

**15.0 STRUCTURES**

This Section 15 includes the requirements for the structures Work for the Design Build Project (Project). This Work shall be completed in accordance with the Contract Documents.

**15.1 Structures Work**

**15.1.1. Bridges**

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

Field Code Changed

**Table 15-1 Replacement Structures**

HWY	Milepost	Structure No.	Description
CO 9	71.448	G-12-C	CO 9 over Middle Fork South Platte River (Basic Configuration)
CO 9	20.107	J-14-C	CO 9 over Louis Gulch (Basic Configuration)
CO 9	15.97	J-15-G	CO 9 over Mack Gulch (Basic Configuration)
US 24	227.095	I-13-G	US 24 over Draw (Basic Configuration)
US 24	271.9	I-15-AO	US 24 over Twin Creek (Basic Configuration)
<a href="#">US 24</a>	<a href="#">271.691</a>	<a href="#">I-15-T</a>	<a href="#">US 24 over Seasonal Wash (Basic Configuration)</a>
US 24	271.691	H-13-N	US 24 over Middle Fork South Platte River (Basic Configuration)
US 24	240.686	M-21-B	US 24 over Lone Tree Arroyo (Basic Configuration)
US 350	51.682	M-21-C	US 350 over Hoe Ranch Arroyo (Basic Configuration)
US 350	50.582	M-21-J	US 350 over Draw (Basic Configuration)
US 350	57.474	M-22-Y	US 350 over Draw (Basic Configuration)
US 350	47.131	N-21-C	US 350 over Jack Treese Arroyo (Basic Configuration)
US 350	48.744	N-21-F	US 350 over Sheep Canyon Arroyo (Basic Configuration)
US 350	10.289	O-19-D	US 350 over Luning Arroyo (Basic Configuration)

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US 350	56.454	M-21-I	US 350 over Draw (Basic Configuration)
<a href="#">US 350</a>	<a href="#">69.817</a>	<a href="#">M-22-U</a>	<a href="#">US 350 over Otero Ditch (Basic Configuration)</a>

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HWY	Milepost	Structure No.	Description
US 24	229.468	I-13-H	US 24 over Draw (Basic Configuration)
US 24	295.45	I-17-X	US 24 over Fountain Creek (ARE)
CO 239	1.74	P-19-G Minor	CO 239 over Pickwire Ditch (ARE)

### 15.1.2. Minor Structures

Minor Structures include the replacement or extension of existing cross culverts within the limits of the roadway widening. If an existing cross culvert is allowed to remain place, the culvert shall be cleaned.

### 15.1.3. Retaining Walls

Permanent retaining wall locations in the Basic Configuration are shown in the reference drawings. Final retaining wall types, sizes, and locations shall be determined by the Contractor. The Contractor may eliminate retaining walls if the grading requirements for the Project are met. Retaining Walls shall be designed and constructed in accordance with the requirements of this Section 15.

## 15.2 Administrative Requirements

### 15.2.1. Structure Numbers or Structure IDs

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

## 15.3 Design Requirements

### 15.3.1. Standards

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

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

Table 15-2 Standards

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

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

**15.3.2. Software**

**15.3.2.1 Design**

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

### 15.3.2.2 Load Rating

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

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

### 15.3.3 Bridge Enterprise Requirements

As outlined in the Colorado Bridge Enterprise Strategies for Enhancing Bridge Service Life, October 9, 2020, the following is the Tier Designation for recommended and required minimum strategies for each structure:

HWY	STRUCTURE	TIER DESIGNATION
US 350	M-21-B	2
US 350	M-21-C	2
US 350	M-21-J	2
US 350	M-22-U	2
US 350	M-22+Y	2
US 350	N-21-C	2
US 350	N-21-F	1
US24	I-13-G	1
US 24	I-15-AO	1
US 24	I-15-T	1
US 24	H-13-N	1
CO 9	G-12-C	1
CO 9	J-14-C	1
CO 9	J-15-G	1
US 350	O-19-D	1
US 350	M-21-I	2
US 24	I-13-H	1
CO 239	P-19-G Minor	2
US 24	I-17-X	1

Required minimum strategy for a structure designation:

Tier 1: Epoxy-Coated Rebar or Galvanized Rebar, Class G Concrete, Precast Deck Panels

Tier 2: Low carbon chromium rebar, Class G Concrete, Precast Deck Panels

### 15.3.4 Materials

#### 15.3.4.1 Concrete

Concrete shall be in accordance with the referenced Standards.

The use of lightweight concrete will not be allowed.

Class G concrete shall be used for all bridge structures. Class D shall be used for all concrete box culverts and steel arch structures.

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

### **15.3.5 Loads and Forces**

#### **15.3.5.1 Live Load**

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

#### **15.3.5.2 Uplift**

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

#### **15.3.5.3 Thermal Forces**

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

### **15.3.6 Geotechnical**

Refer to Section 10 – Geotechnical and Roadway Pavements for Geotechnical requirements.

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

### **15.3.7 Structure Aesthetics Requirements**

#### **15.3.7.1 Aesthetic Requirements for Structures in General**

For consistency within the Project limits, retaining walls within a common viewshed shall incorporate similar visual Aesthetics.

#### **15.3.7.2 Aesthetic Requirements for Walls**

Preliminary layouts of the walls are shown in the reference drawings.

Wall panels shall be cast-in-place or precast concrete and shall be full height. All wall facing shall be of a consistent type (i.e., cast-in-place, precast facing, etc.) within any section of Road and single viewshed. This includes surface treatment and jointing layout. Panel design and

construction shall consider ease of replacement and/or repair.

### 15.3.8 Structure Openings

#### 15.3.8.1 Stock Passes

A stock pass must consist of either a bridge with an opening of 7 feet high, a standard box culvert with an opening 6 feet wide and 7 feet high, an 84-inch culvert, or a structural-plate arch culvert 5 feet – 10 inches span by 7 feet – 8 inches rise. Six inches of earth fill material must be placed in the invert of a round or arch culvert after installation. Rip Rap aprons will not be allowed. The following structures are identified as stock passes:

- Str. M-21-B
- Str. M-21-I
- Str. M-21-J
- Str. N-21-F
- Str. I-13-G
- Str. I-13-H
- Str. J-14-C

#### 15.3.8.2 Fish Habitat

Refer to Book 2, Section 5 – Environmental for natural bottom requirements. The following structures are identified as fish habitat:

- Str. H-13-N
- Str. G-12-C

### 15.3.9 Bridges

#### 15.3.9.1 Geometry

##### 15.3.9.1.1 Geometric Layout

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

##### 15.3.9.2 Type

Bridge types shall follow the guidelines in the *BDM* unless otherwise specified in this Section. Alternate Bridge types will be allowed, but only if they have been accepted for general use by other US State Transportation Authorities for major highways. The Contractor shall demonstrate that the design of the alternate Bridge types and components meet the Project Technical Criteria and perform well under the Project's environmental conditions.

Proposed Bridge types in the Structural Concept Plans/Report historically not used by CDOT shall be submitted for Approval prior to Structure Concept Plan and Report submittals.

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



### 15.3.9.3 Components

#### 15.3.9.3.1 Bridge Rails

Bridge rail shall be, at a minimum, AASHTO *Manual for Assessing Safety Hardware* (MASH) 2016 Test Level 4 (TL-4) compliant. CDOT Bridge Rail Type 9 and Type 10 MASH meet MASH 2016 Test Level (TL-4) and in some cases TL-5 requirements and shall be used.

The Contractor shall provide two (2) 2-inch conduit(s) in all Bridge curb(s) for the required and future utility line(s) on each bridge structure.

#### 15.3.9.3.2 Safety Railing

Safety railing shall be required as specified in the *BDM*.

#### 15.3.9.3.3 Approach Slabs

Approach slabs shall be a minimum of 20 feet in length measured along the centerline of the Bridge, except when other physical features of the Project preclude this minimum length.

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

Bridge rails shall be connected to approach slabs.

Drainage and backfill behind the abutments and beneath the approach slabs shall be as prescribed in the *BDM*.

#### 15.3.9.3.4 Decks

The Contractor shall provide a minimum concrete deck thickness of 8 inches.

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

Full-depth precast deck slabs shall have cast-in-place concrete joint closures, post-tensioning across joints, and an overlay.

Pre-tensioned, precast concrete deck forms shall be a minimum of 3 inches thick and have a full grout or concrete bearing. Full grout is defined as a 1-inch minimum thickness by 2-inch wide grout pad.

The use of concrete stay-in-place deck forms is optional. Metal stay-in-place deck forms are prohibited from use.

If non concrete stay-in place forms are used, they shall be transparent.

The superstructure, substructure, and foundation shall be designed for an extra 5 pounds per square foot (psf) minimum dead load applied to the superstructure for future utilities.

Permanent deck forms will not be allowed for cast-in-place post-tensioned box girders, T-girder deck slabs, or cantilevered portions of decks.

Styrofoam blocks used to support precast deck panels shall be limited to five inches in height, unless approved by Staff Bridge.

Cast-in-place concrete placed on top of 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.

If any part of the 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 #4's at 6-inch spacing spliced to the negative-moment steel reinforcing over piers.

FHWA Design of Bridge Deck Drainage, Hydraulic Engineering publications referred to by CDOT Bridge Design manual states if the proposed vertical grade is less than 0.5%, the designer must specify a gutter grade that will run the water to the inlet boxes from high points between the boxes. If bridge structure is selected, design team shall address drainage issues during final design. The following bridges have less than 0.5% vertical grade:

- M-21-B
- M-21-I
- M-21-J
- M-21-C
- N-21-F

#### 15.3.9.3.5 Deck Joints

The Contactor shall avoid or minimize joints wherever possible.

Bridges in length up to 460 feet (precast or cast-in-place concrete) shall be integral, wherever possible, according to guidelines given in CDOT Bridge Design Manual.

For single-span bridges less than 150 ft. long and continuous-span bridges with a total length less than 250 ft., CDOT prefers to use asphalt-paved approaches and no expansion joints. Aluminum joints shall not be used. The end dam on the approach slab shall be detailed to accommodate overlay.

#### 15.3.9.3.6 Overlays

Bridges shall implement deck protection as discussed in Section 9.9 of the *BDM*.

#### 15.3.9.3.7 Superstructures

Jointless construction shall be implemented as discussed in Section 14.4.1 of the *BDM*. The

use of expansion joints at abutments and piers shall be submitted to CDOT for Approval prior to Structure Concept and Report submittals. Bridges shall be continuous over supports and shall not use intermediate hinges.

#### 15.3.9.3.8 Slope Protection

The Contractor shall provide concrete slope protection, on any slopes from shoulder to top of retaining wall, and on slopes between tiered walls. Slope protection shall conform to the *BDM*. Slope protection on slopes between tiered walls and any slopes from shoulder to the top of retaining wall shall use similar detail. Slope Paving Details shall be included in the structural drawings.

#### 15.3.9.3.9 Bridge Deck Drains

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. Clean outs shall be accessible via an all-weather surface below. Bridge drain systems with "horizontal" runs shall not be used.

The Bridge deck drain system shall be designed and constructed to be easily modified to accommodate future changes to the Bridge. Downspout and outfall locations shall be located such that no changes are required in the future to accommodate the ultimate construction of roadway improvements.

The Bridge deck system shall also comply with requirements in Section 12 - Drainage.

#### 15.3.9.3.10 Utilities

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.

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.

### **15.3.10 Retaining Walls**

The criteria in this Section shall apply to permanent retaining wall Structures. Retaining walls that support traffic for interim phases of traffic and are left in place to become part of the final Structure shall be considered permanent retaining walls and be designed and constructed as such. The first and second phases of two-phase walls shall be considered part of a permanent wall and shall be designed and constructed as such.

The Contractor shall have sole responsibility for the type, Material, performance, and safety of temporary retaining wall Structures.

#### **15.3.10.1 Geometry**

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

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

#### **15.3.10.2 Type**

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

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

Permanent retaining walls and their associated structural support elements constructed for the Project shall be designed to resist corrosion or deterioration for a minimum service life of 100 years.

The latest FHWA geotechnical references and guidelines shall be used in conformance with the Contract and as provided at the following website:

<http://www.fhwa.dot.gov/engineering/geotech/index.cfm>.

Field Code Changed

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

#### 15.3.10.2.1 Mechanically Stabilized Earth (MSE) Walls

The Contractor shall follow the FHWA *Geotechnical Engineering Circular No. 11 – Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volumes I and II* as guidelines for the design and construction of MSE walls. MSE wall designs integrated with abutments shall account for thermal movement of the Bridge and approach settlement.

MSE walls near or in bodies of water shall account for soft saturated soils and scour and shall prevent fine washout between facing elements. MSE walls may be used in scour areas provided the foundation of the wall is located below the scour level determined in accordance with CDOT *Drainage Design Manual*. MSE walls shall be designed for hydrostatic pressure or be constructed using a free-draining Material to account for water fluctuations, including rapid drawdown after flooding conditions to prevent failure.

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

MSE wall panels shall be constructed of reinforced concrete and provide corrosion protection for pre-stressing or post-tensioning steel. The cover to reinforcing steel shall be a minimum of 2 inches. Wall panels in the splash zone shall use epoxy-coated reinforcing steel.

#### 15.3.10.2.2 Anchored Walls

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

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

#### 15.3.10.2.3 Soil Nail Walls

The Contractor shall follow the FHWA *0-IF-03-017 Geotechnical Circular No. 7 Soil Nail Walls*, FHWA *NHI-14-007 Soil Nail Reference Manual*, and the *BDM* as guidelines for the design and

construction of soil nail walls. Soil nail walls may only be used when top-down construction is warranted. The exposed surface of pneumatically placed concrete shall meet the requirements of this Section. Load Tests for soil nails shall be provided in accordance with the above FHWA guidelines.

#### 15.3.11 Maintenance Plan (Owner's Manual)

The Contractor shall submit to CDOT, for Acceptance with the Final Plans and Specifications Packages, maintenance plans 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 100-year replacement Bridge life and 30-year rehabilitation bridge life itemized by the year performed.

### 15.4 Concrete Box Culverts

#### 15.4.1 Box Culverts

Cast-in-place and precast concrete box culverts (CBCs) and wingwalls shall be designed according to the applicable M-Standard drawings and design criteria. Designs not meeting the standard sizes, loadings, or conditions provided in the M-Standard drawings are still required to meet design criteria. These include, but are not limited to, non-standard box culvert spans and heights' CBCs with top and/or bottom corner chamfers; live load surcharge greater than 2 ft.; fill heights or wearing surface thickness greater than those listed in the M-Standards; wingwall subject to live load surcharge; and headwalls subject to live load impact, including transfer of live load impact into the top slab.

Precast box culverts shall be from Qualified Manufacturers List (QML) as a fabricator of precast (not pre-stressed) concrete structures for CDOT projects.

#### 15.4.2 Loading

When designing non-standard CBCs, live load is applied as follows:

For design of culvert walls and bottom slabs, only the design lane load is applied.

For design of culvert top slabs, only axle loads of the design truck or design tandem are applied.

Apply live loads to both earth pressure cases shown in the M-Standard and as described in AASHTO 3.11.7 and AASHTO C3.11.7. Note that, due to the 50 percent reduction in earth pressure, the minimum load factor need not be applied to the 30 lb/ft<sup>3</sup> horizontal earth pressure load case. Live load distribution for various earth fills shall be per AASHTO 12.11.2.1.

It is preferred that bottom slabs for non-standard designs be modeled as rigid, not using soil springs, unless significant benefits can be demonstrated.

Applying thrust forces is inadvisable when designing non-standard CBCs unless significant benefits can be demonstrated. This criterion is consistent with CBC M-Standard and AASHTO BrR rating software design methodology, and is conservative due to unpredictable on-site foundation conditions and preparations. The Engineer may consider the benefits of thrust forces in non-standard designs but shall discuss its use in the Structure Selection Report and obtain approval from Staff Bridge.

### 15.5 Arch Structures

Arch structures shall be designed in accordance with Section 12 of the *BDM* and AASHTO Section 12. Arches shall be detailed in accordance with Bridge Detail Manual, Miscellaneous Structures. For arch culverts, soil structure interaction with refined analysis shall be used for vehicular load and for identifying positive arch action. Live load distribution factors for culverts and arch structures shall be calculated as outlined in Section 12, Buried Structures and Tunnel Liners, of the *BDM*.

Foundations shall be in accordance with recommendations in the Geotechnical report and shall be placed below frost depth or minimum 3 feet.

### 15.6 Removal of Bridges or Structures

Removal of Bridges or Structures shall be in accordance with the referenced Standards and the requirements contained in this section.

The Contractor shall follow the requirements of the Section 7 – Utilities for the removal of the existing utilities on the existing structures.

Concrete deck and, any removed steel girders, any removed steel diaphragms, steel bridge railing, and bearings shall become the property of the Contractor and shall be removed from the site and shall not be reused in the new construction.

All Timber girders and deck boards, from the removed timber bridges, shall be salvaged and remain the property of CDOT. The timber girders and check boards shall be delivered to:

CDOT Maintenance Yard  
24211 County Road 31  
La Junta, CO 81050

The Contractor shall refer to the pre-demolition/renovation asbestos and lead-based paint inspection reports for all Bridges that are part of this Project.

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 open to traffic or over traffic during the different stages of removal. The report/plan shall describe any areas of concern for worker safety and the traveling public. 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.

Removal of the substructure, between abutments of a proposed bridge structure or outside the toe of slope, shall be removed a minimum of two (2) feet below the existing natural ground surface or the proposed ground surface, taking into consideration any current or future improvements.

Removal of the substructure, within proposed side slopes, shall be removed a minimum of four (4) feet below the proposed finished grade. The limits of removal shall be approved by CDOT prior to completing the work.

Removal of the substructure, below the proposed roadway surface in a fill condition, shall be removed a minimum of 8 feet below the bottom of existing girders, including consideration of any current or future utility corridors.

Excavations resulting from substructure removal shall be backfilled with appropriate Structure Backfill (Class 1 or 2) or soil Embankment, to the adjacent existing or proposed grades. The material type will be dictated by the location of the removal. The material shall be approved by CDOT prior to placement.

The Contractor shall schedule a pre-removal meeting at least ten (10) Days prior to removal operations. The meeting shall be coordinated with CDOT.

## 15.7 Submittals

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

### 15.7.1 Preliminary Design Plans

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

#### 15.7.1.1 Structural Concept Plans

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

#### 15.7.1.2 Structure Concept Reports

Structure Concept Reports shall be no more than a three-page description of the Structure type, Materials, foundation types, methods of accommodating differential settlement, design strategy for lateral loads, and design-life considerations for each major Structure. It shall also include a list of transportation authority's actual Projects and references for all Bridges, and foundation



types and retaining wall types not historically used by CDOT. Additional information provided for Structures not historically used by CDOT will not count toward the page limit. The Contractor shall submit the reports to CDOT as part of the Preliminary Design plans submittal.

#### **15.7.1.3 Preliminary Foundation Design Report**

A Preliminary Foundation Design Report shall be submitted for each major Structure and minor Structure as required for the design of foundations for Bridges, retaining walls, and other Structures, in accordance with Book 2, Section 10. The report shall be in draft form and contain design recommendations and substantiating analysis for foundation elements, lateral earth load parameters, soil corrosivity analysis, seismic design parameters, and any other geotechnical design or analysis parameters necessary to complete the design.

#### **15.7.2 RFC Documents**

##### **15.7.2.1 Pre-RFC Documents**

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

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

##### **15.7.2.2 Final RFC Documents**

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

#### **15.7.3 Final Design Documents**

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

##### **15.7.3.1 Final Plans and Specifications**

The final plans and specifications for each Structure shall be signed and sealed by the Contractor's designer in accordance with laws for licensed Professional Engineers in the State of Colorado. Copies in PDF and Bentley OpenRoads format shall be made of all plans for all Structures on the Project and submitted to CDOT on a thumb drive other Approved format.

##### **15.7.3.2 Design and Independent Design Calculations**

The design calculations or the independent calculations shall be prepared by, signed, and sealed by a Professional Engineer licensed in the State of Colorado with a minimum of 10 years

Bridge design experience. Copies in .PDF and electronic format shall be made of design and design-check calculations and submitted to CDOT for Acceptance as part of the Final Design Documents submittal.

Calculations shall be in English (Standard) units and identify which code is utilized and reference the appropriate section in the right-hand column. References shall be included in the calculations to computer programs used to do the calculations. Computer documentation shall include the name of program, vendor, version, and release date; record of software output and Verification of output with manual calculations or other recognized program; clear identification of input and output values and meaning; and check of input.

#### 15.7.3.3 Load Ratings

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

#### 15.7.3.4 Foundation Design Reports

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

#### 15.7.3.5 Final Detail Letter

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

Field Code Changed

#### 15.7.4 Working and Shop Drawings

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

#### 15.7.5 As-Constructed Documents

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

### 15.8 Construction Requirements

The Contractor's Structural Engineer in Responsible Charge shall ensure the design and construction of the bridges and major structures meet design and construction criteria. This person shall be assigned to the Project for the duration of the Project and will be required to be onsite as required to oversee safety critical components of the Work.

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

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

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

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

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

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

**15.9 Deliverables**

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

**Table 15-7 Deliverables**

<b>Deliverable</b>	<b>Review, Acceptance, or Approval</b>	<b>Schedule</b>
Deviations from CDOT's <i>Bridge Design Manual</i> and this Section 15	Approval	Prior to Acceptance of Final RFC Documents
Alternate bridge rating software	Approval	Prior to major and minor Structure ratings
Concrete mix design and procedures	Acceptance	Minimum 3 weeks prior to the anticipated concrete placement date
Bridge types historically not used by CDOT	Approval	Prior to the submittal of the Concept Plans and Report submittals
Use of precast approach slabs	Approval	Prior to Structure Concept Plan and Report submittals
Use of expansion joints at abutments and piers	Approval	Prior to Structure Concept Plan and Report submittals
Wall Structure types not historically used by CDOT	Approval	Prior to the submittal of the Concept Plans and Report submittals

**Book 2 – Technical Requirements**  
**R2B2 DESIGN BUILD**  
**FBR R200-266 (23558) (Grant)**  
**FBR R200-267 (23559) (Non-Grant)**

**SECTION 15 - STRUCTURES**

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Structural Concept Plans	Review	As part of the Preliminary Design Plans submittal
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<b>Deliverable</b>	<b>Review, Acceptance, or Approval</b>	<b>Schedule</b>
Design and independent design calculations	Acceptance	As part of the Final Design Documents submittal
Load ratings	Acceptance	As part of the Final Design Documents submittal
Foundation design reports	Acceptance	As part of the Final Design Documents submittal
Final detail letter	Acceptance	As part of the Final Design Documents submittal
Falsework or shoring plans carrying live traffic	Acceptance	10 Days prior to construction
Structure Concept Reports	Review	As part of the Preliminary Design Plans submittal
Preliminary foundation design report	Review	As part of the Preliminary Design Plans submittal
Final plans and specifications	Acceptance	As part of the Final Design Documents submittal