that was done for different stages of removal and explain whether or not any portion of the Bridge or Structure will remain over traffic during the different stages of removal. The report/plan shall describe any areas of concern for worker safety. The report/plan shall also describe the length of time for the removal, anticipated Roadway closures and proposed detours, the estimated total number of worker shifts, effects of removal on pedestrians, bicycle, and traffic, locations where removed Bridge Material will be temporarily stockpiled, and requirements for disposing of removed Material including any Material painted with lead-based paint.

The Contractor shall be responsible for Verifying existing Structure surveys and as-built plans prior to design of removals, rehabilitations, or widenings. The Contractor shall be responsible for adjusting its designs to accommodate any variances identified in the field relative to the survey and as-built information provided.

A removal report/plan shall also be submitted to CDOT for review, a minimum of fourteen (14) days before removal operations begin for removal, of retaining walls supporting or adjacent to traffic or pedestrian activities, sound walls, overhead sign Structures and traffic signals on the Project.

Bridge removal shall consist of the complete removal (or partial removal as shown on plans) of all existing Superstructures and Substructures prior to construction of new Bridges as further described in the Standard Specifications and this Section 15.

The Contractor shall schedule a pre-removal meeting at least ten (10) days prior to removal operations. The meeting shall be coordinated with the Project Director and include CDOT representatives from Traffic, Safety, Public Involvement, and Staff Bridge.

## 15.2.4. Box Culverts

### 15.2.4.1 New and Existing Box Culverts

New and existing box culverts and drainage facilities within the Project design shall be constructed and/or extended as needed to satisfy new Project geometrics. Anticipated box culverts requiring extension as well as new box culverts are listed in Section 15.0.

A 3-strand cable fence shall be provided at the top of all culvert ends greater than 4-feet of exposed height. The 3-strand cable fence shall be designed and constructed in accordance with the Project Special Provision – Revision of 607 Fence (Special) at the end of this section.

### 15.2.4.2 Design and Rating

New or extended box culverts, replacements, extensions, strengthening of existing box culverts, headwalls, and wingwalls shall meet all requirements of the Project. CDOT's M-Standards shall be used. Box culverts not covered in the CDOT M-Standards shall be designed in accordance with AASHTO LRFD Bridge Design Specifications, CDOT's Bridge Design Manual, and CDOT's Drainage Design Manual. All major and minor box culverts, new and reuse of existing, shall be load rated, documented and submitted to CDOT for review and Approval.

### 15.2.4.3 Maintenance Plan

The Contractor shall provide to CDOT, for review with the final plans and specifications submittal, a maintenance plan for each box culvert Structure type used. This plan shall describe Routine Maintenance Activity and items specific to each component of the specific Structure type. It shall also include a detailed list of all maintenance and rehabilitation Work and the number of times each procedure is anticipated to be performed over the 75-year Structure life, itemized by the year performed.

## 15.2.5. Retaining Walls

### 15.2.5.1 Retaining Wall locations

Preliminary permanent retaining wall locations have been identified on the Roadway plan Reference Drawings. Final retaining wall types and sizes will be determined by the Contractor and shall be designed and constructed with the requirements in Section 15.0 - Structures. See table 15-4 for wall location, approximate length, and general description.

**Table 15-4 List of Proposed Walls**

| Milepost | Approximate Length | Description |
|---|---|---|
| 255.25 | 300 | Cut wall along SH 402 SB Off-Ramp |
| 262.190 | 250 | Fill wall along NB Off-ramp |
| 262.298 | 350 | Cut wall at East Abutment |
| 265.679 | 300 | Fill wall along NB Shoulder, south of the I-25 over Poudre River Bridge |
| 265.900 | 300 | Fill wall along NB Shoulder, north of the I-25 over Poudre River Bridge |

The following criteria shall apply to permanent wall Structures. Walls that support traffic for interim phases of traffic which are left in place and become part of the final Structure shall be considered permanent walls and designed and constructed as such. The first and second phases of two-phase walls shall be considered part of a permanent wall and shall be designed and constructed as such. The Contractor shall have sole responsibility for the type, Material, performance, and safety of temporary retaining wall Structures.

### 15.2.5.2 Geometry

The retaining wall layout shall address slope maintenance above and below the wall and provide returns into the retained fill or cut at retaining wall ends. Final tolerances shall be 1 to 200 for level and plumb. Any residual wall batter shall be into the fill. Where 12 feet (minimum) of generally level terrain is not available between the wall and the ROW line for maintenance access, the wall shall be located a minimum of 10 feet inside the ROW line.

Design and construction shall consider surface and subsurface drainage. Walls which support soil and loads from outside ROW, and are built with MSE soil reinforcements, shall require an appropriate setback from ROW line for the construction of the wall system. A system shall be provided to intercept or prevent surface water from entering behind walls. Lengths of wall without relief joints shall be limited to lengths which control the differential settlement. Walls over 30 inches high may require a fence or barrier at the top of the wall meeting current AASHTO and OSHA requirements.

### 15.2.5.3 Type

Metal walls, including bin and sheet pile walls, recycled Material walls, Mechanically Stabilized Earth (MSE) (Block) walls, and timber walls shall not be permitted for permanent retaining walls. Wall types, selected by the Contractor, shall have been used successfully in similar geotechnical locations and environmental conditions.

### 15.2.5.4 Design Requirements

All permanent retaining walls and their associated structural support elements, constructed for the Project, shall be designed to resist corrosion or deterioration for a minimum service life of 75 years. Fencing on walls shall satisfy OSHA, and/or CDOT maintenance requirements. Outlets for Backfill drainage for any retaining wall type shall be shown on the plans.

Mechanically Stabilized Earth (MSE) walls shall be designed in accordance with the requirements of AASHTO LRFD Bridge Design Specifications. Global stability, overturning, sliding, and settlement calculations shall be performed on all retaining wall systems. MSE wall designs integrated with the abutments shall also address thermal movement of the Bridge and approach settlement. All retaining wall installations shall provide for a positive drainage system of the Backfill. The design of MSE walls near or in bodies of water shall account for soft saturated soils and scour and shall prevent fine washout between facing elements. MSE walls may be used in scour areas provided that the foundation of the wall is located below the scour level. In addition the wall shall be designed for hydrostatic pressure or be constructed using a free draining Material to account for water fluctuations including rapid drawdown after flooding conditions to prevent failure.

All walls near irrigation lines for landscaping shall account for any additional hydrostatic load due to a waterline break. The Contractor may consider the use of free draining Backfill Material and/or leak detection devices to reduce hydrostatic loads on retaining walls. Retaining walls shall be designed according to the seismic criteria from AASHTO LRFD Bridge Design Specifications.

Temporary retaining walls (constructed of Materials not allowed for permanent walls) may be abandoned and left in place. Temporary retaining walls left in place must be completely covered by soil or construction Material so they are not visible. Structural components of temporary retaining walls may be reused as part of permanent retaining wall (two-phase walls) systems, provided all of the structural support elements and Materials of the permanent retaining walls meet the requirements of this Section 15.

### 15.2.5.5 Characteristics

15.2.5.5.1 Mechanically Stabilized Earth (MSE) (Panel) Walls

Wall panels shall be constructed of reinforced concrete and provide corrosion protection for prestressing or post-tensioning steel. The cover to reinforcing steel shall be a minimum of 2 inches. Wall panels exposed to splash from traffic shall use epoxy coated reinforcing steel. Panel joints shall accommodate differential settlement per AASHTO LRFD Bridge Design Specifications.

A technical representative shall be at the job site, as required by the Project Specifications in Book 2 Section 20, to assist the Contractor with the Approved Quality Management Plan. The Contractor shall use the latest FHWA geotechnical references and guidelines in conformance with the Contract, as provided at the following website: http://www.fhwa.dot.gov/engineering/geotech/index.cfm, including the FHWA Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes - Volumes I and II.

A barrier shall be provided to prevent fine washout between horizontal and vertical facing panel joints, panel wall construction joints, or relief joints.

15.2.5.5.2 Mechanically Stabilized Earth (MSE) (Block) Walls

MSE Block type walls shall not be allowed for use on this Project.

15.2.5.5.3 Cast-in-Place Walls

Cast-in-place walls shall be designed and constructed in accordance with AASHTO LRFD Bridge Design Specifications. Construction joint spacing shall accommodate or limit differential settlement. Foundations shall be designed per the geotechnical design requirements and recommendations.

15.2.5.5.4 Anchored Walls

Design and construction shall use FHWA DP-90-068, FHWA RD-82-046, FHWA RD-82-047, "*Design Manual for Permanent Ground Anchor Walls*" FHWA RD-97-130, "Geo*technical Engineering Circular No. 4 - Ground Anchors and Anchored Systems*" FHWA IF-99-015 as guidelines. Anchors shall be encapsulated with plastic sheathing. Proof load Tests for anchors shall be provided in accordance with the above FHWA guidelines.

15.2.5.5.5 Soil Nail Walls

Soil nail walls may only be used when top-down construction is warranted. Soil nail walls shall not be used if ground water seepage will occur. Design and construction shall use FHWA-RD- 89-93, "*Soil Nailing Field Inspectors Manual*" FHWA SA-93-068, "Manual for the Design & Construction Monitoring of Soil Nail Walls" FHWA SA-96-069R, and "Geotechnical Engineering Circular No. 7 - Soil Nail Walls" FHWA IF-03-017. Load testing for nails shall be provided in accordance with the above FHWA guidelines. The exposed surface of pneumatically placed concrete shall meet the Aesthetic requirements of the I-25 CCSE and this Section 15.

15.2.5.5.6 Structural Diaphragm Walls

Structural diaphragm walls may be used when top-down construction is warranted

15.2.5.5.7 Soil Reinforcement

Soil reinforcement for MSE and modular walls shall be galvanized (or epoxy) coated steel, geogrids, or fabrics meeting creep requirements of AASHTO *LRFD Bridge Specifications*. The design shall account for any items projecting through the soil reinforcement. The Contractor shall avoid placing culverts and Utilities perpendicular to soil reinforcement within the reinforced soil mass. Metal portions of soil reinforcement shall be protected from corrosion due to stray electrical currents.

### 15.2.5.6 Retaining Wall Aesthetics

All wall facing shall be of a consistent type (i.e. cast-in- place, precast facing, etc.) within any section of Road, interchange, and single viewshed. This includes surface treatment, pattern, texture, color, and jointing layout. The proposed walls at SH 392 shall match the existing walls at the interchange in type, surface treatment, pattern, texture, color, and jointing layout. An overall negative batter (wall face leaning outward away from fill) between the bottom and the top of the wall is not allowed. Wall facing shall be installed vertically (plus or minus 1/2 inch in 10 feet or as defined in the CDOT Bridge Structure Worksheets for MSE walls) and shall be capped with a cast-in- place or precast concrete cap. Wall facing and cap shall be colored with pigmented sealer.

The Contractor shall produce and submit to CDOT a visual graphic of each retaining wall to demonstrate Aesthetic conformance to the I-25 CCES in Book 3 and requirements in this Section 15. This graphic shall be submitted in both hard and electronic format. In all cases, proposed retaining wall Aesthetics graphics shall include all visible surfaces and slope protection and submitted to CDOT for Approval with the Contractor's proposed General Layout Drawings of each Structure. This submittal shall include drawings illustrating form, texture, and color. As part of the submittal, the Contractor shall provide full-size mockups (10 ft. x 10 ft. minimum) for all surface treatments for texture, color, and quality for Approval by CDOT. For Project consistency, retaining walls within a common viewshed shall incorporate similar visual Aesthetics. Retaining walls for parallel Bridges shall have similar Structure types and Aesthetic treatments.

All Structures with visible concrete surfaces, including those accessible by graffiti vandals, shall have a surface treatment of structural concrete staining. This includes all retaining walls, noise walls, Bridge abutments and piers, Roadway and Bridge barriers, and slope protection.

## 15.2.6. Noise Walls

Noise walls, if required, shall be designed and constructed in accordance with the AASHTO *LRFD Bridge Design Specifications*. Walls within clear zone shall be protected by traffic barrier without collision loads. . Final tolerances shall be 1/8 inch in 1 foot for level and plumb. The design of noise walls shall provide for adequate surface drainage. Noise walls within clear zone shall be designed per AASHTO LRFD Bridge Design Specifications Section 15.8.4 Case 4. When the installation of a noise wall interferes with the access to existing, or proposed fire hydrants, the noise wall installation shall include fire hose access openings and associated identification signs. Location and demand for these openings shall be established in cooperation with the local fire department. Preliminary length and height of the noise wall is shown in NEPA approval documents and shall be confirmed by the Contractor.

### 15.2.6.1 Geometry

When placed behind guardrail, noise walls shall be offset according to applicable standards for that particular guardrail. The Contractor shall place noise walls on top of concrete guardrail when offset space is limited to 10 ft. or less.

### 15.2.6.2 Components

15.2.6.2.1 Panels

Panels shall be constructed of cast-in-place or precast concrete. Panels on Bridges shall be cast-in-place concrete and jointed from longitudinal structural elements of the Bridge. Panel design and construction shall consider ease of replacement and/or repair, and shall limit the risk from falling debris resulting from traffic impacting with the noise wall.

15.2.6.2.2 Posts

Posts shall be reinforced concrete or prestressed concrete.

15.2.6.2.3 Foundations

Foundations shall be posts set in concrete, flowfill, caissons, cast-in-place, or precast reinforced concrete footings. The bottom of all spread footing foundations shall be placed a minimum of 3 feet below finished grade. Reinforcing steel projecting into the above ground portion of walls, subject to splash from the Roadway (areas within 10 feet horizontally of the edge of travel lane), shall be epoxy-coated.

### 15.2.6.3 Noise Wall Aesthetics

All noise walls throughout this Project shall comply with retaining wall aesthetics I-25 CCSE in Book 3 and requirements in this Section 15.

## 15.2.7. Sign Structures

Major sign Structures and supports for Intelligent Transportation System (ITS) Equipment shall be designed and constructed in accordance with AASHTO LRFD *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, 1st Edition with current Interim Revisions. The Contractor shall provide minimum vertical clearances in accordance with the above specified AASHTO requirements and loadings shall consider natural period of vibration from vortex shedding and upward wind pressures from passing trucks. Sign Structures shall be galvanized structural steel (single) tubing, painted in accordance with the I-25 CCSE requirements in Book 4. Draft structural worksheets for single-tube sign supports are available from CDOT. The Contractor shall not mount major sign supports (cantilevered signs, sign bridges, etc.) on MSE retaining walls. Sign Structures shall comply with Section 14.

Variable Message Signs (VMSs) shall be mounted on a sign Structure in accordance CDOT S Standard 614-60. The Contractor shall prepare a structural design for each VMS cabinet and bracket in accordance with the submittals for major Structures as defined in the current CDOT Bridge Design manual and Section 15.

Minor sign Structures and supports shall be constructed in accordance with CDOT *M&S Standard Plans*.

### 15.2.7.1 Components

15.2.7.1.1 Foundations

Drilled caissons shall be used to support overhead and cantilever sign Structures as well as ground mounted VMS Structures. The Contractor shall prepare one general Project foundation report for all sign Structures and shall have one foundation boring within 10 feet of each single caisson supporting large sign supports.

15.2.7.1.2 Connections

Connections shall be made with high strength A325 bolts. Shop splices shall be made with full penetration butt welds. Base connections shall be made with full penetration shop butt welds. All sign connection hardware shall be galvanized with strengthened structural tubing at electrical connection openings.

15.2.7.1.3 Bridge Mounted Signs

The Contractor shall not mount signs or brackets on Bridge Superstructures.

## 15.2.8. Pedestrian Bridges

No Pedestrian Bridges are anticipated for this Project.

## 15.2.9. Tunnels

No Tunnels are anticipated for this Project.

## 15.2.10. Submittals and Reviews

### 15.2.10.1 Preliminary Design Plans (30%)

The Contractor shall submit Preliminary Design Plans (30%) for all major Structures, proposed walls, and box culverts prior to proceeding to final design and preparation of the Final RFC Documents. The Preliminary Design Plans will include Structural Concept Plans, Structural Concept Reports, Life Cycle Cost Analysis, and Preliminary Foundation Investigation Reports.

15.2.10.1.1 Structural Concept Plans

Structural Concept Plans shall consist of General Layout Drawings of all proposed major Structures, walls and box culverts. Bridge plans shall be consistent with the detail requirements for General Layout Drawings as defined by the current CDOT Bridge Detail Manual. For all retaining walls, sound walls, and box culverts the General Layout Drawings shall provide plan, elevation, and typical section details similar to those provided for Bridges.

15.2.10.1.2 Structure Concept Reports

Structure Concept Reports shall consist of a three-page description of the Structure type, Materials, foundation types, methods of accommodating differential settlement, design strategy for lateral loads, and design-life considerations for each proposed Structure. The reports shall include a description of creative or innovative ways the design, construction, and/or choice of structural types will benefit and/or enhance schedule, quality, and cost aspects of the Project and minimize traffic impacts. Provide a list of transportation authorities, actual projects and references for all Bridges, foundation types and retaining wall type not historically used by CDOT. Additional information provided for non-historic Structures will not count toward the page limit. All non-historic Structures will require CDOT Approval prior to proceeding with final design and preparation of the Final RFC Documents. This requirement supersedes the review designations for other Preliminary Design Plans elements.

15.2.10.1.3 Life Cycle Cost Analysis

The Contractor shall submit a 75-year life cycle cost analysis for each proposed Bridge type. The analysis shall clearly state and justify (using historical data) the assumptions used in determining life cycle costs.

Include construction cost and costs for scheduled maintenance and repair. The Contractor shall not include Routine Maintenance Activity (sweeping, cleaning, graffiti, removal, etc.) or demolition and salvage at the end of the 75 years. Maintenance and repair costs shall include Material and labor plus an additional 10 percent for traffic control if required for the Work. Items of maintenance and repair shall include, but not

be limited to, steel painting, decks, railings, overlays, joints, bearings and drainage systems. The Contractor shall use a 5 percent discount rate and user cost of $10.00 per vehicle-hour of delay at year one. The Contractor shall use the present worth method to develop a present total Bridge cost. Life cycle cost analysis shall be based on methods and procedures developed by the National Institute of Standards and Technology (NIST) Bridge LLC or the National Cooperative Highway Research Project (NCHRP) 12-43 Life-Cycle Cost Analysis for Bridges.

#### 15.2.10.1.4 Preliminary Foundation Investigation Report

The Contractor shall submit a Preliminary Foundation Investigation Report for each major Structure and minor Structures as required for the design of foundations for Bridges, retaining walls, noise walls, and other Structures. The report will be in draft form and contain design recommendations and substantiating analysis for foundation elements, lateral earth load parameters, soil corrosivity analysis, seismic design parameters, and any other geotechnical design or analysis parameters necessary to complete the design.

### 15.2.10.2 Pre-Released for Construction (RFC) Review Documents

The Contractor shall submit Released for Construction (RFC) Review Documents for all Structures for review prior to the submittal of the Final RFC Documents. Documents which are required for this submittal include plans and specifications for all Structures, maintenance plans for Bridges and box culverts, Bridge and box culvert load ratings, and foundation investigation reports. Project Aesthetic details shall have been incorporated into the plans. The foundation investigation reports shall be revised from the Preliminary Foundation Investigation Reports and be the basis for the load analysis from seismic and earth loads and the basis for the design of foundation elements. Additional soil borings required for the structural design shall have been completed.

### 15.2.10.3 Final RFC Documents

Upon completion of the comment resolution process identified by the Contractor's Approved QMP resulting from the Pre-Released for Construction (RFC) Review Documents submittal, the Contractor shall submit Final RFC Documents for Acceptance. The Final RFC Documents shall include resubmittal of all elements provided in the Pre-Released for Construction (RFC) Review Documents submittal with all comments addressed as outlined in the QMP. The Final RFC Documents shall include final plans and specifications for all Structures, design calculations and independent design calculations for all major Structures as defined by the current CDOT Bridge Design Manual, independent detail checks of the plans and specifications for major Structures as defined by the current CDOT Bridge Design Manual, maintenance plans for Bridges and box culverts, Bridge and box culvert load ratings, foundation investigation reports, and final submittal letter.

#### 15.2.10.3.1 Final Plans and Specifications for Structures

The final plans and specifications for each Structure shall be signed and sealed by the Contractor's designer in accordance with laws for registration of Professional Engineers in the State of Colorado. Copies in PDF and MicroStation or compatible electronic format shall be made of all plans for all Structures on the Project and submitted to CDOT on computer disk (CD or DVD) or other approved format.

#### 15.2.10.3.2 Design and Independent Design Calculations

The design calculations and independent design check calculations shall be signed and sealed by the Contractor's designer in accordance with laws for registration of Professional Engineers in the State of Colorado. The design calculations or the independent calculations shall be prepared by, signed and sealed by a Professional Engineer in the State of Colorado with a minimum of 10 years Bridge design experience. Copies in PDF and electronic format shall be made of all design and design-check calculations for the Project and submitted to CDOT in electronic format. All calculations shall identify which code is utilized, and reference

the appropriate section in the right-hand column. References shall be included in the calculations to computer programs used to do the calculations. Computer documentation shall include the name of program, vendor, version, and release date; record of software output and verification of output with manual calculations or other recognized program; clear identification of input and output values and meaning; and check of input.

15.2.10.3.3 Bridge and Box Culvert Maintenance Plans

The Contractor shall submit for Approval maintenance plans for all Bridge and box culvert Structures as described in Section 15. This requirement supersedes the Acceptance designations for other Final RFC Documents elements.

15.2.10.3.4 Bridge and Box Culvert Ratings

A Rating Package as defined by the current CDOT Bridge Rating Manual shall be completed and submitted for each Bridge and box culvert as described in Section 15.

15.2.10.3.5 Foundation Investigation Reports

The foundation investigation reports shall be signed and sealed by the Contractor's designer in accordance with laws for registration of Professional Engineers in the State of Colorado.

15.2.10.3.6 Final Submittal Letter

The Contractor's designer shall submit a letter to CDOT certifying that all Structural plans and specifications have been prepared in accordance with the current design standards of CDOT.

### 15.2.10.4 As-Built, Falsework, Shoring, and Shop Drawing Plans

Falsework and shoring plans shall be signed and sealed by a Professional Engineer licensed in the State of Colorado. Shop Drawings and Working Drawings shall be reviewed and approved by the Contractor's structural design Engineer. The Contractor shall submit As-Built Documents with Shop Drawings and Working Drawings for each Structure in accordance with the Contract Documents. The Contractor shall seal Shop Drawings in accordance with Table 105-1 of the CDOT Standard Specifications. Copies in PDF format shall be made of all As-Built and Shop Drawings, and Working Drawings for all Structures on the Project and submitted to CDOT in electronic format.

The Contractor shall follow the Shop Detail Drawing Review/Approval Guidelines developed by the AASHTO/NSBA Steel Bridge Collaboration G1.1-1999 for preparation of steel Shop Drawings.

The Contractor is solely responsible for Shop Drawing accuracy. Shop Drawings shall be submitted in electronic format to CDOT for information only.

### 15.2.10.5 Construction Requirements

CDOT shall be notified 7 days in advance of reductions in vertical clearances or when lane closures, lane reductions, or lane width restrictions are put into effect.

Bridge deck and approach slab surface smoothness shall not deviate more than 3/8 inch in 25 feet as described in the Standard Specifications.

A technical representative shall be at the job site, as required by the Project Specifications in Book 2 Section 20, to assist the Contractor with the Approved Quality Management Plan. The representative shall maintain a construction diary and sign-off on all Hold Points as defined in the Contractor's Approved Quality Management Plan. The diary shall be submitted with the Final Design Documents

## 15.3 Deliverables

At a minimum, the Contractor shall submit the following to CDOT for review, Approval, or Acceptance:

**Table 15-5 Deliverables**

| Deliverable | Review, Acceptance, or Approval | Schedule |
|---|---|---|
| Alternative Bridge Rating Software | Approval | Prior to the preparation of Bridge or Box Culvert Ratings |
| Supplemental Geotechnical Investigation Reports | Acceptance | 30 days following completion of field work |
| Structure Concept Reports for Non-historically used Structures | Approval | As part of the Preliminary Design Plans (30%) Package Submittal |
| Bridge widening girders which are shallower than existing girders | Approval | Prior to initiation of design |
| Refinements to the Project Aesthetic Plan | Acceptance | Prior to associated Structure submittals |
| Visual Graphic of each retaining wall | Approval | Prior to the Preliminary Design Plans (30%) Submittal |
| Structural Concept Report | Acceptance | As part of the Preliminary Design Plans (30%) Package Submittal |
| Preliminary Foundation Investigation Report | Acceptance | With the Preliminary Design Plans (30%) Package for each Structure or noise wall for the Project |
| Pre-Released For Construction Review Documents | Review | Prior to submittal of Final RFC Documents |
| Final Plans and Specifications Package | Acceptance | As part of Final RFC Documents submittal |
| Design and independent design calculations | Acceptance | As part of Final RFC Documents submittal |
| Bridge and box culvert Maintenance plan | Approval | As part of Final RFC Documents submittal |
| Bridge and box culvert load rating (including BrR import files) | Acceptance | As part of Final RFC Documents submittal |
| Foundation Investigation Reports | Acceptance | As part of Final RFC Documents submittal |
| Final Submittal Letter | Acceptance | As part of Final RFC Documents submittal |
| Location of access holes/doors | Approval | 30 days prior to fabrication |
| Concrete mix design and procedures | Acceptance | At least 3 weeks prior to the anticipated concrete placement date |
| Utilities supported by Structures | Approval | 30 days prior to construction |
| Falsework or Shoring plans carrying live traffic | Acceptance | 10 days prior to construction. |
| Bridge/other Structure removal report/plan | Review | 14 days prior to removal operations begin |
| Additional non-destructive methods for testing drilled caissons | Acceptance | As required, for construction of drilled caissons |

| Deliverable | Review, Acceptance, or Approval | Schedule |
|---|---|---|
| As-Built Documents with Shop Drawings and Working Drawings | Acceptance | Prior to final Inspection of the Work |

## 15.4 Project Special Provisions

**REVISION OF SECTION 107**
**PERFORMANCE OF SAFETY CRITICAL WORK**

Section 107 of the Standard Specifications is hereby revised as follows:

Add subsection 107.061 immediately following subsection 107.06 as follows:

107.061 Performance of Safety Critical Work. The following work elements are considered safety critical work for this project:

(1) Overhead girder erection

(2) Removal of Bridges

(3) Work requiring the use of cranes or other heavy lifting equipment to set a girder, to make overhead repairs, or includes special provisions for Removal of Bridge or Removal of Portion of Bridge. Also when construction materials are being lifted that may fall onto active traffic lanes.

The Contractor shall submit, for record purposes only, an initial detailed construction plan that addresses safe construction of each of the safety critical elements. When the specifications already require an erection plan, a bridge removal plan, or a removal of portion of bridge plan, it shall be included as a part of this plan. The detailed construction plan shall be submitted two weeks prior to the safety critical element conference described below. The construction plan shall be stamped “Approved for Construction” and signed by the Contractor. The construction plan will not be approved by the Engineer.

The Construction Plan shall include the following:

(1) Safety Critical Element for which the plan is being prepared and submitted.

(2) Contractor or subcontractor responsible for the plan preparation and the work.

(3) Schedule, procedures, equipment, and sequence of operations, that comply with the working hour limitations.

(4) Temporary works required: falsework, bracing, shoring, etc.

(5) Additional actions that will be taken to ensure that the work will be performed safely.

(6) Names and qualifications of workers who will be in responsible charge of the work:

A. Years of experience performing similar work

B. Training taken in performing similar work

C. Certifications earned in performing similar work

(7) Names and qualifications of workers operating cranes or other lifting equipment

A. Years of experience performing similar work

**-2-**
**REVISION OF SECTION 107**
**PERFORMANCE OF SAFETY CRITICAL WORK**

B. Training taken in performing similar work

C. Certifications earned in performing similar work

(8) The construction plan shall address how the Contractor will handle contingencies such as:

A. Unplanned events (storms, traffic accidents, etc.)

B. Structural elements that don't fit or line up

C. Work that cannot be completed in time for the roadway to be reopened to traffic

D. Replacement of workers who don't perform the work safely

E. Equipment failure

F. Other potential difficulties inherent in the type of work being performed

Name and qualifications of Contractor's person designated to determine and notify the Engineer in writing when it is safe to open a route to traffic after it has been closed for safety critical work.

(9) Erection plan or bridge removal plan when submitted as required elsewhere by the specifications. Plan requirements that overlap with above requirements may be submitted only once.

A safety critical element conference shall be held two weeks prior to beginning construction on each safety critical element. The Engineer, the Contractor, the safety critical element subcontractors, and the Contractor's Engineer shall attend the conference. Required pre-erection conferences or bridge removal conferences may be included as a part of this conference.

After the safety critical element conference, and prior to beginning work on the safety critical element, the Contractor shall submit a final construction plan to the Engineer for record purposes only. The Contractor's Engineer shall sign and seal temporary works, such as falsework, shoring etc., related to construction plans for the safety critical element (1) Overhead girder erection; (2) Removal of Bridge. The final construction plan shall be stamped "Approved for Construction" and signed by the Contractor.

The Contractor shall perform safety critical work only when the Engineer is on the project site. The Contractor's Engineer shall be on site to inspect and provide written approval of safety critical work for which he provided signed and sealed construction details. Unless otherwise directed or approved, the Contractor's Engineer need not be on site during the actual performance of safety critical work, but shall be present to conduct inspection for written approval of the safety critical work.

When ordered by the Engineer, the Contractor shall immediately stop safety critical work that is being performed in an unsafe manner or will result in an unsafe situation for the traveling public. Prior to stopping work, the Contractor shall make the situation safe for work stoppage. The Contractor shall submit an acceptable plan to correct the unsafe process before the Engineer will authorize resumption of the work.

**-3-**

## REVISION OF SECTION 107
## PERFORMANCE OF SAFETY CRITICAL WORK

When ordered by the Engineer, the Contractor shall remove workers from the project that are performing the safety critical work in a manner that creates an unsafe situation for the public in accordance with subsection 108.05.

Should an unplanned event occur or the safety critical operation deviate from the submitted plan, the Contractor shall immediately cease operations on the safety critical element, except for performing any work necessary to ensure worksite safety, and provide proper protection of the work and the traveling public. If the Contractor intends to modify the submitted plan, he shall submit a revised plan to the Engineer prior to resuming operations.

All costs associated with the preparation and implementation of each safety critical element construction plan will not be measured and paid for separately, but shall be included in the work.

Nothing in the section shall be construed to relieve the Contractor from ultimate liability for unsafe or negligent acts or to be a waiver of the Colorado Governmental Immunity Act on behalf of the Department.

## REVISION OF SECTION 202
## REMOVAL OF PORTIONS OF PRESENT STRUCTURE

Section 202 of the Standard Specifications is hereby revised for this project as follows:

### DESCRIPTION

This work consists of removal of the existing concrete box culverts, concrete box culvert wingwalls, bridge approach slabs and sleeper slabs.

### CONSTRUCTION REQUIREMENTS

The existing bridge, and guard rail, to remain shall be prepared to fit the new construction, and shall be protected from damage. All damage shall be repaired immediately at the Contractor's expense. The method of repair shall be approved by the Engineer.

Removal shall include the concrete box culverts, approach slabs and sleeper slabs. All materials removed from the existing structures shall become the property of the Contractor and shall be properly disposed of off-site at the Contractor's expense.

Existing box culverts and wingwalls shall be removed as required in order to allow for the proposed work as shown on the plans. If additional removal of unsound concrete is required, it shall be included in the work. Blasting or the use of explosives will not be allowed.

Reinforcing steel shall be removed to a minimum of one inch inside the existing structure.

The Contractor shall submit the following to the Engineer for review two weeks prior to beginning removal:

- Details of any required falsework.
- Details of the proposed operations showing the methods, sequence and equipment to be used.
- Permanent disposal location for removed materials.

Specific details of the partial removal operations will be left to the Contractor; however, times, methods, and details of removal shall be provided to the Engineer prior to commencement of the work. The Contractor shall be fully responsible for completing the work safely. The Contractor shall remove the existing structure components in such sequence and by such methods that will maintain the stability of members until all members have been removed. The Contractor shall provide adequate temporary falsework, if and where necessary, to maintain the stability of the structures under all conditions.

Subsection 202.11 shall include the following:

Removal of portions of present structure will be measured by the area in square yards, completed to the required depth, and accepted.

## REVISION OF SECTION 202
## REMOVAL OF BRIDGE

Section 202 of the Standard Specifications is hereby revised for this project as follows:

Subsection 202.01 shall include the following:

This work consists of removal of the existing bridges. Bridge removal shall consist of the complete removal of all Superstructure and Substructure elements unless otherwise shown on the plans.

Subsection 202.02 shall include the following:

The removal of the existing bridge shall be performed in a safe manner.

When removal operations are located in proximity to any live water way , additional coordination with other agencies, (United States Army Corps of Engineers (USACE), US Fish and Wildlife Service, US Forest Service, etc.) shall be required.

The Contractor shall submit a Bridge Removal Plan to the Engineer, for record purposes only, at least 20 working days prior to the proposed start of removal operations. This Plan shall detail procedures, sequences, and all features required to perform the removal in a safe and controlled manner. The Bridge Removal Plan shall be stamped “Approved for Construction” and signed by the Contractor. The Bridge Removal Plan will not be approved by the Engineer.

The Bridge Removal Plan shall provide complete details of the bridge removal process, including:

(1) The removal sequence, including staging of removal operations. Sequence of operation shall include a detailed schedule that complies with the working hour limitations.

(2) Equipment descriptions including size, number, type, capacity, and location of equipment during removal operations.

(3) Shoring that exceeds 5 feet in height, all falsework and bracing.

(4) Details, locations and types of protective coverings to be used. The protective covering shall prevent any materials, equipment or debris from falling onto the property below. When removal operations are located over or in proximity to any live waterway, railroad, or pedestrian/bicycle path, additional width of protective covering sufficient to protect these facilities shall be required. Detailed methods for protection of the existing roadway facilities, including measures to assure that people, property, utilities, and improvements will not be endangered.

(5) Detailed methods for protection of live waterways including minimization of turbidity and sedimentation, and protection of existing wetlands.

(6) Detailed methods for mitigation of fugitive dust resulting from the demolition.

(7) Details for dismantling, removing, loading, and hauling steel elements.

(8) Methods of Handling Traffic, including bicycles and pedestrians, in a safe and controlled manner.

A Pre-Removal Conference shall be held at least seven days prior to the beginning of removal of the bridge. The Engineer, the Contractor, the removal subcontractor, the Contractor’s Engineer, and the

**-2-**
**REVISION OF SECTION 202**
**REMOVAL OF BRIDGE**

Traffic Control Supervisor (TCS) shall attend the Pre-Removal Conference. The Bridge Removal Plan shall be finalized at this Conference.

The Contractor's Engineer shall sign and seal (1) and (3) listed above in the final Bridge Removal Plan.

Calculations shall be adequate to demonstrate the stability of the structure remaining after the end of each stage of removal, before traffic is allowed to resume in its normal configuration.

The final Bridge Removal Plan shall be stamped "Approved for Construction" and signed by the Contractor. The Contractor shall submit a final Bridge Removal Plan to the Engineer prior to bridge removal for record purposes only. The Contractor shall not begin the removal process without the Engineer's written authorization.

Submittal of the final Bridge Removal Plan to the Engineer, and field inspection performed by the Engineer, will in no way relieve the Contractor and the Contractor's Engineer of full responsibility for the removal plan and procedures.

Unless otherwise directed, the Contractor's Engineer need not be on site when bridge removal operations are in progress, but shall be present to conduct daily inspection for written approval of the work. The Contractor's Engineer shall inspect and provide written approval of each phase of the removal prior to allowing vehicles or pedestrians on, below, or adjacent to the structure.

The Contractor's Engineer shall certify in writing that the falsework, bracing, and shoring conform to the details of the final Bridge Removal Plan. A copy of the certification shall be submitted to the Engineer.

The Contractor's Engineer shall inspect the bridge removal site and report in writing on a daily basis the progress of the operation and the status of the remaining structure. A copy of this daily report shall be available at the site of the work at all times, and a copy of the previous day's inspection report shall submitted to the Engineer daily.

The Contractor shall have all necessary workers, materials, and equipment at the site prior to closing any lanes to traffic to accommodate bridge removal operations. While the lanes are closed to public traffic, work shall be pursued promptly and without interruption until the roadway is reopened to traffic.

Removal of hazardous material shall be in accordance with Section 250.

The Contractor shall take all steps to avoid contaminating state waters, in accordance with subsection 107.25.

Should an unplanned event occur or the bridge removal operation deviate from the submitted bridge removal plan, the bridge removal operations shall immediately cease after performing any work necessary to ensure worksite safety. The Contractor shall submit to the Engineer, the procedure or operation proposed by the Contractor's Engineer to correct or remedy the occurrence of this unplanned event or to revise the final Bridge Removal Plan.

The Contractor shall submit his Engineer's report in writing, within 24 hours of the event, summarizing the details of the event and the procedure for correction. Before removal of the protective covering, the Contractor shall clean the protective covering of all debris and fine material.

**-3-**
**REVISION OF SECTION 202**
**REMOVAL OF BRIDGE**

Bridge removal may be suspended by the Engineer for the following reasons:

(1) Final Bridge Removal Plan has not been submitted, or written authorization has not been provided by the Engineer to begin the removal.

(2) The Contractor is not proceeding in accordance with the final Bridge Removal Plan, procedures, or sequence.

(3) The Contractor's Engineer is not on site to conduct inspection for the written approval of the work.

(4) Safety precautions are deemed to be inadequate.

(5) Existing neighboring facilities are damaged as a result of bridge removal.

Suspension of bridge removal operations shall in no way relieve the Contractor of his responsibility under the terms of the Contract. Bridge removal operations shall not resume until modifications have been made to correct the conditions that resulted in the suspension, as approved in writing by the Engineer.

The Contractor shall notify all emergency response agencies of the proposed removal work and any detours 24 hours in advance of work. This shall include the Colorado State Patrol, local Police Department, local Fire Department, all local ambulance services, and the Sheriff's Department, as appropriate.

All required traffic control devices, night time flagging stations, barricades and VMS signs shall be in place, with detours in operation, prior to the beginning of removal operations each day. Night work shall conform to the requirements of the MUTCD, Parts 1, 5, and 6.

Prior to reopening the roadway to public traffic, all debris, protective pads, materials, and devices shall be removed and the roadways swept clean.

Explosives shall not be used for removal work without the written approval of the Engineer.

Removal shall include the Superstructure, the Substructure, which includes the piers, the abutments and wingwalls, the bridge rail, and any approach slabs and sleeper slabs.

Removal of the Substructure shall be taken down to at least 1 foot below the natural existing or future ground surface at the lowest point of interface with the abutment, unless otherwise approved by the Engineer. Holes resulting from substructure removal shall be backfilled with Structure Backfill (Class 2) to the adjacent existing grades.

All other materials removed from the existing structure shall become the property of the Contractor and shall be properly disposed of offsite at the Contractor's expense, unless otherwise stated in the plans.

Existing structures, facilities, and surrounding roadways shall not be damaged by the removal operations. Damage that does occur shall be repaired immediately at the Contractor's expense.

## REVISION OF SECTION 202
## REMOVAL OF PORTIONS OF PRESENT STRUCTURE (Class 1, 2 and 3)

Section 202 of the Standard Specifications is hereby revised for this project to include the following:

### DESCRIPTION

This work consists of saw cutting, removal and disposal of existing deteriorated bridge deck concrete. Removal operations shall be conducted so that there will be the least interference with public traffic using the structure.

The applicable classes of removal will be as shown on the plans or as determined by the Engineer. The locations and limits of removal shall be as determined by the Engineer.

### CONSTRUCTION REQUIREMENTS

(a) *General.*

At least 10 days before start of work, the Contractor shall submit to the Engineer details of the removal operations showing the methods and sequence of removal and equipment to be used. The Contractor's submittal shall also include proposed methods used to determine the locations of deteriorating concrete.

All methods and equipment used to accomplish this item shall be approved by the Engineer. Prior to removal of concrete, the bridge deck shall be sounded by the Contractor in the presence of the Contractors ICQC Team, Contractors Engineer, and CDOT for delaminations in accordance with ASTM D4580, Procedure B Chain Drag. All unsound concrete shall be marked, measured, and removed at locations mutually agreed on between the Contractors Engineer and CDOT. The Contractor will not be compensated for removal areas or patching areas not mutually agreed on between the Contractors Engineer and CDOT.

The Contractor shall remove and repair only the amount of work that can be completed and opened to traffic within the designated lane closure times as specified in the Traffic Control Plan.

Sawing of concrete shall be done to a true line, with a vertical face, unless otherwise specified. The approximate depth of saw cut shall be ¾ inch.

The Contractor shall take all steps necessary to prevent cutting or otherwise damaging reinforcing steel, including any vertical stirrups, and/or structural steel including welded shear connectors projecting into the bridge deck. All bars or shear connectors damaged by the Contractor's operations shall be repaired or replaced at the Contractor's expense.

Following sandblasting, the condition of all exposed reinforcing bars shall be inspected by the Engineer. If, in the opinion of the Engineer, the bars are deteriorated to less than 75 percent of their original cross section, the Contractor shall add additional bars as approved by the Engineer. New added bars shall be lap spliced as shown in the plans. Payment for the new reinforcement steel shall be made in accordance with Section 602. If the required lap splice length cannot be utilized, a mechanical splice shall be used. The mechanical splice shall develop at least 125 percent of the specified yield strength of the bar. The Mechanical splice shall be per CDOT list of approved products. All minimum clearances shall be maintained. Payment for the Mechanical splice will be as the weight of reinforcing steel for the designated lap splice for that bar size. As an alternative, the Contractor may remove additional sound concrete to achieve the required lap length. Payment for additional removals and repairs will be based on the unit price for the appropriate class of removal

**2**
**REVISION OF SECTION 202**
**REMOVAL OF PORTIONS OF PRESENT STRUCTURE**

and repair method. Removal and repairs beyond the minimum required lap length will not be paid for.

All reinforcing steel shall be secured to adjacent bars or to the bridge deck as provided in subsection 602.

All areas of the prepared surface contaminated by oil or other materials detrimental to good bond shall be thoroughly cleaned by a method approved by the Engineer. Such cleaning work will not be paid for separately, but shall be included in the work.

(b) *Class 1*.

Class 1 removals shall be used only on bridge decks receiving a thin bonded polyester concrete overlay and shall consist of removing spalling concrete areas to a depth not less than ¾" and not deeper than the center of the top mat of reinforcing steel. Class 1 removal shall consist of removing the surface of the existing bridge deck concrete within the limits shown on the plans, or as designated by the Engineer.

Removal may be performed by chipping, hand tools or shot blasting (sand blasting) in accordance with these specifications or as otherwise approved by the Engineer.

If loose or deteriorated concrete exists below Class 1 limits, Class 2 removal may be required. If Class 1 is immediately adjacent to Class 2 or 3 removals, it shall be taken down to Class 2.

Class 1 removals are not allowed if thin-bonded overlay (polymer concrete) is not used.

(c) *Class 2.*

Removal of Portions of Present Structure (Class 2) shall consist of removing existing bridge deck concrete within the limits shown on the plans, or as designated by the Engineer. Class 2 removal shall begin at the surface of the existing concrete bridge deck and extend to sound concrete, but not less than 1 inch below the top transverse and longitudinal reinforcing steel and shall extend at a maximum to the top of the bottom mat of reinforcing or half bridge deck thickness, whichever is less.

Wherever solid bond between existing concrete and reinforcing steel is lacking, or where more than half of the diameter of the reinforcing bars is exposed by removal of concrete, the concrete adjacent to the bar shall be removed a minimum of one inch below and around the bar to permit new construction to bond to the entire periphery of the bar. Pneumatic hammers heavier than nominal 15 lb. class shall not be used in removing concrete from below and around reinforcing steel. Care shall be taken so as not to fracture sound concrete in the bottom half of the bridge deck.

Removal may be performed by power chipping or hand tools in accordance with these specifications or as otherwise approved by the Engineer.

If loose or deteriorated concrete exists below Class 2 limits, Class 3 removal may be required.

**3**
**REVISION OF SECTION 202**
**REMOVAL OF PORTIONS OF PRESENT STRUCTURE**

(d) *Class 3*.

Removal of Portions of Present Structure (Class 3) shall consist of removing existing bridge deck concrete within the limits shown on the plans, or as designated by the Engineer, following the

Class 2 removal work. The concrete within the designated limits shall be removed full depth from the top of bridge deck to bottom of bridge deck.

The Contractor shall take all precautions necessary to prevent damage to diaphragms and girders below the removal limits and to minimize spalling on the bottom of the bridge deck slab adjacent to the removal boundaries.

*(e) Surface Preparation Equipment.*

Sandblasting equipment shall be capable of removing rust scale from reinforcing bars and removing small chips of concrete partially loosened or fractured by the scarifying or chipping operations.

Pneumatic hammers heavier than nominal 15 pound class will not be permitted. Pneumatic hammers and chipping tools shall not be operated at an angle exceeding 60° relative to the surface of the slab. Such tools may be started in the vertical position but must be immediately tilted to 60° operating angle.

Hand tools such as hammers and chisels shall be provided for removal of final particles of loose, unbonded concrete. Only short, one-handed hammers with a maximum head weight of 5 pounds will be allowed unless Class 3 removal is designated.

## REVISION OF SECTION 202
## REMOVAL OF ASPHALT MAT (PLANING) (SPECIAL)

Section 202 of the Standard Specifications is hereby revised for this project as follows: Subsection 202.02 shall include the following:

All asphalt material and waterproofing membrane shall be removed from the surface of the concrete.

For bridges which are to receive a new waterproofing membrane and new asphalt, the surface of the deck shall be relatively smooth upon completion of removal operations. Jagged or broken edges, that could damage the subsequent waterproofing membrane, shall be removed or ground smooth.

The Contractor is responsible for the condition of the deck prior to and during placement of the new surface treatment.

Subsection 202.09 shall be replaced with the following:

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

1. Methods of removal including confined areas that are unreachable with large equipment.

2. The type and number of all equipment to be used. If cold milling is to be performed for removal of the final ½ inch of asphalt, appropriate information must be provided to demonstrate the equipment meets the requirements of this specification.

The width, location and phasing of removal passes along with the proposed schedule for these passes.

The Contractor shall remove the existing asphalt by cold milling to within ½ inch of the concrete deck. Removal of the remaining ½ inch of asphalt and any existing membrane shall be performed by any one or combinations of the following three methods:

1. Scraping with a loader equipped with a smooth edged bucket (no teeth).

2. Diamond grinding.

3. Cold milling with equipment that has the capabilities and features as described below.

   Cold milling equipment must be able to:

   A. Remove concrete to a depth of ¼ inch.

   B. Provide a surface relief of at most ¼ inch.

   C. Provide a 5/32 inch grade tolerance.

Cold milling equipment must have the following features:

1. 3 or 4 riding tracks.

2. An automatic grade control system with electronic averaging having 3 sensors on each side of the equipment.

**2**
**REVISION OF SECTION 202**
**REMOVAL OF ASPHALT MAT (PLANING) (SPECIAL)**

3. A conveyor system that leaves no debris on the bridge.

4. A drum that operates in an up-milling direction.

5. Bullet tooth tools with tungsten carbide steel cutting tips.

6. A maximum tool spacing of ¼ inch.

7. A maximum operating weight of 66,000 pounds.

8. A maximum track unit weight of 6,000 pounds per foot.

9. New tooth tools at the start of the job.

For all cold milling operations, the Contractor shall:

1. Provide personnel on each side of the milling drum to monitor milling Activities. Maintain constant radio communication with the operator during milling Activities.

2. Verify the depth of the asphalt surfacing every 50 feet at one location on each shoulder and in the traveled way.

3. Saw cut the outline of the asphalt surfacing to be removed.

A small width rotomill (maximum 2-foot head) and low impact hand tools may be used in confined areas where the primary removal equipment will have difficulty accessing.

In the transverse direction, removal shall extend to the face of the barriers. The removal depth near the face of the barriers shall be consistent with the remainder of the bridge deck.

Hydrodemolition and pressure jetting will not be permitted for removal operations.

After cold milling is complete, the Contractor shall ensure that the coarse aggregate remaining above the removal depth is firmly embedded and remove it if it is not.

The Contractor shall prepare the bridge deck surface for placement of the new surface treatment. If cold milling is to be performed for removal of the final ½ inch of asphalt, the Contractor shall furnish a documented history of successfully performing cold milling on bridge decks with equipment similar to that described herein. The documentation shall include three projects within the past five years and shall include equipment type used as well specifics regarding the bridges.

The Contractor shall take all precautions to minimize damage to the expansion devices, barriers and drains. All damage to the bridge expansion devices, barriers and drains resulting from removal operations shall be repaired at the Contractor's expense without time extension.

The Contractor shall take all precautions to minimize damage to the bridge deck that would not ordinarily occur with the removal methods described herein. This includes damage to deck reinforcing and

**3**
**REVISION OF SECTION 202**
**REMOVAL OF ASPHALT MAT (PLANING)(SPECIAL)**

post-tensioning. Such damage resulting from removal operations shall be repaired at the Contractor's expense without time extension.

The Contractor shall provide protection to live traffic and waterways below from any falling debris in work areas where heavy equipment is in use.

Asphalt planing edges shall be tapered if the planing is not completed within the allowable lane closure time and is more than ¾ inch higher in elevation than the adjacent pavement.

Tapered edges transverse to the direction of traffic shall be at a 20:1 (horizontal:vertical) slope. Tapered edges longitudinal to the direction of traffic shall be at a 4:1 (horizontal:vertical) slope.

All removal operations shall be completed parallel to the travel lanes unless otherwise directed by the Engineer.

## REVISION OF SECTION 503
## DRILLED CAISSONS

Section 503 of the Standard Specifications is hereby revised as follows:

Subsection 503.02 shall include the following:

At the bridge piers the void between the caisson and the casing shall be filled with a bentonite slurry. The following mix will yield approximately 1.2 cubic yards of acceptable slurry:

- 50 lbs. dry bentonite powder
- Approximately 125 gallons of water or sufficient amount to make a pourable mix
- 1 cubic yard of sand, free of material larger than ½ inch

Cement, lime, fly ash or other pozzolonic or highly alkaline materials shall not be added. This mixture may be mixed by portable concrete mixers or concrete mixer trucks. Mixers shall be colloidal mixers; tumbler mixers are not allowed.

In Subsection 503.06 delete the first sentence and replace with the following:

Temporary casings shall be 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 groundwater, and shall be watertight.

In Subsection 503.07 delete the second, third, fourth and fifth paragraphs and replace with the following:

Foundation piling shall not be drilled, excavation performed or additional caissons drilled within a clear distance of 20 feet of a recently placed caisson until the concrete for that caisson has attained a minimum strength of 1500 psi as determined by the engineer.

Concrete for each drilled caisson shall be placed in one continuous pour. Concrete shall be carefully placed in its final position by means of a concrete pumping machine and a rigid discharge pipe. The bottom of the discharge pipe shall be lowered to within one foot of the bottom of the drilled hole to start concrete placement and shall be raised at a rate that will keep the discharge pipe continuously embedded in the fresh concrete a minimum of five feet. Air and water shall be excluded from the discharge pipe by keeping it continuously filled. The continuity of the operation shall be maintained without breaking the seal between the concrete mass and the discharge pipe until the placement is completed. The layer of water diluted concrete which has been floated to the top during placement shall be removed to a depth as directed by the Engineer and disposed. In no case shall the removed layer be less than 1 foot thick. Only that concrete which meets specification requirements shall remain as part of the caisson. The caisson concrete shall not be disturbed after it has been deposited.

Bentonite slurry shall be removed and shall become the property of the Contractor. This material shall be disposed of offsite in a responsible manner.

**-2-**
**REVISION OF SECTION 503**
**DRILLED CAISSONS**

Add Subsection 503.071 immediately following Subsection 503.07 as follows:

**503.071 Cross-Hole Sonic Logging.**

(a) *General Requirements.*

The nondestructive testing method called Cross-hole Sonic Logging (CSL) shall be used on all production drilled shafts. The testing shall not be conducted until 48 hours after the placement of all concrete in a shaft, and must be completed within 10 Calendar days after placement on production drilled shafts. The Engineer may specify a longer minimum time if special retarders, mix designs, or other factors result in slower-setting concrete.

CSL installation and testing procedures shall be in accordance with ASTM D6760-08 Section 7.

The CSL tests shall be conducted by an experienced independent testing organization retained by the Contractor and approved by the Engineer prior to testing.

The CSL tests measure the time it takes for an ultrasonic pulse to travel from a signal source in one access tube to a receiver in another access tube. In uniform, good quality concrete, the travel time between equidistant tubes will be relatively constant and correspond to a reasonable concrete pulse velocity from the bottom to the top of the foundation. In uniform, good quality concrete, the CSL test will also produce records with good signal amplitude and energy. Longer travel times and lower amplitude/energy signals can indicate the presence of irregularities such as poor quality concrete, voids, honeycomb, and soil intrusions. The signal will be completely lost by the receiver and CSL recording system for the more severe defects such as voids and soil intrusions. A loss in signal velocity of 20% or less shall be classified as acceptable construction

Upon completion of CSL testing all water shall be removed from access tubes and any other drilled holes.

After the CSL results have been evaluated, required repair of defects has been conducted and the repair has been evaluated with another CSL survey, the CSL tubes shall then be grouted at the direction of the Engineer with an approved prepackaged grout having a minimum compressive strength of 4000 psi.

(b) *Preparation for Testing*

A minimum of four (4) CSL tubes shall be installed in each drilled shaft, equally spaced around the perimeter of the shaft at 90 degrees, as shown in the Contract Plans. The tubes shall be Schedule 40 steel with an inside diameter of 1 ½ inches to 2 inches. Galvanized steel will not be permitted and substitutions will not be allowed. Pipes shall have a round, regular internal diameter free of defects or obstructions. When pipe joints are required they shall be made with firmly tightened threaded couplings (no substitutions are allowed), in order to permit the free, unobstructed passage of a 1.35 inch diameter source and receiver probe. Tubes shall be watertight and free from corrosion with clean internal and external faces to ensure passage of the probes, and to provide good bond with the concrete. Splice locations shall be shown on the shop drawings.

**-3-**
**REVISION OF SECTION 503**
**DRILLED CAISSONS**

CSL pipes shall be fitted with a watertight shoe on the bottom and a removable cap on the top. The pipes shall be securely attached to the interior of the reinforcement cage with a minimum cover of 3 inches.

Pipes shall be installed in each shaft in a regular, symmetric pattern such that each tube is placed the maximum distance possible from each adjacent tube, with a spacing of 90 degrees around the perimeter of the cage as specified above. The tubes shall be as near to parallel as possible, and are typically wire-tied to the reinforcing cage every 3 feet, or are otherwise secured such that the tubes stay in position during placement of the rebar cage and concrete.

The tubes shall extend from ½ foot above the shaft bottoms to at least 3-feet above the shaft tops. Under no circumstances shall the tubes be allowed to rest on the bottom of the drilled excavation. If the shaft top is sub-surface, the tubes shall extend at least 3 feet above the ground or water surface.

All joints in the tubes required to achieve full-length shall be made watertight. Care shall be taken during reinforcement installation operations in the drilled shaft hole so as not to damage the tubes. After placement of the reinforcement cage and prior to concreting the caisson, the tubes shall be filled with clean water as soon as possible (no later than 4 hours after placement of cage) and the tube tops capped or sealed to keep debris out of the tubes. Care shall be exercised in the removal of caps or plugs from the pipes after installation so as not to apply excess torque, hammering, or other stresses which could break the bond between the tubes and the concrete.

The Contractor shall submit to the Engineer for review the proposed CSL system including equipment schematics, material specifications, tube size, installation details, testing procedures, and joint connections at least 30 days prior to starting drilled caisson construction.

(c) *Typical CSL Test Equipment.* Typical CSL test equipment consists of the following components:

1. A microprocessor based CSL system for display of individual CSL records, analog-digital conversion and recording of CSL data, analysis of receiver responses and printing of CSL logs.

2. Ultrasonic source and receiver probes for 1-½ inches to 2-inch inside diameter pipe, as appropriate.

3. An ultrasonic voltage pulsar to excite the source with a synchronized triggering system to start the recording system.

4. A depth measurement device to determine and record depths.

5. Appropriate filter/amplification and cable systems for CSL testing.

(d) *CSL Logging Procedures*

Before the placement of concrete, a minimum of one tube per shaft shall be plumbed and the tube length recorded, including a notation of the tube projection above the shaft tops. Information on the

**-4-**
**REVISION OF SECTION 503**
**DRILLED CAISSONS**

shaft bottom and top elevations and/or length, along with construction dates shall be provided to the Engineer before the CSL tests.

CSL tests shall be conducted between the pairs of tubes encompassing the perimeter and the major diagonals.

Additional logs shall be conducted at no additional cost to the Department in the event anomalies are detected.

The CSL tests shall be carried out with the source and receiver probes in the same horizontal plane unless test results indicate potential defects, in which case, the questionable zone may be further evaluated with angled tests (source and receiver vertically offset in the tubes). CSL measurements shall be made at depth intervals of 0.5 feet or less, and shall be done from the bottom of the tubes working upward to the top of each shaft.

Probes shall be pulled simultaneously, starting from the bottoms of the tubes, over a depth-measuring device. Any slack shall be removed from the cables prior to pulling to provide for accurate depth measurements of the CSL records. Any defects indicated by longer pulse arrival times and significantly lower amplitude/energy signals shall be reported to the Engineer, and further tests shall be conducted as directed by the Engineer to evaluate the extent of such defects.

Additional NDT methods may be used to evaluate possible shaft defects including Single hole Sonic Logging, Gamma-Gamma Nuclear Density Logging, 3D Tomography, and/or Surface Sonic Echo and Impulse Response tests. The Contractor shall provide consultants and/or personnel, on an as needed basis, who are experienced and competent performing the above NDT methods. If a defect is found by the additional NDT, then the cost of the additional NDT shall be the responsibility of the Contractor. If no defect is found by the additional NDT, then the cost of the additional NDT will be the responsibility of the Department.

(e) *CSL Testing Results.*

CSL results shall be presented to the Engineer in a report within five (5) working days after completion of the testing. The test results shall include CSL logs with analyses of:

1. Initial pulse arrival time versus depth

2. Pulse energy/amplitude versus depth

A CSL log shall be presented for each tube pair tested, with any defect zones indicated on the logs and discussed in the test report as appropriate.

Additional needed NDT results shall also be presented to the Engineer in a report format.

Copies of all data (written, electronic, etc.) obtained from the CSL and other NDT inspections shall be submitted to the Department in an expedient manner. These submitted copies shall become the property of the Department.

**-5-**
**REVISION OF SECTION 503**
**DRILLED CAISSONS**

(f) *Evaluation of CSL Test Results*

The Engineer will evaluate the CSL and NDT (if needed) results within five (5) working days after they were received from the Contractor and will determine whether or not the drilled shaft construction is acceptable.

If the NDT records are complex or inconclusive, the Engineer may require coring in accordance with subsection 503.071(g) below, or excavation of the shaft to verify shaft conditions. If a defect is confirmed, the Contractor shall pay for all coring or excavation costs, including grouting of all core holes. If no defect is encountered, the Department will pay for all coring or excavation costs, including grouting of all core holes.

The acceptance of each drilled shaft shall be the decision of the Engineer, based on the results of the shaft integrity testing report(s), including shaft coring, and other information on the shaft placement.

Rejection of a shaft based on the shaft integrity testing shall require conclusive evidence that a defect exists in the shaft which will result in inadequate or unsafe performance under expected loads.

In the case that any shaft is determined to be unacceptable, the Contractor shall submit a plan for remedial repairs to the Engineer for approval. Any modifications to the foundation shafts and load transfer mechanisms caused by the remedial action will require calculations and working drawings stamped by a Professional Engineer registered in the State of Colorado for all foundation elements affected. All labor and materials required to perform remedial shaft repairs shall be provided at no cost to the Department and with no extension of the contract time.

(g) *Core Drilling of Drilled Shaft Concrete*

When directed by the Engineer, production drilled shafts that are determined to be unacceptable by the CSL tests shall be cored to determine the quality of the concrete. One core sample shall be taken from each defective shaft for the full depth of the irregularities and for three (3) feet above and below the irregularity.

Because it is desired to obtain a high percentage of core recovery for visual inspection and testing methods, equipment shall be as follows:

1. The core drill shall be in good condition and capable of delivering a smooth flow of power to the bit, both in rotation and down thrust. The pump shall be in good condition and of the positive displacement type. The pump shall be capable of delivering a minimum of 15 gallons of water per minute at 200 psi. It shall be equipped with a relief valve set to release at a maximum of 200 psi. It shall be equipped with a pressure gauge with range from 0 psi to 1,000 psi.

2. The drill shall be size HW or larger. The core barrel shall be size HW or larger, M series, double-tubed, with a chromed inner barrel. The diamond set bit for each hole shall be of best quality, new, and with a minimum of four waterways. The Engineer may require a new bit or

**-6-**
**REVISION OF SECTION 503**
**DRILLED CAISSONS**

replacement of the core barrel at any time when inspection indicates excessive wear or loss of diamonds.

3. The core drill machine shall be set so that the drill force will be exactly vertical and so there will be not more than five (5) feet of laterally unsupported drill rod between the bottom of the drill spindle (chuck) and the top of the shaft concrete when the hydraulic feed is in the up position. When longer laterally unsupported sections of drill stem are necessary, braced casing or rigidly braced guides must be used to prevent lateral whip.

An accurate log of cores shall be kept and the cores shall be placed in a suitable wooden crate and properly marked showing the shaft depth at each interval of core recovery. The cores along with two (2) copies of the coring log shall be turned over to the Engineer for inspection and testing.

Construction shall not proceed above the drilled shaft until the quality of the concrete in the shaft, as represented by the core samples, is determined to be acceptable and notification to continue construction is given by the Engineer.

If the quality of the concrete in a drilled shaft is determined to be acceptable, or after shaft remedial repairs are complete and accepted by the Engineer, the Contractor shall grout the core hole with an approved prepackaged grout having a minimum compressive strength of 4000 psi.

## REVISION OF SECTION 504
## SOIL NAIL WALL

Section 504 of the Standard Specifications is hereby revised for this project to include the following:

### DESCRIPTION

**504.06** This work consists of designing and constructing a permanent soil nailed wall as specified herein and as shown on the project plans.

The work includes developing detailed design calculations and plans, excavating in staged lifts in accordance with the shop drawings and approved submittals for drilling soil nail holes to the diameter and length required to develop the specified capacity; grouting the nails; providing and installing the specified drainage features; providing and installing bearing plates, washers, nuts, and other required miscellaneous materials; and constructing the required temporary shotcrete face.

### MATERIALS

**504.07** Concrete shall be Class D, conforming to the requirements of Section 601. Reinforcing Steel shall conform to the requirements of Section 602. Shotcrete shall conform to the requirements of Section 641 as revised for this project. Forms and falsework shall conform to the requirements of subsections 601.09 and 601.11.

**504.08 Soil Nails.**

(a) *Nail Solid Bar.* Bars shall conform to AASHTO M31, Grade 60 or 75 or ASTM A 722 for Grade 150. Bars shall be deformed, continuous without splices or welds, new, straight, undamaged, bare, or epoxy-coated, or encapsulated as shown on the plans. Bars shall be threaded a minimum of 6 inches on the wall anchorage end to allow proper attachment of bearing plate and nut. Threading may be continuous spiral deformed ribbing provided by the bar deformations (continuous thread bars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, the next-larger bar number designation from that shown on the plans shall be provided at no additional cost.

(b) *Bar Coupler.* Bar couplers shall develop the full ultimate tensile strength of the bar as certified by the manufacturer.

(c) *Fusion Bonded Epoxy Coating.* Epoxy coating shall conform to ASTM A 775. The minimum thickness shall be 0.016 inch and shall be electrostatically applied. Bend test requirements are waived. Coating at the wall anchorage end of epoxy-coated bars may be omitted over the length provided for threading the nut against the bearing plate.

(d) *Encapsulation.* Encapsulation shall be minimum 0.04-inch thick, corrugated, HDPE tube conforming to AASHTO M252 or corrugated PVC tube conforming to ASTM D1784, Class 13464-B.

504.09 Soil Nail Appurtenances.

(a) *Centralizer.* Centralizers shall be manufactured from Schedule 40 PVC pipe or tube, steel, or other material not detrimental to the nail steel; wood shall not be used. Centralizers shall be securely attached to the nail bar; sized to position the nail bar within 1 inch of the center of the drill hole; sized to allow tremie pipe insertion to the bottom of the drill hole; and sized to allow grout to freely flow up the drill hole.

**-2-**
**REVISION OF SECTION 504**
**SOIL NAIL WALL**

(b) *Nail Grout.* Grout shall be a neat cement or sand/cement mixture with a minimum 3 day compressive strength of 1,500 psi and a minimum 28-day compressive strength of 3,000 psi conforming to AASHTO T106.

(c) *Fine Aggregate.* Fine aggregate shall conform to AASHTO M6.

(d) *Portland Cement.* Portland Cement shall conform to AASHTO M85, Type I, II, III, or V.

(e) *Admixtures.* Admixtures shall conform to AASHTO M194. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout subject to review and acceptance by the Engineer. Accelerators are not permitted. Expansive admixtures may be used only in grout used for filling sealed encapsulations. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's recommendations.

(f) *Film Protection.* Polyethylene film shall conform to AASHTO M171.

**504.10 Bearing Plates, Nuts, and Welded Stud Shear Connectors.**

(a) *Bearing Plates.* Bearing plates shall conform to AASHTO M183.

(b) *Nuts*. Nuts shall conform to AASHTO M291, grade B, hexagonal, fitted with beveled washer or spherical seat to provide uniform bearing.

(c) *Shear Connectors*. Shear connectors shall conform to AASHTO Construction Specifications, Section 11.3.3.1.

**504.11 Welded Wire Fabric and Reinforcing Steel.** Welded Wire Fabric shall conform to AASHTO M55 or ASTM A497. Reinforcing Steel shall conform to AASHTO M31, Grade 60, deformed.

**504.12 Geocomposite Sheet Drain.** Geocomposite Sheet Drain shall be manufactured with a drainage core (e.g., geonet) and a drainage geotextile attached to or encapsulating the core. The drainage core shall be manufactured from long chain synthetic polymers composed of at least 85 percent by mass of polypropylenes, polyester, polyamine, polyvinyl chloride, polyoleofin, or polystyrene and having a minimum compressive strength of 40 psi when tested in accordance with ASTM D 1621 Procedure A. The drainage core with the geotextile fully encapsulating the core shall have a minimum flow rate of 5 gallons per minute per foot of width tested in accordance with ASTM D 4716. The test conditions shall be under an applied load of 10 psi at a gradient of 1.0 after a 100-hour seating period.

**504.13 Underdrain and Perforated Pipe.**

(a) *Pipe.* Pipe shall conform to ASTM D 1785 Schedule 40 PVC solid and perforated wall; cell classification 12454-B or 12354-C, wall thickness SDR 35, with solvent weld or elastomeric joints.

(b) *Fittings*. Fittings shall conform to ASTM D3034, Cell classification 12454-B or C, wall thickness SDR 35, with solvent or elastomeric joints.

**-3-**
**REVISION OF SECTION 504**
**SOIL NAIL WALL**

**504.14 Temporary Shotcrete.** The Contractor shall submit for approval, all materials, methods, and control procedures for this work.

**CONSTRUCTION REQUIREMENTS**

**504.15 Construction Qualifications.** The soil nailing contractor shall have completed at least 3 permanent soil nail retaining wall projects during the past 3 years totaling at least 10,000 square feet of wall face area and at least 500 permanent soil nails.

The soil nailing contractor shall also provide a Registered Professional Engineer with experience in the construction of permanent soil nail retaining walls on at least 3 completed projects over the past 3 years. The soil nailing contractor shall not use consultants or manufacturer's representatives to meet the requirements of this section. The soil nailing contractor shall provide on-site supervisors and drill operators with experience installing permanent soil nails on at least three projects over the past 3 years.

**504.16 Submittals.** The soil nailing contractor shall submit a brief description of at least 3 completed projects, including the owning agency's name, address, and current phone number; location of project; project contract value; and scheduled completion date and actual completion date for the project.

At least 10 calendar days before starting soil nail work, the soil nailing contractor shall identify the Engineer, on-site supervisors, and drill operators assigned to the project, and submit a summary of each individual's experience. Only those individuals designated as meeting the qualifications requirements shall be used for the project. The soil nailing contractor shall not substitute for any of these individuals without written approval of the Engineer. The Engineer will approve or reject the soil nailing contractor qualifications and staff within 15 working days after receipt of the submission. Work shall not be started on any soil nail wall or materials ordered until the soil nailing contractor's qualifications have been approved by the Engineer. The Engineer may suspend the work if the soil nailing contractor substitutes unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, the Contractor shall be fully liable for additional costs resulting from the suspension of work and no adjustment in contract time resulting from the suspension of the work will be allowed.

The Contractor shall submit design drawings indicating the general sizes, dimensions and arrangement of the soil nail wall as shown on the plans. Details shall identify soil nail anchorage requirements, anchor spacing and length, bearing plate requirements, temporary shotcrete and final cast-in-place facing wall and reinforcing steel designs, and wall drainage requirements. The drawings shall also include details as recommended by the Contractor's Engineer, marked locations of the soil nails on the shotcrete wall, typical sections near the bottom and top of wall, at expansion joints, near vertical wall steps, and a detailed description of the general soil nail wall system installation sequence.

The Contractor shall provide the necessary survey and alignment control during the excavation for each lift, locating drill holes and verifying limits of wall installation. At least 10 days before starting soil nail work, the soil nailing contractor shall submit a Construction Plan to the Engineer that includes the following:

(1) The start date and proposed detailed wall construction sequence.

(2) Drilling and grouting methods and equipment, including the drill hole diameter proposed to achieve

**-4-**
**REVISION OF SECTION 504**
**SOIL NAIL WALL**

the specified pullout resistance values shown on the plans and any variation of these along the wall alignment.

(3) Nail grout mix design, including compressive strength test results (per AASHTO T106) supplied by a qualified independent testing lab verifying the specified minimum 3-day and 28-day grout compressive strengths. Previous test results for the same grout mix completed within one year of the start of grouting may be submitted for verification of the required compressive strengths.

(4) Nail grout placement procedures and equipment.

(5) Temporary shotcrete materials and methods.

(6) Soil nail testing methods and equipment setup.

(7) Identification number and certified calibration records for each test jack and pressure gauge and load cell to be used. Jack and pressure gauge shall be calibrated as a unit. Calibration records shall include the date tested, the device identification number, and the calibration test results and shall be certified for an accuracy of at least 2 percent of the applied certification loads by a qualified independent testing laboratory within 90 days prior to submittal.

(8) Manufacturer Certificates of Compliance for the soil nail ultimate strength, nail bar steel, Portland cement, centralizers, bearing plates, epoxy coating, and encapsulation.

The Engineer will approve or reject the soil nailing contractor's Construction Plan within 30 working days after the submission. Approval of the Construction Plan does not relieve the Contractor of responsibility for the successful completion of the work.

**504.17 Storage and Handling.** Soil nail bars shall be stored and handled in a manner to avoid damage or corrosion. Bars exhibiting abrasions, cuts, welds, weld splatter, corrosion, or pitting shall be replaced. Bars exhibiting damage to encapsulation or epoxy coating shall be replaced. Repaired epoxy coating areas shall have a minimum 0.012-inch thick coating.

**504.18 Excavation.** The height of the exposed unsupported final excavation face cut shall not exceed the vertical nail spacing plus the required reinforcing lap or the short-term stand-up height of the ground, whichever is less. Excavation shall be completed to the final wall excavation line and shotcrete applied in the same work shift, unless otherwise approved by the Engineer. Application of the shotcrete may be delayed up to 24 hours if the soil nailing contractor can demonstrate that the delay will not adversely affect the excavation face stability.

Excavation of the next-lower lift shall not proceed until nail installation, reinforced shotcrete placement, attachment of bearing plates and nuts, and nail testing have been completed and accepted in the current lift. Nail grout and shotcrete shall have cured for at least 72 hours or attained at least their specified 3-day compressive strength before excavation of the next underlying lift.

**504.19 Nail Installation.** Nail length and drill hole diameter used shall be that necessary to develop the load capacity to satisfy the acceptance criteria for the design load required, but not less than the lengths or diameters shown on the plans. Holes shall be drilled for the soil nails at the locations, elevations, orientations, and lengths shown on the shop drawings. Drilling equipment and methods shall be suitable

**-5-**
**REVISION OF SECTION 504**
**SOIL NAIL WALL**

for the ground conditions and conform to the accepted installation methods submitted by the soil nailing contractor. Drilling muds or other fluids shall not be used to remove cuttings. If caving ground is encountered, cased drilling methods shall be used to support the sides of the drill holes. Self-drilling nail bars (also known as hollow, self-grouting or pressure grouted nail bars) shall not be used. Nail bars shall be as shown on the plans. Centralizers sized to position the bar within 1 inch of the center of the drill hole shall be used. Centralizers shall be used as shown on the plans so that their maximum center-to-center spacing does not exceed 8 feet. Centralizers shall also be used within 1.5 feet from the top and bottom of the drill hole.

**504.20 Grouting.** The drill hole shall be grouted after installation of the nail bar and within 2 hours of completion of drilling. The grout shall be injected at the lowest point of each drill hole through a grout tube or casing. The outlet end of the conduit shall be kept from delivering grout below the surface of the grout as the conduit is withdrawn to prevent the creation of voids. The drill hole shall be completely filled in one continuous operation. Cold joints in the grout column are not allowed except at the top of the test bond length of proof tested production nails.

Nail grout shall be tested according to AASHTO T106 at a frequency of one test per mix design and a minimum of one test for every 52 cubic yards of grout placed. Grout cube test results shall be provided to the Engineer within 24 hours of testing.

**504.21 Nail Testing.** Both verification and proof testing of designated test nails shall be performed. Verification tests shall be performed on sacrificial test nails at locations shown on the shop drawings. Proof tests shall be performed on a minimum of 5 percent of the production nails in each row, with a minimum of one proof test per row of nails. Testing of a nail shall not be performed until the nail grout and shotcrete facing have cured for at least 72 hours or attained their specified 3-day compressive strength.

Testing equipment shall include 2 dial gauges, dial gauge support, jack and pressure gauge, electronic load cell, and a reaction frame. The pressure gauge shall be graduated in 75 psi increments or less. The nail head movement shall be measured with a minimum of 2 dial gauges capable of measuring to 0.001 inch.

**504.22 Verification Testing Of Sacrificial Nails.** Verification testing shall be performed prior to installation of production nails to confirm the appropriateness of the Contractor's drilling and installation methods, and verify the required nail pullout resistance.

Verification test nails shall have both bonded and unbonded lengths. Along the unbonded length, the nail bar shall not be grouted. The unbonded length of the test nails shall be at least 3 feet. The bonded length of the soil nail during verification tests, $L_{BVT}$, shall be at least 5 feet but not longer than a maximum length, $L_{BVT\ max}$, such that the nail load does not exceed 90 percent of the nail bar tensile allowable load during the verification test. Therefore, the following requirements shall be met:

$L_{BVT}$ shall be within the limits for $L_{BVTmax}$, but never less than 5 feet minimum.

**-6-**
**REVISION OF SECTION 504**
**SOIL NAIL WALL**

The length $L_{BVTmax}$ is defined as:

$L_{BVTmax} = (C_{RTY} \cdot A_t \cdot f_y) / (r_{PO})$

where,

$C_{RTY}$ = Reduction coefficient. Use $C_{RTY} = 0.9$ for Grade 60 and 75 bars. If the Engineer allows Grade 150 bars on the project, use $C_{RTU} = 0.8$;

$A_t$ = Nail bar net cross-sectional area after threading;

$f_y$ = Nail bar yield tensile strength;

$r_{PO}$ = Nominal pullout resistance (per unit length) of soil nail = $\pi \cdot q_u \cdot D_{DH}$

$q_u$ = Bond Strength

$D_{DH}$ = Drill hole diameter

The maximum bonded length shall be based on production nail maximum bar grade. Larger bar sizes shall be provided at no additional cost if required to meet the 5 foot minimum test bonded length requirement.

The Verification Test Load (VTL) shall be determined as follows:

$VTL = L_{BVT} \cdot r_{PO}$

The VTL shall be calculated based on as-built bonded lengths.

Verification tests shall be performed by incrementally loading the verification test nails to 100 percent of the VTL in accordance with the following loading schedule. If pullout is not achieved up to VTL, test loads larger than VTL may be applied to attempt to reach pullout. The soil nail movements at each load increment shall be recorded.

**Verification Test Loading Schedule**

| Load | Hold Time |
|---|---|
| AL | 1 minute |
| 0.13 VTL | 10 minutes (Recorded at 1,2,4,5,10) |
| 0.25 VTL | 10 minutes (Recorded at 1,2,4,5,10) |
| 0.38 VTL | 10 minutes (Recorded at 1,2,4,5,10) |
| 0.50 VTL | 10 minutes (Recorded at 1,2,4,5,10) |
| 0.63 VTL | 10 minutes (Recorded at 1,2,4,5,10) |
| 0.75 VTL (Creep Test) | 60 minutes |
| 0.88 VTL | 10 minutes |
| 1.00 VTL | 10 minutes |
| (AL) | 1 minute (record permanent set) |

**-7-**
**REVISION OF SECTION 504**
**SOIL NAIL WALL**

The alignment load (AL) shall be the minimum load required to align the testing apparatus and shall not exceed 2.5 percent of the VTL. Dial gauges shall be set to "zero" after the alignment load has been applied. Following application of the maximum load the load shall be reduced to the alignment load (0.025 VTL maximum) and the permanent set recorded.

Each load increment shall be held for at least 10 minutes. The verification test nail shall be monitored for creep at the 0.75 VTL load increment. Nail movements shall be measured and recorded during the creep portion of the test in increments of 1 minute, 2, 4, 5, 6, 10, 20, 30, 50, and 60 minutes. The load shall be maintained during the creep test within 2 percent of the intended load by use of the load cell.

504.23 Proof Testing Of Production Nails. Successful proof testing shall be performed on 5 percent of the production soil nails in each nail row or a minimum of 1 per row. The Engineer will determine the locations and number of proof tests prior to nail installation in each row unless otherwise shown on the plans. Production proof test nails shall have both bonded and temporary unbonded lengths. The temporary unbonded length of the test nail shall be at least 3 feet. The bonded length of the soil nail during proof production tests, $L_{BPT}$, shall be the least of 5 ft. and a maximum length, $L_{BPT\ max}$, such that the nail load does not exceed 90 percent of an allowable value of the nail bar tensile load during the proof production test. Therefore, the following requirements shall be met:

$L_{BPT}$ shall be between 5 feet, minimum, and $L_{BPT\ max}$.

The length $L_{BPT\ max}$ is defined as:

$L_{BPT\ max} = (C_{RTY} \cdot A_t \cdot f_y) / (r_{PO} \cdot 0.75)$

Where,

$C_{RTY}$ = Reduction coefficient. Use $C_{RTY} = 0.9$ for Grade 60 and 75 bars. If the engineer allows Grade 150 bars on the project, use $C_{RTU} = 0.8$;

$A_t$ = Nail bar net cross-sectional area after threading;

$f_y$ = Nail bar yield tensile strength;

$r_{PO}$ = Nominal pullout resistance (per unit length) of soil nail = $\pi \cdot q_u \cdot D_{DH}$

$q_u$ = Bond Strength

$D_{DH}$ = Drill hole diameter

The maximum bonded length shall be based on production nail maximum bar grade. Fully grouted test nails must not be proof tested.

The Proof Test Load (PTL) shall be determined as follows:

$PTL = L_{BPT} \times r_{PO} \cdot 0.75$

The PTL shall be calculated based on as-built bonded lengths.

Proof tests shall be performed by incrementally loading the proof test nail up to 100 percent of the PTL in accordance with the following loading schedule. The soil nail movements shall be recorded at each load increment.

**-8-**
**REVISION OF SECTION 504**
**SOIL NAIL WALL**

**Proof Test Loading Schedule.**

| Load | Hold Time |
|---|---|
| AL | 1 |
| 0.17 PTL | Until Movement Stabilizes |
| 0.33 PTL | Until Movement Stabilizes |
| 0.50 PTL | Until Movement Stabilizes |
| 0.67 PTL | Until Movement Stabilizes |
| 0.83 PTL | Until Movement Stabilizes |
| 1.00 PTL (Creep Test) | 10 recorded at 1,2,4,5,6, and 10 |
| AL | 1 |

The alignment load (AL) should be the minimum load required to align the testing apparatus and shall not exceed 2.5 percent of the PTL. Dial gauges shall be set to “zero” after the alignment load has been applied.

The creep period shall start as soon as the maximum test load (1.00 PTL) is applied and the nail movement shall be measured and recorded at 1 minute, 2, 4, 5, 6, and 10 minutes. Where the nail movement between 1 minute and 10 minutes exceeds 0.04 inch, the maximum test load shall be maintained for an additional 50 minutes and movements recorded at 20 minutes, 30, 50, and 60 minutes. All load increments shall be maintained within 5 percent of the intended load.

**504.24 Test Nail Acceptance Criteria.** A test nail shall be considered acceptable when all of the following criteria are met:

(1) For verification tests, the total creep movement is less than 0.04 inch between the 1- and 10-minute readings at 0.75 VTL, less than 0.08 inch between the 6- and 60- minute readings at 0.75 VTL, and the creep rate is linear or decreasing throughout the creep test load hold period.

(2) For proof tests, the total creep movement is less than 0.04 inch between the 1- and 10-minute readings and the creep rate is linear or decreasing throughout the creep test load hold period. If this movement is exceeded, PTL must be maintained for an additional 50 minutes with readings recorded at 20, 30, 50, and 60 minutes. If the creep test is extended, the total creep movement shall be less than 0.08 inch between the 6- and 60-minute readings.

(3) For verification and proof tests, the total measured movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the test nail unbonded length.

(4) A pullout failure does not occur at less than 1.00 VTL under verification testing and less than 1.00 PTL test load under proof testing. Pullout failure is defined as the inability to further increase the test load while there is continued pullout movement of the test nail. The pullout failure load shall be recorded as part of the test data.

**-9-**
**REVISION OF SECTION 504**
**SOIL NAIL WALL**

The Contractor shall maintain the stability of the hole for the temporary unbonded test length for subsequent grouting. If the unbonded test length of production proof test nails cannot be satisfactorily grouted subsequent to testing, the proof test nail shall become sacrificial and shall be replaced with an additional production nail installed at the Contractor's expense.

**504.25 Test Nail Rejection.** If a test nail does not satisfy the acceptance criterion:

(1) For verification test nails, the Engineer will evaluate the results of each verification test. Installation methods that do not satisfy the nail testing requirements will be rejected. The Contractor shall propose alternative methods and install replacement verification test nails. Replacement test nails shall be installed and tested at the Contractor's expense.

(2) For proof test nails, the Engineer may require the Contractor to replace some or all of the installed production nails between a failed proof test nail and the adjacent passing proof test nail. Alternatively, the Engineer may require the installation and testing of additional proof test nails to verify that adjacent previously installed production nails have sufficient load carrying capacity. Installation and testing of additional proof test nails or installation of additional or modified nails as a result of proof test nail failures shall be at the Contractor's expense.

504.26 Wall Drainage Network. All elements of the wall drainage network shall be installed and secured as shown on the plans. The drainage network shall consist of installing geocomposite drain strips, PVC connection pipes, and weepholes as shown on the plans. All elements of the drainage network shall be installed prior to shotcreting.

(a) *Geocomposite Drain Strips.* Geocomposite drain strips shall be centered between the columns of nails as shown on the Plans. The drain strips shall be at least 12 inches wide and placed with the geotextile side against the ground. The strips shall be secured to the excavation face and shotcrete prevented from contaminating the geotextile. Drain strips shall be vertically continuous. Splices shall be made with a 12 inch minimum overlap such that the flow of water is not impeded. Drain plate and connector pipe shall be installed at the base of each strip as shown on the plans. Damage to the geocomposite drain strip which may interrupt the flow of water shall be repaired.

**504.27 Shotcrete Facing.** Construction shotcrete facing shall be installed in accordance with Section 641. Where shotcrete is used to complete the top ungrouted zone of the nail drill hole near the face, the nozzle shall be positioned into the mouth of the drill hole to completely fill the void.

(a) *Attachment of Nail Head Bearing Plate and Nut.* Bearing plate, washers, and nut shall be attached to each nail head as shown on the plans. While the shotcrete construction facing is still plastic and before its initial set, the plate shall be uniformly seated on the shotcrete by hand-wrench tightening the nut. Where uniform contact between the plate and the shotcrete cannot be provided, the plate shall be set in a bed of grout. After grout has set for 24 hours, the nut shall be hand-wrench tightened. Bearing plates with headed studs shall be located within the tolerances shown on the Plans.

(b) *Shotcrete Facing Tolerances.* Construction tolerances for the shotcrete facing from plan location and plan dimensions are as follows:

- Horizontal location of welded wire mesh; reinforcing bars, and headed studs: ½ inch

**-10-**
**REVISION OF SECTION 504**
**SOIL NAIL WALL**

- SOIL NAIL WALL Location of headed studs on bearing plate: ¼ inch
- Spacing between reinforcing bars: 1 inch
- Reinforcing lap, from specified dimension: 1 inch
- Complete thickness of shotcrete: If troweled or screeded: 0.6 inch; If left as shot: 1.2 inch
- Planeness of finish face surface-gap under 10 foot straightedge: If troweled or screeded: 0.6 inch; If left as shot: 1.2 inch
- Nail head bearing plate deviation from parallel to wall face: 10 degrees

**504.28 Forms And Falsework.** Forms and falsework shall conform to subsections 601.09 and 601.11 respectively.

**504.29 Reinforcing Steel.** Reinforcing steel shall be installed in accordance with Section 602.

**504.30 Structural Concrete.** Structural concrete shall be placed in accordance with Section 601.

504.31 Architectural Surface Finishes. The Contractor shall design and furnish textured form liners, install form liners, and apply a surface finish (color or stain application) that will duplicate the pattern shown on the plans. Detailed drawings of the form liner shall be submitted for approval by the Engineer in accordance with Subsection 105.02. Before production work begins, a 3 foot high, by 1.5 foot wide, 10 foot long test panel shall be constructed on site using the same forming methods, procedures, form liner, texture configuration, expansion joint, concrete mixture and color or stain application proposed for the production work. Production work shall not begin until the Engineer has approved the test panel.

**504.32 Backfilling Behind Wall Facing Upper Cantilever.** Backfill shall be relatively free draining granular material compacted within 3 ft. behind the wall facing upper cantilever using light mechanical tampers.

**504.33 Acceptance.** Material for the soil nail retaining wall will be accepted based on the manufacturer production certification or from production records. Construction of the soil nail retaining wall will be accepted based on visual inspection and the relevant production testing records.

## SECTION 519
## THIN BONDED OVERLAY (POLYESTER CONCRETE)

Section 519 is hereby added to the Standard Specifications as follows:

### DESCRIPTION

**519.01** This work consists of furnishing and placing a Polyester Polymer Concrete (PPC) overlay system with a High Molecular Weight Methacrylate (HMWM) resin primer on concrete surfaces. The surface of the concrete shall be prepared and the PPC overlay system shall be applied in accordance with these specifications in conformity with the lines, grades, thickness, and typical cross-sections shown on the plans or as approved by the Engineer.

This work includes patching of Class 1 and Class 2 deck removal areas using polyester concrete material. Polyester patching of Class 2 removal areas shall be limited to 10 square feet per patch and no more than 10 percent of the deck area per span. Additional patching of Class 2 and all Class 3 removals shall require Concrete as designated in the plans.

### QUALIFICATIONS AND SUBMITTALS

**519.02** The Contractor shall submit the Overlay System, System Provider Qualifications, Contractor Qualifications, System Provider Technical Representative Qualifications, Overlay Placement Plan, Certificates of Compliance with laboratory testing for each property, and any other relevant documents for the overlay system at least 15 days prior to the Polyester Overlay Pre-paving Conference and delivery of any of the overlay materials. These submittals are for approval and shall be directed to the Engineer.

(a) *Overlay System.* The Contractor shall submit two copies of the System Provider's material information, written installation instructions, material safety data sheets, and independent test results for approval.

(b) *System Provider Qualifications.* The Contractor shall install an overlay system with all components provided through a single System Provider, with documented experience successfully supplying 5 projects of similar size and scope within the past 5 years. The Contractor shall submit documentation of the System Providers project experience including the following:

1. Project construction date
2. Overlay quantities
3. Reference name and contact information for owner representative

(c) *Contractor Qualifications.* The Contractor shall submit documentation of successful projects placing structural concrete (bridge decks or concrete pavement) and PPC overlay systems to established grade lines using similar equipment as specified herein within the past 5 years. The documentation of Contractors qualifications shall include the following:

1. Project construction date
2. Overlay quantities
3. Reference name and contact information for owner representative

**-2-**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

If the Contractor does not have 5 years of experience placing structural concrete and PPC overlay systems with at least 10 documented successful projects, the Contractor shall arrange for a qualified System Provider Technical Representative with 5 years of documented experience with PPC to be on site throughout the duration of the project to ensure proper construction of the polyester concrete.

If the Contractor has 5 years of experience placing structural concrete and PPC overlay systems with at least 10 documented successful projects, the qualified System Provider Technical Representative with 5 years of documented experience with PPC shall, at a minimum, be on site throughout the placement of the first two bridge overlay placements and shall be available for the remainder of the project as requested by the Engineer.

(d) *System Provider Technical Representative Qualifications.* The System Provider Technical Representative shall have a minimum of 5 years of experience with PPC and be completely competent in all aspects of the work, including all materials to install the overlay system. The Technical Representative shall have experience on a minimum of 5 successful projects of similar size and scope within the past 5 years. The Contractor shall submit documentation of the System Providers Technical Representative's experience including the following:

(1) Years of Experience with polyester concrete

(2) Project construction date

(3) Overlay quantities

(4) Reference name and contact information for owner representative

The Technical Representative shall be available on site to facilitate the installation of polyester concrete. This includes, but not limited to, surface preparation, polyester concrete application, and polyester concrete cure.

(e) ***Overlay Placement Plan:*** The Contractor shall submit an Overlay Placement Plan that includes the following:

1. Schedule of overlay work and testing for each bridge
2. Staging plan describing overlay placement sequence including:
   - A. Contractor shall pave from high side of the bridge to the low side; no gaps between passes will be allowed.
   - B. Cold joints between passes shall be within 1 foot of the stripe lines or centered within a lane.
   - C. Staging Plan Sheets shall describe overlay placement sequence including:
     - i. Paving widths
     - i. Anticipated paving lengths
     - ii. Paving directions

**-3-**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

iii. Joint locations

iv. Location of proposed trial overlay(s)

3. Description of equipment used for:

   A. Surface preparation including grinding and shot blasting

   B. Applying HMWM resin

   C. Measuring, mixing, placing, and finishing the polyester concrete overlay

   D. Applying sand

   E. Method of protecting and finishing inlets and bridge drains

4. Method for preventing leakage of primer onto areas of deck that have not received surface preparation.

5. Method for isolating expansion joints including pourable joints at the abutment and over the piers

6. Method for measuring and maintaining overlay thickness and profile.

7. Tining plan showing tining locations and describing methods that will be used for hand tining.

8. Mainline tining shall be automated with the finisher.

9. Cure time for polyester concrete

10. Storage and handling of HMWM resin and polyester concrete components

11. Procedure for disposal of excess HMWM resin, polyester concrete, and containers

12. Procedure for cleanup of mixing and placement equipment

(f) *Equipment.* The Contractor shall submit documentation of certification of scales that will be used to calibrate the mobile mixing truck. The certification shall be dated within the last month. A new certification shall be done if any adjustments are made to the scales.

The Contractor shall submit a documented history of the use of the paving machine to successfully place Polyester Polymer Concrete overlays on major bridge projects for review and approval by the Engineer.

(g) Materials Samples: Samples of materials, from the same lots used for the project, for all components of the overlay system shall be submitted by the manufacturer, if requested by CDOT,

to the Materials Section a minimum of sixty (60) days prior to the overlay application. Samples shall be representative of the materials to be used in the overlay application and shall consist of one four-liter sample for each liquid and a 5 pound sample for each dry component

## MATERIALS

**519.03** The Contractor shall submit a Certified Test Report for all of the materials associated with the polyester concrete overlay in accordance with subsection 106.13 and accompanied by certified test reports from independent accredited laboratories.

**-4-**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

The polyester concrete shall consist of polyester resin binder and aggregate as specified below. It shall also include a compatible primer which when mixed with other specified ingredients and applied as specified herein, is capable of producing a polyester concrete meeting the requirements of this specification.

**519.04 Polyester Resin Binder.**

Polyester resin binder shall have the following properties:

1. Be an unsaturated isophthalic polyester-styrene co-polymer. The resin content shall be 12% +/-1% of the weight of the dry aggregate.

2. Contain at least 1 percent by weight gamma-methacryloxypropyltrimethoxysilane, an organosilane ester silane coupler.

3. Be used with a promoter that is compatible with suitable methyl ethyl ketone peroxide and cumene hydroperoxide initiators.

4. Have the values for the material properties shown in Table 519-1:

Accelerators or inhibitor may be required to achieve proper setting time of polyester concrete. They shall be used as recommended by the overlay System Provider.

**Table 519-1**
**POLYESTER RESIN BINDER PROPERTIES (Tested each lot sent to the job)**

| Property | Test Method | Requirement |
|---|---|---|
| Viscosity* | ASTM D 2196 | $0.1x10^{-5}$ to $2.9x10^{-5}$ psi (0.075 to 0.20 Pa) RVT No.1 Spindle, 20 RPM at 77 °F |
| Specific Gravity* | ASTM D 1475 | 1.05 to 1.10 at 77 °F |
| Elongation | ASTM D 638 | 35 percent, minimum Type I specimen, thickness 0.25 ± 0.03” at Rate = 0.45 inch/minute. |
| | ASTM D 618 | Sample Conditioning: 18/25/50+5/70 |
| Tensile Strength | ASTM D 638 | 2,500 psi, minimum Type I specimen, thickness 0.25 ± 0.03” at Rate = 0.45 inch/minute. |
| | ASTM D 618 | Sample Conditioning: 18/25/50+5/70 |

* Test shall be performed before initiator is added

**519.05 High Molecular Weight Methacrylate (HMWM) Primer.** Primer for the concrete surface shall be a wax-free low odor, high-molecular-weight methacrylate primer, and consist of a resin, initiator, and promoter. The primer shall conform to Table 519-2 and the promoter shall be as recommended by the System Provider.

**-5-**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

Initiator for the methacrylate resin shall consist of a metal drier and peroxide. If supplied separately from the resin, the metal drier shall not be mixed with the peroxide directly. The containers shall not be stored in a manner that allows leakage or spilling to contact the containers or materials of the other.

**Table 519-2**
**HIGH MOLECULAR WEIGHT METHACRYLATE RESIN PROPERTIES (Tested yearly)**

| Property | Test Method | Requirement |
|---|---|---|
| Viscosity* | ASTM D 2196 | $4.0 \times 10^{-5}$ psi (0.025 Pa) maximum (Brookfield RVT with UL adapter, 50 RPM at 77 °F) |
| Volatile Content* | ASTM D 2369 | 30 percent, maximum |
| Specific Gravity* | ASTM D 1475 | 0.90 minimum at 77 °F |
| Flash Point | ASTM D 3278 | 180 °F minimum |
| Vapor Pressure* | ASTM D 323 | 0.04 inch Hg, maximum at 77 °F |
| PCC Saturated Surface- Dry Bond Strength (Adhesive) | California Test 551, part 5 | 700 psi, minimum at 24 hours and 70 ± 1°F (with polyester concrete at 12% resin content by weight of the dry aggregate) |

*Test shall be performed before initiator is added

**519.06 Aggregates.** Polyester concrete aggregate shall have the following properties:

1. Have not more than 45 percent crushed particles retained on the No. 8 sieve when tested in accordance with AASHTO Test Method T335.

2. Provide fine aggregate consisting of natural sand.

3. Have a weighted-average aggregate absorption of no more than 1.0 percent when tested under AASHTO Test Methods T84 and T85.

4. At the time of mixing with resin, have moisture content of not more than one half of the weighted-average aggregate absorption when tested under AASHTO Test Method T255.

5. Comply with the requirements for the aggregate gradation shown in Table 519-3:

**6**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

**Table 519-3**
**AGGREGATE GRADATION (Tested yearly)**

| Sieve Size | Percent Passing |
|---|---|
| 3/8” | 100 |
| No. 4 | 62-85 |
| No. 8 | 45-67 |
| No. 16 | 29-50 |
| No. 30 | 16-36 |
| No. 50 | 5-20 |
| No. 100 | 0-7 |
| No. 200 | 0-3 |

Sand for abrasive sand finish shall have the following properties:

1. Be commercial-quality blast sand.

2. Have not less than 95 percent pass the No. 8 sieve and not less than 95 percent retained on the No. 20 sieve when tested under AASHTO Test Method T27.

3. Have an average absorption of not more than 1 percent when tested under AASHTO Test Method T85.

**519.07 Composite System.**

**Table 519-4**
**COMPOSITE PROPERTIES (Tested every 2 years)**

| Property | Test Method | Requirement |
|---|---|---|
| PPC Saturated Surface Dry Bond Strength | CT 551 | 500 psi minimum at 24 hrs. and 70F (without primer, at 12% resin content by weight of the dry aggregate, on Saturated Surface Dry Specimen) |
| Abrasion Resistance | CT 550 | <2g weight loss (at 12% resin content by weight of the dry aggregate) |
| Modulus of Elasticity | ASTM C 469 | 1,000,000 psi to 1,500,000psi (at 12% resin content by weight of the dry aggregate) |

**CONSTRUCTION REQUIREMENTS**

**519.08 Polyester Overlay Pre-paving Conference.** A Pre-paving Conference shall be held before any overlay paving operations begin. Attendees shall include all parties involved in the work.

**-7-**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

**519.09 Trial Application.** Prior to constructing the overlay, one or more trial applications shall be placed on a previously constructed concrete base to determine the initial set time and to demonstrate the effectiveness of the mixing, placing, and finishing equipment proposed. The set time can be determined when the in-place PPC cannot be deformed by pressing with a finger, indicating the resin binder is no longer in a liquid state. Each trial application shall be the planned paving width, at least 6 feet long, and the same thickness as the specified overlay. The trial applications shall be tined as per the tining requirements in this specification for the final application. The trial application(s) shall replicate field conditions and be constructed using the same equipment as the production work. The location of the trial application(s) shall be approved by the Engineer. Trial applications shall be properly disposed of off-site by the Contractor.

The number of trial applications required shall be as many as necessary for the Contractor to demonstrate the ability to construct an acceptable trial overlay section and competency in ability to perform the work.

Overlay pull bond testing shall be performed in accordance with the acceptance testing herein. Acceptable test results shall be achieved on a trail application before the installation may proceed.

**519.10 Equipment.** All equipment for cleaning the existing concrete surface and mixing and applying the overlay system shall be in accordance with the System Provider's recommendations as approved by the Engineer prior to commencement of any work.

(a) *Mixing Equipment.* A continuous mixer shall be used for all polyester concrete overlay applications.

The continuous mixer shall:

1. Employ an auger screw/chute device.

2. Be equipped with an automatic metering device that measures and records aggregate and resin volumes. Record volumes at least every five minutes, including time and date. Submit recorded volumes at the end of the work shift.

3. Have a visible readout gage that displays volumes of aggregate and resin being recorded.

4. Produce a satisfactory mix consistently during the entire placement.

A portable mechanical mixer of appropriate size for proposed batches, as recommended by the System Provider and approved by the Engineer, may be used for all PPC patching applications and for smaller area applications of less than 2000 cubic feet per contract.

(b) *Finishing Equipment*. A self-propelled slip-form paving machine, which is modified or specifically built to effectively place the PPC overlay in a manner that meets the objectives and requirements of the project, shall be used for all polyester concrete overlay applications. The paving machine shall:

1. Employ a vibrating pan to consolidate and finish the PPC.

2. Be fitted with hydraulically controlled grade automation to establish the finished profile. The automation shall be fitted with substrate grade averaging devices on both sides of the new placement; the device shall average 15 feet in front and behind the automation sensors. The

sensor shall be constructed to work with string-line control. It is acceptable to match grade when placing lanes adjacent to previously placed PPC.

3. Be equipped with controls capable of maintaining the screed at the specified transverse slope within plus or minus 0.1 percent.

4. Have sufficient engine power and weight to provide adequate vibration of the finishing pan while maintaining consistent forward placement speed.

Finishing of patches of Class 1and Class 2 deck removal areas shall be completed using hand finishing tools to make it flush with the top of the existing deck surface.

**519.11 Surface Preparation.**

Existing bridge decks shall be repaired prior to the application of the polyester concrete overlay as shown in the plans and as determined in the field. Spalled and delaminated areas of the deck shall be removed down to sound concrete in accordance with Special Provision 202 – Removal of Portions of Present Structure (Class 1, 2 and 3). All removal areas shall be patched to provide a uniform overlay thickness.

Patching mortars with magnesium phosphate will not be allowed on decks receiving a polyester concrete overlay. Existing mortars that are over 28 days old may remain in place.

All cement-based deck patching material, including mortar and concrete, shall attain a minimum compressive strength of 3000 psi, cure a minimum 5 days, and pass the moisture transmission test prior to placing the polyester concrete overlay.

For newly constructed bridge decks and approach slabs, the deck shall cure a minimum of 28 days and attain the required Field Compressive Strength per Standard Specification 601 prior to overlay placement.

The surface of concrete substrate shall be prepared for application of the overlay by *shotblasting* in order to remove all existing grease, slurry, oils, paint, dirt, striping, cure compound, membrane, or any other contaminants that could interfere with the proper adhesion of the overlay system.

The final prepared surface shall adhere to the following requirements:

1. The areas to be overlaid shall be cleaned by shotblasting or abrasive sandblasted in the event that the shotblaster cannot access areas to be prepared. Cleaning shall not commence until all work involving the repair of the concrete deck surface has been completed and the deck is dry. All contaminants shall be picked up and stored in the vacuum unit and no dust shall be created during the blasting operation that will obstruct the view of motorists in adjacent roadways. The travel speed and/or number of passes of the shotblasting unit shall be adjusted so as to result in all weak or loose surface mortar being removed and the aggregates of the concrete being exposed, as well as a visible change in the concrete color. Cleaned surfaces shall not be exposed to vehicular traffic unless approved by the Engineer. If the deck becomes contaminated before placing the overlay, the Contractor shall shotblast or abrasive sandblast the contaminated areas to the satisfaction of the Engineer at no additional cost.

**-9-**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

2. Any loose particles shall be removed prior to the overlay placement by magnets and compressed air and vacuuming such that no trapped particles remain. Power washing will not be allowed.

3. The areas to be overlaid shall be blown off with compressed air just prior to placement of the primer and shall be completely dry.

4. Surface Preparation Pull Bond Testing shall be performed by the Contractor and submitted to the Engineer for acceptance.

**519.12 Application of Overlay.** Methods shown in this specification are typical of general installations and may be modified per the System Provider's recommendations as approved by the Engineer. The application of the overlay shall not begin until the deck patches have cured for 5 days, or is completely surface dry in accordance with ASTM D4263. Actual surface conditions at the time of overlay placement should be evaluated based on more than just time to dry. The surface should be free of any standing water or darkening of the surface that would indicate locations of previously standing water. The entire surface to receive PPC overlay should uniformly appear light in color, and show no further lightening when drying methods such as compressed air or propane torch are applied. There should be no evidence of moisture in substrate cracks. The concrete surface temperature shall be between 40 and 100 °F. Night work may be required when temperatures cannot be met during the day. Stockpiled materials shall not be stored on the bridge deck.

(a) *HMWM Primer Application.* Immediately before placing primer, all exposed surfaces shall be completely dry and blown clean with oil-free compressed air. Exposed surfaces shall be protected from precipitation and heavy dew during and after the application of the primer.

After the exposed surfaces have been prepared and allowed to dry, primer shall be applied in accordance with the System Provider's recommendations. Primer shall be placed within 5 minutes of mixing at approximately 90sf/gal or the rate recommended by the System Provider.

Primer shall be uniformly spread to completely cover surfaces to be overlaid. Care shall be taken to avoid excess application that results in puddling. Excess material shall be removed or distributed to meet the required application rate. Primer shall be reapplied to any areas that appear dry after 15 minutes of absorbing the material.

Primer shall not be allowed to leak onto areas that have not received surface preparation.

(b) *Polyester Concrete Application.* The polyester concrete shall be applied after 15 minutes and within 2 hours after the primer has been applied. The polyester concrete shall be placed prior to gelling or 15 minutes following addition of initiator, whichever occurs first, or within a more restrictive range if recommended by the System Provider.

The polyester resin binder shall be initiated and blended completely. Aggregate shall be added and mixed for at least two minutes when a portable mechanical mixer is used.

Polyester concrete shall have an initial set time of at least 30 minutes and at most 120 minutes when tested using an initial-setting time Gillmore needle under ASTM C 266. The set time can be determined in the field when the in-place PPC cannot be deformed by pressing with a finger,

**-10-**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

indicating that the resin binder is no longer in a liquid state. If the initial set is not within 30-120 minutes, the material shall be removed and replaced. Shorter times may be required by the System Provider and approved by the Engineer.

The overlay shall be consolidated and finished to the required grade and cross-section using a PPC paver as defined herein.

Placement of the overlay to the profile and cross-section shall be controlled by taut reference line string-lines on both sides of the paver. Placement and finishing equipment shall use the string-lines as a reference for automatic hydraulic control of finished grade. The reference elevation and string-line shall be established by the Contractor and is subject to the approval of the Engineer.

Although the paver should yield a finished surface, additional finishing may be necessary. PPC shall be finished as necessary through traditional concrete finishing methods, producing a slight resin bleed indicating complete consolidation of aggregates.

A surface friction sand finish of at least 2.2 lbs. per square yard shall be broadcast onto the glossy surface immediately after finishing and before resin gelling occurs. Surface friction sand shall be broadcast after finishing and prior to tining by hand; if the tining device is mounted directly to the paving machine the surface friction sand shall be broadcast after tining. To ensure adequate pavement friction, the completed PPC overlay surface shall be free of any smooth or "glassy" areas such as those resulting from insufficient quantities of surface aggregate.

Any such surface defects shall be repaired by the Contractor in the manner recommended by the System Provider and approved by the Engineer at no additional cost.

The coefficient of friction of the treated surface must be at least 0.35 when tested in accordance with California Test 342.

The overlay shall be longitudinally tined. Tining shall produce grooves of 1/8 inch by 1/8 inch spaced at ¾ - 1" inch apart. Tining grooves shall be neat in appearance and uniform in depth. Tining devices shall be maintained clean and free from encrusted mortar, polyester resin, sand and polyester concrete to ensure uniform groove thickness.

Unless indicated on the plans, tining shall run parallel with the direction of traffic and shall extend across the entire applied deck surface except for 1' next to the curb. The tining shall not be performed too early whereby the grooves may close up, or too late whereby the grooves are of inadequate depth.

All working deck joints shall be extended through the overlay and be sealed according to the details in the plans.

Polyester concrete overlay edges shall be tapered if the overlay is not completed within the allowable lane closure time and is more than ¾ inch higher in elevation than the adjacent pavement.

**-11-**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

Tapered edges transverse to the direction of traffic shall be at a 20:1 (horizontal:vertical) slope. Tapered edges longitudinal to the direction of traffic shall be at a 4:1 (horizontal:vertical) slope. Tapers may remain and be overlaid with polyester concrete overlay.

(c) *Curing*. The Contractor shall protect the overlay from moisture for a minimum of 4 hours.

The Contractor shall allow the overlay to cure sufficiently before subjecting it to loads or traffic of any nature that may damage the overlay. Cure time depends upon the ambient and deck temperatures.

The overlay shall be considered cured to a firm, hard state when 4 hours have passed or a minimum reading of 25 on a properly calibrated Schmidt hammer.

(d) *Saw Cut Joints*: Saw cutting and sealing of all joints shall be done according to the joint specifications and the details in the plans. The time of sawing shall be determined by the Contractor to prevent random cracking and raveling from the sawing. The time will be dependent upon weather conditions, temperature, and other factors affecting the setting of the polyester concrete. If uncontrolled cracking occurs, the contractor shall repair the crack as recommended by the System Provider and as approved by the Engineer.

**519.13 Acceptance Testing.** Acceptance of the deck patch, surface preparation, and thin bonded overlay will be determined by the Engineer based on moisture transmission tests, vertical axis pull bond tests, and smoothness quality testing performed by the Contractor.

(a) *Materials Sampling*: Contractor shall provide access to equipment in order to acquire materials samples and measuring of resin binder levels in the resin tank of the mobile mixing truck.

(b) *Deck Patch Moisture Transmission Testing.* Moisture transmission tests shall be performed by the Contractor using the Plastic Sheet Method in accordance with ASTM- D4263. This test consists of an eighteen inch by eighteen inch square of clear plastic sheeting that is sealed to the concrete surface with tape on all four sides. After sixteen hours, if any condensation is found on the underside of the plastic or if the concrete surface is darkened, the test will be considered failing.

(c) *Overlay Pull Bond Testing.* Vertical axis pull bond tests shall be performed after 24 hours by the Contractor in accordance to ASTM C1583, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-Off Method). . At a minimum, 2 pull bond tests shall be performed on each bridge. For bridges with deck areas greater than 25,000 square feet, additional tests shall be performed at a frequency of one test per 25,000 square feet of additional deck area, rounded up. Additional testing may be required as directed by the Engineer.

The test result shall be the average of the number of tests for each structure, drilled a minimum of 0.25" but no greater than 0.50" below the bond line.

The bond strength of the PPC overlay system on normal weight concrete shall be 250 psi. An acceptable test will demonstrate that the overlay bond strength is sufficient by producing a concrete subsurface failure area greater than 50% of the test surface area. The contractor shall repair all bond test locations with polymer overlay in accordance with this specification.

**-12-**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

(d) *Smoothness Quality Testing.* The finished transverse and longitudinal surface elevation of the pavement shall be measured using a 10 foot straightedge. Areas to be measured will be as directed by the Engineer. The Contractor shall furnish an approved 10 foot straightedge, depth gauge, and operator to aid the Engineer in testing the pavement surface.

**519.14 Corrective Work.**

(a) *Repair of Surface Defects.* The repair materials and finishing methods for surface defects in the overlay shall be in accordance to those used for the application of the overlay. All surface defects shall be repaired to the satisfaction of the Engineer before acceptance of the work is made.

(b) *Correction for Smoothness.* Areas showing high spots of more than 3/16 inch in 10 feet shall be marked and diamond ground until the high spot does not exceed 3/16 inch in 10 feet. Longitudinal tining shall be grooved to restore the longitudinal texture (tining).Areas showing low spots of more than 3/16 inch in 10 feet shall be marked and prepared with shot blasting or sandblasting, primed, and filled with either resin or mixed material. The use of resin or mixed material shall be as recommended by the System Provider and approved by the Engineer.

(c) *Replacement of Defective Overlay.* A defective overlay, or portion thereof, resulting in failing overlay pull bond test results shall be removed and replaced at the Contractor's expense. 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 Engineers approval shall not relieve the Contractor of the responsibility of producing work in conformity with the Contract.

(d) *Defective Tining*: If the Engineer determines tining to be unacceptable, based on criteria in 519.12 (b), the tined surface shall be repaired with resin and the repaired surface shall be textured per requirements in 601.15(e)2.

The Contractor shall collect a ticket for each pass or portion of a pass that is provided by each mixer, and ensure that the following information is shown on each ticket:

1. Project Number
2. Bridge Number
3. Date and Time
4. Ticket Number
5. Material Type
6. Location of Placement (Lane and Station Limits)
7. Aggregate Weight
8. Polyester Resin Binder Weight

**-13-**
**SECTION 519**
**THIN BONDED OVERLAY (POLYESTER CONCRETE)**

The tickets shall be available on site for CDOT personnel to inspect.

Each day the Contractor shall provide to the Engineer separate envelopes for each bridge which contains the previous day's signed tickets and the following:

1. On each envelope: Project Number, Bridge Number, Date of Paving, Type of Material, Daily Total, Cumulative Total, and Suppliers Name.

2. One of the following:

   A. Two adding machine tape tabulations of the weight tickets with corresponding totals run and signed by different persons,

   B. One signed adding machine tape tabulation of the weight tickets that has been checked and signed by a second person,

   C. Signed check tape of computer scale tickets that have a cumulative total. These scale tickets must be consecutive.

3. A comparison of the actual yield for each day's placement to the theoretical yield. Theoretical yield shall be based on the actual area paved and the planned thickness of the mixture being placed. Any variance greater than 5% shall be indicated on the envelope and a written explanation included.

## SECTION 522
## DUPLEX COATING SYSTEM

Section 522 of the standard specifications is hereby added to the Standard Specifications for this project as follows:

### DESCRIPTION

**522.01** This work consists of hot dip galvanizing and duplex coating steel structures as shown in the Contract.

### MATERIALS AND CONSTRUCTION REQUIREMENTS

**522.02**

(a) *General*. The Contractor shall provide, install, and repair if necessary, all steel items that are prepared and coated in conformance with this Section. All repair and replacement of the finished coating necessary for final acceptance shall be at the Contractor's expense.

Steel products to be galvanized and coated shall be cleaned of weld spatter and bevel finished at exposed corners, edges and points. Areas having welds, cuts, bores, notches, or grooves shall also be beveled unless otherwise noted in the Contract or directed by the Engineer. Bevel work shall produce a uniform, smooth finish for galvanizing. Bevel size to be used is based on steel thickness and other criteria as follows:

| Steel Thickness/Type | Bevel Size (inches) |
|---|---|
| Less than ½" thick | 1/32" to 1/16" |
| Over ½" thick | 1/16" to 1/8" |
| Bores, notches & grooves | root face of 1/32" to 1/16" |

Welds shall be cleaned and finished according to AWS standards.

All coating measurements shall be taken with a Type 2 fixed probe Dry Film Thickness (DFT) gauge. The gauge shall be calibrated, and measurements shall be taken, according to the Society for Protective Coatings (SSPC) Standard PA-2.

(b) *Galvanizing.* Galvanizing shall be done in accordance with the Contract requirements and AASHTO M 111 (ASTM A123) for the type of material being galvanized, except that items shall only be quenched with ambient air. The poles and arms for traffic signals and signs shall be hot dipped galvanized inside and outside. Chromate treatment of any type will not be permitted. Zinc-phosphate pretreatment or acrylic passivation pretreatments shall be as described in (d) below.

The Contractor shall submit a certificate of compliance (COC), conforming to subsection 106.12, confirming that all materials meet or exceed the galvanizing requirements described herein.

All galvanized surfaces shall be free from drips, slag, or surface irregularities.

Spot areas not requiring galvanizing shall be marked and cleanly patched with material that prevents galvanization but does not weaken the adjacent spelter coating. Repair of patched areas shall be achieved by metallizing as described in (c) below.

**-2-**
**SECTION 522**
**DUPLEX COATING SYSTEM**

Prior to galvanizing, the Contractor's galvanizer shall notify the Engineer in writing that the galvanized order is chromate free and air quenched. Products not certified chromate free by the Contractor's galvanizer shall be tested prior to galvanizing. The Contractor shall provide the Engineer with certification from an independent ASTM accredited laboratory listing all individual items that test chromate free. Testing shall comply with ASTM D-2092 Appendix X2. Test results shall be provided to the Engineer prior to galvanizing.

(c) *Repair of Galvanized Products.* Uncoated areas or damaged coating exceeding applicable specification limits shall be re-galvanized to meet the original specification requirements. Cuts made after galvanizing shall be ground, beveled, and smoothed before repair. Damaged galvanized areas shall be re-galvanized or metallized.

Re-galvanizing shall conform to ASTM A-780, Annex A1. Metalizing shall conform to ASTM A-780, Annex A3, except that minor repair areas shall be cleaned according to SSPC method SP-3. SSPC Method SP-2 may be used to clean difficult access areas. Thickness of the repair coat shall match adjacent galvanizing, as measured by a calibrated DFT gauge.

Coating imperfections such as burring, runs or drips, high spots, heavy dross, or ash inclusion shall be removed and cleaned at the Contractor's expense. Areas of re-work falling below zinc thickness limits shall be repaired at the Contractor's expense.

Printed Technical Data Sheets (PTDS) shall be provided to the Engineer for repair materials used.

(d) *Preparing Galvanized Surfaces for Coating.* Products shall be inspected for shipping and handling damage before surface preparation begins. Damage shall be reported to the Contractor's galvanizer and to the Engineer prior to repair. The Engineer will determine whether damaged items are to be repaired or replaced. Minor repair of galvanizing shall conform to (c) above, and shall be at the Contractor's expense.

The Contractor shall prepare each surface to be coated so that it has a slightly roughened profile without removing over 1.0 mil of the galvanized coating. Minimum ASTM zinc thickness specifications shall still apply after preparation.

Surfaces of fasteners to be coated shall be lightly brushed or sanded in a manner that will remove the least amount of zinc.

Surfaces that become soiled after pretreatment shall be cleaned prior to coating by low pressure, mild detergent wash and rinse. Stained or oiled surfaces may also be mildly scrubbed with a soft bristle nylon brush. Stubborn stains may be mildly scrubbed with a mix of 1 - 2 percent ammonia solution and thoroughly rinsed. Wash and rinse pressure shall not exceed 100 psi at 185° F temperature.

Surface preparation work shall be done according to one of the following methods:

**-3-**
**SECTION 522**
**DUPLEX COATING SYSTEM**

1. *Zinc-Phosphate Pretreatment.* This treatment may be used only on new galvanizing less than 48 hours of age.

   Items shall be immersed in a bath of acidic zinc-phosphate solution for 3 - 6 minutes, rinsed with clean water, and dried. The first epoxy coat shall be applied within 48 hours after immersion treatment.

   If treated items are shipped to a different coating facility they shall be rewashed, rinsed and dried to remove surface soiling. The first epoxy coat must still be applied within 48 hours after immersion treatment.

2. *Acrylic Passivation Pretreatment.* This treatment may be used only on fresh hot galvanizing or new galvanizing less than 48 hours of age. Only chrome-free solutions shall be used, applied by a method that ensures complete coverage of all surfaces to be coated. The Contractor shall provide the Engineer with treatment dates for each item and the PTDS for the solutions used.

   The Contractor's galvanizer may apply solution to fresh hot galvanizing that is less than 6 hours of age, still clean, and dry and that has cooled to treatment application temperature guidelines.

   If newly galvanized items are shipped to another treatment facility they shall be washed, rinsed and dried to remove surface soiling. The solution shall then be applied and cured according to the supplier's instructions.

   Fully cured and treated items shall be rewashed, rinsed, and dried again just before coating. Items not coated within 100 days of treatment shall be abrasive blasted in conformance with subsection (d) 3.

3. *Abrasive Blasting.* This treatment may be used on galvanized items of any age if beveling requirements as listed in the third and fourth paragraphs of subsection (a) have been met.

   The Contractor shall notify the Engineer in writing at least five working days before blasting begins. Zinc thickness shall be measured and recorded immediately after blasting and provided to the Engineer within 48 hours of blasting. Thickness limits and measurement frequency shall comply with the original applicable ASTM specification. Blast operations shall reasonably conform to ASTM Standard Practice D-6386, Subsection 5.4.1 except for small areas falling below required zinc thickness. These areas shall be repaired in accordance with subsection (c). No single area shall exceed 2 inches at its largest width or 12 inches at its longest dimension. The total repair area shall not exceed 1 percent of the coatable surface of the item; if limits are exceeded or zinc thickness is below the specification requirement, the item shall be re-galvanized in conformance with the original specification.

   The Contractor shall measure and record the size, location and repair method used for all repairs. This information shall be included on the report of thickness measurements.

**-4-**
**SECTION 522**
**DUPLEX COATING SYSTEM**

The first epoxy coat shall be applied within 24 hours of abrasive blasting. Items shall be cleaned free of blast debris before coating. Compressed air used to clean items shall be free of oil, residue, oil and other harmful contaminants.

Thickness measurement is not required after surface preparation work has been completed.

(e) *Coating and Paint Systems.* Prepared items shall be coated with a two or three coat system described in this subsection. Alternative coating systems shall be pre-approved in writing by the Engineer. Manufacturer's PTDS for each coating type shall state test values for ASTM requirements of this subsection. Prior to product use the coating supplier shall provide the PTDS and certify to the Engineer in writing that all furnished coating materials meet applicable requirements of this subsection.

Faying surfaces shall not be painted unless written approval is given by the Engineer. All shop fabrication, including welds and attachments, shall be completed prior to coating unless otherwise specified in the Contract or directed in writing by the Engineer.

Inorganic zinc coatings shall not be used. Combined DFT of all coats applied over the galvanizing shall range from 6.5 to 10 mils with a topcoat DFT of 3 mils minimum. Dried color of the base coat and topcoat shall be visually contrasting. Finished color shall not vary more than 4 $\Delta E^*_{ab}$ units from the specified color determined in accordance with ASTM D 2244.

Volatile Organic Compound (VOC) levels shall not exceed 3.5 pounds per gallon for each applied coat. Dry films shall contain less than 1 percent lead and other toxic heavy metals. The zinc concentration of each epoxy coat shall not exceed 40 percent. Top coats shall have a semi-gloss value of 50-75.

All coatings shall be able to withstand temperatures up to 180° F without sag, blister, or peel damage. Topcoat formulation shall provide weathering, chemical, and ultraviolet (UV) resistance. All coatings shall meet the following ASTM requirements as amended:

(1) Corrosion Weathering. ASTM D-5894, minimum 6-cycles of exposure:
Corrosion rating of 8 or higher according to ASTM D-1654.
Blistering rating of 8 or higher according to ASTM D-714.

(2) Impact Resistance. ASTM D-2794, 30 day test:
Epoxies – Minimum 40 inch-pounds
All Topcoats – Minimum 90 inch-pounds

(3) Adhesion Testing. ASTM D-4541, 30 day test, Minimum 500 psi for either: Method B - flat surface or Method E - curved surface.

(4) Abrasion Resistance. ASTM D-4060, 30 day test: Maximum 90 mg loss after 1000 cycles with a CS10 or CS17 wheel.

(5) Flexibility. ASTM D-522, 30 day test - Method B: Epoxies shall pass a 180 degree bend over a ¾ inch mandrel. All Topcoats shall pass a 180 degree bend over a 3/8 inch mandrel.

**-5-**
**SECTION 522**
**DUPLEX COATING SYSTEM**

Each coat shall be applied uniformly to provide an appearance free of laps, streaks, sags, drips, pinholes, and other discontinuities; all such defects shall be repaired prior to product shipment.

The Contractor's coater shall measure the DFT of each applied coat according to SSPC, Guide PA-2, except that measurements shall be taken with a calibrated Type 2 fixed probe gauge. Thickness records shall be provided to the Engineer prior to project shipment. The following two coating systems do not require pre-approval:

1. Powder Coating. The Contractor's coater shall oven preheat the articles to abate out-gassing potential. The Contractor's coater shall use compatible materials and coating processes to obtain proper coat to coat adhesion.

   The epoxy powder base coat shall measure 2 to 6 mils DFT and be applied by electrostatic or airstatic spray. The powder formulation shall be a non-hybrid epoxy of anti-gassing grade.

   The powder topcoat shall be electrostatic or airstatic spray applied and measure 3 to 6 mils DFT. The powder formulation shall be a non-acrylic, high-build, aliphatic-based, enhanced polyester or urethane polyester of anti-gassing grade.

2. Liquid Coating. The Contractor's coater shall apply coats by conventional or airless spray according to the supplier's guidelines. Minimal striping at difficult work areas is permissible. The Contractor's Coater shall use proper work methods and compatible materials to obtain proper coat adhesion. Thinning of paints shall be done according to the manufacturer's instructions so that thinned products conform to the solids content and VOC limits of this subsection.

   The epoxy base coat shall measure 2 to 6 mils DFT. Paint shall be a low-blush epoxy polyamide, or a low-blush cycloaliphatic bisphenol-A polyamine. Minimum solids by weight of all epoxies used shall be 68 percent.

   The topcoat shall measure 3 to 6 mils DFT. Paint shall be an aliphatic-based urethane polyester or aliphatic-based polyurea urethane. Specially formulated aliphatic-based polyaspartic polyureas may also be used over compatible epoxy bases.

(f) *Repair of Coated Products.* The Contractor shall repair damage from shipment, installation, field welding, or other Activity during the construction. Damage shall be reported to the Engineer prior to repair. Repairs shall be as directed by the Engineer.

Significant repair procedures require written submittal of a proposed repair process from the Contractor. The Engineer shall approve the proposal in writing before repairs begin. Significant repairs are classified as:

(1) Any damaged area to the base coat material over 1 square inch

(2) Total repair areas exceeding 5 percent of the coating per item

(3) Any single topcoat repair area over 64 square inches

**-6-**
**SECTION 522**
**DUPLEX COATING SYSTEM**

Minor and touchup repair of topcoats shall be done as follows:

A UV rated, aliphatic-based liquid topcoat paint shall be used. The paint shall be compatible with the existing topcoat material and closely match existing color. The paint shall meet the requirements of subsection (e). The paint supplier shall provide the Engineer with PTDS for the products used.

Single areas smaller than 8 square inches requiring repair shall be scuffed with 220 grit sandpaper or equivalent scuff material. Larger areas up to 64 square inches may be cleaned according to SSPC, Method SP-2. All border areas at the undamaged topcoat shall be scuffed with 220 grit material.

Cleaned, scuffed areas shall be bordered and coated by airless or conventional spray. Work areas shall be adequately shielded to contain errant spray. Fresh repair areas shall be protected as necessary during the initial cure. Repair thickness shall reasonably match the adjacent coating.

The repair coat shall provide an appearance free of sags, runs, streaks, drips, pinholes, or other discontinuities. Spray can paint repair shall not be used**.**

(g) *Conditions for Final Acceptance of Coating.* Within six weeks immediately prior to final project acceptance, the Engineer and a representative of CDOT's Staff Bridge Branch will conduct a final inspection of the coating. The Contractor's Superintendent shall also attend the inspection. Before final project acceptance, the Contractor shall repair the following defects found during the inspection:

Peeling on any portion of the coatings.

a. Blistering on any portion of the coatings.

b. Color fading below a 35 gloss rating, in accordance with ASTM D523.

c. Mottling defects that exceed 3 percent of the topcoat surface.

d. Visible cracking of the topcoat material.

e. Visible rusting discoloration on the coating.

f. Sag or other evidence of coating adhesion loss.

## REVISION OF SECTION 601
## CONCRETE (PATCHING)

Section 601 of the Standard Specifications is hereby revised for this project to include the following:

### DESCRIPTION

This work consists of furnishing and placing concrete patching material in accordance with these specifications and in conformity with the lines, grades and dimensions as shown on the plans or established.

### MATERIALS

Concrete for patching shall conform to the following:

Concrete or mortar patching materials shall be a be polymer modified Portland cement based concrete and shall be one of the following:

(1) CTS Cement Manufacturing, Rapid Set DOT Mix
(2) Quikcrete Companies, Rapid Road Repair
(3) Equal Alternative approved by the Engineer

Equal Alternative materials shall demonstrate 1/32-inch maximum mid panel and end crack widths as tested by NTPEP in a one-year field evaluation. Refer to rapid-set concrete patch materials at www.ntpep.org

The Contractor shall obtain and provide to the Engineer documentation from the material supplier of the expiration dates of the material components that will be used on the project.

Concrete patching material shall attain an average compressive strength of at least 3,000 psi at 3 hours and 4,000 psi at 24 hours.

Concrete patching material compressive strengths shall be tested according to ASTM C39 or ASTM C109. The compressive strengths shall be used to develop a strength versus time curve for the material. Three strength data points shall be determined to assess the necessary time to wait before traffic is allowed on the material.

Concretes or mortars shall provide a minimum bond strength of 2,000 psi, as tested by ASTM C882.

Concretes or mortars shall have a relative durability factor greater than 90 and a mass loss not to exceed 2.0 percent as tested by ASTM C666.

Concretes or mortars shall have a maximum expansion of 0.05 percent, at 28 days as tested by ASTM C596.

ASTM C39, C109, C882 and C596 testing shall be from the same lot of material being used on the project. Certified Test Reports shall be submitted to the Engineer for approval at least 2 weeks prior to placement.

Samples from two bags from the same lot to be used on the project shall be submitted by the Contractor before the patching material is to be used on the project to an accredited Lab to verify bond strength, compressive strength, and set time properties. Tests results shall be submitted to the Engineer for

**-2-**
**REVISION OF SECTION 601**
**CONCRETE (PATCHING)**

acceptance one week prior to incorporating the material into the project. Verification of the strength properties will be achieved if the test results are either equal in strength or stronger than those advertised. Verification of the set time will be achieved if the set time is equal or less than the advertised value. . Test results from other projects using the same lot may be submitted. If the project uses material from more than one lot, test results are required for each lot used.

*(a)* *Electrical resistivity.* The Contractor shall submit documentation from the manufacturer confirming the concrete or mortar material has been tested in accordance with ASTM C1760, or by electrical test procedure submitted to the Engineer for approval, and has an electrical resistivity (reciprocal of conductivity) equal to or less than 15,000 Ohm-Centimeters.

Materials having resistivity higher than 15,000 Ohm-cm are considered non-conductive. Non-conductive materials may be used with special anode installation methods, as recommended by the anode manufacturer and as approved by the Engineer. All additional work to address the special installation methods shall be at the Contractor's expense.

**CONSTRUCTION REQUIREMENTS**

Concrete patching material shall be placed in the repair areas before the expiration date of the material.

Proportions of all mix components shall be weighed on a calibrated scale provided by the Contractor.

The Contractor shall produce a ticket for each mixed batch with the following information shown on each ticket:

(1) Project No.
(2) Bridge No.
(3) Structure Temperature
(4) Date and Time of batch
(5) Material Type, name, and manufacturer
(6) Material expiration date
(7) Weight of bag mix concrete
(8) Weight of extending aggregate
(9) Weight of water or liquid component
(10) Location of placement (Lane and Station Limits)

The tickets shall be available on site for CDOT personnel to inspect.

Each day the Contractor shall provide to the Engineer tickets for each bridge in separate envelopes stating Project Number, Bridge Number, Date of Paving, Type of Material, Daily Total, and Cumulative Total

Concrete patching material minimum and maximum thicknesses shall be per recommendation of the material manufacturer.

Concrete patching material site preparation, batching, extending with aggregate, mixing, placement, placement during cold temperatures, consolidation, and curing shall be in accordance with the

**-3-**
**REVISION OF SECTION 601**
**CONCRETE (PATCHING)**

manufacturer's recommendations. A mix may be extended per the manufactures recommendations up to 90% of the manufacturer's maximum extension.

The surface of concrete patching material shall be flush and have a similar texture as the adjacent driving surfaces.

The Contractor shall submit a report consisting of the mix proportions and compressive strength vs time curve information to the Engineer at least two weeks before the material is to be used on the project.

Two field information cylinders or cubes shall be taken each day deck patching material is placed with compressive strength determined at 24 hours according to ASTM C 39 or ASTM C109.

Areas patched with Concrete (Patching) shall not be opened to traffic until the Contractor demonstrates that the concrete patching material has reached a compressive strength of 3,000 psi using the compressive strength versus time curve developed for the material.

## REVISION OF SECTION 601
## GALVANIC ANODES

Section 601 of the Standard Specifications is hereby revised for this project to include the following:

### DESCRIPTION

This work consists of furnishing and installing galvanic anodes in bridge deck at locations as shown on the plans.

### MATERIALS

Galvanic anodes shall be one of the following:

(1) "Galvashield XP2" as manufactured by Vector Corrosion Technologies,
1330 Bellaire Street
Broomfield, CO 80020
303-465-5806

(2) "MasterProtect 8105 CP" as supplied by BASF Corporation,
889 Valley Park Drive,
Shakopee, MN 55379
800-433-9517

(3) "Sentinel Silver" as manufactured by Euclid Chemical
19218 Redwood Rd.
Cleveland, OH 44110
800-321-7628

(4) "Galvashield XP+" as supplied by Sika Corporation
201 Polito Ave.
Lyndhurst, NJ 07071
248-577-0980

Galvanic anodes shall be pre-manufactured and consist of a minimum of 100 grams of zinc conforming to ASTM B6 Special High Grade, cast around a pair of steel tie wires conforming to bright annealed ASTM A82.

The concrete patching material shall be as shown on the plans or as approved. If non-conductive materials are used the Contractor shall contact the manufacturer of the anodes to gain a full understanding of any special treatments that will be required and the process to properly install the anodes. The documentation of the anode manufacturer's approval acceptance of the patching material and any special treatment requirements and installation instructions shall be submitted to the Engineer for approval prior to start of repair work. Any grout used for grout beds or encapsulation of anodes shall have compressive strength equivalent to the deck concrete.

### CONSTRUCTION REQUIREMENTS

Anodes shall be installed the same day as preparation and cleaning of steel reinforcement to bright metal at the anode tie wire connection. The anode units, in cementitious patching material, shall be pre-wet to achieve a saturated surface dry condition, and the repair shall be completed while the anodes are in this condition.

**-2-**
**REVISION OF SECTION 601**
**GALVANIC ANODES**

Anodes used with material having resistivity greater than 15,000 Ohm-Centimeters (Ohm-cm) shall be specially treated and installed in accordance with manufacturer recommendations. The treatment and special installation shall be at the Contractor's expense.

Galvanic anodes shall be installed in accordance with manufacturer's recommendations. Anodes shall be placed 18 to 24 inches apart on the perimeter, based on rebar spacing. Anode may be placed in the middle of the patching material area if the spacing requirement cannot be met. The anode shall have a minimum 1.5 inch top cover to the surface of the new concrete deck patch and a 1 inch minimum side and bottom clear cover.

Galvanic anodes shall be secured with anode tie wires as close as possible to the patch edge while achieving minimum cover requirements. The tie wires shall be wrapped around the cleaned reinforcing steel and twisted tight to allow little or no free movement.

Prior to placing new concrete, galvanic anodes shall be installed in accordance with the manufacturer's recommendations and inspected for proper connection to reinforcing steel.

*(a) Electrical Continuity.*
Electrical connection between anode tie wire and reinforcing steel shall be confirmed by measuring DC resistance (ohm) or potential with a multi-meter.

Electrical connection is acceptable if the DC resistance measured with multi-meter is less than 1 ohm or the DC potential is less than 1 mV.

Electrical continuity of the exposed reinforcing steel within the repair area shall be confirmed. If necessary, electrical continuity shall be established with steel tie wire.

Electrical continuity between the areas is acceptable if the DC resistance measured with multi-meter is less than 1 ohm or the potential is less than 1 mV.

The Contractor shall furnish the Department with a multi-meter to independently check the electrical connection. The multi-meter shall become the property of the Department.

Payment shall be full compensation for all labor, equipment, and materials required to install the galvanic anodes.

Electrical continuity wiring and testing will not be measured and paid for separately, but shall be included in the work.

The multi-meter will not be measured and paid for separately, but shall be included in the work.

If additional anodes are found to be required during construction, these additional anodes will be paid for at the original Contract unit price.

Any special treatment of the anodes that is required by anode supplier due to the type of patching material used, including but not limited to, grout beds between substrate and anode, or grout encapsulation of the anodes, shall be included in the work.

## REVISION OF SECTIONS 601 and 708
## STRUCTURAL CONCRETE STAIN

Section 601 and 708 of the Standard Specifications are hereby revised to include the following:

Subsection 601.01 is revised to include the following:

This work consists of: (1) Class 1 ordinary surface finish of concrete to receive Concrete Stain; (2) sandblasting to remove form release agents and other deleterious material (3) providing and applying an opaque structural concrete stain to all concrete surfaces previously designated in the Contract to receive a structure concrete stain; and (4) provide up to 5-gallons of pre-mixed touch-up stain in aerosol spray cans.

The contractor shall provide one foot by one foot test panel to the Engineer for each specified color for approval two (2) weeks prior to ordering materials.

The structural concrete stain shall be one of the following products or Approved equals:

1. RAINSTOPPER RS400 – Semi Transparent Stain
   Textured Coatings of America
   Pro-Coat Systems, Inc.
   5775 Stapleton Drive North
   Denver, Colorado 80216
   303-322-9009

2. "Acrylic" Structural Concrete Stain
   Anchor Paint Co. of Denver, Inc.
   641 South Jason
   Denver, Colorado 80223-2305
   303-744-2361

3. Bridge and Highway Concrete Sealer, B97-Series
   The Sherwin-Williams Company
   543A Santa Fe Drive
   Denver, Colorado 80204
   303-893-1303

Subsection 601.03 is revised to include the following:

Structural Concrete Stain as specified in subsection 708.08.

Subsection 601.09(f) is revised to include the following:

All concrete forms shall be treated with a water based concrete form release agent prior to placing reinforcement for surfaces to which structural concrete stain is to be applied.

Subsection 601.14 (a), third paragraph, is deleted and replaced with the following:

Structural concrete stain shall be the final finish for all concrete surfaces designated on the plans and in these specifications.

Subsection 601.14(b)4 is deleted and replaced with the following:

Unless otherwise shown in the Contract, the structural concrete stain shall be applied to all exposed concrete elements of the structure above the ground line, and shall extend 1-foot below the finished ground line. Bridge bearing devices, curb and barrier cover plates, fence, and steel bridge rail components shall be masked or otherwise protected to prevent structural concrete stain from coming into contact with them.

**-2-**

**REVISION OF SECTIONS 601 and 708**
**STRUCTURAL CONCRETE STAIN**

The color of the Structural Concrete Stain shall have the written approval of the Engineer prior to final batching and application on the project. The final color of the approved structural concrete stain shall be determined as follows:

1. 2 foot by 2 foot samples of the colors required by the Contract, shall be submitted to the Engineer for Approval. The Stain samples shall be applied to a surface similar in texture to the concrete surface on which the stain will be applied on the project. The Stain samples shall be applied by the same methods to be used in field application.
2. At least three weeks prior to beginning of the application of the structural concrete stain, 100 sf test panels shall be prepared for final color Approval. The test panels shall be produced on the actual concrete surface on which the final product will be placed, at a location recommended by the Contractor and approved by the Engineer. The stain shall be applied to the test panels by the same methods to be used in the final field application. The Engineer will be allowed three business days for the stain to dry after stain application to the test panels and to issue Approval.

Concrete finishing and curing shall be completed in accordance with the specification prior to the application of the Stain. The concrete finish to which the structural concrete stain is to be applied shall be a Class 1 Ordinary Finish, except as modified below:

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 Stain. 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 1/2 inch or larger in any dimension, broken corners and edges, and other defects. The mortar mix shall include an approved bonding agent. The quantity and application procedure of the bonding agent shall be 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 3/4 inch shall be filled in layers that do not exceed 1/2 inch in thickness.
3. Within 24 hours prior to applying structural concrete stain, the concrete surface to be coated shall be cleaned by water blasting at a minimum pressure of 3,000 psi and at a rate of 4 to 14 gallons/minute, 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 re-cleaned as required prior to application of the coating.

New concrete shall be at least 28 Days old or as approved in writing by the stain manufacturer before it is applied.

**-3-**
**REVISION OF SECTIONS 601 and 708**
**STRUCTURAL CONCRETE STAIN**

Two coats of stain shall be applied. Each coat shall be applied at a rate of 200 to 250 square feet per gallon. (Approximately 3 mils dry film thickness.) The second coat shall not be applied until at least 12 hours after the application of the first coat

If the surface is contaminated between coats it shall be re-cleaned as stated above prior to application of the next coat.

The stain shall be mixed mechanically and applied by spraying. Workmanship shall be such that the final stained surface is colored uniformly and presents a pleasing appearance. Any areas determined by the Engineer to be insufficiently stained shall be re-stained.

The stain 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 twenty-four hours. The surface to be stained shall be dry and free of frost.

Subsection 708.08 is revised to include the following:

708.08 Structural Concrete Stain: The Stain shall be a one-component, non-vapor barrier, solvent based acrylic resin. No sand or other texturing agents will be permitted.

PHYSICAL PROPERTIES

Solid by Weight: 51%, plus or minus 2%

Solids by Volume: 34%, plus or minus 2%

A material safety data sheet (MSDS) prepared in accordance with Federal Standard 313 and a complete set of manufacturers mixing and application instructions shall be submitted to the Engineer before the Contractor begins applying the Stain.

## REVISION OF SECTION 604
## VANE GRATE INLET (SPECIAL)

Section 604 of the Standard Special Provisions is hereby revised for this project as follows:

### DESCRIPTION

Subsection 604.01 shall include the following:

This work includes the furnishing and placing of approach slab vane grate inlets special in accordance with details shown on plans and specifications.

### MATERIALS

Subsection 604.02 shall include the following:

All vane grate inlet special, grates and castings shall be grey cast iron class 35, meeting the requirements of ASTM A48-83, AASHTO M105-82.

### CONSTRUCTION REQUIREMENTS

Subsection 604.03 shall include the following:

Vane grate inlet special shall be installed at the location shown on the plans.

Prior to fabrication and construction of the Vane Grate Inlet Special item, two sets of working drawings which comply with requirements of section 105 shall be submitted to the engineer for information only. The working drawings will not be approved or returned.

## REVISION OF SECTION 607
## FENCE (SPECIAL)

Section 607 of the Standard Specifications is hereby revised for this project as follows: Subsection 607.01 shall include the following:

Fence (Special) shall consist of 3 cables supported by pipe posts bolted to the tops of retaining walls as shown on the plans. Fence (Special) shall be 42 inches tall and the cables equally spaced.

Subsection 607.02 shall include the following:

Posts, and horizontal and diagonal members shall be standard or extra strong steel pipe, as noted in the plans, satisfying ASTM A53 Type E or S, Grade B (fy = 35 ksi). All fittings and connections dependent on the pipe's inside diameter shall be modified as necessary for proper fit-up, as approved by the Engineer.

Steel plate and bar steel shall conform to ASTM Grade 50 (fy = 50,000 psi).

Post tops, cable clamps, eye bolts, thimbles and other required fittings shall be high strength steel. All post tops shall be watertight. The eye of the eye bolts shall be either drop forged or formed with a full penetration weld, at the Contractor's option. The eye shall develop 100 percent of the bolt strength.

Turnbuckles shall be high strength and shall have jaw or eye ends as shown on the plans. Turnbuckles shall have a minimum breaking strength of 2,700 pounds. At the option of the Contractor, turnbuckles shall be steel pipe type or drop forged steel.

Crimped sleeve clamps and stop sleeve clamps shall be nonferrous metal, shall develop the strength of the cable, and shall be the color of the cable.

Cable shall be wire strand or rope with a minimum diameter of 1/4 inch and shall have a minimum breaking strength of 1,800 pounds. Cable shall be galvanized in conformance with the requirements in Federal Specification RR-W-410D.

Subsection 607.03 shall include the following:

The cables shall be tensioned to provide taut railings between posts. Cable must have a maximum deflection of 3 inches in any direction when a 200 pound load is applied. Provide 4 anchor bolts at each post location. Anchor bolts shall be designed to resist a 400 pound load applied in any direction at the top of the post.

## REVISION OF SECTION 607
## FENCE CHAIN LINK (SPECIAL) (120-INCH)

Section 607 of the Standard Specifications is hereby revised for this project as follows:

Subsection 607.02 shall include the following:

All materials shall meet the requirements specified in AASHTO M181 except as otherwise noted in the plans and these specifications. The Contractor shall provide certification from the manufacturer that all materials used are in compliance with the requirements of the plans and these specifications.

All material shall be galvanized. When required by the plans the fence shall also be vinyl coated. The color shall be as noted in the plans. All exposed materials shall have a uniform coloration. Temporary members and attachments that are to be removed need not be vinyl coated. The inside of pipes shall not be vinyl coated. When the fence is vinyl coated bolts and nuts shall be either vinyl coated or painted to match fence coating. Anchor bolts, threaded rods, anchor studs, post dowels, and other unexposed portions of anchorage assemblies shall be galvanized and not vinyl coated or painted.

The Contractor shall furnish to the Engineer for approval a 12" X 12" sample of the fabric (showing the exact coating and fabric construction to be used) and manufacturer's literature covering all aspects of the system he intends to install before ordering or fabricating any parts.

The fabric shall be AASHTO M181 Class C; or, when vinyl coating is specified in the plans, Class B. The mesh and wire sizes shall be as specified in the plans. When 3/8" mesh with 2 gauge wire is specified in the plans the following properties shall apply.

For other mesh and wire sizes the properties shall be as specified by AASHTO M181.

| | |
|---|---|
| Mesh | 3/8" clear opening |
| Core wire breaking strength | 650 lbs (minimum) |
| Core wire diameter | (0.105 inch +/-0.005") |
| Galvanizing, Class C fabric | (1.2 oz./sq. ft.) |
| Galvanizing, Class B fabric | (0.30 oz./sq. ft.) |
| Vinyl Coating Class B Fabric | (0.008 inch +/-0.002 inch) |

Tension wires shall be AASHTO M181 Type 1 Class 2; or, when vinyl coating is specified in the plans, Type 4.

Tension wires and their fittings shall have a minimum breaking strength of 8540 newtons (1920 pounds).

Truss rods and their fittings shall have a minimum breaking strength of 17080 newtons (3840 pounds) for fences without horizontal members and with a minimum prestress force given by the plans.

Posts and horizontal members shall be standard or extra strong steel pipe, as noted in the plans, satisfying ASTM A53 Type E or S, Grade B (Fy = 242 Mpa (35000 psi)); or, at the Contractor's option, ASTM A466 Grade D pipe (345 Mpa (50000 psi)) minimum yield strength) conforming to the following table may be substituted for both the standard and extra strong pipe of the same outside diameter called for in the plans. All fittings and connections dependent on the pipe's inside diameter shall be modified as necessary for proper fit-up, as approved by the Engineer.

**-2-**
**REVISION OF SECTION 607**
**FENCE CHAIN LINK (SPECIAL) (120-INCH)**

Alternative Pipe

| Nominal Diameter mm (In.) | Outside Diameter mm (In.) | Kg. (Lb.) per Meter (Ft.) | Wall Thickness mm (In.) |
|---|---|---|---|
| 32 (1.25) | 42 (1.660) | 2.73 (1.836) | 2.82 (0.111) |
| 38 (1.50) | 48 (1.900) | 3.40 (2.281) | 3.05 (0.120) |
| 50 (2.00) | 60 (2.375) | 4.64 (3.117) | 3.30 (0.130) |
| 63 (2.50) | 73 (2.875) | 6.91 (4.640) | 4.06 (0.160) |

Stretcher bars, truss rods, tension wires, post tops, and other required fittings and hardware shall be commercial quality steel, or better, or cast or malleable iron as appropriate to the article. A pair of two tension wires with appropriate turnbuckles or other adjustment devices, may be substituted for each truss rod.

Post clips, wire ties, or hog rings shall be galvanized 4.2 mm (9 gauge) or 1.9 mm (14 gauge) (before galvanizing) steel wire, and vinyl coated when specified by the plans. Wire ties shall be given at least one complete turn. Ends of wire ties shall be directed away from traffic.

Subsection 607.03 shall include the following:

For fences without permanent horizontal members and with a minimum prestress force given by the plans, the following shall apply.

The total pretension force in the tension wires and the mesh combined shall not be less than the value shown in the plans. Each tension wire, truss rod, and the mesh should have some pretension and shall not be slack. This is to assure the strength and stiffness of the fence system under the anticipated loads.

The Contractor shall control the quality of the fence tensioning by checking that the deflection of the fence does not exceed the value shown in the plans when the test load described in the plans is applied. The Engineer may choose to assure this quality by observing these tests, or by performing tests of his own. If the deflection is excessive, the Contractor shall re-tension the fence components.

The temporary horizontal members shall be removed after the tensioning of the fence is accepted.

The Contractor shall develop working drawings for approval by the engineer that detail the fence post spacing around the light standard location at the pier.

## REVISION OF SECTION 618
## PRESTRESSED CONCRETE

Section 618 of the Standard Specifications is hereby revised for this project as follows:

In subsection 618.02 second paragraph delete the first sentence.

In subsection 618.04(c)(7) delete the last sentence.

In subsection 618.04(c)(14) delete the first two paragraphs.

In subsection 618.07(c)2 delete item (1).

Delete Subsection 618.08.