15.0 STRUCTURES

15.1 Standards

The standards used for design and construction of the structures for this Project shall be as indicated in the listing in Book 3, or as specifically referenced in this Section.

15.1.1 Software

The following software shall be used for this Project:

VIRTIS, Bridge Load Rating, Version 6.0.0 (AASHTOWARE), Build Date November 7, 2006, AASHTO.

15.2 Design Requirements

15.2.1 Materials

15.2.1.1 Concrete

Type II or Type I cement shall be used for cast-in-place concrete. Type III cement may be used for precast concrete. Class B shall be used for panel noise barriers, abutments, piers and walls. Class BZ concrete shall be used for drilled caissons. Class B, BZ shall be used for filling post holes and slope paving. Class D or H shall be used for all conventionally reinforced bridge decks and bridge rails. Class D, PS, or S40 shall be used for all pretensioned 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. The proposed mix design and procedures shall meet the above requirements and shall be submitted for Acceptance by CDOT. The use of lightweight concrete will not be allowed.

Minimum design concrete strengths shall meet the requirements of Section19, Section 601 of the Standard Specifications.

Maximum design concrete strengths used for design shall be:

Cast-in-place:	f'c = 6,000 psi
Precast:	f'c = 9,500 psi

15.2.1.2 Pre-Tensioning Steel

The maximum diameter for prestressing strands shall be 0.6 inches for a 2-inch minimum spacing and 0.5 inches for a 1.75-inch minimum spacing.

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. Prestressing systems shall be 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, and box culverts shall adhere to the requirements of Table 1, Subsection No. 8.1 of the CDOT Bridge Design Manual. The design category for the anticipated level of de-icing salt application shall be “High”. Abutments and pier columns exposed to splash from adjacent roadway shall use epoxy-coated reinforcing steel conforming to the requirements of the Standard Specifications. Splash zone is defined as anything within 10 feet horizontally of the flow line. All reinforcing shall consist only of deformed bars per ASTM A 615.

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, and 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 Book 2, Section 19, (509), color as Accepted by CDOT, or shall be weathering steel as Approved by CDOT.

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). 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 thickness of any flange of a girder or composite girder (excluding the bottom flange of box girders) shall be 1/2 inch. 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 minimum width of any flange of a girder or composite girder shall be twelve inches.

Shear connectors shall penetrate at least three inches above the bottom of the slab, and shall be at least three inches below the top of the slab. The use of partial-length cover plates welded to rolled sections will not be allowed. 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 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.

15.2.2 Design Parameters

15.2.2.1 General

The Contractor shall complete the design in accordance with AASHTO LRFD Bridge Design Specifications, Fourth Edition, 2007 with 2008 Interim, except as otherwise noted in this section. All design calculations and plans shall be in English (Standard) units. Horizontally-curved steel bridges shall be designed in accordance with the AASHTO Guide Specifications for Horizontally Curved Steel Highway Bridges 2003.

Bridge superstructure types that would require falsework or shoring are allowed, and shall meet all required vertical and horizontal clearances. Bridges that are over the railroad facilities shall be designed and constructed in accordance with all applicable standards and requirements of the Railroad.

For bridges, stain (or paint for steel structures) shall be applied to surfaces in accordance with the Aesthetic Treatment Concepts for each particular structure. All other visible, exposed and accessible concrete surfaces shall have a surface treatment of concrete stain. This includes all retaining walls, noise barriers and slope paving.

15.2.2.2 Loads and Forces

The Contractor shall design all structures, except as otherwise noted in this section, for loads and forces in accordance with the AASHTO LRFD Bridge Design Specifications, Fourth Edition, 2007, with 2008 Interim or as stated herein.

Architectural elements and components to be constructed as part of bridges and retaining walls, shall be designed using the International Building Code, edition 2006, if the design of these elements is not covered by the appropriate AASHTO specification.

1. Live Loads. The Contractor shall design new highway bridges and walls using the AASHTO LRFD Bridge Design Specifications, Fourth Edition, 2007 with 2008 Interim. All structures shall be designed for the Colorado Permit Truck. Impact loads for highway bridges shall be as per the AASHTO LRFD Bridge Design Specifications, Fourth Edition, 2007. Pedestrian bridges shall be designed per the AASHTO Guide Specifications for Design of Pedestrian Bridges and the AASHTO LRFD Bridge Design Specifications. All pedestrian bridges shall also be designed for AASHTO Standard H 10 Truck live load to account for maintenance and emergency vehicles or as defined in the Bridge Design Manual.

2. Dead Loads. The Contractor shall design all highway bridge structures for an additional 36-psf dead load for a total (future and initial) 3-inch wearing surface.

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

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

5. Seismic. The Contractor shall design all structures in accordance with the AASHTO LRFD Bridge Design Specifications. (USE LATEST EDITION AND INCLUDE LATEST INTERIM DATES AVAILABLE BEFORE ADVERTISEMENT)

6. Load Rating. The Contractor shall load rate all highway bridges accordance with the AASHTO Manual for Condition Evaluation of Bridges, 2nd Edition, 2000, with 2001 and 2003 Interims, and the CDOT Bridge Rating Manual. LRFD bridge designs shall satisfy all of the specification requirements of the AASHTO LRFD Bridge Design Specifications, Fourth Edition, 2007 with 2008 Interim.

7. Wind Loads. The Contractor shall design all Highway bridges for the wind loads specified in the appropriate AASHTO LRFD Specification. 15.2.2.3 Geotechnical Data

15.2.2.3 Geotechnical Data

Geotechnical testing has been conducted for this Project in the area of the 120th and US 36 as well as 120th and Commerce Street. 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 Project-specific geotechnical documents completed for this Project. Additional boring logs and laboratory test results shall be presented in the formats outlined in those documents.

The soil and rock samples collected as part of this geotechnical engineering exploration are available at Rocksol Consulting Group Inc.

If the Contractor wants to obtain these geotechnical samples, they will have 90 Days from NTP1 to take possession of them. At the end of 90 Days, if the Contractor has not taken possession of the samples, then the geotechnical firm will dispose of these materials at their own discretion. If the Contractor does take possession of these samples, then the Contractor shall assume full responsibility for both 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

The Contractor shall perform geotechnical analysis as required for the design of retaining walls, bridges and other structures foundations. Design recommendations and substantiating analysis shall be documented in foundation design reports, submitted to CDOT for Acceptance, as a part of the Preliminary Design Packages and/or the In-Process Design Packages for Structures as described in this Section.

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. There shall be a 2-foot berm at the top of the slopes at the front face of abutments and a 2-foot minimum dimension from the top of this berm to the bottom of girder. Minimum vertical clearance of 16.5 feet (from traveled way and shoulders) shall be provided unless otherwise Approved by CDOT for all grade separations, allowing for future pavement overlays on the roadway below and for future widenings as shown in the Contract Documents. Bridge deck and approach slab surface smoothness shall not deviate more than 3/8 inch in 25 feet, determined as described in Book 2, Section 19 (412.17).

15.2.3.2 Type

Bridge type will not be restricted to those historically used by CDOT. Other types and components may be used, but will be allowed only if they have been accepted for general use by other transportation authorities and the Contractor can demonstrate that the design of the bridge type and components will perform well under the Project's environmental conditions, including frequent freeze-thaw cycles, anti-icing and de-icing. Experimental bridge types, timber bridges, masonry bridges, and structural-plate arches are not permitted. Tied-arch bridges will not be permitted. 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. The Contractor shall submit proposed non-historic bridge types to CDOT for Approval. If not supplied in the Contract Documents, the Contractor shall obtain structure numbers for new structures from CDOT Staff Bridge.

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 inspection and shall be designed and detailed for ease of replacement, including jack locations, and required jack sizes. The bridge shall be designed to withstand the loads and forces with the superstructure jacked.

Superstructures consisting of I-girders with exposed cross frames shall be made accessible with walkways (see 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 an inside depth of 5 feet or less that don't have access doors shall be provided with low-point drainage through the bottom slab. If there is no asphalt overlay and waterproofing membrane or silica-fume overlay, they shall be provided with epoxy coated mild steel reinforcing. 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 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 holes shall be submitted for approval by CDOT. CDOT Standard Structural Worksheet B-618-2 shows typical bottom-slab access-door details. The doors shall be placed at locations which do not impact traffic under the bridge, and 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 locked by a single padlock. Access holes through diaphragms shall be 2 feet, 6 inches in diameter, minimum.

15.2.3.4 Components

1. Bridge Rails and Pedestrian Fencing.

   The Contractor shall design and construct bridge rails and pedestrian fencing that match the face, color and overall shape of barriers shown in the Aesthetic Treatment Concepts.Bridge rails on the 120th Avenue Connection bridges over US-36 and Commerce Street shall be CDOT's Bridge Rail Type 8. The Contractor shall use bridge rails on approach slabs. The Contractor shall design and construct pedestrian fencing/railing in accordance with AASHTO LRFD Specifications. All pedestrian fencing mounted on bridge structures shall match the Aesthetic Treatment Concepts and meet fencing requirements in the AASHTO LRFD. Cover plates shall be used over breaks in the bridge rail or curbs to provide structural and safety shape continuity across the joint in the bridge rail and to provide face-of-curb continuity across the joint in the curb for traffic loading at these breaks in bridge rail and curb.

2. Approach Slabs.

   The Contractor shall provide an approach slab at the end of each highway bridge. The approach slab shall be a minimum of 20 feet in length measured along the centerline of the bridge. 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 function as a barrier to keep water out of the joint between wingwall or retaining wall and along 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 reduce water in embankment fills 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 end drains shall be located so as to minimize the amount of water flowing across all joints.

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

3. Decks.

   The Contractor shall provide a minimum concrete deck thickness of 8 inches. Open or filled grating decks and orthotropic decks will not be permitted. Concrete decks designed by the simplified "Ontario", or any empirical methods, will not be permitted. Precast deck slabs shall require cast-in-place joint closures and post tensioning across joints and an overlay. Pretensioned, precast concrete deck forms shall be a minimum of 3 inches thick and have a full grout or concrete bearing. Full grout is defined as a 1-inch minimum thickness by 2-inch wide grout pad. Stay-in-place metal deck forms are permitted. If stay-in-place metal forms are used, the superstructure, substructure, and foundation shall be designed for an extra 5 psf minimum dead load applied to the superstructure. Parallel bridges shall have a minimum 1-inch (4-inch preferred) longitudinal gap between decks or parapets, or shall be tied together to make one structure. Permanent deck forms shall not be allowed between girders or stringers where the longitudinal deck joint is located. Permanent deck forms shall not be allowed for cast-in-place post-tensioned box girder or T-girder deck slabs, or cantilevered portions of decks. In order for the cast-in-place portion of concrete placed on top of the top flange of a precast double tee or precast box girder to be considered composite with the precast top flange, the minimum total laminated deck thickness shall be 8 inches, the minimum cast-in-place thickness shall be 4-3/4 inches, and the top surface of the precast top flange shall be roughened. Precast Double Tees or Precast Box Girders without a cast-in-place deck placed on top shall not be allowed. If any part of a deck resists tension, the stress in the deck in this area shall not exceed 3 times the square root of f'c, $(3 \times (f'c)^{1/-2})$. Minimum longitudinal steel in the top mat of cast-in-place decks shall be number 4s at 6-inch spacing spliced to the negative-moment steel reinforcing.

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's Staff Bridge Technical Memorandums. Use only CDOT-approved strip seals for joints with expected maximum 3 inch movement or modular joints for expected movements 3 inches or greater. 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 especially LRFD fatigue requirement. Modular joints shall be tested for fatigue loading according to 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%. 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.

5. Overlays.

   The Contractor shall provide an initial bridge deck overlay with segmental systems, precast deck slab systems, and any bridge superstructure system that would require shoring for future deck replacement. Overlays shall be 3-inch asphalt over a waterproofing membrane for bridges. 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, may be used. Latex-modified overlays shall not be used.

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. Deflection criteria shall be considered. Utilities shall not be placed on structures without the Approval of CDOT and, if Approved, 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 if they have been Approved by CDOT to be placed on the structure. 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 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 structures shall be 1.5 ft. 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 minimum 2-inch clearance between parallel bars including spirals.

   Under full dead load, without live load, and after all losses, no part of the top or bottom girder fiber which resists moments using prestressing shall be in tension. Under full loads, after losses, tension due to live load shall not be permitted if well-

distributed, fully-bonded reinforcing is not provided in these areas. Negative camber is prohibited in precast concrete members under full dead load, without live load and after all losses.

The minimum concrete strength, f'c, shall be 4500-psi, if any portion of the cast-in-place concrete member forms any part of the deck.

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

Precast girder segments shall be bonded with epoxy or concrete closure pours. The top surfaces 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. Cover plates shall not be used. The minimum flange thickness shall be 5/8 inches. The minimum flange width shall be 12 inches. 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 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 be located at 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.

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 location of all Fracture Critical Members (FCMs) shall be clearly delineated on the plans. 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 half-size copies of the bridge plan sheets 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 plans shall be submitted to CDOT with the rating package for the bridge.

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 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 high-load multirotational (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, for some reason, 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, when used, 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 bolts 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 Preapproved 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 minimum bearing height shall be 7 inches.

8. Piers and Pier Caps.

   The Contractor shall design a type of pier cap that will be consistent with the Aesthetic Treatment Concepts. 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-36 and adjacent ramp improvements.

9. Abutments.

   The Contractor shall provide integral or semi-integral, end-diaphragm-type abutments for bridge structures 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. Retaining-wall wingwalls may be used in lieu of cantilevered wingwalls at abutments for all aesthetic categories of bridges. The length of cantilevered wingwalls and/or retaining walls from the end of the abutments of a U-type abutment shall be 4 feet longer than the point of intersection of the embankment slope with the roadway finished grade. Bridge monuments shall be supported on separate foundations.

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 2.

11. Foundations.

    The Contractor shall ensure that differential settlement will not exceed 1/2 inch within a pier or abutment or span length in (feet)/400 between adjacent bents or abutments. Contractor shall Design for down-drag on deep foundations where required. Spread footings are acceptable if the bottom of the footing is located below frost heave. Foundations of integral abutments with skews between the axis of the abutment and the direction of allowed movement of less than 56 degrees 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, where concrete is placed below water. 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 Acceptance of CDOT.

    Dynamic monitoring of driven-pile foundations using the Pile Driving Analyzer or PDA tests shall be performed a minimum of two piles per structure, each at a separate foundation element (abutment or pier foundation), and a minimum of 2% of driven piles for the Project, to verify that 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 re-strike. 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 QPM, subject to Acceptance of CDOT. Static axial-load tests on drilled shafts shall be performed in locations where drilled shafts will be used and the vertical loads will 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.

12. Drainage.

    Bridge deck drainage and end-drainage systems shall be designed in accordance with the CDOT Bridge Design Manual. Gutter flow at both ends of bridges shall be intercepted. Stormwater flowing toward the bridge shall be intercepted prior to the approach slab. Stormwater flowing away from the bridge shall be intercepted prior to leaving the approach slab. All stormwater shall be directed to an appropriate outfall. 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 flow path. 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 splash on vehicular traffic and pedestrian 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. In addition the bridge deck system shall comply with requirements listed in Section 12 regarding permitting.

The bridge deck drain system shall be designed and constructed to be easily modified to accommodate future changes to the median 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-36 and adjacent ramp improvements.

13. Utilities.

    The Contractor shall identify, maintain, and coordinate all utility location on structures. Hanging of electrical or telephone conduits or utilities shall not be permitted under deck overhangs or on bridge rail. Protection of the pipes from the settlement of the abutment backfill shall be provided. Utility placement on bridge structures shall be by the Approval of CDOT.

14. Median.

    The concrete curb and median cover material 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 concrete and reinforcement.

15.2.3.5 Maintenance Plan

The Contractor shall provide to CDOT for Acceptance, a maintenance plan for each bridge type used. This plan shall describe routine maintenance and items specific to each component of the specific bridge 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. This list shall be the same as that used for life-cycle cost analysis provided in accordance with this Section.

15.2.3.6 Existing Bridge Repairs (Not Used)

15.2.3.7 Removal of Bridge structure (Not Used)

15.2.3.8 Aesthetics

Aesthetics for both structures shall be per the Aesthetic Treatment Concepts in the Reference Documents. Both structures will have similar color and textures. In all cases, proposed structure aesthetics, including all visible surfaces, shall be submitted to CDOT for review with the Contractor's proposed general layouts of each structure. This submittal shall include drawings illustrating form, texture, and color. The Contractor shall provide full-size mockups for all proposed surface treatments showing texture, color, and quality for Approval by CDOT. For Project consistency, structures shall incorporate similar visual aesthetics. The Contractor shall

produce and submit to CDOT for Approval, a graphic of each structure to demonstrate structural consistency. This graphic shall be submitted in both hard and electronic format.

In relation to architectural treatments, the 120th Avenue over US-36 bridge requires full compliance with the Aesthetic Treatment Concepts. The 120th Avenue over Commerce Street bridge requires full compliance with the Aesthetic Treatment Concepts, except that no bridge monuments are required.

Structures and their locations are as follows:

Structure Location	Structure Number
120th Avenue over US 36	E-16-XU
120th Avenue over Commerce Street	E-16-XV

If deck overhangs exceed the limits in Section 8.2 of the CDOT Bridge Design Manual, a structural analysis shall be performed to determine if a lateral load distribution system is required for the wet concrete pour and screed loads.

15.2.4 Retaining Walls

All retaining walls throughout the project area shall comply with the Aesthetic Treatment Concepts and this Section. The Contractor shall have sole responsibility for the type, material, performance and safety of temporary retaining structures.

15.2.4.1 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 where possible. 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 5 feet inside the ROW line, except for the short wall required from Commerce Street Stations 95+ to 96+ left, where the wall footing may be as close as 1 foot 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 the ROW line for the construction of the wall, or a temporary construction easement shall be required. 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 5 feet high where access is open to the public.

15.2.4.2 Type

Metal walls, including bin walls and sheet-pile walls, recycled material walls and timber walls will 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.

15.2.4.3 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 walls (MSE) shall be designed in accordance with the requirements of AASHTO Standard Specifications for Highway Bridges, 17th Edition without interims. Global stability, overturning, and sliding calculations shall be performed on all retaining wall systems. All retaining wall installations shall include 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 also shall prevent fines washout between facing elements. 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 approved 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.

15.2.4.4 Characteristics

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 for 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. See Section 206 of the Standard Specifications for backfill requirements.

   A representative from the wall manufacturer shall be at the job site during all phases of wall construction to assist the Contractor with QC/QA. The Contractor shall use FHWA-SA-96-071, FHWA-SA-96-072, "Geosynthetic Design and Construction Guidelines" FHWA HI-95-038, "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes" FHWA NHI-00-043, and "Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes" FHWA NHI-00-044 as guidance for design requirements.

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

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

   A mechanical connection to the wall facing shall be provided; friction connections relying on gravity alone will not be permitted unless every course of block is connected to the MSE soil mass with a reinforcing layer. The Contractor shall make a list of proposed block wall locations for approval by CDOT. MSE Block Walls are not acceptable for walls at the bridge locations.

A representative from the wall manufacturer shall be at the job site during all phases of wall construction to assist the Contractor with QC/QA. The Contractor shall use FHWA-SA-96-071, FHWA-SA-96-072, "Geosynthetic Design and Construction Guidelines" FHWA HI-95-038, "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes" FHWA NHI-00-043, and "Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes" FHWA NHI-00-044 as guidance for design requirements.

A barrier shall be provided to prevent fines washout between horizontal and vertical block joints, block wall construction joints, or relief joints.

3. Cast-in-Place Walls.

   Cast-in-place walls shall be designed and constructed in accordance with AASHTO LRFD Bridge Design Specifications, Fourth Edition, 2007, with 2008 Interims. Construction-joint spacing shall accommodate or limit differential settlement.

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.

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 be a problem. 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 surfaces shall be faced to meet the aesthetic requirements of the Aesthetic Treatment Concepts.

6. 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 Standard 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.

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

15.2.4.5 Wall Aesthetics

All retaining walls throughout the Project area shall comply with the Aesthetic Treatment Concepts and this Section. The support structure (retaining the earth) can be any standard

conventional type wall, cast-in-place wall, mechanical stabilized earth, sheet piling, concrete caisson, or h-piles. The wall facing shall be textured cast-in-place concrete, precast concrete or concrete masonry units as described in the Aesthetic Treatment Concepts. All wall facing shall be of a consistent type (i.e. cast-in-place, precast 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) 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 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.

In all cases, proposed structure aesthetics, including all visible surfaces, shall be submitted to CDOT for Acceptance. This submittal shall include drawings illustrating form, texture and color. The Contractor shall provide full-size mockups (10 ft. x 10 ft. minimum) for all surface treatments showing texture, color and quality for Acceptance by CDOT.

The Contractor will be allowed latitude in the type of wall, provided there is a consistency of appearance within viewsheds. For the purposes of retaining walls, viewsheds are as defined in this Section.

The wall required from Commerce Street Stations 95+ to 96+ left shall be either cast in place concrete or block faced MSE with a cap.

15.2.5 Noise Walls (Not Used)

15.2.5.1 Geometry (Not Used

15.2.5.2 Components (Not Used)

15.2.5.3 Noise Wall Aesthetic (Not Used)

15.2.6 Sign Structures (Not Used)

15.2.6.1 (Not Used)

15.2.7 Submittals and Reviews

15.2.7.1 Technical Concepts

The Contractor shall submit a structural concept report prior to proceeding with the initial design and Release for Construction Documents, for Acceptance by CDOT, for any structure type that is proposed for the Project. Suggested submittal contents include elevation views and cross sections depicting structure components (for bridges only, others 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.

15.2.7.2 Structural Concept Report Elements

1. Life Cycle Cost Analysis.

   The Contractor shall:

A. Provide a 75-year life-cycle cost analysis of each proposed bridge type.

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

C. 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% 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% 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.

2. Bridges.

The Contractor shall submit, for Approval by CDOT:

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

C. A list of the transportation authorities that have used the proposed bridge type (include actual Projects and references).

3. Retaining Walls.

The Contractor shall submit, for Approval by CDOT:

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

B. A description of methods of accommodating settlement and differential settlement.

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

D. The location of walls and identification of wall type.

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

4. Concept Plans.

After Approval of the bridge type, as defined above, and prior to beginning initial design, the Contractor shall provide concept plans that include the following:

A. Plans, elevations, and appropriate typical Sections for each bridge type.

B. Plan views of the Project that identify each bridge location and type.

C. Plan views of the Project that identify each wall location and type.

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

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

15.2.7.3 Design

1. Reviews.

Contractor reviews will be conducted in accordance with the Contractor's approved QMP. Shop drawings shall be submitted to CDOT for information only. The Contractor is solely responsible for shop drawing accuracy.

When requested by CDOT, the Contractor shall submit three separate structural design packages for each major structural element within the Project (bridges, retaining walls, culverts). The structural design packages are defined as:

A. Preliminary Design Package. Completed General Layout drawing(s) shall be submitted for each major structural element. The geometry and proposed structure type shall have been finalized, shown and detailed in the Contractor's Drawings. Aesthetic requirements shall have been identified and incorporated into the Contractor's Drawings. Additional soil borings (if required) shall have been identified and the foundation system shall be shown in the Contractor's Drawings. The preliminary design packages are equivalent to a traditional CDOT Field Inspection Review (FIR) set.

B. In-Process Design Package. For this package the final structural design shall have been completed, but not necessarily the independent design check. All major structural drawings shall have been completed and the first independent plan check of those drawings shall have been completed. Tabular (bridge) geometry drawings and minor miscellaneous details need not be completed and submitted with this package. Additional soil borings required for major structures shall have been completed and the final foundation report shall be finished and included with the package.

C. Release for Construction Documents and Revisions to Release for Construction Documents. The independent design check shall have been completed and the original final structural design calculations shall be revised and corrected based on comments from the independent design check. Project aesthetic details shall have been incorporated into the Contractor's Drawings. Structural drawings shall have been completed and the independent plan check shall be complete. Project-special specifications shall have been completed. All changes or revisions resulting from the in-process design review shall be incorporated into the Release for Construction Documents. If required by earlier review comments, the final foundation report shall be updated and resubmitted with this package. The As-Built plans shall include as many geology sheets as necessary for each bridge and retaining wall on the Project. Test holes that were done previous to the Project should be shown with a disclaimer. The final plans shall also include hydraulics sheets for all bridges, and bridge deck elevation sheets.

For minor structural elements, such as sign structures and noise walls, the Contractor will only be required to submit Release for Construction and As-Built document packages.

2. Release for Construction, Revisions to Release for Construction and As-Built Documents.

   Contractor Drawings and Contractor Specifications for each structure shall be signed and sealed by the Contractor's designer in accordance with laws for registration of professional engineers in Colorado. Copies in .pdf and MicroStation electronic format shall be made of all plans for all structures on the Project and submitted to CDOT in computer disk (CD or DVD) format.

3. 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: 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 designer 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 in computer disk (CD or DVD) format. Rating packages for all new bridge structures and affected existing structures shall be submitted in accordance with the CDOT Bridge Rating Manual. In addition, final bridge and wall construction costs itemized per CDOT pay items marked as "FOR INFORMATION ONLY" shall be submitted.

15.3 Construction

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 for Road and Bridge Construction. Copies in .pdf format shall be made of all As-Built and shop drawings, and working drawings for all structures on the Project and submitted to CDOT in computer disk (CD or DVD) format.

15.3 Construction Requirements

The CDOT Permit Office shall be notified two working days in advance of when vertical clearances are reduced, or when lane closures, lane reductions, or lane-width restrictions are put into effect.

15.3.1 Project Special Provisions

See Book 2 Section 15 Exhibits.