Texas A&M Transportation Institute
3135 TAMU
College Station, TX 77843-3135

979-845-6375
Fax: 979-845-6107
http://tti.tamu.edu/crashtesting

TECHNICAL MEMORANDUM

Contract No.: **T4541-AV**
Tech Memo No.: **600771 (405160-40)**
Project Name: **Pre-stressed Concrete Beam Type TL-2 Guardrail System at 31-inch Rail Height**
Sponsor: **Roadside Safety Research Program Pooled Fund Study**

DATE: **April 23, 2015**

TO: **Leni Oman,** Director, Research Office
Washington State Department of Transportation
Transportation Building, MS: 47372
Olympia, Washington 98504-7372

COPY TO: **Rhonda Brooks**, Washington State DOT
Erlinda Olivarez, TTI RDO
D. L. Bullard, Jr., Head, TTI Roadside Safety & Physical Security Systems
Roger P. Bligh, TTI Roadway Safety Program
Rebecca Haug, TTI Roadside Safety & Physical Security Systems

FROM: **William F. Williams**, P.E., Associate Research Engineer, TTI Roadside Safety & Physical Security Systems

FOR MORE INFORMATION:
Name: William F. Williams
Phone: 979-862-2297
Email: w-williams@ttimail.tamu.edu

SUMMARY REPORT:

INTRODUCTION

The West Virginia Department of Transportation (WVDOT) currently uses a side-mounted bridge rail system on pre-stressed concrete beam bridges that are designated for National Cooperative Highway Research Program (NCHRP) *Report 350* Test Level 2 (TL-2) impact conditions (*1*). This bridge rail system uses a W6×25 post with a welded side bracket. Each post with welded bracket is anchored to the side of the pre-cast/pre-stressed beam elements using four threaded inserts cast into the side of the beam element. The rail element for the system consists of a single HSS8×4×$^{3}/_{16}$ tube member with a 12-gauge W-beam rail element attached to the front face of the tube. The current height of the rail system is approximately 28.375 inches in height. The purpose of this project is to review the current geometry and design features of the bridge rail system with the height of the rail increased to the 31-inch height.

BACKGROUND

Many states currently use a side-mounted bridge rail similar to the one currently used by WVDOT. Ohio Department of Transportation (ODOT) currently uses a side-mount design very similar to the one used by WVDOT for *NCHRP Report 350* Test Level 3 (TL-3) applications. A photo of the ODOT design is shown in Figure 1.

Figure 1 – Ohio Department of Transportation Side Mount Bridge Rail

In December 2010, Texas A&M Transportation Institute (TTI) completed a research project that consisted of making improvements to the ODOT side-mount bridge rail design to improve the performance for American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*) TL-3 impact conditions (*2*). One of the enhancements made to the design was to increase the height of the bridge rail to 31 inches. This project was performed for Ohio Department of Transportation Office of Research and Development, State Job Number 134394 (TTI Project Number 476890-1) and dated December 2010 (*3*). The objective of this study was to investigate the performance of the ODOT Deep Beam Bridge Railing system per the *NCHRP Report 350* TL-3. A combination of analytical study, computer simulation, and testing approach were addressed to accomplish the objective of this study. The final design developed for this project can be used in new construction or retrofit applications will bring the system in compliance with the *NCHRP Report 350* performance criteria per TL-3. The modified ODOT Deep Beam bridge rail design using 6 ft-3 inch post spacing, as shown in Figure 2, was considered to be acceptable with respect to the *NCHRP Report 350* TL- 3 assessment criteria.

This conclusion was based on engineering strength analysis and nonlinear finite element simulation performed for this project. The added rail on the top of the bridge rail helped reduce potential vehicular dynamics instability that may occur if only the original rail (less height) was used. Also, the additional lower rail (rub rail) provided protection against tire snagging in the opening below the main rail and the deck. This snagging mode could be detrimental for small

vehicle impacts due to the subsequent excessive deformation and increased ride-down acceleration.

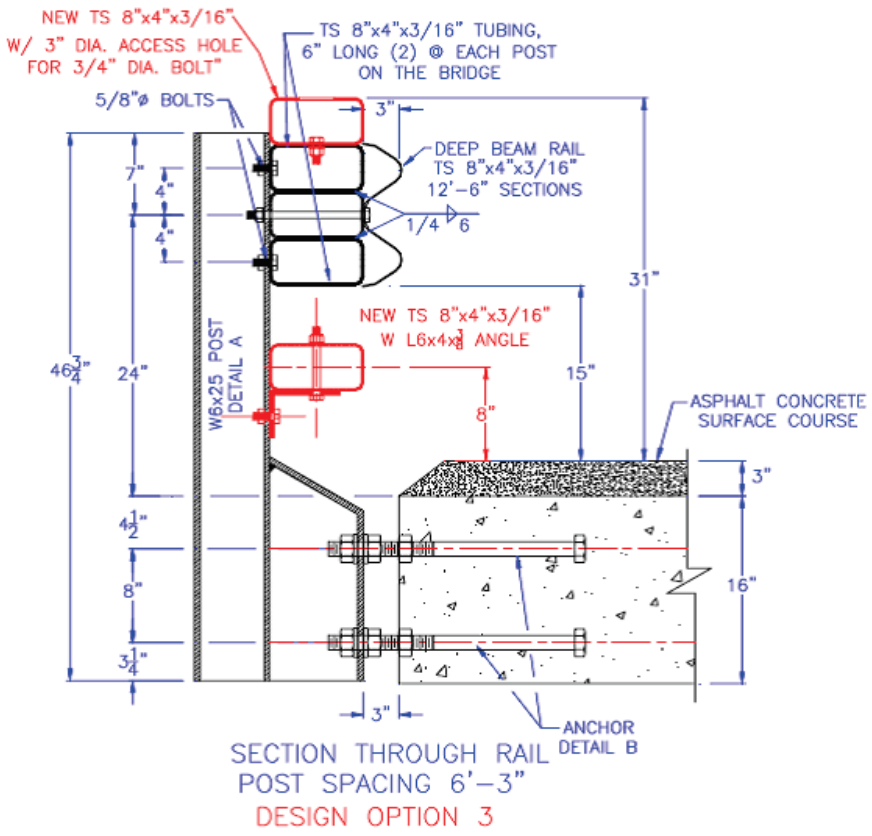


Figure 2 – Modified Ohio Deep Beam TL-3 Bridge Railing Design (6 ft-3 inch Post Spacing)

This system can be implemented in the field subsequent to Federal Highway Administration (FHWA) Office of Safety approval of the simulation results presented herein or the full scale crash tests which were recommended. The modified design presented herein represents an onsite retrofit installation that could be practically performed by a qualified construction crew.

The research team recommended using an approved crashworthy transition (ODOT transition GR 3.4) in conjunction with the design shown in Figure 2. A modification was suggested for that transition detail to accommodate the added top and rub rails in the modified ODOT Deep Beam bridge rail. One example would be to turn the top rail toward the middle rail at an angle and to extend the rub rail along few transition posts and then turn it back toward the field side.

OBJECTIVE

The purpose of this study is to increase the height of the WVDOT Pre-stressed Concrete Beam TL-2 Guardrail system to 31 inches above the pavement surface. Figure 3 shows the current WVDOT Bridge Rail raised to the 31-inch height.

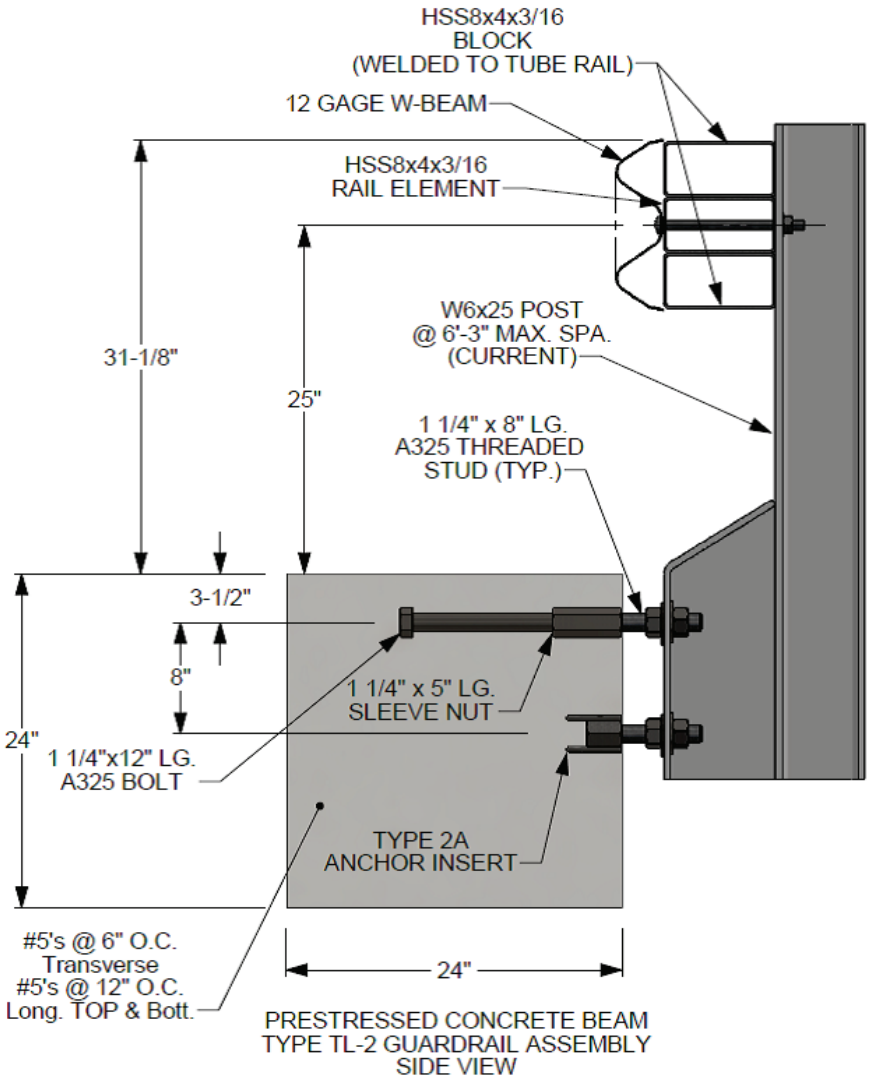


Figure 3 – West Virginia DOT Pre-stressed Concrete Beam TL-2 Guardrail (6 ft-3 inch Post Spacing) at 31-inch Height

The height of the rail system, shown in Figure 3, may vary several inches depending on the thickness of the asphalt wearing surface. As part of this project, engineering strength analyses were performed on the post to determine if the W6×25 post size is acceptable with respect to the *MASH* TL-2 impact loads on the bridge rail system at the increased rail height of 31 inches. Other features of the railing system were analyzed and redesigned as part of this project. These features include investigating the post to determine if modification(s) can be made to improve performance and reduce fabrication cost. In addition, the details of the post will be investigated to see if height adjustment (added holes for anchorage) can be added such that the height of the bridge rail system can be adjusted to accommodate asphalt overlays on the bridges.

PRODUCTS

Provided herein are the design details of the modified 31-inch tall side-mount bridge rail that meet the strength requirements of *MASH* TL-2. The work plan for this project is provided as follows.

WORK PLAN

Task 1 – Perform Engineering Strength Analyses and Develop Details for the Modified Pre-stressed Concrete Beam Type TL-2 Guardrail System

The researchers have reviewed the existing details of the current 28-inch height bridge rail design shown below in Figure 4, and have increased the height to 31 inches.

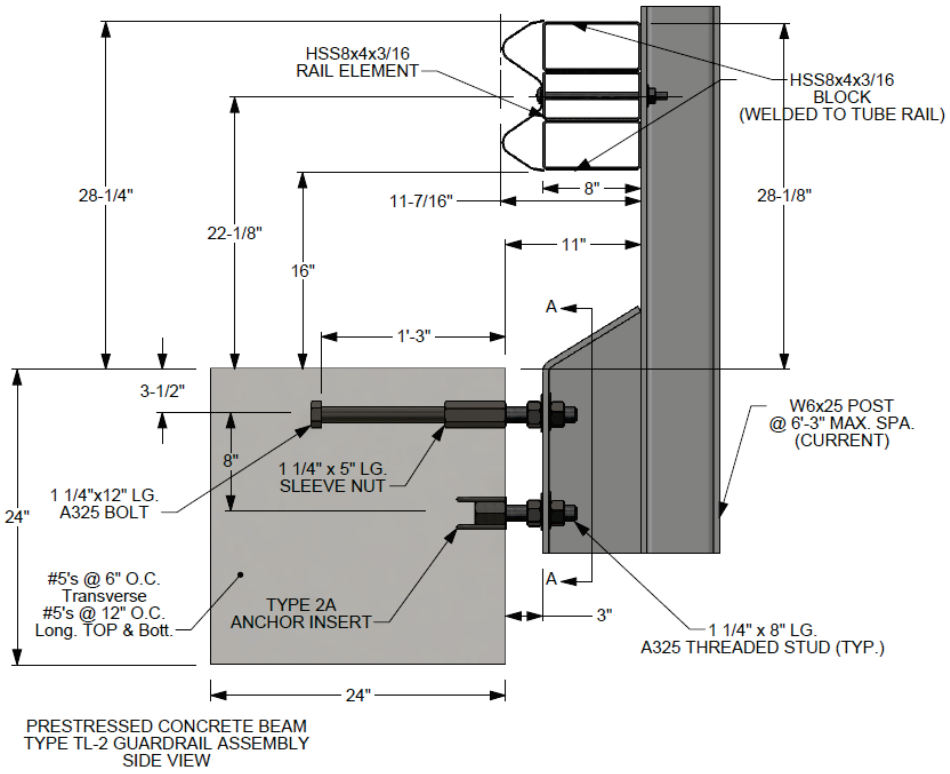


Figure 4 – West Virginia DOT Pre-stressed Concrete Beam TL-2 Guardrail (6 ft-3 inch Post Spacing) at 28⅜-inch Height

Engineering strength analyses were performed on the post to determine if the new post size and anchoring details meet the strength requirements of *MASH* TL-2 impact conditions. The modified design is shown below in Figure 5. The design shown below meets the strength requirements of *MASH* TL-2. The post and steel block out have been modified such that these two components can be bolted together. Some adjustment (+4 inches) can be accommodated in this connection.

After increasing the rail height to 31 inches, there was a significant opening between the main rail and the deck of 18⅞ inches. The lower rail (HSS8×4×$^{3}/_{16}$) was added to provide protection against tire snagging in the space between the main rail and the deck. Also, stiffeners were added in the W8×24 block out and post for strength. Additional details for the new design

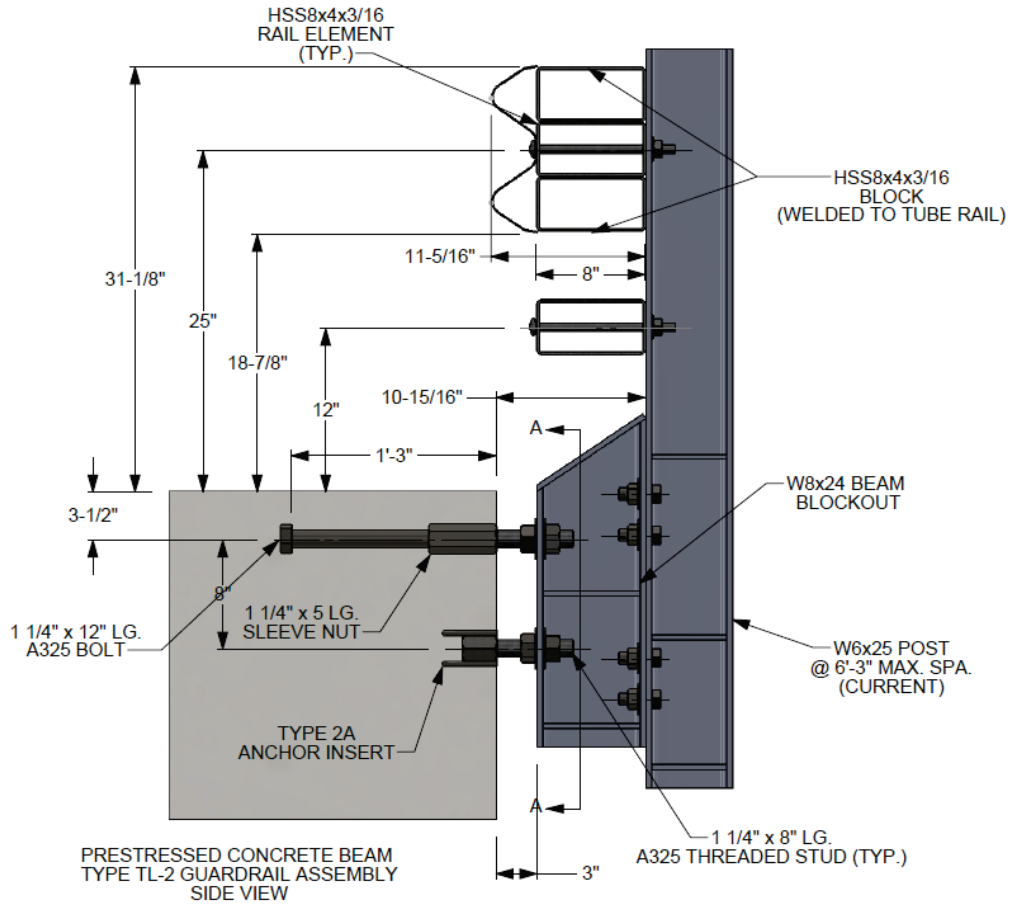


Figure 5 – Modified Pre-Stressed Concrete Beam TL-2 Guardrail (6 ft-3 inch Post Spacing) at 31⅛-inch Height

IMPLEMENTATION

Based on the analyses results, the details presented herein are recommended for implementation on bridges for *MASH* TL-2 applications.

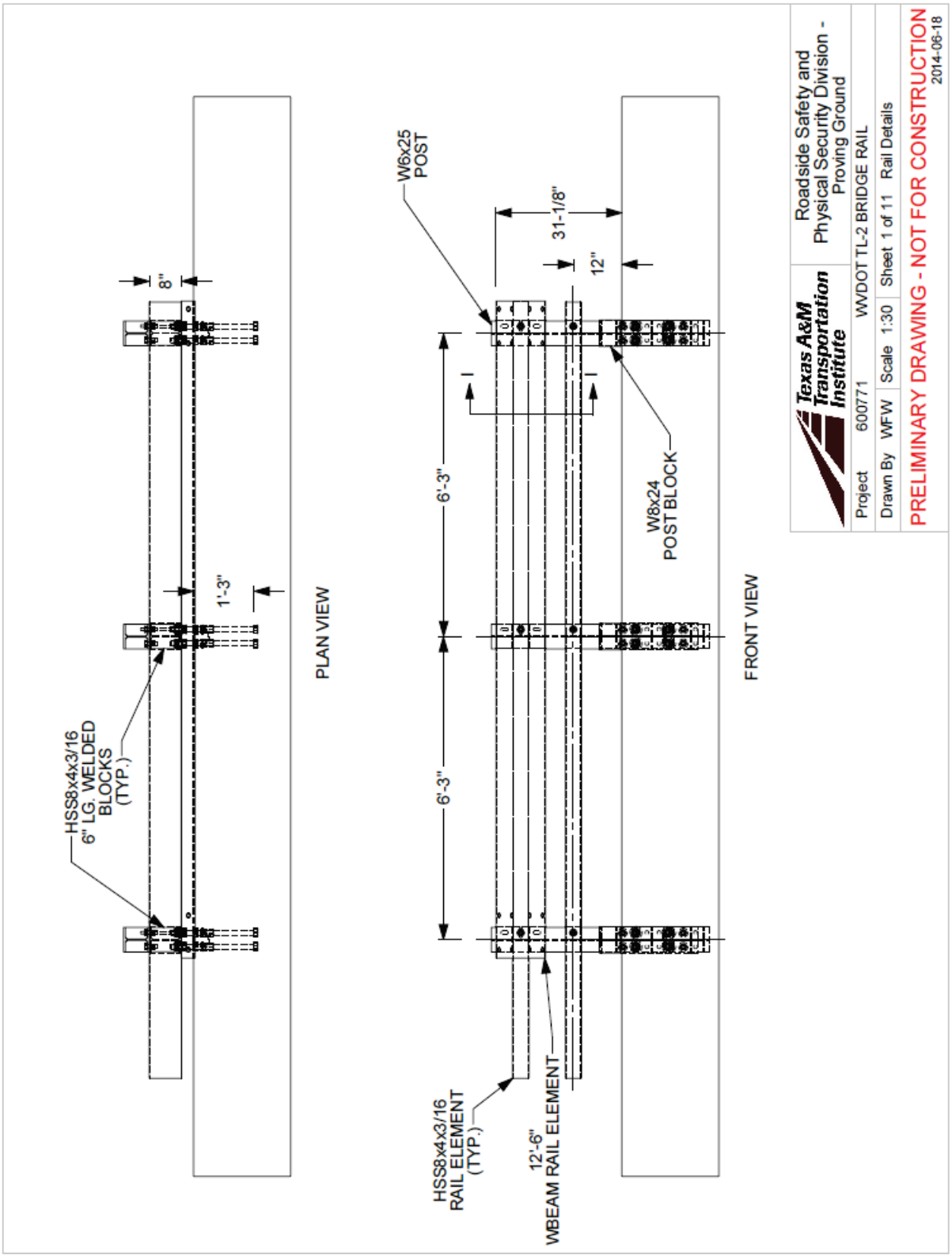
REFERENCES

1.) National Cooperative Highway Research Program (NCHRP) *Report 350*, "Recommended Procedures for the Safety Performance Evaluation of Highway Features," Transportation Research Board, National Research Council, 1993.

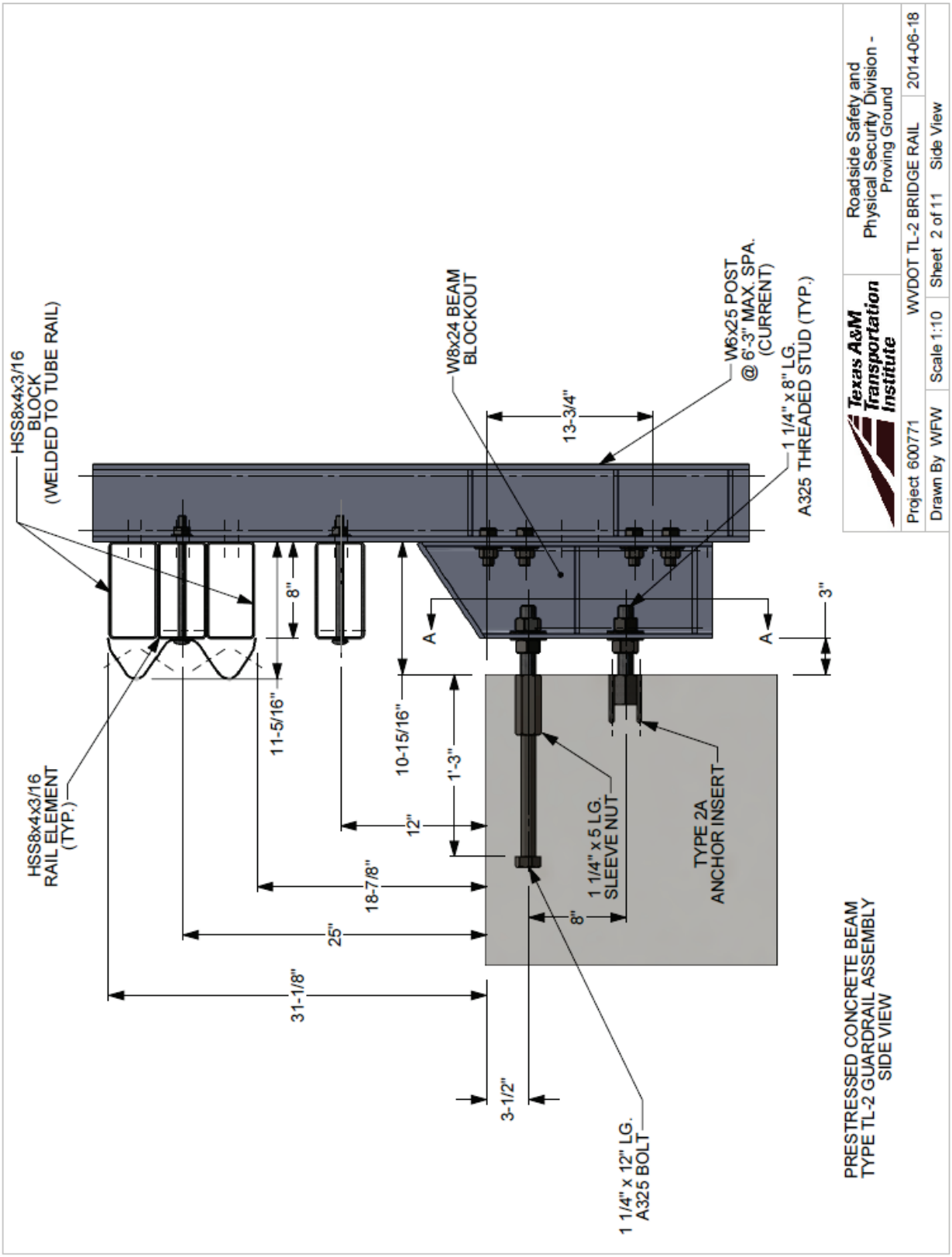
2.) AASHTO. *Manual for Assessing Safety Hardware*. American Association of State Highway and Transportation Officials (AASHTO), 2009.

3.) Ohio Department of Transportation Side Mount Bridge Rail, Ohio Department of Transportation Office of Research and Development, State Job Number 134394 (TTI Project Number 476890-1), dated December 2010.

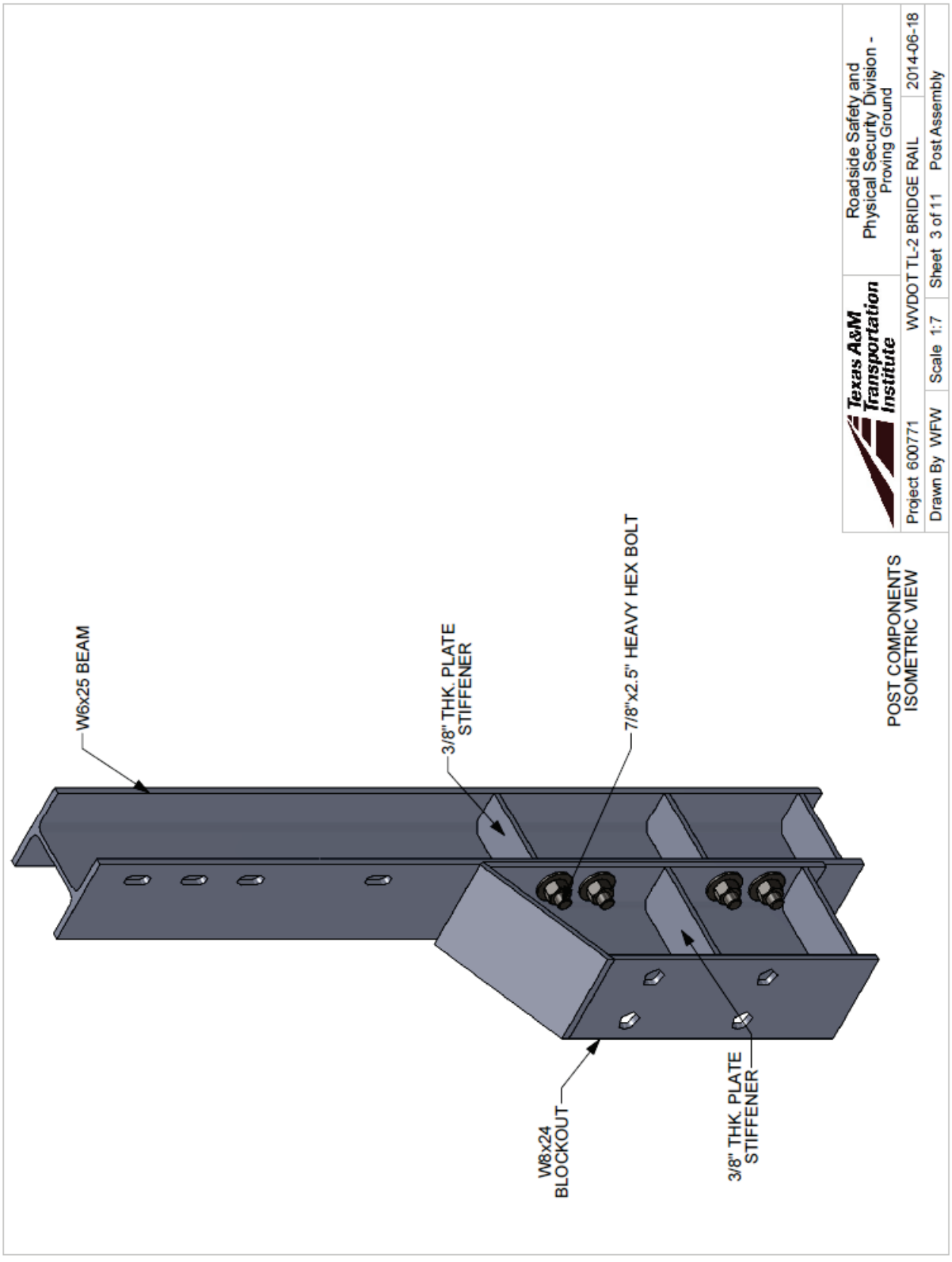
APPENDIX A
DETAILS OF PRESTRESSED CONCRETE GUARDRAIL



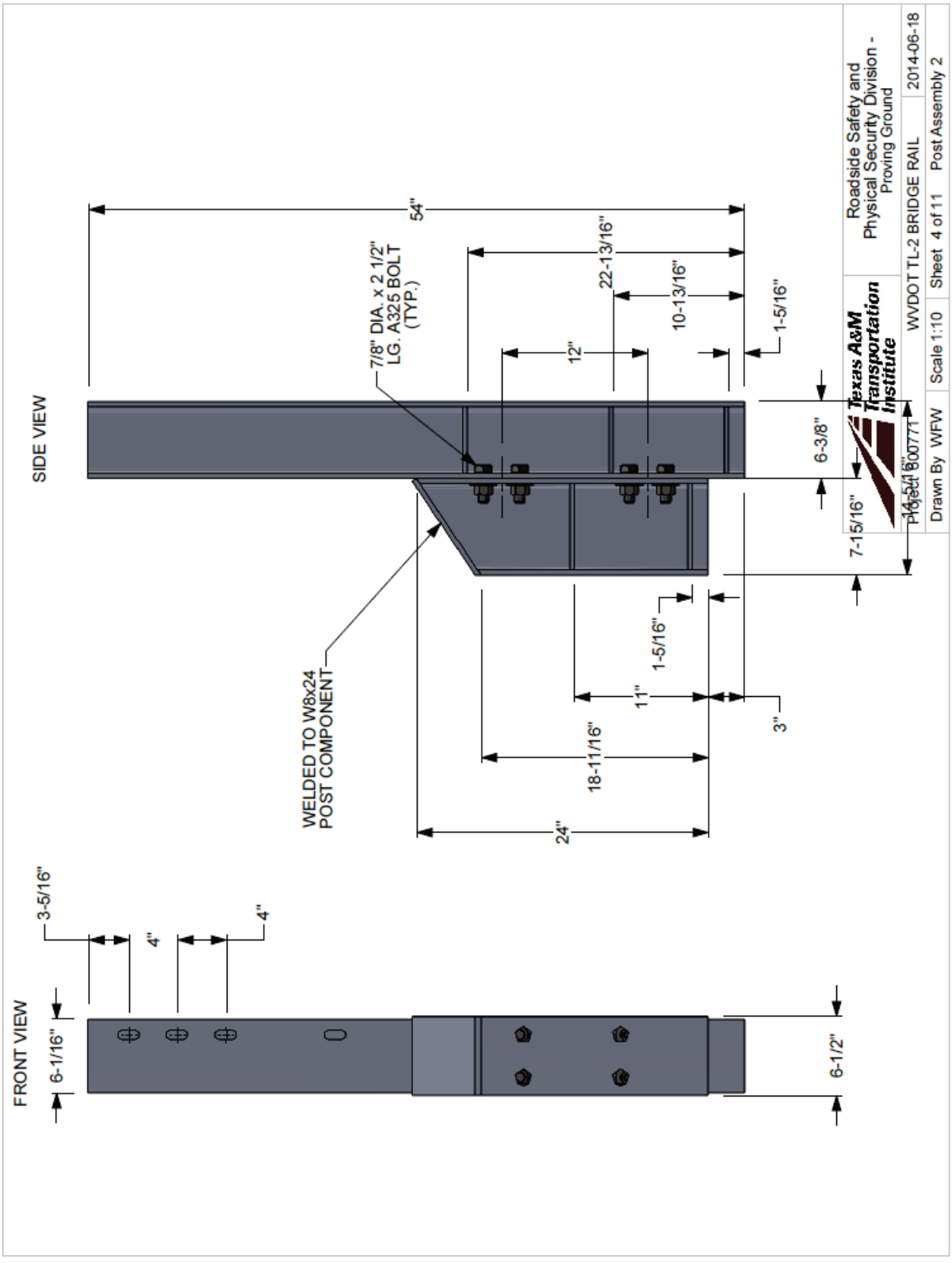
A-1


HSS8x4x3/16
BLOCK
(WELDED TO TUBE RAIL)
W8x24 BEAM
BLOCKOUT
W6x25 POST
@ 6'-3" MAX. SPA.
(CURRENT)
1 1/4" x 8" LG.
A325 THREADED STUD (TYP.)
13-3/4"
8"
3"
A
A
HSS8x4x3/16
RAIL ELEMENT
(TYP.)
11-5/16"
10-15/16"
1'-3"
12"
18-7/8"
25"
31-1/8"
1 1/4" x 5 LG.
SLEEVE NUT
TYPE 2A
ANCHOR INSERT
8"
3-1/2"
1 1/4" x 12" LG.
A325 BOLT
PRESTRESSED CONCRETE BEAM
TYPE TL-2 GUARDRAIL ASSEMBLY
SIDE VIEW
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project 600771
WVDOT TL-2 BRIDGE RAIL
2014-06-18
Drawn By WFW
Scale 1:10
Sheet 2 of 11
Side View

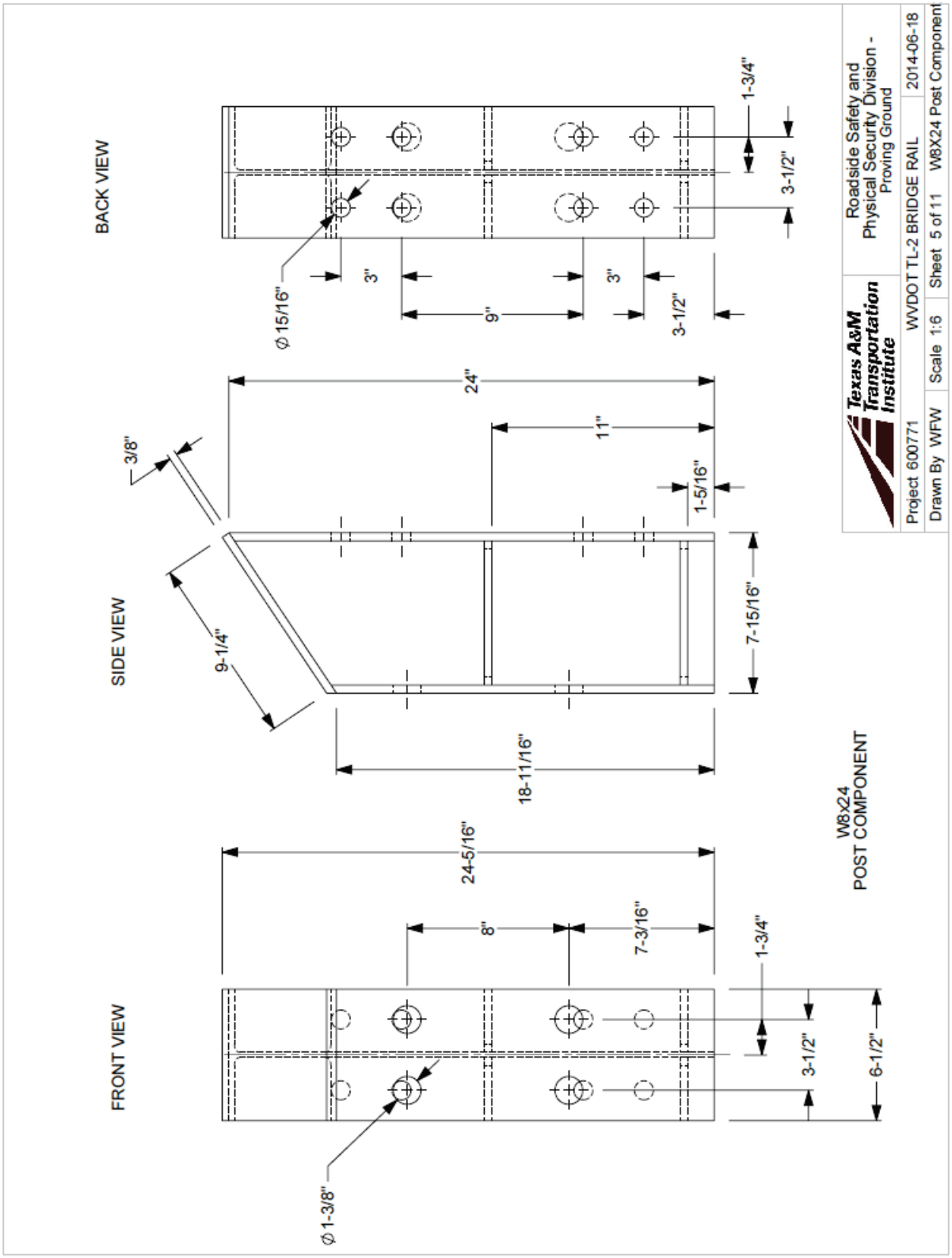
A-2


W6x25 BEAM
3/8" THK. PLATE STIFFENER
7/8"x2.5" HEAVY HEX BOLT
W8x24 BLOCKOUT
3/8" THK. PLATE STIFFENER
POST COMPONENTS
ISOMETRIC VIEW
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project 600771
WVDOT TL-2 BRIDGE RAIL
2014-06-18
Drawn By WFW
Scale 1:7
Sheet 3 of 11
Post Assembly

A-3


SIDE VIEW
54"
7/8" DIA. x 2 1/2" LG. A325 BOLT (TYP.)
22-13/16"
10-13/16"
12"
1-5/16"
6-3/8"
7-15/16"
14-5/16"
1-5/16"
11"
3"
18-11/16"
24"
WELDED TO W8x24 POST COMPONENT
FRONT VIEW
3-5/16"
4"
4"
6-1/16"
6-1/2"
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
WVDOT TL-2 BRIDGE RAIL
2014-06-18
Project 600771
Drawn By WFW
Scale 1:10
Sheet 4 of 11
Post Assembly 2

A-4


BACK VIEW
SIDE VIEW
FRONT VIEW
W8x24
POST COMPONENT
Ø 15/16"
3"
9"
3"
3-1/2"
1-3/4"
3-1/2"
24"
11"
1-5/16"
3/8"
9-1/4"
7-15/16"
18-11/16"
24-5/16"
8"
7-3/16"
1-3/4"
3-1/2"
6-1/2"
Ø 1-3/8"
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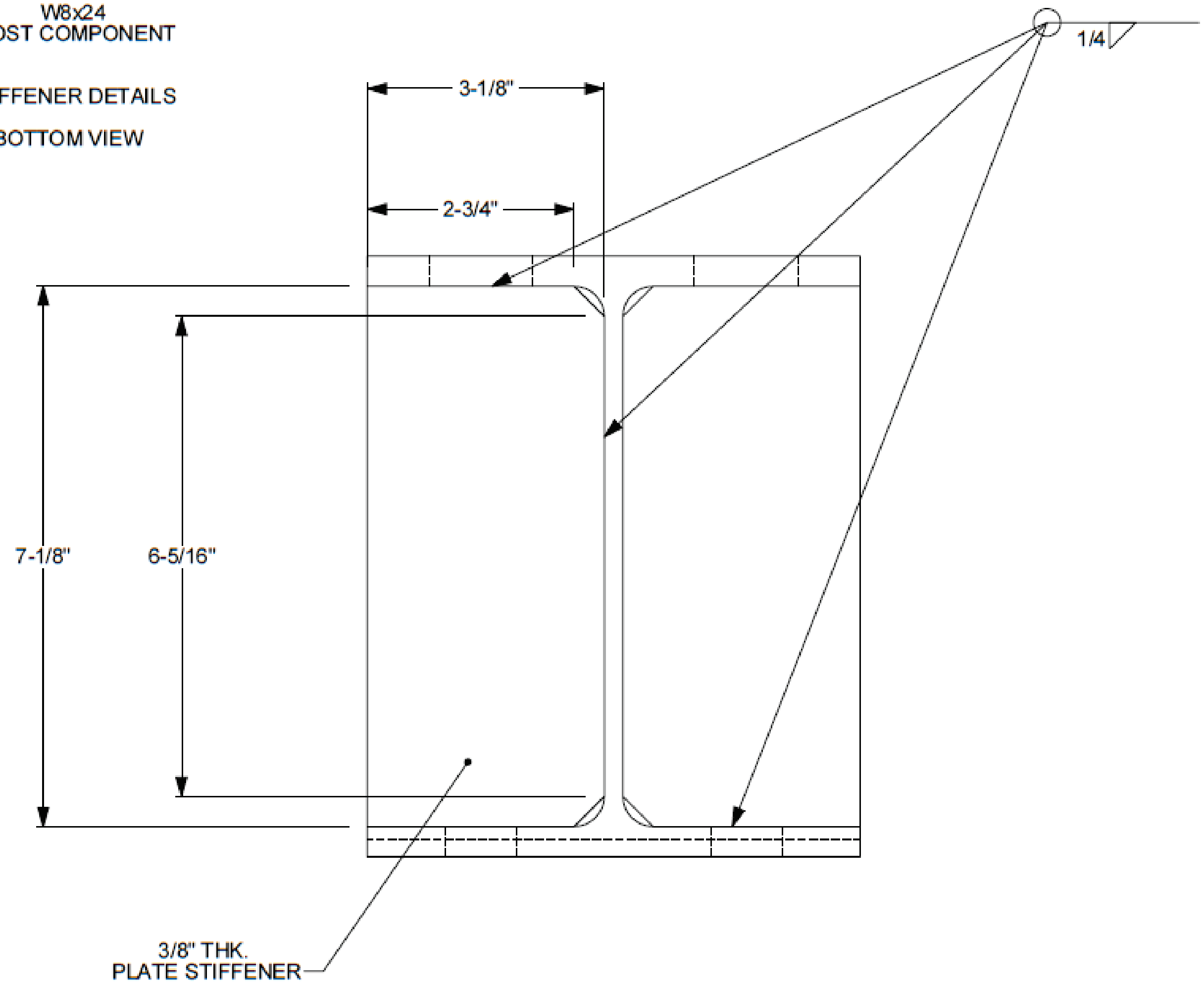
Roadside Safety and Physical Security Division - Proving Ground
Project 600771
WVDOT TL-2 BRIDGE RAIL
2014-06-18
Drawn By WFW
Scale 1:6
Sheet 5 of 11
W8X24 Post Component

A-5

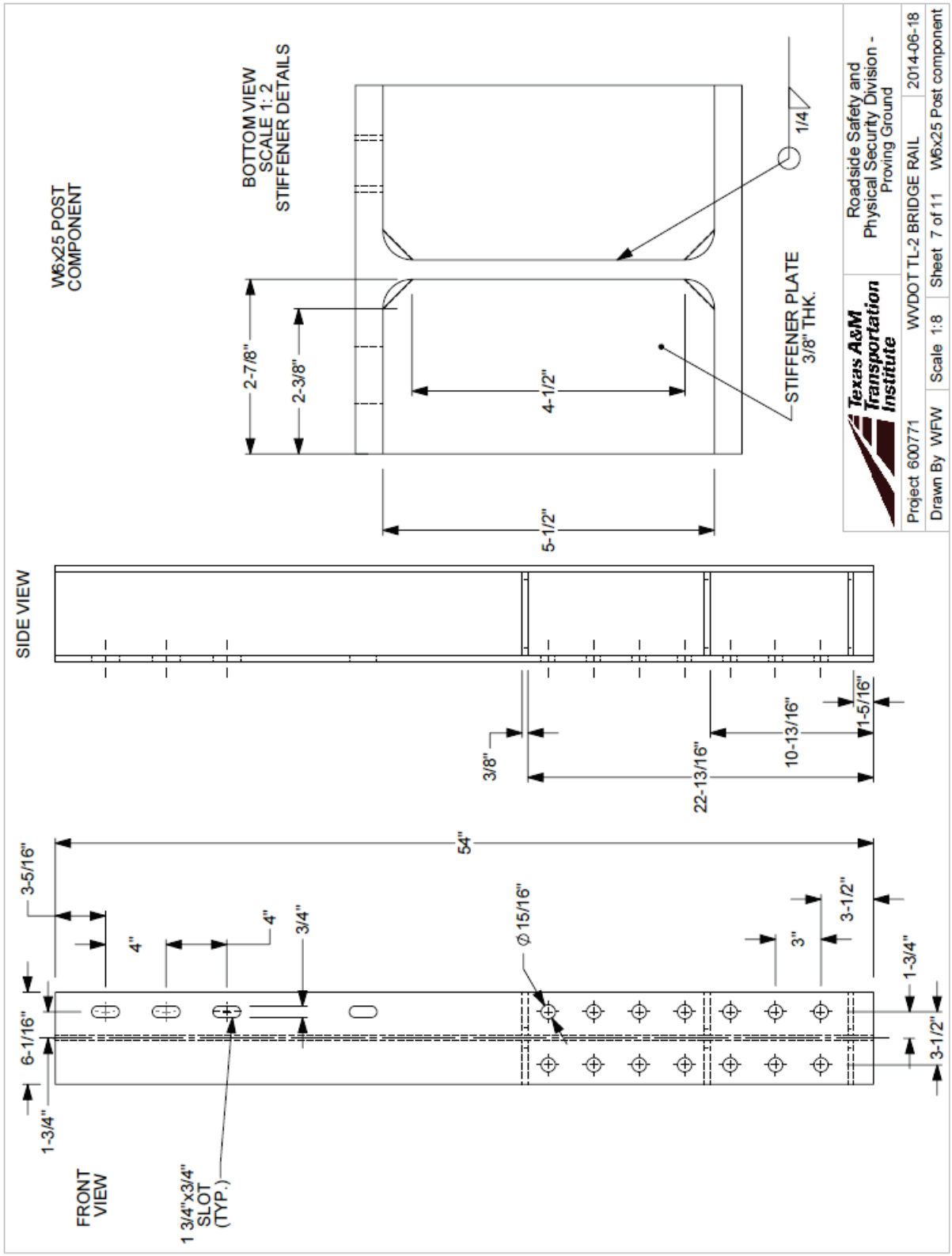
W8x24
POST COMPONENT

STIFFENER DETAILS

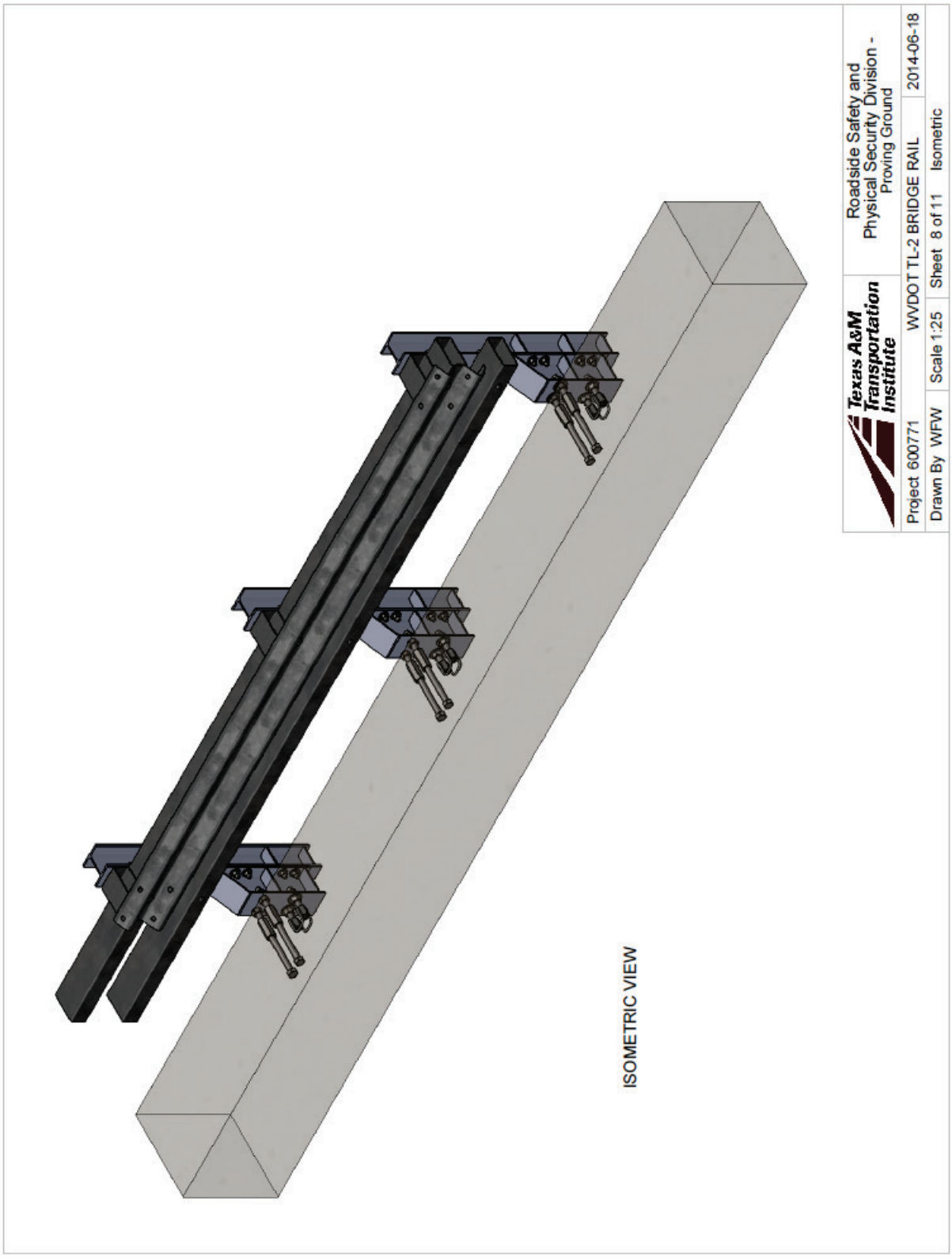
BOTTOM VIEW



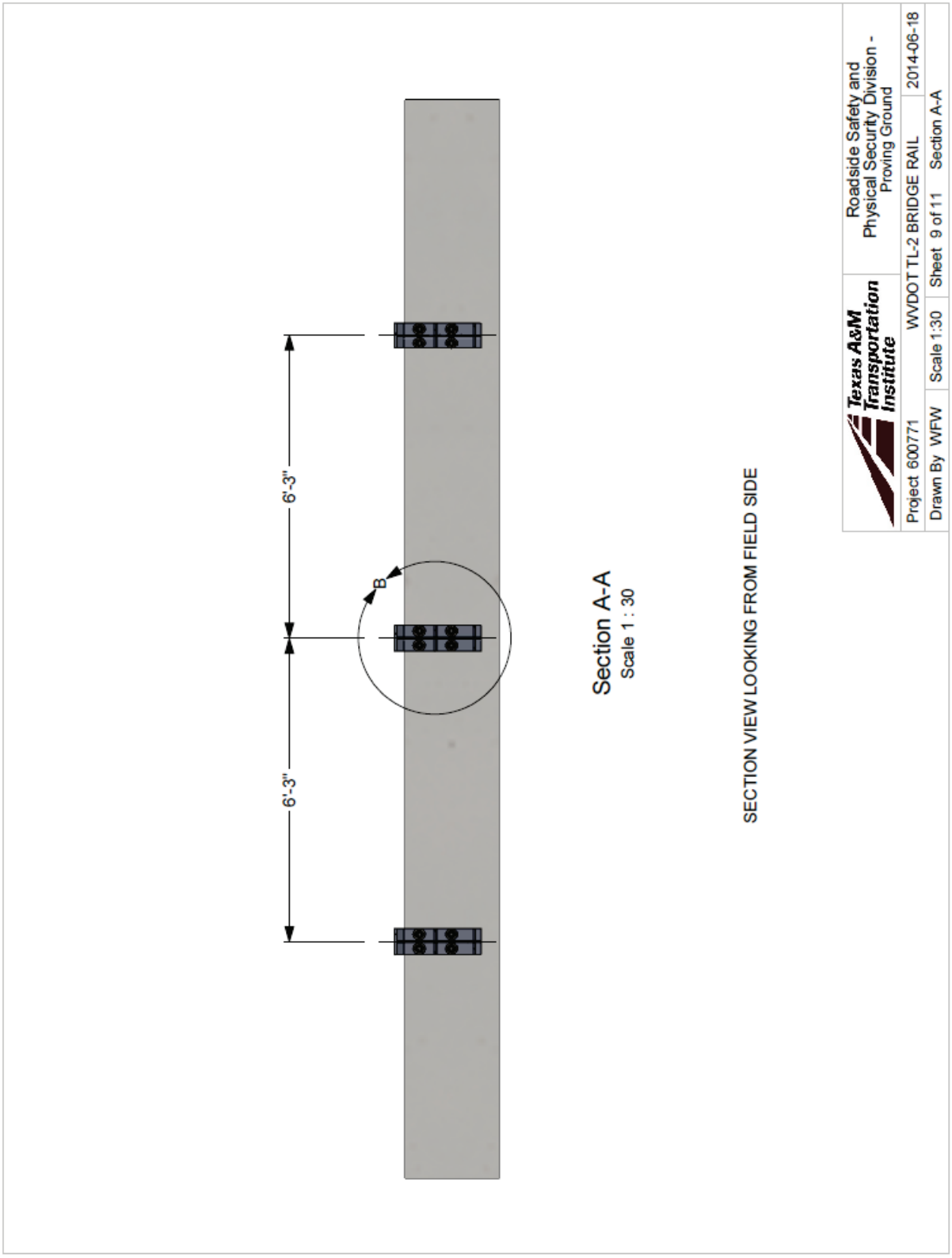
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground		
Project 600771	WVDOT TL-2 BRIDGE RAIL		2014-06-18
Drawn By WFW	Scale 1:2	Sheet 6 of 11	W8x24 Post component


W6x25 POST COMPONENT
BOTTOM VIEW
SCALE 1: 2
STIFFENER DETAILS
2-7/8"
2-3/8"
4-1/2"
5-1/2"
1/4
STIFFENER PLATE
3/8" THK.
SIDE VIEW
3/8"
22-13/16"
10-13/16"
1-5/16"
54"
3-5/16"
4"
4"
3/4"
Ø 15/16"
3"
3-1/2"
1-3/4"
6-1/16"
1-3/4"
3-1/2"
FRONT VIEW
1 3/4"x3/4" SLOT (TYP.)
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project 600771
WVDOT TL-2 BRIDGE RAIL
2014-06-18
Drawn By WFW
Scale 1:8
Sheet 7 of 11
W6x25 Post component

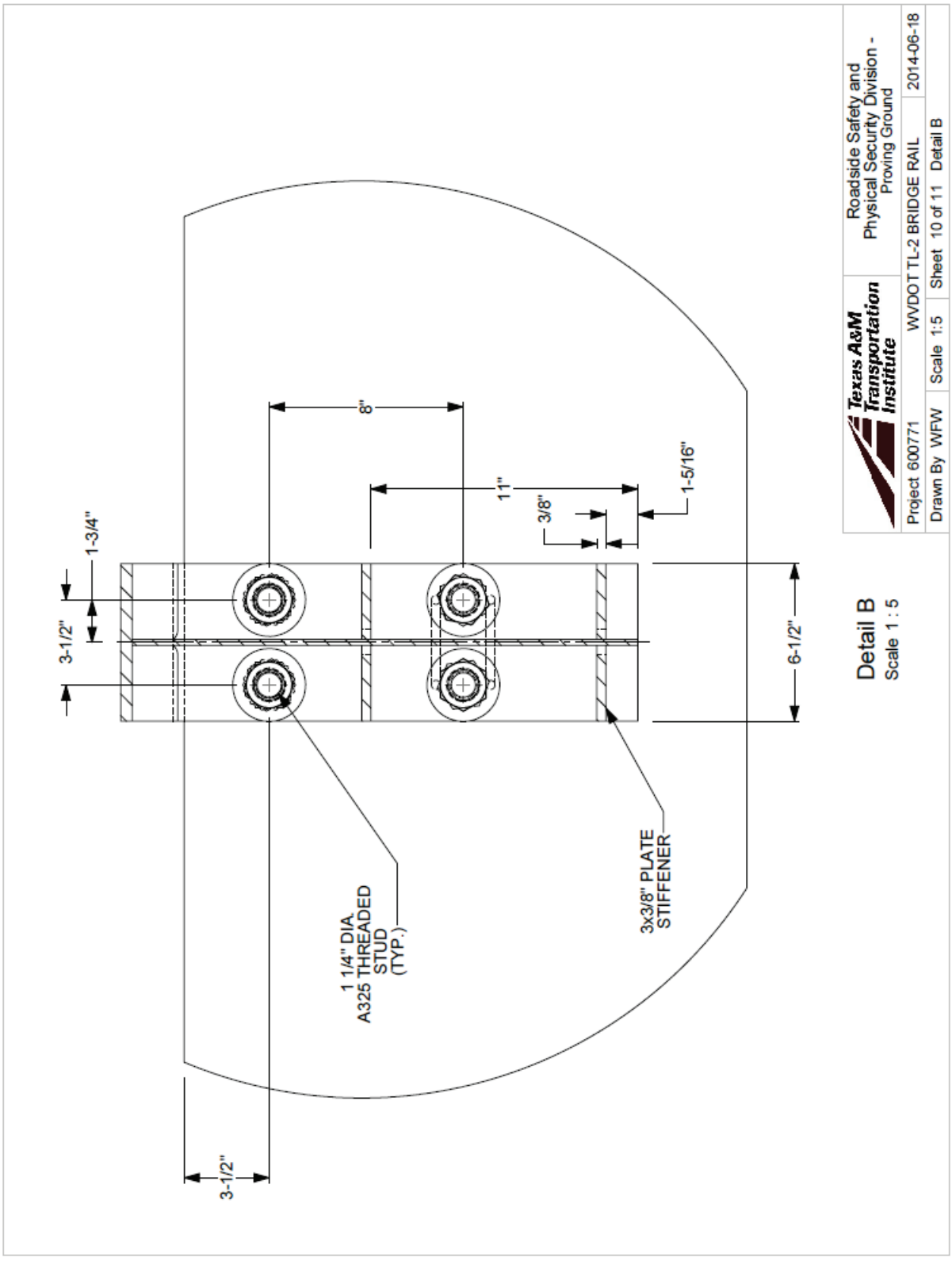
A-7


ISOMETRIC VIEW
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project 600771
WVDOT TL-2 BRIDGE RAIL
2014-06-18
Drawn By WFW
Scale 1:25
Sheet 8 of 11
Isometric

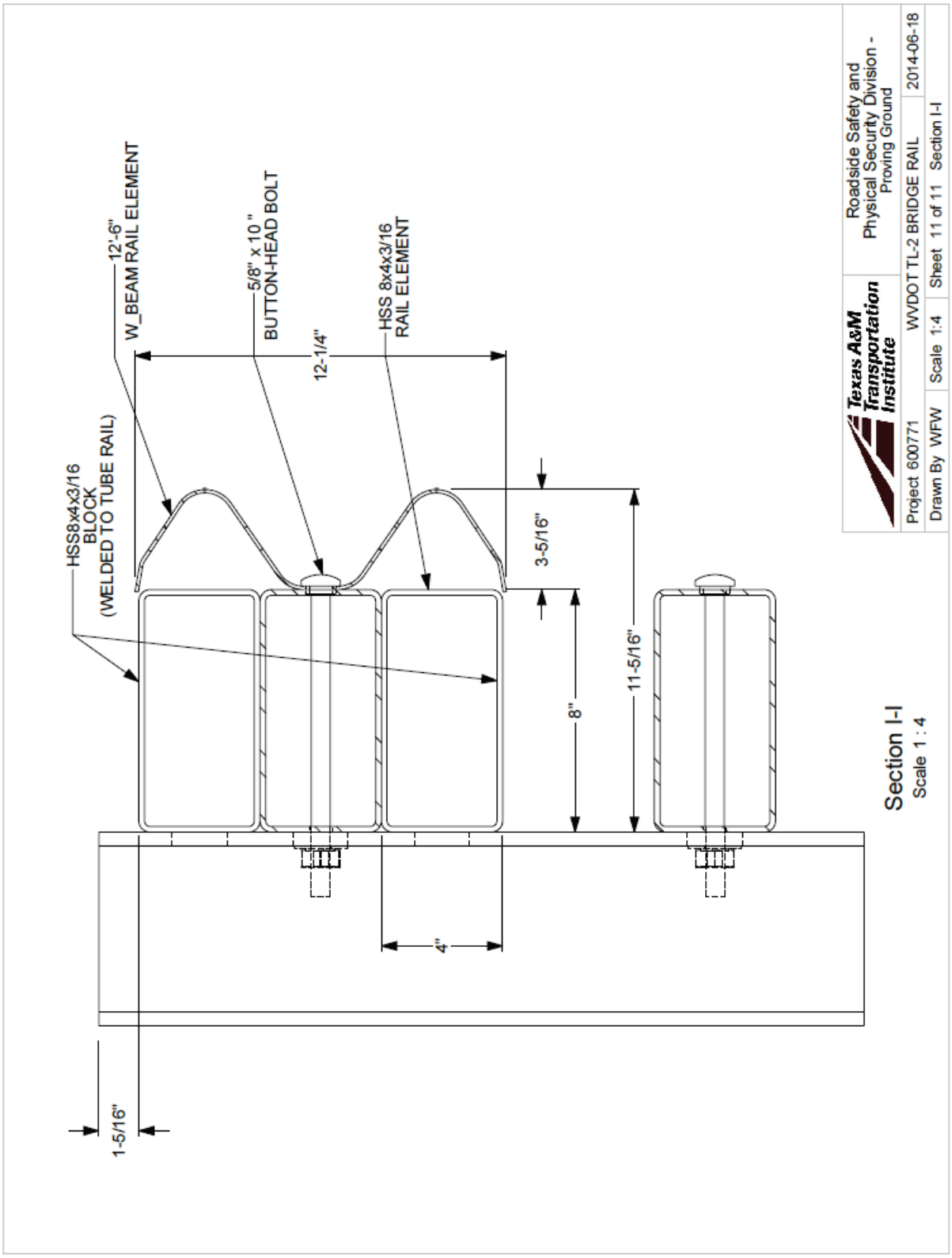
A-8


6'-3"
6'-3"
B
Section A-A
Scale 1 : 30
SECTION VIEW LOOKING FROM FIELD SIDE
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project 600771
WVDOT TL-2 BRIDGE RAIL
2014-06-18
Drawn By WFW
Scale 1:30
Sheet 9 of 11
Section A-A

A-9


8"
11"
3/8"
1-5/16"
1-3/4"
3-1/2"
6-1/2"
3-1/2"
1 1/4" DIA.
A325 THREADED
STUD
(TYP.)
3x3/8" PLATE
STIFFENER
Detail B
Scale 1 : 5
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project 600771
WVDOT TL-2 BRIDGE RAIL
2014-06-18
Drawn By WFW
Scale 1:5
Sheet 10 of 11 Detail B

A-10


W_BEAM RAIL ELEMENT
12'-6"
5/8" x 10 "
BUTTON-HEAD BOLT
HSS 8x4x3/16
RAIL ELEMENT
12-1/4"
HSS8x4x3/16
BLOCK
(WELDED TO TUBE RAIL)
3-5/16"
8"
11-5/16"
4"
1-5/16"
Section I-I
Scale 1 : 4
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Roadside Safety and Physical Security Division - Proving Ground
Project 600771
WVDOT TL-2 BRIDGE RAIL
2014-06-18
Drawn By WFW
Scale 1:4
Sheet 11 of 11 Section I-I

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