STRUCTURE SELECTION REPORT

FOR

SH92 over UNION PACIFIC RAILROAD

Project: SH92 Austin to Hotchkiss Corridor

Bridge I-05-Z

Prepared for:

Colorado Department of Transportation

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Contents

1.0 Project Description

This project is a 1.7-mile segment of State Highway 92 (SH92) between the towns of Austin and Hotchkiss in western Colorado. The project will provide an improved 2-lane roadway by reconstructing and widening SH92 to address safety concerns and improve capacity and pavement surface. As part of the improvements, a bridge will be constructed to replace an existing at-grade crossing between the road and existing Union Pacific Railroad (UPRR).

2.0 Design Criteria

This structure will be designed per the CDOT Bridge Design Manual, the AASHTO LRFD Bridge Design Specifications Sixth Edition 2012, the BNSF-Union Pacific Railroad Guidelines for Railroad Grade Separations, and applicable sections of the AREMA Manual for Railway Engineering.

Design Criteria for the preferred option is as follows:

Design Data

Design Method: Load and Resistance Factor Design
Live Load: HL 93 Truck and Lane Load, and Tandem Vehicle
Dead Load: Assumes 36 psf for a bridge deck overlay

Materials

Class D Concrete:	f'c = 4,500 psi
Class B Concrete:	f'c = 4,500 psi
Class BZ Concrete:	f'c = 4,000 psi
Reinforcing Steel:	fy = 60,000 psi
	Epoxy coated reinforcement will be used for the bridge superstructure and substructure. Black reinforcement will be used in the drilled caissons.

Precast Prestressed Concrete

Class PS Concrete:	Release Strength: f'ci = 6,000 psi min
	Final Strength: f'c = 9,000 psi max
Prestressing Strands:	ASTM A416, Grade 270, 0.6" diameter uncoated 7 wire low relaxation

3.0 Evaluation of Items Affecting Structure Configuration

3.1 Horizontal and Vertical Alignment

Two alignments were considered during the initial evaluation: the UPRR over SH92 and SH92 over the UPRR. CDOT and UPRR have agreed that the preferred option is a three-span bridge with SH92 over the existing railroad. This decision was based on several items as listed below:

- UPRR preference for a grade separation structure to be constructed with the least amount of interruption to railroad operations,
- Fewer railroad right-of-way concerns,
- Fewer concerns regarding the evaluation of the railroad as a historic resource,
- Constructability,
- Lower cost.

The proposed SH92 horizontal alignment at the UPRR crossing is in a left-horizontal curve as stations increase (eastward). The bridge will have two 12-foot lanes, two 8-foot shoulders, and Type 7 bridge rail with fencing.

The existing UPRR track under the proposed bridge is in a spiral curve and consists of a single track with no maintenance road. CDOT and the UPRR have agreed that the proposed design accommodates the current track plus a maintenance road. Adding room for a future track was considered; however, a future track is not recommended based on considerations such as existing track capacity, feasibility and cost-effectiveness. The required minimum horizontal clearance from the centerline (CL) of track to a wall, bridge abutment or pier is 25 feet; however, bridge piers can be located within 25 feet of the CL of track provided that crash walls or heavy construction criteria are used in accordance with UPRR design criteria. The absolute minimum distance of 18 feet from the CL of the track to the face of a pier will be maintained. Modifications to the existing railroad track may be necessary such as the addition of an inside guardrail between the rails. These issues will be coordinated with the UPRR.

The vertical alignment of SH92 is in a crest vertical curve at the proposed bridge. A minimum vertical clearance of 23'-4" over the UPRR will be provided in accordance with UPRR criteria.

The maximum design speed for the roadway is 65 mph.

3.2 Environmental Constraints

There are no known environmental constraints at this location. Environmental constraints will be re-evaluated as the design progresses.

3.3 Utilities

There are only a few utilities in the vicinity of the proposed bridge. Two existing overhead electric lines run through the east abutment location and will have to be relocated. An existing gas line runs under the bridge through the middle span, and also through the east abutment and may need to be relocated. No other known utilities, railroad communication or signaling equipment are located in the construction area.

3.4 Constructability

The new alignment of SH92 will be offset from the existing alignment and such that the existing at-grade crossing can continue to be used during construction. Therefore, the new bridge can be constructed in a single phase of the project. It is important to note that no modifications to the existing rail alignment are planned and it may be necessary to temporarily disrupt service of the railroad during certain construction activities such as placing girders or pouring the deck concrete. These issues will be coordinated with the UPRR as appropriate.

3.5 Architectural Requirements

There are no architectural requirements for this bridge based on direction from CDOT.

3.6 Geology

As described in the Draft Geotechnical Recommendations (CDOT 2/16/2012), the geology consists of medium dense sand/gravel and stiff to very stiff clay/silt underlain by medium to very hard shale bedrock. The test holes in the vicinity of the proposed bridge are TH3, TH4, TH5 and TH6 which are located at Abutment 1, Pier 2, Pier 3 and Abutment 4 respectively. Bedrock was encountered at the following elevations:

Test Hole	Location	Existing Ground Elevation (feet amsl)	Bedrock Elevation (feet amsl)
TH3	Abutment 1	5,367	5,363
TH4	Pier 2	5,377	5,368
TH5	Pier 3	5,380	5,379
TH6	Abutment 4	5,382	5,381

Ground water was not encountered at the aforementioned test holes.

4.0 Type Selection

4.1 Structure Span Configuration

The preferred alignment as directed by CDOT is SH92 over the UPRR. Initially, several span configurations for this alignment were considered before CDOT and the UPRR agreed upon a preferred alternative. These options are briefly discussed below.

1. A single span of approximately 195 feet, with tall wall abutments skewed parallel to the railroad alignment: This option would provide the required 25 foot clearance from the CL of the UPRR track. This option was disregarded due to a very large skew. In addition, the span length would require a steel superstructure or post-tensioned concrete which are typically more expensive than precast prestressed (i.e., pre-tensioned) concrete girders.
2. A three-span option (no skew) with both pier columns located outside of the 25-foot clear zone: Placing the pier columns outside the clear zone results in a maximum span of 185 feet. This span does not necessarily prohibit using precast prestressed concrete girders, but the location

of the bridge and the girder depth is problematic for transporting BT96 girders that would be required for this span. Other superstructures that are capable of spanning 185 feet include steel girders or post-tensioned concrete. Both of these superstructure options have a longer construction period when compared to precast prestressed concrete girders which presents greater impacts to the project site. This option was disregarded for several reasons including; the feasibility for shipping deep precast girders to the site; apparent cost-effectiveness; and construction time associated with post-tensioned concrete girders or steel girders.

3. A three-span option (no skew) with one pier inside the 25 foot clear zone: This option results in span lengths (maximum span of 164'-6") that will allow the use of BT78 girders. According to local precasters, this is the tallest and longest girder that can feasibly be shipped to the site. Steel girders could also be used for this structure but was not chosen as discussed in Section 4.2. This option would have two, hammerhead piers. Advantages of this option when compared to the others include apparent cost-effectiveness, constructability, and minimizing impacts to the UPRR.
4. A four-span option (no skew) with all piers located outside of the 25-foot clear zone: This option would have two hammerhead piers outside the 25 foot clear zone and a "straddle bent" pier spanning the UPRR track. With this option, the span lengths are short enough to allow the use of BT54 girders. A four-span structure using a straddle bent has cost and constructability (duration and impact to the UPRR) implications that preclude this option from selection.

The preferred span configuration is the three-span (option 3) with one pier located inside the 25 foot clear zone as initially agreed upon by CDOT and the UPRR. The proposed span lengths are 87'-9", 164'-6", and 95'-9". The superstructure will be supported on reinforced concrete piers and stub abutments. All piers have a hammerhead pier cap supported by a single column founded on a drilled shaft. The columns will be designed in accordance with UPRR heavy construction criteria because the horizontal clearance for one pier (north of the UPRR track) is less than 25 feet. Provision for the maintenance road will be provided on the south side of the UPRR track where there is 25 feet of clearance. Both abutments are integral stub abutments on driven H-Piles. The substructure elements are aligned perpendicular to the CL of SH92. A General Layout consisting of a Plan, Elevation, and Typical Section can be found in Appendix A.

4.2 Superstructure Alternatives

Two superstructure types were considered for the preferred span configuration (option 3), precast prestressed concrete Bulb-Tee (BT) girders and welded steel plate girders. Advantages and disadvantages of each structure type are summarized below.

4.2.1 Precast Prestressed Concrete BT Girders with a Concrete Deck

A precast prestressed concrete BT girder superstructure with a concrete deck is a feasible superstructure type. This type of superstructure is commonly used as an economical solution for simple and continuous span bridges for small and moderately long spans. A maximum span of 164'-6" requires five BT78 girders.

A BT78 girder with an 8-inch concrete deck, 3-inch asphalt overlay, and an assumed 4-inch haunch results in approximately a 7'-9" superstructure depth. This superstructure depth is the estimated maximum superstructure depth that can be used in conjunction with the pier cap depths (for caps located over the tracks) in order to set the vertical alignment.

As previously noted, girder lengths will vary to accommodate the span arrangement; however, girders in this range can be easily fabricated and transported to the construction site.

The heavier concrete girder superstructure typically requires larger columns and foundations when compared to a steel superstructure; however the heavy construction requirements will most likely control the pier sizes as opposed to the superstructure weight.

Construction time is relatively short, construction details and forming are very simple, and future deck replacement is relatively straightforward.

A preliminary estimate of probable construction costs determined that the precast concrete BT78 girder bridge type will cost approximately $106 per square foot of bridge deck. The material cost as well as constructability must be considered in the selection of precast prestressed concrete girders.

The following summarizes the advantages and disadvantages of this structure type:

Advantages:

- Efficient fabrication and availability of fabricators;
- Less fabrication time than steel plate girders;
- Simple details and deck forming;
- Minimal maintenance activities required during the life of the bridge;

Disadvantages:

- Heavier girders cause increased cost due to a larger foundation being required
- Predicted and actual girder camber may be different which can complicate deck construction

4.2.2 Welded Steel Plate Girders with a Concrete Deck

Welded steel plate girder superstructure with a concrete deck is also a feasible superstructure type. Welded steel plate girder superstructures can be used for the same spans as BT girders, but can also be used for longer spans.

The span lengths for this option are the same as the BT girder option. Welded steel plate girders in this span range can be easily fabricated and transported to the construction site; however field splices will be required for this span configuration.

Steel girders typically require longer fabrication and erection times than precast concrete girders. Field splices and diaphragms add to the cost and time to construct the bridge. Utilization of weathering steel could be used to lower long-term maintenance costs.

The lighter steel girder superstructure typically requires slightly smaller columns and foundations; however the heavy construction requirements will most likely offset this advantage.

A preliminary estimate of probable construction costs determined that the welded steel plate girder bridge type will cost approximately $131 per square foot of bridge deck. The material cost and constructability aspects must also be considered in the selection of welded steel plate girders.

The following summarizes the advantages and disadvantages of this structure type:

Advantages:

- Lighter girders typically result in decreased substructure cost;
- Simple details and deck forming;
- Shop fabricated girders;
- Minimizes deck construction complications with regard to girder camber.

Disadvantages:

- More fabrication time than precast pre-tensioned concrete girders;
- Weathering steel can cause staining of abutments;
- More long term maintenance;
- Expensive materials cost on a unit cost basis.

4.3 Superstructure Type Evaluation

The evaluation of superstructure types is based on cost as well as other items discussed in Section 4.2. A detailed cost estimate is included here that includes substructure costs based on the discussion in Section 5.0.

Precast Prestressed BT78

Item No.	Description	Unit	Total	Unit Cost	Extended Cost	
206	Structure Excavation	CY	20	$ 10.00	$ 200.00	
206	Structure Backfill (Class 1)	CY	665	$ 20.00	$ 13,300.00	
206	Mechanical Reinforcement of Soil	CY	533	$ 20.00	$ 10,660.00	
403	Hot Mix Asphalt (Grading S)(100)(PG 76-28)	TON	282	$ 55.00	$ 15,510.00	
502	Steel Piling (HP 12x74)	LF	1050	$ 65.00	$ 68,250.00	
503	Drilled Caisson (96 inch)	LF	120	$ 700.00	$ 84,000.00	
515	Waterproofing Membrane	SY	1738	$ 15.00	$ 26,070.00	
518	Bridge Expansion Device (0-4 inch)	LF	84	$ 150.00	$ 12,600.00	
601	Concrete Class B (Bridge)	CY	240	$ 500.00	$ 120,000.00	
601	Concrete Class D (Bridge)	CY	798	$ 550.00	$ 438,900.00	
601	Structural Concrete Coating	SY	1786	$ 10.00	$ 17,860.00	
602	Reinforcing Steel (Epoxy Coated)	LB	184291	$ 0.85	$ 156,647.35	
606	Bridge Rail Type 7	LF	782	$ 85.00	$ 66,470.00	
607	Fencing (84")	LF	782	$ 25.00	$ 19,550.00	
618	Prestressed Concrete I (BT 78)	LF	2436	$ 220.00	$ 535,920.00	
				TOTAL:	$ 1,585,937.35	
				DECK AREA:	15,093	sq ft
				COST/SF:	$ 106.00	

Steel Plate Girder

Item No.	Description	Unit	Total	Unit Cost	Extended Cost	
206	Structure Excavation	CY	20	$ 10.00	$ 200.00	
206	Structure Backfill (Class 1)	CY	665	$ 20.00	$ 13,300.00	
206	Mechanical Reinforcement of Soil	CY	533	$ 20.00	$ 10,660.00	
403	Hot Mix Asphalt (Grading S)(100)(PG 76-28)	TON	282	$ 55.00	$ 15,510.00	
502	Steel Piling (HP 12x74)	LF	1050	$ 65.00	$ 68,250.00	
503	Drilled Caisson (96 inch)	LF	120	$ 700.00	$ 84,000.00	
509	Structural Steel	LB	528255	$ 1.75	$ 924,446.25	
515	Waterproofing Membrane	SY	1738	$ 15.00	$ 26,070.00	
518	Bridge Expansion Device (0-4 inch)	LF	84	$ 150.00	$ 12,600.00	
601	Concrete Class B (Bridge)	CY	240	$ 500.00	$ 120,000.00	
601	Concrete Class D (Bridge)	CY	798	$ 550.00	$ 438,900.00	
601	Structural Concrete Coating	SF	1786	$ 10.00	$ 17,860.00	
602	Reinforcing Steel (Epoxy Coated)	LB	184291	$ 0.85	$ 156,647.35	
606	Bridge Rail Type 7 (Special)	LF	782	$ 85.00	$ 66,470.00	
607	Fencing (84")	LF	782	$ 25.00	$ 19,550.00	
				TOTAL:	$ 1,974,463.60	
				DECK AREA:	15,093	sq ft
				COST/SF:	$ 131.00	

The most cost effective superstructure type is precast prestressed BT78 girders.

5.0 Substructure and Foundation Type Selection

Substructure types were selected based on their ability to adequately resist the applied loading, conform to geometric constraints, and efficiently achieve the function for the least cost. Based on the Geotechnical Recommendations (CDOT 3/12/2012), the recommended foundation types for the proposed bridge are driven H-piles and drilled shafts. It is anticipated that H-piles will be utilized at the abutments and a single drilled shaft will be used at each pier location.

5.1 Abutment Evaluation and Type Selection

Abutments support the end of the superstructure, transmitting axial and lateral loads to the foundation, and accommodate superstructure movements.

Feasible abutment types include:

- Beam seat abutments, supported by deep foundations. The abutments are relatively short in height, and therefore resist lateral soil loads from a short retained fill. Beam seat abutments can accommodate superstructure movements by use of expansion bearings.
- Integral abutments, supported by semi-flexible deep foundations. The abutments are relatively short in height, and therefore resist lateral soil loads from a short retained fill, unless a gap is constructed between the abutments and retained fill. Integral abutments can accommodate superstructure movements by displacing with the superstructure.

- Tall wall abutments; supported on shallow foundations or deep foundations. Tall abutments resist large lateral soil loads from a large retained fill. Tall abutments can accommodate superstructure movements by use of expansion bearings.

The abutment types listed above were evaluated based on the structure configuration and loading. The most efficient solution is the second alternative, integral abutments, supported by deep semi-flexible H-Pile foundations.

5.2 Pier Evaluation and Type Selection

Piers provide intermediate support of the superstructure, transmitting axial, bending, and lateral loads to the foundation. Piers accommodate superstructure movements by use of expansion bearings or by flexural displacement.

Feasible pier types include:

- Multi-column piers (columns located within width of the superstructure) with pier caps located below the superstructure depth, supported by deep foundations;

- Single-column piers with cantilevered pier caps (hammer head) located below the superstructure depth, supported by deep foundations.

Feasible pier types were evaluated for the structure configuration. The selected solution is the single-column pier with hammerhead pier caps located below the superstructure. This type of pier will meet the horizontal and vertical clearance requirements of the UPRR.

Due to the proximity of the columns to the railroad tracks, heavy construction in accordance with UPRR criteria will be used.

6.0 Recommendation

Bridge I-05-Z

The recommended structure type is a precast prestressed BT78 girder bridge consisting of three spans (87'-9", 164'-6", 95'-9"). The abutments will be integral abutments and most likely will be founded on H-piles. The piers will have a hammerhead cap supported by a single column founded on drilled shafts.

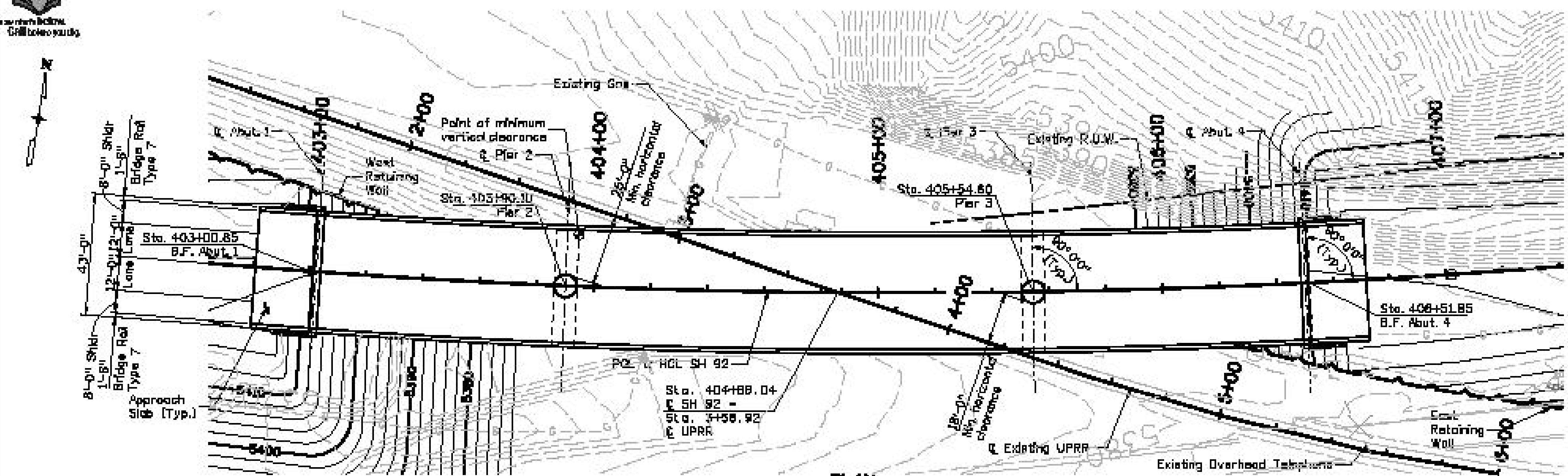
MSE Wall (I-05-A and I-05-B) Considerations

Walls I-05-A (east wall) and I-05-B (west wall) primarily run parallel to SH92 and start at abutments 4 and 1 respectively. These are MSE walls that retain the embankment needed to raise SH92 over the UPRR. The wall length and bridge length are codependent. Since MSE wall construction is typically cheaper than bridge construction per foot of roadway, the bridge length was set as short as possible which maximizes the wall lengths.

During preliminary design and prior to the FIR meeting held on September 7, 2011 and the release of the Geotechnical Report dated April 27, 2012, the estimated cost of the MSE Walls was approximately $1.5 million. At the FIR, CDOT implicitly approved the present wall/bridge design. After the release of the April 27, 2012 geotechnical findings, the design team determined that the MSE walls required caisson foundations in some areas and overexcavation and backfill with Aggregate Base Course (Class 3) in other areas in order to improve bearing capacity and satisfy global stability requirements. This increased the wall cost to over $4.5 million. Although a cost comparison between walls/bridge structures is not part of the original Structure Selection Reports for the MSE Walls or the Bridge, it is anticipated that the wall cost is comparable to a bridge structure.

After discussions between the Region and Staff Bridge, it was determined that a cost comparison between walls and bridge would not benefit the project and the design should continue in its current configuration.

7.0 Appendix A



PLAN

CIRCULAR CURVE DATA
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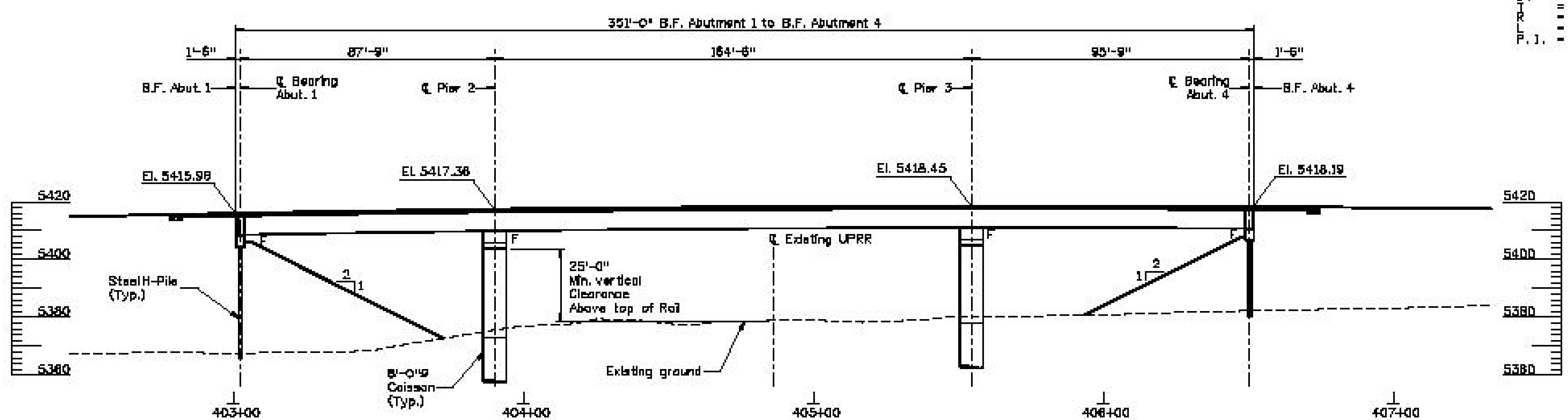
Dc = 01°59'39"
T = 388.15
R = 2885.00
L = 771.81
P.I. = 403+18.61



SECTION

Taken along PGL & HCL SH 92

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Unit Information	Unit Leader Initials		AUG 2011		Phone: 972-249-5285 FAX: 970-249-6018	Void:	Sheet Subset: BRIDGE / Subset Sheets: B103 of B104	Sheet Number
URS					Region 3 RA			

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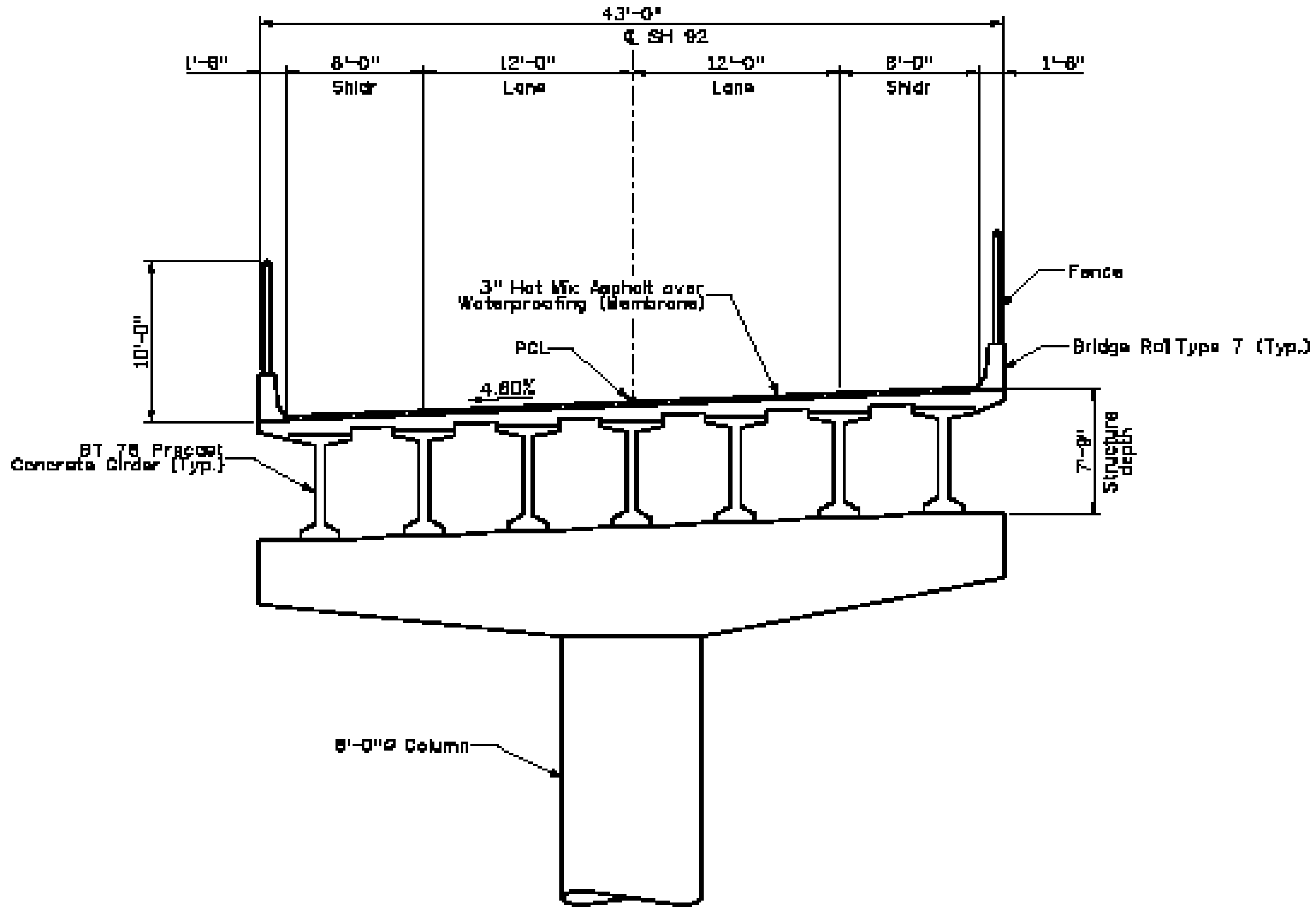
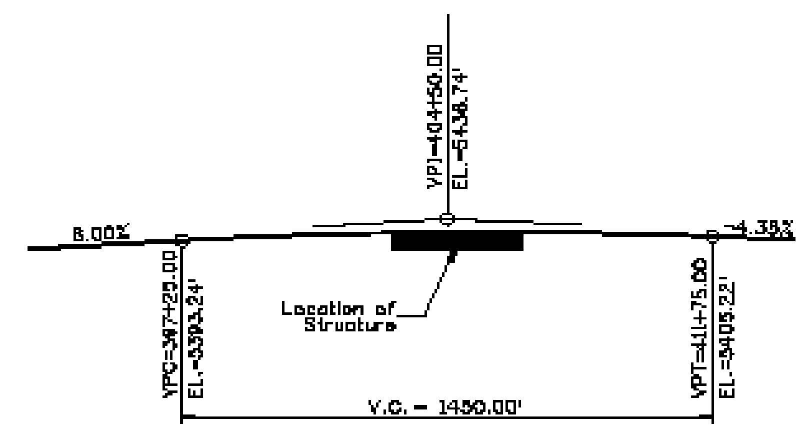


TYPICAL SECTION



SH 92 PROFILE GRADE

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Print Date: 8/12/2011	Sheet Revisions	Colorado Department of Transportation	As Constructed
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Horiz. Scale: 1:10 / Vert. Scale:	PRELIMINARY PLANS	Phone: 970-249-5285 FAX: 970-249-6018	Revised:
Unit Information / Unit Leader Initials	AUG 2011	Region 3 / RA	Void:
URS			

GENERAL LAYOUT (2)

Designer:	C. PARENT	Structure Numbers	
Detailer:	D. STRONG		
Sheet Subsets:	BRIDGE	Subset Sheets: B104 of B104	

Project No./Code
HB 0924-020
14934
Sheet Number -