US 6 Bridges - Design Build Project

I-25 Bridge Replacement

Structure Type Study

(Proposed Structure F-16-ZC)

Prepared for CDOT Region 6
Project Number: BR 0061-083 (18838)
July 2012

Executive Summary

The Project includes improvements and reconstruction along the US 6 (6th Avenue) corridor from a western terminus located just east of Sheridan Blvd and an eastern terminus located past the BNSF Railroad Bridge Structure west of the US 6 / I-25 interchange. Included within these limits is the US 6 over I-25 interchange.

The US 6 over I-25 bridge replacement is located in the I-25 Valley Highway corridor in the Denver metropolitan area. The existing bridge has a sufficiency rating of 54.2, is considered functionally obsolete and is near the end of its 50-year useful life. The existing bridge does not meet current vertical clearance requirements. Due to the above issues, in addition to the existing bridge geometrics not being compatible with the proposed roadway geometrics, rehabilitation of the existing bridge is not warranted.

The objective of the structure type selection process is to determine an economical structure type that is constructible, and that meets the project goals and requirements. This structure type study evaluates various structure layouts and type options for cost and constructability and will select the recommended structure type.

A minimum structure width (157'-0') of the replacement structure was determined from the preferred alignment outlined in the *Valley Highway Environmental Impact Statement (EIS)*. Using the preferred interchange alignment for I-25 and meeting the required 16'-6" minimum vertical clearance requirements requires a two span structure with approximately 95'-6" span lengths.

Three structure types, composite steel I-girder, precast prestressed bulb tee girder and adjacent precast prestressed box girder have been evaluated for a two span configuration to replace the existing structure. Preliminary design of structure types was performed to determine preliminary construction cost estimates. Construction costs for replacing this bridge are estimated to be $5.5 million.

On the basis of the evaluation contained in the Structure Type Study, the recommended structure type is:

> **Precast Prestressed Adjacent Box Girder (BX35 x 48"), (95'-6", 95'-6") continuous spans, 5" concrete deck topping, 3" SMA, and 3" average haunch, resulting in a 3'-10" superstructure depth. Substructure is multi column piers founded on caissons, a semi-integral vertical wall abutment founded on H-pile pattern with a concrete cap at Abutment 1 and a semi-integral vertical secant wall with cast-in-place facing at Abutment 3.**

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1.0 Introduction

Figure 1. US 6 Bridge

The Project generally includes improvements at the I-25/US 6 interchange, partial closure of the Bryant Street interchange, a diamond interchange at US 6/Federal Boulevard with slip ramps to Bryant Street and a braided ramp from Federal Boulevard to eastbound US 6, improvements to Federal Boulevard between 5th and 7th Avenues, conversion of 5th Avenue to two-way operation east of Federal Boulevard, upgrading portions of the South Platte River Trail to current standards in areas impacted by construction, reconstruction of US 6 with collector-distributor roads/auxiliary lanes from Federal Boulevard to the BNSF Railroad Bridge Structure, in-kind replacement of impacted facilities for Barnum East Park as further defined in the Contract Documents and including adding a bicycle/pedestrian Bridge Structure connecting Barnum Parks South and North, replacement of existing Bridge Structures as further described herein, and overlay of US 6 westerly to Sheridan Boulevard.

The Project includes improvements and reconstruction along the US 6 (6th Avenue) corridor from a western terminus located just east of Sheridan Blvd and an eastern terminus located past the BNSF Railroad Bridge Structure east of the US 6 / I-25 interchange. Included within these limits is the US 6 bridge over I-25.

A Structure Selection Report (SSR) shall be prepared for each bridge within the project limits. The report will evaluate typical structure options for each bridge and shall evaluate:

- Existing Bridge Condition
- Proposed Structure Layout
- Staging
- Geotechnical
- Substructure Alternatives
- Utilities
- Aesthetics requirements
- Environmental
- Structural design criteria
- Construction Cost Estimate

In the SSR, a General Layout shall be prepared for the preferred alignment option. The layout will include both horizontal and vertical alignment and general dimensions of the bridge elements. Areas of temporary and permanent impact required to construct the bridge can be

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established. The preferred structure type will be determined by the criteria established in the SSR.

2.0 Existing Bridge Condition

Structure F-16-DU is a continuous two span, cast-in-place concrete rigid frame structure built in 1958 and widened in 1966. The continuous span lengths from back face of abutment to centerline pier are (85.6' - 85.6'). The bridge has been classified as functionally obsolete with a 54.2 Sufficiency Rating and 25.0 Inventory Rating. The low sufficiency rating and poor condition of the structure is primarily due to deterioration, cracking, and spalling of the columns, girders, abutments and deck.

The existing bridge is supported by multi-column bents founded on spread footings. The foundation material is gravel that transitions into hard shale with depth below the bottom of footing.

The bridge accommodates four through travel lanes in each direction, bridge rails as well as a center median barrier and four shoulders for a total out to out bridge width of 148'-7". The bridge carries an estimated 137,000 cars a day over I-25. According to the as-built plans, the existing bridge profile drops to the east at a 2.03% grade. The bridge CDOT Vertical Clearance Report states the minimum vertical clearance over I-25 is 15.0 feet. There are no major utilities on the bridge.

3.0 Proposed Structure Layout

3.1 Bridge Width

The EIS describes the required lane configurations in the preferred option at the interchange location. The proposed layout for US 6 includes six 12'-0" through lanes, two 12'-0" ramp acceleration lanes, a 10'-0" outside shoulder, a 4'-0" median shoulder, three 12'-0" median shoulders, a 4'-0" outside shoulder, two 2'-0" median barriers, and two 1'-6" Type 7 Bridge Rails for a total required out to out width of 157'-0". Figure 2 illustrates the proposed interchange layout. The maximum width of the proposed bridge is limited due to the existing Pier 8G column on Flyover Bridge F-16-OL at the southeast corner and the existing Pier 11 column on Bridge F-16-OG on the northeast corner. Flyover Bridge F-16-OG also has Pier 10 located in the median between northbound and southbound traffic just east of Abutment 3. US 6 is located on a tangent through this section of roadway over I-25.

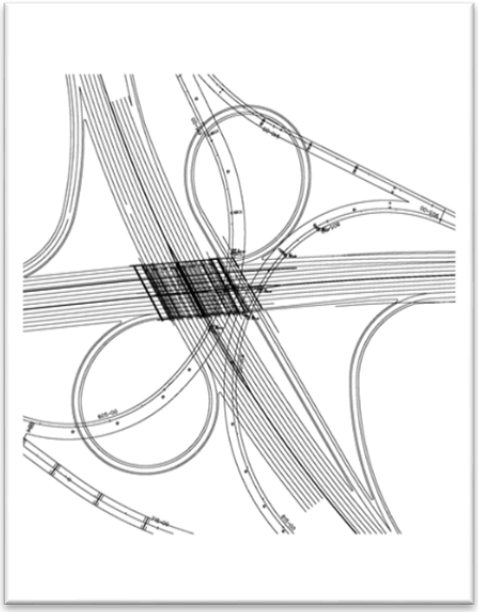

Figure 2. Proposed I-25 Interchange

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3.2 Span Length

Layout of the bridge length is determined from the ultimate lane configuration of I-25 as described in the EIS. The proposed layout for I-25 ultimate configuration includes four 12'-0" through lanes in each direction, one 12'-0" southbound ramp lane, two 12'-0" shoulders, two Type 7 roadway barriers, one 24'-0" median including barrier and additional distance to account for the horizontal curvature of I-25 and staging the construction. A total bridge length of 192'-8" from centerline abutment to centerline abutment would be sufficient to span the roadway below. Due to the available superstructure depth, a single span option is not viable. Two spans (96'-4", 96'-4") are recommended to span I-25 with a pier in the median. The bridge piers are skewed approximately 23 degrees right ahead to US 6.

The number of spans that were initially considered for this project included one, two, and three span alternatives. The two span option is the only recommended span configuration. The reasons for selecting a two span option include the following:

- **One span option (not recommended):** Would eliminate construction in the I-25 median, but cannot accommodate the available 4.00' structure depth.
- **Two span option (recommended):** To meet the available superstructure depth of 4.00', a two span option with a pier in the median is a viable option. Placing the abutments near the outside edge of shoulder allows the span lengths to work.
- **Three or Four span options (not recommended):** Adding a short end span at the west side would create a short span and create an uplift condition on the abutment that is undesirable, in addition to encroaching on the ramp. A ramp tunnel is proposed east of the bridge. Adding a span to the east side instead of using a tunnel was considered but was not evaluated further due to the existing flyover pier columns. The existing columns infringe on the proposed superstructure, could possibly be undermined during construction, and would have to be evaluated for any additional loading due to the proposed bridge. An additional span would also require further evaluation of the proposed project construction phasing.

3.3 Available Structure Depth

Based on a continuous two span bridge of about 96.5' per span, recommended superstructure depths, according to AASHTO LRFD, Table 2.5.2.6.3-1, are shown in Table 1 below. To calculate the girder depth, it is assumed to use the CDOT 8"minimum deck thickness and a 4" haunch for Bulb Tee Girders, 0.027L (from AASHTO) for Plate Girders and 5" topping with 3" haunch for adjacent box beams.

Girder Type	Ratio	Minimum Depth (ft)	Girder Depth (in)
PC/PS Concrete Bulb Tee	.040	3.86	42
Composite Steel Plate Gdr	.032	3.09	30 (web)
Adjacent PC/PS Box Beams	.025	2.41	35

Table 1 Minimum Superstructure Depths

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Due to clearance issues with the I-25 to US 6 flyovers, the profile of US 6 can only be minimally raised at this location. Making the problem worse is the existing sub-standard vertical clearance to I-25. The southwest corner only has a 15.0' vertical clearance. So, I-25 has to be lowered a minimum of 1.5' just to meet current clearance criteria. If I-25 is lowered too much, it creates drainage issues with the South Platte River and getting roadway runoff to flow into the river. If I-25 is lowered below the river it would require an expensive pump station.

The proposed profile allows for a structure depth of only 4.0', which is too shallow for a continuous span Bulb Tee Girder structure type. For the proposed span lengths of this bridge, precast pre-stressed concrete has historically come in significantly cheaper than continuous steel plate girders. For this reason, the steel option will not be considered. To meet the structure depth recommendations, the adjacent box beam option will be the only one considered.

4.1 Staging

A preliminary assessment of replacing the bridge requires the construction to be phased in three stages. The three stage construction also allows for additional traffic staging to be accomplished.

Stage 1 requires the demolition and construction of the northern portion of the bridge. Traffic will remain on the existing bridge and consists of two 11' WB through lanes, one 11' WB on-ramp lane, 6' median and traffic barrier, two 11' EB through lanes, two 2' minimum shoulders and a 2' traffic barrier adjacent to the demolition line.

Stage 2 requires the demolition and construction of the center portion of the bridge. Traffic remaining on the existing bridge consists of two 11' WB through lanes, two 11' EB through lanes, 6' median and traffic barrier, two 2' minimum shoulders and a 2' traffic barrier adjacent to the demolition line. The newly constructed portion from Stage 1 will have one 11' WB on-ramp lane, one 11' WB through lane, two 2' minimum shoulders and a 2' traffic barrier adjacent to the construction line.

Stage 3 includes a two part demolition of the remaining portion of the existing bridge along with two traffic phase shifts. Traffic remaining on the existing bridge consists of two 11' EB through lanes, two 2' minimum shoulders and a 2' traffic barrier adjacent to the demolition line. The newly constructed portion from Stages 1-2 will have one 11' WB on-ramp lane, two 11' WB through lanes, two 2' minimum shoulders and a 2' traffic barrier adjacent to the construction line. A traffic shift moves the two 11' EB traffic lanes and a 6' median and barrier to the newly constructed Stage 1-2 portions. This allows for the final demolition and construction of the remainder of the bridge.

5.0 Geotechnical

A preliminary assessment of the foundation types has not been performed on the project at this time. Based on previous construction projects near the project site, deep foundations such as drilled caissons and H-pile are acceptable options for the foundations. Geotechnical borings have been performed to determine rock depths. At the I-25 interchange location, bedrock is estimated

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to be approximately 40' at the west abutment, 23' at the median pier and 47' at the east abutment from existing grade elevation.

Much of I-25 in the project area, particularly at the interchanges, is constructed on artificial fill. This artificial fill is composed of varying amounts of clay, silt, sand, gravel, and other debris including concrete, brick, wood, vegetation, and trash ranging in thickness from 5 to 40 feet. There have been many quarry operations adjacent to the river. Because many of the abandoned quarries were later used as landfills, artificial fill may include debris, trash, and other landfill material.

6.0 Substructure Alternatives

Competent bedrock exists approximately 25' below the existing I-25 pavement. The depth of rock indicates typical deep foundations such as piles and drilled caissons would be the recommended foundation type.

7.0 Utilities

There are no known utilities to be proposed on the bridge. There are two existing underground electric lines, a storm sewer line and water line located in the vicinity of the bridge.

8.0 Aesthetics

At this time, there are no plans to develop special aesthetic details for the US 6 bridge. Minor aesthetic treatment, such as colors and form liner patterns, should be developed prior to the completion of the final design. The developed details should be aesthetically pleasing with distinctive color; texture and material treatments which help break down scale and create a sense of place. The series of bridges on the project should share common elements while maintaining its own unique identity. Components that create identity include character, detailing, color and materials. The developed architectural details should integrate well with the characteristics of the surrounding area. Possible areas where architectural treatments may be applied include barriers, abutment walls, wingwalls, columns and girders.

9.0 Environmental

This section discusses the potential for soil and groundwater contamination to be encountered in the project area. Areas of contaminated soil and groundwater must be identified so they can be avoided, if reasonably possible. Encountering soil and groundwater contamination during construction without prior knowledge may affect a project in terms of worker safety, cost, schedule, and agency and public relations.

A *Modified Environmental Site Assessment* (MESA) was performed in support of the Valley Highway EIS process (FHU, 2005h). The MESA was prepared based on the American Society for Testing and Materials (ASTM) *Standard Practice for Environmental Site Assessments* (ASTM, 2000), CDOT guidance (CDOT, 2002d), and through consultation with CDOT and CDPHE (FHU, 2003b). The purpose of the MESA is to identify recognized and potential

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environmental conditions in the project area that could adversely affect the project, to aid in effectively screening and evaluating the feasibility of system alternatives and aid in the right-of way process.

Several areas of known contaminated soil and groundwater are located in the project area. Chlorinated solvent and petroleum contaminated soil and groundwater are located in the vicinity of the Broadway and I-25 interchange. Petroleum contaminated soil and groundwater is also present east of the I-25 and US 6 interchange. The I-25 and US 6 interchange is located west of the Union Pacific Burnham Shops (the former Denver & Rio Grande rail yard), the Rio Grande LUST site, and the former Lake Archer. Three closed and one active LUST sites and the active Union Pacific–Burnham Shops ERNS spill are located in the vicinity of the interchange. The interchange is also located near the Lake Archer reservoir with potential soil and groundwater contamination and methane concerns. The fill material for the Lake Archer reservoir is unknown but may have included municipal and industrial debris. A diesel-contaminated groundwater plume is located west of the interchange. Landfill debris, contaminated soil and groundwater, and methane may be encountered in the area of the I-25 and US 6 interchange.

10.0 Design Criteria

10.1 Design Specifications

- CDOT Staff Bridge Design Manual – May 2009
- CDOT Staff Bridge Technical Memorandums
- "AASHTO LRFD Bridge Design Specifications", 6th Edition
- CDOT Standard Specifications for Road and Bridge Construction, 2011

11.0 Construction Cost Estimate

In determining initial construction cost, major construction items will be quantified and priced using standard unit costs established from CDOT's Cost Data book. Below is a list of the estimated bridge costs for the superstructure type options. These construction costs do not include costs for roadway, traffic control, design, construction management or contingency.

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Table 2. Estimated Construction Cost

Summary of Approximate Quantites Date: 7/16/2012
US 6 Bridges
US 6 over I-25

CONTRACT ITEM NO.	CONTRACT ITEM	UNIT	Approximate Quantities	2007 AVE UNIT COST	2008 AVE UNIT COST	2010 AVE UNIT COST	Estimated UNIT COST	Estimated TOTAL COST
US 6 / I-25	**Strucuture dimensions (length by width)**	200.25	157.00					
202-00400	Removal of Bridge	EACH	1	$ 104,005.30	$ 75,509.02	$ 57,452.50	$ 150,000.00	$ 150,000.00
206-00000	Structure Excavation	CY	8,700	$ 17.33	$ 7.96	$ 7.79	$ 8.00	$ 69,600.00
206-00100	Structure Backfill (Class 1)	CY	5,000	$ 35.66	$ 28.20	$ 16.68	$ 20.00	$ 100,000.00
206-00360	Mechanical Reinforcement of Soil	CY	5,000	$ 17.58	$ 25.20	$ 17.57	$ 18.00	$ 90,000.00
206-01781	Shoring (Area 1)	L S	1	$ 26,214.06	$ 36,860.57	$ 37,938.22	$ 20,000.00	$ 20,000.00
206-01782	Shoring (Area 2)	L S	4	$ 37,630.74	$ 37,500.00	$ 47,768.80	$ 30,000.00	$ 120,000.00
403-09210	Stone Matrix Asphalt	TON	680	$ 71.70	$ 71.32	$ 81.73	$ 80.00	$ 54,400.00
502-11274	Steel Piling (HP 12x74)	LF	1,350	$ 51.99	$ 77.73	$ 48.44	$ 75.00	$ 101,250.00
503-00036	Drilled Caisson (36 Inch)	LF	2,700	$ 262.14	$ 231.03	$ 285.87	$ 275.00	$ 742,500.00
503-00054	Drilled Caisson (54 Inch)	LF	400	$ 411.15	$ 433.89	$ 594.01	$ 500.00	$ 200,000.00
513-00600	Bridge Drain	EACH	4	$ 3,714.29	$ 10,893.33	$ 3,000.00	$ 3,500.00	$ 14,000.00
515-00120	Waterproofing (Membrane)	SY	4,111	$ 10.20	$ 15.41	$ 13.71	$ 12.00	$ 49,332.00
518-01004	Bridge Expansion Device (0-4 Inch)	LF	344	$ 186.87	$ 267.88	$ 154.74	$ 160.00	$ 55,040.00
601-03040	Concrete Class D (Bridge)	CY	2,900	$ 473.70	$ 432.91	$ 396.97	$ 400.00	$ 1,160,000.00
601-40300	Structural Concrete Coating	SY	2,110	$ 7.95	$ 7.55	$ 9.09	$ 10.00	$ 21,100.00
602-00020	Reinforcing Steel (Epoxy Coated)	LB	445,000	$ 1.02	$ 0.99	$ 0.79	$ 1.15	$ 511,750.00
606-10700	Bridge Rail Type 7	LF	491	$ 83.69	$ 95.69	$ 74.52	$ 100.00	$ 49,100.00
606-10705	Bridge Rail Type 7 (Special)	LF	491	$ 102.49	$ 72.75	$ 85.96	$ 200.00	$ 98,200.00
613-00100	1 Inch Electrical Conduit	LF	300	$ 5.65	$ 10.31	$ 11.08	$ 10.00	$ 3,000.00
613-00200	2 Inch Electrical Conduit	LF	600	$ 9.30	$ 14.96	$ 9.56	$ 10.00	$ 6,000.00
618-01994	Prestressed Concrete Box (Depth 32" Through 48")	SF	29,260	$ 49.89	$ 62.72	#N/A	$ 65.00	$ 1,901,900.00
	Subtotal of accounted construction items						**South Bound Bridge:**	**$ 5,517,172**
							Cost per SF:	***$175***

APPENDIX A

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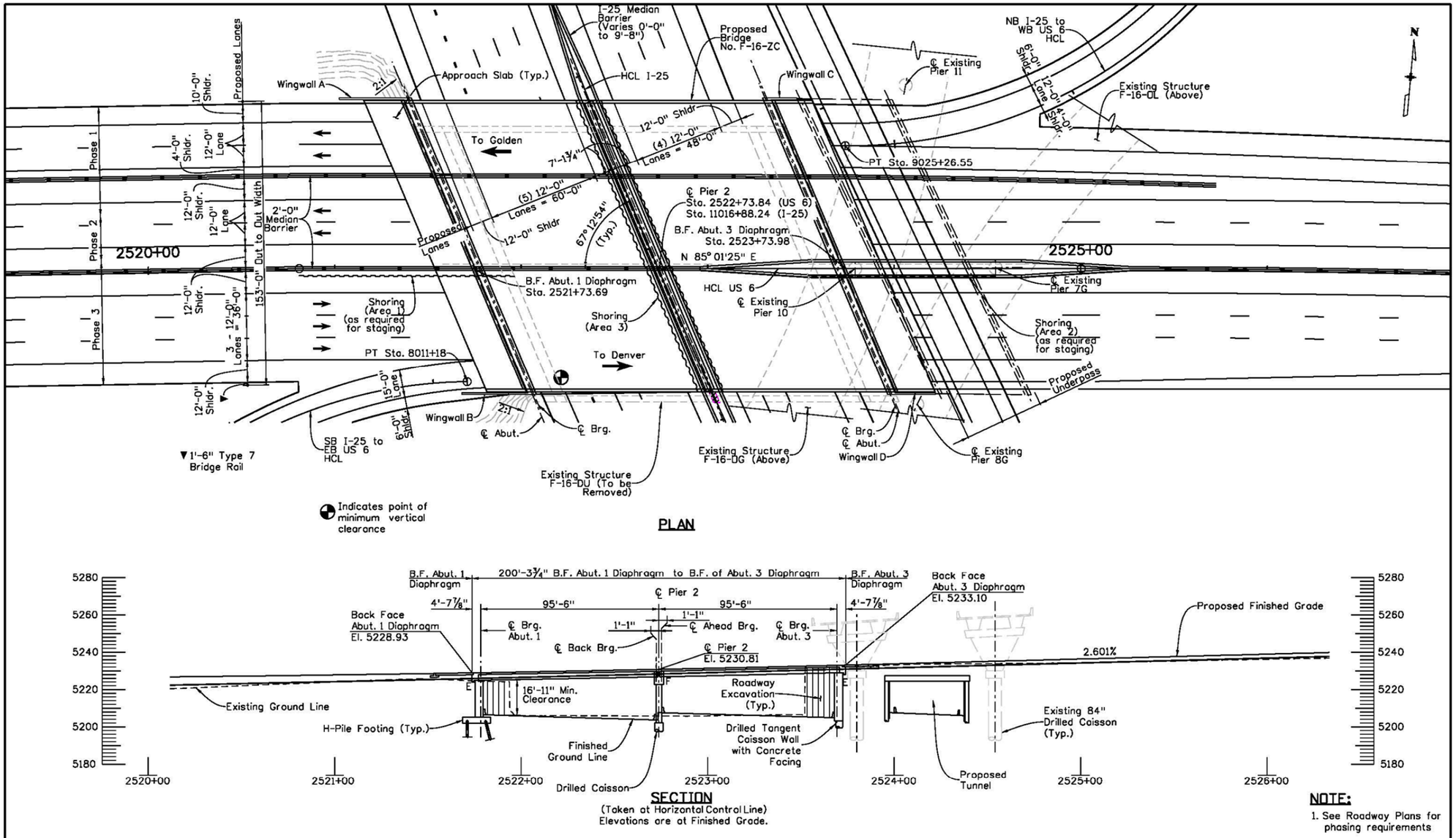
PLAN
SECTION
(Taken at Horizontal Control Line)
Elevations are at Finished Grade.
Indicates point of minimum vertical clearance
To Golden
To Denver
2520+00
2525+00
Wingwall A
Wingwall B
Wingwall C
Wingwall D
Approach Slab (Typ.)
HCL I-25
HCL US 6
Proposed Bridge No. F-16-ZC
Existing Structure F-16-OL (Above)
Existing Structure F-16-DU (To be Removed)
Existing Structure F-16-DG (Above)
Proposed Underpass
Shoring (Area 1) (as required for staging)
Shoring (Area 2) (as required for staging)
Shoring (Area 3)
PT Sta. 8011+18
PT Sta. 9025+26.55
B.F. Abut. 1 Diaphragm Sta. 2521+73.69
B.F. Abut. 3 Diaphragm Sta. 2523+73.98
℄ Pier 2 Sta. 2522+73.84 (US 6) Sta. 11016+88.24 (I-25)
N 85° 01'25" E
Proposed Lanes
Phase 1
Phase 2
Phase 3
153'-0" Out to Out Width
2'-0" Median Barrier
1'-6" Type 7 Bridge Rail
SB I-25 to EB US 6 HCL
NB I-25 to WB US 6 HCL
℄ Existing Pier 11
℄ Existing Pier 10
℄ Existing Pier 7G
℄ Existing Pier 8G
200'-3¾" B.F. Abut. 1 Diaphragm to B.F. of Abut. 3 Diaphragm
Back Face Abut. 1 Diaphragm El. 5228.93
Back Face Abut. 3 Diaphragm El. 5233.10
℄ Pier 2 El. 5230.81
Proposed Finished Grade
2.601%
Existing Ground Line
H-Pile Footing (Typ.)
Finished Ground Line
Drilled Caisson
Roadway Excavation (Typ.)
Drilled Tangent Caisson Wall with Concrete Facing
Existing 84" Drilled Caisson (Typ.)
Proposed Tunnel
16'-11" Min. Clearance
NOTE:
1. See Roadway Plans for phasing requirements
Print Date: 9/19/2012
File Name: 18192BRDG_US6_I25 GENERAL LAYOUT.dgn
Horiz. Scale: 1:50
Vert. Scale: As Noted
Unit Information
Unit Leader Initials
Sheet Revisions
Date:
Comments
Init.
Colorado Department of Transportation
8833 South Wadsworth Court
Littleton, CO 80128
Phone: 303-972-9112 FAX: 303-972-9114
Region 6
MDP
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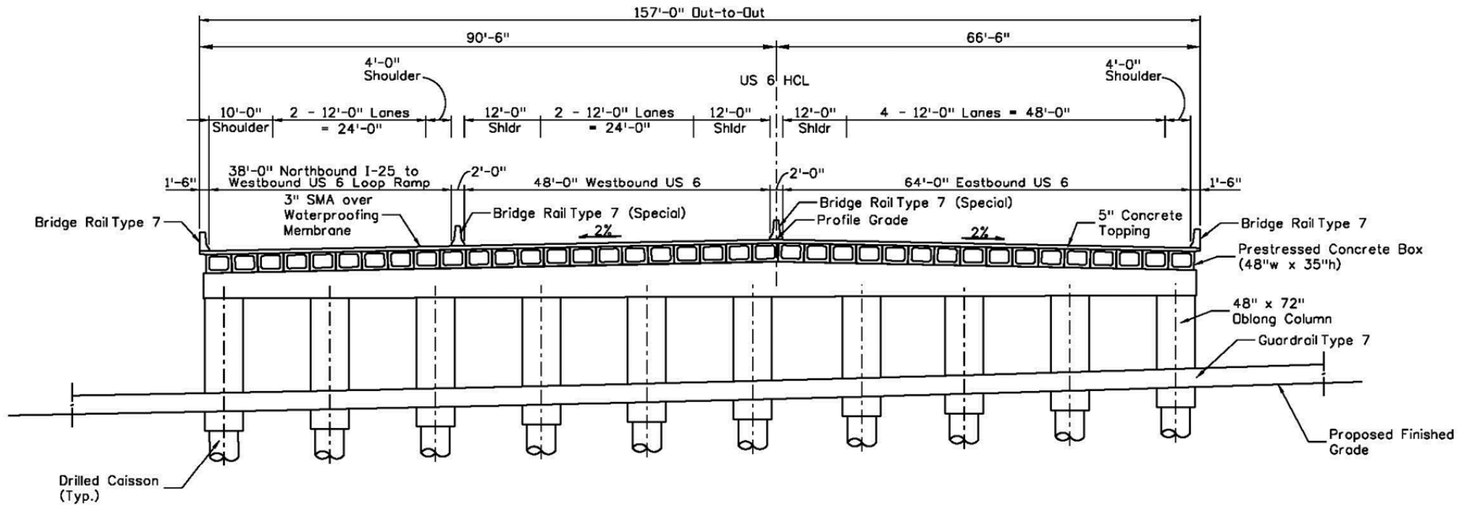
Date: 09-19-12
Void:
US 6 OVER I-25
GENERAL LAYOUT
Designer: H. REED
Detailer: H. REED
Sheet Subset: BRIDGE
Structure Numbers F-16-ZC
Subset Sheets: of XXX
Project No./Code
US 6 BRIDGES DESIGN BUILD PROJECT
18838
Sheet Number



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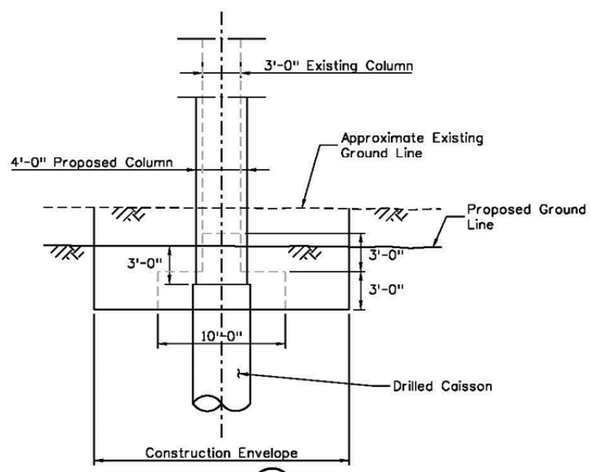
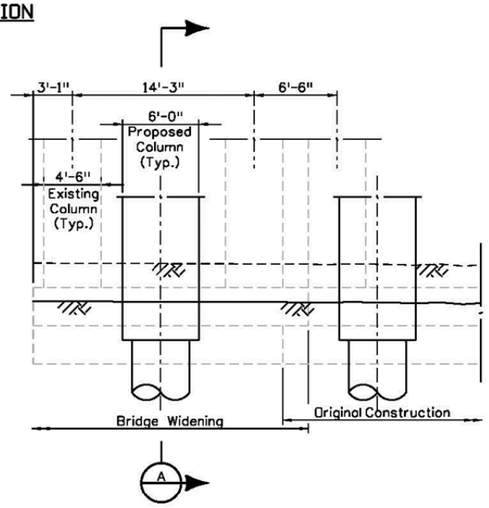


SECTION A



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Horiz. Scale: 1:20 Vert. Scale: As Noted	R-X	Region 6 MDP	Void:
Unit Information Unit Leader Initials			

US 6 OVER I-25 TYPICAL SECTION	Designer: H. REED	Structure Numbers	F-16-DU	Project No./Code: US 6 BRIDGES DESIGN BUILD PROJECT
	Detailer: H. REED			18838
	Sheet Subset: BRIDGE	Subset Sheets: of		Sheet Number

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