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Administrative Requirements

The Contractor shall design, and construct all of the following structures required to make the Project fully functional and economical, in accordance with the Contract Requirements.

1. Structure number I-05-Z for the proposed Railroad crossing bridge at MP 14.4
2. Wall number I-05-A for East retaining wall at abutment 4
3. Wall number I-05-B for West retaining wall at abutment 1
4. Wall number I-05-C for Cast-in-Place retaining wall at M.P. 15.1
5. Big Gulch concrete arch culvert extension at station 429+87.82
6. Drainage and irrigation structures

The Railroad Crossing bridge and walls shown in the Reference Documents may be modified to provide a better value design, accelerated bridge construction and the construction cost that meets project constraints identified within this document and the current standards. Specifically, the Contractor may choose to adjust bridge length, structure geometry, and span-depth configuration to reduce wall heights, and eliminate UPRR crossing arm and controller box conflicts as shown in Reference Documents. The Contractor may choose to eliminate walls if all design criteria is met. The Contractor may also choose to modify Big Gulch Concrete Arch Culvert to meet the project constraints and current design requirements.

When the Contractor chooses to modify the structures, the Contractor shall clearly understand that additional work and costs occurred during the design and construction shall be the contractor's responsibility and there will not be any Change Order to CDOT.

Standards

The standards used for design and construction of the structures for this project shall be as listed on the plans, or as specifically referenced in this section.

The requirements of a document version (standard, specification, or other) referenced in this section will take precedent over the requirements of the documents listed on the plans.

Standards referenced by this section include:

All of the documentation found at the following web site address and any documents referenced therein:

http://www.coloradodot.info/library/bridge/bridge-manuals/bridge-design-manual

http://www.coloradodot.info/library/bridge/bridge-manuals/bridge-rating-manual

http://www.coloradodot.info/library/bridge/bridge-manuals/bridge-detail-manual

http://www.coloradodot.info/library/bridge/bridge-manuals/metric-bridge-geometry-manual

http://www.coloradodot.info/library/bridge/miscbridgedocs/techmemos/design-memos

http://www.coloradodot.info/library/bridge/miscbridgedocs/techmemos/rating-memos

http://www.coloradodot.info/library/bridge/design-standards

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http://www.coloradodot.info/business/designsupport/bulletins_manuals/construction-bulletins/current

http://www.coloradodot.info/business/designsupport/construction-specifications/2011-Specs/2011-specs-book

http://www.coloradodot.info/business/designsupport/construction-specifications/2011-Specs/standard-special-provisions

http://www.coloradodot.info/library/bridge/miscbridgedocs/accelerated-bridge-construction

AASHTO LRFD Bridge Design Specifications, Customary U.S. Units, 6th Edition, with 2013 Interim Revisions and any documents referenced therein.

AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, with 2012 and 2014 Interim Revisions. Seismic design may be done using either the AASHTO Guide Specification for LRFD Seismic Bridge Design or the AASHTO LRFD Bridge Design Specifications, but shall be consistent and use one or the other for the design of all components of the bridge.

AASHTO the Manual for Bridge Evaluation, 2nd Edition, 2010 with 2013 Interim Revisions

ASHTO LRFD Bridge Construction Specifications, 3rd Edition, 2010 with 2014 Interim Revisions

The 2011 Edition of the Standard Specifications for Road and Bridge Construction as published by the Colorado Department of Transportation and any documents referenced therein. This includes the Standard Special provisions which include revisions to the 2011 Edition of the Standard Specifications for Road and Bridge Construction and any documents referenced therein.

Software

The following software shall be used for this Project:

AASHTOWare Bridge Rating, VIRTIS (Version 6.4.1),

MicroStation V8i, CDOT drawing standards are provided in this project for use. The contractor shall create a MicroStation Drawing environment that exactly matches the environment used internally at CDOT.

Design Requirements

Structure Selection Report

The structure selection reports provided in the Referenced Documents shall be considered preliminary. Should the contractor want to provide an alternative girder or wall type, the Contractor will be required to submit a new structure selection reports for the Engineer review and approval. Each report shall include the study of at least three structure types and provide

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the summary of the recommended feasible structure type for the construction. The structure selection reports shall meet or exceed the requirements outlined in the CDOT Bridge Design Manual and the project requirements in this section.

Materials

Concrete

Concrete shall be in accordance with the Referenced Standards.

Concrete shall include Structural Concrete Coating as described in CDOT Standard Specification 601.14.

Structural Concrete Stain

Structural concrete Stain shall be in accordance with the Referenced Standards.

Prestressing Steel

Prestressing Steel shall be in accordance with the Referenced Standards.

Post-Tensioning Steel Systems

Post Tensioning Steel Systems shall be in accordance with the Referenced Standards.

Reinforcing Steel

Reinforcing Steel shall be Grade 60 reinforcing steel. All reinforcing steel shall be epoxy coated unless otherwise noted in accordance with the Referenced Standards.

Structural Steel

Structural Steel shall be AASHTO M270 Grade 50 (ASTM A-572) unless otherwise noted in accordance with the Referenced Standards.

Design Parameters

General

Design Parameters shall be in accordance with the Referenced Standards and the requirements contained in this section.

All design calculations and plans shall be performed in English (Standard) units.

Structure or bridge design, bridge rating, quantity estimate, bridge geometry and structural 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 in the calculations. Computer documentation shall include: name of program, vendor, version

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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.

Loads and Forces

Load and Forces for bridge design shall be in accordance with the Referenced Standards and the requirements contained in this section.

1. Dead loads

   Utilities (future and existing): As Appropriate

   3" HMA Overlay (future and initial): 36 psf

   Unit Weight Prestressed Concrete:

   Shall be in accordance with the referenced Standards

2. Live Loads
   Shall be in accordance with the referenced Standards

3. Thermal Forces

   The following thermal coefficient and temperature ranges shall be used for designing the new structures:

   Thermal Coefficient: 0.000006/°F concrete, 0.0000065/°F steel

   Design Temperatures: shall be in accordance with the referenced Standards

4. Load Rating

   The Contractor shall load rate all highway bridges in accordance with the AASHTO Manual for Bridge Evaluation, and the CDOT Bridge Rating Manual, latest revisions.

Load and Forces for wall, and drainage and irrigation structure designs shall be in accordance with the Referenced Standards and Documents.

Geotechnical Data

See Section 10 – Geotechnical and Roadway Pavements for Geotechnical requirements. See Geotechnical Memorandums for structure foundation recommendations in the Reference Documents. The Contractor shall be responsible for final geotechnical reports and recommendations.

Bridges

Geometry

Bridge Geometry shall be in accordance with the referenced Standards and the requirements contained in this section.

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See Section 13 - Roadway and Section 12 - Hydraulics for additional structure requirements.

The bridge width shall have a curb-to-curb width equal to 40'-0".

Type

Bridge Type shall be in accordance with the referenced Standards and the requirements contained in this section. Structure type will not be restricted to those typically 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 and anti-icing chemicals.

Experimental bridge types, timber bridges, masonry bridges, hunched girder bridges, all types of truss bridges and structural plate arches are not permitted. Post-tensioned cast-in-place concrete box girder type is not allowed since deck is not feasible to be replaced in the future bridge rehabilitation. Expansion devices in the deck and abutment wall connections are not allowed, but are required in the sleeper slabs at the approach slab ends.

The Contractor shall submit, to the Engineer for Approval, non-typical bridge types in the Structure Concept Plan.

The following structural requirements are to be met when new and innovative concepts or accelerated bridge construction (ABC) techniques are employed:

- A corrosion engineering consulting firm as approved by CDOT's Project Engineer with expertise in the prevention of corrosion for civil engineering structures shall be retained by the Contractor to review the integrity of the proposed connection details for a 75 year design life. The Contractor shall submit the results of this evaluation to the CDOT Project Engineer for CDOT's use in determining the acceptability of the proposed connection details.
- Field welded plates can only be used as temporary supports for bridge elements during erection and shall not be placed in a prestressed load path to prevent elements from seating properly.
- Match casting in prestressed elements shall be used to eliminate joint shifting in post-tensioned connections. Additionally, post-tensioning strands and bars shall be long enough to provide sufficient force for ultimate strength and service strength stress requirements after anchor set and long term losses have occurred.

Inspection Access

Bridge Inspection Access shall be provided in accordance with the referenced Standards.

Structure Components

Structure Components shall be in accordance with the referenced Standards and the requirements contained in this section.

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Bridge Rails

Bridge Rail Type 7 shall be used with 92 Inch Chain Link Fence attached on the bridge rail as shown in the Project Reference Documentation.

The final finish for the surfaces of the type 7 bridge rail and curbs shall be Class 2. All other exposed concrete surfaces shall receive a Class 1 final finish to one foot below the ground line.

A colored structural concrete stain shall be provided on the exposed bridge rails.

Approach Slabs

Bridge approach slabs are required at Structure I-05-Z and shall be in accordance with the referenced standards. All the provisions for bridge deck concrete shall also apply to approach slab concrete.

Decks

The Contractor shall provide a minimum concrete deck thickness of 8 inches in accordance with the Referenced Standards.

Open or filled grating decks and orthotropic decks will not be permitted.

Concrete decks designed to the simplified "Ontario", or any empirical methods, will not be permitted.

Precast Full-Depth Transverse Deck slabs if it is selected for accelerated bridge construction by the Contractor, shall be match cast or provided with an approved cast-in-place closure pour and longitudinally post-tensioned for continuous span bridge.

Precast pre-tensioned concrete deck forms with partial C-I-P concrete deck as an alternative of the ABC shall be temporarily supported on blocking with a 1:1 aspect ratio and in accordance with the Referenced Standards and Documents.

Permanent Steel Deck Forms are not allowed for all concrete girders.

Permanent deck forms shall not be allowed for T-girder deck slabs, or for box culverts 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 Girders to be considered composite with the precast top flange, the total laminated deck thickness shall be 8 inches minimum, the cast-in-place thickness shall be 4-3/4 inches minimum, and the top surface of the precast top flanges shall be roughened.

Precast Double Tees, Precast Box Girders or longitudinal Precast Slabs without a cast-in-place deck placed on top will not be allowed. If any part of a deck resists tension the stress in the deck in this area shall not exceed 3-sqrt f'c. Minimum longitudinal steel in the top mat of cast in place decks shall be No. 4's at 6 inch spacing spliced to the negative moment steel reinforcing.

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Other joint and connection details shall be used upon approval by CDOT Project Engineer.

Concrete deck of the bridge shall be able to be replaced in the future deck rehabilitation project as required by the Referenced Standards.

Girders

Girders shall be in accordance with the referenced standards.

Negative camber is prohibited in Precast Concrete Members under full dead load, without live load and after all losses.

Deck Joints

The bridge is short enough as noted in accordance with the reference Standards to eliminate the need for deck expansion joints. In the event that the bridge is extended the Expansion joints shall be placed in accordance with the referenced Standards.

Expansion Joints

Expansion joints in sleeper slabs at approach slabs shall be continuous. The Contractor to submit approach slab details to CDOT to ensure expansion joints are continuous. If expansion joint approach is not acceptable, the contractor shall provide new expansion joints for entire width of Structure I-05-Z.

Overlays

The Contractor shall provide an initial 3" HMA surface over waterproofing membrane to enhance bridge deck durability. The waterproofing membrane shall be applied in accordance with Section 515 of the CDOT Standard Specifications. Traffic shall not be placed on bridge deck prior to waterproofing membrane and HMA overlay placement.

See Section 10 – Geotechnical and Roadway Pavements for HMA requirements.

Bearings

Bearings shall be designed and installed in accordance with the Referenced Standards.

Piers and Pier Caps

Piers and Pier Caps shall be in accordance with the Referenced Standards.

Abutments

Structure backfill in abutments shall be mechanically stabilized backfill and in accordance with the Referenced Standards. The length of cantilevered wingwalls and/or retaining walls from

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the end of the abutments of U-type abutment shall be 4 feet longer than the point of intersection of the embankment slope, along outside face of cantilevered wingwalls or retaining walls, with the roadway finished grade. If the required length of cantilevered wingwalls is longer than 16 feet from the end of U-type abutment diaphragms as recommended by the Reference Standards, the Contractor shall submit the detail and design for the Engineer Approval.

Structural Color

A colored Structural Concrete Stain finish will be required on exposed concrete surfaces. The color sample panel shall be equivalent to Federal Standard 595C Color, and is to be selected from test panels provided by the Contractor. All exposed surfaces shall receive Structural Concrete Stain to one foot below the ground line.

All structural steel shall be painted in accordance with Section 509 of the Standard Specifications. The color shall be equivalent to Federal Standard 595C color and is to be selected from test panels provided by the Contractor.

Slope Protection

Slope Protection shall be in accordance with the referenced Standards. The Contractor shall provide concrete slope paving on embankment slope to protect erosion around the abutments and wingwalls.

Foundations

Foundations of the bridge shall be in accordance with the Referenced Standards.

Drainage

See Section 12 – Hydraulics for bridge drainage requirements. No deck drains are allowed. No bridge rails with scuppers are allowed.

Utilities

Hanging of electrical or telephone conduits or utilities is not permitted under deck overhangs or on bridge rail.

Protection of utility conduits from the settlement of the abutment backfill shall be provided.

Utility placement and loads on bridge structures shall be approved by the Engineer.

Retaining Walls

General

Retaining Walls shall be in accordance with the Referenced Standards. If the Contractor proposes to modify and design the retaining walls rather than using the CDOT Worksheets,

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the design, details and design check calculations shall be submitted to the Engineer for approval.

Geometry

Retaining Wall geometry shall be in accordance with the Referenced Standards. The Contractor is allowed to modify wall geometry to meet the project constraints and current design requirements.

Type

Retaining Wall Type shall be in accordance with the Referenced Standards. Wall Type Selection Report shall be submitted to the Engineer for review and approval.

Design Requirements

Retaining Wall design shall be in accordance with the Referenced Standards. If the Contractor proposes to modify and design the retaining walls rather than using the CDOT Worksheets, the design, details and design check calculations shall be submitted to the Engineer for approval.

Characteristics

Retaining Wall characteristics shall be in accordance with the referenced Standards.

Design Reviews

Shop drawings of the bride and retaining walls shall be submitted to the Engineer for information and review only. The Contractor is solely responsible for shop drawing accuracy.

CDOT Bridge Rating Manual shall be used for the bridge rating package submittals.

Concrete Arch Culvert Extension (Big Gulch) and Dranage Structures

General

Concrete Arch Culvert, irrigation and drainage structures shall be in accordance with the referenced Standards. The contractor is allowed to modify and design the culvert to meet the project constraints and current design requirements.

Geometry

Concrete Arch Culvert geometry shall be in accordance with the Referenced Standards.

Type

Concrete Arch Culvert Type shall be in accordance with the Referenced Standards.

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Design Requirements

Concrete Arch Culvert, irrigation and drainage structure design shall be in accordance with the Referenced Standards. If the Contractor proposes to modify and design the culvert, the design, details and design check calculations shall be submitted to the Engineer for review and approval.

Characteristics

Concrete Arch Culvert characteristics shall be in accordance with the Referenced Standards.

Design Reviews

Shop drawings shall be submitted to the Engineer for information and review only. The Contractor is solely responsible for shop drawing accuracy.

Construction

General

Construction of all structures shall be in accordance with the Referenced Standards.

Deliverables

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

Deliverable	Acceptance or Approval	Schedule
Structure Selection Report (if re-submitted)	Approval	60 days before submitting RFC plans
RFC Structural Plans & Specifications Package (Structural Plans to be provided in both pdf and dgn formats) (see description below)	Acceptance	Prior to Construction
Structure Selection Reports	Approval	60 days before submitting RFC plans

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RFC Plans and Specification Package

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. The summary of quantities of all structures shall be included in structure drawing packages for information only in accordance with the Referenced Standards. All structural drawings shall have been completed and the final independent plan check of all the drawings shall be complete. Project special specifications shall have been completed. All changes or revisions resulting from the in-process design review shall be incorporated into the Final Design Documents. If required by earlier review comments, the final foundation report shall be updated and resubmitted with this package.

The Final 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.

Contractor Drawings and Contractor Specifications for each structure shall be signed and sealed by the Contractor's designer in accordance with the professional registration laws of Colorado.

All calculations shall be signed and sealed by the Contractor's designer in accordance with the professional registration laws of Colorado. Copies in pdf format shall be made of all design and design check calculations for the Project and then submitted to CDOT.

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Project Special Provisions

REVISION OF SECTION 202
REMOVAL OF PORTIONS OF PRESENT STRUCTURE

DESCRIPTION

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

Subsection 202.01 shall include the following:

> This work shall include the removal of portions of the following as shown on the plans or as directed by the Engineer: arch culvert walls, headwall, footings, toewall, and bottom slab; culvert wingwalls, footings, and toewalls.

CONSTRUCTION REQUIREMENTS

Subsection 202.02 shall include the following:

> At least 10 days before beginning culvert removal the Contractor shall submit to the Engineer details of the removal operations showing the methods and sequence of removal and equipment to be used. If additional removal of unsound concrete is required, it shall be included in the work. All methods and equipment used to accomplish this item shall be approved by the Engineer.

In subsection 202.02 delete the sixth paragraph and replace with the following:

> A sawcutting approximately one inch deep shall be made to a true line along the limits of all removals. The minimum depth of a saw cut shall be 1 inch, or to the depth of the reinforcing steel, whichever occurs first. A sawcutting shall also be made along the limits of removal on all concrete faces which may be visible in the completed work.

Subsection 202.08 paragraph 3 shall include the following;

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

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REVISION OF SECTION 206
STRUCTURE BACKFILL

Section 206 of the Standard Specifications is hereby revised for this project as follows:

Delete subsection 206.02, and replace with the following:

206.02 General. All structure backfill, bed course material, and filter material will be accepted in place.

(a) *Structure Backfill.* Class 1 with geotextile reinforcement layers (Mechanically Stabilized Backfill) and Class 2 structure backfill shall be composed of non-organic mineral aggregates and soil from excavations, borrow pits, or other sources. Material shall conform to the requirements of subsection 703.08. Class of material shall be as specified in the Contract or as designated.

Structure backfill (flow-fill) meeting the following requirements shall be used to backfill bridge abutments and culverts. The Contractor may substitute structure backfill (flow-fill) for structure backfill (class 1) or structure backfill (class 2) in other backfill areas of the project.

Ingredients	**Lbs./Cu.Yd**
Cement	50
Coarse Aggregate (AASHTO No. 57 or 67)	1700
Fine Aggregate (AASHTO M 6)	1845
Water	325 (or as needed)

The amount of water shall be such that the structure backfill (flow-fill) flows into place properly without excessive segregation. Approximately 39 gallons of water per cubic yard of structure backfill (flow-fill) is normally needed.

The Contractor may substitute 30 pounds per cubic yard of cement and 30 pounds per cubic yard of fly ash for 50 pounds per cubic yard of cement or may substitute 60 pounds per cubic yard of cement and 60 pounds per cubic yard of fly ash for 100 pounds per cubic yard of cement.

Recycled broken glass (glass cullet) is acceptable as part or all of the aggregate. Aggregate including glass must conform to the required gradations. All containers used to produce the cullet shall be empty prior to processing. Chemical, pharmaceutical, insecticide, pesticide, or other glass containers containing or

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REVISION OF SECTION 206
STRUCTURE BACKFILL

having contained toxic or hazardous substances shall not be allowed and shall be grounds for rejecting the glass cullet. The maximum debris level in the cullet shall be 10 percent. Debris is defined as any deleterious material which impacts the performance of the flowfill including all non-glass constituents.

(b) *Bed Course Material.* Material shall conform to the requirements of subsection 703.07. Upon approval, aggregate base course conforming to the requirements of subsection 703.03 may be used in lieu of bed course material.

(c) *Filter Material.* Class A, Class B, and Class C filter material shall conform to the requirements of subsection 703.09. Class of material shall be as specified or designated.

Delete paragraphs 13 and 14 of subsection 206.03 and replace with the following:

The maximum layer thickness for structure backfill (flow-fill) shall be 3 feet. The structure backfill (flow-fill) shall be consolidated with suitable mechanical vibrators operating within the flow-fill.

Vibrators shall be of a type and design approved by the Engineer. They shall be capable of frequencies of at least 10,000 vibrations per minute, in air. The vibration at any point shall be of sufficient duration to accomplish consolidation, but shall not be prolonged to the point where segregation occurs.

Subsection 206.07 shall include the following:

Structure excavation and structure backfill required for all culverts and extensions will not be measured and paid for separately, but shall be included in the work.

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REVISION OF SECTION 503
DRILLED CAISSONS

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

Add Subsection 503.071 immediately following Subsection 503.07 as follows:

503.071 Cross-Hole Sonic Logging

(a) *General Requirements.*

The nondestructive testing method called Cross-hole Sonic Logging (CSL) shall be used on ~~all~~ drilled caissons for the bridge piers.

The testing shall not be conducted until 48 hours after the placement of all concrete in a caisson, and must be completed within 20 calendar days after placement on production drilled caissons. The Engineer may specify a longer minimum time if special retarders, mix designs, or other factors result in slower-setting concrete.

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

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

Upon completion of CSL testing all water shall be removed from access tubes and any other drilled holes. After the CSL results have been evaluated, required repair of defects has been conducted and the repair has been evaluated with another CSL survey, the CSL tubes shall then be grouted at the direction of the Engineer with an approved prepackaged grout having a minimum compressive strength of 4000 psi.

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REVISION OF SECTION 503
DRILLED CAISSONS

(b) *Preparation for Testing*

The greater of a minimum of four (4) CSL tubes or one (1) CSL tube per linear foot of the drilled caisson diameter, which maximum number of CSL tubes controls, shall be installed in each drilled caisson, equally spaced around the perimeter of the caisson at 90 degrees.

The CSL tubes shall be Schedule 40 steel with an inside diameter of 1 ½ inches. Galvanized steel will not be permitted. Substitution will not be permitted. Pipes shall have a round, regular internal diameter free of defects or obstructions, including any at pipe joints (all pipe joints shall be threaded without any couplings), in order to permit the free, unobstructed passage of a 1.35 inch diameter source and receiver probe. Tubes shall be watertight and free from corrosion with clean internal and external faces to ensure passage of the probes, and to provide good bond with the concrete.

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

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

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

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

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REVISION OF SECTION 503
DRILLED CAISSONS

The Contractor shall submit to the Engineer for review the proposed CSL system including equipment schematics, material specifications, tube size, installation details, testing procedures, and joint connections at least 14 days prior to starting drilled caisson construction.

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

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

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

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

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

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

(d) *CSL Logging Procedures*

Before the placement of concrete, a minimum of one tube per caisson shall be plumbed and the tube length recorded, including a notation of the tube projection above the caisson tops. Information on the caisson bottom and top elevations and/or length, along with construction dates shall be provided to the Engineer before the CSL tests.

CSL tests shall be conducted between the pairs of tubes encompassing the perimeter and the major diagonals. Testing shall be in accordance with ASTM D 6760. Additional logs shall be conducted at no additional cost to the Department in the event anomalies are detected.

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

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REVISION OF SECTION 503
DRILLED CAISSONS

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

Additional NDT methods may be used to evaluate possible caisson defects including Single hole Sonic Logging, Gamma-Gamma Nuclear Density Logging, 3D Tomography, and/or Surface Sonic Echo and Impulse Response tests.

(e) *CSL Testing Results*

CSL results shall be presented to the Engineer in a report. The test results shall include CSL logs with analyses of:

1. Initial pulse arrival time versus depth
2. Pulse energy/amplitude versus depth

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

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

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

(f) *Evaluation of CSL Test Results*

The Engineer will evaluate the CSL and NDT (if needed) results within 7 days of receipt from the Contractor and determine whether or not the drilled caisson construction is acceptable. The concrete condition shall be evaluated using the methodology described in Section 20.2.1 of the FHWA Geotechnical Engineering Circular Number 10 (Publication No. FHWA-NHI-10-016 Drilled Shafts: Construction Procedures and LRFD Design Methods, FHWA 2010). The Contractor shall provide consultants and/or personnel, on an as needed basis, who are experienced and competent performing the above NDT methods. If a defect is found by the additional NDT, then the cost of the additional NDT shall be the responsibility of the Contractor.

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DRILLED CAISSONS

If the NDT records are complex or inconclusive, the Engineer may require coring in accordance with subsection 503.071(g) below, or excavation of the caisson to verify caisson conditions. If a defect is confirmed, the Contractor shall pay for all coring or excavation costs, including grouting of all core holes.

The acceptance of each drilled caisson shall be the decision of the Engineer, based on the results of the caisson integrity testing report(s), including caisson coring, and other information on the caisson placement. Rejection of a caisson based on the caisson integrity testing shall require conclusive evidence that a defect exists in the caisson which will result in inadequate or unsafe performance under expected loads.

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

(g) *Core Drilling of Drilled Caisson Concrete*

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

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

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

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7. The drill shall be size HW or larger. The core barrel shall be size HW or larger, M series, double-tubed, with a chromed inner barrel. The diamond set bit for each hole shall be of best quality, new, and with a minimum of four waterways. The Engineer may require a new bit or replacement of the core barrel at any time inspection indicates excessive wear or loss of diamonds.

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

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

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

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

Subsection 503.09 shall include the following:

Cross-Hole Sonic Logging, including but not limited to all preparation, materials, labor, equipment testing, analysis of results, and reporting will not be measured and paid for separately and shall be included in the work.