

15.0 STRUCTURES

This Section 15 includes the requirements for the structures Work for the US 550/160 Connection South Design Build Project (Project). This Work shall be completed in accordance with the Contract Documents.

15.1 Structures Work

15.1.1. Bridges

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

Table 15-1 Action for Existing Bridges

Milepost	Structure No.	Description	Work
16.877	P-05-AG	US 550 over US 160 (Grandview Bridge)	Remove Type 10M steel post and railing. Concrete curb is to remain in place. Install combination bicycle railing on both sides of Bridge

Refer to Table 15-2 and this Section for new Bridge Structures to be constructed in accordance with Book 2, Section 1, Basic Configuration and Additional Requested Elements (ARE) for the Project. General layouts are provided in the Reference Documents for information.

Table 15-2 New Bridges

Milepost	Structure No.	Approximate Length (ft)	Description
14.193	P-05-AS	43	SB US 550 over Wildlife Underpass A (ARE)
14.193	P-05-AT	43	NB US 550 over Wildlife Underpass A (ARE)
15.258	P-05-AU	46	SB US 550 over Wildlife Underpass B (Basic Configuration)
15.258	P-05-AV	46	NB US 550 over Wildlife Underpass B (Basic Configuration)
16.367	P-05-AZ	476	NB & SB US 550 over Gulch A (Basic Configuration)
16.637	P-05-BA	240	NB & SB US 550 over Gulch B (Basic Configuration)

15.1.2. Minor Structures

Anticipated minor Structures include hydraulic Structures and small mammal pipe culvert crossings. Book 2, Section 5, includes small mammal crossing requirements.

15.1.3. Retaining Walls

Permanent retaining wall locations in the Basic Configuration are shown in the reference drawings. Final retaining wall types, sizes, and locations shall be determined by the Contractor. The Contractor may use the preliminary retaining wall locations in Table 15-4 subject to final detailed design, choose alternative

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locations, or eliminate retaining walls if the grading requirements for the Project are met. Retaining Walls shall be designed and constructed in accordance with the requirements of this Section 15.

Refer to Table 15-3 and this Section for the Work required on existing retaining walls.

Table 15-3 Action for Existing Retaining Walls

Milepost	Structure No.	Description	Work
Ramp B	P-05-AU	Cut wall	Add wall facing panels in accordance with Structure Aesthetic requirements.
Ramp B	P-05-AW	Cut wall	Remove portion of wall as necessary to construct new roundabout south of US 550/US 160 interchange. Add wall facing panels in accordance with Structure Aesthetic requirements.

Refer to Table 15-4 and this Section for new retaining wall Structures that may be constructed.

Table 15-4 New Retaining Walls

Milepost	Structure No.	Length (ft)	Description
15.674	R550A015698RRA	130	Fill wall along SB Frontage Road
15.764	R550A015821RRA	220	Fill wall along SB Frontage Road
16.201	R550A016475RRA	345	Cut wall along NB US 550
16.531	R160A088447RRA	200	Cut wall along NB US 550
16.802	R160A088848RRA	140	Fill wall SB US 550 at Roundabout

15.1.4. Sign Structures

Refer to Table 15-5 for new sign Structures to be constructed on this Project.

Table 15-5 New Sign Structures

Milepost	Structure No.	Description
87.4	SIGN-O-05-C	WB US 160
90.3	SIGN-O-05-D	EB US 160
15.2	SIGN-P-05-A	Variable Message Sign Board NB US 550

15.2 Administrative Requirements

15.2.1. Structure Numbers or Structure IDs

As required in the CDOT *Bridge Design Manual* (BDM), the Contractor shall obtain from the Colorado Department of Transportation (CDOT) the Structure numbers or Structure IDs for CDOT-managed structural assets and for new Structures added to the Project not included in Section 15.1. Location changes for new Structures listed in this Section may require a new or revised Structure number or ID to

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be requested. Structure numbers or IDs shall be shown on the Released for Construction (RFC) Documents.

15.3 Design Requirements

15.3.1. Standards

The Contractor shall design and construct the Project in accordance with the requirements of the standards in the BDM and documents referenced in Book 3. The Contractor shall use the latest adopted edition at the time of the Proposal Due Date.

The *BDM* defines policy and procedures currently in effect for the design, rehabilitation, and repair of Bridges and other Roadway Structures on the Project. The *BDM* presents the minimum requirements for Structures, except as otherwise noted in this Section 15. Deviations from the *BDM* and this Section 15 shall be submitted to CDOT for Approval prior to Acceptance of Final RFC Documents.

Table 15-6 Standards

Author or Agency	Title
American Association of State Highway and Transportation Officials (AASHTO)	<i>Load and Resistance Factor Design (LRFD) Bridge Design Specifications</i>
AASHTO	<i>LRFD Bridge Construction Specifications</i>
AASHTO	<i>Guide Specifications for Design and Construction of Segmental Concrete Bridges</i>
AASHTO	<i>Guidelines for Steel Girder Bridge Analysis</i>
AASHTO	<i>Manual for Bridge Evaluation</i>
AASHTO	<i>AASHTO LFRD Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals</i>
AASHTO	<i>Guide Specifications for LRFD Seismic Design</i>
AASHTO	<i>AASHTO/AWS D1.5 M- D 1.5, Bridge Welding Code</i>
AASHTO	<i>Guide for Development of Bicycle Facilities</i>
AASHTO	<i>Guide Specifications for Fracture Critical Non- Redundant Steel Bridge Members</i>
AASHTO	<i>Guide Specifications for Horizontally Curved Steel Highway Bridges</i>
AASHTO	<i>AASHTO LRFD Guide Design Specifications for Bridge Temporary Works</i>
AASHTO	<i>AASHTO M-203 Standard Specification for Steel Strand, Uncoated Seven-Wire for Concrete Reinforcement</i>
AASHTO	<i>AASHTO/NSBA Steel Bridge Collaboration Shop Detail Drawing Review/Approval Guidelines</i>
American Society for Testing and Materials (ASTM)	<i>ASTM A-416 Standard Specification for Low-Relaxation, Seven-Wire Steel Strand for Prestressed Concrete</i>
ASTM	<i>ASTM D-1143 Standard Test Methods for Deep Foundations Under Static Axial Compressive Load</i>
CDOT	<i>Bridge Design Manual</i>
CDOT	<i>Bridge Detail Manual</i>
CDOT	<i>Bridge Structural Worksheets</i>

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Author or Agency	Title
CDOT	<i>Bridge Rating Manual</i>
CDOT	<i>Deck Geometry Manual</i>
CDOT	<i>Retaining & Noise Wall Inspection & Asset Management Manual</i>
CDOT	<i>Bridge Technical Memorandums</i>
CDOT	<i>Standard Specifications for Road and Bridge</i>
CDOT	<i>Standard Special Provisions</i>
CDOT	<i>Survey Manual</i>
CDOT	<i>Roadway Design Guide</i>
CDOT	<i>Drainage Design Manual</i>
CDOT	<i>Construction Manual</i>
CDOT	<i>Standard Plans, M & S Standards</i>
CDOT	<i>Sign Design Manual</i>
CDOT	<i>Supplement to Standard Highway Signs</i>
Federal Highway Administration (FHWA)	<i>Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Slopes</i>
FHWA	<i>Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes</i>
FHWA	<i>FHWA RD-97-130 Design Manual for Permanent Ground Anchor Walls</i>
FHWA	<i>FHWA DP-90-068, Permanent Ground Anchors, Volume 1, Final Report</i>
FHWA	<i>FHWA IF-99-015 Geotechnical Engineering Circular No. 4 – Ground Anchors and Anchored Systems,</i>
FHWA	<i>Geotechnical Engineering Circular No. 7 – Soil Nail Walls</i>
FHWA	<i>FHWA HI-95-038 “Geosynthetic Design and Construction Guidelines”</i>
FHWA	<i>Manual for the Design & Construction Monitoring of Soil Nail Walls</i>
FHWA	<i>FHWA NH-00-043 Mechanically Stabilized Earth Walls and Reinforced Soil Slopes</i>
FHWA	<i>FHWA RD-73-93, Analysis and Design Problems in Modeling Slurry Wall Construction</i>
FHWA	<i>FHWA SA-93-068, Soil Nailing Field Inspectors Manual-Soil Nail Walls</i>
FHWA	<i>Hydraulic Design Series (HDS) No. 4, Introduction to Highway Hydraulics</i>

15.3.2. Software

15.3.2.1 Design

According to *BDM* Section 4.2, CDOT Staff Bridge does not support a preapproved list of software but reserves the right to disallow any software on a regular or case-by-case basis.

15.3.2.2 Load Rating

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

1. AASHTOWare Bridge Rating (BrR). The Contractor shall confirm with CDOT which version to use.
2. If a Bridge type is selected that cannot be rated using the above software package, the Contractor shall submit to CDOT a proposed alternate Bridge rating method for Approval prior to the preparation of Bridge or concrete box culvert ratings.

15.3.3. Materials

15.3.3.1 Concrete

Class B concrete shall be used for slope paving.

Class BZ concrete shall be used for drilled caissons.

Class D concrete shall be used for abutments, piers, walls, conventionally reinforced Bridge decks, diaphragms, approach slabs, and Bridge rails.

Concrete mix classes may be substituted per the CDOT *Standard Specifications for Road and Bridge Construction* (CDOT *Standard Specifications*) and the *BDM*.

The use of lightweight concrete will not be allowed.

Reference the *Geotechnical Data Report US 550 South Connection to US 160 (GDR)*, dated March 11, 2019 in Book 4 for water-soluble sulfate percentages.

Proposed concrete mix designs and procedures shall be submitted for Acceptance by CDOT at least 3 weeks prior to the anticipated concrete placement date.

15.3.3.2 Post-Tensioning Steel Systems

Corrosion protection shall be provided for the strands and shall consist of grout-filled galvanized or non-metallic ducts.

15.3.3.3 Structural Steel

Structural steel shall conform to AASHTO M 270, Grades 36, 50, or 70.

Weathering steel may be used for Bridge Superstructures. Weathering steel shall conform to AASHTO M 270, Grades 36W, 50W or 70W.

The Charpy V-notch Impact Energy Requirements shall be for Test Zone 2.

Reference the *GDR* in Book 4 for soil properties that can contribute to corrosion of buried metal.

15.3.3.4 Steel Coatings

Bridge rail shall be galvanized structural steel, colored in accordance with Project Special Provision Section 522 – Environmental Stain (Galvanized), included in this Section 15.

15.3.4. Loads and Forces

15.3.4.1 Live Load

Temporary Bridges shall be load rated for HL93 and CDOT permit vehicles.

15.3.4.2 Uplift

Bridge spans shall be proportioned to avoid uplift at supports due to non-seismic loads.

15.3.4.3 Thermal Forces

Temperature ranges for cold climates shall be used per the American Association of State Highway and Transportation Officials (AASHTO) *Load and Resistance Factor Design (LRFD) Bridge Design Specifications*.

15.3.5. Geotechnical

Geotechnical subsurface investigations conducted within the vicinity of the Structures are documented in the *GDR* included in Book 4. Geotechnical memos that include recommendations to support the reference designs including: Structure foundation type, wall type and landslide mitigation are included in geotechnical memos in the Reference Documents. Supplemental geotechnical investigations, per Book 2, Section 10; will be required for sign Structures and Structures in segments of the Project beyond the Base Configuration. Additionally, supplemental geotechnical investigations will be required for proposed Structure designs where the geotechnical investigation requirements of the *BDM* and *AASHTO LRFD Bridge Design Specifications* are not met by the *GDR*.

15.3.6. Structure Aesthetics Requirements

15.3.6.1 Aesthetic Requirements for Structures in General

New Bridges and walls, and existing walls, where indicated, require Aesthetic treatments to match the corridor Aesthetic scheme established by the previous CDOT U.S. 160 4th Lane at Farmington Hill Project (Grandview Interchange). The shapes, patterns, colors and rustication shall match the style set by the Grandview interchange considering potentially different Structure types. As-Constructed drawings for the Grandview Interchange are included in Reference Documents which provides details on the Aesthetics constructed for the interchange.

For consistency within the Project limits, retaining walls within a common viewshed shall incorporate similar visual Aesthetics. Parallel Bridges shall have similar Structure types and Aesthetic treatments.

Aesthetic refinements shall be submitted to CDOT for Acceptance prior to the Preliminary Design Plans submittal. The formliner pattern selection shall be submitted to CDOT for Acceptance prior to the Preliminary Design Plans submittal.

Structures with visible concrete surfaces shall have a surface treatment of structural concrete coating. This includes retaining walls, Bridge abutments and piers, Roadway and Bridge barriers, and slope protection.

15.3.6.2 Aesthetic Requirements for Bridges

15.3.6.2.1 US 550 over Wildlife Underpasses A and B

Wingwalls shall meet the requirements of Section 15.3.6.3.

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Structural colored concrete coating shall be applied to wingwalls, curbs, and exterior and bottom faces of exterior concrete girders. Concrete surface finish shall be Class 1.

15.3.6.2.2 US 550 over Gulches A and B

Designs should achieve a slender and well-balanced appearance. Piers shall be located symmetrically about the midpoint of the bridge. Discontinuities in the depths of girders from span to span will not be allowed.

The Contractor shall provide approach monuments on each side of the Road, at each abutment, for each Bridge, similar to Grandview interchange.

Wingwalls shall meet the Aesthetic requirements of Section 15.3.6.3.

Structural colored concrete coating shall be applied to wingwalls, curbs, barriers, exterior and bottom faces of exterior concrete girders, and surfaces of Substructures. Concrete surface finish shall be Class 1.

No formliners or rustications are required on Bridge Substructures.

The Contractor shall submit a Bridge Aesthetic Report to CDOT for Approval Prior to Preliminary Design Plans submittal. This report shall demonstrate to CDOT that the structure meets a slender and well-balanced appearance for CDOT Approval. In addition to the appearance this report shall also demonstrate and document how all Aesthetic requirements will met.

Steel girders shall be weathering steel.

15.3.6.3 Aesthetic Requirements for Walls

Preliminary layouts of the walls are shown in the reference drawings. The Contractor shall choose wall geometries to blend with the topography as much as practical. Walls shall be tiered to avoid massive vertical, or near vertical faces. The height of walls or tiers shall be limited to 20 feet. A setback between faces of tiered walls shall be at least 6 feet.

Wall panels shall be cast-in-place or precast concrete and shall be full height. 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. Panel design and construction shall consider ease of replacement and/or repair.

No horizontal seams at grid line joints will be allowed for formliners. All joints shall occur per layout grids and shall be straight and clean. Joints or striations shall intersect within 0.25 inch at panel matches. Any horizontal banners, rustications or straight-line elements found on retaining walls and Bridge abutments shall align correctly, lines that are visually intended to match up on a horizontal plane shall meet with no offset or irregular match, to within 0.25 inch. All cold joints shall have chamfered edges. All formwork blemishes shall be patched and given a Class 1 finish, per CDOT Standard Specifications prior to coatings. The concrete walls, caps, coping, and adjacent barriers shall be covered with structural concrete coating.

The Contractor shall submit to CDOT for Approval a visual graphic of each retaining wall prior to preliminary design plans and report submittals. This graphic shall be submitted in both hard and electronic format. Proposed retaining wall Aesthetics graphics shall include all visible surfaces and slope protection shall be submitted to CDOT prior to the Preliminary Design Plans submittal. This submittal shall include drawings illustrating form, texture, and color.

The Contractor shall provide full-size mockups (4 feet x 4 feet minimum) for all surface treatments for texture, color, and quality for Acceptance by CDOT with the preliminary design plans for each Structure.

15.3.7. Bridges

15.3.7.1 Geometry

15.3.7.1.1 Geometric Layout

Fill and cut slopes along the longitudinal axis of Bridges shall not be steeper than 2:1 (H:V) perpendicular to the abutment. A 2-foot minimum width berm shall be at the top of the slope at the front face of abutment and a 2-foot minimum vertical dimension from the top of this berm to the bottom of girder. See the *BDM* Figures 11-1, 11-3 and 11-4.

15.3.7.1.2 Wildlife Underpasses

The minimum sized opening for a wildlife underpass shall be in accordance with Book 2, Section 5.

15.3.7.2 Type

Bridge types shall follow the guidelines in the *BDM* unless otherwise specified in this Section. Alternate Bridge types will be allowed, but only if they have been accepted for general use by other US State Transportation Authorities for major highways. The Contractor shall demonstrate that the design of the alternate Bridge types and components meet the Project Technical Criteria and perform well under the Project's environmental conditions, including frequent freeze-thaw cycles, anti-icing, and de-icing. Proposed Bridge types in the Structural Concept Plans/Report historically not used by CDOT shall be submitted for Approval prior to Structure Concept Plan and Report submittals.

Experimental Bridge types, timber Bridges, and masonry Bridges will not be allowed. The use of structural-plate arches is allowed for wildlife underpasses and not allowed for water crossings.

15.3.7.3 Components

15.3.7.3.1 Bridge Rails

Development of CDOT MASH-tested Bridge rail systems are in process and have not been completed at the time of distribution of these Technical Criteria. To comply with FHWA minimum TL3 MASH-tested Bridge rail requirements after December 31, 2019, CDOT will issue a Change Order to the Contract.

Bridge rail requirements are as follows:

1. Wildlife Underpasses A and B rails shall be Bridge Rail Type 7.
2. Gulches A and B and Grandview Bridge rails shall be combination railing.

Combination railing shall:

1. Be similar to Bridge Rail Type 10M
2. Conform to AASHTO design requirements for bicycle railing.
3. Be a minimum height of 54 inches.
4. Be submitted for Approval as part of the Preliminary Design Plans submittal.

Cover plates shall be used over the interior face of joints on concrete median barrier and concrete Bridge rail curb to provide safety shape continuity across the joint. Bridge rails shall be used on approach slabs.

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Two spare 2-inch diameter conduits shall be provided in Bridge rails on the outside Shoulder of Bridges. The spare conduits shall extend at least 2 feet beyond the end of the sleeper beam at both ends of the Bridge and terminate in a junction box. The final location of the conduit shall be coordinated with the Roadway typical section beyond the sleeper beam.

15.3.7.3.2 Fencing

Chain link fence shall not be used on Bridges or wingwalls.

15.3.7.3.3 Drop-Off Protection

Bridge walls and wingwalls that may be accessed from the Highway by descending from the edge of pavement shall be categorized as CDOT Maintenance Personnel Protection and be protected by 3-cable fence, pedestrian railing, or safety railing. When deer fence is designated to be installed adjacent to a wall, deer fence shall be used. All other walls shall provide at a minimum tie-off points to conduct routine maintenance.

15.3.7.3.4 Approach Slabs

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.

The use of precast approach slabs shall be submitted to CDOT for Approval prior to Structure Concept Plan and Report submittals.

Bridge rails shall be connected to approach slabs.

Drainage and backfill behind the abutments and beneath the approach slabs shall be as shown on CDOT Bridge Structural Worksheet Backfill Drawings B-206-F1, B-206-F2, B-206-01, or B-206-M2.

Approach slabs shall not be used as jump spans.

15.3.7.3.5 Decks

Open or filled and partially filled metal grid decks, orthotropic steel decks, aluminum decks, fiber-reinforced polymer decks, and sandwich deck panels shall not be used.

Full-depth precast deck slabs shall have cast-in-place concrete 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.

The use of concrete stay-in-place deck forms is optional and maybe used for cantilevered portions of deck. Metal stay-in-place deck forms are prohibited from use. Precast double tees or precast box girders without a cast-in-place Bridge deck or concrete topping shall not be used.

15.3.7.3.6 Expansion Joints

Aluminum joints shall not be used.

The end dam on the approach slab shall be detailed to accommodate overlay.

Joints 0 to 4 inches and larger located at an abutment shall have a drain trough and outlet.

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15.3.7.3.7 Overlays

Bridge overlays shall be $\frac{3}{4}$ inch Polyester Polymer Concrete when the adjacent Roadway pavement is concrete.

15.3.7.3.8 Superstructures

Jointless construction shall be implemented as discussed in Section 14.4.1 of the *BDM*. The use of expansion joints at abutments and piers shall be submitted to CDOT for Approval prior to Structure Concept and Report submittals. Bridges shall be continuous over supports and shall not use intermediate hinges.

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

Bridge deck drainage and anti-icing pipes shall not be located inside box girders.

Shear studs on steel girders shall be field welded in accordance with Section 509.20(h) of the *Standard Specifications for Road and Bridge Construction*.

The use of pins and hangers will not be allowed. Category D or poorer weld details in tension zones subject to fatigue stress ranges shall be avoided.

Preparation of steel Shop Drawings shall follow the AASHTO/National Steel Bridge Alliance (NSBA) Steel Bridge Collaboration Shop Detail Drawing Review/Approval Guidelines.

Girders shall be lettered sequentially starting with "A" for each Bridge Structure on the RFC Documents.

Jacking locations and required jack sizes for bearing replacement shall be shown on the RFC Documents. Bridges shall be designed to withstand anticipated applied loads and forces with the Superstructure jacked at the locations shown on the RFC Documents.

15.3.7.3.9 Abutments

The bottom of the abutment cap shall extend a minimum of 18 inches below the bottom of riprap or slope protection, as shown in Figures 11-1, 11-3, and 11-4 in the *BDM*.

Integral or semi-integral abutments shall be used wherever applicable.

15.3.7.3.10 Slope Protection

Riprap or an Approved alternative shall be provided for the top 20 feet of slopes under Gulch A and B Bridges.

15.3.7.3.11 Bridge Deck Drains

No intermediate deck drains are allowed.

15.3.7.3.12 Barrier

Median barrier shall be Guardrail Type 9 Single Slope Barrier anchored to the Bridge deck and approach slabs.

15.3.7.3.13 Anti-icing

Components of the FAST anti-icing/de-icing system shall be installed on Gulch A and Gulch B Bridges in accordance with Book 2, Section 19 and Book 2, Section 19, Appendix 1. The Contractor is responsible for integrating the FAST anti-icing/de-icing system into all components of the Bridges where installed.

15.3.8. Retaining Walls

The criteria in this Section shall apply to permanent retaining wall Structures. Retaining walls that support traffic for interim phases of traffic and are left in place to become part of the final Structure shall be considered permanent retaining walls and be 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.

15.3.8.1 Geometry

Retaining wall layouts shall address slope maintenance above and below the wall and provide returns into the retained fill or cut at retaining wall ends. Residual wall batter shall be into the fill or cut.

Lengths of walls without relief joints shall be limited to lengths that control the differential settlement.

15.3.8.2 Type

Retaining wall types shall follow the guidelines in the BDM unless otherwise specified in this Section. Other wall types will be allowed, but only if they have been accepted for general use by other US State Transportation Authorities. The Contractor shall demonstrate that the design of the retaining wall types and components meet the Project technical requirements and perform well under the Project's geotechnical and environmental conditions, including frequent freeze-thaw cycles, anti-icing, and de-icing. Proposed retaining wall types in the Structural Concept Plans/Report historically not used by CDOT shall be submitted to CDOT for Approval prior to Structure Concept Plan and Report submittals.

Experimental retaining wall types will not be allowed. Metal walls, including bin and sheet pile walls, recycled Material walls, Mechanically Stabilized Earth (MSE) block walls, and timber walls shall not be used for permanent retaining walls.

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.

The latest FHWA geotechnical references and guidelines shall be used in conformance with the Contract and as provided at the following website: <http://www.fhwa.dot.gov/engineering/geotech/index.cfm>.

Retaining wall installations shall provide for a positive drainage system of the Backfill. Backfill drainage outlets shall be shown on the plans. Retaining walls near irrigation lines for landscaping shall account for additional hydrostatic load due to a waterline break. Free draining Backfill Material and/or leak detection devices to reduce hydrostatic loads on retaining walls may be used.

15.3.8.2.1 Mechanically Stabilized Earth (MSE) Walls

The Contractor shall follow the FHWA *Geotechnical Engineering Circular No. 11 – Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volumes I and II* as

guidelines for the design and construction of MSE walls. MSE wall designs integrated with abutments shall account for thermal movement of the Bridge and approach settlement.

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 the foundation of the wall is located below the scour level determined in accordance with CDOT *Drainage Design Manual*. MSE walls 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.

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

MSE 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 in the splash zone shall use epoxy-coated reinforcing steel.

15.3.8.2.2 Anchored Walls

The Contractor shall follow the *FHWA DP-90-068 Permanent Ground Anchors, Volume 1, Final Report*; *FHWA RD-82-046* and *FHWA RD-82-047 Tiebacks*; *FHWA RD-97-130 Design Manual for Permanent Ground Anchor Walls*, and *FHWA IF-99-015 Geotechnical Engineering Circular No. 4 - Ground Anchors and Anchored Systems* as guidelines for the design and construction of anchored walls.

Anchors shall be encapsulated with plastic sheathing. Load Tests for anchors shall be provided in accordance with the above FHWA guidelines.

15.3.8.2.3 Soil Nail Walls

The Contractor shall follow the *FHWA 0-IF-03-017 Geotechnical Circular No. 7 Soil Nail Walls*, *FHWA NHI-14-007 Soil Nail Reference Manual*, and the *BDM* as guidelines for the design and construction of soil nail walls. Soil nail walls may only be used when top-down construction is warranted. The exposed surface of pneumatically placed concrete shall meet the requirements of this Section. Load Tests for soil nails shall be provided in accordance with the above FHWA guidelines.

15.3.8.3 Components

15.3.8.3.1 Fencing

Chain link fence shall not be used on retaining walls.

15.3.8.3.2 Drop-Off Protection

New retaining walls that may be accessed from the highway by descending from the edge of pavement shall be categorized as CDOT Maintenance Personnel Protection and protected by 3-cable fence, pedestrian railing, or safety railing. When deer fence is designated to be installed adjacent to a wall, deer fence should be used. All other walls shall provide at a minimum tie-off points to conduct routine maintenance.

15.3.9. Sign Structures

Major sign Structures and supports for Intelligent Transportation System (ITS) Equipment shall be designed and constructed in accordance with *AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*; with Book 2, Section 14, and this Section 15.

The minimum vertical clearance to overhead sign supports shall be 18 feet 6 inches.

Design of loadings shall consider the natural period of vibration from vortex shedding and upward wind pressures from passing trucks.

Sign Structures shall be galvanized structural steel (single) tubing, and may be colored in accordance with the Section 522 – Environmental Stain (Galvanized). 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 panels shall comply with Book 2, Section 14.

A Variable Message Sign (VMS) board shall be mounted on a sign Structure in accordance *CDOT S Standard 614-60*. The Contractor shall prepare a Structural design for the VMS cabinet and bracket in accordance with the submittals for major Structures, as defined in the *BDM* and this Section.

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

15.3.9.1 Components

15.3.9.1.1 Foundations

Drilled caissons shall be used to support overhead and cantilever sign Structures, as well as the ground-mounted Structures. The Contractor shall submit as part of the preliminary design plans submittal one general Project sign Structures foundation report for Acceptance. There shall be a minimum of 1 foundation boring within 10 feet of each single caisson supporting large sign supports.

15.3.9.1.2 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.

15.3.9.1.3 Bridge-Mounted Signs

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

15.4 Submittals

Submittals shall be prepared, Reviewed, and submitted in accordance with the requirements set forth in Book 2, Section 3.

15.4.1. Preliminary Design Plans

The Contractor shall submit Preliminary Design Plans for proposed major Structures and walls prior to proceeding to final design and preparation of the Pre-RFC Documents. The Preliminary Design Plans shall include Structure Concept Plans, Structure Concept Reports, and Preliminary Foundation Design Reports.

15.4.1.1 Structural Concept Plans

Structural Concept Plans shall include general layout drawings of proposed major Structures and retaining walls. Bridge plans shall be consistent with the *Bridge Detail Manual* for general layout drawings, as defined by the *BDM*. For proposed retaining walls, the general layout drawings shall provide plan, elevation, and typical section details like those provided for major Structures. The Contractor shall submit the plans to CDOT as part of the Preliminary Design plans submittal.

15.4.1.2 Structure Concept Reports

Structure Concept Reports shall be no more than 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 major Structure. It shall also include a list of transportation authority's actual Projects and references for all Bridges, and foundation types and retaining wall types not historically used by CDOT. Additional information provided for Structures not historically used by CDOT will not count toward the page limit. The Contractor shall submit the reports to CDOT as part of the Preliminary Design plans submittal.

15.4.1.3 Preliminary Foundation Design Report

A Preliminary Foundation Design Report shall be submitted for each major Structure and minor Structure as required for the design of foundations for Bridges, retaining walls, and other Structures, in accordance with Book 2, Section 10. The report shall 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.

15.4.2. RFC Documents

15.4.2.1 Pre-RFC Documents

Pre-RFC Documents shall be submitted for proposed CDOT-managed Structural assets. Pre-RFC Documents shall include plans and specifications; major and minor Structure load ratings; and the Foundation Design Report.

The Foundation Design Report shall be revised from the Preliminary Foundation Design Report and be the basis for the load analysis from seismic and earth loads and the basis for the design of foundation elements. Supplemental soil borings required for Structures design shall have been completed.

15.4.2.2 Final RFC Documents

The Final RFC Documents shall include resubmittal of the Pre-RFC Documents listed above with all comments addressed.

15.4.3. Final Design Documents

Final Design Documents shall include final plans and specifications for proposed CDOT-managed structural assets; design calculations and independent design calculations for major Structures; independent detail checks of the plans and specifications for major Structures; major and minor Structure load ratings, Foundation Design Reports, and a final submittal letter.

15.4.3.1 Final Plans and Specifications

The final plans and specifications for each Structure shall be signed and sealed by the Contractor's designer in accordance with laws for licensed 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.

15.4.3.2 Design and Independent Design Calculations

The design calculations or the independent calculations shall be prepared by, signed, and sealed by a Professional Engineer licensed in the State of Colorado with a minimum of 10 years Bridge design experience. Copies in .PDF and electronic format shall be made of design and design-check calculations and submitted to CDOT for Acceptance as part of the Final Design Documents submittal.

Calculations shall be in English (Standard) units and 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.

15.4.3.3 Load Ratings

A load rating package, as defined by the CDOT *Bridge Rating Manual*, shall be completed and submitted for Acceptance as part of the Final Design Documents submittal for each major and minor Structure prior to the start of Bridge construction activities.

15.4.3.4 Foundation Design Reports

The Foundation Design Reports shall be signed and sealed by the Contractor's designer in accordance with laws for licensed Professional Engineers in the State of Colorado.

15.4.3.5 Final Detail Letter

The Contractor's designer shall submit a letter containing a Professional Engineer's stamp to CDOT for Acceptance as part of the Final Design Documents submittal certifying that Structure plans and specifications have been prepared in accordance with the current CDOT design standards. An example letter can be found at <https://www.codot.gov/library/bridge/form-letters>.

15.4.4. Working and Shop Drawings

The Contractor shall submit Working and Shop Drawings in accordance with Table 105-1 of the CDOT *Standard Specifications*. Preparation of steel Shop Drawings shall follow the Shop Detail Drawing Review/Approval Guidelines developed by the AASHTO/NSBA Steel Bridge Collaboration G1.1-1999. Working and Shop Drawing accuracy is the sole responsibility of the Contractor and shall be submitted for information only.

15.4.5. As-Constructed Documents

As-Constructed Documents shall be submitted for each proposed Structure in accordance with Book 2, Section 3.

15.5 Construction Requirements

A technical representative shall be at the Project Site to assist the Contractor with the Approved QMP for Structures. The representative shall maintain a construction diary. The diary shall be submitted with the Final RFC Documents.

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The Contractor shall notify CDOT 7 Days in advance of reductions in vertical clearances or when lane closures, lane reductions, or lane width restrictions are put into effect.

Falsework shall be designed in accordance with the AASHTO *Guide Design Specifications for Bridge Temporary Works*. Shoring areas that are considered a risk to the traveling public shall require an independent design check. Falsework or shoring carrying live traffic shall be submitted for Acceptance 10 Days prior to construction.

Temporary retaining walls constructed of Materials not allowed for permanent walls may be abandoned and left in place. Temporary retaining walls left in place shall be completely covered by soil or construction Materials, 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 structural support elements and Materials of the permanent retaining walls meet the requirements of this Section 15.

Exposed concrete surfaces in the splash zone shall be sealed. The limits of concrete sealer shall be shown on the plans.

Concrete guardrails shall not be cast monolithically with integral pier caps.

Installers of prestressing, post-tensioning systems shall be Post-Tensioning Institute (PTI) certified.

15.6 Deliverables

The following Deliverables shall be submitted to CDOT for Review, Acceptance, or Approval:

Table 15-7 Deliverables

Deliverable	Review, Acceptance, or Approval	Schedule
Deviations from CDOT's <i>Bridge Design Manual</i> and this Section 15	Approval	Prior to Acceptance of Final RFC Documents
Alternate bridge rating software	Approval	Prior to major and minor Structure ratings
Concrete mix design and procedures	Acceptance	Minimum 3 weeks prior to the anticipated concrete placement date
Refinements to the Project Aesthetic guidelines	Acceptance	Prior to Preliminary Design Plans submittal
Bridge Aesthetic Report	Approval	Prior to Preliminary Design Plans submittal
Formliner pattern	Acceptance	Prior to Preliminary Design Plans submittal
Retaining wall Aesthetic graphics	Approval	As part of the Preliminary Design Plans submittal
Full-size mockup of all surface treatments	Acceptance	As part of the Preliminary Design Plans submittal
Bridge types historically not used by CDOT	Approval	Prior to the submittal of the Concept Plans and Report submittals
Combination railing details	Approval	As part of the Preliminary Design Plans submittal
Chain link fence vinyl coating color	Approval	As part of the Preliminary Design Plans submittal
Use of precast approach slabs	Approval	Prior to Structure Concept Plan and Report submittals

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Deliverable	Review, Acceptance, or Approval	Schedule
Use of expansion joints at abutments and piers	Approval	Prior to Structure Concept Plan and Report submittals
Wall Structure types not historically used by CDOT	Approval	Prior to the submittal of the Concept Plans and Report submittals
Sign Structures Foundation Report	Acceptance	As part of the Preliminary Design Plans submittal
Structural Concept Plans	Review	As part of the Preliminary Design Plans submittal
Structure Concept Reports	Review	As part of the Preliminary Design Plans submittal
Preliminary foundation design report	Review	As part of the Preliminary Design Plans submittal
Final plans and specifications	Acceptance	As part of the Final Design Documents submittal
Design and independent design calculations	Acceptance	As part of the Final Design Documents submittal
Load ratings	Acceptance	As part of the Final Design Documents submittal
Foundation design reports	Acceptance	As part of the Final Design Documents submittal
Final detail letter	Acceptance	As part of the Final Design Documents submittal
Falsework or shoring plans carrying live traffic	Acceptance	10 Days prior to construction

15.7 Project Special Provisions

The following Project Special Provisions supplement or modify the CDOT *Standard Specifications for Road and Bridge Construction* and take precedence over the CDOT *Standard Specifications* and plans. The Contractor is responsible to have a copy of the CDOT *Standard Specifications* at all times on the Project Site.

Revision of Section 105 – Segmental Concrete Control Work
Revision of Section 107 – Performance of Safety Critical Work
Revision of Section 202 – Removal of Portions of Present Structure
Revision of Section 502 – Drilling Holes to Facilitate Pile Driving
Revision of Section 503 – Drilled Caissons
Revision of Section 504 – Concrete Panel Facing Phased Built GRS Walls
Revision of Sections 509 and 708 – Painting of Aluminum Access Doors for Steel Structures
Revision of Section 513 – Bridge Drain
Revision of Section 515 – Concrete Sealer (Calcium Nitrate)
Section 519 – Thin Bonded Overlay (Polyester Concrete)
Section 522 – Environmental Stain (Galvanized)
Revision of Section 601 – Painting of Aluminum Access Doors for Concrete
Revision of Sections 601 and 708 – Structural Concrete Stain
Revision of Section 604 – Vane Grate Inlet
Revision of Section 618 – Prestressed Concrete

REVISION OF SECTION 105 SEGMENTAL CONCRETE CONTROL OF WORK

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Section 105 of the Standard Specifications is hereby revised for the project as follows:

Subsection 105.02 shall include the following:

The Contractor shall submit, as soon as possible, but not more than 120 calendar-days following the "Notice to Proceed", complete final plans and computations for review and approval. These final plans must be approved before any approvals will be made on working and shop drawings. Plans and computations will be required for only those portions of the work that are modified, changed or affected.

The submittal of the computations and drawings will not absolve the Contractor of any responsibility for fabrication plans required under Section 105 or elsewhere in these specifications.

The contract time shall apply. No extensions of these dates will be allowed for preparation, submittal or approval of plans or computations.

The Contractor shall submit for review the information which shall include, but not necessarily be limited to, the following:

- (1) Detailed shop drawings in accordance with Section 618.
- (2) Locations and layout drawing of the casting site.
- (3) Method and length of curing. Include complete details of the fabrication system to be used, including the forms, foundations and geometry controls.
- (4) Details of handling, storing and transporting segments.
- (5) Schedule of casting and erection of segments with approximate dates; the schedule shall show chronological order of every phase and stage of erection and construction of the superstructure and shall include a detailed plan for handling traffic during erection.
- (6) Concept drawings showing schematic methods for handling and erecting segments; these are not working drawings but are provided for information only. The Contractor shall submit for review, by CDOT, proposed erection details and appropriate calculations showing the methods, equipment, and construction loads analysis involved with the various bridge components. No erection of the precast segments will be permitted until the erection details are approved by the Contractor's Engineer.
- (7) A list of proposed handling and erection equipment. Proposed handling and erection equipment shall be consistent with the concept shown on the plans to assure compatibility with the overall design. The design and construction of special handling and erection equipment is the Contractor's responsibility.
- (8) A casting curve prepared in accordance with casting and erection methods and schedule proposed by the Contractor. The casting curve shall be of sufficient accuracy to allow the determination of control point settings for accurately casting the segments. The preparation of the casting curve shall recognize all deviations from straight line and deformations due to the final required alignment and due to dead load, erection loads, post-tensioning stresses, including secondary moments, creep and shrinkage.

Final Work Plan

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It shall be the Contractor's responsibility to submit deflections and camber data for each stage of construction, as required, to construct the structure to its final grade. The procedure used shall account for the effect of time dependent prestress losses, shrinkage and creep which occur during the construction phase. The data for the entire bridge shall be submitted for approval by the Contractor's Engineer prior to commencing the erection.

The camber of the structure will be monitored at each stage and corrective actions, as approved by CDOT, shall be performed by the Contractor to assure proper erection of the structure to its final grade.

The final work plan shall include graphs, charts or tables showing the theoretical location of forming. This data shall be furnished to CDOT for use in checking the erection.

The final work plan shall also include complete details of the system to be used, including all geometry controls.

Design Calculations

Design calculations shall be submitted for falsework, travelers, staging, forms and any other temporary construction which may be required, and which will be subject to calculated stresses. Calculations also shall be submitted to support the system and method of stressing proposed by the Contractor. The calculations shall be done under the direct supervision of a professional engineer registered in the State of Colorado and shall be approved by him and contain his seal.

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 portion of bridge P-05-AG
- (3) Temporary works: falsework, shoring that exceeds 5 feet in height, cofferdams, and temporary bridges
- (4) 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 Portion of Bridge. Also, when construction materials are being lifted that may fall onto active traffic lanes.
- (5) Excavation and embankment adjacent to the roadway, especially if it requires shoring
- (6) Work operations such as pile driving and jack hammering which may create vibration and cause debris to fall into traffic.
- (7) Rockfall mitigation

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

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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 CDOT.

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
 - 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
- (9) Name and qualifications of Contractor's person designated to determine and notify CDOT in writing when it is safe to open a route to traffic after it has been closed for safety critical work.
- (10) 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. CDOT, 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 CDOT 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 elements, (4) Removal of Portion of Bridge and (5) Temporary Works. 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 Contractor's 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 CDOT, 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,

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the Contractor shall make the situation safe for work stoppage. The Contractor shall submit an acceptable plan to correct the unsafe process before CDOT will authorize resumption of the work.

When ordered by the CDOT, 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 108.06.

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, and shall submit a revised plan to the CDOT 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:

Subsection 202.01 shall include the following:

This work shall include the removal of all or portions of the following: Bridge rail on Structure Number P-05-AG. Removal operations shall be conducted so that there will be the least interference with public traffic using the structure.

Subsection 202.02 shall include the following:

At least 10 days before beginning bridge removal the Contractor shall submit to CDOT details of the removal operations showing the methods and sequence of removal and equipment to be used.

Steel Bridge rail post and railings shall be carefully dismantled and stockpiled at locations as designated. The Division will transport the material salvaged from the stockpile site to the maintenance yard. The Contractor will be required to load the material salvaged on the Division's hauling equipment.

All methods and equipment used to accomplish this item shall be approved by the Contractor's Engineer.

Within 24 hours before new concrete is placed, the entire surface upon which new concrete bonds shall be sandblasted to roughen the surface and remove all fractured or loose particles to promote good bond with the new concrete.

**REVISION OF SECTION 502
DRILLING HOLES TO FACILITATE PILE DRIVING**

Section 502 of the Standard Specifications is hereby revised for this project as follows:

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Subsection 502.06 shall include the following:

When the plans call for drilled holes filled with slurry or mud made from clay or bentonite, the diameter of the drilled holes shall be at least two inches greater than either the pile diameter or the diagonal corner to corner measurement of the pile cross section, unless otherwise designated on the plans. Oversized holes due to sloughing, drifting, over-drilling, or other causes shall be filled with the accepted slurry or mud at the contractor's expense.

The following mixture will yield approximately 1.2 cubic yards of an acceptable slurry or mud:

- (a) 50 lbs. dry bentonite powder
- (b) Approximately 125 gallons of water (or sufficient amount to make a pourable mix)
- (c) 1 cubic yard of sand; (approximately 2800 lbs.) reasonably free of material larger than 1/2 inch.

The sand need not be clean. Local soil reasonably free of material larger than 1/2 inch may be substituted for the sand. Cement, lime, flyash, or other pozzolanic or highly alkaline materials shall not be added.

This mixture may be mixed by auger in the drilled hole, by paddle type mortar mixers, by portable or semiportable concrete mixers, or by drum type concrete mixer trucks.

If the mixture is placed or mixed in the hole prior to pile driving, the top two to three feet of the hole may be filled with loose local soil to prevent splashing of the slurry or mud.

**REVISION OF SECTION 503
DRILLED CAISSONS**

Revision of Section 503 of the Standard Special Provisions is hereby revised as follows:

Add the following sentence to beginning of the first paragraph of Subsection 503.21:

CSL testing is required for drilled caissons equal to or greater than 4-feet in diameter, at single shaft locations, and at river crossings.

**REVISION OF SECTION 504
CONCRETE PANEL FACING PHASED BUILT GRS WALL**

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

Description

504.01 This work consists of constructing a Concrete Panel Facing Geosynthetic Reinforced Soil (GRS) Retaining Wall System at the locations and to the lines and grades shown on the plans. The Phase II (two) concrete panel facing installation can only be commenced till the major portion of Phase I (one) GRS wall settlement completion. Only geosynthetic reinforcement as specified in this specification may be used as GRS reinforcement in the reinforced structure backfill zone. The retained structure backfill zone is the structure backfill retained by the reinforced structure backfill zone as shown on the plans.

Materials

504.02 Shop Drawings. Unless specified in the plans shop drawings are only required for panel to wire basket connection of GRS walls with the default reinforcing spaced at 1'-0". If soil reinforcement spacing for phase I (one) wall requirement is not met (or as required to quantify and build the complete wall in one phase as dictated by special site geometry) the shop drawings will include the following.

The shop drawings shall provide the details necessary to demonstrate compliance with the Contract, including:

- (a) *Wall Layouts.* Wall layouts shall conform to lines and grades on the plans including start, corner, and end stations, leveling pad step breaks, total number of panels and top and bottom of wall elevations. For walls with rail anchoring slabs, the top of panel elevations shall be within 8 inches of the elevation shown on the plans measured from the bottom of anchoring slab. The construction batter required to achieve the batter shown on the plans shall be shown on the shop drawings. If temporary walls are required for the construction of permanent wall, the permanent wall vendor shall provide the shop drawings and certified material test reports for temporary walls.
- (b) *Phase I Wire Basket Facing and Reinforcement Locations.* Unless otherwise shown on the plans, each layer of soil reinforcement is required to form a soil wrap inside of and along the entire height of the basket for wrap around (terminating ~4 FT. from the face of the wall). Secondary reinforcement if required will be detailed in the plans.

Phase II Panel to Wire Basket connection detail, and limits of special panels at curved wall corner shall be shown. The back of each panel shall be logically numbered with its location.

- (c) *Wall Elevations.* Except for the top of the leveling pad, wall elevations given on the plans are based on the desirable wall height. The actual panel and reinforcement elevations shall be marked on the shop drawings by taking into account the supplied panel as well as special panel heights for matching the front and top finished grade.
- (d) *Soil Reinforcement Material.* The soil reinforcement type, Minimum Average Roll Value of the Ultimate tensile strength T_{ULT} (MARV) for geosynthetic soil reinforcement, spacing, lengths, elevations, and the corresponding wall design height shall be shown on the shop drawings. The starting and ending stations for change in grade of reinforcement material shall be shown for walls with different grade of reinforcement material at the same elevation. Material grade shall be clearly identified on each roll of reinforcement to avoid errors in placement. Spacing (1'-0" Typ.) of the reinforcement layers shall be as specified in the plans.
- (e) *The soil reinforcement length (RL).* The soil reinforcement length for phase I wire basket wall shall be measured from front face of wire basket to the end of soil reinforcement as measured to the neat end. Soil reinforcement lengths shall not be less than the lengths specified on the plans.

The Reinforcement Lengths shown on the shop drawings shall be the reinforcement length required for internal stability and pull out only. External Stability (bearing pressure, sliding and overturning) and global stability shall already be checked by the design Engineer of record.

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(f) *Panel Size and Soil Reinforcement Spacing.*

1. Except for full height panels, the maximum panel size is 50 square feet and the minimum panel height shall be 30 inches.
2. For full height panels, the maximum panel width shall be 10 feet and the maximum panel height shall be 20 feet. Differential deflection between adjacent panels shall be limited to 1/500. The vendor shall supply design calculations regarding panel concrete crack size control during shipment and construction and estimated joint width and differential deflection limits. The use of full height panels with widths greater than 10 feet or heights greater than 40 feet shall be as approved by CDOT.
3. The maximum vertical spacing between layers of adjacent soil reinforcement shall not exceed 12 inches. Except the half height panel used at the top and bottom of wall, including all partial and extended height panels at the top of wall there shall be at least two connectors per panel/basket interface.
4. Shiplap joints shall be required at horizontal and vertical joints for segmental panel walls and all vertical joints for full height panel walls. The gap between two adjacent panels shall be ½ to 1 inch. Shiplap joints are not required at the vertical joints of segmental and full height panel. A minimum of 12 inches depth of continuous Class 2 Geotextile is installed behind the joints as shown in the plans prior to Class D concrete infill between the Phase I wire basket and the Phase II panel. Geotextile (Class 2) will not be measured and paid for separately but shall be included in the work. Neoprene cushions shall be provided at all horizontal joints as shown in the plans.

(g) *Long Term Design Strength (LTDS) of Reinforcement.*

1. The design charts on the plans define the strengths required for the zone of mechanical reinforcement of soil. Based on the total summed LTDS, the reinforcement proposed by the shop drawings for a specific wall height shall meet or exceed the total LTDS shown on the plans. This proposed reinforcement shall allow for a maximum of plus or minus 15 percent variation in each individual layer.
2. Metallic (Inextensible) Soil Reinforcement not allowed.
3. Geosynthetic Soil Reinforcement. Geosynthetic soil reinforcement shall be a woven geotextile. For polyester (PET), polypropylene (PP), and high-density polyethylene (HDPE) reinforcement, the LTDS of material shall be determined using the following K percentages to ensure the required design life. Unless otherwise specified, LTDS shall not exceed the following K percent of its ultimate tensile strength, T_{ULT} (MARV), i.e.

$$LTDS = K * T_{ULT} (MARV)$$

$$\text{Where } K = \frac{\phi}{RF(ID) \times RF(D) \times RF(CR)}$$

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RF(ID): Installation damage reduction factor

RF(D): Durability reduction factor

RF(CR): Creep reduction factor

Meet AASHTO LRFD and/or FHWA GRS design method for 75 years design life.

(1) Geogrid or Geofabric sheet reinforcement (HDPE, PET, PP):

Products	K (Geogrid)	K (Fabric)
PE & PP	27%	18%
PET	35%	30%

(2) Woven Geotextile will meet minimum bi-axial MARV of ultimate tensile of 4800 LB./FT. and a minimum tensile strength of 2400 LB./FT @ 5% strain based on ASTM D4595.

(3) All products not listed above: Follow AASHTO equations 11.10.6.4.3b-1 & 11.10.6.4.3b-2 using independently certified test results.

(h) *Design Heights and Supplied Reinforcing Material.* Unless otherwise defined on the plans, the wall design height shall be measured vertically from the top of the leveling pad to the top of the concrete rail anchoring slab for walls with railing, or to the top of the precast concrete coping for walls without railing. For walls that are in front of a bridge abutment that is founded on a MSE foundation, the design height used to determine the soil reinforcement length shall be measured vertically from the top of the leveling pad to the top of the roadway carried by the bridge and the wall. Bridge approach slabs shall not be considered in the design of the GRS wall.

For geosynthetic reinforcement, if the default geofabric with 1'-0" spacing is not used the required reinforcement LTDS and the supplied LTDS (determined in accordance with the K factors or depletion of material as defined above) with corresponding brand and grade of material shall be marked clearly on the elevation view or in a tabulation summary CDOT approval. The LTDS of the supplied reinforcement grade must meet or exceed the required LTDS corresponding to the reinforcement spacing provided.

(i) *Tiered Walls.* For the reinforcement layouts of tiered walls, the overall geometry, the reinforcement length and the sum of the LTDS provided from all layers in all tiers shall be in close conformity with the retaining wall system shown on the plans in order to ensure that local, global, and internal stability requirements have been met.

(j) *Obstructions.* Details for the placement of soil reinforcement around obstructions (i.e. steel piles, concrete piers, concrete boxes, pipes, etc.) shall be shown on the shop drawings. Design calculations shall be provided showing that the internal stability of the wall meets the required safety factors in the area of the obstruction.

(k) *Table of Quantities.* **Not Required if default Geofabric with 1'-0" spacing is used.** A table comparing the Structural Backfill (Class 1), Mechanically Reinforced Soil (MRS), Geomembrane, and Panel Facing quantities shown on the plans to the quantities shown in the shop drawings and percent difference (positive percent indicates an increase in shop drawing quantities from the plans) shall be

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shown on the shop drawings. Structure Backfill (Class 1), Geogrid Reinforced Soil, Geomembrane, and Panel Facing quantities shall be calculated in accordance with the Contract.

- (l) *Placement Schedule. Not Required if default Geofabric with 1'-0" spacing is used.* Geomembrane placement schedule and clearances to soil reinforcements shall be shown.
- (m) *Vertical Slip Joints.* Locations of vertical slip joints for differential settlement relief shall be as specified in subsection 504.16.

504.03 Backfill. Unless otherwise specified on the plans, wall backfill material in the reinforced structure backfill zone and the associated trapezoidal retained structure backfill zone shall conform to the requirements for Structure Backfill (Class 1) of Section 206. For reinforcement tensile stress and associated pullout, a friction angle of 34 degrees shall be assumed for Structure Backfill (Class 1). With the installation of isolation geomembrane, Structure Backfill (Class 1) shall be considered to be non-aggressive soil for corrosion and durability computations. All reinforcing elements shall be designed to ensure a minimum design life of 75 years for permanent structures.

504.04 Leveling Pad. Concrete for the leveling pad shall be Concrete (Class D) conforming to the requirements of Section 601. Unless specified on the plans, the maximum vertical step shall be no greater than 36 inches. The leveling pad shall be reinforced only at the steps. When the toe of wall is founded on slope steeper than 1.5 (H) to 1 (V), the leveling pad shall be constructed with reinforced concrete with same reinforcing schedule as at its steps. Leveling pad concrete shall be cured for at least 12 hours before placement of the concrete panels. To avoid panel cracking from high contact points, a ¼ inch thick expansion joint material with the same thickness as the panels may be installed between the first layer of panels and the leveling pad.

504.05 Geomembrane and Joint. A Geomembrane shall be installed on all walls at the top of the reinforced structure backfill zone and retained structure backfill zone to intercept surface runoff and prevent salt penetration into the backfill of the wall as shown on the plans. The Geomembrane shall meet the requirements of subsection 712.07 (a) for geomembrane and be LLDPE with a minimum thickness of 30 mils. It shall be spliced with a dual track field seamed joint in accordance with ASTM D4437 or ASTM D5820. For small local coverage areas, less than 30 square feet, the membrane may be spliced using a 6 inch minimum overlap and an adhesive or a single seam portable thermal welding tool, as suggested by the membrane manufacturer and approved by CDOT. Unless otherwise shown on the plans, the membrane shall have a minimum coverage length measured perpendicular to the wall face of at least the wall Design Height (DH) plus Soil Reinforcement Length (RL) plus 1.5 feet. The membrane shall be installed with a slope between 20:1 (minimum) and 10:1 (maximum) , as shown in the plans, from the panel facing to a drainage system located at the cut or pre-filled slope as shown on the plans.

The drainage system shall consist of a 12 inch wide Geo-Composite strip drain inserted into a slot in the Geomembrane, at 10 foot maximum spacing, that collects the water from the membrane and conveys it to a water collector system at the toe of the 1:1 slope as shown on the plans. The water collector system shall consist of a 4 inch diameter perforated collector pipe surrounded by Filter Material Class B and wrapped with Class 1 Geotextile. A 4 inch diameter non-perforated drain pipe, at 100 foot maximum spacing, shall be used to discharge the water in the water collector system out the face of the wall.

For complex geometry (such as structural skew, superelevation, tiered wall and staged construction) a detailed layout of the membrane and drainage system shall be provided as working drawings in accordance with subsection 105.02 by the Contractor and as approved by CDOT.

For tiered walls, a Geomembrane shall be installed between the top of the bottom wall and the toe of the top wall as shown on the plans.

504.06 Pre-Cast Concrete Panel Facing Unit and Panel Joint Material. The pre-cast concrete panels shall conform to the requirements shown on the plans and these specifications including the color, texture, dimensions and pattern. These facing units shall be factory made with Class B Concrete with the following additional requirements:

- (1) Minimum Cementitious Content specified by contract. Approved mix design shall be used per the contract.
- (2) Ambient form temperature: shall be a minimum of 40° F and rising when casting panels.
- (3) Pre-cast panels shall be cured in accordance with NPCA, QC Manual Chapter 4, section 4.5.
- (4) NPCA, QC Manual shall contain: Safety, pre & post-pour inspection criteria and procedures; applicable ASTM standards for concrete testing procedures, personnel qualifications, certifications, equipment calibrations, and repair procedures for precast units. The NPCA, QC Manual shall be submitted to the governing agency upon request. Proof of conformance to specific federal, state or local standards shall be maintained on file at the fabrication location.
- (5) Lifting Inserts / Lifting Hardware materials used in precast concrete products shall be verified for capacity, and shall have an adequate factor of safety, taking into account the various forces acting on the device(s), including form release suction, impact and various positioning of the product during handling. (OSHA 29 CFR 1926.704(d))
- (6) Pre-Pour / Post-Pour Operations inspections shall be performed and documented per the procedures outlined in the Quality Control Manual.
- (7) Hot and Cold Weather Precautions: During hot weather, the concrete temperature, at the time of placement, shall not exceed 90 degrees F. Hot weather is defined as; High ambient temperature, High concrete temperature, Solar radiation and wind. During cold weather, the concrete temperature, at the time of placement, shall not be less than 50 degrees F. Cold weather is defined as; Average daily temperature is less than 45 degrees F.; The ambient temperature is not greater than 50 degrees F. for more than one-half of any 24-hour period.
- (8) Concrete Curing: Moisture retention and control of hydration curing temperatures shall be maintained. The maximum hydration curing temperature shall not exceed 150 degrees F.

Reinforcing steel shall conform to the requirements of Section 602 of the specifications. The concrete in the pre-cast units shall be compacted using a vibrating table, grid vibrator, or screed vibrator. All panels shall be cast face down on flat level surface.

Panel dimensions and facing treatment shall conform to the architectural requirements shown on the plans. Width of panel from center to center of joint shall be an even whole increment of the pattern dimensions selected to match the architectural treatment. Thickness shall be a minimum of 6 inches plus the depth of rustication. Panel shall be cast to the dimension that accommodates the architectural treatment.

Panels may be longer than 5 feet provided their section strength can be shown to accommodate handling and erection without cracking. Soil reinforcement attachment devices shall be within 1 inch of shop drawing locations. All unit dimensions shall be within ¼ inch of plan. Concrete surface for the front face of the wall shall match the architectural treatment requirements and structural concrete color shown on the plans. Squareness determined by the difference between two diagonals, shall not exceed ½ inch. Surface defects on the front face textured surface, shall not exceed 3/16 inch when measured with a 5 foot straight edge, except when intentionally roughened.

CDOT shall be allowed access to the manufacturer's facilities to inspect and sample units from lots prior to delivery with a minimum of 2 working days advance notice. CDOT will reject any concrete panels, which do not meet the requirements of this specification. Panels shall not be shipped until the concrete strength, at the time of shipping, is greater than 0.9 times f'_c . The Contractor shall notify CDOT in writing at least 3 working days before shipment of panels begins.

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At horizontal joints, a cellular type or molded expansion joint material shall be placed and shall be a size suggested by the supplier and approved by CDOT.

504.07 Certifications, Calculations and Testing Reports. The Contractor shall provide the following reports, certifications, calculations and checklists as needed to accompany the shop drawing submittal. All engineering calculations, as stated in subsections 504.07(f), 504.07(g), 504.07(j), 504.07(k), 504.12(e), 504.12 (f), 504.12(g), and 504.12(i) shall be certified and stamped by a Professional Engineer licensed in the State of Colorado.

- (a) Certification of T_{ULT} (MARV). For geo-synthetic reinforced system only, the Contractor shall submit a certification letter from the manufacturer which provides the T_{ULT} (MARV) and certifies the T_{ULT} (MARV) of the supplied materials have been determined in accordance with ASTM D4595 or ASTM D6637 as appropriate.
- (b) Mill Report for Metallic Reinforcements and Connectors. This includes, but is not limited to mill certifications on weldability, ultimate tensile and yield strength.
- (c) Report of The Panel-Reinforcement Connection Test. **NOT REQUIRED UNLESS PROPOSED SOIL REINFORCEMENT DEVIATES FROM THE STANDARD PLANS.** The test report shall be prepared and certified by an independent laboratory. The panel to reinforcement connection test method shall conform to the industrial standards. The report shall provide data on the ultimate as well as service limit state.
- (d) Report for Soil to Reinforcement Interface Pullout Test. **NOT REQUIRED UNLESS PROPOSED SOIL REINFORCEMENT DEVIATES FROM THE STANDARD PLANS.** The test report shall be prepared and certified by an independent laboratory. The soil to reinforcement interface pullout test method shall conform to the requirements of ASTM D6706. Tests shall include the full range of overburden pressures defined by wall design heights.
- (e) Certification of Facial Panel to Wire Basket Long-Term Connection Strength. **NOT REQUIRED UNLESS SPECIFIED IN THE PLANS.** Certification shall include calculations to demonstrate that the facial panel to reinforcement connection meets or exceeds current AASHTO 75 years design life requirements.
- (f) Certification of Reinforcement Pullout. **NOT REQUIRED UNLESS PROPOSED SOIL REINFORCEMENT DEVIATES FROM THE STANDARD PLANS.** Certification shall be provided with detail calculations to demonstrate that reinforcement pullouts meet or exceed current AASHTO requirements. For metal reinforcement breakage and pullout, calculations shall include a combination of 75 years material depletion of carbon steel and galvanization loss.
- (g) Report and Certification for the Initial Concrete Compression Strength, Shipping and Handling Stress. Cylinder compressive test is acceptable to verify the initial concrete strength of panel at time of shipping. Concrete tensile stress shall not exceed the modulus of rupture. Report shall include calculations of panel cracking stress according to the proposed method of lifting and shipping. Before panel shipping from precast yard to wall site, the Contractor's Engineer will approve the time of shipping, method of lifting and supporting condition during shipping as well as storage condition at the site before panel installation. Products shall conform to PCI MNL 117, 120, 122, and 127 as applicable.
- (h) Calculations. **NOT REQUIRED UNLESS PROPOSED SOIL REINFORCEMENT DEVIATES FROM THE STANDARD PLANS.** Calculation of the LTDS of reinforcement shall conform to AASHTO LRFD

requirements.

- (i) Efflorescence and Air Content Test. Panel shall be visually efflorescence free. Efflorescence control agent shall be used in concrete mix design. When fly ash is used as the efflorescence control agent, the fly ash shall be ASTM C618 Class F fly ash and shall be a minimum of 20 percent by weight of the total cementitious material content. Air Content shall be determined in accordance with AASHTO T152. Concrete shall be tested a minimum of the first three batches each day and then once per five batches for the rest of the day to assure specified air entrainment.
- (j) Submittal Checklist. The Contractor shall submit the Panel Faced MSE (or as approved for GRS) Wall Submittal Checklist, Form 1402 with the Certifications, Calculations and Testing Report submittal package included with the shop drawing submittal.

504.08 Hybrid or Smaller Panel MSE Wall Systems.

Only Micropile A-Frame wall systems are allowed. System is subject to all requirements in this project special provision. Installation of micropiles through fabrics allowed with required pre-installed sacrificial pilot pipes.

The Contractor shall submit the dry cast facing MSE Wall Submittal Checklist, Form 1401 or the wet cast facing MSE Wall Submittal Checklist, Form 1402, with the Certifications, Calculations and Testing Report submittal package included with the shop drawing submittal.

Construction Requirements

504.09 Approval and Qualifications of GRS (or MSE equivalent) Wall Installer. The job site wall foreman shall have experience in construction of at least five transportation related GRS walls within the last three years. Transportation related GRS walls are walls that carry or are adjacent to vehicular traffic and are constructed with MSE reinforcement in the reinforced structure backfill zone. The foreman must have prior experience or adequate training on the products that the Contractor elects to use in the project. The resume and credentials of the foreman shall be submitted to CDOT for approval prior to the pre-construction meeting. The foreman shall be on the site for 100 percent of time during which the work is being done.

504.10 Wall Test Segment. The wall test segment shall be the first segment of the wall constructed. The wall test segment shall be constructed in the presence of the Technical Representative and CDOT and shall include construction of each of the 5 elements listed in 504.15 below. The minimum length of the wall test segment shall be 40 feet or the full length of the wall if less than 40 feet. A wall test segment shall be constructed for the first wall constructed from each wall product used on the project.

504.11 Technical Representative of Wall Product Supplier. NOT REQUIRED UNLESS SPECIFIED IN THE PLANS. The Contractor shall arrange for a technical representative (Tech Rep) of the manufacturer of the selected wall products to be present during the construction of each wall test segment. If the selected wall products are supplied from different manufactures, a Tech Rep from each wall product shall be present. The Tech Rep shall be present for construction of the wall test segment and each of the following elements:

- (1) Placement of a minimum of the first four layers of primary soil reinforcement and backfill,
- (2) If obstructions (i.e. steel piles, concrete piers/abutments, concrete boxes, pipes, etc.) exist, placement of primary soil reinforcement and backfill at obstructions,

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- (3) Placement of a minimum of the first two rows of panels or a minimum of a four foot wall height,
- (4) If a vertical slip joint is required, construction of the vertical slip joint in a minimum of a two row portion of panels or a minimum of a four foot wall height, and
- (5) If corners are required, construction of a corner representative of the corners in the wall in the project in a minimum of a two row portion of panels or a minimum of a four foot wall height.

Before construction of the wall test segment the Tech Rep shall provide the Contractor and CDOT the following:

- (1) Technical instructions as required in the construction of the earth retaining wall system.
- (2) Product specific specifications in the placement of the soil reinforcement and backfill in accordance with the wall system.
- (3) Guidelines in placing the facing units and attaching them to the soil reinforcement in accordance with the system requirements.
- (4) Provide technical assistance to the facing unit fabricator.

At the completion of the wall test segment the Tech Rep shall provide the following:

- (1) Documentation that the wall test segment was constructed in accordance with the product specific specifications. This documentation shall include a location description (starting and ending stations and elevations) of the wall test segment.
- (2) Documentation that the job site wall foreman is familiar with the wall products used to construct the walls on the project.

After completion of the wall test segment the Tech Rep shall be available whenever there is any special field condition such as change of geological condition, when there are equipment or personnel changes, or when requested by CDOT.

504.12 Facial Panel Quality Control, Placing Plan and Daily Placement Logs. Before the start of wall construction, the Contractor shall provide a panel-placing plan and shall supply daily placement logs to CDOT weekly and at the completion of the wall. The daily placement log shall consist of an elevation view of the wall showing the dates, number of panels placed, and the serial numbers of the panels placed. The panel quality control shall contain multiple submittals if required by subsections 504.12(g) and (h). Panels shall be labeled with serial number for each panel and corresponding certification with one set of random samples tested for each 220 panels or 5500 square foot of wall face.

At least one certification with supporting test results is required for each wall. Test results will be reviewed and pre-approved by CDOT before shipment. The Contractor shall coordinate and mark the panel and backfill placing sequence on the daily placement logs. The log serves as means for CDOT to identify where each panel was placed.

504.13 Wall with Curved Alignments, Tight Curved Corners, and Sections Adjacent To Bridge Abutment. The Contractor shall provide a placement plan that shows curved layouts, special corner panel, sequence of panel placement, and construction off-sets as recommended by the manufacture. For tight curved corners, 8-foot radius or less, and dissimilar foundations such as bridge abutment, to avoid panels with random cracks, the Contractor shall install vertical slip joints as shown on the shop drawings.

504.13 Excavation and Backfill. The base of leveling pad shall receive the same compaction as cut area required by subsection 203.07. The Contractor shall report to CDOT in writing density test results for any unsatisfactory bearing material that does not meet the minimum 90 percent compaction for walls less than 16 feet high and 95 percent of T-180 for walls higher than 16 feet. If the excavation for the placement of the leveling pad exposes an unsatisfactory bearing material, CDOT may require removal and replacement of that material. The removed material shall be replaced with Structure Backfill (Class 1) compacted in conformance with subsection 206.03. CDOT with the assistance of the geotechnical engineer of record will provide the limits including the depth of removal. As directed by CDOT, and if required, Structure Backfill (Class 1) shall be reinforced with soil reinforcements in conjunction with wick drains and outlet pipes.

The Contractor shall grade the foundation for the bottom of the wall for a width equal to or exceeding the limits of the Reinforcement Length (RL) plus 18 inches as shown on the plans. This graded area shall be compacted with an appropriate vibratory roller weighing a minimum of 8 tons for at least five passes or as directed by CDOT. For cut wall with continuous seepage, phasing of foundation construction or a different drainage and foundation improvement plan may be necessary.

The reinforced structure backfill zone and the retained structure backfill zone portion immediately behind the wall as defined on the plans shall be Structure Backfill (Class 1). Recycled asphalt recycled concrete and flow-fill material shall not be substituted for Structure Backfill (Class 1). Each compacted layer of backfill within a distance equal to the reinforcement spacing away from the back of the panels shall not exceed 4 inches. The triangular or trapezoidal portion behind the concrete panels and above the spill of backfill, as shown on the plans, shall be filled with $\frac{3}{8}$ + inch crushed rock, filter aggregates with filter fabric, or wall system specific fill as approved by CDOT.

Density tests behind and parallel to the wall in the triangular or trapezoidal portion above the backfill spill zone are not required. Each compacted layer of backfill shall be in even increments up to 8 inches thick. The fill and compaction operation shall start 3 feet from the wall back face and progress toward the end of the reinforcement. All Structure Backfill (Class 1) including fill material under the wall and on-site material as allowed by subsection 504.08 shall be compacted to a density of at least 95 percent of the maximum density according to AASHTO T 180. For on-site foundation material containing more than 30 percent retained on the $\frac{3}{4}$ inch sieve, a method of compaction consisting of a conventional heavy vibratory roller starting with minimum 5 passes shall be used to establish the number of passes required to exceed the 95 percent T180.

At least 6 inches of material shall be in place prior to operation of tracked vehicles over soil with reinforcement. Only power operated roller or plate compaction equipment weighing less than 1,000 pounds is allowed within 3 feet of the front of the wall face. The reinforcement shall not be connected to the wall until the compacted fill is at or slightly higher than the location of the connector.

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Backfill containing frost or frozen lumps shall not be used. Backfill that has been placed and becomes frozen shall be removed and replaced at the Contractor's expense. If cold weather conditions prevent the placement of Structure Backfill (Class 1), the Contractor may use Filter Material Class B as backfill without compaction at the Contractor's expense and approved by CDOT. The Contractor shall provide a test report, prepared and certified by an independent laboratory, that the internal friction angle of soil for the Filter Material Class B meets or exceeds that shown on the plans.

The Contractor shall place additional panels including partial height panels and properly compacted fill material to return the finished grade to the plan elevations if settlement, as determined by CDOT, has occurred. A final inspection before the installation of rail anchoring slab will be made after construction settlement, if any, has occurred or 30 days after the completion of the wall. The Contractor shall provide immediate temporary storm water protection and wind erosion control at the end of each day during construction. If settlement occurs as the result of loss of backfill due to wind or water erosion, non-conforming backfill such as frozen fill or over-saturated fill, or if the backfill does not meet compaction requirements, the Contractor shall remove the backfill, wash the soil reinforcement, and bring the elevation to the finished grade at the Contractor's expense. Before final project acceptance, the Contractor shall repair any backfill losses due to wind and water erosion.

To avoid the foundation of the leveling pad being washed out by rain, the area in front of the wall and around the leveling pad shall be backfilled as soon as practicable.

504.15 Reinforcement. Geosynthetic reinforcement shall be slightly pre-tensioned. The minimum coverage ratio for woven fabric reinforcement shall be 100 percent and an overlap between rolls is not required. Soil reinforcement shall not be cut to avoid obstruction unless shown on the shop drawings. Equivalent strength geogrid may be used above the waterproofing membrane.

504.16 Leveling Pad. The foundation of the leveling pads shall meet the requirement of subsection 504.09 for steel and concrete. The leveling pad shall be level within the tolerance of $\frac{1}{8}$ inch for any two points along the length of a panel, and within $\frac{1}{4}$ inch for any two points 10 feet apart. If the wall is not level, the panels will bind against each other causing spall of the edges and corners.

Cushion or shimming material (Expansion Joint Material, Concrete Mortar Grout, Roofing Felt or Geosynthetic Reinforcement) shall be used to support panels directly founded on the leveling pad. Before starting a new course of panels, the Contractor shall take steps to ensure that the wall elevations are matched at the neighboring panels. Cushion or shimming material shall be used to obtain necessary panel elevations at next leveling pad step. No more than 2 shims (each $\frac{3}{16}$ -inch-thick) should be required to level the panels on the leveling pad.

504.17 Wooden Wedges. Wooden wedges are used to help to hold the panels at the correct batter during the backfill operation. The wooden wedges shall be made from hard wood (such as oak, maple or ash). Wooden wedges shall be removed as soon as the precast panels above the wedged panels are completely erected and backfilled. There shall not be more than three rows of wooden wedges in place at one time. Panels that crack or spall due to failure to remove the wooden wedges shall be repaired or replaced.

504.18 Panel Facing. For walls that support a roadway, the wall layout line at the leveling pad shall be setback and pre-measured with appropriate batter (5 to 8 percent) from the top of the panels according to the offset with respect to the centerline of the road. For walls adjacent to a roadway, the wall layout line at the leveling pad shall be directly offset from the centerline of the road. An overall negative batter (wall face leaning outward) between the bottom and the top of the wall is not allowed. Unless otherwise noted on the plans for battered walls, the final wall face shall be vertical, or have a positive batter of not greater than 5 percent for construction control purpose. The surface of the wall face shall be tested with a 10 foot

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straightedge laid along the surface in horizontal and vertical directions. Except as necessary for horizontal alignment of the wall, convex deviation of the wall face from the straightedge (belly wall) shall not be allowed, and concave deviation from the straightedge shall be less than ½ inch.

Walls without a rail-anchoring slab, cast-in-place reinforced concrete coping with uniform exposed height is required to match the required finished elevations as well as to retain the panels' lateral deformation. For walls with rail anchoring slabs, the top of panel elevations shall be within 8 inches of the bottom of the anchoring slab. Cast-in-place concrete or saw-cut partial height panels may be used to accomplish this.

Where the Geomembrane for drainage interferes with the continuation of reinforcement, the panels beyond the termination shall be reinforced with the same grade of additional soil reinforcing material to maintain the total amount of reinforcement per panel. To avoid leaking or soil erosion through the joint, a filter fabric at least 12 inches wide shall be glued to the panels behind all vertical joints.

As shown on the plans, facing panels directly exposed to spray from deiced pavements and indirect windborne spray shall have three coats of water resistant or repellent concrete sealer applied to the front face of the wall before the wall is opening to traffic.

For completed wall or parts of completed wall, before final payment any damages including blemish and discoloring of panel shall be replaced or repaired. Sand blasting may be used if accepted by CDOT.

504.19 Fill under Leveling Pad. For walls requiring fill under the planned elevation of the leveling pad, the Contractor may lower the elevation of the leveling pad as approved by CDOT, except that the finished elevation at the top of the wall shall not be altered. As requested by the Contractor, and with CDOT's approval, the higher wall shall be redesigned with longer reinforcement length and revised reinforcement schedule.

**REVISION OF SECTIONS 509 & 708
PAINTING OF ALUMINUM ACCESS DOORS FOR STEEL STRUCTURES**

Sections 509 & 708 of the Standard Specifications are hereby revised for this project as follows:

Subsection 509.24 shall include the following:

Aluminum access doors shall receive a solvent cleaning to remove grease, oil, etc. (SSPC-SPI) followed by a brush blast to provide a profile similar to the structural steel. The access doors shall receive one coat of primer as described in the Revision of Section 708.03.

Subsection 708.03 shall include the following:

If Alternate 1, Alkyd System, is to be used on the structural steel, the aluminum access doors shall receive one coat of vinyl wash primer conforming to Mil-P-15328. Following the application of this primer, the doors will be painted the same as the structural steel (one field coat of primer followed by the top coat). Coating thicknesses shall be the same as specified for the structural steel.

If Alternate 2, Inorganic Zinc-Rich Polyurethane System, is used on the structural steel, the aluminum access doors shall receive one coat of vinyl wash primer conforming to Mil-P-15328. Following application of the vinyl wash primer, the same polyurethane top coat as used on the structural steel shall be applied to the access doors (minimum 3.0 mils dry film thickness).

The manufacturer of the primer shall certify in writing, that the primer used is compatible with the cleaned aluminum access doors and the polyurethane top coat to be used on the structural steel.

**REVISION OF SECTION 513
BRIDGE DRAIN**

Section 513 is hereby added to the Standard Specifications for this project as follows:

Description

513.01 This work shall consist of furnishing and placing bridge drains in accordance with the details shown on the plans and the specifications.

Materials

513.02 Pipe for bridge drains shall meet the requirements of ASTM A53 and shall be standard weight.

Down spout pipe shall be hot dipped galvanized after fabrication. Galvanizing shall meet the requirements of AASHTO M111.

Metal used in the manufacture of castings shall meet the requirements of ASTM A48 Class 35B.

Construction Requirements

513.03 Bridge drains shall be placed and secured at the locations shown on the plans prior to placement of concrete.

Prior to fabrication of this item, two sets of working drawings which comply with the requirements of Section 105 shall be submitted to CDOT for information only. The working drawings will not be approved or returned.

**REVISION OF SECTION 515
CONCRETE SEALER (CALCIUM NITRITE)**

Section 515 of the Standard Specifications is hereby revised for this project as follows:

Subsection 515.01 shall include the following:

This work consists of applying a penetrating corrosion inhibitor to finished surfaces of existing concrete or to cut surfaces of existing concrete prior to placement of new concrete. The corrosion inhibitor shall be placed under the direction of a manufacturer's representative in accordance with the manufacturer's instructions and as described herein.

Subsection 515.02 shall include the following:

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The corrosion inhibitor shall consist of calcium nitrite and liquid carriers or penetrating vehicles, or organic inhibitors such as amino alcohols. The corrosion inhibitor shall conform to AASHTO M194, except for the requirements in tables 1, and 2, and sections 11 through 17. The corrosion inhibitor shall be one on the approved products list of the Division. If there are no approved products on the list the corrosion inhibitor shall be a product approved by CDOT. If the plans specify the use of a calcium nitrite inhibitor, the inhibitor shall be calcium nitrite, if the plans specify the use of an organic inhibitor, an organic inhibitor shall be used. If the plans do not specify the type of inhibitor, either or both types of inhibitor may be used either individually or in combination, provided that the combination use is in accordance with the manufacturer's recommendations.

Subsection 515.05 (a) shall include the following:

Prior to the application of the corrosion inhibitor, surfaces to be treated shall be cleaned by air, sand, or water blasting and flushed with water until all material and contaminants which may interfere with the inhibitor's penetration have been removed.

Subsection 515.05 (b) shall include the following:

The corrosion inhibitor shall be applied when the surface to be treated has been dry for at least 24 hours and above a temperature of 40F, or within a more restrictive temperature range if recommended by the manufacturer.

Subsection 515.05 (c) shall include the following:

After the exposed surfaces have been prepared and allowed to dry, coats of corrosion inhibitor shall be applied in accordance with the manufacturer's recommendations. Each coat shall be evenly applied. Each application shall be allowed to dry prior to making the next application. Exposed surfaces shall be protected from precipitation and heavy dew during and after the application of the penetrating inhibitor. Traffic shall not be allowed on the treated surface until the corrosion inhibitor has penetrated the concrete and the liquid corrosion inhibitor is no longer visible on the surface. The Contractor shall follow all manufacturer's recommendations, including penetration time, prior to opening treated surfaces to traffic or completing the work.

Enough coats shall be applied so that each square yard of treated surface shall have absorbed 0.12 lb. of calcium nitrite or organic inhibiting agent. When treating areas from which deteriorated concrete has been removed, lap the treated area onto the adjacent surface at least 2' beyond the removal.

**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 CDOT.

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Polyester concrete shall be used as the patching material if Class 1 removals are called for in the plans. Polyester concrete shall not be used as the patching material for Class 2 or Class 3 deck removal areas.

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, Equipment, Certificates of Compliance with laboratory testing for each property, and any other relevant documents for the overlay system at least 15 working 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 CDOT.

(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 Provider's 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 polyester polymer concrete systems on bridge decks or concrete pavement to established grade lines using similar equipment as specified herein within the past 5 years. The documentation of Contractor's qualifications shall include the following:

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

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 provide technical support for the materials. Once the Contractor has demonstrated an acceptable experience level with the PPC the requirements for the onsite Technical Representative may be reduced at CDOT's discretion.

(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 dates

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- (3) Overlay quantities
- (4) Reference name and contact information for owner representatives

The Technical Representative shall be available on site to facilitate the installation of polyester concrete. This includes, but is not limited to, trial slab preparation and PPC application, deck surface preparation and PPC application, and polyester polymer 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:
 - i. Paving widths
 - ii. Anticipated paving lengths
 - iii. Paving directions
 - a) Contractor shall pave from high side of the bridge to the low side
 - b) No gaps between passes will be allowed
 - iv. Joint locations
 - a) Cold joints between passes shall be within 1 foot of the lane lines or centered within a lane
 - v. Location of proposed trial overlay(s)
- (3) Description of equipment used for:
 - i. Surface preparation including grinding and shot blasting
 - ii. Applying HMWM resin
 - iii. Measuring, mixing, placing, and finishing the polyester concrete overlay
 - iv. Applying sand
 - v. 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.
 - i. Mainline tining shall be automated with the finisher.
- (8) Cure time for polyester concrete.
- (9) Storage and handling of HMWM resin and polyester concrete components.
- (10) Procedure for disposal of excess HMWM resin, polyester concrete, and containers.
- (11) 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 CDOT.

(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 to the Materials Section a minimum of 7 working 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 4-liter sample for each liquid and a 5 pound sample for each dry component. The Contractor shall perform a minimum of one gradation analysis per project of

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combined sand and aggregate taken from the belt during production. Additional gradations may be required as directed by CDOT.

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.

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 percent +/-1percent 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 sec (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.

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	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.

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	4.0x10 ⁻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)	Colorado Procedure – Laboratory 4302	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:

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 (Bond Strength)	Colorado Procedure – Laboratory 4302	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)

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Abrasion Resistance	Colorado Procedure – Laboratory 4301	<2g weight loss (at 12% resin content by weight of the dry aggregate)
Modulus of Elasticity	ASTM C 469	1,000,000 psi to 2,000,000psi (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.

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 and a minimum of 20 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 applications shall replicate field conditions and be constructed using all the same equipment as the production work including the paving machine and volumetric mixer. The location of the trial applications shall not be on the bridge deck or approach slab and shall be approved by CDOT. 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 trial application before the installation may proceed.

The methods, installer, or Overlay System may be rejected after three trial applications if not shown to be adequate or in compliance with this specification as ordered by CDOT.

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 CDOT prior to commencement of any work.

(a) Measuring Equipment:

The following equipment shall be provided:

- (1) Certified Scales used to calibrate the mobile truck mixing equipment.
- (2) Means to measure the resin levels in the tank of the mobile truck mixer during paving operations and access to the resin tank.

(b) Mixing Equipment: A continuous mixer shall be used for all polyester concrete overlay applications. The Contractor shall submit a written calibration plan that is specific to the Contractor’s continuous mixing truck(s). The calibration plan shall be submitted a minimum of seven calendar days prior to use of the mixer(s).

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The continuous mixer shall:

- (4) Employ an auger screw/chute device.
- (5) Be equipped with an automatic metering device that measures and records aggregate and resin weights and/or volumes. Record weights or volumes at least every five minutes, including time and date. Submit recorded volumes at the end of the work shift.
- (6) Have a visible readout gage that displays weights or volumes of aggregate and resin being recorded.
- (7) Produce a satisfactory mix consistently during the entire placement.
- (8) Be calibrated by certified scales provided by the Contractor. Calibration shall be verified by demonstrating that the computer tickets are within 2% of actual material weights. With CDOT witnessing, the contractor shall produce three consecutive batches of aggregate that have batch tickets and actual material weights that are within 2 percent of each other, and three consecutive batches of resin that have batch tickets and actual material weights that are within 2 percent of each other. The calibration shall be verified on each project, and the calibration shall be done every 60 calendar days. Additional calibration verification will be required as directed by CDOT if quantities or production rates are in question.

A portable mechanical mixer of appropriate size for proposed batches, as recommended by the System Provider and approved by CDOT, may be used for all PPC patching applications and for smaller area applications of less than 4000 square feet per bridge or pavement section.

- (c) 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.
- (4) Have sufficient engine power and weight to provide adequate vibration of the finishing pan while maintaining consistent forward placement speed.
- (5) Mainline tining shall be automated with the finisher.
- (6) Be capable of forward or reverse motion.

Finishing of patches of Class 1 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 removed areas shall be patched prior to overlay to provide a uniform thickness.

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Patching mortars with magnesium phosphate will not be allowed on decks receiving a polyester concrete overlay. Existing mortars that are over 28 calendar days old may remain in place if determined to be sound and acceptable by CDOT.

All cement-based deck patching material, including mortar and concrete, shall attain a minimum compressive strength of 3000 psi, cure a minimum 5 calendar days, and pass the Deck Patch 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 calendar 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. Steel shot shall comply with SSPC-AB3 and recycled steel shot shall comply with SSPC-AB2.

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 CDOT. If the deck becomes contaminated before placing the overlay, the Contractor shall shotblast or abrasive sandblast the contaminated areas, per recommendation of the System Supplier's Technical Representative, and to the satisfaction of CDOT at no additional cost to the project.
- (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.

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 CDOT. The application of the overlay shall not begin until the deck patches have cured for 5 calendar days, completely surface dry in accordance with ASTM D4263 or have a moisture content of 5% or less when measured by a moisture meter approved by CDOT. 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 degrees Fahrenheit rising and 100 degrees Fahrenheit falling, or per System Provider's recommendation, whichever is higher or lower, respectively. Night work may be required when temperatures cannot be met during the day. Stockpiled materials shall not be stored on the bridge deck.

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- (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. Primer shall be applied with push brooms or rollers. 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. The set time can be determined in the field when the in-place PPC cannot be deformed by pressing with a finger, 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 set times may be required if suggested by the System Provider and approved by CDOT.

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 CDOT.

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 CDOT at no additional cost to the project.

The overlay shall be longitudinally tined unless Plans indicate that the overlay shall be textured per Section 601.15(e)2.

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Tining shall produce grooves of 1/8 inch by 1/8 inch spaced at $\frac{3}{4}$ - 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.

Polyester concrete overlay edges shall be tapered if the overlay is not completed within the allowable lane closure time and is more than $\frac{3}{4}$ inch higher in elevation than the adjacent pavement.

If the overlay thickness is greater than $\frac{3}{4}$ inch in height, longitudinal polyester concrete tapered edges parallel to the direction of traffic shall be tapered to not less than a 4:1 (horizontal:vertical) slope. Transverse temporary asphalt tapered edges perpendicular to the direction of traffic shall be tapered to not less than a 50:1 (horizontal:vertical) slope. Longitudinal polyester tapers may remain and be overlaid with polyester concrete overlay. Transverse temporary asphalt tapers shall have a bond breaker and be completely removed prior to overlay placement.

- (c) **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 CDOT.
- (d) **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.

519.13 Acceptance Testing. Acceptance of the deck patch, surface preparation, and thin bonded overlay will be determined by CDOT based on materials sampling, 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. An alternative to the Plastic Sheet Method is a Moisture Meter Test, with a Moisture Meter approved by CDOT, with a passing moisture reading on the patch or patches, of 5% or below. The patches to be tested will be approved by CDOT.
- (c) **Overlay Pull Bond Testing:** Vertical axis pull bond tests shall be performed after 24 hours by the Contractor in accordance with 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

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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 15,000 square feet, additional tests shall be performed at a frequency of one test per 15,000 square feet of additional deck area, rounded up. Additional testing may be required as directed by CDOT.

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 percent of the test surface area. The Contractor shall repair all bond test locations with polymer overlay in accordance with this specification.

(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 CDOT. The Contractor shall furnish an approved 10 foot straightedge, depth gauge, and operator to aid CDOT 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 with those used for the application of the overlay. All surface defects shall be repaired to the satisfaction of CDOT 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, saw cut, removed with diamond grinding, and replaced at the Contractors expense.
- (c) **Replacement of Defective Overlay:** A defective overlay, identified by sounding for delamination or a failing pull bond test result, shall be removed and replaced at the Contractor's expense. The Contractor shall submit a written corrective work proposal to CDOT, 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 CDOT. CDOT's approval will not relieve the Contractor of the responsibility of producing work in conformity with the Contract.
- (d) **Defective Tining:** If CDOT determines tining to be unacceptable on any deck surfaces measuring 30 square feet or more, 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.

SECTION 522 ENVIRONMENTAL STAIN (GALVANIZED)

Section 522 of the Standard Specifications is hereby revised for this project to include the following

Description

This work consists of applying an environmentally and animal safe, non-caustic, non-pigment based surface stain to all visible galvanized steel surfaces including galvanized steel supports to achieve the specified color, as shown on the Plans.

Materials

Environmental surface stain shall consist of a clear soluble solution of natural elements and soft buffered organic acids. No pigment based colorants shall be added to achieve the desired color. The stain shall react with the target surface over a period of 7 - 21 days to produce a consistent color and matte finish as specified on the plans, and as approved by CDOT. The stain shall be resistant to fading in the sun and have a minimum life expectancy of 25 years.

In all situations involving the approval of submittals, the Contractor will coordinate with CDOT.

Construction Requirements

The Contractor shall submit a copy of the manufacturer's product Safety Data Sheet for all related products (including cleaning agents) together with instructions for application of stain a minimum of 5 days prior to staining the sample section. Proposed methods to control overspray, spillage and protection of adjacent surfaces shall be submitted in writing for approval by CDOT. Staining shall not begin until written approval of these methods has been received.

- (a) *Stain Sample.* The Contractor shall apply stain to a minimum 12 inch sample section of galvanized metal. If staining will occur onsite the Contractor shall stain the sample in the presence of CDOT. The Contractor shall notify CDOT a minimum of 7 days prior to staining the sample section. The Contractor shall prepare and stain the sample section with the same materials, tools, equipment and methods to be used in staining final surfaces. The applied stain shall be allowed to cure for a minimum of 21 days. The sample shall be submitted to CDOT for approval. The cost of materials and labor necessary to achieve the accepted sample shall be included in the price of the work. In the event more than one sample section is required, each additional sample shall be included in the price of the work. The Contractor shall use the approved sample as the standard of comparison in determining acceptability of staining.
- (b) *Stain Application.* Prior to application of the stain onto the metal surface, excessive oils, dirt, and other contaminants shall be cleaned with cleaning agents conforming to the manufacturers recommendations and approved by CDOT. All surfaces shall be dry before application of stain. Stain shall be applied in accordance with manufacturer's recommendations to achieve a color consistent with the approved sample.
1. If spray application is used, the Contractor shall follow manufacturer's recommendations. The Contractor shall minimize overspray on undesired surfaces and protect adjacent surfaces from overspray. Spray application shall not be performed under windy or rainy conditions. Stain shall be applied uniformly, free from sags, runs or defects of any kind. Irregularities shall be corrected according to the stain manufacturer's recommendations. Stained surfaces shall be kept dry for a period of 5 days following the application of stain.
 2. If Immersion application is used, the Contractor shall immerse the structure in a controlled area following manufacturer's recommendations. The Contractor shall minimize splashing, dripping and runoff on surfaces not intended for stain application. The structure shall have a uniform appearance, free from sags, runs or defects of any kind. Irregularities shall be corrected according to the manufacturer's recommendations. Stained surfaces shall be kept dry for a period of 5 days following the application of stain.
 3. Multiple applications, per manufacturers' recommendations, may be required to achieve the color of the approved stain sample.

4. Final approval of products by CDOT will occur when stain has achieved the color of the approved stain sample.
 5. All substandard items not achieving the color of the approved stain sample will be rejected.
- (e) *Storage of Materials.* Stained surfaces shall be stored properly at the construction yard after delivery, before, and up to, the time of installation. If components stack (e.g. guardrail), spacers shall be placed between rows to allow for necessary airflow. Items shall be stacked perpendicular to the ground sloped to allow for proper drainage. Items shall be elevated so they do not come into direct contact with soil or plant matter. The Contractor shall also conform to other standard storage procedures and manufacturer recommendations regarding storage. It is the responsibility of the Contractor to ensure that all components are stored properly on site.

**REVISION OF SECTION 601
PAINTING OF ALUMINUM ACCESS DOORS
FOR CONCRETE STRUCTURES**

Section 601 of the Standard Specifications is hereby revised for this project as follows:

Subsection 601.14(b)4 shall include the following:

Aluminum access doors shall receive a solvent cleaning to remove grease and oil (SSPC-SPI) followed by a brush blast.

The aluminum access doors shall receive one coat of vinyl wash primer conforming to Mil-P-15328. Following the application of this primer, the doors will be coated with Structural Concrete Coating conforming to Revision of Section 601 Structural Concrete Coating.

The manufacturer of the primer shall certify in writing, that the primer used is compatible with the cleaned aluminum access doors and the Structural Concrete Coating to be used on the Structural Concrete.

**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 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

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- 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.

For Bridges, structural concrete stain (or paint for steel Structures) shall be applied to surfaces for each Structure and applied to exposed surfaces of bridge rails, exterior edges decks, deck overhangs, exterior girder outside and exposed flanges, exposed bottom flanges on interior girders, abutments to 1 foot below grade, pier columns to 1 foot below grade and wingwalls to 1 foot below grade. Stain limits on bridge rails shall apply to railings on approach slabs. 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 color of the Structural Concrete Stain shall have the written approval of CDOT prior to final batching and application on the project. The final color of the approved structural concrete stain shall be determined as follows:

1. 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 CDOT. The stain shall be applied to the test panels by the same methods to be used in the final field

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application. CDOT will be allowed three business days for the stain to dry after stain application to the test panels.

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.

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

2. 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.

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 CDOT 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.

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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 CDOT before the Contractor begins applying the Stain.

**REVISION OF SECTION 604
VANE GRATE INLET**

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

Description

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

Materials

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

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 CDOT for information only. The working drawings will not be approved or returned.

**REVISION OF SECTION 618
PRESTRESSED CONCRETE**

Section 618 of the Standard Specifications is hereby revised for this project as follows:

In subsection 618.02(b) delete the second sentence and replace with the following:

The Contractor/Fabricator shall keep Certified Mill Test Reports (CMTR's) on file for all steel and metal products used, and shall furnish copies of CMTR's when requested.

In subsection 618.05(a) delete the second paragraph and replace with the following:

The anticipated production schedule, including the start of work, phase work and shipment dates shall be submitted to the QA Representative before any work begins. Fabrication shall not be started until the shop drawings have been returned with the Contractor's Engineer review stamp, indicating Reviewed, no

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exception taken; or Reviewed, revise as noted in accordance with subsection 105.02, and delivered to the Contractor's site of fabrication.

Delete subsection 618.05(b) and replace with the following:

- (b) *Production Schedule Changes.* Accelerated changes to the proposed production schedule, including start of work, phase work, and shipment dates, shall require advance notification be provided to the QA Representative. The Notice of change shall be received at least 48 hours before fabrication begins, unless otherwise approved in writing by the QA Representative.

Delete subsection 618.05(c) and replace with the following:

- (c) *Notice of Shipment.* The QA Representative shall be notified at least 72 hours before shipment of prestressed members to the job site.

Delete subsection 618.06(a) and replace with the following:

- (a) *Process Control and Quality Assurance.* Process Control (PC) of prestressed concrete fabrication is the responsibility of the Contractor. The fabrication plant shall possess and maintain a current Precast/Prestressed Concrete Institute (PCI) certification for Prestressed Concrete. The Contractor shall designate a PC Manager who shall be responsible for product quality requirements as defined in the specifications and the Contractor's approved PC plan (PCP). The PC Manager shall possess and maintain certification at Level II minimum, from the Prestressed Concrete Institute (PCI), and shall have one year minimum of construction related experience. The PC Manager shall not be supervised by the Contractor's production section. If grouting for post-tensioning ducts of combination tensioned members is done by the precast girder fabricator, the PC Manager shall possess and maintain an American Segmental Bridge Institute (ASBI) Certified Grouting Technician Certificate. If prestressing, duct and anchorage installation, duct and anchorage inspection, stressing of tendons, air testing of ducts, or grouting of ducts of bonded tendons of the post-tensioning system is done by the precast girder fabricator the PC Manager shall possess a PTI Level I – Bonded Tendon Training Certificate. The PC manager shall perform the inspection or directly supervise all phases.

Quality Assurance inspection shall be performed on all pretensioned, post-tensioned, and combination tensioned members. The QA Representative acts for and on behalf of CDOT on all matters within the scope of the contract documents, as delegated by CDOT. QA administration will be performed to the extent necessary to assure contract compliance. Fabrication inspection QA personnel shall have training, certification and work experience as described in Section 3.0 of the CDOT Staff Bridge Fabrication Inspection Manual.

Repeated out of tolerance work, including dimensional non-conformance, shall be considered as recurring deficiencies. Recurring deficiencies shall be considered as evidence that required PC is not being provided. When the QA Representative determines that fabrication operations are producing recurring defects that do not conform to the Contract and PCP requirements, the Contractor will be notified in writing that the present work is unacceptable. Work shall not continue until the PC Manager has submitted a written proposal addressing corrective procedures that the Contractor will take to prevent recurrence of the non-conforming work. Fabrication shall not resume until the proposal has been reviewed and accepted in writing by the QA Representative.

Delete subsection 618.06(c) and replace with the following:

- (c) *Frequency.* PC inspection and testing at all intervals of duct and anchorage placement, duct splices at closure pours, onsite duct air pressure tests, forming, tensioning, steel and concrete placement, curing, and storage operations shall be performed in accordance with the accepted PCP. The PCP

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shall contain provisions for increased frequencies of inspection and testing when operations or products do not conform to the Contract.

Delete subsection 618.06(d)1 and replace with the following:

1. Prestressing Steel - Tensioning reports for each setup, showing the jacking force calculations; initial and final jacking force used; calculated and final net measured elongation; applicable stressing corrections for seating, slippage, shortening, rotation movement, and temperature; Certified Mill Test Reports for prestressing steel used; jack identification number and calibration date; and date and time of stressing.

In subsection 618.06(d)2 delete the following item from the list:

- (7) Actual curing enclosure humidity charts or graphs

Delete subsection 618.06(d)6 and replace with the following:

6. Product camber and length measurements shall be submitted to the QA Representative a minimum of seven calendar days prior to shipping. Deviation from this requirement shall require advance written notification to the QA Representative.

In subsection 618.06(d)8, second paragraph, delete the second sentence and replace with the following:

In the presence of the QA Representative, the Contractor shall pressurize the duct to 30 psi and lock-off the outside air source.

In subsection 618.07(a)9 delete the first paragraph and replace with the following:

Hold-down devices shall be placed: within a 20 inch horizontal tolerance from the locations shown on the plans if placement is moved toward the center of the girder; or within a 40 inch horizontal tolerance from the locations shown on the plans if placement is moved toward the girder ends. If minimum or maximum placement locations are shown on the plans, the placement tolerances shall not encroach beyond those locations.

In subsection 618.07(c)1, first paragraph, item (5) shall include the following:

- (iv) Be a holder of a current Certified Grouting Technician Certificate from the American Segmental Bridge Institute (ASBI).

Delete subsection 618.07(c)2(1) and replace with the following:

Alternative anchorage systems, including all associated anchor zone reinforcing steel associated with the alternative anchorage system, and all details of the alternative anchorage system shall be shown on approved shop drawings and signed and sealed by a Professional Engineer who is registered in the State of Colorado and who is an employee of the post-tensioning system supplier or anchorage supplier.

In subsection 618.07(c)3, third paragraph, delete the first sentence and replace with the following:

The ducts shall be mortar tight and accurately placed within ¼ inch of the positions shown on the approved shop drawings.

In subsection 618.07(c)3, sixth paragraph, delete the third sentence and replace with the following:

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In addition, at draped tenon high points, two additional high point grout vents shall be located three feet beyond all high points in both directions.

In subsection 618.08(1), last paragraph, delete the third and fourth sentences and replace with the following:

Construction joints shall not pass under distribution plates or anchors.

In subsection 618.09(b) delete the third and fourth rows in Table 618-1 and replace with the following:

Property	Test Value	Test Method
Volume Change at 24 hours and 28 days	0.0% to + 0.2%	ASTM C1090 1
Expansion	0.0% (minimum) 2% (maximum)	ASTM C940

In subsection 618.09(b) delete the last paragraph.

In subsection 618.09(d), second paragraph, Item (1), delete the second sentence and replace with the following:

The Gelman filtration funnel shall be pressurized to a minimum of 50 psi and the maximum percent bleed shall be zero.

In subsection 618.09(d)(4) delete the second sentence and replace with the following:

The efflux time shall be within the values established in Table 618-1.

In subsection 618.09(d) delete the second sentence of the sixth paragraph and replace with the following:

To ensure that the tendon remains filled with grout, the outlet shall be closed, and the pumping pressure allowed to build to a minimum of 75 psi before the inlet vent is closed.

In subsection 618.09(d) delete the last sentence of the seventh paragraph and replace with the following:

After the grout has hardened, the standpipe shall be replaced with a cap.

In subsection 618.09(e) the second paragraph shall include the following:

Ice may be used to cool the water but shall not be added directly to the mixed grout. Dry ice and liquefied carbon dioxide shall not be used for cooling purposes.

Delete subsection 618.11(a) and replace with the following:

(a) *Classification.* Concrete shall be Class PS.

Delete subsection 618.11(b) and replace with the following:

(b) *Concrete Mix Components.* The Contractor shall develop a mix design for Class PS concrete. The mix design shall conform to the requirements of Section 601 and CP-62. Materials sources shall be listed on the Contractor's mix design. The PC manager must notify the QA Representative in writing

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before changing the sources as listed in the PCP. Changes in mix design material sources or proportions, except for admixtures, require a new mix design to be submitted to CDOT for approval at least five days prior to the new mix being used in production.

Delete subsection 618.11(c) and replace with the following:

- (c) *Equipment Calibration and Verification.* The Contractor shall implement a plan for equipment calibration and verification of testing apparatus in compliance with ASTM C1077. The calibration records shall be made available to the QA Representative upon request.

Delete subsection 618.11(e)5 and replace with the following:

5. Minimum inner form temperature shall be 32 °F and free of ice at the time of concrete placement.

In subsection 618.11(f) delete the first sentence of the first paragraph and replace with the following:

Finishing Fresh Concrete. Open surfaces of fresh concrete shall be worked as little as possible to obtain the finish shown on the plans.

In subsection 618.11(g) add the following after the first sentence of the first paragraph:

The Contractor's PC representative casting QA concrete cylinders shall be ACI Concrete Field Testing Technician – Grade I certified.

Delete subsection 618.11(g)1 and replace with the following:

1. Test cylinder specimens shall be prepared in accordance with ASTM C31.

Delete subsection 618.11(g)2 and replace with the following:

2. Cylinders will be tested in accordance with ASTM C39 by CDOT. The average strength of at least two test cylinders shall be equal to or greater than the specified strength. When evaluating a single test consisting of three 28-day standard cured cylinders, if the compressive strength of any one cylinder differs from the average by more than 10 percent, that cylinder will be discarded, and the average strength determined using the strengths of the remaining two cylinders. If the compressive strength of more than one cylinder differs from the average by more than 10 percent, all three cylinders will be used to determine the compressive strength.

When the compressive strength of the concrete is less than that specified in the contract, the structural adequacy of the element will be evaluated by CDOT. The Contractor may request to core the element represented by the low strength results. If approved by CDOT, the locations of the cores shall be as directed by CDOT. Coring shall be at the expense of the Contractor and witnessed by the Project Engineer or designee. Coring shall take place no more than 45 days after casting. A minimum of three cores shall be collected with a minimum diameter of 3 inches. The cores shall be obtained by the Contractor and immediately turned over to CDOT for compressive strength testing. Cores shall be obtained in accordance with AASHTO T24 with the exception that immediately after removal from the structure, cores will be cured at a temperature between 60 to 80 °F and at a relative humidity below 60 percent for 24 to 48 hours prior to testing. When evaluating a single test consisting of three cores, if the compressive strength of any one core differs from the average by more than 10 percent, that core shall be discarded and the average strength determined using the strengths of the remaining two cores. If the compressive strength of more than one core differs from the average by more than 10 percent, all

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three cores will be used to determine the compressive strength. If the average core compressive strength is greater than the average of the cylinder compressive strength,

the core strength will be used in CDOT's evaluation. If the core compressive strength is less than the cylinder compressive strength, the cylinder strength will be used in CDOT's evaluation.

Final determination of acceptance or rejection of the element shall be at the sole discretion of CDOT based on evaluation of the cylinders and/or core strengths. If the element is accepted, the core holes shall be filled with a non-shrink grout or mortar approved by CDOT. Patching of the core holes shall be at the expense of the Contractor/Fabricator.

In subsection 618.11(g)5 add the following after the last sentence of the paragraph:

This test shall be conducted for each load of concrete in which compressive strength specimens are cast in accordance with ASTM C39.

In subsection 618.11(g)6 add the following after the last sentence of the paragraph:

This test shall be conducted for each load of concrete in which compressive strength specimens are cast in accordance with ASTM C39.

In subsection 618.11(g)7 add the following after the last sentence of the paragraph:

This test shall be conducted for each load of concrete in which compressive strength specimens are cast in accordance with ASTM C39.

In subsection 618.11(g)8 add the following after the last sentence of the paragraph:

This test shall be conducted for each load of concrete in which compressive strength specimens are cast in accordance with ASTM C39.

In subsection 618.11(g)9 add the following after the last sentence of the paragraph:

This test shall be conducted for each load of concrete in which compressive strength specimens are cast in accordance with ASTM C39.

In subsection 618.12(a)3 add the following after the last sentence of the paragraph:

The Contractor shall monitor the internal concrete temperature using thermocouples with concrete temperature recorded at intervals not to exceed 15 minutes. A minimum of two thermocouples shall be installed in the element at a maximum spacing of 75 feet with a maximum distance from either end of 40 feet. Thermocouples shall be installed at the center of mass of the element as uniformly as practical to provide accurate temperature monitoring information. An element is defined as a single precast prestressed concrete girder or beam or cast-in-place span. When multiple elements are cast simultaneously in a single bed, the temperature monitoring thermocouples shall be at a maximum spacing of 75 feet. Temperature logs shall be submitted to CDOT prior to transporting the element to the project site. When the internal temperature of the element exceeds 160 °F, the Contractor shall submit a mitigation plan to ensure future castings do not exceed the 160 °F maximum temperature requirement.

The mitigation plan shall also include procedures for sampling and testing the element to identify the potential risk for Delayed Ettringite Formation, and/or waterproofing applications to protect against moisture intrusion. The mitigation plan shall be submitted to CDOT for review and approval. Acceptance

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or rejection of the element exceeding the temperature specification will be based on review and assessment of the specific curing temperature logs and the submitted documentation. The element shall not be shipped until the Contractor receives written acceptance from CDOT.

Delete subsection 618.12(c)4 and replace with the following:

4. The internal and surface temperature of the concrete shall not exceed 160 °F.

In subsection 618.13 delete the last sentence of the second paragraph and replace with the following:

The QA Representative will accept, or reject, the finished repair work in writing.

In subsection 618.13 delete the third sentence of the fourth paragraph and replace with the following:

The proposal shall include a detailed description of repair materials, and the methods the Contractor intends to use to evaluate the finished repair work.

In subsection 618.13(b) delete the second paragraph and replace with the following:

Repair methods shall adequately restore structural integrity of the product. When repairs have been completed, the Contractor's Engineer shall examine and analyze the product for construction and service load capacity. A PE stamped letter shall be provided by the Contractor's Engineer certifying that the repair work meets all design serviceability criteria. Evaluation and test data shall be submitted along with the written certification. The finished repair work, including aesthetic acceptability, shall meet the approval of CDOT.

Delete subsection 618.14(a) and replace with the following:

- (a) *Finishing Hardened Concrete Products.* Finished and repaired areas shall reasonably match the coloration and profile characteristics of the adjacent concrete. Loose concrete laitance shall be removed from the product before storage.

In subsection 618.14(c) delete the fifth paragraph and replace with the following:

At least one week prior to the Pre-Erection Conference, the Contractor shall submit an Erection Plan to CDOT. The Erection Plan will be reviewed by CDOT and comments will be submitted in writing within one week. CDOT's comments shall be addressed in the final plan. The Final Erection Plan shall be signed and sealed by the Contractor's Engineer and marked "Approved for Construction". If falsework is required, falsework drawings shall conform to and be submitted in accordance with subsection 601.11.

In subsection 618.14(c) delete the third sentence of the seventh paragraph and replace with the following:

The erection subcontractor shall review and verify that the piece marks are properly located on the components to be erected, their orientation in the erected structure, and the shop drawing piece mark convention used by the girder fabricator at the Pre-Erection Conference.

In subsection 618.14(c) delete the last sentence of the eighth paragraph and replace with the following:

Additional conferences may also be requested by the Contractor, if approved by CDOT.

In subsection 618.14(c) delete the ninth paragraph and replace with the following:

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The Contractor shall submit a final Erection Plan to CDOT prior to girder erection for acceptance. The Contractor's Engineer shall sign and seal (1), (5) and (7) listed above in the final Erection Plan. The final Erection Plan shall be stamped "Approved for Construction" and signed by the Contractor. The Contractor shall not proceed with the Erection Plan until CDOT has provided written acceptance of the plan.

In subsection 618.14(c) delete the tenth paragraph and replace with the following:

When a bridge spans traffic of any kind, including those where vehicles, railroad, watercraft, or pedestrians have access onto, underneath, or adjacent to the bridge, the Contractor's Engineer shall inspect and provide stamped written approval of the stability of the erected girders prior to opening the area beneath the girders to traffic. The Contractor shall perform daily inspections of the erected girders and other permanent and temporary bridge elements until the deck concrete has attained the full design compressive strength. The Contractor's Engineer shall provide an inspection form to CDOT that lists the items the Contractor will document during the daily inspection of the erected girders. The inspection form shall include inspection items specific to each bridge being constructed. The Contractor shall provide CDOT and the Contractor's Engineer with written documentation of these inspections within 24 hours of each inspection.

In subsection 618.15 delete the first sentence of the third paragraph and replace with the following:

The cores shall be delivered in a wrapped and moist condition to the certified test laboratory as listed in the PCP.