Texas A&M Transportation Institute
Proving Ground

TRNo. 618851-01-1

EVALUATION OF A MEDIAN GUARDRAIL TRANSITION TO MEDIAN F-SHAPE CONCRETE BARRIER

Sponsored by
Roadside Safety Pooled Fund

TEXAS A&M TRANSPORTATION INSTITUTE PROVING GROUND
Roadside Safety & Physical Security
Texas A&M University System RELLIS Campus
Building 7091
1254 Avenue A
Bryan, TX 77807

A2LA ACCREDITED
ISO 17025 Laboratory
Testing Certificate # 2821.01

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
Evaluation of a Median Guardrail Transition to Median F-Shape Concrete Barrier	January 2024
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Nathan D. Schulz and William J. L. Schroeder	TRNo. 618851-01-1
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Texas A&M Transportation Institute Proving Ground 3135 TAMU College Station, Texas 77843-3135	11. Contract or Grant No. Project TPF 5
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Roadside Safety Pooled Fund Research Office MS 47372 Transportation Building Olympia, WA 98504-7372	Technical Report: January 2024
	14. Sponsoring Agency Code

15. Supplementary Notes

Name of Contacting Representative: Evan Pursel

16. Abstract

The purpose of the test reported herein was to assess the performance of the Median Guardrail Transition to Median F-Shape Barrier according to the safety-performance evaluation guidelines included in the second edition of the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*) (*1*). The crash test was performed in accordance with *MASH* Test 3-21 (TL-3):

1. ***MASH* Test 3-21:** A 2270P vehicle weighing 5000 lb impacting the Longitudinal Barrier Transition at 25 degrees while travelling at 62 mi/h.

This report provides details on the design development using computer simulations, Median Guardrail Transition to Median F-Shape Barrier test installation, the crash test and results, and the performance assessment of the Median Guardrail Transition to Median F-Shape Barrier for *MASH* TL-3 evaluation criteria.

The Median Guardrail Transition to Median F-Shape Barrier did not meet the performance criteria for *MASH* TL-3.

17. Key Words	18. Distribution Statement
MASH, Guardrail, Longitudinal Barrier, Crash Test, Transition, Median, Deformation, Computer Simulation	No restrictions. This document is available to the public through NTIS: National Technical Information Service Alexandria, Virginia 22312 http://www.ntis.gov

19. Security Classification. (of this report)	20. Security Classification. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	98	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized.

Evaluation of a Median Guardrail Transition to Median F-Shape Concrete Barrier

by
Nathan D. Schulz, Ph.D.
Assistant Research Scientist
Texas A&M Transportation Institute

and

William J. L. Schroeder
Research Engineering Associate
Texas A&M Transportation Institute

TRNo. 618851-01-1
Contract No.: TPF 5

Sponsored by the

Roadside Safety Pooled Fund

January 2024

TEXAS A&M TRANSPORTATION INSTITUTE
College Station, Texas 77843-3135

DISCLAIMER

The contents of this report reflect the views of the authors, who are solely responsible for the facts and accuracy of the data and the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Roadside Safety Pooled Fund, The Texas A&M University System, or the Texas A&M Transportation Institute (TTI). This report does not constitute a standard, specification, or regulation. In addition, the above listed agencies/companies assume no liability for its contents or use thereof. The names of specific products or manufacturers listed herein do not imply endorsement of those products or manufacturers.

The results reported herein apply only to the article tested. The full-scale crash test was performed according to TTI Proving Ground quality procedures and American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware, Second Edition (*MASH*) guidelines and standards.

The Proving Ground Laboratory within TTI's Roadside Safety and Physical Security Division ("TTI Lab") strives for accuracy and completeness in its crash test reports. On rare occasions, unintentional or inadvertent clerical errors, technical errors, omissions, oversights, or misunderstandings (collectively referred to as "errors") may occur and may not be identified for corrective action prior to the final report being published and issued. If, and when, the TTI Lab discovers an error in a published and issued final report, the TTI Lab will promptly disclose such error to Roadside Safety Pooled Fund, and both parties shall endeavor in good faith to resolve this situation. The TTI Lab will be responsible for correcting the error that occurred in the report, which may be in the form of errata, amendment, replacement sections, or up to and including full reissuance of the report. The cost of correcting an error in the report shall be borne by the TTI Lab. Any such errors or inadvertent delays that occur in connection with the performance of the related testing contract will not constitute a breach of the testing contract.

THE TTI LAB WILL NOT BE LIABLE FOR ANY INDIRECT, CONSEQUENTIAL, PUNITIVE, OR OTHER DAMAGES SUFFERED BY THE ROADSIDE SAFETY POOLED FUND OR ANY OTHER PERSON OR ENTITY, WHETHER SUCH LIABILITY IS BASED, OR CLAIMED TO BE BASED, UPON ANY NEGLIGENT ACT, OMISSION, ERROR, CORRECTION OF ERROR, DELAY, OR BREACH OF AN OBLIGATION BY THE TTI LAB.

REPORT AUTHORIZATION

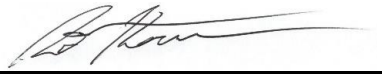
REPORT REVIEWED BY:

Glenn Schroeder
Research Specialist
Drafting & Reporting

Ken Reeves
Research Specialist
Electronics Instrumentation

Adam Mayer
Research Specialist
Construction

Richard Badillo
Research Specialist
Photographic Instrumentation



Robert Kocman
Research Specialist
Mechanical Instrumentation

William J. L. Schroeder
Research Engineering Associate
Research Evaluation and Reporting

Bill L. Griffith
Research Specialist
Quality Manager

Matthew N. Robinson
Research Specialist
Test Facility Manager & Technical Manager

Nathan D. Schulz, Ph.D.
Assistant Research Scientist

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lb/in^2

*SI is the symbol for the International System of Units

Chapter 1. INTRODUCTION

The purpose of the test reported herein was to assess the performance of a Median Guardrail Transition to Median F-Shape Barrier according to the safety-performance evaluation guidelines included in the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*), Second Edition (*1*). The crash test was performed in accordance with *MASH* Test 3-21 (as discussed in Chapter 4).

1.1. OBJECTIVE

The purpose of this research was to evaluate and develop guidelines for a MASH Test Level 3 (TL-3) compliant transition from strong post median guardrail to various heights of precast/cast-in-place median F-Shape barrier. The analysis and evaluation of these systems were conducted with finite element computer simulations and full-scale crash testing.

1.2. BACKGROUND

Previous testing was conducted on a median guardrail transition to a median single slope concrete barrier (*2*). Figure 1.1 shows the transition system. A total of four full-scale crash tests were performed to evaluate the MASH compliance of the system. The system was evaluated at three different transition locations. First, the transition from the median single slope concrete barrier to the median guardrail with quarter post spacing and w-beam rub rail was evaluated with MASH Test 3-21. Second, the transition from the median guardrail with quarter post spacing and w-beam rub rail to the median guardrail with half post spacing was evaluated with MASH Tests 3-20 and 3-21. Third, the transition from the median guardrail with half post spacing to the standard length of need median guardrail was evaluated with MASH Test 3-20. The transition system was found to be compliant for MASH TL-3.

Figure 1.1. MASH TL-3 Median Guardrail Transition to Median Single Slope Barrier. (*2*)

Chapter 2. TRANSITION DESIGN AND ANALYSIS*

2.1. INTRODUCTION

This chapter presents the details of the modeling and simulation effort related to the development and evaluation of a median guardrail transition to a median f-shape concrete barrier.

A design was developed for transitioning a median guardrail to a median f-shape concrete barrier utilizing the transition design details from a previously tested single slope version (*2*). The design consisted of the following key components:

- Median F-Shape concrete barrier – 14 ft total length
- Median guardrail with standard w-beam posts and blockouts spaced at 75 inches – 56 ft 3 inches total length
- Median guardrail with standard w-beam posts and blockouts spaced at 37.5 inches – 12ft 6inches total length
- Median guardrail with standard w-beam posts and blockouts spaced at 37.5 inches – 9ft 4.5inches total length
- W-beam rub rail with tapered blockouts – 10 ft 7 inches total length

The research team utilized finite element (FE) simulations to aid with the design development and evaluate the system according to MASH TL-3. Specifically, two design options for the rub rail attachment to the f-shape median concrete barrier were evaluated. Also, different heights of the f-shape median concrete barrier were evaluated.

Only MASH Test 3-21 was conducted to evaluate the performance of the transition system. The design elements for the transition from standard length-of-need median guardrail to median guardrail with half post spacing and design elements for the transition from median guardrail with half post spacing to median guardrail with quarter post spacing and a rub rail element were previously evaluated through full-scale crash testing (*2*). Thus, it was only necessary to conduct MASH Test 3-21 at the transition from the median guardrail with quarter post spacing and a rub rail element to the median f-shape concrete barrier.

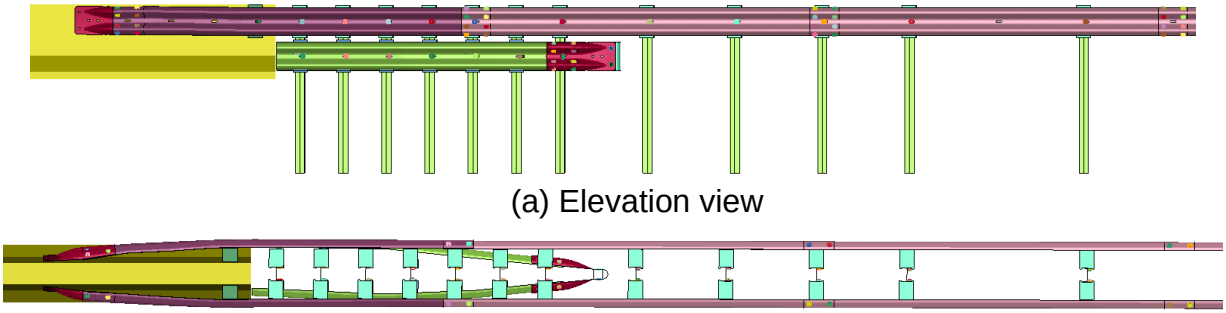
2.2. MODEL

A FE model of the median transition system was developed for evaluation before conducting full-scale crash testing. The model included the concrete barrier, steel posts, w-beam rail, rub rail, wood blockouts, and guardrail bolts. The concrete barrier was modeled using rigid material representation. The guardrail posts and rails were modeled using MAT_PIECEWISE_LINEAR_PLASTICITY. The wood blockouts were

---

* *The opinions/interpretations identified/expressed in this section of the report are outside the scope of TTI Proving Ground's A2LA Accreditation.*

modeled using MAT_ELASTIC. Figure 2.1 shows elevation and plan views of the transition model.



(a) Elevation view

(b) Plan View

Figure 2.1. FE Transition Model.

2.3. SIMULATIONS

All simulations were performed using the finite element method. LS-DYNA, which is a commercially available general purpose FE software, was used for all the analyses. A 5,000-lb Dodge Ram pickup truck vehicle model was used for the simulations. Figure 2.2 shows the vehicle.

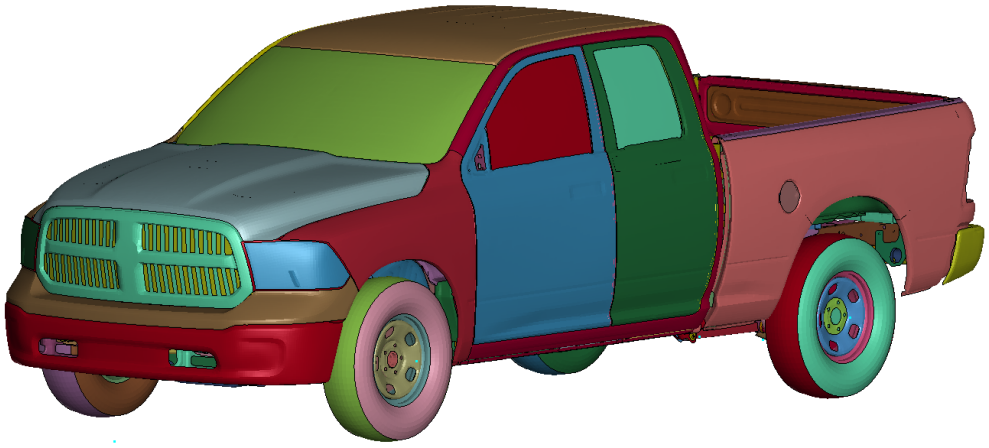
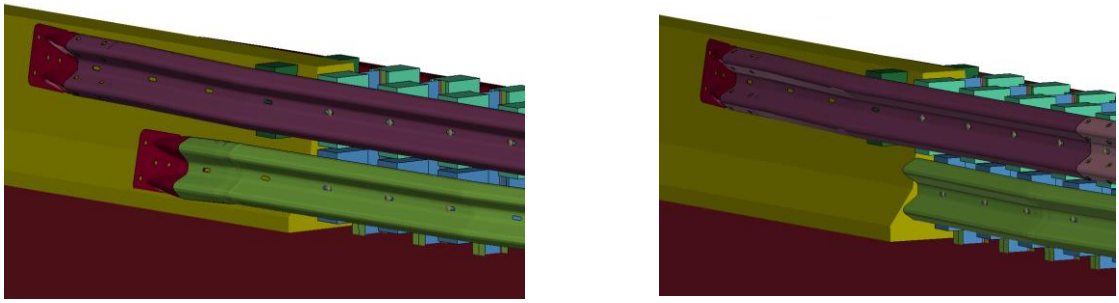


Figure 2.2. FE Pickup Truck Vehicle Model.

The researchers performed impact simulations using MASH Test 3-21 impact conditions. This involves the vehicle model impacting the transition system at an impact speed and angle of 62 mi/h and 25 degrees. The vehicle impacted the transition 6.3 ft upstream from the upstream end of the concrete parapet for all simulations. This impact location was selected based on the previous testing of the single slope median transition crash testing (*2*).

2.3.1. Rub Rail Design

Two options were considered for connecting the w-beam rub rail to the median f-shape concrete barrier. First, the rub rail attaches to the face of the f-shape barrier using a w-beam terminal connector. Second, the rub rail attaches to the upstream end of the f-shape barrier through an angle bracket. Figure 2.3 shows these two design options.



(a) Attached to barrier face (b) Attached to barrier end

Figure 2.3. Rub Rail Design Options

Computer simulations were performed for both design options. Figure 2.4 and Figure 2.5 show sequential images for the simulation runs. Table 2.1 shows the occupant risk values for the simulation runs. The transition design with the rub rail attached to the barrier face resulted in a rollover of the pickup truck vehicle. As a result, this design was considered unsatisfactory for MASH evaluation criteria. The transition design with the rub rail attached to the barrier end successfully redirected the pickup truck vehicle during the simulation. The vehicle remained stable throughout the impact event and all the occupant risk values were within the MASH limits. Thus, this transition design was considered satisfactory for MASH evaluation criteria.

The transition design with the rub rail attached to the barrier end was selected as the better design option based on the satisfactory MASH crashworthy performance.

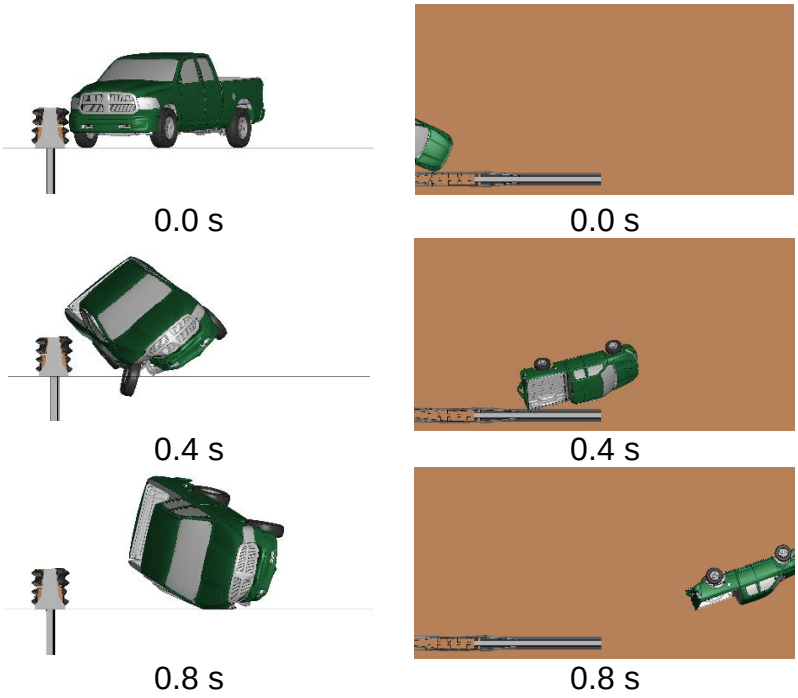


Figure 2.4. Sequential Images for MASH Test 3-21 Simulation – Rub Rail Attached on Barrier Face.

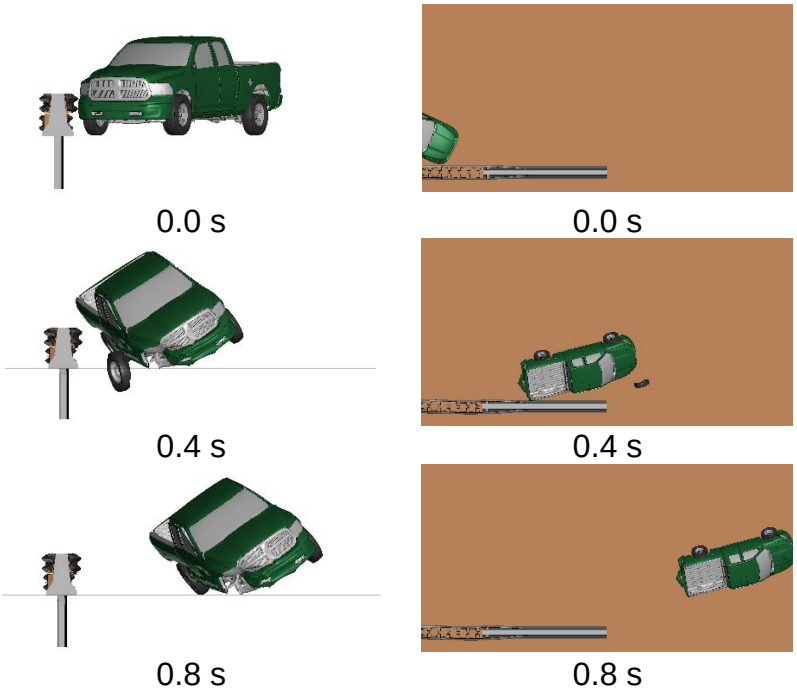


Figure 2.5. Sequential Images for MASH Test 3-21 Simulation – Rub Rail Attached on Barrier End.

Table 2.1. Occupant Risk Values for Rub Rail Design Options.

	Simulation w/ Rub Rail Attached to Barrier Face	Simulation w/ Rub Rail Attached to Barrier End
OIV, Longitudinal (ft/s)	19.6	19.6
OIV, Lateral (ft/s)	28.0	27.5
RDA, Longitudinal (g)	-4.9	-7.4
RDA, Lateral (g)	-8.7	-9.1
Roll (deg)	89.7	39.1
Pitch (deg)	-16.8	-10.2
Yaw (deg)	32.8	33.9

2.3.2. Barrier Height

Simulations were conducted to evaluate different f-shape median barrier heights. The critical barrier height in terms of MASH crashworthy performance would be selected for full-scale crash testing. Heights of 32 inches, 42 inches, and 50 inches were considered for evaluation. A 1:2.4 taper was used for the 42-inch and 50-inch barriers on the upstream end.

Figure 2.6 shows the sequential images for simulations with the three barrier heights. Table 2.2 shows the occupant risk results for the simulations. All three barrier heights resulted in the successful redirection of the pickup truck vehicle and a stable vehicle throughout the impact event. The occupant risk values were below the MASH limits for the three barrier heights.

The occupant risk values were similar between the three barrier heights. The 32-inch median f-shape barrier resulted in the highest roll angle of 39 degrees. This barrier height was determined to be most critical due to the roll angle and was selected for the full-scale crash testing. If the crash testing is successful, then the other less critical barrier heights would be considered satisfactory for MASH.

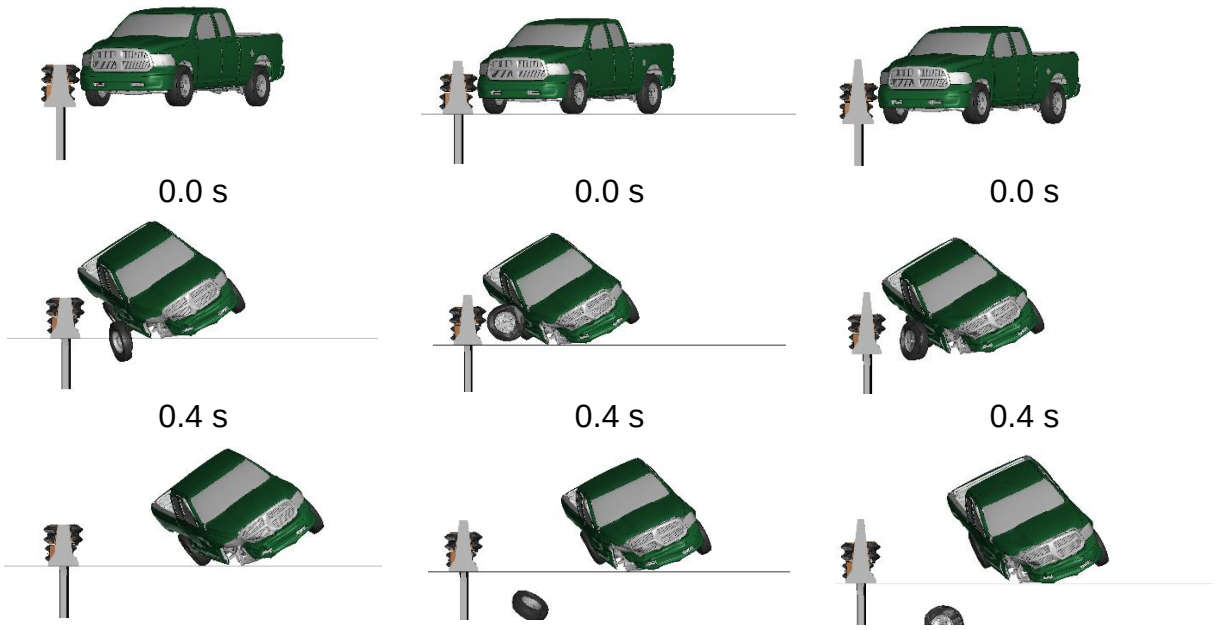


Figure 2.6. Sequential Images for Different F-Shape Median Barrier Heights.

Table 2.2. Occupant Risk Comparison for Different Barrier Heights.

	Simulation w/ 32-inch Barrier	Simulation w/ 42-inch Barrier	Simulation w/ 50-inch Barrier
OIV, Longitudinal (ft/s)	19.6	19.3	19.4
OIV, Lateral (ft/s)	27.5	28.0	28.1
RDA, Longitudinal (g)	-7.4	-8.1	-8.9
RDA, Lateral (g)	-9.1	-8.5	-9.2
Roll (deg)	39.1	34.8	32.3
Pitch (deg)	-10.2	-9.4	-10.1
Yaw (deg)	33.9	33.7	34.0

2.4. OTHER DESIGN CONSIDERATIONS

2.4.1. Rub Rail Connection

The design with the rub rail attachment to the barrier end indicated satisfactory performance for the MASH Test 3-21 criteria. One concern with this design was the w-beam rail extends beyond the f-shape concrete barrier face in the reverse direction (Figure 2.7). This presents a snagging hazard for vehicles impacting in the direction from concrete barrier to guardrail. While there is no MASH test for a reverse-direction impact on a transition system, it is worthwhile to consider from a design perspective. This is especially true as this system is intended to be used in median applications. To

counteract this snagging potential, a design modification was made by adding a w-beam terminal connector component on the end of the rub rail. Figure 2.8 shows the modified transition design with the w-beam terminal connector.

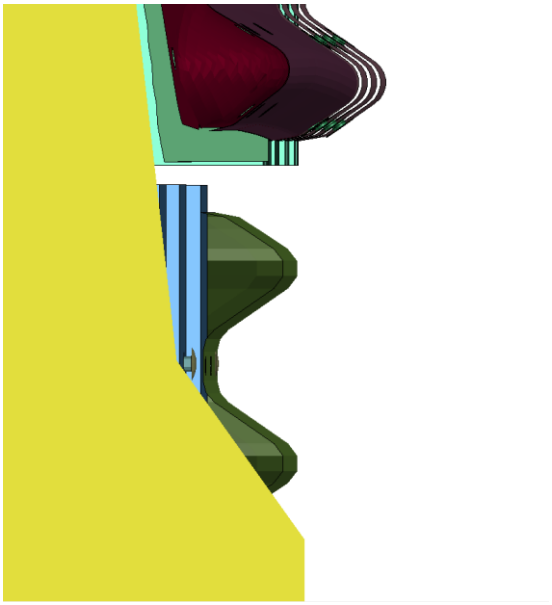


Figure 2.7. Rub Rail Transition Design (Upstream View).

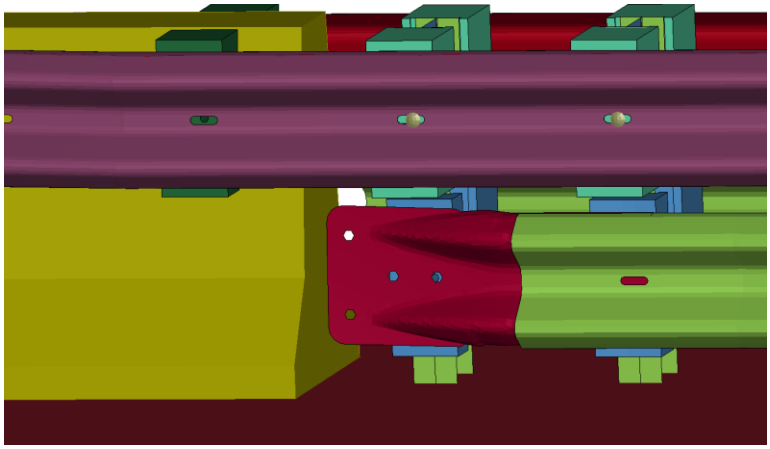


Figure 2.8. Rub Rail Transition Desing with W-Beam Terminal Connector.

2.4.2. Barrier Configuration

There are different barrier applications that can be utilized with this transition design. State DOTs may use precast barrier segments or cast-in-place barrier segments. Barrier segments may have concrete pavement or asphalt embedment.

Also, they may be doweled into a foundation. There can be variance for each of these configurations (e.g., different asphalt embedment depth).

The final transition design consisted of dowel bars embedded into a concrete foundation. This represented a worst-case rigid configuration for the transition design. This was considered worst-case as it allows for possibly higher occupant risk values and vehicle deformation.

2.5. SUMMARY

Finite element simulations were performed to analyze the performance of a median guardrail transition to a median f-shape concrete barrier design. Various design options and configurations were considered and evaluated. The transition designs were evaluated according to MASH Test 3-21.

The transition design with a rub rail attached to the barrier end indicated satisfactory performance for the MASH evaluation criteria. A 32-inch median f-shape barrier height was also found to be satisfactory and was determined to be the most critical barrier height due to having the highest roll angle.

The final transition design was considered for full-scale crash testing in the subsequent chapters.

Chapter 3. SYSTEM DETAILS

3.1. TEST ARTICLE AND INSTALLATION DETAILS

The installation consisted of a median W-beam guardrail system which transitioned to a median F-shape cast in place concrete barrier. The W6x8.5 posts were spaced at 75 inches for the 43 feet 9-inch section of length of need, followed by four spaces of 37-1/2 inches and six spaces of 18-3/4 inches, which then attached to the concrete barrier. This last section of guardrail also had a W-beam rub rail with a blockout on either side just below the W-beam guardrail. The upstream end of the installation was terminated with a median terminal. The total length of the installation was 95 feet 10 inches.

Figure 3.1 presents the overall information on the Median Guardrail Transition to Median F-Shape Barrier, and Figure 3.2 thru Figure 3.7 provide photographs of the installation. Appendix A provides further details on the Median Guardrail Transition to Median F-Shape Barrier. Drawings were provided by the Texas A&M Transportation Institute (TTI) Proving Ground, and construction was performed by DMA Contractors and TTI Proving Ground personnel.

3.2. DESIGN MODIFICATIONS DURING TESTS

No modifications were made to the installation during the testing phase.

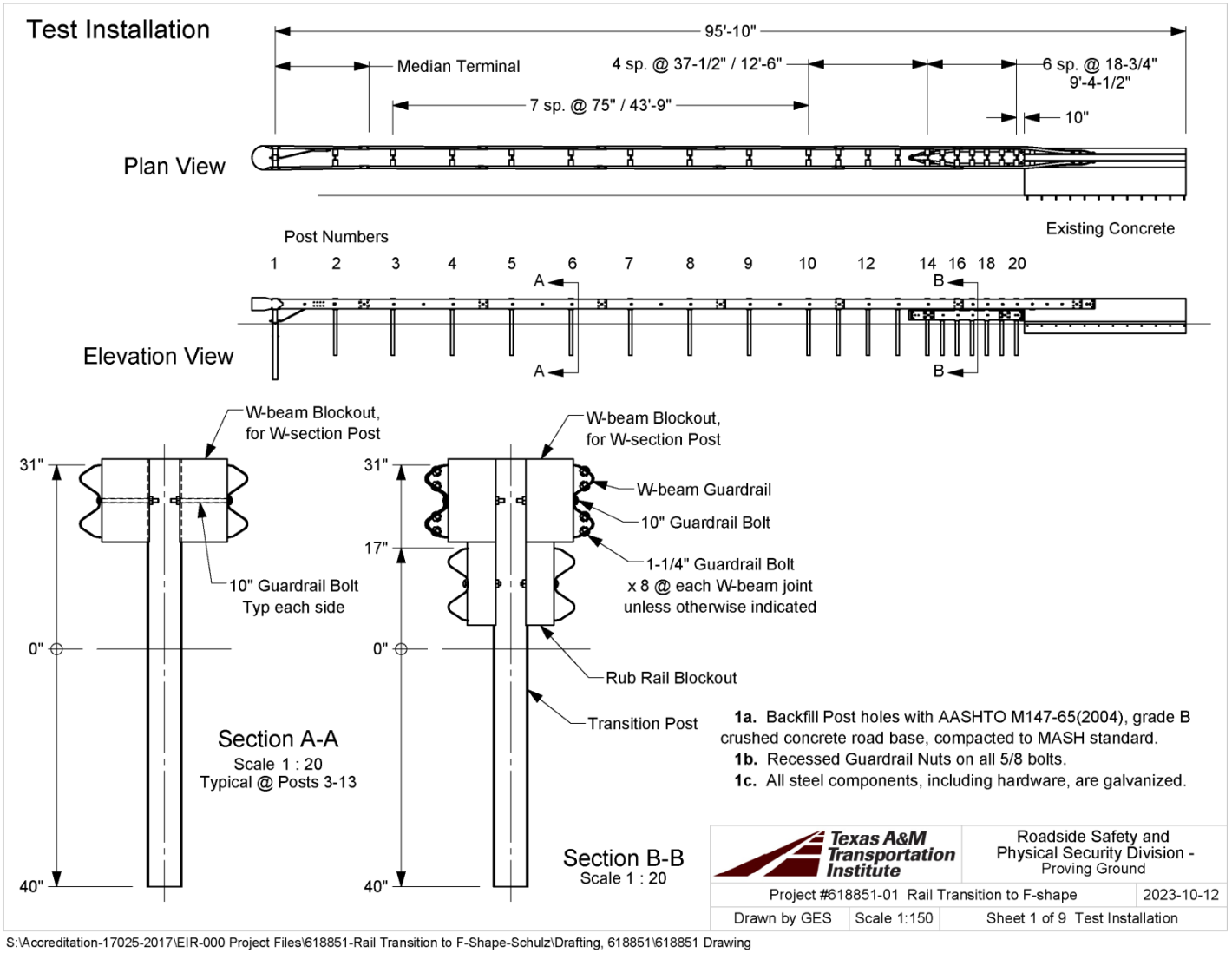


Figure 3.1. Details of Median Guardrail Transition to Median F-Shape Barrier.

Figure 3.2. Median Guardrail Transition to Median F-Shape Barrier prior to Testing.

Figure 3.3. Median Guardrail Transition to Median F-Shape Barrier at Impact prior to Testing.

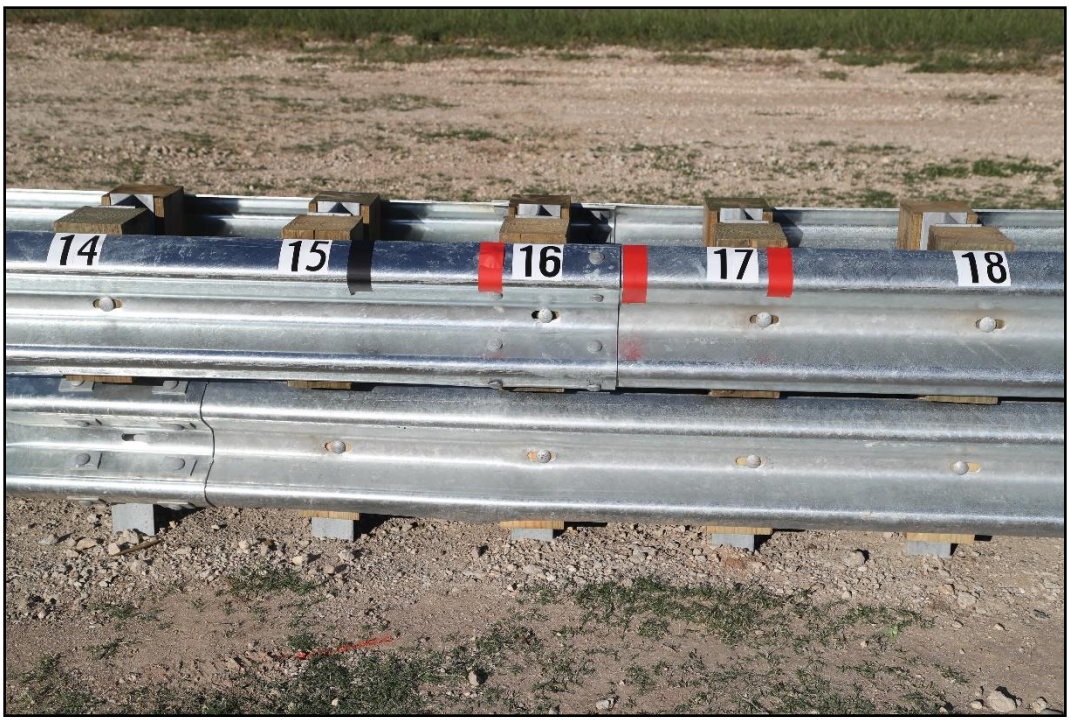


Figure 3.4. Close-up View of the Median Guardrail Transition to Median F-Shape Barrier at Impact prior to Testing.

Figure 3.5. Median Guardrail Transition to Median F-Shape Barrier Upstream Rub Rail Termination prior to Testing.

Figure 3.6. Downstream View of the Median Guardrail Transition to Median F-Shape Barrier prior to Testing.

Figure 3.7. In-line View of the Median Guardrail Transition to Median F-Shape Barrier prior to Testing.

3.3. MATERIAL SPECIFICATIONS

Appendix B provides material certification documents for the materials used to install/construct the Median Guardrail Transition to Median F-Shape Barrier. Table 3.1 shows the average compressive strengths of the concrete on the day of the test, 2023-10-16.

Table 3.1. Concrete Strength.

Location	Design Strength (psi)	Avg. Strength (psi)	Age (days)	Detailed Location
Deck	3600	4365	49	100% of the deck
Barrier	3600	3990	25	100% of the barrier

3.4. SOIL CONDITIONS

The test installation was installed in standard soil meeting Type D Grade 1 of AASHTO standard specification M147-17 “Materials for Aggregate and Soil Aggregate Subbase, Base, and Surface Courses.”

In accordance with Appendix B of *MASH*, soil strength was measured the day of the crash test. During installation of the Median Guardrail Transition to Median F-Shape Barrier for full-scale crash testing, two 6-ft long W6×16 posts were installed in the immediate vicinity of the Median Guardrail Transition to Median F-Shape Barrier using the same fill materials and installation procedures used in the test installation and the standard dynamic test.

On the day of Test 3-21, 2023-10-16, loads on the post at deflections were as shown in Table 3.2. The backfill material in which the Median Guardrail Transition to Median F-Shape Barrier was installed met minimum *MASH* requirements for soil strength.

Table 3.2. Soil Strength for Test 618851-01-1.

Displacement (in)	Minimum Load (lb)	Actual Load (lb)
5	4420	7818
10	4981	9000
15	5282	9600

Chapter 4. TEST REQUIREMENTS AND EVALUATION CRITERIA

4.1. CRASH TEST PERFORMED/MATRIX

Table 4.1 shows the test conditions and evaluation criteria for *MASH* TL-3 for Longitudinal Barrier Transitions. The target critical impact point (CIP) for the test was determined using the information provided in *MASH* Section 2.2.1 and Section 2.3.2 and using computer simulations. Figure 4.1 shows the target CIP for *MASH* Test 3-21 on the Median Guardrail Transition to Median F-Shape Barrier.

Table 4.1. Test Conditions and Evaluation Criteria Specified for *MASH* TL-3 Longitudinal Barrier Transition.

Test Designation	Test Vehicle	Impact Speed	Impact Angle	Evaluation Criteria
3-21	2270P	62 mi/h	25º	A, D, F, H, I

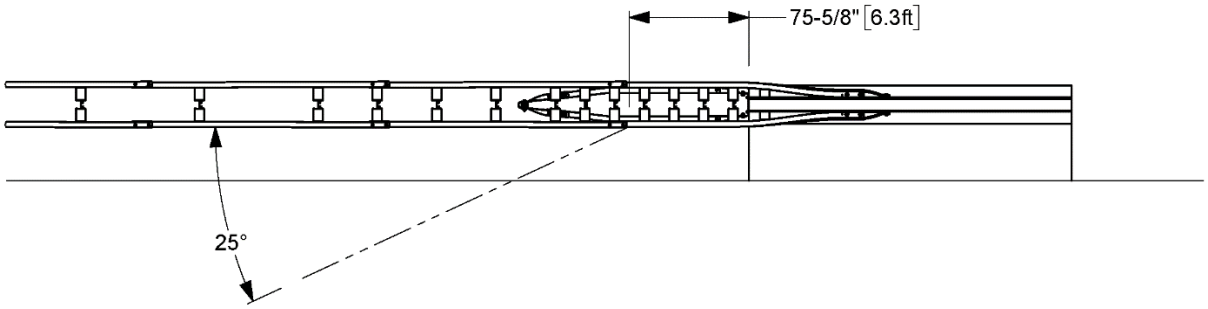


Figure 4.1. Target CIP for *MASH* Test 3-21 on Median Guardrail Transition to Median F-Shape Barrier.

The crash tests and data analysis procedures were in accordance with guidelines presented in *MASH*. Chapter 5 presents brief descriptions of these procedures.

4.2. EVALUATION CRITERIA

The appropriate safety evaluation criteria from Tables 2-2 and 5-1 of *MASH* were used to evaluate the crash test reported herein. Table 4.1 lists the test conditions and evaluation criteria required for *MASH* TL-3, and Table 4.2 provides detailed information on the evaluation criteria.

Table 4.2. Evaluation Criteria Required for *MASH* Testing.

Evaluation Factors	Evaluation Criteria
A.	Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.
D.	Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of *MASH*.
F.	The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.
H.	Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 30 ft/s, or maximum allowable value of 40 ft/s.
I.	The occupant ridedown accelerations should satisfy the following: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.

Chapter 5. TEST CONDITIONS

5.1. TEST FACILITY

The full-scale crash test reported herein was performed at the TTI Proving Ground, an International Standards Organization (ISO)/International Electrotechnical Commission (IEC) 17025-accredited laboratory with American Association for Laboratory Accreditation (A2LA) Mechanical Testing Certificate 2821.01. The full-scale crash test was performed according to TTI Proving Ground quality procedures, as well as *MASH* guidelines and standards.

The test facilities of the TTI Proving Ground are located on The Texas A&M University System RELLIS Campus, which consists of a 2000-acre complex of research and training facilities situated 10 mi northwest of the flagship campus of Texas A&M University. The site, formerly a United States Army Air Corps base, has large expanses of concrete runways and parking aprons well suited for experimental research and testing in the areas of vehicle performance and handling, vehicle-roadway interaction, highway pavement durability and efficacy, and roadside safety hardware and perimeter protective device evaluation. The sites selected for construction and testing are along the edge of an out-of-service apron/runway. The apron/runway consists of an unreinforced jointed-concrete pavement in 12.5-ft × 15-ft blocks nominally 6 inches deep. The aprons were built in 1942, and the joints have some displacement but are otherwise flat and level.

5.2. VEHICLE TOW AND GUIDANCE SYSTEM

For the testing utilizing the 2270P vehicle, each was towed into the test installation using a steel cable guidance and reverse tow system. A steel cable for guiding the test vehicle was tensioned along the path, anchored at each end, and threaded through an attachment to the front wheel of the test vehicle. An additional steel cable was connected to the test vehicle, passed around a pulley near the impact point and through a pulley on the tow vehicle, and then anchored to the ground such that the tow vehicle moved away from the test site. A 2:1 speed ratio between the test and tow vehicle existed with this system. Just prior to impact with the installation, the test vehicle was released and ran unrestrained. The vehicle remained freewheeling (i.e., no steering or braking inputs) until it cleared the immediate area of the test site.

5.3. DATA ACQUISITION SYSTEMS

5.3.1. Vehicle Instrumentation and Data Processing

The test vehicle was instrumented with a self-contained onboard data acquisition system. The signal conditioning and acquisition system is a multi-channel data acquisition system (DAS) produced by Diversified Technical Systems Inc. The accelerometers, which measure the x, y, and z axis of vehicle acceleration, are strain gauge type with linear millivolt output proportional to acceleration. Angular rate sensors,

measuring vehicle roll, pitch, and yaw rates, are ultra-small, solid-state units designed for crash test service. The data acquisition hardware and software conform to the latest SAE J211, Instrumentation for Impact Test. Each of the channels is capable of providing precision amplification, scaling, and filtering based on transducer specifications and calibrations. During the test, data are recorded from each channel at a rate of 10,000 samples per second with a resolution of one part in 65,536. Once data are recorded, internal batteries back these up inside the unit in case the primary battery cable is severed. Initial contact of the pressure switch on the vehicle bumper provides a time zero mark and initiates the recording process. After each test, the data are downloaded from the DAS unit into a laptop computer at the test site. The Test Risk Assessment Program (TRAP) software then processes the raw data to produce detailed reports of the test results.

Each DAS is returned to the factory annually for complete recalibration and to ensure that all instrumentation used in the vehicle conforms to the specifications outlined by SAE J211. All accelerometers are calibrated annually by means of an ENDEVCO® 2901 precision primary vibration standard. This standard and its support instruments are checked annually and receive a National Institute of Standards Technology (NIST) traceable calibration. The rate transducers used in the data acquisition system receive calibration via a Genisco Rate-of-Turn table. The subsystems of each data channel are also evaluated annually, using instruments with current NIST traceability, and the results are factored into the accuracy of the total data channel per SAE J211. Calibrations and evaluations are also made anytime data are suspect. Acceleration data are measured with an expanded uncertainty of ±1.7 percent at a confidence factor of 95 percent (k = 2).

TRAP uses the DAS-captured data to compute the occupant/compartment impact velocities, time of occupant/compartment impact after vehicle impact, and highest 10-millisecond (ms) average ridedown acceleration. TRAP calculates change in vehicle velocity at the end of a given impulse period. In addition, maximum average accelerations over 50-ms intervals in each of the three directions are computed. For reporting purposes, the data from the vehicle-mounted accelerometers are filtered with an SAE Class 180-Hz low-pass digital filter, and acceleration versus time curves for the longitudinal, lateral, and vertical directions are plotted using TRAP.

TRAP uses the data from the yaw, pitch, and roll rate transducers to compute angular displacement in degrees at 0.0001-s intervals, and then plots yaw, pitch, and roll versus time. These displacements are in reference to the vehicle-fixed coordinate system with the initial position and orientation being initial impact. Rate of rotation data is measured with an expanded uncertainty of ±0.7 percent at a confidence factor of 95 percent (k = 2).

5.3.2. Anthropomorphic Dummy Instrumentation

According to *MASH*, use of a dummy in the 2270P vehicle is optional, and no dummy was used in the test.

5.3.3. Photographic Instrumentation Data Processing

Photographic coverage of the test included two digital high-speed cameras:

- One placed overhead with a field of view perpendicular to the ground and directly over the impact point.
- One placed with a field of view parallel to and aligned with the installation at the downstream end.
- [*]One placed at an oblique angle upstream from the installation on the traffic side.

A flashbulb on the impacting vehicle was activated by a pressure-sensitive tape switch to indicate the instant of contact with the Median Guardrail Transition to Median F-Shape Barrier. The flashbulb was visible from each camera. The video files from these digital high-speed cameras were analyzed to observe phenomena occurring during the collision and to obtain time-event, displacement, and angular data. A digital camera recorded and documented conditions of the test vehicle and the installation before and after the test.

[*] Unfortunately, there was a recording issue during the test, which led to the high-speed video for the oblique upstream angle camera being unrecoverable.

Chapter 6. *MASH* TEST 3-21 (CRASH TEST 618851-01-1)

6.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 6.1 for details of *MASH* impact conditions for this test and Table 6.2 for the exit parameters. Figure 6.1 and Figure 6.2 depict the target impact setup.

Table 6.1. Impact Conditions for *MASH* TEST 3-21, Crash Test 618851-01-1.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	62	±2.5 mi/h	61.3
Impact Angle (deg)	25	±1.5°	25.3
Impact Severity (kip-ft)	106	≥106 kip-ft	115.4
Impact Location	75.6 inches upstream from the upstream end of the concrete barrier	±12 inches	74.5 inches upstream from the upstream end of the concrete barrier

Table 6.2. Exit Parameters for *MASH* TEST 3-21, Crash Test 618851-01-1.

Exit Parameter	Measured
Speed (mi/h)	46.3
Trajectory (deg)	2.5
Heading (deg)	6.6
Brakes applied post impact (s)	2.0
Vehicle at rest position	163 ft downstream of impact point 12 ft to the field side Vehicle positioned 110° left relative to the installation
Comments:	Vehicle remained upright and stable Vehicle crossed the exit box [a] 81 ft downstream from loss of contact. The vehicle snagged on the W-beam at post 18 and tore a portion of the rail.

[a] Not less than 32.8 ft downstream from loss of contact for cars and pickups is optimal.

Figure 6.1. Median Guardrail Transition to Median F-Shape Barrier/Test Vehicle Geometrics for Test 618851-01-1.

Figure 6.2. Median Guardrail Transition to Median F-Shape Barrier/Test Vehicle Impact Location for Test 618851-01-1.

6.2. WEATHER CONDITIONS

Table 6.3 provides the weather conditions for test 618851-01-1.

Table 6.3. Weather Conditions for Test 618851-01-1.

Date of Test	2023-10-16
Wind Speed (mi/h)	11
Wind Direction (deg)	360
Temperature (°F)	62
Relative Humidity (%)	55
Vehicle Traveling (deg)	325

6.3. TEST VEHICLE

Figure 6.3 and Figure 6.4 show the 2018 RAM 1500 used for the crash test. Table 6.4 shows the vehicle measurements. Figure C.1 in Appendix C.1 gives additional dimensions and information on the vehicle.

Figure 6.3. Impact Side of Test Vehicle before Test 618851-01-1.

Figure 6.4. Opposite Impact Side of Test Vehicle before Test 618851-01-1.

Table 6.4. Vehicle Measurements for Test 618851-01-1.

Test Parameter	Specification	Tolerance	Measured
Dummy (if applicable)[a] (lb)	165	N/A	N/A
Inertial Weight (lb)	5000	±110	5032
Gross Static[a] (lb)	5000	±110	5032
Wheelbase (inches)	148	±12	140.5
Front Overhang (inches)	39	±3	40
Overall Length (inches)	237	±13	227.5
Overall Width (inches)	78	±2	78.5
Hood Height (inches)	43	±4	46
Track Width[b] (inches)	67	±1.5	68.3
CG aft of Front Axle[c] (inches)	63	±4	61.2
CG above Ground[c,d] (inches)	28	28	28.6

Note: N/A = not applicable; CG = center of gravity.

[a] If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.

[b] Average of front and rear axles.

[c] For test inertial mass.

[d] 2270P vehicle must meet minimum CG height requirement.

6.4. TEST DESCRIPTION

Table 6.5 lists events that occurred during Test 618851-01-1. Figures C.4, and C.5 in Appendix C.2 present sequential photographs during the test.

Table 6.5. Events during Test 618851-01-1.

Time (s)	Events
0.0000	Vehicle impacted the installation
0.0180	Posts 17 and 18 began to lean toward field side
0.0250	Posts 19 and 20 began to lean toward field side
0.0430	Vehicle began to redirect
0.0610	Vehicle front drivers side bumper made contact with concrete barrier
0.2640	Vehicle was parallel with installation
0.2770	Vehicle rear drivers side bumper made contact with rail
0.3510	Vehicle exited the installation at 46.3 mi/h with a heading of 6.6 degrees and a trajectory of 2.5 degrees

6.5. DAMAGE TO TEST INSTALLATION

The W-beam and rub rail were deformed and scuffed at impact. The vehicle snagged on the W-beam and tore 40% of the front rail from the bottom and 25% of the back rail from the bottom at post 18. The soil fell back in the hole around posts 18-20, making soil gap measurements impossible at these posts. The traffic side blockout at post 20 broke in half. Table 6.6 describes the soil gap and post lean of the Median Guardrail Transition to Median F-Shape Barrier . Table 6.7 describes the deflection and working width of the Median Guardrail Transition to Median F-Shape Barrier. Figure 6.5 and Figure 6.6 show the damage to the Median Guardrail Transition to Median F-Shape Barrier.

Table 6.6. Soil Gap and Post Lean of the Median Guardrail Transition to Median F-Shape Barrier for Test 618851-01-1.

Post	Traffic Side Soil Gap (inches)	Post Lean to Field Side from Vertical (degrees)
13	0.1	0.0
14	0.5	0.9
15	0.8	2.3
16	0.8	2.5
17	1.3	3.1
18	Not measurable	4.3
19	Not measurable	3.9
20	Not measurable	2.7

Table 6.7. Deflection and Working Width of the Median Guardrail Transition to Median F-Shape Barrier for Test 618851-01-1.

Test Parameter	Measured
Permanent Deflection/Location	2.8 inches toward field side, at the midspan of posts 18 and 19
Dynamic Deflection	8.4 inches toward field side at the rail at post 18
Working Width [a] and Height	38.3 inches, at a height of 30.0 inches at the field side of the rail at post 18

[a] Per *MASH*, "The working width is the maximum dynamic lateral position of any major part of the system or vehicle. These measurements are all relative to the pre-impact traffic face of the test article." In other words, working width is the total barrier width plus the maximum dynamic intrusion of any portion of the barrier or test vehicle past the field side edge of the barrier.

Figure 6.5. Median Guardrail Transition to Median F-Shape Barrier at Impact Location after Test 618851-01-1.

Figure 6.6. Vehicle Snag at Post 18 on the Median Guardrail Transition to Median F-Shape Barrier after Test 618851-01-1.

6.6. DAMAGE TO TEST VEHICLE

Figure 6.7 and Figure 6.8 show the damage sustained by the vehicle. Figure 6.9 and Figure 6.10 show the interior of the test vehicle. Table 6.8 and Table 6.9 provide details on the occupant compartment deformation and exterior vehicle damage. Figures C.2 and C.3 in Appendix C.1 provide exterior crush and occupant compartment measurements.

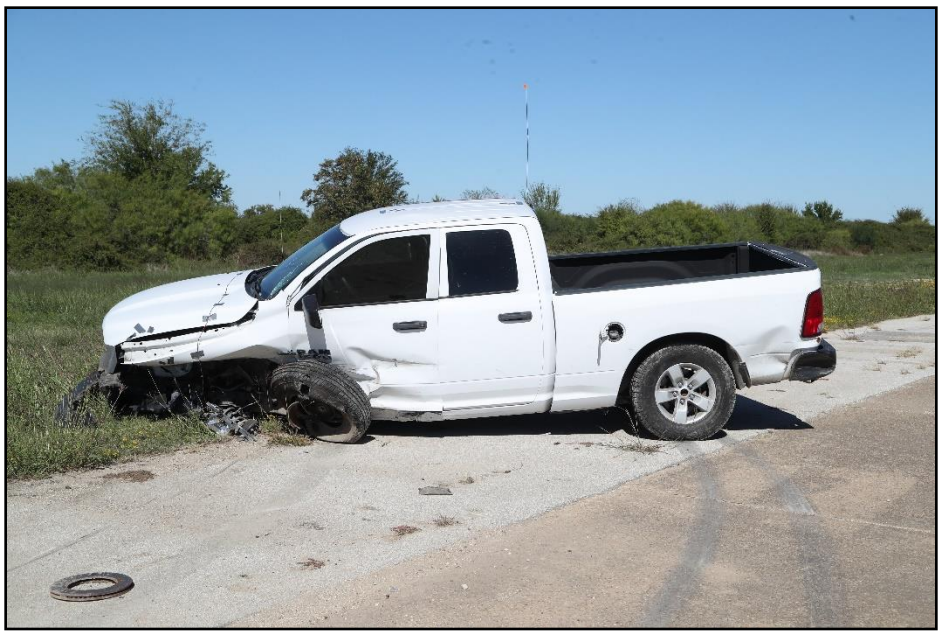


Figure 6.7. Impact Side of Test Vehicle after Test 618851-01-1.

Figure 6.8. Front Impact Side of Test Vehicle after Test 618851-01-1.

Figure 6.9. Interior of Test Vehicle on Impact Side after Test 618851-01-1.

Figure 6.10. Seam Separation on Impact Side after Test 618851-01-1.

Table 6.8. Occupant Compartment Deformation 618851-01-1.

Test Parameter	**Specification** (inches)	**Measured** (inches)
Roof	≤4.0	0.8
Windshield	≤3.0	0.0
A and B Pillars	≤5.0 overall/≤3.0 lateral	1.0
Foot Well/Toe Pan	≤9.0	11.5
Floor Pan/Transmission Tunnel	≤12.0	3.0
Side Front Panel	≤12.0	6.5
Front Door (above Seat)	≤9.0	0.0
Front Door (below Seat)	≤12.0	0.0

Table 6.9. Exterior Vehicle Damage 618851-01-1.

Side Windows	The side windows remained intact
Maximum Exterior Deformation	19 inches in the front plane at the left front corner at bumper height
VDS	11LFQ5
CDC	11FLEW3
Fuel Tank Damage	None
Description of Damage to Vehicle:	The left front bumper, fender, and door were dented. There were cracks in the windshield due to the flexing of the vehicle and not due to penetration by the test article. The grill, radiator, and support were damaged. The left headlight broke off. The left front tire blew out and the wheel broke. The left control arm was ripped off, the spring popped out, and the shock was bent on the left side. The A pillar was bent and the left front door had a 9.5-inch gap at the top. There was a buckle in the roof measuring 9 inches long, 7 inches wide, and 0.8 inches deep. The left rear cab corner, rear quarter fender, and rear bumper were dented. The left side foot well had some separating at the seam. The maximum deformation was 11.5 inches at the foot well/toe pan.

6.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 6.10. Figure C.6 in Appendix C.3 shows the vehicle angular displacements, and Figures C.7 through C.9 in Appendix C.4 show acceleration versus time traces.

Table 6.10. Occupant Risk Factors for Test 618851-01-1.

Test Parameter	Specification [a]	Measured	Time
OIV, Longitudinal (ft/s)	≤40.0 *30.0*	25.2	0.1030 seconds on left side of interior
OIV, Lateral (ft/s)	≤40.0 *30.0*	23.3	0.1030 seconds on left side of interior
Ridedown, Longitudinal (g)	≤20.49 *15.0*	8.3	0.1030 - 0.1130 seconds
Ridedown, Lateral (g)	≤20.49 *15.0*	8.3	0.1030 - 0.1130 seconds
Theoretical Head Impact Velocity (THIV) (m/s)	N/A	10.2	0.1005 seconds on left side of interior
Acceleration Severity Index (ASI)	N/A	1.7	0.0529 - 0.1029 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal (g)	N/A	-12.5	0.0449 - 0.0949 seconds
50-ms MA Lateral (g)	N/A	11.2	0.0291 - 0.0791 seconds
50-ms MA Vertical (g)	N/A	-3.6	0.0937 - 0.1437 seconds
Roll (deg)	≤75	20.4	0.4849 seconds
Pitch (deg)	≤75	13	0.5014 seconds
Yaw (deg)	N/A	48.8	0.9650 seconds

[a] *Values in italics are the preferred MASH values*

6.8. TEST SUMMARY

Figure 6.11 summarizes the results of *MASH* Test 618851-01-1.

0.000 s

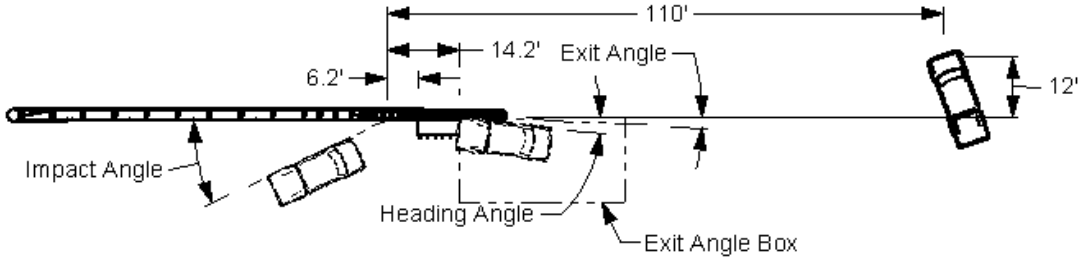
0.200 s

0.400 s

0.600 s

GENERAL INFORMATION	
Test Agency	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.	*MASH* 2016, Test 3-21
TTI Project No.	618851-01-1
Test Date	2023-10-16
TEST ARTICLE	
Type	Longitudinal Barrier Transition
Name	Median Guardrail Transition to Median F-Shape Barrier
Length	95 ft-10 inches
Key Materials	Concrete barrier, W-beam guardrail, Wide flange guardrail post, Transition post, Timber Blockout
Soil Type and Condition	AASHTO M147-65(2004), grade B crushed concrete, damp
TEST VEHICLE	
Type/Designation	2270P
Year, Make and Model	2018 RAM 1500
Inertial Weight (lb)	5032
Dummy (lb)	N/A
Gross Static (lb)	5032
IMPACT CONDITIONS	
Impact Speed / Impact Angle	61.3 mi/h / 25.3°
Impact Location	74.5 inches upstream from the upstream end of the concrete barrier
Impact Severity (kip-ft)	115.4

EXIT CONDITIONS			
Exit Speed (mi/h)	46.3		
Trajectory/Heading Angle (deg)	2.5 / 6.6		
Exit Box Criteria	Vehicle crossed the exit box 81 ft downstream from loss of contact.		
Stopping Distance	163 ft downstream 12 ft to the field side		
TEST ARTICLE DEFLECTIONS			
Dynamic (inches)	8.4		
Permanent (inches)	2.8		
Working Width / Height (inches)	38.3 / 30.0		
VEHICLE DAMAGE			
VDS	11LFQ5		
CDC	11FLEW3		
Max. Ext. Deformation (inches)	19		
Max Occupant Compartment Deformation	11.5 inches in the foot well/toe pan		
OCCUPANT RISK VALUES			
Long. OIV (ft/s)	25.2	Max 50-ms Long. (g)	-12.5
Lat. OIV (ft/s)	23.3	Max 50-ms Lat. (g)	11.2
Long. Ridedown (g)	8.3	Max 50-ms Vert. (g)	-3.6
Lat. Ridedown (g)	8.3	Max Roll (deg)	20.4
THIV (m/s)	10.2	Max Pitch (deg)	13
ASI	1.7	Max Yaw (deg)	48.8



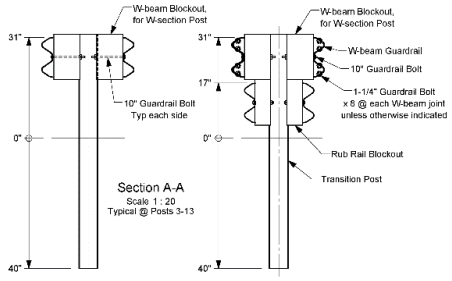


Figure 6.11. Summary of Results for *MASH* Test 3-21 on Median Guardrail Transition to Median F-Shape Barrier.

Chapter 7. SUMMARY

The crash test reported herein was performed in accordance with *MASH* Test 3-21 on the Median Guardrail Transition to Median F-Shape Barrier.

Table 7.1 shows that the Median Guardrail Transition to Median F-Shape Barrier did not meet the performance criteria for *MASH* TL-3.

Table 7.1. Assessment Summary for *MASH* Test 3-21 on Median Guardrail Transition to Median F-Shape Barrier.

Evaluation Criteria	Description	Test 618851-01-1
A	Contain, Redirect, or Controlled Stop	S
D	No Penetration into Occupant Compartment	Fail
F	Roll and Pitch Limit	S
H	OIV Threshold	S
I	Ridedown Threshold	S
Overall	Evaluation	Fail

Note: S = Satisfactory;
[1] See Table 4.2 for details

Chapter 8. CONCLUSIONS*

A design was developed and evaluated for a median guardrail transition to a median f-shape concrete barrier. The design was evaluated through computer simulations to determine design features and select the critical worst-case configuration.

The median guardrail to median f-shape concrete barrier transition system was evaluated through full-scale crash testing. *MASH* Test 3-21 was conducted on the system. The crash test was considered a failure due to the vehicle occupant compartment deformation exceeding the MASH limit. The vehicle had a deformation of 11.5 inches in the foot well/toe pan region, which exceeds the *MASH* limit of 9 inches. Thus, the transition system was considered unsatisfactory for *MASH* TL-3 evaluation criteria.

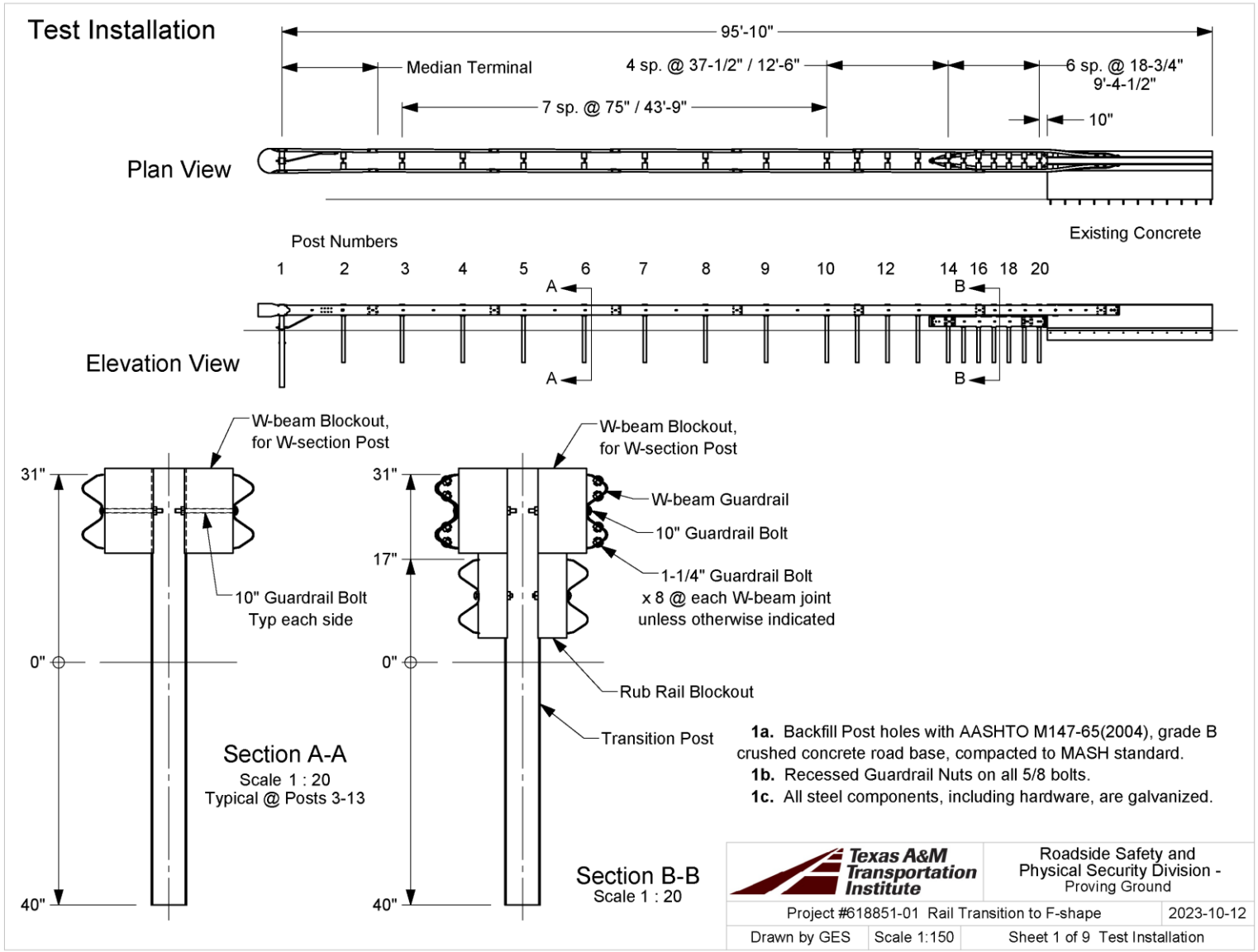
Additional research is needed to develop a *MASH* crashworthy design for a median guardrail transition to a median f-shape concrete barrier.

* *The opinions/interpretations identified/expressed in this section of the report are outside the scope of TTI Proving Ground's A2LA Accreditation.*

REFERENCES

1. AASHTO. *Manual for Assessing Safety Hardware*, Second Edition. American Association of State Highway and Transportation Officials, Washington, DC, 2016.
2. A. Abu-Odeh, N. Schulz, M. Kiani, A. Sheil, W. Menges, W. Schroeder, B. Griffith, and D. Kuhn. *MASH TL-3 Transition Between Median Guardrail and Median Concrete Barrier*. Test Report No. 0-6990-R1. Texas A&M Transportation Institute, College Station, TX, 2021.

APPENDIX A. DETAILS OF MEDIAN GUARDRAIL TRANSITION TO MEDIAN F-SHAPE BARRIER



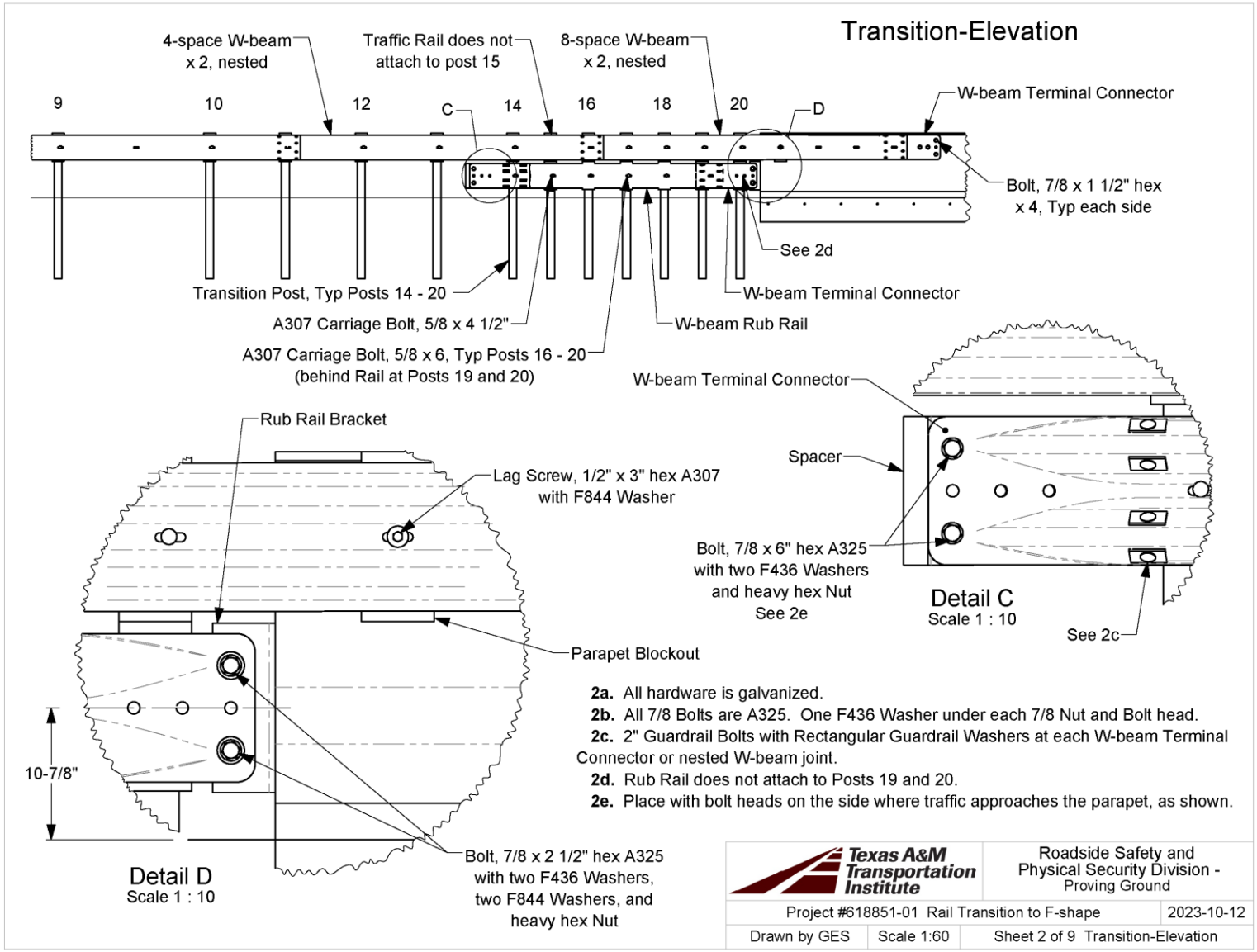
1a. Backfill Post holes with AASHTO M147-65(2004), grade B crushed concrete road base, compacted to MASH standard.

1b. Recessed Guardrail Nuts on all 5/8 bolts.

1c. All steel components, including hardware, are galvanized.

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground
Project #618851-01 Rail Transition to F-shape		2023-10-12
Drawn by GES	Scale 1:150	Sheet 1 of 9 Test Installation

S:\Accreditation-17025-2017\EIR-000 Project Files\618851-Rail Transition to F-Shape-Schulz\Drafting, 618851\618851 Drawing

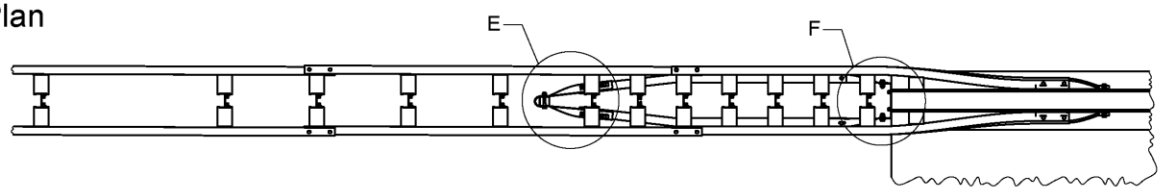


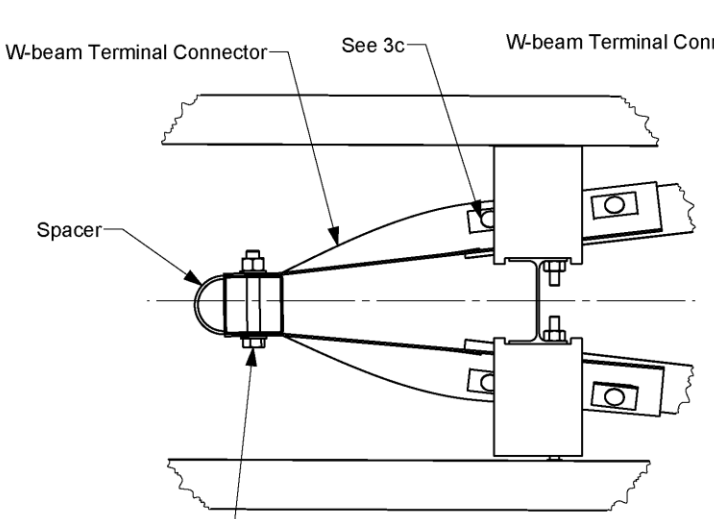
2a. All hardware is galvanized.
2b. All 7/8 Bolts are A325. One F436 Washer under each 7/8 Nut and Bolt head.
2c. 2" Guardrail Bolts with Rectangular Guardrail Washers at each W-beam Terminal Connector or nested W-beam joint.
2d. Rub Rail does not attach to Posts 19 and 20.
2e. Place with bolt heads on the side where traffic approaches the parapet, as shown.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #618851-01 Rail Transition to F-shape		2023-10-12
Drawn by GES	Scale 1:60	Sheet 2 of 9 Transition-Elevation

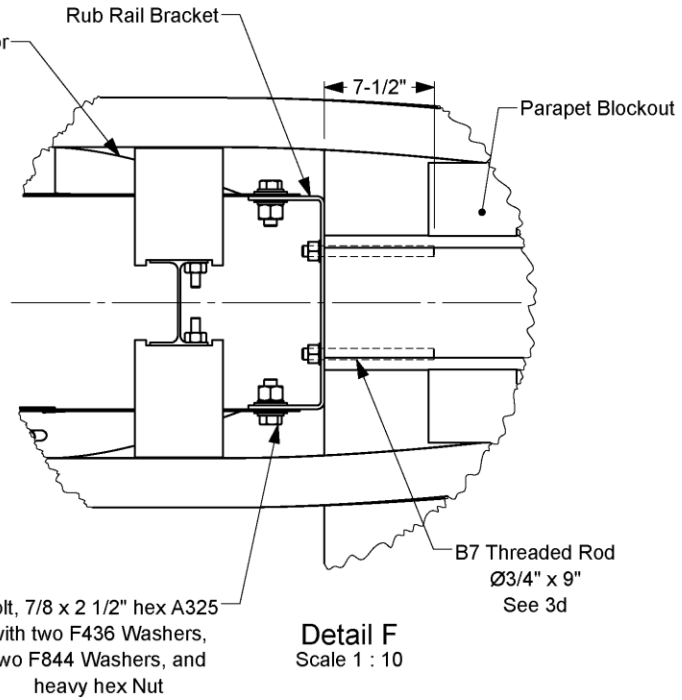
S:\Accreditation-17025-2017\EIR-000 Project Files\618851-Rail Transition to F-Shape-Schulz\Drafting, 618851\618851 Drawing

Transition-Plan





Detail E
Scale 1 : 10



Detail F
Scale 1 : 10

3a. All hardware is galvanized.

3b. All 7/8 Bolts are A325. One F436 Washer under each 7/8 Nut and Bolt head.

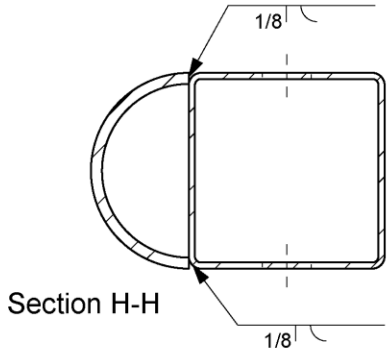
3c. 2" Guardrail Bolts at each W-beam Terminal Connector to W-beam joint, with a Rectangular Guardrail Washer between Terminal Connector and Nut or Bolt head.

3d. With F436 Washer and Heavy Hex Nut, 4 places. Secure with Hilti HIT-RE 500 V3 epoxy according to manufacturer's instructions, with 7-1/2" embedment.

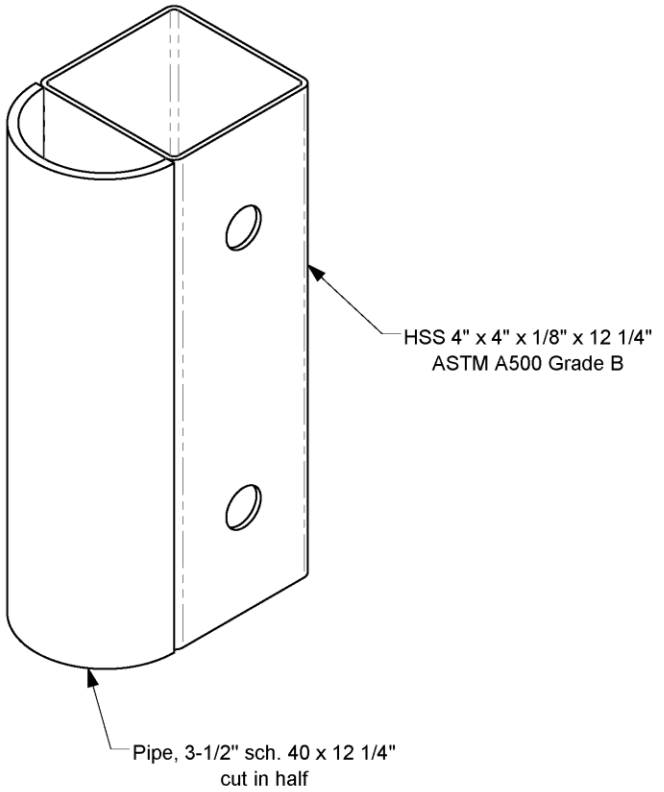
3e. Place with bolt heads on the side where traffic approaches the parapet, as shown.

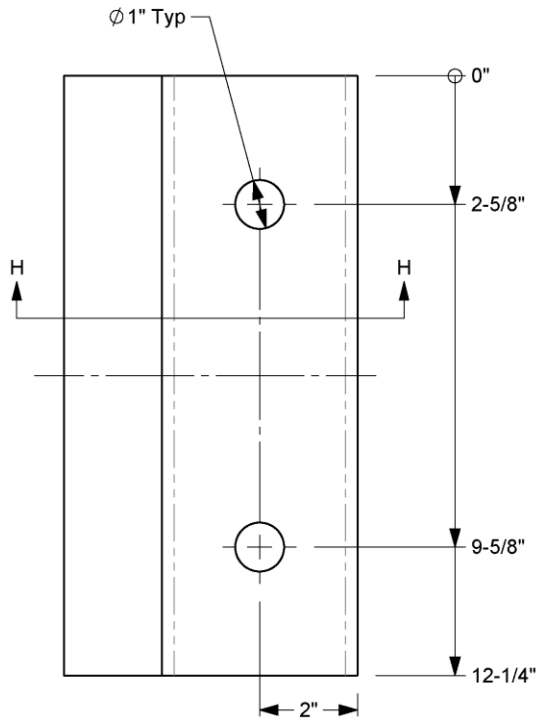
Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground
Project #618851-01 Rail Transition to F-shape		2023-10-12
Drawn by GES	Scale 1:60	Sheet 3 of 9 Transition-Plan

S:\Accreditation-17025-2017\EIR-000 Project Files\618851-Rail Transition to F-Shape-Schulz\Drafting, 618851\618851 Drawing



Spacer

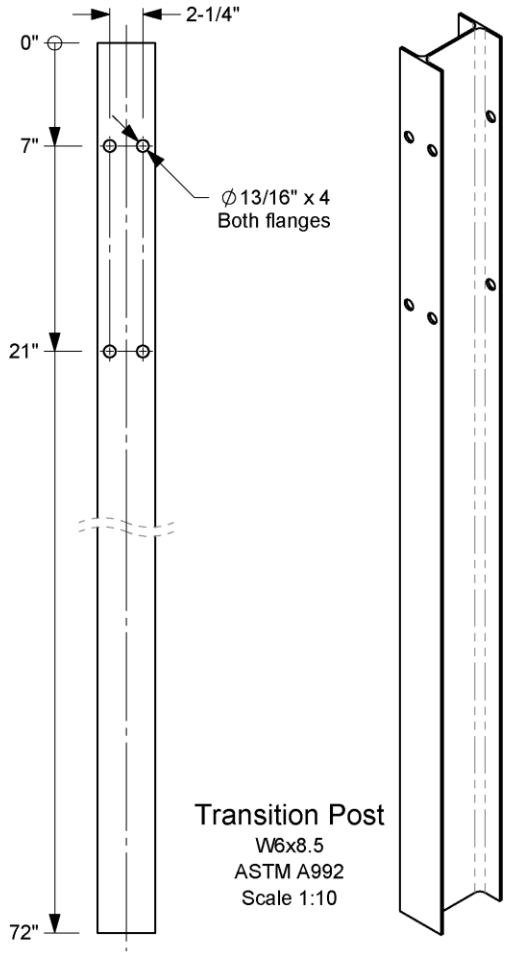




4a. Galvanize after fabrication is complete.

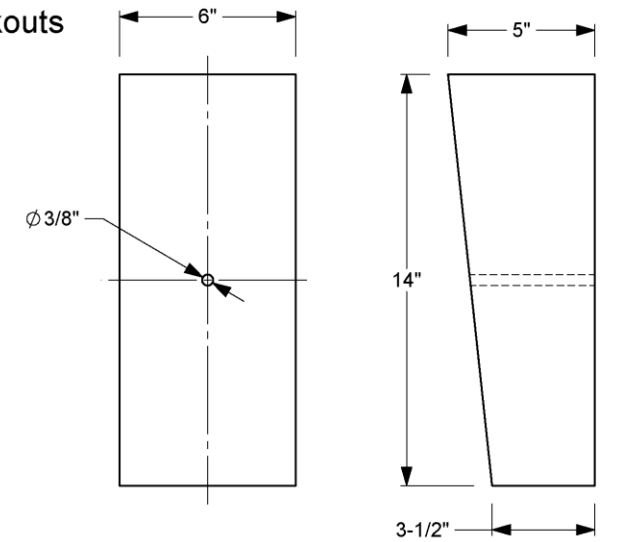
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #618851-01 Rail Transition to F-shape		2023-10-12
Drawn by GES	Scale 1:3	Sheet 4 of 9 Spacer

S:\Accreditation-17025-2017\EIR-000 Project Files\618851-Rail Transition to F-Shape-Schulz\Drafting, 618851\618851 Drawing

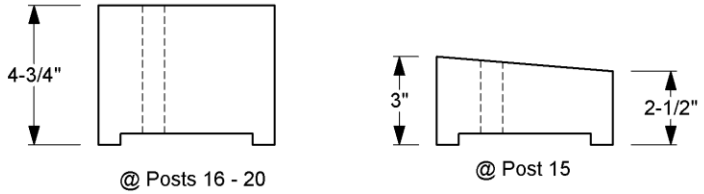


Transition Post
W6x8.5
ASTM A992
Scale 1:10

Post and Blockouts



Parapet Blockout
Pressure Treated Timber



@ Posts 16 - 20

@ Post 15

Rub Rail Blockouts
Plan View - See 5b

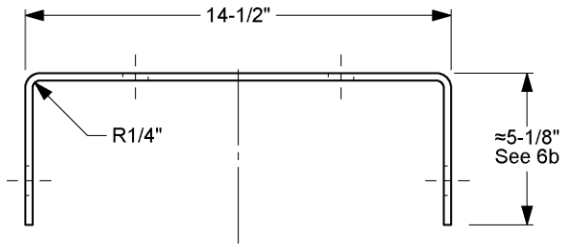
5a. Galvanize steel components after fabrication is complete.
5b. See Timber Blockout for W-section Post drawing sheet for all other dimensions.

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground	
Project #618851-01 Rail Transition to F-shape			2023-10-12
Drawn by GES	Scale 1:5	Sheet 5 of 9 Post and Blockouts	

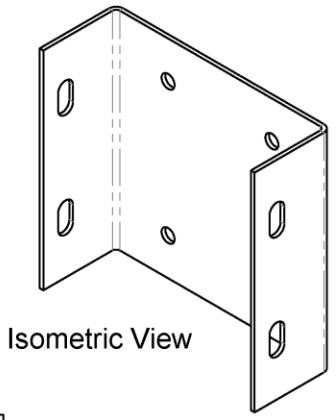
S:\Accreditation-17025-2017\EIR-000 Project Files\618851-Rail Transition to F-Shape-Schulz\Drafting, 618851\618851 Drawing

Rub Rail Bracket

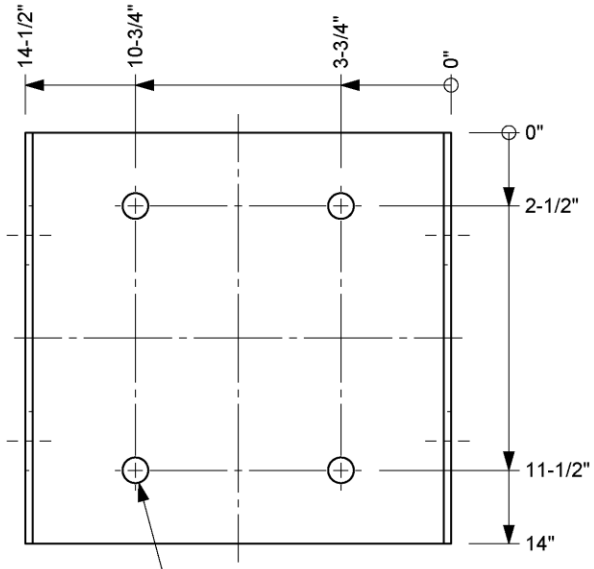
Plate, 14" x 1/4" x 24"
ASTM A36

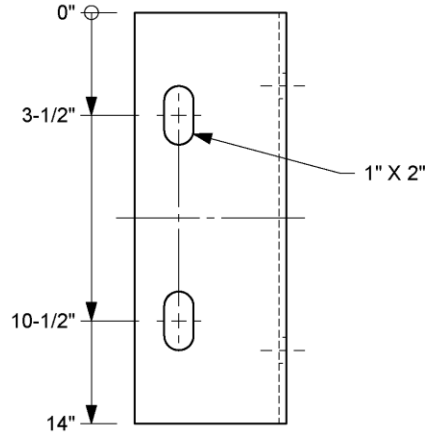


Plan View



Isometric View





Elevation Views

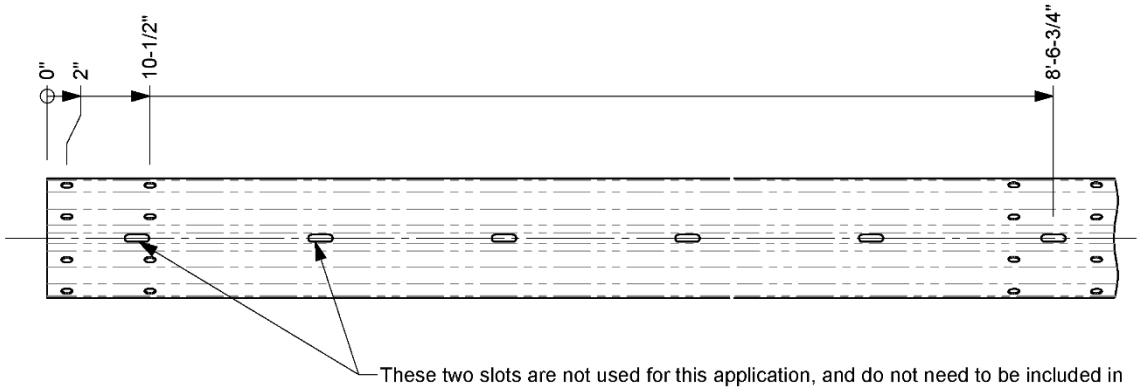
6a. Galvanize after fabrication is complete.
6b. Dimension is approximate. Plate is 24" before bending.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #618851-01 Rail Transition to F-shape		2023-10-12
Drawn by GES	Scale 1:5	Sheet 6 of 9 Rub Rail Bracket

S:\Accreditation-17025-2017\EIR-000 Project Files\618851-Rail Transition to F-Shape-Schulz\Drafting, 618851\618851 Drawing

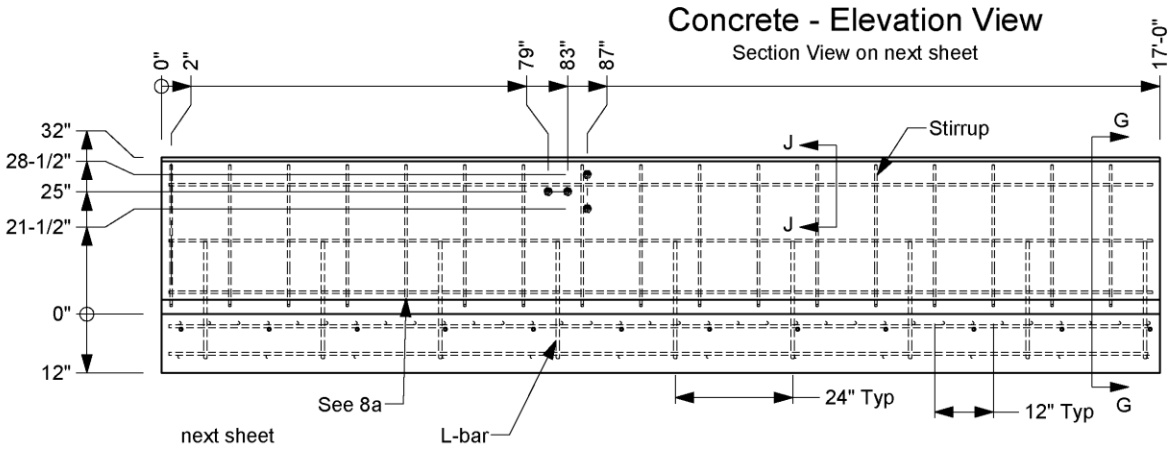
W-beam Rub Rail

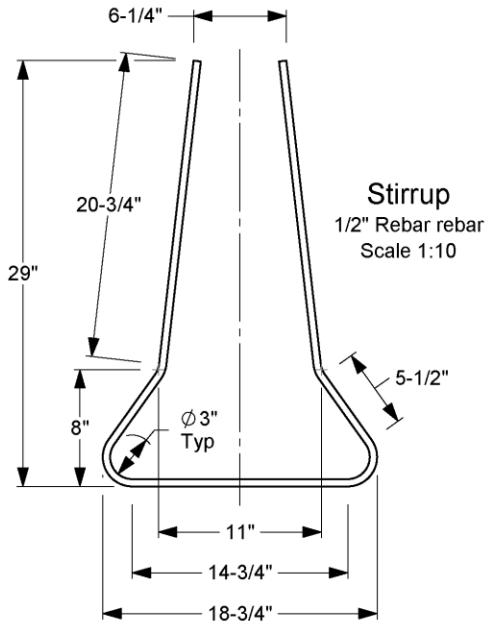
Standard 12-gauge 8-space W-beam, cut off to the length shown,
with additional slots for splice bolts added where shown

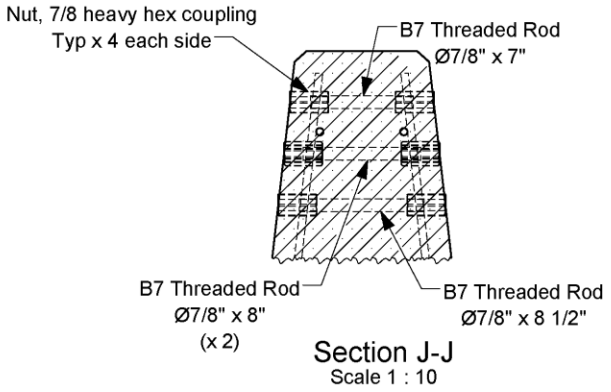


Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground	
Project #618851-01 Rail Transition to F-shape			2023-10-12
Drawn by GES	Scale 1:15	Sheet 7 of 9 W-beam Rub Rail	

S:\Accreditation-17025-2017\EIR-000 Project Files\618851-Rail Transition to F-Shape-Schulz\Drafting, 618851\618851 Drawing



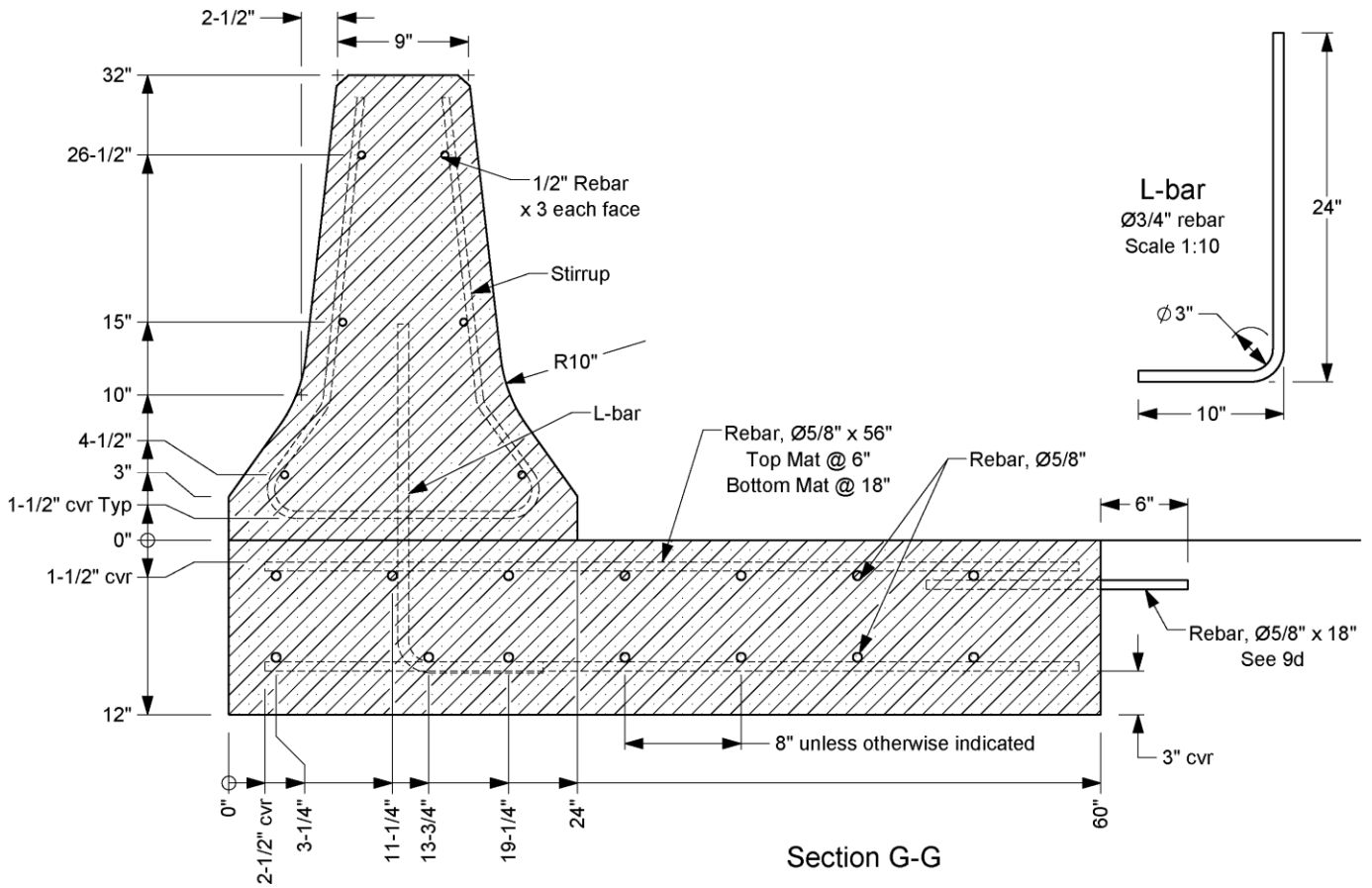




8a. Concrete is TxDOT Class C (3,600 psi).
8b. Insert B7 Threaded Rods to midpoint (+0, -1/8") of the coupling nuts.
8c. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).
8c. All rebar is grade 60.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #618851-01 Rail Transition to F-shape		2023-10-12
Drawn by GES	Scale 1:30	Sheet 8 of 9 Concrete - Elevation

S:\Accreditation-17025-2017\EIR-000 Project Files\618851-Rail Transition to F-Shape-Schulz\Drafting, 618851\618851 Drawing



Section G-G

9a. Concrete is TxDOT Class C (3,600 psi).

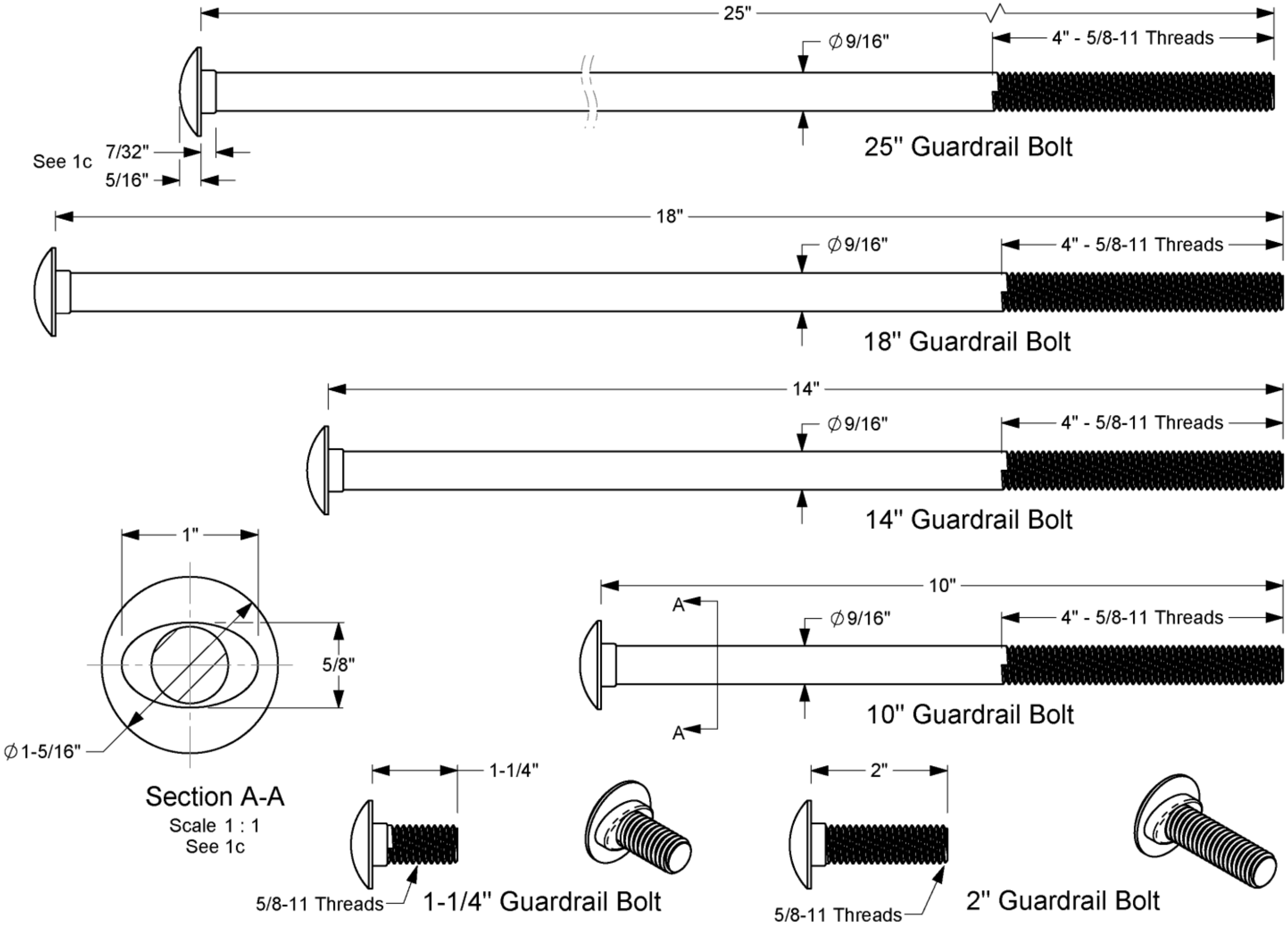
9b. 1" Chamfer (3/4" each way) top edges of parapet.

9c. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover). All rebar is grade 60.

9d. Secure in existing concrete with Hilti HIT-RE 500 V3 epoxy according to manufacturer's instructions, at 18" spacing with 6" embedment.

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground	
Project #618851-01 Rail Transition to F-shape			2023-10-12
Drawn by GES	Scale 1:10	Sheet 9 of 9 Concrete Cross Section	

S:\Accreditation-17025-2017\EIR-000 Project Files\618851-Rail Transition to F-Shape-Schulz\Drafting, 618851\618851 Drawing

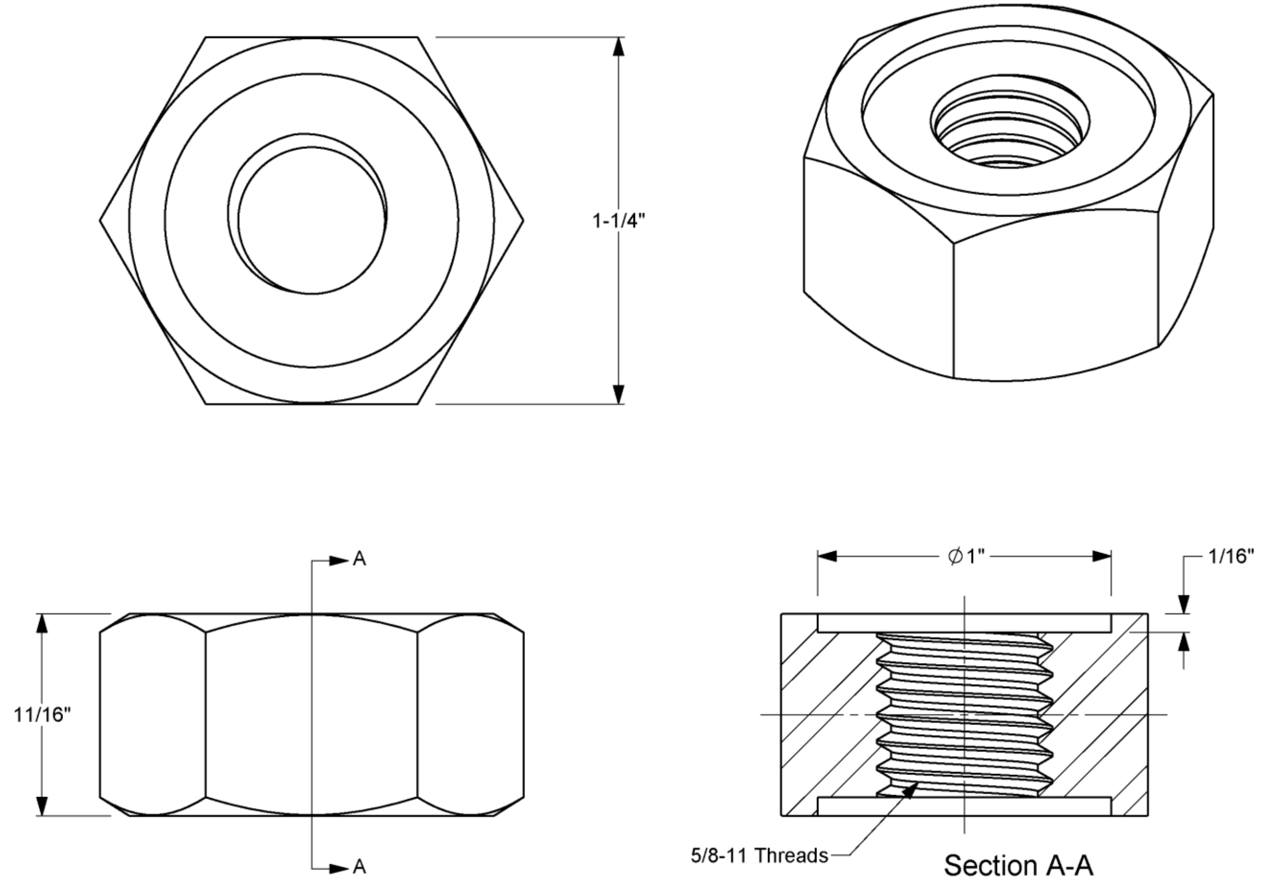


1a. Material is ASTM A307.
1b. All bolt sizes not used in all projects. See system drawing.
1c. Head and shoulder dimensions typical all lengths.

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground
Guardrail Bolt		2020-07-08
Drawn by GES/WS	Scale 1:2	Sheet 1 of 1

T:\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\Guardrail Bolt

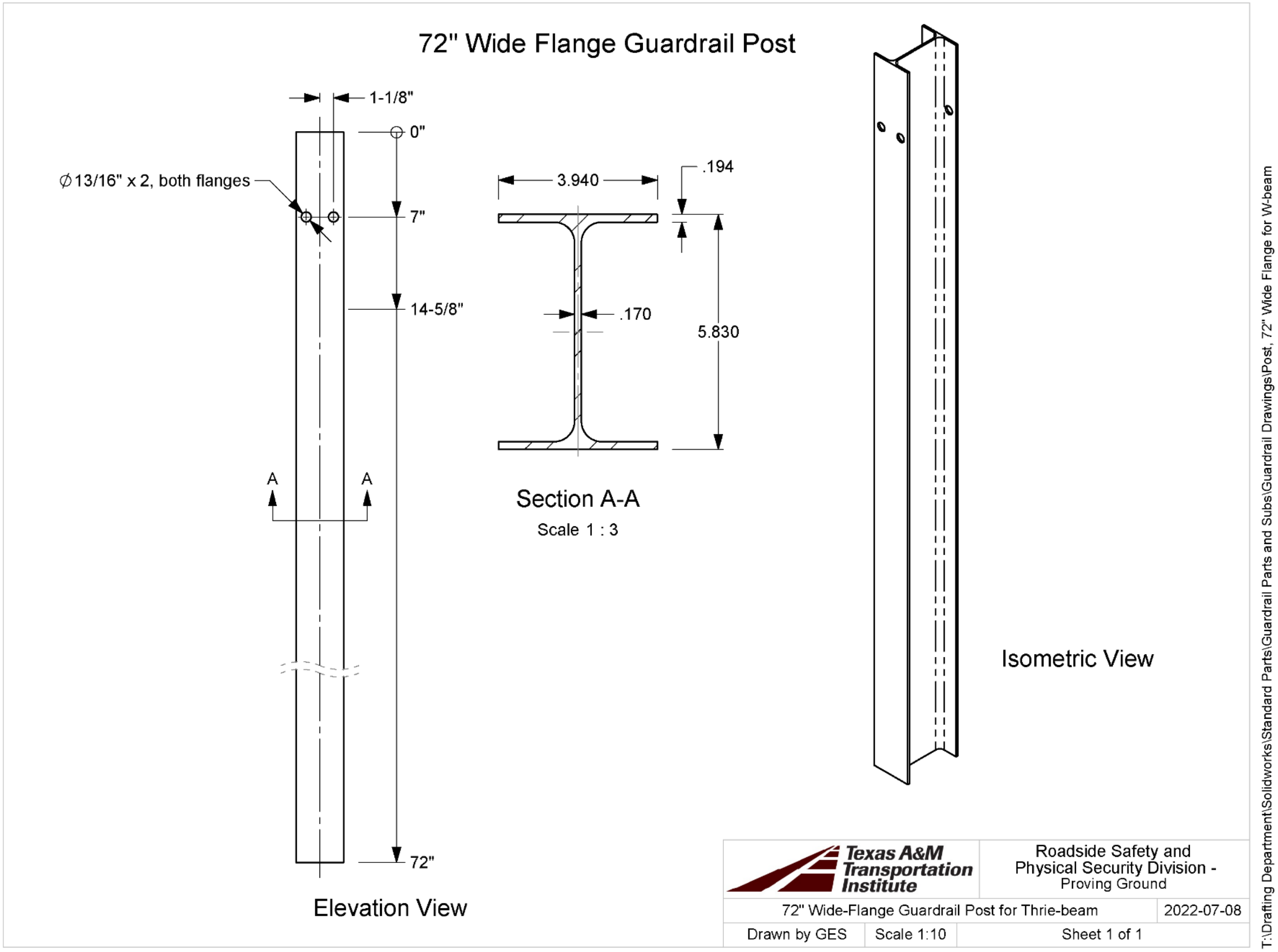
Recessed Guardrail Nut



1a. Material is ASTM A 563 Grade A.

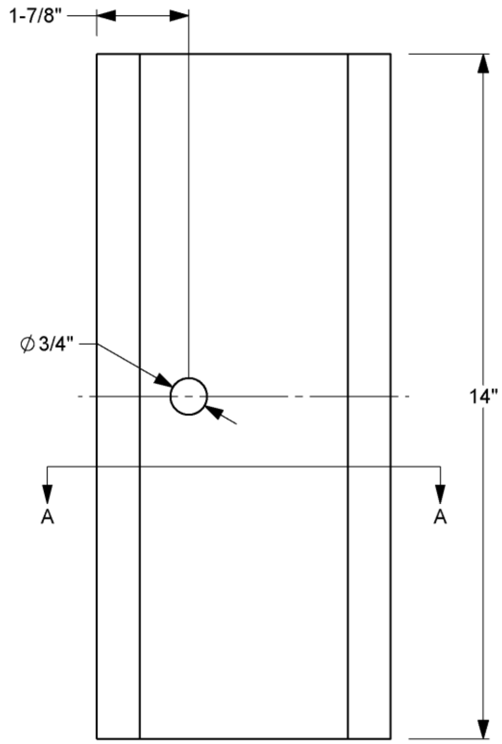
Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground	
Recessed Guardrail Nut			2022-07-18
Drawn by GES	Scale 2:1	Sheet 1 of 1	

T:\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\Nut, Recessed Guardrail

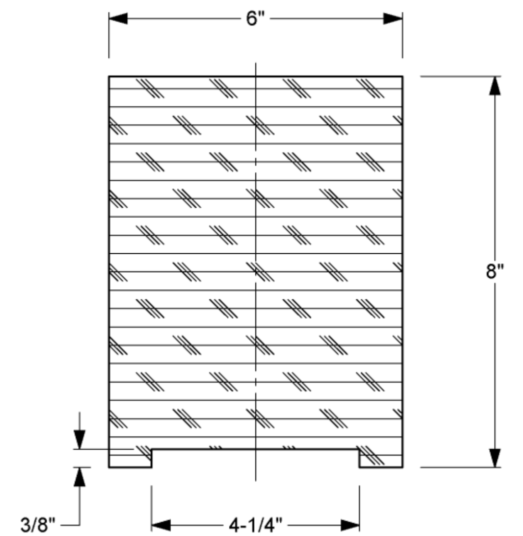

72" Wide Flange Guardrail Post
1-1/8"
0"
∅13/16" x 2, both flanges
7"
14-5/8"
A
A
72"
Elevation View
3.940
.194
.170
5.830
Section A-A
Scale 1 : 3
Isometric View
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
72" Wide-Flange Guardrail Post for Thrie-beam
2022-07-08
Drawn by GES
Scale 1:10
Sheet 1 of 1
T:\Drafting Department\Solidworks\Standard Parts and Subs\Guardrail Parts\Guardrail Drawings\Post, 72" Wide Flange for W-beam

Timber Blockout for W-section Post

All dimensions except hole diameter are nominal



Elevation View

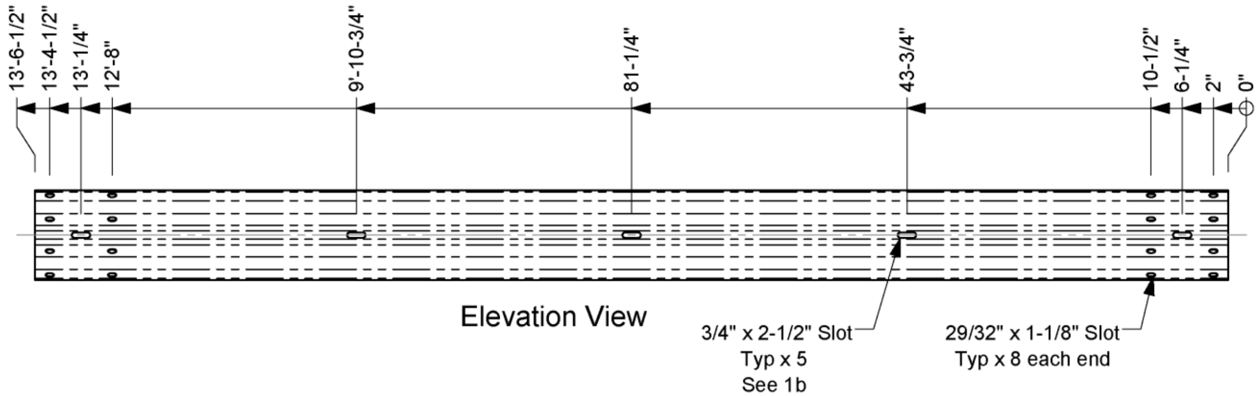


Section A-A

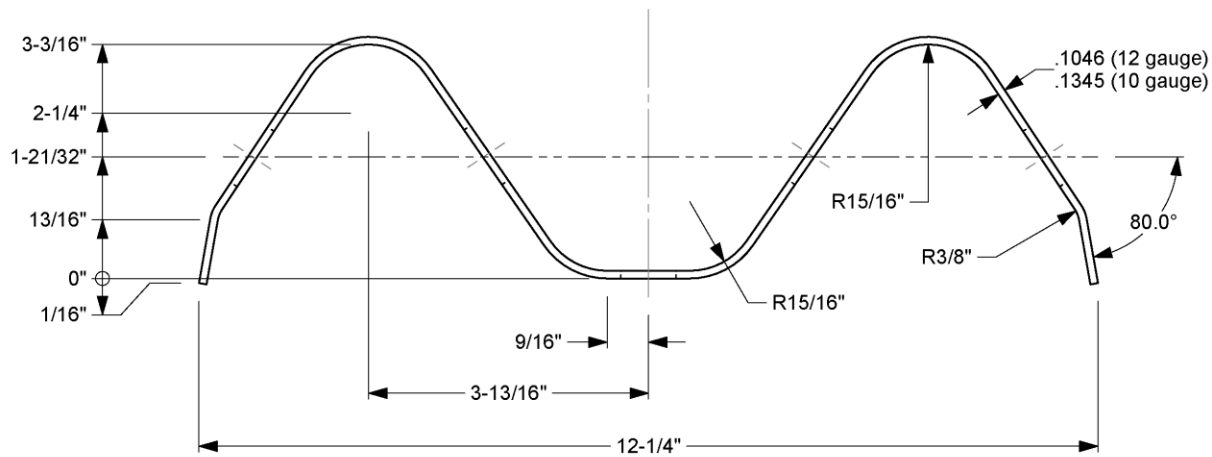
1a. Timber blockouts are treated with a preservative in accordance with AASHTO M 133 after all cutting and drilling.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Timber Blockout, for W-section Post		2022-12-16
Drawn by GES	Scale 1:3	Sheet 1 of 1

T:\Drafting Department\Solidworks\Standard Parts and Subs\Guardrail Parts and Subs\Guardrail Drawings\Timber Blockout for W-section Post



Elevation View



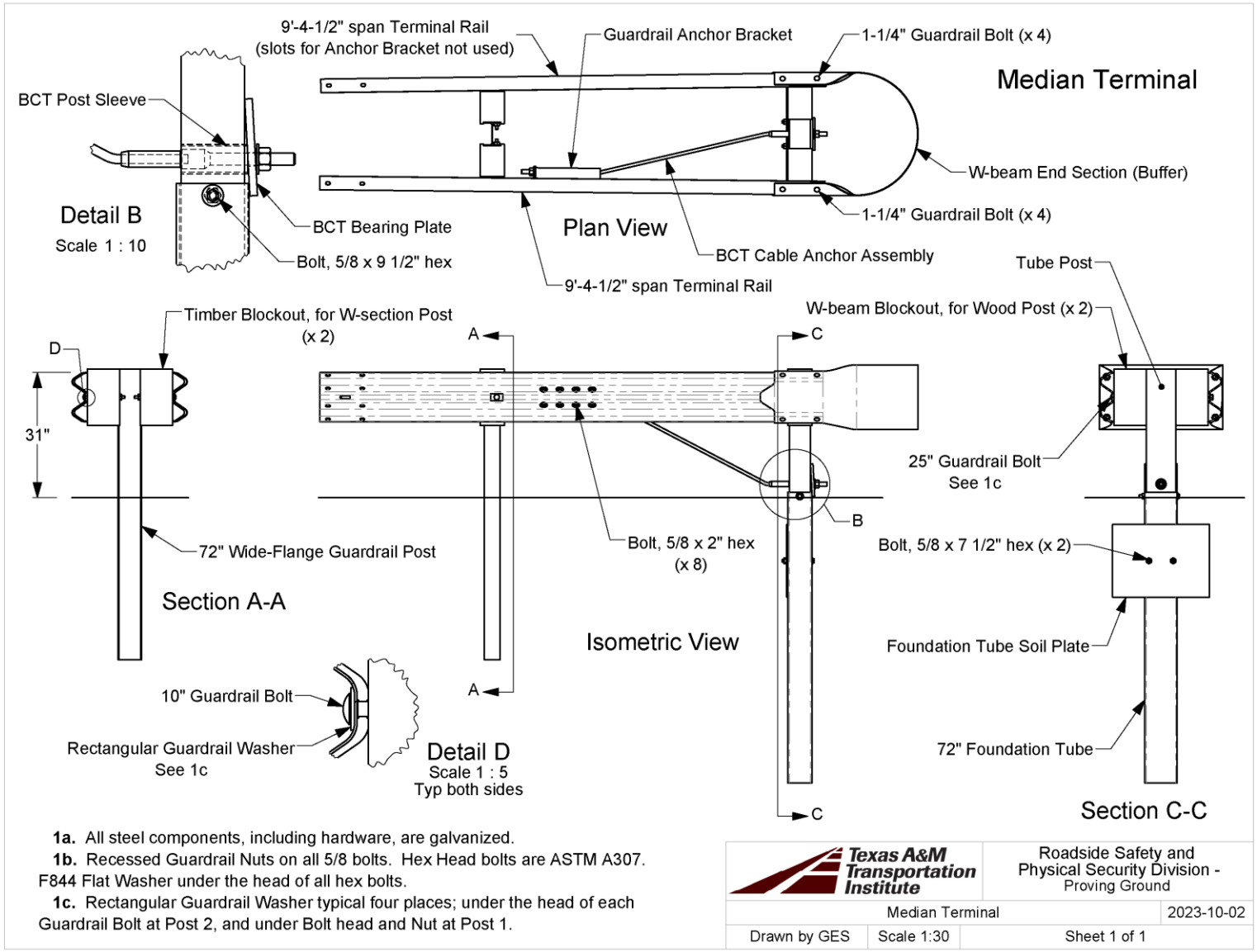
Section View

1a. Manufacture per AASHTO M180 specifications.

1b. 4-space Guardrail is shown. Slots typical x 3 for 2-space W-beam spaced at 75", and typical x 9 for 8-space W-beam spaced at 18-3/4". Slots are typical x 4 at 37-1/2" for 9'-4-1/2" span W-beam.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
W-beam Guardrail		2022-07-13
Drawn by GES	Scale 1:20	Sheet 1 of 1

T:\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\W-Beam Guardrail



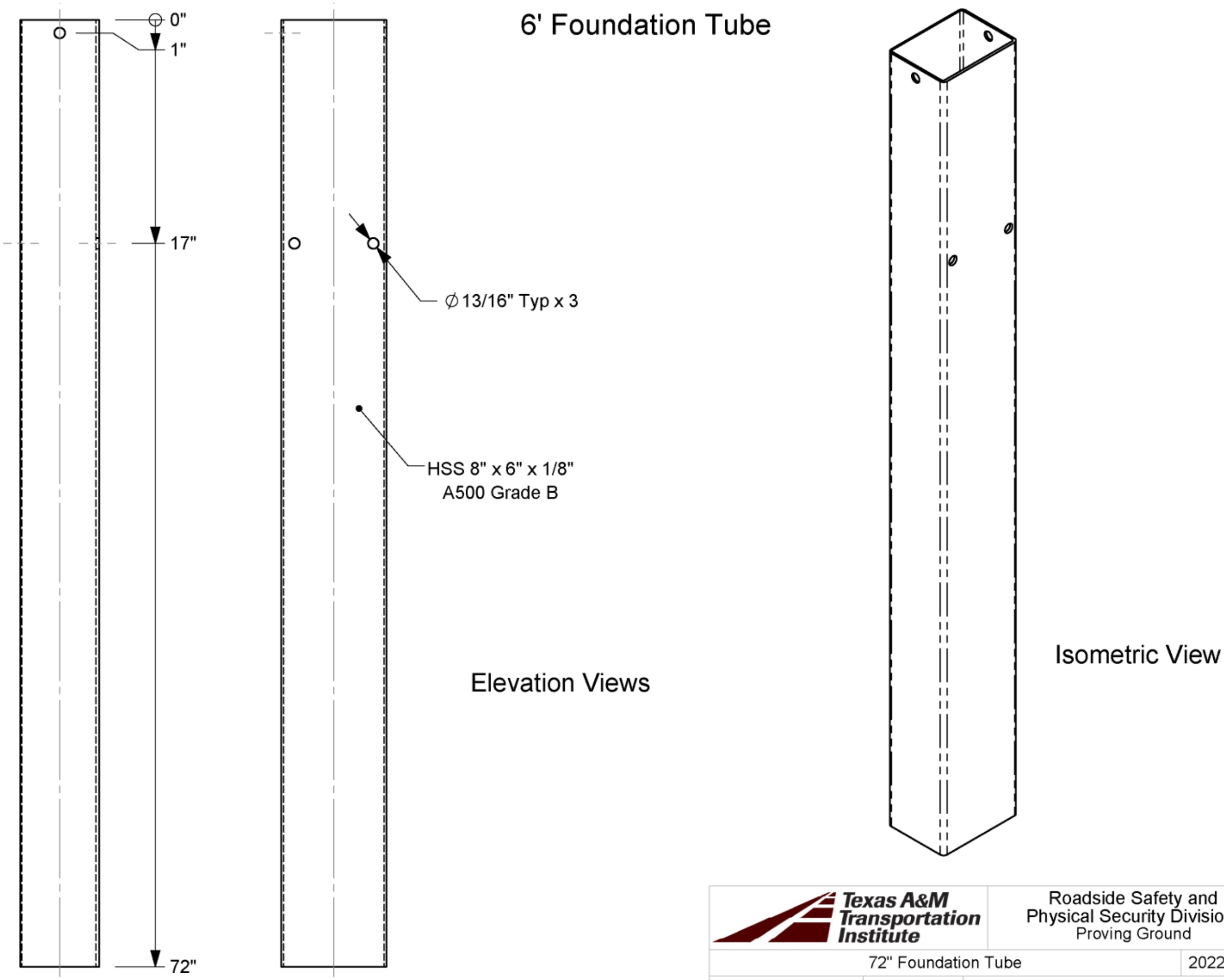
1a. All steel components, including hardware, are galvanized.

1b. Recessed Guardrail Nuts on all 5/8 bolts. Hex Head bolts are ASTM A307. F844 Flat Washer under the head of all hex bolts.

1c. Rectangular Guardrail Washer typical four places; under the head of each Guardrail Bolt at Post 2, and under Bolt head and Nut at Post 1.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Median Terminal		2023-10-02
Drawn by GES	Scale 1:30	Sheet 1 of 1

S:\Accreditation-17025-2017\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\Median Terminal

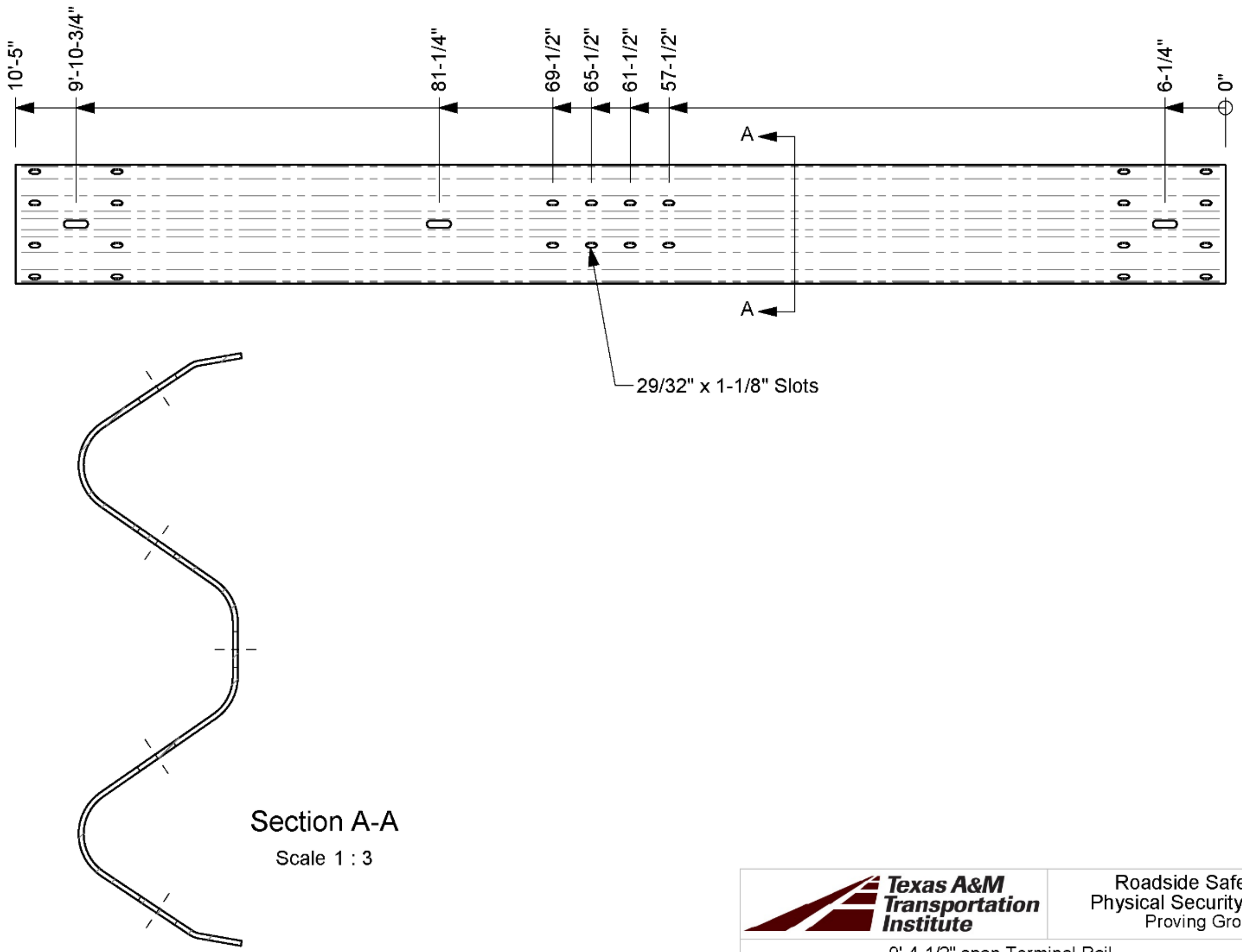


Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
72" Foundation Tube		2022-07-08
Drawn by GES	Scale 1:10	Sheet 1 of 1

T:\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\6' Foundation Tube

9'-4-1/2" span Terminal Rail

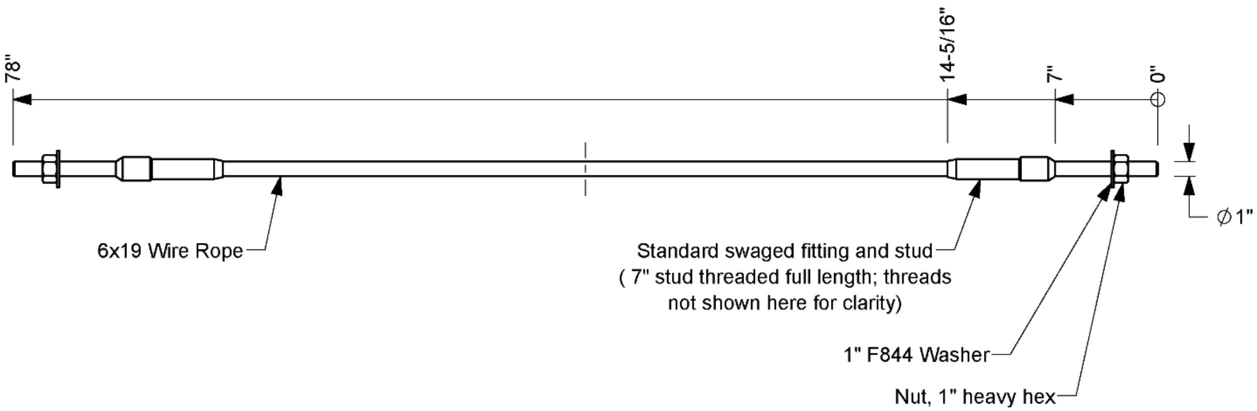
See W-beam Guardrail Drawing for all dimensions not shown here.



Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
9'-4-1/2" span Terminal Rail		2023-07-19
Drawn by GES	Scale 1:15	Sheet 1 of 1

S:\Accreditation-17025-2017\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\9'-4.5in span Terminal Rail

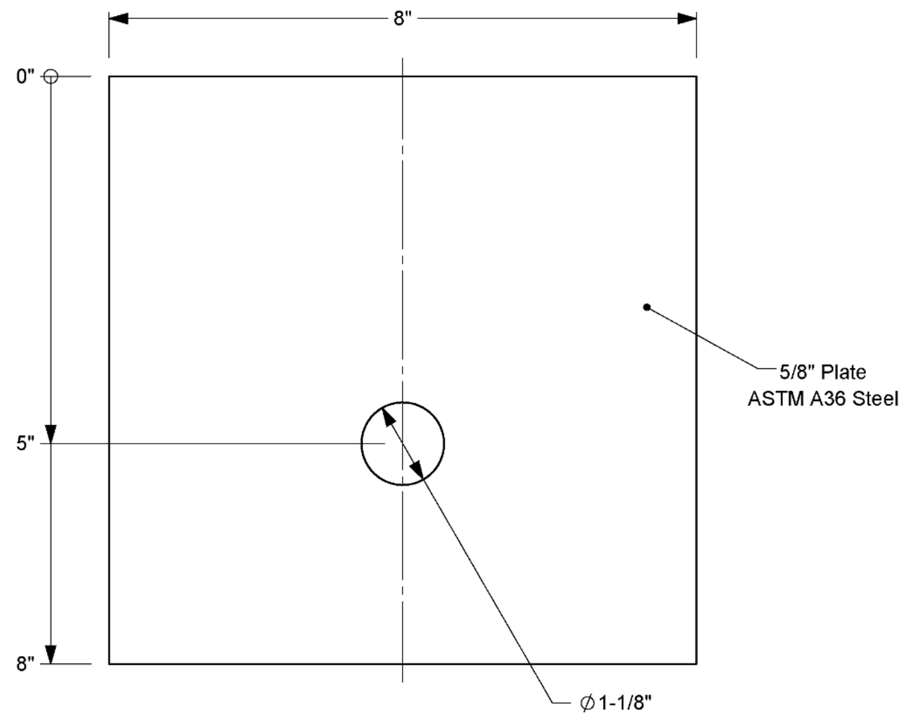
BCT Anchor Cable



Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground	
BCT Anchor Cable			2020-02-24
Drawn by GES	Scale 1:10	Sheet 1 of 1	

S:\Accreditation-17025-2017\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\BCT Anchor Cable

BCT Bearing Plate

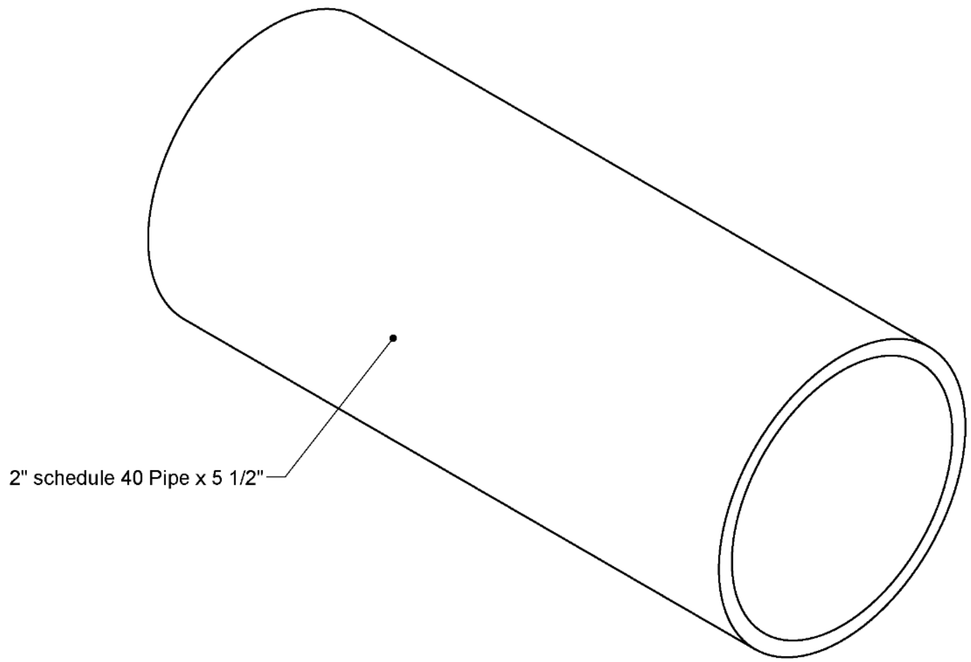


Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground

BCT Bearing Plate		2022-08-05
Drawn by GES	Scale 1:2	Sheet 1 of 1

T:\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\BCT Bearing Plate

BCT Post Sleeve

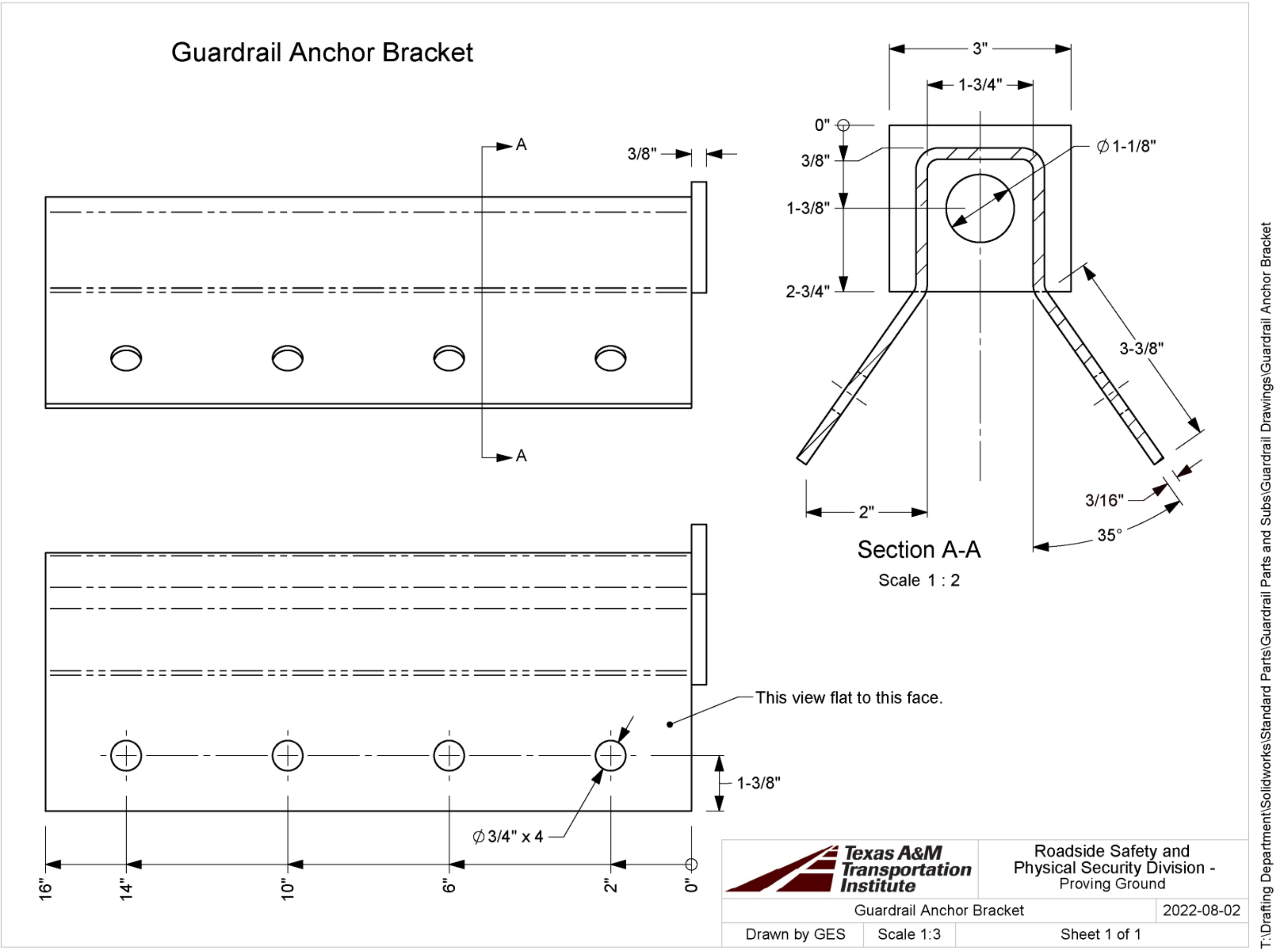


Texas A&M Transportation Institute

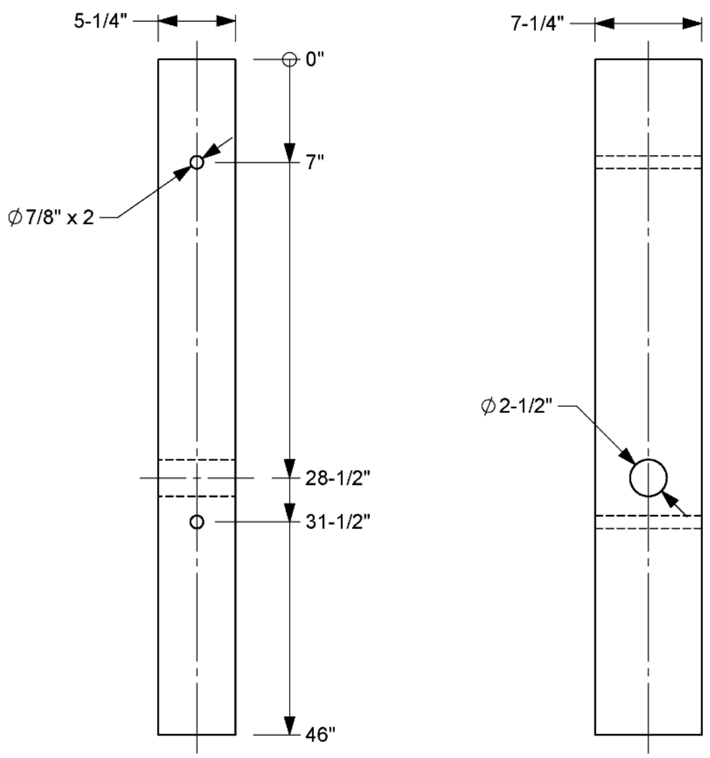
Roadside Safety and Physical Security Division - Proving Ground

BCT Post Sleeve		2022-08-05
Drawn by GES	Scale 1:1	Sheet 1 of 1

T:\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\BCT Post Sleeve


Guardrail Anchor Bracket
A
A
3/8"
3"
1-3/4"
0"
3/8"
1-3/8"
2-3/4"
∅ 1-1/8"
3-3/8"
2"
3/16"
35°
Section A-A
Scale 1 : 2
This view flat to this face.
1-3/8"
∅ 3/4" x 4
16"
14"
10"
6"
2"
0"
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Guardrail Anchor Bracket
2022-08-02
Drawn by GES
Scale 1:3
Sheet 1 of 1
T:\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\Guardrail Anchor Bracket

Post, Tube



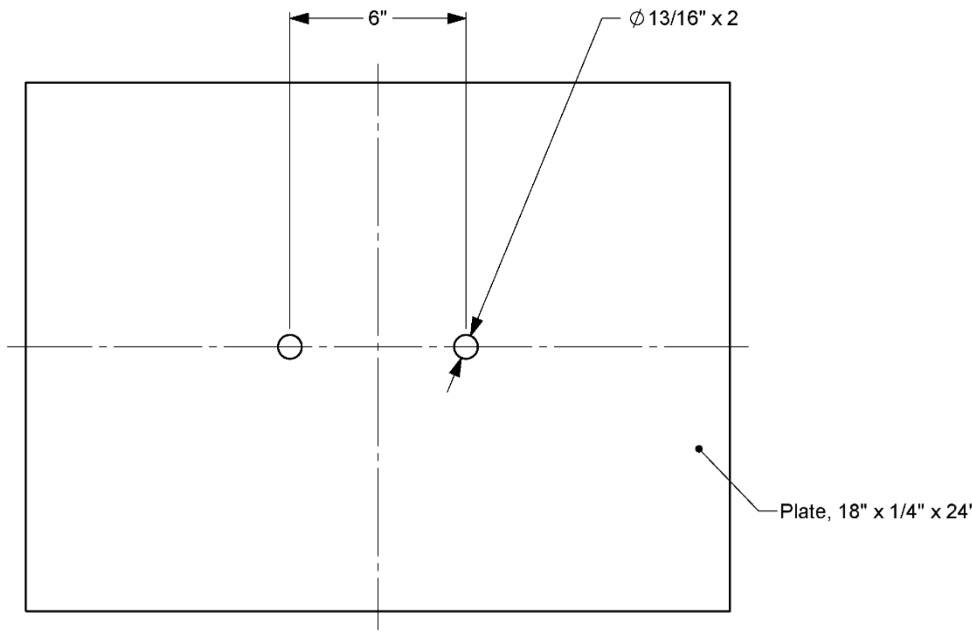
Elevation Views

1a. Timber posts are treated with a preservative in accordance with AASHTO M 133 after all cutting and drilling.

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground	
Tube Post			2022-07-08
Drawn by GES	Scale 1:10	Sheet 1 of 1	

T:\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\Post, Tube

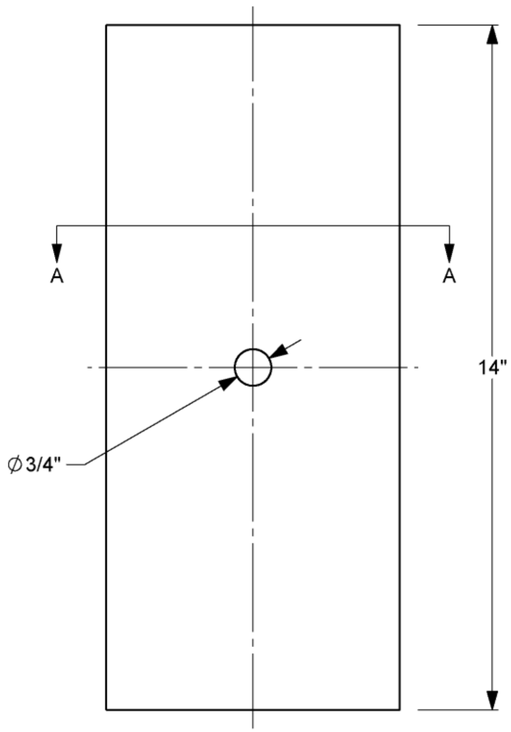
Soil Plate



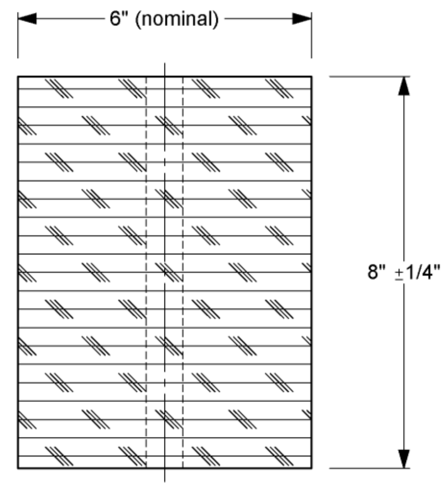
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Foundation Tube Soil Plate		2020-02-24
Drawn by GES	Scale 1:5	Sheet 1 of 1

S:\Accreditation-17025-2017\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\Soil Plate

Timber Blockout for 6x8 Wood Post



Elevation View

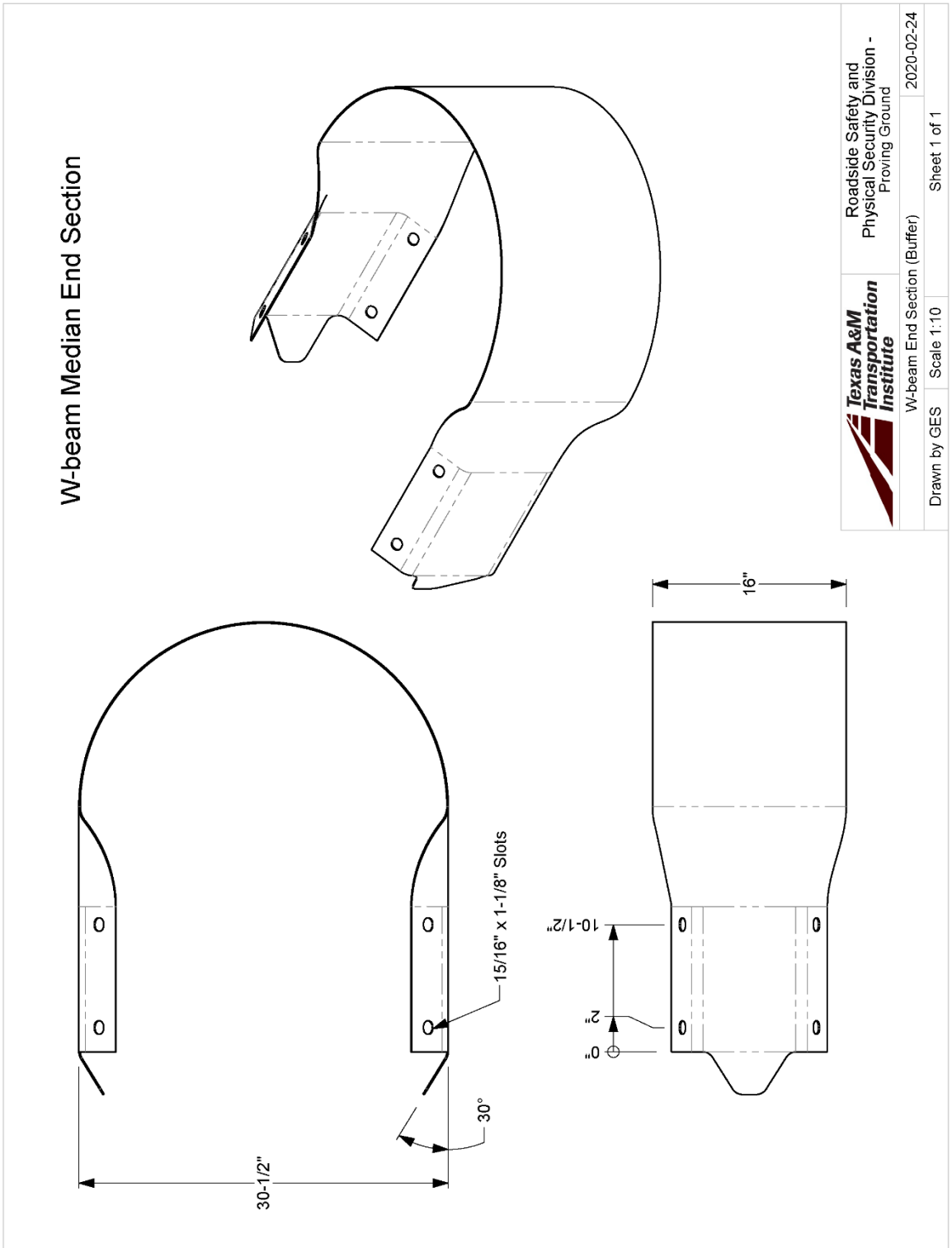


Section A-A

1a. Timber blockouts are treated with a preservative in accordance with AASHTO M 133 after all cutting and drilling.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
W-beam Blockout, for Wood Post		2020-02-24
Drawn by GES	Scale 1:3	Sheet 1 of 1

S:\Accreditation-17025-2017\Drafting Department\Solidworks\Standard Parts\Guardrail Parts and Subs\Guardrail Drawings\Timber Blockout for 6x8 Wood Post


W-beam Median End Section
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
W-beam End Section (Buffer)
2020-02-24
Drawn by GES
Scale 1:10
Sheet 1 of 1
16"
10-1/2"
2"
0"
15/16" x 1-1/8" Slots
30°
30-1/2"

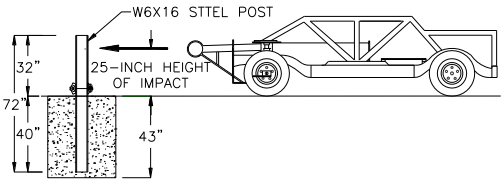
APPENDIX B. SUPPORTING CERTIFICATION DOCUMENTS

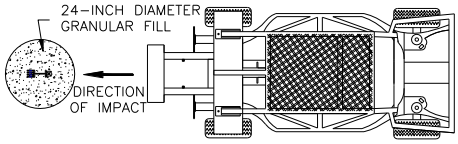
Dynamic Test Setup

Post-Test Photo of post

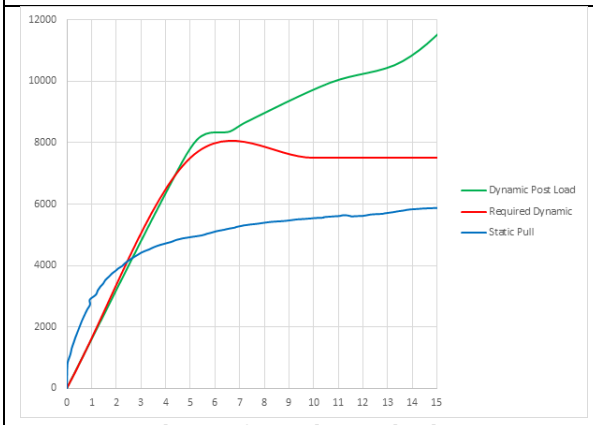
Static Load Test

Post-Test Photo

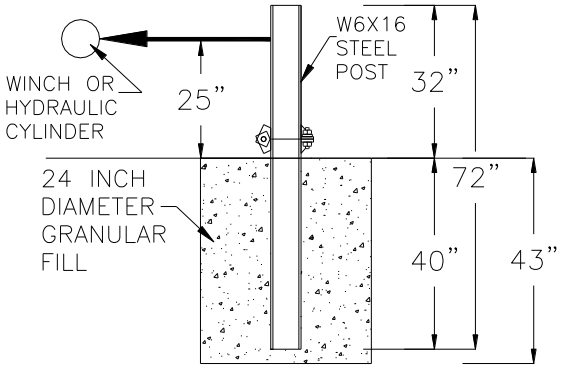




Dynamic Test Installation Details



Comparison of Load vs. Displacement



Static Load Test Installation Details

Date	2020-02-02
Test Facility and Site Location	TTI Proving Ground, 3100 SH 47, Bryan, TX 77807
In Situ Soil Description (ASTM D2487)	Sandy gravel with silty fines
Fill Material Description (ASTM D2487) and sieve analysis	Type D Grade 1 Crushed Concrete Road Base
Description of Fill Placement Procedure	12-inch lifts tamped with a pneumatic compactor for 20 sec
Bogie Weight	2020 lb
Impact Velocity	19.2 mph

Soil Strength Performance Test

MASH, Appendix B

Project Number: 618851-01-1

Date of Crash Test: 2023-10-16

Post No. 1 of 2 Fill Moisture: % Native Moisture: %

Temperature: 50 ° F Humidity: 86%

File Name:

Displacement (in.)	*Pull Force (Lbf)	Minimum Force (Lbf)	Pass / Fail
5	7818	3940	P
10	9000	5500	P
15	9600	6540	P

*Do not exceed 10,000 lbf

Test Post Location: 42 ft ☒ South ☐ North of terminal post

ft ☐ East ☐ West of terminal post

Performed by: Ed & Matt Date: 2023-10-16

618851

CMC STEEL TEXAS
1 STEEL MILL DRIVE
SEGUIN TX 78155-7510

CERTIFIED MILL TEST REPORT

For additional copies call
800-227-6489

We hereby certify that the test results presented here are accurate and conform to the reported grade specification

Rolando A Davila
Quality Assurance Manager

HEAT NO.:3121534 SECTION: REBAR 19MM (#6) 20'0" 420/60 GRADE: ASTM A615-22 Gr 420/60 ROLL DATE: 04/03/2023 MELT DATE: 03/27/2023 Cert. No.: 85386233 / 121534A619	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 85386233 BOL#: 75303443 CUST PO#: 946841 CUST P/N: DLVRY LBS / HEAT: 10815.000 LB DLVRY PCS / HEAT: 360 EA

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.44%	Bend Test Diameter	3.750IN		
Mn	0.88%				
P	0.009%				
S	0.036%				
Si	0.17%				
Cu	0.34%				
Cr	0.08%				
Ni	0.17%				
Mo	0.062%				
V	0.000%				
Cb	0.001%				
Sn	0.013%				
Al	0.001%				
Yield Strength test 1	67.4ksi				
Tensile Strength test 1	107.6ksi				
Elongation test 1	16%				
Elongation Gage Lgth test 1	8IN				
Tensile to Yield ratio test1	1.60				
Bend Test 1	Passed				

The Following is true of the material represented by this MTR:

*Material is fully killed and is Hot Rolled Steel
*100% melted, rolled, and manufactured in the USA
*EN10204:2004 3.1 compliant
*Contains no weld repair
*Contains no Mercury contamination
*Manufactured in accordance with the latest version of the plant quality manual
*Meets the "Buy America" requirements of 23 CFR635.410, 49 CFR 661
*Warning: This product can expose you to chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov

REMARKS :

CMC STEEL TEXAS
1 STEEL MILL DRIVE
SEGUIN TX 78155-7510

CERTIFIED MILL TEST REPORT

For additional copies call
830-372-8771

We hereby certify that the test results presented here are accurate and conform to the reported grade specification

Rolando A Davila
Quality Assurance Manager

HEAT NO.:3109273 SECTION: REBAR 16MM (#5) 20'0" 420/60 GRADE: ASTM A615-20 Gr 420/60 ROLL DATE: 10/02/2021 MELT DATE: 09/28/2021 Cert. No.: 83626709 / 109273A371	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 83626709 BOL#: 74427251 CUST PO#: 898366 CUST P/N: DLVRY LBS / HEAT: 48072.000 LB DLVRY PCS / HEAT: 2304 EA

Characteristic	Value
C	0.45%
Mn	0.88%
P	0.012%
S	0.049%
Si	0.16%
Cu	0.33%
Cr	0.15%
Ni	0.16%
Mo	0.063%
V	0.000%
Cb	0.001%
Sn	0.012%
Al	0.000%
Yield Strength test 1	67.5ksi
Tensile Strength test 1	107.9ksi
Elongation test 1	14%
Elongation Gage Lgth test 1	8IN
Tensile to Yield ratio test1	1.60
Bend Test 1	Passed

Characteristic	Value
Bend Test Diameter	2.188IN

Characteristic	Value

The Following is true of the material represented by this MTR:

**Material is fully killed*
**100% melted and rolled in the USA*
**EN10204:2004 3.1 compliant*
**Contains no weld repair*
**Contains no Mercury contamination*
**Manufactured in accordance with the latest version of the plant quality manual*
**Meets the "Buy America" requirements of 23 CFR635.410, 49 CFR 661*
**Warning: This product can expose you to chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov*

REMARKS :

CMC STEEL TEXAS
1 STEEL MILL DRIVE
SEGUIN TX 78155-7510

CERTIFIED MILL TEST REPORT

For additional copies call
830-372-8771

We hereby certify that the test results presented here are accurate and conform to the reported grade specification

Rolando A Davila
Quality Assurance Manager

HEAT NO.:3111165 SECTION: REBAR 13MM (#4) 20'0" 420/60 GRADE: ASTM A615-20 Gr 420/60 ROLL DATE: 12/12/2021 MELT DATE: 12/07/2021 Cert. No.: 83693955 / 111165A130	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 83693955 BOL#: 74533988 CUST PO#: 904440 CUST P/N: DLVRY LBS / HEAT: 2191.000 LB DLVRY PCS / HEAT: 164 EA

Characteristic	Value
C	0.46%
Mn	0.91%
P	0.010%
S	0.055%
Si	0.19%
Cu	0.27%
Cr	0.09%
Ni	0.14%
Mo	0.041%
V	0.000%
Cb	0.000%
Sn	0.009%
Al	0.002%
Yield Strength test 1	70.1ksi
Tensile Strength test 1	107.8ksi
Elongation test 1	13%
Elongation Gage Lgth test 1	8IN
Tensile to Yield ratio test1	1.54
Bend Test 1	Passed

Characteristic	Value
Bend Test Diameter	1.750IN

The Following is true of the material represented by this MTR:

**Material is fully killed*
**100% melted and rolled in the USA*
**EN10204:2004 3.1 compliant*
**Contains no weld repair*
**Contains no Mercury contamination*
**Manufactured in accordance with the latest version of the plant quality manual*
**Meets the "Buy America" requirements of 23 CFR635.410, 49 CFR 661*
**Warning: This product can expose you to chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov*

REMARKS :

04-24-2015 03:09 Load - 2248928 BL - 3759560 BLR466
Rik-Mar Fabricators, Inc Heat - U00058
Cust. PO - Order-Line - 12316149 / 3

3½ Sch 40 PE

SOUTHLAND TUBE INCORPORATED
3525 Richard Arrington, Jr., Blvd. N.
Birmingham, AL 35234
Phone (205) 251-1884
Lab Fax (205) 421-4561
Lab@SouthlandTube.com

TEST REPORT

Customer Name: KLOECKNER METALS CORPORATION
Customer PO No: 6919375

Spec/Grade:	ASTM A500-10a Grade B/C	Heat No.:	U00058
Description:	CARBON STEEL TUBING	Print Date:	4/22/2015
Size/Length:	3.5" Sch 40 21'	Wall Thickness:	0.3260

Carbon (C):	0.2300	Tin (Sn):	0.0080	Vanadium (V):	0.0020
Manganese (Mn):	0.8600	Nickel (Ni):	0.0100	Columbium (Cb):	0.0070
Phosphorus (P):	0.0110	Chromium (Cr):	0.0400	Titanium (Ti):	0.0010
Sulphur (S):	0.0110	Molybdenum (Mo):	0.0090	Boron (B):	0.0003
Silicon (Si):	0.0160	Aluminum (Al):	0.0230	Calcium (Ca):	0.0000
Copper (Cu):	0.0300	Nitrogen (N):	0.0070	Carbon Equiv. (CE):	0.3862

Sample Number	Sample Date	Tensile (psi)	Yield (psi)	Elongation (%)
SL47660	2/12/2015	74,700	63,700	27.50

We hereby certify that the above figures are correct as contained in the records of this company. Testing, where it is performed, is performed according to applicable standards (Yield Strength determined using 0.2% offset method and Elongation is measured over a 2" gauge length). Finished goods that require destructive testing by either flattening or flaring to meet the requirements of the standard to which they are certified have been destructively tested in accordance with the pertinent standard.

PO 6192S1
Item # 1

Ron Lowery
Laboratory Manager
Southland Tube Incorporated

Melted & Manufactured in the U.S.A.

STI Pickup No: 04LB161 STI Order No: 00362474 STI Item No: 4.0RS4021

08-11-2023 03:17 Load - 4349337 BL - 3937214 blr466

Custom Fabricators Heat - SN2554

Cust. PO - 04109 Order - 22703290

NUCOR TUBULAR PRODUCTS

6226 W. 74TH STREET
CHICAGO, IL 60638
Tel: 708-496-0380
Fax: 708-563-1950

https://www.nucortubular.com
https://www.ntpportal.com
Certificate Number: BHM 30334

Sold By:
NUCOR TUBULAR PRODUCTS INC.
BIRMINGHAM DIVISION
3525 RICHARD ARRINGTON JR. BLVD N
BIRMINGHAM, AL 35201
Tel: 205 251-1884
Fax: 205 251-1553

Purchase Order No: 7854824
Sales Order No: BHM 509353 - 1
Bill of Lading No: BHM 59472 - 1
Invoice No:

Shipped: 7/18/2023
Invoiced:

Sold To:
1187 - KLOECKNER METALS - BUDA/HOUSTON
500 COLONIAL PARKWAY
SUITE 500
ROSWELL, GA 30076

Ship To:
2 - KLOECKNER METALS CORP BUDA
2560 SOUTH LOOP 4
BUDA, TX 78610

CERTIFICATE of ANALYSIS and TESTS

Customer Part No:

TUBING A500 GRADE B(C)
4" SQ X 1/8" X 40'

Certificate No: BHM 30334
Test Date: 7/17/2023

Total Pieces	Total Weight Lbs
12	3,101

Bundle Tag	Mill	Heat	Specs	Y/T Ratio	Pieces	Weight Lbs
283734	40N	SN2554	YLD=68700/TEN=75600/ELG=24.8/RWB=84	0.9087	12	3,101

Mill #: 40N Heat #: SN2554 Carbon Eq: 0.2891 Heat Src Origin: MELTED AND MANUFACTURED IN THE USA

C	Mn	P	S	Si	Al	Cu	Cr	Mo	V	Ni	Nb	Cb
0.2000	0.3800	0.0070	0.0030	0.0320	0.0400	0.1300	0.0500	0.0200	0.0020	0.0400	0.0060	0.0060

Sn	N	B	Ti	Ca
0.0010	0.0068	0.0003	0.0020	0.0018

T/R FAX

Certification:

I certify that the above results are a true and correct copy of records prepared and maintained by NUCOR TUBULAR PRODUCTS INC. Sworn this day, 7/17/2023.

THE SPECIFICATIONS LISTED BELOW REPRESENT THE CURRENT ISSUED DATES OF THESE STANDARDS. THIS DOES NOT INDICATE THAT THE MATERIAL ABOVE CONFORMS TO EACH OR ALL OF THE STANDARDS. WE CERTIFY THE MATERIAL ABOVE TO THE SPECIFICATION LISTED IN THE LINE DESCRIPTION.

CURRENT STANDARDS:
A252-19
A500/A500M-21
A513/A513M-21
ASTM A53/A53M-20| ASME SA-53/SA-53M-21
A847/A847M-14
A1085/A1085M-15
IN COMPLIANCE WITH EN 10204 SECTION 4.1
INSPECTION CERTIFICATE TYPE 3.1

Nora Oukajji

Nora Oukajji
Metallurgist/Quality Supervisor

PO# 618851
Item #1

Triple S

Beshert STEEL PROCESSING

CERTIFICATE OF ANALYSIS

Cert Number 67791-11 7/3/2023
Test Reference 88297

TRIPLE-S STEEL SUPPLY CO.
6000 JENSEN DRIVE
HOUSTON, TX 77026

Issued from
BESHERT STEEL PROCESSING
JOINT VENTURE OF
STEEL WAREHOUSE CO. &
TRIPLE-S STEEL HOLDINGS INC.
15355 JACINTO PORT BOULEVARD
HOUSTON, TX 77015

Sold To: TRIPLE-S STEEL SUPPLY CO., 6000 JENSEN DRIVE, HOUSTON, TX 77026
Ship To: DALLAS/FORT WORTH - PRIME STOCK, 3000 BRASWELL DRIVE, FORT WORTH, TX 76111

Reference

Customer 100200/4 Your Order TXN-11391 (5/30/2023)
Our Order 32688-6-1 Packing List 67791-1 (7/3/2023)

Product Information

HOT ROLLED PLATE A36/SA36
0.2500" x 60" x 120"
Part PL36TML1460
Conform To ASTM-A36-.246-.258 7/1/2019

Heat	Tag	Pcs	LBS
2A5263	38442E	10	5,107

Chemical Composition C.E.: 0.2444 D.I.: 0

C	Mn	Si	P	S	Cr	Ni	Mo
0.148	0.553	0.014	0.013	0.009	0.018	0.005	0.00
Cu	**Al**	**N**	**V**	**Ti**	**Cb**	**CbV**	**B**
0.004	0.042	0.0046	0.00	0.001	0.00	0.00	0.0006
Sn							
0.002							

Physical Tests

YIELD - H (T)	TENSILE - H (T)	ELONGATION - H (T)	YIELD - M (T)
47.1 KSI	59.1 KSI	30.3 %	46.2 KSI
TENSILE - M (T)	**ELONGATION - M (T)**		
60.6 KSI	31.2 %		

PRODUCT OF COIL
COUNTRY OF ORIGIN: BRAZIL

PO# 618851
Item #2

7/3/2023 01:25 PM 1

July 11, 2023

A36 Plate
1/4 x 60 x 120

Certified Analysis

VALTIR

Valtir, LLC
2548 N.E. 28th St.
Ft Worth (THP), TX 76111 Phn:(817) 665-1499
Customer: TEXAS A&M TRANSPORTATION INSTI
ROADSIDE SAFETY & PHYSICA
BUSINESS OFFICE
3135 TAMU
COLLEGE STATION, TX 77843-3135

Project: STOCK

Order Number: 1360178 Prod Ln Grp: 0-OE2.0
Customer PO: 618851
BOL Number: 91828 Ship Date:
Document #: 1
Shipped To: TX
Use State: TX

618851

As of: 8/16/23

Qty	Part #	Description	Spec	CL	TY	Heat Code/ Heat	Yield	TS	Elg	C	Mn	P	S	Si	Cu	Cb	Cr	Vn
14	11G	12/12'6/3"1.5/S			2	F11823												
			M-180	A	2	AA8107	59,700	86,800	21.0	0.210	0.490	0.007	0.001	0.020	0.013	0.000	0.090	0.002
			M-180	A	2	AA8108	56,700	80,000	24.0	0.210	0.480	0.007	0.002	0.020	0.120	0.001	0.090	0.002
			M-180	A	2	AA8110	62,400	86,800	20.0	0.230	0.470	0.008	0.002	0.020	0.110	0.000	0.090	0.002
			M-180	A	2	AA8112	62,800	84,400	23.0	0.210	0.480	0.006	0.002	0.030	0.120	0.000	0.080	0.003
	11G				2	F11823												
			M-180	A	2	AA8107	59,700	86,800	21.0	0.210	0.490	0.007	0.001	0.020	0.013	0.000	0.090	0.002
			M-180	A	2	AA8108	56,700	80,000	24.0	0.210	0.480	0.007	0.002	0.020	0.120	0.001	0.090	0.002
			M-180	A	2	AA8110	62,400	86,800	20.0	0.230	0.470	0.008	0.002	0.020	0.110	0.000	0.090	0.002
			M-180	A	2	AA8112	62,800	84,400	23.0	0.210	0.480	0.006	0.002	0.030	0.120	0.000	0.080	0.003
	11G				2	F12223												
					2	288226												
					2	288237												
					2	288238												
					2	288239												
			M-180	A	2	AA8110	62,400	86,800	20.0	0.230	0.470	0.008	0.002	0.020	0.110	0.000	0.090	0.002
			M-180	A	2	EA3750	57,100	80,000	23.0	0.190	0.500	0.014	0.002	0.020	0.140	0.000	0.050	0.002
	11G				2	F12323												
					2	288226												
					2	288239												
			M-180	A	2	AA8471	59,100	81,200	20.0	0.200	0.460	0.007	0.001	0.030	0.090	0.000	0.050	0.002
			M-180	A	2	CA7527	58,900	80,300	19.0	0.200	0.490	0.007	0.003	0.030	0.120	0.000	0.070	0.002
	11G				2	F13122												
			M-180	A	2	277506	65,000	84,374	24.3	0.200	0.790	0.016	0.004	0.010	0.120	0.000	0.080	0.001
			M-180	A	2	277540	59,744	76,903	26.9	0.180	0.740	0.010	0.004	0.010	0.100	0.001	0.050	0.002
			M-180	A	2	277541	61,280	79,207	25.9	0.190	0.730	0.010	0.002	0.020	0.100	0.001	0.040	0.001

Certified Analysis

618851

VALTIR

Valtir, LLC
2548 N.E. 28th St.
Ft Worth (THP), TX 76111 Phn:(817) 665-1499
Customer: TEXAS A&M TRANSPORTATION INSTI
ROADSIDE SAFETY & PHYSICA
BUSINESS OFFICE
3135 TAMU
COLLEGE STATION, TX 77843-3135
Project: STOCK

Order Number: 1360178 Prod Ln Grp: 0-OE2.0
Customer PO: 618851
BOL Number: 91828 Ship Date:
Document #: 1
Shipped To: TX
Use State: TX

As of: 8/16/23

Qty	Part #	Description	Spec	CL	TY	Heat Code/ Heat	Yield	TS	Elg	C	Mn	P	S	Si	Cu	Cb	Cr	Vn
10	61G	12/25/3*1.5/S			2	F10823												
			M-180	A	2	1217676	59,500	81,700	23.0	0.210	0.800	0.008	0.002	0.030	0.090	0.000	0.030	0.002
			M-180	A	2	1217676	59,500	81,700	23.0	0.210	0.800	0.008	0.002	0.030	0.090	0.001	0.030	0.002
			M-180	A	2	2217668	57,700	78,300	24.0	0.210	0.810	0.009	0.002	0.030	0.110	0.000	0.050	0.003
			M-180	A	2	2217670	62,700	84,600	26.0	0.210	0.810	0.008	0.005	0.020	0.100	0.000	0.050	0.002
	61G				2	F11223												
			M-180	A	2	285749	62,430	79,902	24.5	0.190	0.730	0.009	0.004	0.010	0.090	0.000	0.050	0.001
			M-180	A	2	285750	62,382	81,485	24.3	0.190	0.730	0.007	0.005	0.010	0.090	0.001	0.050	0.001
			M-180	A	2	285752	62,974	81,111	24.6	0.190	0.730	0.009	0.002	0.010	0.090	0.000	0.050	0.001
			M-180	A	2	286152	60,197	77,373	26.1	0.190	0.730	0.008	0.004	0.010	0.090	0.001	0.080	0.002
			M-180	A	2	286570	63,814	81,890	22.2	0.190	0.750	0.005	0.003	0.010	0.100	0.001	0.060	0.002
	61G				2	F11723												
			M-180	A	2	287476	62,655	81,111	23.6	0.180	0.720	0.004	0.002	0.010	0.080	0.001	0.050	0.000
			M-180	A	2	287477	63,839	83,839	25.2	0.200	0.720	0.006	0.003	0.010	0.080	0.000	0.050	0.000
			M-180	A	2	AA8110	62,400	86,800	20.0	0.230	0.470	0.008	0.002	0.020	0.110	0.000	0.090	0.002
			M-180	A	2	AA8112	62,800	84,400	23.0	0.210	0.480	0.006	0.002	0.030	0.120	0.000	0.080	0.003
	61G				2	F11823												
			M-180	A	2	AA8107	59,700	86,800	21.0	0.210	0.490	0.007	0.001	0.020	0.013	0.000	0.090	0.002
			M-180	A	2	AA8108	56,700	80,000	24.0	0.210	0.480	0.007	0.002	0.020	0.120	0.001	0.090	0.002
			M-180	A	2	AA8110	62,400	86,800	20.0	0.230	0.470	0.008	0.002	0.020	0.110	0.000	0.090	0.002
			M-180	A	2	AA8112	62,800	84,400	23.0	0.210	0.480	0.006	0.002	0.030	0.120	0.000	0.080	0.003
20	533G	6'0 POST/8.5/DDR/7	A-36			1114803	54,500	67,500	28.3	0.070	0.840	0.007	0.022	0.230	0.130	0.015	0.040	0.002
	533G		A-36			2104723	54,000	66,200	26.0	0.070	80.000	0.013	0.020	0.200	0.100	0.014	0.040	0.002
	533G		A-709			59110730	59,045	72,898	23.3	0.090	0.860	0.012	0.024	0.220	0.250	0.013	0.150	0.001

Certified Analysis

VALTIR

Valtir, LLC
2548 N.E. 28th St.
Ft Worth (THP), TX 76111 Phn:(817) 665-1499

Customer: TEXAS A&M TRANSPORTATION INSTI
ROADSIDE SAFETY & PHYSICA
BUSINESS OFFICE
3135 TAMU
COLLEGE STATION, TX 77843-3135

Project: STOCK

Order Number: 1360178 Prod Ln Grp: 0-OE2.0
Customer PO: 618851
BOL Number: 91828 Ship Date:
Document #: 1
Shipped To: TX
Use State: TX

As of: 8/16/23

Qty	Part #	Description	Spec	CL	TY	Heat Code/ Heat	Yield	TS	Elg	C	Mn	P	S	Si	Cu	Cb	Cr	Vn
8	926G	10/END SHOE/EXTRA HOLE	M-180	B	2	284576	62,994	81,589	24.2	0.200	0.730	0.010	0.001	0.020	0.090	0.000	0.070	0.001
	926G		RHC		2	L11921												
			M-180	B	2	260786	62,000	80,172	24.7	0.190	0.730	0.011	0.002	0.020	0.130	0.000	0.080	0.000
			M-180	A	2	260788	63,565	80,754	25.4	0.180	0.720	0.011	0.003	0.020	0.080	0.000	0.080	0.002
			M-180	A	2	260791	64,389	83,182	22.3	0.200	0.720	0.011	0.002	0.020	0.120	0.000	0.070	0.000
			M-180	A	2	261141	61,855	79,140	23.9	0.190	0.710	0.010	0.003	0.020	0.130	0.000	0.060	0.001
			M-180	A	2	261147	61,123	79,606	24.2	0.190	0.720	0.009	0.003	0.010	0.110	0.000	0.070	0.001
			M-180	A	2	261612	63,653	81,142	26.6	0.190	0.720	0.011	0.005	0.010	0.100	0.001	0.080	0.002
			M-180	A	2	261614	61,668	78,433	24.0	0.180	0.720	0.012	0.003	0.020	0.120	0.000	0.100	0.002
			M-180	A	2	262184	61,577	79,100	25.4	0.190	0.730	0.012	0.003	0.020	0.060	0.000	0.060	0.000
			M-180	A	2	262455	65,000	826,100	24.5	0.190	0.730	0.013	0.002	0.030	0.110	0.000	0.080	0.002
			M-180	A	2	262456	62,025	80,574	24.9	0.190	0.720	0.011	0.003	0.020	0.110	0.000	0.060	0.007
60	3300G	5/8" WASHER F844 A/W	F844-3300			P40153 R77297												
100	3340G	5/8" GR HEX NUT	FAST			23-54-013												
60	3400G	5/8"X2" GR BOLT	A307-3400G			A70716-9												
50	4076B	WD BLK RTD 6X8X14	WOOD			4850												

Upon delivery, all materials subject to Valtir, LLC Storage Stain Policy QMS-LQ-002.

ALL STEEL USED WAS MELTED AND MANUFACTURED IN USA AND COMPLIES WITH THE BUY AMERICA ACT, 23 CFR 635.410.
ALL GUARDRAIL MEETS AASHTO M-180, ALL STRUCTURAL STEEL MEETS ASTM A36 UNLESS OTHERWISE STATED.

Certified Analysis

618851

VALTIR

Valtir, LLC
2548 N.E. 28th St.
Ft Worth (THP), TX 76111 Phn:(817) 665-1499
Customer: TEXAS A&M TRANSPORTATION INSTI
ROADSIDE SAFETY & PHYSICA
BUSINESS OFFICE
3135 TAMU
COLLEGE STATION, TX 77843-3135

Order Number: 1360178 Prod Ln Grp: 0-OE2.0
Customer PO: 618851
BOL Number: 91828 Ship Date:
Document #: 1
Shipped To: TX
Use State: TX

As of: 8/16/23

Project: STOCK

ALL COATINGS PROCESSES OF THE STEEL OR IRON ARE PERFORMED IN USA AND COMPLIES WITH THE "BUY AMERICA ACT", 23 CFR 635.410.
ALL GALVANIZED MATERIAL CONFORMS WITH ASTM A-123 (US DOMESTIC SHIPMENTS)
ALL GALVANIZED MATERIAL CONFORMS WITH ASTM A-123 & ISO 1461 (INTERNATIONAL SHIPMENTS)

FINISHED GOOD PART NUMBERS ENDING IN SUFFIX B,P, OR S, ARE UNCOATED

BOLTS COMPLY WITH ASTM A-307 SPECIFICATIONS AND ARE GALVANIZED IN ACCORDANCE WITH ASTM A-153, UNLESS OTHERWISE STATED.

NUTS COMPLY WITH ASTM A-563 SPECIFICATIONS AND ARE GALVANIZED IN ACCORDANCE WITH ASTM A-153, UNLESS OTHERWISE STATED.
WASHERS COMPLY WITH ASTM F-436 SPECIFICATION AND/OR F-844 AND ARE GALVANIZED IN ACCORDANCE WITH ASTM F-2329, UNLESS OTHERWISE STATED.
3/4" DIA CABLE 6X19 ZINC COATED SWAGED END AISI C-1035 STEEL ANNEALED STUD 1" DIA ASTM 449 AASHTO M30, TYPE II BREAKING STRENGTH – 46000 LB

State of Texas, County of Tarrant. Sworn and subscribed before me this 16th day of August, 2023 .

Notary Public:
Commission Expires: /

Angela Ruth Humphrey
My Commission Expires
6/24/2026
Notary ID 133827723

Angela Ruth Humphrey

Valtir, LLC
Certified By:
Quality Assurance

218142

August 24, 2023

K-T Bolt Manufacturing Company, Inc.®
1150 Katy Fort-Bend Road
Katy, Texas 77494
Ph: 281-391-2196 Fax: 281-391-2673
certs@k-tbolt.com

618851

Original Mill Test Report

Company:	**Mack Manufacturing & Machine**
Part Description:	**1 pcs. 7/8" (9) x 7" All Thread Studs**
Material Specification:	**ASTM A193 – '19 Grade B7**
Coating Specification:	**Galvanized per ASTM F2329 – A153**
Purchase Order Number:	**39414**
Lot Number:	**76350-3**
Material Heat Number:	**58050969**
Comments:	

Chemical Analysis

C	Mn	P	S	N	Si	Ni
.41%	.90%	.009%	.007%	.0112%	.33%	.14%
Cr	**Mo**	**Cu**	**Sn**	**B**	**Al**	**V**
.92%	.194%	.25%	.003%	.0001%	.026%	.003%
Ti						
.003%						

100% Melted and Manufactured in the USA - Values reflect original mill test report

Tensile Test Results

Property	#1 ksi
Tensile:	138
Yield:	124
Elongation %:	15%
ROA %:	60%

Comments

Test results reflect the original mill test report

K-T Bolt Manufacturing Co., Inc.

Quality Representative

K. Dyess

218144

August 24, 2023

K-T Bolt Manufacturing Company, Inc.®
1150 Katy Fort-Bend Road
Katy, Texas 77494
Ph: 281-391-2196 Fax: 281-391-2673
certs@k-tbolt.com

618851

Original Mill Test Report

Company:	**Mack Manufacturing & Machine**
Part Description:	**2 pcs. 7/8" (9) x 8" All Thread Studs**
Material Specification:	**ASTM A193 – '19 Grade B7**
Coating Specification:	**Galvanized per ASTM F2329 – A153**
Purchase Order Number:	**39414**
Lot Number:	**76350-5**
Material Heat Number:	**58050969**
Comments:	

Chemical Analysis

C	Mn	P	S	N	Si	Ni
.41%	.90%	.009%	.007%	.0112%	.33%	.14%
Cr	**Mo**	**Cu**	**Sn**	**B**	**Al**	**V**
.92%	.194%	.25%	.003%	.0001%	.026%	.003%
Ti						
.003%						

100% Melted and Manufactured in the USA - Values reflect original mill test report

Tensile Test Results

Property	#1 ksi
Tensile:	138
Yield:	124
Elongation %:	15%
ROA %:	60%

Comments

Test results reflect the original mill test report

K-T Bolt Manufacturing Co., Inc.

Quality Representative

K. Dsen

218143

August 24, 2023

K-T Bolt Manufacturing Company, Inc.®
1150 Katy Fort-Bend Road
Katy, Texas 77494
Ph: 281-391-2196 Fax: 281-391-2673
certs@k-tbolt.com

618851

Original Mill Test Report

Company: Mack Manufacturing & Machine
Part Description: 1 pcs. 7/8" (9) x 8 ½" All Thread Studs
Material Specification: ASTM A193 – '19 Grade B7
Coating Specification: Galvanized per ASTM F2329 – A153
Purchase Order Number: 39414
Lot Number: 76350-4
Material Heat Number: 58050969
Comments:

Chemical Analysis

C	Mn	P	S	N	Si	Ni
.41%	.90%	.009%	.007%	.0112%	.33%	.14%
Cr	Mo	Cu	Sn	B	Al	V
.92%	.194%	.25%	.003%	.0001%	.026%	.003%
Ti						
.003%						

100% Melted and Manufactured in the USA - Values reflect original mill test report

Tensile Test Results

Property	#1 ksi
Tensile:	138
Yield:	124
Elongation %:	15%
ROA %:	60%

Comments

Test results reflect the original mill test report

K-T Bolt Manufacturing Co., Inc.

Quality Representative

K. Dyess

618851

American Eagle Steel
565 Aberdeen Dr.
Crete, IL 60417

JOB MATERIAL CERTIFICATION

Job No: 790197 **Job Information** **Certified Date:** 12/6/22

Containers: S20817150 S20817152 S20817216

Customer: American Eagle Steel Co., LLC

Ship To: 317 East 11th Street
Chicago Heights, IL 60411

Vulcan Part No: HRB B7 .8750x288 BC/105

Customer Part No: HRB B7 .8750x288 BC/105

Customer PO No: 2681A and B

Shipped Qty: 13557 lbs

Order No: 473226

Line No: 2

Note:

Applicable Specifications

Type	Specification	Rev	Amend	Option
-	ASTM F1554 Gd 105 S4	2020		
Heat Treat	ASME SA-193/SA-193M B7	2019		
	ASTM A193 B7 S11	2020		
	ASTM A434 BC	2018		

Test Results

See following pages for tests

Certified Chemical Analysis

Heat No: 58050969/05 Origin: USA

C	Mn	P	S	Si	Cr	Mo	Ni	V	Cu
0.41	0.90	0.009	0.007	0.33	0.92	0.194	0.14	0.003	0.25
Al	Sn	Ti	N	B	CI	RR	G.S.	Macro S	Macro R
0.026	0.003	0.003	0.0112	0.0001	5.77	70.3:1	Fine	1	1
Macro C	J1	J2	J3	J4	J5	J6	J7	J8	J9
1	57	57	57	57	57	57	57	57	56
J10	J12	J14	J16	J18	J20	J24	J28	J32	
55	52	50	49	48	48	46	44	41	

Notes

Processed material is Tempered - Stress Relieved. No welding performed on the material. No Mercury used in the production of this material. Melted and Manufactured in the USA.
Grade - 4140/42
EAF Melted

Plex 12/6/22 10:49 AM vulc.mgul Page 1 of

618851

American Eagle Steel
565 Aberdeen Dr.
Crete, IL 60417

JOB MATERIAL CERTIFICATION

Job No: 790197 | **Job Information** | **Certified Date: 12/6/22**

Containers: S20817150 S20817152 S20817216

Test Results

Part No: HRB B7 .8750x288 BC/105

Test No: 75572 Test: Heat Treat Info

Description	Austenitizing Temp (F)	Tempering Temp (F)	Run Speed (ft/min)	Quench Water Temp (F)	Note
	1,617	1,345	26.7	88	

Test No: 75573 Test: Tensile Test

Description	Tensile Strength (ksi)	Yield Strength (0.2% Offset) (ksi)	Elongation (4D) (%)	ROA (%)	Note
	143	128	21	57	
	142	128	21	59	
	143	129	21	60	
	142	126	20	58	
	144	129	19	58	
	143	128	20	60	

Test No: 75574 Test: Hardness Test

Description	Midradius Hardness	Surface Hardness	Core Hardness	Hardness Scale	Note
	31	30	31	HRC	
	30	29	30	HRC	
	30	28	30	HRC	
	30	28	29	HRC	
	30	30	29	HRC	
	31	30	30	HRC	

Test No: 75575 Test: Charpy Test

Description	Test Temp (F)	Test 1 (ft-lb)	Test 2 (ft-lb)	Test 3 (ft-lb)	Average (ft-lb)	Note
	-20	66	66	65	66	

Test No: 75576 Test: Full-Sized Tensile Test

Description	Tensile Strength (ksi)	Yield Strength (ksi)	Elongation (%)	Elongation Gauge Length	ROA (%)	Note
	138	124	15	8 in.	60	

The reported test results conform to the specifications listed above.
The reported test results are the actual values measured on the samples taken from the production lot.
Material was manufactured, tested, and inspected as required by the product standard and in accordance with Vulcans ISO 9001:2015 Quality Management System registered June 30th, 2017.
Vulcan Steel Products lab is ISO 17025:2017 accredited for tensile, Brinell and Rockwell hardness, Charpy impact, and carb/decarb testing.
Material was tested in accordance with the current revision of ASTM A370, F606, and F2328 test methods.
All Q&T material is demagnetized.
This test report shall not be reproduced or distributed, except in full, nor shall it be modified in any way without the written permission of Vulcan Steel Products.
Document is in accordance with EN 10204 - 3.1B of 2004 (3.1).

Gotman, Mike - Material Testing and Tech. Support Manager — 12/6/22 Date

Ptax 12/6/22 10:49 AM vulc.mgut Page 2 of

Certified Analysis

VALTIR

Valtir, LLC
2548 N.E. 28th St.
Ft Worth (THP), TX 76111 Phn:(817) 665-1499
Customer: TEXAS A&M TRANSPORTATION INSTI
ROADSIDE SAFETY & PHYSICA
BUSINESS OFFICE
3135 TAMU
COLLEGE STATION, TX 77843-3135

Project: STOCK

Order Number: 1360178 Prod Ln Grp: 0-OE2.0
Customer PO: 618851
BOL Number: 91828 Ship Date:
Document #: 1
Shipped To: TX
Use State: TX

618851

As of: 8/16/23

Qty	Part #	Description	Spec	CL	TY	Heat Code/ Heat	Yield	TS	Elg	C	Mn	P	S	Si	Cu	Cb	Cr	Vn
14	11G	12/12'6/3"1.5/S			2	F11823												
			M-180	A	2	AA8107	59,700	86,800	21.0	0.210	0.490	0.007	0.001	0.020	0.013	0.000	0.090	0.002
			M-180	A	2	AA8108	56,700	80,000	24.0	0.210	0.480	0.007	0.002	0.020	0.120	0.001	0.090	0.002
			M-180	A	2	AA8110	62,400	86,800	20.0	0.230	0.470	0.008	0.002	0.020	0.110	0.000	0.090	0.002
			M-180	A	2	AA8112	62,800	84,400	23.0	0.210	0.480	0.006	0.002	0.030	0.120	0.000	0.080	0.003
	11G				2	F11823												
			M-180	A	2	AA8107	59,700	86,800	21.0	0.210	0.490	0.007	0.001	0.020	0.013	0.000	0.090	0.002
			M-180	A	2	AA8108	56,700	80,000	24.0	0.210	0.480	0.007	0.002	0.020	0.120	0.001	0.090	0.002
			M-180	A	2	AA8110	62,400	86,800	20.0	0.230	0.470	0.008	0.002	0.020	0.110	0.000	0.090	0.002
			M-180	A	2	AA8112	62,800	84,400	23.0	0.210	0.480	0.006	0.002	0.030	0.120	0.000	0.080	0.003
	11G				2	F12223												
					2	288226												
					2	288237												
					2	288238												
					2	288239												
			M-180	A	2	AA8110	62,400	86,800	20.0	0.230	0.470	0.008	0.002	0.020	0.110	0.000	0.090	0.002
			M-180	A	2	EA3750	57,100	80,000	23.0	0.190	0.500	0.014	0.002	0.020	0.140	0.000	0.050	0.002
	11G				2	F12323												
					2	288226												
					2	288239												
			M-180	A	2	AA8471	59,100	81,200	20.0	0.200	0.460	0.007	0.001	0.030	0.090	0.000	0.050	0.002
			M-180	A	2	CA7527	58,900	80,300	19.0	0.200	0.490	0.007	0.003	0.030	0.120	0.000	0.070	0.002
	11G				2	F13122												
			M-180	A	2	277506	65,000	84,374	24.3	0.200	0.790	0.016	0.004	0.010	0.120	0.000	0.080	0.001
			M-180	A	2	277540	59,744	76,903	26.9	0.180	0.740	0.010	0.004	0.010	0.100	0.001	0.050	0.002
			M-180	A	2	277541	61,280	79,207	25.9	0.190	0.730	0.010	0.002	0.020	0.100	0.001	0.040	0.001

Certified Analysis

618851

VALTIR

Valtir, LLC
2548 N.E. 28th St.
Ft Worth (THP), TX 76111 Phn:(817) 665-1499

Customer: TEXAS A&M TRANSPORTATION INSTI
ROADSIDE SAFETY & PHYSICA
BUSINESS OFFICE
3135 TAMU
COLLEGE STATION, TX 77843-3135

Project: STOCK

Order Number: 1360178 Prod Ln Grp: 0-OE2.0
Customer PO: 618851
BOL Number: 91828 Ship Date:
Document #: 1
Shipped To: TX
Use State: TX

As of: 8/16/23

Qty	Part #	Description	Spec	CL	TY	Heat Code/ Heat	Yield	TS	Elg	C	Mn	P	S	Si	Cu	Cb	Cr	Vn
10	61G	12/25/3*1.5/S			2	F10823												
			M-180	A	2	1217676	59,500	81,700	23.0	0.210	0.800	0.008	0.002	0.030	0.090	0.000	0.030	0.002
			M-180	A	2	1217676	59,500	81,700	23.0	0.210	0.800	0.008	0.002	0.030	0.090	0.001	0.030	0.002
			M-180	A	2	2217668	57,700	78,300	24.0	0.210	0.810	0.009	0.002	0.030	0.110	0.000	0.050	0.003
			M-180	A	2	2217670	62,700	84,600	26.0	0.210	0.810	0.008	0.005	0.020	0.100	0.000	0.050	0.002
	61G				2	F11223												
			M-180	A	2	285749	62,430	79,902	24.5	0.190	0.730	0.009	0.004	0.010	0.090	0.000	0.050	0.001
			M-180	A	2	285750	62,382	81,485	24.3	0.190	0.730	0.007	0.005	0.010	0.090	0.001	0.050	0.001
			M-180	A	2	285752	62,974	81,111	24.6	0.190	0.730	0.009	0.002	0.010	0.090	0.000	0.050	0.001
			M-180	A	2	286152	60,197	77,373	26.1	0.190	0.730	0.008	0.004	0.010	0.090	0.001	0.080	0.002
			M-180	A	2	286570	63,814	81,890	22.2	0.190	0.750	0.005	0.003	0.010	0.100	0.001	0.060	0.002
	61G				2	F11723												
			M-180	A	2	287476	62,655	81,111	23.6	0.180	0.720	0.004	0.002	0.010	0.080	0.001	0.050	0.000
			M-180	A	2	287477	63,839	83,839	25.2	0.200	0.720	0.006	0.003	0.010	0.080	0.000	0.050	0.000
			M-180	A	2	AA8110	62,400	86,800	20.0	0.230	0.470	0.008	0.002	0.020	0.110	0.000	0.090	0.002
			M-180	A	2	AA8112	62,800	84,400	23.0	0.210	0.480	0.006	0.002	0.030	0.120	0.000	0.080	0.003
	61G				2	F11823												
			M-180	A	2	AA8107	59,700	86,800	21.0	0.210	0.490	0.007	0.001	0.020	0.013	0.000	0.090	0.002
			M-180	A	2	AA8108	56,700	80,000	24.0	0.210	0.480	0.007	0.002	0.020	0.120	0.001	0.090	0.002
			M-180	A	2	AA8110	62,400	86,800	20.0	0.230	0.470	0.008	0.002	0.020	0.110	0.000	0.090	0.002
			M-180	A	2	AA8112	62,800	84,400	23.0	0.210	0.480	0.006	0.002	0.030	0.120	0.000	0.080	0.003
20	533G	6'0 POST/8.5/DDR/7	A-36			1114803	54,500	67,500	28.3	0.070	0.840	0.007	0.022	0.230	0.130	0.015	0.040	0.002
	533G		A-36			2104723	54,000	66,200	26.0	0.070	80.000	0.013	0.020	0.200	0.100	0.014	0.040	0.002
	533G		A-709			59110730	59,045	72,898	23.3	0.090	0.860	0.012	0.024	0.220	0.250	0.013	0.150	0.001

Certified Analysis

VALTIR

Valtir, LLC
2548 N.E. 28th St.
Ft Worth (THP), TX 76111 Phn:(817) 665-1499
Customer: TEXAS A&M TRANSPORTATION INSTI
ROADSIDE SAFETY & PHYSICA
BUSINESS OFFICE
3135 TAMU
COLLEGE STATION, TX 77843-3135
Project: STOCK

Order Number: 1360178 Prod Ln Grp: 0-OE2.0
Customer PO: 618851
BOL Number: 91828 Ship Date:
Document #: 1
Shipped To: TX
Use State: TX

As of: 8/16/23

Qty	Part #	Description	Spec	CL	TY	Heat Code/ Heat	Yield	TS	Elg	C	Mn	P	S	Si	Cu	Cb	Cr	Vn
8	926G	10/END SHOE/EXTRA HOLE	M-180	B	2	284576	62,994	81,589	24.2	0.200	0.730	0.010	0.001	0.020	0.090	0.000	0.070	0.001
	926G		RHC		2	L11921												
			M-180	B	2	260786	62,000	80,172	24.7	0.190	0.730	0.011	0.002	0.020	0.130	0.000	0.080	0.000
			M-180	A	2	260788	63,565	80,754	25.4	0.180	0.720	0.011	0.003	0.020	0.080	0.000	0.080	0.002
			M-180	A	2	260791	64,389	83,182	22.3	0.200	0.720	0.011	0.002	0.020	0.120	0.000	0.070	0.000
			M-180	A	2	261141	61,855	79,140	23.9	0.190	0.710	0.010	0.003	0.020	0.130	0.000	0.060	0.001
			M-180	A	2	261147	61,123	79,606	24.2	0.190	0.720	0.009	0.003	0.010	0.110	0.000	0.070	0.001
			M-180	A	2	261612	63,653	81,142	26.6	0.190	0.720	0.011	0.005	0.010	0.100	0.001	0.080	0.002
			M-180	A	2	261614	61,668	78,433	24.0	0.180	0.720	0.012	0.003	0.020	0.120	0.000	0.100	0.002
			M-180	A	2	262184	61,577	79,100	25.4	0.190	0.730	0.012	0.003	0.020	0.060	0.000	0.060	0.000
			M-180	A	2	262455	65,000	826,100	24.5	0.190	0.730	0.013	0.002	0.030	0.110	0.000	0.080	0.002
			M-180	A	2	262456	62,025	80,574	24.9	0.190	0.720	0.011	0.003	0.020	0.110	0.000	0.060	0.007
60	3300G	5/8" WASHER F844 A/W	F844-3300			P40153 R77297												
100	3340G	5/8" GR HEX NUT	FAST			23-54-013												
60	3400G	5/8"X2" GR BOLT	A307-3400G			A70716-9												
50	4076B	WD BLK RTD 6X8X14	WOOD			4850												

Upon delivery, all materials subject to Valtir, LLC Storage Stain Policy QMS-LQ-002.

ALL STEEL USED WAS MELTED AND MANUFACTURED IN USA AND COMPLIES WITH THE BUY AMERICA ACT, 23 CFR 635.410.
ALL GUARDRAIL MEETS AASHTO M-180, ALL STRUCTURAL STEEL MEETS ASTM A36 UNLESS OTHERWISE STATED.

Certified Analysis

618851

VALTIR

Valtir, LLC
2548 N.E. 28th St.
Ft Worth (THP), TX 76111 Phn:(817) 665-1499
Customer: TEXAS A&M TRANSPORTATION INSTI
ROADSIDE SAFETY & PHYSICA
BUSINESS OFFICE
3135 TAMU
COLLEGE STATION, TX 77843-3135

Order Number: 1360178 Prod Ln Grp: 0-OE2.0
Customer PO: 618851
BOL Number: 91828 Ship Date:
Document #: 1
Shipped To: TX
Use State: TX

As of: 8/16/23

Project: STOCK

ALL COATINGS PROCESSES OF THE STEEL OR IRON ARE PERFORMED IN USA AND COMPLIES WITH THE "BUY AMERICA ACT", 23 CFR 635.410.
ALL GALVANIZED MATERIAL CONFORMS WITH ASTM A-123 (US DOMESTIC SHIPMENTS)
ALL GALVANIZED MATERIAL CONFORMS WITH ASTM A-123 & ISO 1461 (INTERNATIONAL SHIPMENTS)

FINISHED GOOD PART NUMBERS ENDING IN SUFFIX B,P, OR S, ARE UNCOATED

BOLTS COMPLY WITH ASTM A-307 SPECIFICATIONS AND ARE GALVANIZED IN ACCORDANCE WITH ASTM A-153, UNLESS OTHERWISE STATED.

NUTS COMPLY WITH ASTM A-563 SPECIFICATIONS AND ARE GALVANIZED IN ACCORDANCE WITH ASTM A-153, UNLESS OTHERWISE STATED.
WASHERS COMPLY WITH ASTM F-436 SPECIFICATION AND/OR F-844 AND ARE GALVANIZED IN ACCORDANCE WITH ASTM F-2329, UNLESS OTHERWISE STATED.
3/4" DIA CABLE 6X19 ZINC COATED SWAGED END AISI C-1035 STEEL ANNEALED STUD 1" DIA ASTM 449 AASHTO M30, TYPE II BREAKING STRENGTH – 46000 LB

State of Texas, County of Tarrant. Sworn and subscribed before me this 16th day of August, 2023 .

Notary Public:
Commission Expires: /

Angela Ruth Humphrey
My Commission Expires
6/24/2026
Notary ID 133827723

Angela Ruth Humphrey

Valtir, LLC
Certified By:
Quality Assurance

Texas A&M Transportation Institute	QF 7.3-01 Concrete Sampling	Doc. No. QF 7.3-01	Revision Date: 2020-07-29
Quality Form	Revised by: B.L. Griffith Approved by: D. L. Kuhn	Revision: 7	Page: 1 of 1

Project No: 618851 **Casting Date:** 8/16/2023 **Mix Design (psi):** 3600

Name of Technician Taking Sample: Terracon

Name of Technician Breaking Sample: Terracon

Signature of Technician Taking Sample: Terracon

Signature of Technician Breaking Sample: Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	Frank154	81626	100% of deck

Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average

TEXCRETE
Redi-mix Concrete Company

180109

REMIT PAYMENT TO:
P.O. BOX138
KURTEN, TX 77862

5222 Sandy Point RD.
Bryan, TX 77807

18935 Circle Lake Dr.
Pinehurst, TX 77362

17534 SH 6 South
College Station, TX 77845

2687 HWY 105
Montgomery, TX 77333

BCS DISPATCH - 979-316-2906
PINEHURST DISPATCH - 936-232-5815
OFFICE - 979-985-3636

TEXAS A&M TRANSPORTATIO
RELLIS CAMPUS, BRYAN TX

RT 2818, RT HWY 21, LT SILVER HILL, RT AT
THE "T", RT HWY 47, LT INTO RELLIS ENTRANCE,
STAY STRAIGHTALL THE WAY DOWN TO THE GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
7:34	TXC3600	4.00	4.00	1804			85438
DATE		**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
9/16/23	TTIRELL	4.00	4.00			5.00 in	81626

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
4.00 yd	TXC3600	DDTC, 3600, RG, 5",		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
7:48	8:05				
FINISH UNLOADING	**LEFT JOB**	**ARRIVED AT PLANT**	**ON SITE TESTING**		
			TESTING LAB: TERRACON GESSNER CME OTHER		
TESTED			**AIR**	**CYLINDERS**	
☐ YES ☐ NO					

Tax
Prev. PMT
Ticket Total

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

Contains Portland Cement, Wear Rubber Boots and Gloves. PROLONGED CONTACT MAY CAUSE BURNS. Avoid Contact With Eyes and Prolonged Contact with Skin. In Case of Contact with Skin or Eyes, Rinse Thoroughly With Water. If Irritation Persists. Get Medical Attention. **KEEP CHILDREN AWAY.**

CONCRETE is a PERISHABLE COMMODITY and BECOMES THE PROPERTY of the PURCHASER UPON LEAVING the PLANT. ANY CHANGES or CANCELLATION of ORIGINAL INSTRUCTIONS MUST be TELEPHONED to the OFFICE BEFORE LOADING starts. The undersigned promises to pay all costs, including reasonable attorney's fees. incurred in collecting any sums owed.

All accounts not paid within 30 days of delivery will bear interest at the rate of 18% per annum. Not Responsible For Reactive Aggregate or Color Quality. No Claim Allowed Unless Made at Time Material is Delivered.
A $25.00 Service Charge and Loss of the Cash Discounted will be Collected on all Returned Checks. Demerge charge after 90 min. will be $100.00/hr.

PROPERTY DAMAGE RELEASE
(TO BE SIGNED IF DELIVERY TO BE MADE INSIDE CURB LINE)

Dear Customer - The driver of this truck in presenting this RELEASE to you for your signature is of the opinion that the size and weight of this truck may possibly cause damage to the premises and/or adjacent property if he places the material in this load where you desire it. It is our wish to help you in everyway that we can, but in order to do this the driver is requesting that you sign this RELEASE relieving him and this supplier from any responsibility from damage that may occur to the premises and or adjacent property, buildings, sidewalks, driveways, curbs, etc. by the delivery of this material and that you also agree to help him remove mud from the wheels of his vehicle so that he will not liter the public streets. Further as additional consideration: the undersigned agrees to indemnify and hold harmless the driver of this truck and this supplier for any and all damage to the premises and /or adjacent property which may be claimed by anyone to have arisen out of delivery of this order SIGNED:

X _____

Excessive Water is Detrimental to Concrete Performance.
H_2O Added by Request/Authorized By:

_____GAL X_____
WEIGHMASTER

Surcharge for credit cards

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE HEALTH WARNING NOTICE AND SUPPLIER WILL NOT BE RESPONSIBLE FOR ANY DAMAGE CAUSED WHEN DELIVERING INSIDE CURB LINE.

LOAD RECEIVED BY

X _____

180109

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0278
Service Date: 08/16/23
Report Date: 10/04/23
Task: PO# 618851

Terracon
6198 Imperial Loop
College Station, TX 77845-5765
979-846-3767 Reg No: F-3272

Client
Texas Transportation Institute
Attn: Bill Griffith
TTI Business Office
3135 TAMU
College Station, TX 77843-3135

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information
Specified Strength: 3,600 psi @ 28 days

Mix ID: TXDOT 3600
Supplier: Texcrete
Batch Time: 0734 **Plant:** Bryan
Truck No.: 154 **Ticket No.:** 81626

Sample Information
Sample Date: 08/16/23 **Sample Time:** 0830
Sampled By: Matcek, James
Weather Conditions: Cloudy
Accumulative Yards: 4.0 **Batch Size (cy):** 4
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: Median Transition
Placement Location: Median Transition
Sample Description: 6-inch diameter cylinders

Field Test Data

Test	Result	Specification
Slump (in):	4 1/2	
Air Content (%):	2.5	
Concrete Temp. (F):	83	
Ambient Temp. (F):	75	
Plastic Unit Wt. (pcf):	148.2	
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	6.02	28.46		10/04/23	49 F	124,710	4,380	6	JTE
1	B	Good	6.02	28.46		10/04/23	49 F	115,550	4,060	6	JTE
1	C	Good	6.02	28.46		10/04/23	49 F	129,100	4,540	6	JTE
1	D	Good	6.02	28.46		10/04/23	49 F	127,400	4,480	2	JTE

Initial Cure: Outside in shade **Final Cure:** Field Cured

Comments: **F = Field Cured**
Note: Reported air content does not include Aggregate Correction Factor (ACF).

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).

Terracon Rep.: Matcek, James **Start/Stop:** 0700-0930
Reported To: Bill at TTI
Contractor: TTI
Report Distribution:
(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

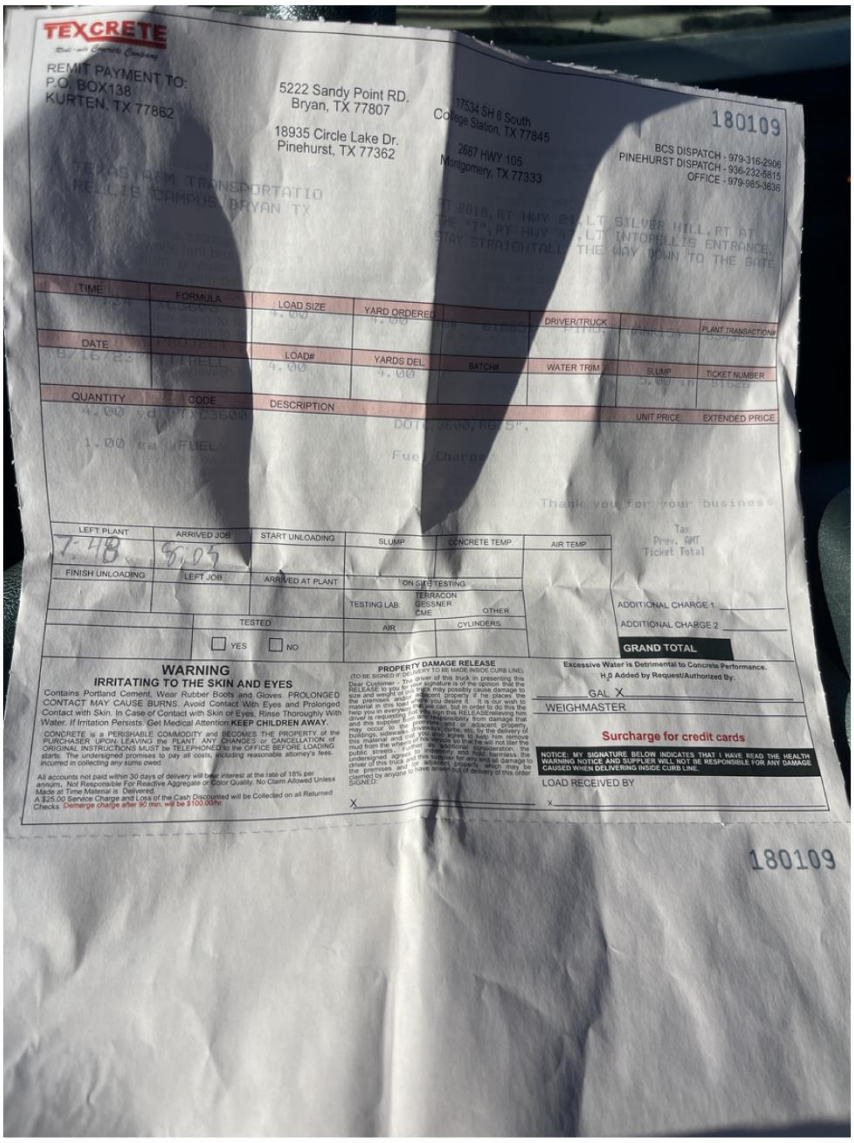
Reviewed By: Alexander Dunigan, P.E.
Project Manager

Test Methods: ASTM C 31, ASTM C143, ASTM C231, ASTM C1064

Photo Log

Report Number: A1171057.0278
Service Date: 08/16/23
Report Date: 10/04/23
Task: PO# 618851

Terracon
6198 Imperial Loop
College Station, TX 77845-5765
979-846-3767 Reg No: F-3272



(P1) Batch tickets

Texas A&M Transportation Institute	QF 7.3-01 Concrete Sampling	Doc. No. QF 7.3-01	Revision Date: 2020-07-29
Quality Form	Revised by: B.L. Griffith Approved by: D. L. Kuhn	Revision: 7	Page: 1 of 1

Project No: 618851 **Casting Date:** 9/18/2023 **Mix Design (psi):** 3600

Name of Technician Taking Sample: Terracon

Name of Technician Breaking Sample: Terracon

Signature of Technician Taking Sample: Terracon

Signature of Technician Breaking Sample: Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	Frank154	83138	100% of Barrier

Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average

TEXCRETE
Redi-mix Concrete Company

175304

REMIT PAYMENT TO:
P.O. BOX138
KURTEN, TX 77862

5222 Sandy Point RD.
Bryan, TX 77807

18935 Circle Lake Dr.
Pinehurst, TX 77362

17534 SH 6 South
College Station, TX 77845

2687 HWY 105
Montgomery, TX 77333

BCS DISPATCH - 979-316-2906
PINEHURST DISPATCH - 936-232-5815
OFFICE - 979-985-3636

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
DATE		LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP

FINISH UNLOADING	LEFT JOB	ARRIVED AT PLANT	ON SITE TESTING
			TESTING LAB: TERRACON GESSNER CME OTHER

TESTED	AIR	CYLINDERS
☐ YES ☐ NO		

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

Contains Portland Cement, Wear Rubber Boots and Gloves. PROLONGED CONTACT MAY CAUSE BURNS. Avoid Contact With Eyes and Prolonged Contact with Skin. In Case of Contact with Skin or Eyes, Rinse Thoroughly With Water. If Irritation Persists, Get Medical Attention.**KEEP CHILDREN AWAY.**

CONCRETE is a PERISHABLE COMMODITY and BECOMES THE PROPERTY of the PURCHASER UPON LEAVING the PLANT. ANY CHANGES or CANCELLATION of ORIGINAL INSTRUCTIONS MUST be TELEPHONED to the OFFICE BEFORE LOADING starts. The undersigned promises to pay all costs, including reasonable attorney's fees incurred in collecting any sums owed.

All accounts not paid within 30 days of delivery will bear interest at the rate of 18% per annum. Not Responsible For Reactive Aggregate or Color Quality. No Claim Allowed Unless Made at Time Material Is Delivered.
A $25.00 Service Charge and Loss of the Cash Discounted will be Collected on all Returned Checks. Demurrage charge after 5 min. will be $100.00/hr

PROPERTY DAMAGE RELEASE
(TO BE SIGNED IF DELIVERY TO BE MADE INS DE CURB LINE)

Dear Customer - The driver of this truck in presenting this RELEASE to you for your signature is of the opinion that the size and weight of this truck may possibly cause damage to the premises and/or adjacent property in the places the material in this load where you desire it. It is our wish to help you in everyway that we can, but in order to do this the driver is requesting that you sign this RELEASEreliewing him and this supplier from any responsibility from damage that may occur to the premises and or adjacent property, buildings, sidewalks, driveways, curbs, etc by the delivery of this material and that you also agree to help him remove mud from the wheels of his vehicle so that he will not liter the public streets. Further as additional consideration; the undersigned agrees to indemnify and hold harmless the driver of this truck and this supplier for any and all damage to the premises and for adjacent property which may be claimed by anyone to have arisen out of delivery of this order SIGNED:

X _____

Excessive Water is Detrimental to Concrete Performance.
H_2O Added by Request/Authorized By:

_____ GAL X _____
WEIGHMASTER

Surcharge for credit cards

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE HEALTH WARNING NOTICE AND SUPPLIER WILL NOT BE RESPONSIBLE FOR ANY DAMAGE CAUSED WHEN DELIVERING INSIDE CURB LINE.

LOAD RECEIVED BY

x _____

175304

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0280
Service Date: 09/18/23
Report Date: 10/13/23 Revision 1 - Break Data
Task: PO# 618851

Terracon
6198 Imperial Loop
College Station, TX 77845-5765
979-846-3767 Reg No: F-3272

Client
Texas Transportation Institute
Attn: Bill Griffith
TTI Business Office
3135 TAMU
College Station, TX 77843-3135

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information
Specified Strength: 3,500 psi @ 7 days

Mix ID: TXC3600
Supplier: Texcrete
Batch Time: 0744 **Plant:**
Truck No.: 154 **Ticket No.:** 175304

Sample Information
Sample Date: 09/18/23 **Sample Time:** 0815
Sampled By: Colby Berger
Weather Conditions: Sunny
Accumulative Yards: 4/4 **Batch Size (cy):** 4
Placement Method: Direct Discharge
Water Added Before (gal): 10
Water Added After (gal): 0
Sample Location: Median transition north west corner of runway
Placement Location: Median transition
Sample Description: 6-inch diameter cylinders

Field Test Data

Test	Result	Specification
Slump (in):	5 1/2	
Air Content (%):	1.6	
Concrete Temp. (F):	86	
Ambient Temp. (F):	71	
Plastic Unit Wt. (pcf):		
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	6.00	28.27		10/13/23	25 F	120,470	4,260	2	DD
1	B	Good	6.00	28.27		10/13/23	25 F	109,420	3,870	2	DD
1	C	Good	6.00	28.27		10/13/23	25 F	108,480	3,840	2	DD
1	D						Hold				

Initial Cure: Outside Plastic Lids **Final Cure:** Field Cured

Comments: **Not tested for plastic unit weight. F = Field Cured**
Note: Reported air content does not include Aggregate Correction Factor (ACF).

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).

Terracon Rep.: Colby Berger
Reported To: Bill w/ TTI
Contractor: TTI
Report Distribution:
(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

Start/Stop:

Reviewed By: Alexander Dunigan, P.E.
Project Manager

Test Methods: ASTM C 31, ASTM C143, ASTM C231, ASTM C1064

APPENDIX C. *MASH* TEST 3-21 (CRASH TEST 618851-01-1)

C.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2023-10-16 Test No.: 618851-01-1 VIN No.: 1C6RR6FT4JS157433

Year: 2018 Make: RAM Model: 1500

Tire Size: 265/70 R 17 Tire Inflation Pressure: 35 psi

Tread Type: Highway Odometer: 118929

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

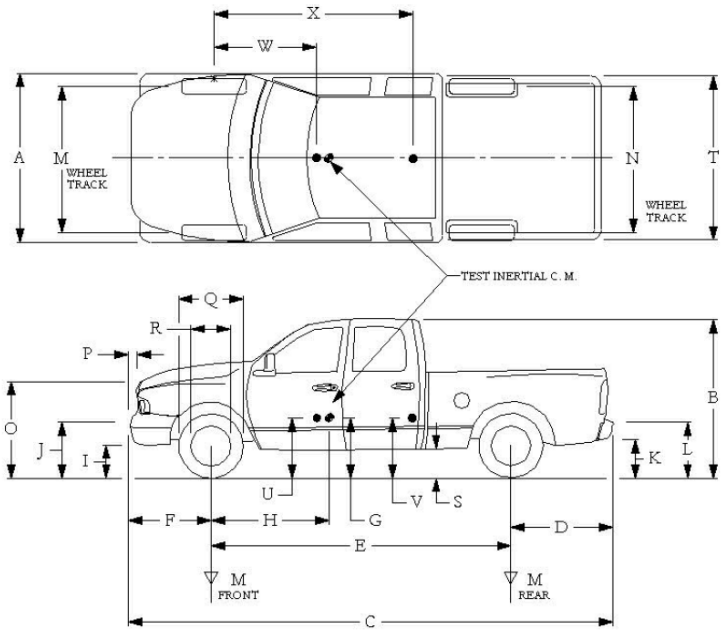
NOTES: None

Engine Type: V-8
Engine CID: 5.7 liter

Transmission Type:
☑ Auto or ☐ Manual
☐ FWD ☑ RWD ☐ 4WD

Optional Equipment:
None

Dummy Data:
Type:
Mass:
Seat Position:



Geometry: inches

A	78.50	F	40.00	K	20.00	P	3.00	U	26.75
B	74.00	G	28.62	L	30.00	Q	30.50	V	30.25
C	227.50	H	61.17	M	68.50	R	18.00	W	
D	44.00	I	11.75	N	68.00	S	13.00	X	79.00
E	140.50	J	27.00	O	46.00	T	77.00		

Wheel Center Height Front	14.75	Wheel Well Clearance (Front)	6.00	Bottom Frame Height - Front	12.50
Wheel Center Height Rear	14.75	Wheel Well Clearance (Rear)	9.25	Bottom Frame Height - Rear	22.50

RANGE LIMIT: A=78 ±2 inches; C=237 ±13 inches; E=148 ±12 inches; F=39 ±3 inches; G = > 28 inches; H = 63 ±4 inches; O=43 ±4 inches; (M+N)/2=67 ±1.5 inches

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	3700	M_{front}	2940	2841	2841
Back	3900	M_{rear}	2086	2191	2191
Total	6700	M_{Total}	5026	5032	5032

(Allowable Range for TIM and GSM = 5000 lb ±110 lb)

Mass Distribution:
lb LF: 1430 RF: 1411 LR: 1108 RR: 1083

Figure C.1. Vehicle Properties for Test 618851-01-1.

Date:	2023-10-16	Test No.:	618851-01-1	VIN No.:	1C6RR6FT4JS157433
Year:	2018	Make:	RAM	Model:	1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width _____	Bowing: B1 _____ X1 _____
Corner shift: A1 _____	B2 _____ X2 _____
A2 _____	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _____
< 4 inches _____	
≥ 4 inches _____	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max*** Crush								
1	AT FRONT BUMPER	19	14	44	-	-	-	-	-	-	-9
2	AT FRONT BUMPER	19	19	62	-	-	-	-	-	-	74
	Measurements recorded										
	☑ inches or ☐ mm										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

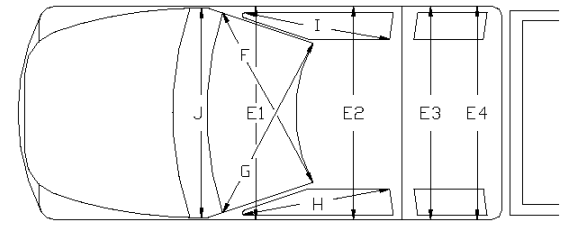
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

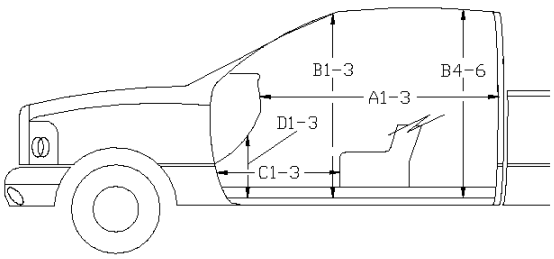
***Measure and document on the vehicle diagram the location of the maximum crush.

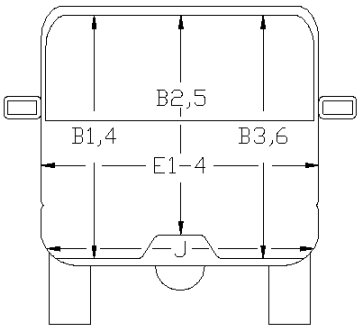
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure C.2. Exterior Crush Measurements for Test 618851-01-1.

Date:	2023-10-16	Test No.:	618851-01-1	VIN No.:	1C6RR6FT4JS157433
Year:	2018	Make:	RAM	Model:	1500







*Lateral area across the cab from driver's side kickpanel to passenger's side kickpanel.

OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	65.00	64.00	-1.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	42.00	-3.00
B2	38.00	39.00	1.00
B3	45.00	45.00	0.00
B4	39.50	38.75	-0.75
B5	43.00	43.00	0.00
B6	39.50	39.50	0.00
C1	26.00	14.50	-11.50
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	11.00	13.25	2.25
D2	0.00	0.00	0.00
D3	11.50	11.50	0.00
E1	58.50	61.25	2.75
E2	63.50	65.75	2.25
E3	63.50	63.50	0.00
E4	63.50	63.50	0.00
F	59.00	59.75	0.75
G	59.00	58.75	-0.25
H	37.50	36.50	-1.00
I	37.50	37.50	0.00
J*	25.00	18.50	-6.50

Figure C.3. Occupant Compartment Measurements for Test 618851-01-1.

C.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure C.4. Sequential Photographs for Test 618851-01-1 (Overhead Views).

(a) 0.000 s (b) 0.100 s

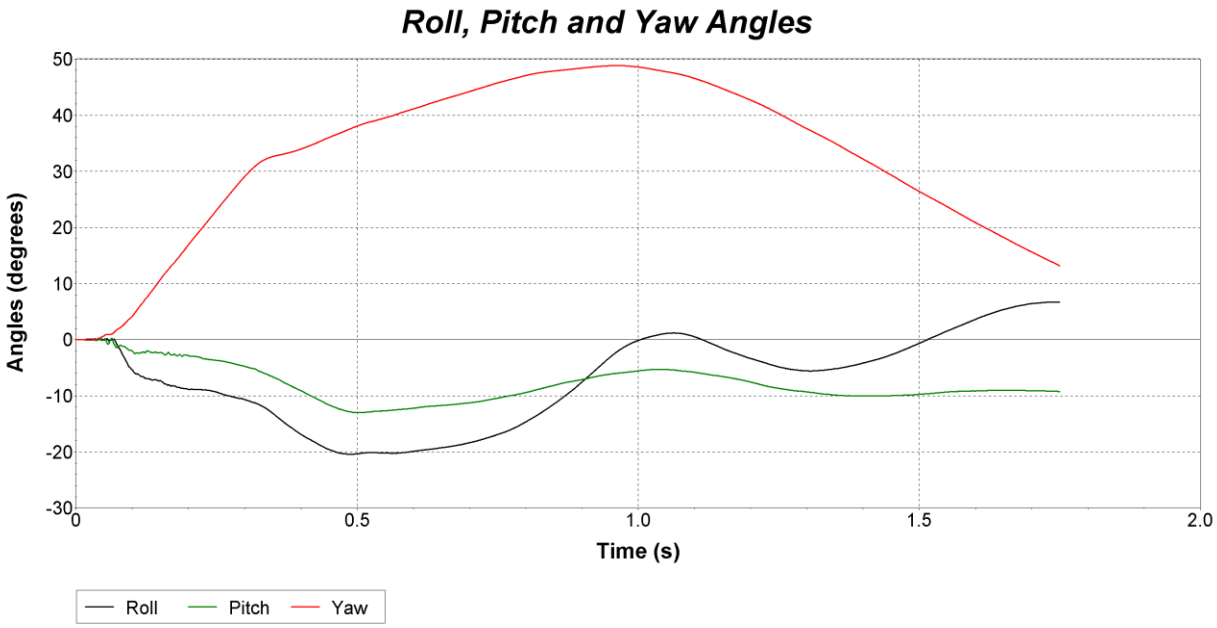
(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

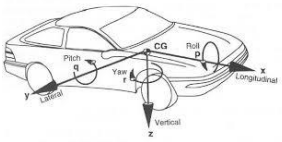
Figure C.5. Sequential Photographs for Test 618851-01-1 (Frontal Views).

C.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

1. Yaw.
2. Pitch.
3. Roll.



Test Number: 618851-01-1
Test Standard Test Number: *MASH* Test 3-21
Test Article: Median Guardrail Transition to Median F-Shape Barrier
Test Vehicle: 2018 RAM 1500
Inertial Mass: 5032 lbs
Gross Mass: 5032 lbs
Impact Speed: 61.3 mi/h
Impact Angle: 25.0°

Figure C.6. Vehicle Angular Displacements for Test 618851-01-1.

C.4. VEHICLE ACCELERATIONS

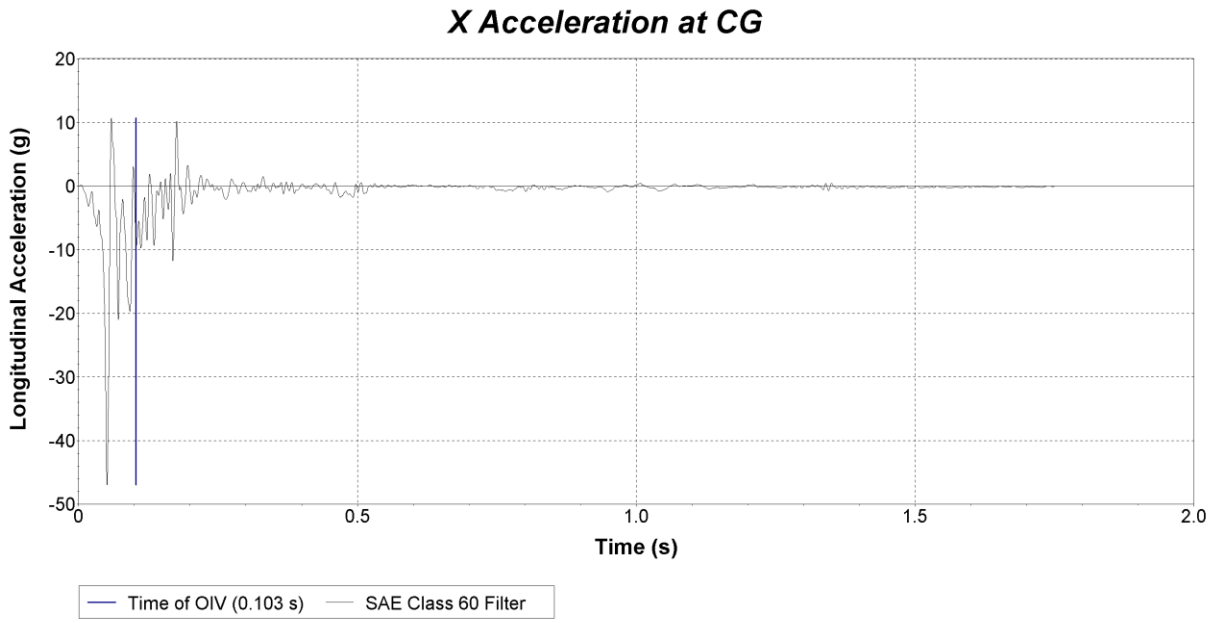


Figure C.7. Vehicle Longitudinal Accelerometer Trace for Test 618851-01-1 (Accelerometer Located at Center of Gravity).

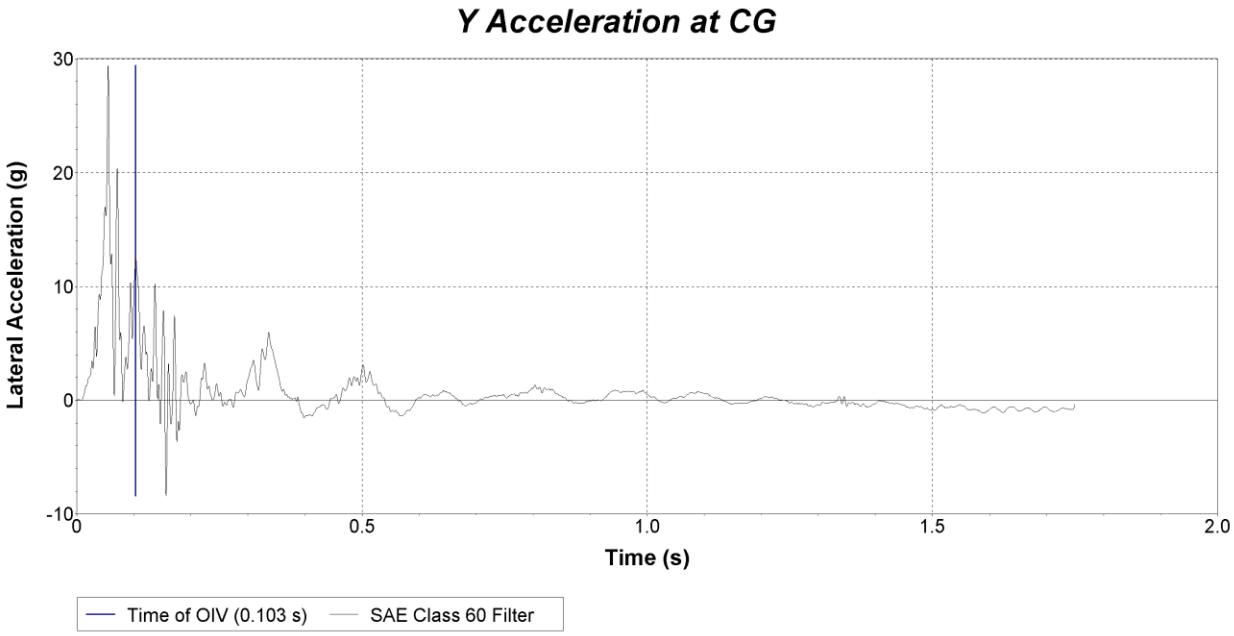


Figure C.8. Vehicle Lateral Accelerometer Trace for Test 618851-01-1 (Accelerometer Located at Center of Gravity).

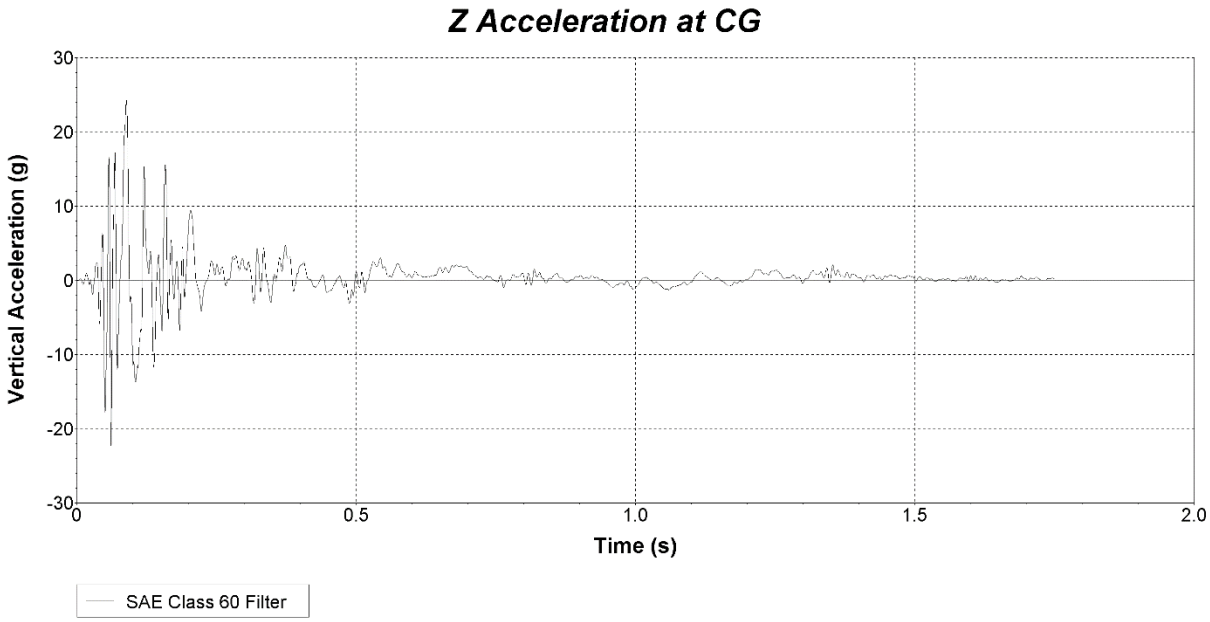


Figure C.9. Vehicle Vertical Accelerometer Trace for Test 618851-01-1 (Accelerometer Located at Center of Gravity).