



# US 6 Bridges - Design Build Project

## I-25 NB to WB US 6 Exit Ramp Tunnel

*Structure Type Study*

(Proposed Structure F-16-ZD)



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 (6<sup>th</sup> 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 exit ramp tunnel for I-25 Northbound to US 6 Westbound.

The tunnel is located directly east of the US 6 over I-25 bridge replacement and is located in the I-25 Valley Highway corridor in the Denver metropolitan area. The proposed tunnel location moves the exit ramp out from under the existing I-25 Bridge to near the end of the proposed approach slab. Available superstructure depth is insufficient to allow the ramp to stay under a bridge with increased span length. See the Structure Selection Report for the I-25 Bridge Interchange Replacement for addition information.

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 tunnel length (175'-7 1/2") was determined from the preferred alignment outlined in the *Valley Highway Environmental Impact Statement (EIS)*. The required tunnel section width (40'-0") was determined from the probable ultimate ramp configuration. A required 16'-6" minimum vertical clearance must also be met.

Due to staging requirements and the need to coordinate construction of the tunnel with construction of the I-25 interchange bridge, tangent caissons can be utilized as shoring and as tunnel walls. Use of caissons also minimizes disturbance to the existing flyover bridge piers. Wall panels or a cast-in-place facing can be constructed to finish the wall surface. An integral top slab will be used as a roof to hold out the fill and water above. Construction costs for building this tunnel are estimated to be \$1.8 million.

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

**40'-0" wide x 175'-7" Tunnel utilizing tangent caisson walls with concrete facing and a solid slab roof.**

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## 1.0 Introduction

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 5<sup>th</sup> and 7<sup>th</sup> Avenues, conversion of 5<sup>th</sup> 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.



Figure 1. US 6 Bridge at I-25

The Project includes improvements and reconstruction along the US 6 (6<sup>th</sup> 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 tunnel for I-25 northbound exit ramp to US 6 westbound.

The Project includes improvements and reconstruction along the US 6 (6<sup>th</sup> 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 tunnel for I-25 northbound exit ramp to US 6 westbound.

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

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

## 2.0 Existing Bridge Condition

Directly adjacent to the proposed tunnel location is existing Structure F-16-DU which 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'). See the I-25 bridge interchange structure selection report for additional information. Currently, the I-25 northbound exit ramp to westbound US 6 runs underneath the existing bridge. The proposed tunnel location moves the ramp lane out from under the bridge.

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 Tunnel Section Width

The required tunnel section includes width for the proposed US 6 exit lane in addition to a possible future lane. Future reconfiguration of the US 6 and 8<sup>th</sup> Ave interchanges could possibly combine the exit lanes for each road creating a collector distributor road. The final future configuration of the revised interchanges has not been finalized at this point. Thus, the proposed section allows for the possibility of adding a future lane. For a two lane roadway, *AASHTO Green Book* requires an absolute minimum roadway between curbs equal to the greater of the approach pavement width plus 2' or 24' minimum. In addition, for a two lane roadway, *AASHTO Green Book* has a preferred minimum roadway between curbs equal to 24' lanes plus 5' and 10' shoulders for a total distance between curbs of 39.0'. Raised or protected emergency egress paths also need to be provided outside each of the shoulders. The pathways need to meet the 1.5' absolute minimum or 2.5' preferred minimum width described in the *AASHTO Green Book*. When practical, tunnels should also meet requirements for life safety of the travelers as outlined in the *National Fire Protection Association (NFPA) 502 – Standard for Road Tunnels, Bridges, and Other Limited Access Highways*. One of these requirements is a protected 3.6' minimum emergency egress path. In trying to meet the preferred AASHTO requirements along with fitting

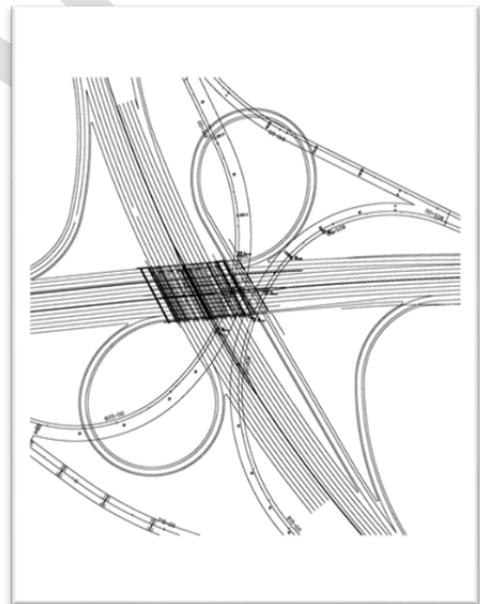


Figure 2. Proposed I-25 Interchange

the tunnel between the existing bridge piers, the proposed section for the tunnel includes capacity to carry two 12'-0" through lanes, a 4'-0" outside shoulder, a 4'-0" inside shoulder, two 2'-6" emergency egress paths, and two 1'-6" Type 7 Bridge Rails for a total required width between wall faces of 40'-0". Figure 2 illustrates the proposed bridge layout. The maximum width of the proposed tunnel is limited due to the existing Pier 8G column on Bridge F-16-OL at the southeast corner and the existing Pier 11 column on Bridge F-16-OG on the northeast corner. 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.

### 3.2 Tunnel Length

Layout of the tunnel length is determined from the ultimate lane configuration of US 6 as shown in the proposed roadway plans. The proposed layout for US 6 ultimate configuration at the bridge 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 roadway section width of 157'-0". Accounting for the tunnel being skewed to the section by approximately 25 degrees, a tunnel length of 175'-7 1/2" is required. Final tunnel length can be adjusted to tie in with the adjacent I-25 interchange structure.

### 3.3 Available Structure Depth

Based on a simple span slab of about 43.0', a recommended minimum slab depth, according to AASHTO LRFD, Table 2.5.2.6.3-1, is 26". A slab depth of 36" will be used in the estimate to account for additional load due to fill above the top slab.

There is sufficient depth between the proposed profiles of the exit ramp and US 6 to allow the slab and needed fill height to be to meet the required 16'-6" minimum vertical clearance.

## 4.1 Staging

A preliminary assessment of replacing the adjacent I-25 interchange bridge requires the construction to be phased in three stages. The three stage construction also allows for additional traffic staging to be accomplished. The tunnel construction staging must match that of the adjacent bridge. A summary of the bridge staging is outlined below.

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 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. Due to staging requirements and the need for shoring, it is recommended to use tangent caisson walls that can function as both the shoring and be used as the tunnel walls. The walls will require either a cast-in-place or precast panel finish.

## 7.0 Utilities

There are no known utilities to be proposed in the tunnel except for conduit lines for lighting. There are two existing underground electric lines, a storm sewer line and water line located in the vicinity of the tunnel.

## 8.0 Aesthetics

At this time, there are no plans to develop special aesthetic details for the US 6 Bridge Project. 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 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”, 6<sup>th</sup> Edition

- CDOT Standard Specifications for Road and Bridge Construction, 2011
- FHWA Road and Tunnel Design Guidelines
- Technical Manual for Design and Construction of Road Tunnels

## 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.

Table 1. Estimated Construction Cost

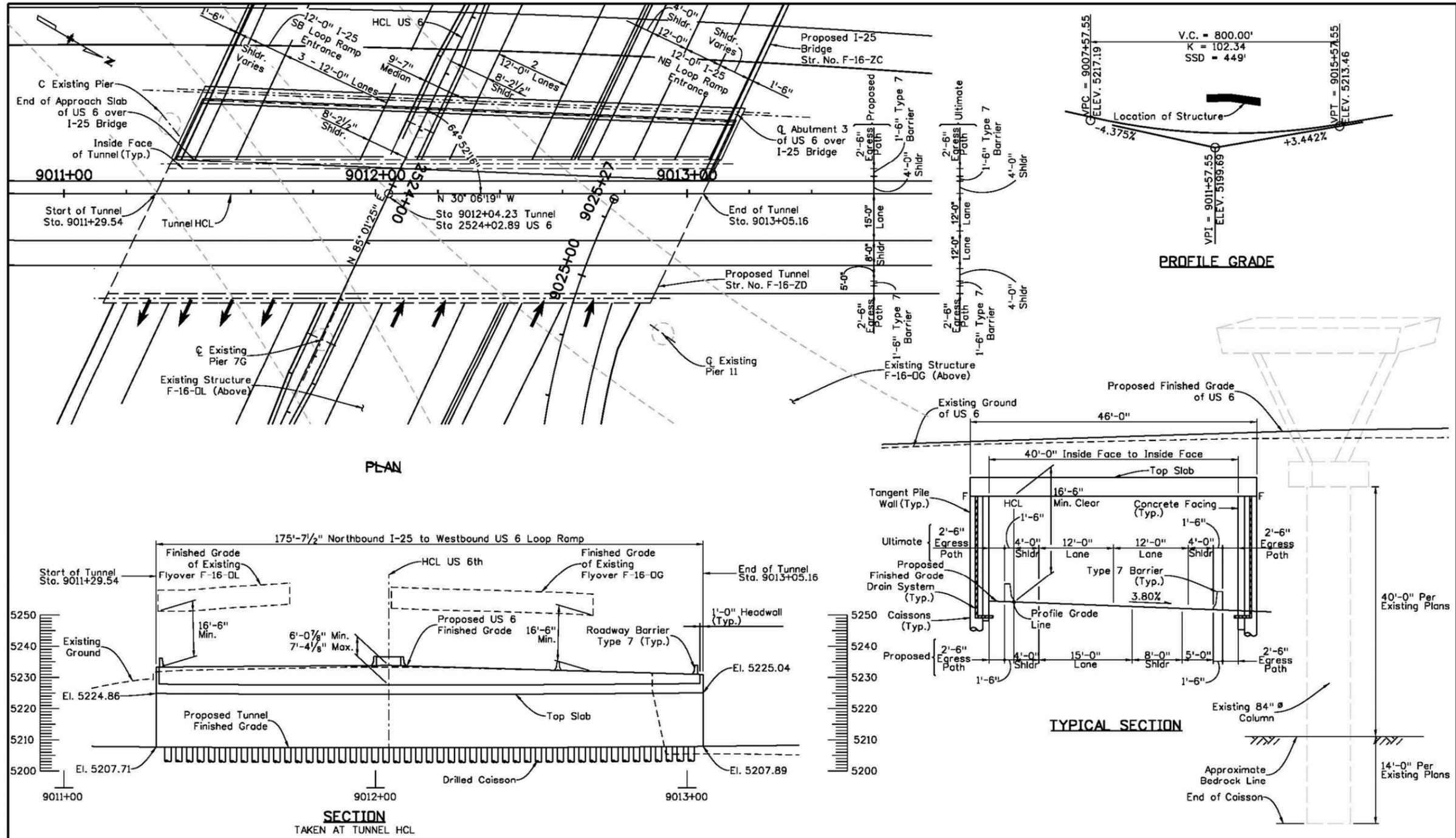
Summary of Approximate Quantities  
US 6 Bridges  
I-25 Ramp Tunnel

Date: 7/16/2012

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
Tunnel	Structure dimensions (length by width)	175.63	40.00					
206-00000	Structure Excavation	CY	3,250	\$ 17.33	\$ 7.96	\$ 7.79	\$ 8.00	\$ 26,000.00
206-00100	Structure Backfill (Class 1)	CY	310	\$ 35.66	\$ 28.20	\$ 16.68	\$ 30.00	\$ 9,300.00
503-00024	Drilled Caisson (24 Inch)	LF	5,500	\$ 99.80	\$ 144.58	\$ 88.04	\$ 200.00	\$ 1,100,000.00
601-03040	Concrete Class D (Bridge)	CY	1,150	\$ 473.70	\$ 432.91	\$ 396.97	\$ 400.00	\$ 480,000.00
601-40300	Structural Concrete Coating	SY	705	\$ 7.95	\$ 7.55	\$ 9.09	\$ 10.00	\$ 7,050.00
602-00020	Reinforcing Steel (Epoxy Coated)	LB	175,000	\$ 1.02	\$ 0.99	\$ 0.79	\$ 1.15	\$ 201,250.00
613-00100	1 Inch Electrical Conduit	LF	250	\$ 5.65	\$ 10.31	\$ 11.08	\$ 10.00	\$ 2,500.00
<b>Subtotal of accounted construction items</b>								<b>South Bound Bridge: \$ 1,806,100</b>
								<b>Cost per SF: \$257</b>

## APPENDIX A

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NB I-25 TO WB US 6 TUNNEL GENERAL LAYOUT/TYP. SECTION			
Designer:	H. REED	Structure Numbers	F-16-ZD
Detailer:	H. REED	Sheet Subset:	
		Subset Sheets:	of

Project No./Code	US 6 BRIDGES DESIGN BUILD PROJECT
	18838
Sheet Number	