15.0 STRUCTURES

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

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

Replacement Bridges shall be constructed for the Project at the following locations:

- US-6 over Bryant (Str. # F-16-ZA)
- US-6 EB C-D Road over Bryant St (Bryant St under Ramp) (Str. # F-16-ZB)
- US-6 over the Platte River (Str. # F-16-YZ)
- US-6 over I-25 (Str. # F-16-ZC)
- US-6 over BNSF RR (Str. # F-16-YJ)
- Federal Blvd over US-6 (Str. # F-16-XO)

New Bridges shall be constructed for the Project at the following locations:

- Federal Blvd to EB US 6 Braided Ramp (Str. # F-16-ZE)
- NB I-25 to WB US 6 Tunnel (Str. # F-16-ZD)
- Barnum Park Pedestrian Bridge (Str. # to be requested by Contractor)

No Project Structure shall preclude anything required as part of the I-25 Valley Highway FEIS/ROD as further defined in Section 1. This includes any current or future improvements identified by the Urban Drainage and Flood Control District.

If any additional major structures are required during the final design process, the Contractor shall obtain Structure numbers from CDOT Staff Bridge
No Bridge pier will be allowed in the center of the Platter River channel.

15.1 Administrative Requirements

15.1.1 Standards

The ,versions of the referenced software, standards, data, and reports which are current at the time of the Proposal Due Date, including all interim revisions and updates, shall be used unless specified otherwise in this Section 15.

15.1.2 Software

The following software shall be used to load rate Structures on this Project:

1. VIRTIS, Bridge Load Rating (AASHTOWARE)
2. BRASS-CULVERT, Culvert Load Rating 15.2 Design Requirements

15.2 Design and Construction Requirements

15.2.1 Materials

15.2.1.1 Concrete

Cement types recommended in the geotechnical report shall be used for cast-in-place concrete in contact with soils.. High sulfate content soils shall require Type V cement. Type III cement may be used for pre-cast concrete. Class B concrete shall be used for noise wall panels, abutments, piers and walls. Class BZ concrete shall be used for drilled caissons. Class B, BZ concrete shall be used for filling post holes and slope paving. Class D or H concrete shall be used for all conventionally reinforced Bridge decks, diaphrams, approach slabs, and Bridge rails. Class D, PS, or S40 concrete shall be used for all pre-tensioned or post-tensioned concrete. The concrete used for cast-in-place Bridge decks shall be dense, with low permeability, highly resistant to abrasion, and shall resist cracking due to creep and shrinkage. The Bridge deck concrete shall have a maximum water/cement ratio (w/c) of 0.44, chloride permeability of 2000 coulombs or less in 56 Days as tested in accordance with AASHTO T 277 and shrinkage of 500 microstrain or less as tested per ASTM C157. If Class D is used, the Contractor shall use a standard Class D mix. Concrete mix Classes may be substituted per the CDOT Standard Specifications.The proposed concrete mix design and procedures shall meet the above requirements and shall be submitted for Acceptance by CDOT at least 3 weeks prior to the anticipated concrete placement date.

The use of lightweight concrete will not be allowed.

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

Maximum design concrete strengths used for design shall be:

Cast-in-place: f'c = 6.0 ksi

Precast: f'c = 10.0 ksi

15.2.1.2 Pre-tensioning Steel

The minimum center-to-center strand spacing shall be 1 ¾ inches for 0.5 inch diameter strand and 2 inches for 0.6 inch diameter strand.

15.2.1.3 Post-Tensioning Steel Systems

The Contractor shall provide corrosion protection for the strands consisting of grout filled galvanized or non-metallic ducts. Grout shall meet the requirements of Section 618 of the Standard Specifications. Installers of pre-stressing, post-tensioning systems shall be Post – Tensioning Institute (PTI) certified. The diameter for strands shall be 0.6 inches or 0.5 inches.

15.2.1.4 Reinforcing Steel

The use of epoxy coated reinforcing steel for all Bridges, walls, tunnels, noise walls,and box culverts shall be as defined in Table 1, subsection no. 8.1 of the CDOT Bridge Design Manual and CDOT Bridge Technical Memorandums. . The design category for anticipated level of de-

icing salt application shall be "High". Abutments and pier columns exposed to splash from the adjacent Roadway shall use epoxy coated reinforcing steel. Splash zone is defined as anything within 10 feet horizontally of the outside edge of Roadway shoulder. All reinforcing shall consist of deformed bars only per ASTM A 615 and conform to the requirements of the Standard Specifications.

15.2.1.5 Structural Steel

Structural steel shall conform to AASHTO M 270, Grades 36, 36W, 50, 50W, 70 or 70W. Structural steel supplied for main load-carrying members or components in tension, which are non-redundant, shall be designated as fracture-critical, meeting the Charpy V-notch tests for Zone 2 in AASHTO M 222/M 222M and AASHTO M 223/M 223M. All structural steel shall be painted per Section 509 of the Standard Specifications and the architectural requirements in this Section 15. Weathering steel may be used if allowed by the Book 4 Project Aesthetics Treatment Plan.

15.2.2 Design Parameters

15.2.2.1 General

The Contractor shall complete the design in accordance with AASHTO Load Resistance Factor Design (LRFD) Bridge Design Specifications Sixth Edition 2012, except as otherwise noted in this Section 15. All design calculations and plans shall be performed in English (Standard) units. Horizontally curved steel Bridges shall be designed in accordance with the AASHTO Guide Specifications for Horizontally Curved Steel Girder Highway Bridges.

Bridge superstructure types that would require temporary falsework or shoring for construction are allowed and shall meet all required vertical and horizontal clearances for both temporary conditions (construction) and final conditions. All falsework shall be designed in accordance with the AASHTO Guide Design Specifications for Bridge Temporary Works. All grade separated crossing of railroad facilities shall be designed and constructed in accordance with the current BNSF Railway – Union Pacific Railroad Guidelines for Railroad Grade Separation Projects and the American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering.

For Bridges, stain (or paint for steel structures) shall be applied to surfaces for each particular Structure in accordance with the Book 4, Project Aesthetics Treatment Plan. All other visible, exposed, and accessible concrete surfaces shall have a surface treatment of concrete stain. This shall include all retaining walls, noise walls, and slope paving.

15.2.2.2 Loads and Forces

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

Architectural elements and components to be constructed as part of Bridges, retaining walls, and noise walls shall be designed using the International Building Code if the design of these elements is not covered by the appropriate AASHTO specification.

15.2.2.2.1 Live Loads

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

15.2.2.2.2 Dead Loads

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

15.2.2.2.3 Uplift

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

15.2.2.2.4 Thermal Forces

The Contractor shall use temperature ranges for moderate climates per AASHTO LRFD.

15.2.2.2.5 Seismic

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

15.2.2.2.6 Load Rating

The Contractor shall load rate all new Highway Bridges, box culverts, and Bridge widenings in accordance with the AASHTO Manual for Bridge Evaluation and the CDOT Bridge Rating Manual. Structures designed in accordance with the LRFD Design Specification shall be rated by the Load and Resistance Factor Rating (LRFR) method. Structures that are not designed in accordance with the AASHTO LRFD Design Specification shall be rated by the Load Factor Rating (LFR) method. The load rating methodology shall be consistent with the design methodology. Load ratings shall be provided electronically to CDOT prior to Bridge construction activities.

15.2.2.2.7 Wind Loads.

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

15.2.2.3 Geotechnical Data

Geotechnical testing has been conducted previous to this Contract in the area of the Structures as included in Book 4. The Contractor shall determine the additional geotechnical information required and conduct supplemental investigations as necessary to complete the final design. When planning and conducting additional investigations, the Contractor shall refer to the referenced Book 4 geotechnical documents completed for this Project. Additional boring logs and laboratory test results shall be presented in similar format as those Book 4 documents.

The referenced Book 4 soil and rock samples collected as part of this geotechnical engineering exploration are available at the geotechnical firm:

RockSol Consulting Group, Inc.
6510 W. 91st Ave, Suite 130
Westminster, CO 80031
Phone: 303-962-9300
Contact_ www.rocksol.com

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

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

15.2.2.4 Structure Foundation Analysis and Design Recommendations

The Contractor shall perform geotechnical analysis as required for the design of foundations for retaining walls, Bridges and other Structures. Design recommendations and substantiating analysis shall be documented in a Foundations Design Report as a part of the In-Process Design Packages for Structures as further described in this Section 15.

15.2.2.5 Structure Aesthetics

The Contractor shall adhere to the Book 4 Project Aesthetics Treatment Plan and Book 3 CBE Guidance Documents – CBE Funding for Structure Aesthetics. Any further refinements shall be submitted to CDOT for Acceptance prior to any associated structural submittals, which includes the following:

Treatment concepts and details for all structures (Bridges, retaining walls, noise walls, etc.) shall meet the requirements of this Section 15, shall be consistent with and complement the existing corridor aesthetic treatments, and shall provide (as a minimum) the baseline aesthetic treatments, approach, and commitments included in the I-25 Valley Highway FEIS/ROD, Aesthetics and Urban Design Report, and Addendum in Book 4.

15.2.3 Bridges

15.2.3.1 Geometry

All fill and cut slopes along the longitudinal axis of Bridges with spill-through abutments shall not be steeper than 2:1 (H:V) perpendicular to abutment. There shall be a 2-foot minimum width berm at the top of the slopes at the front face of spill-thru abutments and a 2-foot minimum vertical dimension from the top of this berm to the bottom of girder. Minimum vertical clearance of 16 feet, 6 inches (from traveled way and outside edge of shoulder) shall be provided for all grade separations with allowance for future pavement overlays on the Roadway below and for future widenings. The Contractor shall also maintain the existing minimum vertical clearance, or

better, over the traveled way and outside edge of shoulders at existing and proposed Bridges during construction of the Project.

15.2.3.2 Type

Bridge and retaining wall types will not be restricted to those historically used by CDOT. Other types will be allowed, but only if they have been accepted for general use by other state or federal transportation authorities. The Contractor must also demonstrate that the design of the Bridge and retaining wall types and components will meet the Project criteria and perform well under the Project's environmental conditions, including frequent freeze-thaw cycles, anti-icing and de-icing. Experimental Bridge and retaining wall types, timber Bridges, masonry Bridges and structural-plate arches will not be allowed. Bridges shall incorporate as few joints and bearings as possible, be continuous over supports, not use intermediate hinges, and use integral or semi-integral abutments wherever possible. Bridge types selected shall allow for and facilitate future Bridge widening. The Contractor shall submit, for Approval, all proposed Bridge and retaining wall types historically not used by CDOT in the Structural Concept Plans/Report.

15.2.3.3 Inspection Access

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

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

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

15.2.3.4 Components

15.2.3.4.1 Bridge rails and pedestrian fencing.

The Contractor shall design and construct bridge rails and pedestrian fencing (on bridges with sidewalks) that match the face, color and overall shape of barriers as defined in the Project Aesthetics Treatment Plan according to this Section 15. The Contractor shall use bridge rails on approach slabs. The Contractor shall design and construct pedestrian fencing/railing in

accordance with AASHTO LRFD Bridge Design Specifications. Bridge rails subject to vehicular impact shall be designed to meet TL-4 loading in accordance with AASHTO LRFD Bridge Design Specifications. Current CDOT bridge rails that meet the above criteria, such as Type 7 and Type 10 bridge rails, are acceptable and do not have to be designed and crash tested. Alternate railing proposed shall be required to meet these requirements and be crash tested.

Pedestrian railing attached to bridge rails shall be installed behind the bridge rail face, or back side of the bridge rail. All pedestrian fencing mounted on bridge structures shall meet fencing and screening requirements in the AASHTO LRFD Bridge Design Specifications. Cover plates shall be used over the face of joints on the interior and exterior concrete bridge rails, and on curbs and sidewalks to provide structural and safety shape continuity across the joint.

15.2.3.4.2 Approach Slabs.

The Contractor shall provide an approach slab at each end of each Bridge. The approach slab 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. Approach slabs shall be separate from, and fit between, cantilevered wingwalls or retaining wall wingwalls so that the approach slab can freely rotate about the abutment. Bridge rails shall be connected to approach slabs. The bridge rails shall be designed to function as a barrier to keep water out of the joint between wingwall/retaining wall and the edge of approach slab. The approach slab for Highway Bridges shall be at least the same width as the Bridge deck, and provide for expansion and contraction at the approach pavement interface where required. Approach slabs shall be anchored to the abutment. The Contractor shall design and construct an underdrain system beneath all approach slabs to remove water at Bridge abutments. Backfill behind the abutments shall be as shown in the CDOT Bridge Structural Worksheets Backfill Drawings B-206-F1 or B-206-M1. Bridge approach slab drains shall be located so as to minimize the amount of water flowing across all joints.

Differential settlement across approach slabs shall be designed such that they will not produce a grade break that is more than 1-inch within one (1) year of Final Acceptance. The Contractor shall implement ground improvement techniques to the approach embankment subgrade if necessary to meet this requirement.

15.2.3.4.3 Decks.

The Contractor shall provide a minimum concrete deck thickness of 8 inches, except that decks and toppings for prefabricated pedestrian truss Bridges or adjacent precast prestressed box Bridges shall be 5 inches minimum. Open or filled grating decks and orthotropic decks will not be permitted. Concrete decks designed to the simplified “Ontario”, or any empirical methods, will not be permitted. Full depth precast deck slabs shall require cast-in-place joint closures, post tensioning across joints and an overlay. Pre-tensioned, pre-cast concrete deck forms shall be a minimum of 3 inches thick and have a full grout or concrete bearing. Full grout is defined as a 1 inch minimum thickness by 2 inch wide grout pad. Stay-in-place metal deck forms are permitted except for the pedestrian bridge decks. If stay-in-place metal forms are used, the superstructure, substructure, and foundation shall be designed for an extra 5 pounds per square foot (psf) minimum dead load applied to the superstructure. Parallel Bridges shall either have a minimum 2-inch (4-inch preferred) longitudinal gap between decks or parapets or shall be tied together to make one Bridge. Permanent deck forms will not be allowed for cast-in-place post-tensioned box girders, T-girder deck slabs, or cantilevered portions of decks. Cast-in-place

concrete placed on top of a pre-cast double tee or pre-cast box girders shall be considered composite with the pre-cast top flange if the minimum total laminated deck thickness is 8 inches, the minimum cast-in-place thickness is 5 inches and the top surface of the pre-cast top flange is roughened. Pre-cast double tees or pre-cast box girders without a cast-in-place deck placed on top will not be allowed. If any part of a deck resists tension, the stress in the deck in this area shall not exceed 0.0948 times the square root of f'c, $(0.0948 \times (f'c)^{1/2})$ where f'c is in ksi. Minimum longitudinal steel in the top mat of cast-in-place decks shall be #4s at 6-inch spacing spliced to the negative-moment steel reinforcing over piers.

15.2.3.4.4 Deck Joints.

The Contactor shall avoid or minimize joints wherever possible. Bridges in length up to 640 feet (steel) or 790 feet (precast or cast-in-place concrete) shall be jointless, wherever possible, according to guidelines given in CDOT Bridge Design Manual. A minimum 0 to 4-inch joint shall be placed at the end of approach slabs unless Approved otherwise by CDOT. Use of only strip seals for joints as reflected in CDOT Bridge Structural Worksheet - Bridge Expansion Device (0-4 inch) B-518-1, or CDOT Approved equal, with expected maximum 4-inch movement or modular joints for expected movements of 4-inches or greater shall be allowed. Design and location of joints shall provide for maintenance accessibility and future replacement. Aluminum joints will not be permitted. Modular joints shall be designed by LRFD and shall include LRFD fatigue requirements. Modular joints shall be tested for fatigue loading according to National Cooperative Highway Research Program (NCHRP) Report 402, Fatigue Design of Modular Bridge Expansion Joints (1997) Appendix A & Appendix B. Expansion devices shall be set to provide a smooth surface between the final grade into the device and the final grade out from the device. A smooth surface is defined as a maximum grade break, at or 30 feet either side of the device, of 0.3 percent. To facilitate the proper placement of expansion devices, the tabular Bridge geometry shall include a bent line for the expansion devices on a Bridge or approach slab. Asphaltic expansion devices and asphaltic plug joints shall not be used for any new construction.

15.2.3.4.5 Overlays.

The Contractor shall provide an initial overlay system for all Bridge decks. Bridge overlays shall be 3-inch SMA over a waterproofing membrane . The asphalt overlay with a waterproofing membrane shall be used on both the Bridge deck and associated approach slab. Thin-bonded overlays, such as epoxy or polyester, shall be used when widening an existing bridge with a bare concrete deck. In this case, the thin-bonded overlay will be applied to both the existing deck and the widened portion. Latex-modified overlays shall not be used. Pedestrian Bridges do not require an overlay.

15.2.3.4.6 Superstructures.

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

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

structures are preferred. For concrete box girder structures, the Contractor shall consider the effects of a temperature gradient. The design of cast-in-place concrete box girders shall include the weight of the deck formwork left in place in the design of the superstructure, substructure, and foundation.

The maximum shear reinforcement spacing for cast-in-place mildly reinforced or post-tensioned concrete Bridges shall be 1.5 feet. The minimum shear strength of steel for prestressed or post-tensioned concrete girders shall be at least Av=135 x b'/fy, with b' the web width in inches, and fy the yield strength of the reinforcing in psi. Webs shall have at least double this minimum reinforcement for a distance d in front of anchorages. Minimum side-face steel shall be 1.5 times the minimum shear steel for areas more than the depth of girder from the supports and shall be spaced at 1 foot maximum. All reinforcing steel shall have a minimum 2 inch clearance between parallel bars including spirals.

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

The minimum concrete strength f'c shall be 4.5 ksi for any cast-in-place concrete member which forms part of a deck. The design of precast girders should not be made dependent on continuity, or require post-tensioning, unless doing so significantly reduces the cost of the structure. For simple spans made continuous, the beneficial effects of continuity on girder design should not be used unless the number of girder lines is reduced

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

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

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

Stiffeners with diaphragms connected to them shall be welded with fillet welds to the top and bottom flange. The skew angle between bearing stiffeners and web shall not be less than 60 degrees.

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

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

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

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

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

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

15.2.3.4.7 Bearings.

The Contractor shall design and locate bearings to allow maintenance accessibility and future replacement. Substructure drawings shall show locations for lifting when removing bearings. Elastomeric pads and steel reinforced elastomeric bearings, with or without sliding surfaces, are the preferred bearing types. Sliding surfaces shall be polytetrafloroethylene (PTFE) with a stainless steel mating surface. Bearings shall be either elastomeric pads (CDOT Type I), steel reinforced elastomeric bearings with or without PTFE and stainless steel sliding surfaces (CDOT Type I or Type II), or HLMR bearings (CDOT Type III). The thickness of Type II bearings shall be designed so that the acceptable shear deflection limits of the pad are not exceeded if slip does not occur. The design of elastomeric pads and steel reinforced elastomeric bearings shall be such that pad walk-out will not occur by including pad-walkout restraints. Sole plates shall have a 3/4 inch minimum thickness. At expansion bearings, the edge of the sole plate shall not slide past the edge of the elastomeric pad by the use of a positive stop. The Contactor shall provide at least 3 inches of cover between anchor bolt

centerlines and the edge of the concrete pedestal. The Contactor shall provide reinforcement for pedestals greater than 3 inches high. Suppliers of bearings devices shall only be those on CDOT's pre-approved product list. Only one bearing type shall be used across the width of the Bridge at any given substructure location. Elastomeric pads and steel reinforced elastomeric bearing devices shall not be mixed with HLMR bearings at any one particular Bridge. The maximum bearing height for Type 1 bearings shall be 7 inches.

15.2.3.4.8 Piers and Pier Caps.

The Contractor shall design a type of pier cap that will be consistent with the Project Aesthetics Treatment Plan according to this Section 15. Drop caps or integral caps are acceptable. Integral caps are preferred with cast-in-place concrete box section systems. The Contractor shall minimize the use of integral steel pier caps. Inspection access for integral steel pier caps shall be provided. Aesthetic treatments on piers shall extend below existing grade and be considered for ultimate template as necessary to accommodate future construction of US 6 and adjacent ramp improvements. Concrete guardrail shall not be cast monolithically with the pier.

15.2.3.4.9 Abutments.

The Contractor shall provide integral, or semi-integral, end diaphragm-type abutments for Bridges whenever possible. See CDOT Bridge Design Manual, Section 7.2-Mechanically Stabilized Earth (MSE) walls, which may serve as abutment support for Bridge superstructure loads and as meeting requirements of this Section 15. Retaining wall wingwalls may be used in lieu of cantilevered wingwalls at abutments for all categories of Bridges and according to the Project Aesthetics Treatment Plan and this Section 15. Cantilevered wingwalls and/or retaining walls shall extend 4 feet beyond the point of intersection of the embankment slope with the roadway finished grade. Bridge monuments shall be supported on separate foundations.

15.2.3.4.10 Slope Protection.

The Contractor shall provide concrete slope protection for all slopes under Bridges, on any slopes from shoulder to top of retaining wall, and on slopes between tiered walls. Slope protection shall conform to details contained in CDOT Standard Structural Worksheets Slope Paving Details, Drawings No. B-507-1 and B-507-2. Slope protection on slopes between tiered walls and any slopes from shoulder to the top of retaining wall shall use similar detail.

15.2.3.4.11 Foundations.

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

The Contractor's Quality Management Plan (QMP) shall include inspection of all drilled caisson operations using non-destructive testing for non-redundant (single shaft) drilled caissons. Cross Sonic Log (CSL) or impact echo are acceptable methods of non-destructive testing for drilled caissons. Additional methods for non-destructive testing, that are in accordance with the

AASHTO/ASTM/FHWA guidelines, may be considered for use on this Project subject to incorporation into the Approved QMP.

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

15.2.3.4.12 Drainage.

Bridge deck drainage and approach slab drainage systems shall be designed in accordance with the CDOT Bridge Design Manual. Scour analyses shall be based on the procedures in the FHWA HEC-18, Scour at Bridges, and HEC-20, Stream Stability at Highways. Scour countermeasures shall be designed in accordance with the FHWA HEC-23, Design of Countermeasures. Stormwater flowing toward the Bridges shall be intercepted prior to flowing onto the approach slab. Stormwater which falls on bridges shall be intercepted before it reaches expansion joints. All stormwater shall be directed to an outfall conforming to the Contract requirements. Permanent erosion protection shall be designed and installed at all outfall locations to prevent the occurrence of erosion. Outfalls shall have a well-defined and protected channel or pipe flow path. Sheet flow will not be allowed. Energy dissipation in the channel shall be required.

All Bridge deck drain inlets shall be grated. The Bridge deck drainage system shall be compatible with the structural reinforcement, components, and aesthetics of the Bridge. Outfalls shall be positioned to avoid corrosion of structural members, and drainage or splash on vehicular traffic and pedestrian of bike areas below the Bridge. Downspouts for Bridge drains shall be minimum 10-inch diameter galvanized steel pipe, and shall meet the requirements of ASTM A53, Grade B, and standard weight schedule 40. Downspout 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. Cleanouts shall be provided for downspout systems.

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

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

be located such that no changes are required in the future to accommodate the ultimate construction of US 6 and adjacent ramp improvements.

15.2.3.4.13 Utilities.

The Contractor shall identify, maintain, and coordinate all Utility locations on Structures. Hanging of electrical conduits, telephone conduits, or other Utilities shall not be permitted under deck overhangs or on Bridge rail. Protection of conduits from the settlement of the abutment backfill shall be provided. Utility placement on Structures shall be by the Approval of CDOT according to requirements of this Section 15. Utilities shall be hidden from view in superstructure elevation. Empty conduits may be allowed as required for future utility needs.

15.2.3.4.14 Median

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

15.2.3.5 Maintenance Plan

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

15.2.3.6 Existing Bridge Repairs

None are anticipated for this Project.

15.2.3.7 Removal of Bridges or Structures

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

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

Bridge removal shall consist of the complete removal of all existing superstructures and substructures prior to construction of new Bridges as further described in the Standard Specifications and this Section 15.
Removal of the substructure shall be taken down to at least 1 foot below the future ground surface at the lowest point of interface, including consideration of any current or future improvements identified by the Urban Drainage and Flood Control District as well as other current or future recreational uses in all other areas of the Project. Holes resulting from substructure removal shall be backfilled with Structure Backfill (Class 2) to the adjacent existing grades. The Contractor shall schedule a pre-removal meeting at least ten (10) Days prior to removal operations. The meeting shall be coordinated with the Project Director and include CDOT representatives from Traffic, Safety, Public
Involvement, and Staff Bridge.

15.2.3.8 Structure Aesthetics

Aesthetics for Structures shall be per the Project Aesthetics Treatment Plan and this Section 15. The Contractor shall produce and submit to CDOT a visual graphic of each Structure to demonstrate aesthetic conformance to the Plan. This graphic shall be submitted in both hard and electronic format. In all cases, proposed Structure aesthetics graphics shall include all visible surfaces and slope protection and submitted to CDOT for Approval with the Contractor's proposed general layouts of each Structure. This submittal shall include drawings illustrating form, texture, and color. As part of the submittal, the Contractor shall provide full-size mockups for all surface treatments for texture, color, and quality for Approval by CDOT. For Project consistency, Structures within a common viewshed shall incorporate similar visual aesthetics. Parallel Bridges shall have similar Structure types and aesthetic treatments.

All Structures with visible concrete surfaces, including those accessible by graffiti vandals, shall have a surface treatment of concrete stain. This includes all retaining walls, noise barriers, concrete roadway/bridge barriers, and slope protection.

15.2.4 Box Culverts

15.2.4.1 Existing Box Culverts

Existing box culverts and drainage facilities altered by the Project design shall be removed and replaced unless the following criteria can be met:

1. Evaluate and verify the existing structure has adequate hydraulic capacity.

2. Evaluate the current operating/inventory rating and document the existing structure is in acceptable condition and suitable for extended use of 75 years for the required loading.

3. Provide a Life cycle cost analysis of the modified existing structure, if required, according to requirements of this Section 15

Existing box culvert Structures and locations are listed below:

Structure Description
Barnum Lake Outfall

15.2.4.2 Design

New box culverts, replacements, extensions, strengthening of existing box culverts, headwalls, and wingwalls shall meet all requirements of the Project. CDOT's M-Standards shall be used. Box culverts not covered in the CDOT M-Standards shall be designed in accordance with AASHTO LRFD Bridge Design Specifications (Fifth Edition, with 2010 Interim Revisions), CDOT's Bridge Design Manual, and CDOT's Drainage Design Manual. All box culverts, new and reuse of existing, shall be load rated, documented and submitted to CDOT using the BRASS-CULVERT software.

15.2.4.3 Maintenance Plan

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

15.2.5 Retaining Walls

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

15.2.5.1 Geometry

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

Design and construction shall consider surface and subsurface drainage. Walls which support soil and loads from outside ROW, and are built with MSE soil reinforcements, shall require an appropriate setback from ROW line for the construction of the wall or a temporary construction easement shall be required in accordance with requirements in Section 8, Right-of-Way. A system shall be provided to intercept or prevent surface water from entering behind walls. Lengths of wall without relief joints shall be limited to lengths which control the differential settlement. A fence or pedestrian railing shall be provided at the top of walls over 30 inches high, and otherwise meet current OSHA and building code safety requirements for all retaining wall installations.

15.2.5.2 Type

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

15.2.5.3 Design Requirements

All permanent retaining walls and their associated structural support elements, constructed for the Project, shall be designed to resist corrosion or deterioration for a minimum service life of 75 years. Mechanically Stabilized Earth (MSE) walls shall be designed in accordance with the requirements of AASHTO LRFD Bridge Design Specifications, Sixth Edition 2012. Global stability, overturning, and sliding calculations shall be performed on all retaining wall systems. All retaining wall installations shall provide for a positive drainage system of the backfill. The design of MSE and modular 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 can be used in scour areas, but the foundation of the wall needs to be below the scour level. The wall itself would either have to be designed for hydrostatic pressure or use a free draining material to account for water fluctuations. Fencing on walls shall satisfy OSHA, and/or CDOT maintenance requirements

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

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

15.2.5.4 Characteristics

15.2.5.4.1 Mechanically Stabilized Earth (MSE) (Panel) Walls.

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

A representative from the wall manufacturer shall be at the job site during all phases of wall construction to assist the Contractor with Quality Control/Quality Assurance. The Contractor shall use the latest FHWA geotechnical references and guidelines in conformance with the Contract, as provided at the following website: http://www.fhwa.dot.gov/engineering/geotech/index.cfm, including the FHWA Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes - Volumes I and II.

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

15.2.5.4.2 Mechanically Stabilized Earth (MSE) (Block) Walls.

Will not be allowed for use on this Project.

15.2.5.4.3 Cast-in-Place Walls.

Cast-in-place walls shall be designed and constructed in accordance with AASHTO *LRFD* Bridge Design Specifications, Sixth Edition, 2012.. Construction-joint spacing shall accommodate or limit differential settlement.

15.2.5.4.4 Anchored Walls.

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

15.2.5.4.5 Soil Nail Walls.

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

15.2.5.4.6 Structural Diaphragm Walls

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

15.2.5.4.7 Soil Reinforcement

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

15.2.5.5 Retaining Wall Aesthetics

All retaining walls throughout this Project shall comply with the Project Aesthetics Treatment Plan and requirements in this Section 15. All wall facing shall be of a consistent type (i.e. cast-in-place, pre-cast facing, concrete masonry units, etc.) within any section of road, interchange and single viewshed. This includes surface treatment, pattern, texture, color, and jointing layout. An overall negative batter (wall face leaning outward away from fill) between the bottom and the top of the wall is not allowed. Wall facing shall be installed vertically (plus or minus 1/2 inch in 10 feet or as defined in the CDOT Bridge Structure Worksheets for MSE walls) and shall be capped with a cast-in-place or precast concrete cap. Wall facing and cap shall be colored with pigmented sealer.

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

All Structures with visible concrete surfaces, including those accessible by graffiti vandals, shall have a surface treatment of concrete stain. This includes all retaining walls, noise barriers, concrete roadway/bridge barriers, and slope protection

15.2.6 Noise Walls

Noise walls, if required, shall be designed and constructed in accordance with AASHTO Guide Specifications for Structural Design of Sound Barriers, with 1992 and 2002 Interim Revisions. Noise walls shall be designed for an 80-mph wind with specified gust factor (30 percent). Final tolerances shall be 1/8 inch in 1 foot for level and plumb. The design of noise walls shall provide for adequate surface drainage. Noise walls within 10 feet of traffic shall be designed for a minimum wind load of 27 psf. When the installation of a noise wall interferes with the access to existing, or proposed fire hydrants, the noise wall installation shall include fire hose access openings and associated identification signs. Location and demand for these openings shall be established in cooperation with the local fire department.

15.2.6.1 Geometry

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

15.2.6.2 Components

15.2.6.2.1 Panels

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

15.2.6.2.2 Posts

Posts shall be reinforced concrete, prestressed concrete, or galvanized steel.

15.2.6.2.3 Foundations

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

15.2.6.3 Noise Wall Aesthetics

All noise walls throughout this Project shall comply with the Project Aesthetics Treatment Plan and requirements in this Section 15. Panels shall be colored on both sides with concrete stain. Panels shall span between and be supported by painted steel, wide flange columns, or pre-cast I-section columns, ranging from 10 feet to 30 feet on center. The minimum barrier height is 7 feet, 0 inches above grade and the maximum barrier height is 21 feet, 0 inches above grade. If sound barriers are located within the clear zone (as defined by AASHTO) they shall have a Type 7 concrete barrier along the base of the traffic side of the wall.

Aesthetics for noise walls shall be per the Project Aesthetics Treatment Plan and this Section 15. The Contractor shall produce and submit to CDOT a visual graphic of each noise wall to demonstrate aesthetic conformance to the Plan. This graphic shall be submitted in both hard and electronic format. In all cases, proposed noise wall aesthetics graphics shall include all visible surfaces and slope protection and submitted to CDOT for Acceptance with the Contractor's proposed general layouts of each Structure. This submittal shall include drawings illustrating form, texture, and color. As part of the submittal, the Contractor shall provide full-size mockups (10 ft. x 10 ft. minimum) for all surface treatments for texture, color, and quality for Acceptance by CDOT. For Project consistency, noise walls within a common viewshed shall incorporate similar visual aesthetics. Walls for parallel noise walls shall have similar Structure types and aesthetic treatments.

All Structures with visible concrete surfaces, including those accessible by graffiti vandals, shall have a surface treatment of concrete stain. This includes all retaining walls, noise walls, concrete roadway/bridge barriers, and slope protection

15.2.7 Sign Structures

Major sign Structures and supports for Intelligent Transportation System (ITS) equipment shall be designed and constructed in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 5th Edition with 2010 Interim Revisions. The Contractor shall provide minimum vertical clearances in accordance with the above specified AASHTO requirements and loadings shall consider natural period of vibration from vortex shedding and upward wind pressures from passing trucks. Sign Structures shall be galvanized structural steel (single) tubing, painted in accordance with the Project Aesthetics Treatment Plan requirements of the Contract. Draft structural worksheets for single-tube sign supports are available from CDOT Staff Bridge Branch. The Contractor shall not mount major sign supports (cantilevered signs, sign bridges, etc.) on MSE retaining walls. However, if unavoidable, the Contractor shall coordinate sign support design with the MSE wall manufacturer to ensure wall design and details will support sign loads.

Variable Message Signs (VMSs) shall be mounted on a sign bridge. The Contractor shall prepare a structural design for each VMS structure and provide to CDOT for Approval prior to issuance of Released for Construction documents.

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

15.2.7.1 Components

15.2.7.1.1 Foundations

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

15.2.7.1.2 Connections.

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

15.2.7.1.3 Bridge Mounted Signs.

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

15.2.8 Pedestrian Bridges

15.2.8.1 Design Criteria

In addition to the criteria outlined here, pedestrian Bridge truss structures shall follow the Project Special Provision in Appendix A, Section 628 – Bridge Girder and Deck Unit. Pedestrian Bridge truss structures shall be designed and constructed in accordance with the CDOT Bridge Design Manual, *AASHTO LRFD Guide Specifications for Design of Pedestrian Bridges 2nd edition -*

2009 and the *AASHTO LRFD Bridge Design Specifications – Sixth Edition, 2012*. The Contractor shall provide a 17'-6" minimum vertical clearances in accordance with CDOT and AASHTO requirements. Unless determined otherwise by the Contractor, the pedestrian Bridge does not need to be designed for the CDOT Type 3 Legal Load Vehicle as required in CDOT's Bridge Design Manual – Subsection 2.2. Pedestrian railing shall be in conformance with the Book 4 Aesthetic Treament Plan and extend from both ends of approach slabs as a minimum. Curbs shall be provided on each side of the pedestrian walkway to prevent water from flowing onto the area below and to allow mounting of any required fence posts if needed. Watertight expansion joints shall be provided, as needed, along the length of the Bridge.

15.2.9 Tunnels

15.2.9.1 Design Criteria

Design and Construction of any tunnels on the Project shall follow the criteria and standards outlined in FHWA's *Technical Manual for Design and Construction of Road Tunnels – Civil Elements*, Report No. FHWA-NHI-10-034, http://www.fhwa.dot.gov/bridge/tunnel/pubs/nhi09010/index.cfm . A tunnel is defined as enclosed roadways with vehicle access that is restricted to portals regardless of type of structure or method of construction. Road tunnels following this definition exclude enclosed roadway created by air-rights, structures such as highway Bridges, railroad Bridges or other Bridges. Roadway and structural designs shall meet the requirements of current AASHTO specifications outlined in the AASHTO LRFD Bridge Design Specifications-Sixth Edition, 2012. Requirements for items such as emergency egress, fire protection and detection, and traffic control as outlined in the *National Fire Protection Association (NFPA) 502 – Standard for Road Tunnels, Bridges, and Other Limited Access Highways,* shall also be met. Provisions shall be made to address the operational and maintenance aspects of the tunnel such as traffic control, ventilation, lighting, life safety systems, and maintenance. Items requiring frequent maintenance, such as lighting, should be accessible with minimal interruption to traffic operations. Computational fluid dynamics analysis should be used to establish an appropriate design for the ventilation. . A waterproofing system shall be provided. The drainage system should be designed to deal with surface drainage as well as any groundwater infiltration into the tunnel. *FHWA Road Tunnel Design Guidelines*, Report No. FHWA-IF-05-023, http://www.fhwa.dot.gov/publications/focus/05nov/03.cfm can be used as a basis for providing design criteria for items such as lighting, drainage and ventilation that are not provided elsewhere. The design life of the tunnel shall be 125 years.

Each side of the tunnel section shall include a 2.5' egress path and Type 7 Bridge Rail. A variance from *NFPA* requirements is acceptable for the total egress width since it meets *AASHTO* requirements. The ultimate tunnel section shall also include two 4' shoulders and two 12' traffic lanes for a total wall face to wall face width of 40.0'.

15.2.10 Submittals and Reviews

15.2.10.1 Technical Concepts

The Contractor shall submit a Structural Concept Report, prior to proceeding with the initial design, for Acceptance by CDOT for any Structure that is proposed for the Project. Suggested submittal contents include elevation views and cross sections depicting structure components for Bridges and other Structures as the Contractor desires. Also included shall be a maximum two-page description of type, materials, strategy for lateral loads, and design-life considerations for each proposed Structure.

15.2.10.2 Structural Concept Plans/Report Elements

15.2.10.2.1 Life Cycle Cost Analysis

The Contractor shall submit for Approval by CDOT:

15.2.10.2.1.1

A 75-year life cycle cost analysis of each proposed Bridge type.

15.2.10.2.1.2

Clearly state and justify (using historical data) the assumptions used in determining life cycle costs.

15.2.10.2.1.3

Include construction cost and costs for scheduled maintenance and repair. The Contractor shall not include routine maintenance (sweeping, cleaning, graffiti, removal, etc.) or demolition and salvage at the end of the 75 years. Maintenance and repair costs shall include material and labor plus an additional 10 percent for traffic control if required for the Work. Items of maintenance and repair shall include, but not be limited to steel painting, decks, railings, overlays, joints, bearings and drainage systems. The Contractor shall use a 5 percent discount rate and user cost of $10.00 per vehicle-hour of delay at year one. The Contractor shall use the present worth method to develop a present total Bridge cost. Life cycle cost analysis shall be based on methods and procedures developed by the National Institute of Standards and Technology (NIST) Bridge LLC or the National Cooperative Highway Research Project (NCHRP) 12-43 Life-Cycle Cost Analysis for Bridges.

15.2.10.2.2 Bridges (or foundation type) not Historically used by CDOT

The Contractor shall submit for Approval by CDOT:

15.2.10.2.2.1

A minimum one-page description of each Bridge type (or foundation type) not historically used by CDOT.

15.2.10.2.2.2

A list of the transportation authorities that have used the proposed Bridge type (include actual projects, application, performance, and references).

15.2.10.2.3 Retaining Walls not Historically used by CDOT

The Contractor shall submit for Approval by CDOT:

15.2.10.2.3.1

A minimum one-page description of each retaining wall type not historically used by CDOT.

15.2.10.2.3.2

A description of methods of accommodating settlement and differential settlement.

15.2.10.2.3.3

A description of the type of foundation for each type of wall.

15.2.10.2.3.4

The location of walls and identification of wall type.

15.2.10.2.3.5

A list of transportation authorities that have used the proposed wall type (include actual projects and references).

15.2.10.2.4 Concept Plans

After Approval of the Bridge type (or foundation type) not historically used by CDOT submittal, and prior to beginning final design, the Contractor shall submit for Approval by CDOT concept plans that include the following:

15.2.10.2.4.1

Plans, elevations, and appropriate typical sections for each Bridge type.

15.2.10.2.4.2

Plan views of the Project identifying each Bridge location and type.

15.2.10.2.4.3

Plan views of the Project identifying each wall location and type.

15.2.10.2.4.4

Description of conceptual solutions for complex structural problems identified by the Contractor.

15.2.10.2.4.5

Description of creative or innovative ways the design, construction, and/or choice of structural types will benefit and/or enhance schedule, quality, and cost aspects of the Project and minimize traffic impacts.

15.2.11 Design

15.2.11.1 Reviews

Reviews will be conducted in accordance with the Contractor's Approved Quality Management Plan. Shop drawings shall be submitted for review by the Contractor's Engineer. The Contractor is solely responsible for shop drawing accuracy. Structure drawings shall conform to the CDOT CADD Standards. Structure drawing standards shall be addressed in the Contractor's Approved Quality Management Plan. The requirements for this section also apply to noise walls required for the Project.

15.2.11.2 Progress Submittals

When requested by CDOT, the Contractor shall submit three separate structural design packages for each Bridge, retaining wall, box culvert, and tunnel within the Project.

The Structural design packages are defined as:

15.2.11.2.1 Preliminary Design Package

Completed general layout drawing(s) shall be submitted to CDOT. The final geometry and proposed Structural type shall have been finalized and shall be shown and detailed in the Drawings. Aesthetic requirements shall have been identified and incorporated into the Drawings according to requirements of this Section 15. Additional soil borings (if required) shall have been identified and the foundation system shall be shown in the Drawings. The preliminary design packages are equivalent to a traditional CDOT Field Inspection Review (FIR) set.

15.2.11.2.2 In-Process Design Package

For this submittal, the final Structural design shall have been completed, but not necessarily the independent design check. All drawings shall have been completed and the first independent plan check of those drawings shall have been completed. Tabulator (Bridge) geometry drawings and minor miscellaneous details need not be completed and submitted with this package. Additional soil borings required for the Structural design shall have been completed and the final foundation report shall be finished and included with the package.

15.2.11.2.3 Final Plans and Specification Package

For this submittal, the independent design check shall have been completed and the original final design calculations shall be revised and corrected based on comments from the independent design check. Project aesthetic details shall have been incorporated into the Drawings. All Drawings shall have been completed, and the final independent plan check of all the Drawings shall be complete. Project special specifications shall have been completed. A maintenance plan for each Bridge describing routine maintenance and items specific to each component of the Bridge shall be completed according to requirements of this Section 15 and

included in this submittal. All changes or revisions resulting from the in-process design review shall be incorporated into the final design documents. If required by earlier review comments, the final foundation report shall be updated and resubmitted with this package.

15.2.11.2.4 Minor Structural Elements

The Contractor shall be required to submit only a final design document package for minor structural elements, such as sign structures and noise walls.

15.2.11.3.1 Released for Construction, Revisions to Released for Construction and As-Built Documents

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

15.2.11.3.2 Documentation

Design and design-check calculations shall have pages numbered and include a table of contents. All calculations shall identify which code is utilized, and reference the appropriate section in the right-hand column. References shall be included in the calculations to computer programs used to do the calculations. Computer documentation shall include the name of program, vendor, version, and release date; record of software output and verification of output with manual calculations or other recognized program; clear identification of input and output values and meaning; and check of input. All calculations shall be signed and sealed by the Contractor's Engineer in accordance with the laws for registration of professional engineers in Colorado. Copies in PDF format shall be made of all design and design-check calculations for the Project and then submitted to CDOT on computer disk (CD or DVD) format. Bridge rating packages for all new Bridges and affected existing structures shall be submitted in accordance with the CDOT Bridge Rating Manual.

15.2.11.2.5 As-Built, Falsework, Shoring, and Shop Drawing Plans

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

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

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

15.2.11.2.6 Construction Requirements

The CDOT Permit Office shall be notified 2 Working Days in advance of reductions in vertical clearances or when lane closures, lane reductions, or lane width restrictions are put into effect.

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

A representative from the wall manufacturer shall be at the job site during all phases of MSE wall construction to assist the Contractor in QC/QA. The representative shall maintain a construction diary and sign-off on all hold points as defined in the Contractor's Approved Quality Management Plan. The diary shall be submitted with the final Design Documents.

15.3 Deliverables

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

Deliverable	Review Acceptance or Approval	Schedule
Design exceptions	Approval	Prior to any associated structural submittals
Revisions to Project Aesthetics Treatment Plan	Acceptance	Prior to any associated structural submittals
PDA testing criteria including number, type, layout and location	Acceptance	According to Contractor's Quality Management Plan (QMP)
Proposed non-historic Bridge, foundation or wall type not used by CDOT	Approval	Prior to submittal of the Structural Concept Plans/Report
Proposed foundation type for wall type	Approval	With proposed non-historic Bridge, foundation or wall type not used by CDOT and with the Structural Concept Plans/Report.
Proposed methods of accommodating settlement and differential settlement for wall Structures	Approval	With proposed non-historic Bridge, foundation or wall type not used by CDOT
Structural Concept Report	Acceptance	After Approval of the Bridge foundation type not historically used by CDOT submittal and prior to the submittal of the Preliminary Design Package
Life cycle cost analysis	Approval	With the Structural Concept Plans/Report

Proposed location of wall and wall type	Approval	With the Preliminary Design Package
Structure aesthetics graphic	Approval	With the Preliminary Design Package
Preliminary Design Package	review	When requested by CDOT
Structure aesthetics full size mock-ups	Acceptance	With the Preliminary Design Package for each Structure required for the Project.
Noise wall aesthetics graphics	Acceptance	With the Preliminary Design Package for each noise wall required for the Project.
Noise wall full size mock-ups	Acceptance	With the Preliminary Design Package for each noise wall required for the Project.
Foundation Design Report	Acceptance	With the Preliminary Design Package for each Structure or noise wall for the Project
In-process design package	Review	When requested by CDOT
Final Plans and Specifications Package	Acceptance	Prior to when Released for Construction documents are issued.
Maintenance plan for each Structure	Approval	With the Final plans and Specifications Package
Bridge load rating	Acceptance	With the Final Plans and Specifications Package
Minor structural elements	Review	With the Final Plans and Specifications Package
Released for Constuction documents and associated revisions	Acceptance	According to the Contractor's Quality Management Plan
Bridge/retaining wall removal report/plan	Review	14 Days prior to removal operations begin
Additional non-destructive methods for testing drilled caissons	Acceptance	As required, for construction of drilled caissons
Location of access holes/doors	Approval	30 Days prior to fabrication
Concrete mix design and procedures	Acceptance	At least 3 weeks prior to the anticipated concrete placement date

Utilities on Structures	Approval	30 Days prior to construction
Structural Design for each VMS	Approval	Prior to when Released for Construction documents are issued
As-Built Documents	Acceptance	According to Contractor's Quality Management Plan (QMP)

All deliverables shall also conform to the requirements of Section 3, Quality Management.