Texas A&M Transportation Institute
Proving Ground

Test Report No. 616401-01

MULTI-DIRECTIONAL BASE DESIGN FOR STEEL BEAM NON-PROPRIETARY LARGE SIGN SUPPORTS

Sponsored by
Roadside Safety Pooled Fund

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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 Multi-directional Base Design for Steel Beam Non-proprietary Large Sign Supports		5. Report Date January 2025 6. Performing Organization Code
7. Author(s) James C. Kovar, Daniel Curran, and Brianna E. Bastin		8. Performing Organization Report No. TRNo. 616401-01
9. Performing Organization Name and Address Texas A&M Transportation Institute Proving Ground 3135 TAMU College Station, Texas 77843-3135		10. Work Unit No. (TRAIS) 11. Contract or Grant No. Contract T4541
12. Sponsoring Agency Name and Address Roadside Safety Pooled Fund Research Office MS 47372 Transportation Building Olympia, WA 98504		13. Type of Report and Period Covered Technical Report: June 2021 - January 2025 14. Sponsoring Agency Code
15. Supplementary Notes Name of Contacting Representative: Ted Whitmore		

16. Abstract

Many larger sign support assemblies are evaluated through full-scale crash testing with an impact angle of 0 degrees, which represents a normal direction of traffic that allows reading the signage while traveling. However, some of these larger support structures are installed where perpendicular traffic is exposed to impacts with the support structures. This situation is often found at intersections. The Roadside Safety Pooled Fund prioritized the development of a MASH compliant design for a multi-directional support structure for larger signs. Multi-directional designs have been developed for smaller sign supports, but this project is aimed at the larger supports for larger signs and sign assemblies.

In this project, the research team evaluated two designs for larger sign supports, one for a large Route Marker Assembly and one for a guide sign. These two systems were designed to be crash tested with two impact angles, 0 degrees and 90 degrees. After a failure in *MASH* test 3-72 at 90 degrees on the guide sign system, the research team modified the fuse plate design to promote activation. This modified design also failed to meet *MASH* evaluation criteria. Subsequent crash tests evaluated the effectiveness of increasing the mounting height of the sign. These new designs were crash tested according to *MASH* test 3-72 criteria, and all failed to meet *MASH* evaluation criteria.

The research team recommends future research to investigate a modified design which limits the airborne trajectory of the posts and sign panel. This may include further modifications to the fuse plate, a restraint mechanism on the posts, raising the height of the fuse plate but retaining the mounting height of the sign, or other design changes.

17. Key Words		18. Distribution Statement	
Route Marker Assembly, guide sign, crash test, *MASH*, support structure		No restrictions.	
19. Security Classification. (of this report) Unclassified	20. Security Classification. (of this page) Unclassified	21. No. of Pages 308	22. Price

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

Multi-directional Base Design for Steel Beam Non-proprietary Large Sign Supports

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Report 616401-01
Contract No.: T4541

Sponsored by the

Roadside Safety Pooled Fund

January 2025

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The results reported herein apply only to the article tested. The full-scale crash tests were 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.

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ACKNOWLEDGEMENTS

This research project was performed under a pooled fund program between the following States and Agencies. The authors acknowledge and appreciate their guidance and assistance.

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REVISION LOG

Revision Number	Change(s) Made	Date

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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

Support structures are evaluated for American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*) (*1*) compliance with respect to the anticipated direction of impacting vehicles. Many of the larger guide signs or Route Marker Assembly assemblies are evaluated through full-scale crash testing with an impact angle of 0 degrees, which represents a normal direction of traffic that allows reading the signage while traveling. However, some of these larger support structures are installed where perpendicular traffic is also exposed to impacts with the support structures. This situation is often found at intersections. The Roadside Safety Pooled Fund prioritized the development of a MASH compliant design for a multi-directional support structure for larger signs. Multi-directional designs have been developed for smaller sign supports, but this project is aimed at the larger supports for larger signs and sign assemblies. This report details the literature review, state survey, wind load analysis, and full-scale crash testing completed under this project.

CHAPTER 2. LITERATURE REVIEW

2.1. OVERVIEW

This chapter documents the literature review performed for this project. The research team reviewed relevant research regarding large sign support systems. Because the larger signs typically utilize more than one post, this literature review covers research on dual sign support systems.

2.2. TEMPORARY LARGE GUIDE SIGNS (*3*)

The objective of this research was to develop support systems for temporary installations of guide signs. The report includes crash tests conducted on two wooden sign support designs and one steel sign support design. Both utilized large aluminum signs. The first support tested, shown in Figure 2-1, consisted of three 6-inch × 8-inch, Grade 1, Southern Yellow Pine wood supports. The supports were spaced 33 inches apart and were weakened with 4-inch diameter holes located 4 inches and 18 inches above grade. An 8-ft × 16-ft wide (128 square ft) aluminum sign was supported. This design passed the *MASH* 3-60 low speed test (19 mi/hr) at 0 degrees but failed the *MASH* 3-61 high speed test (62 mi/hr) at 0 degrees due to windshield penetration. Figure 2-2 shows the vehicle damage from the *MASH* test 3-61.

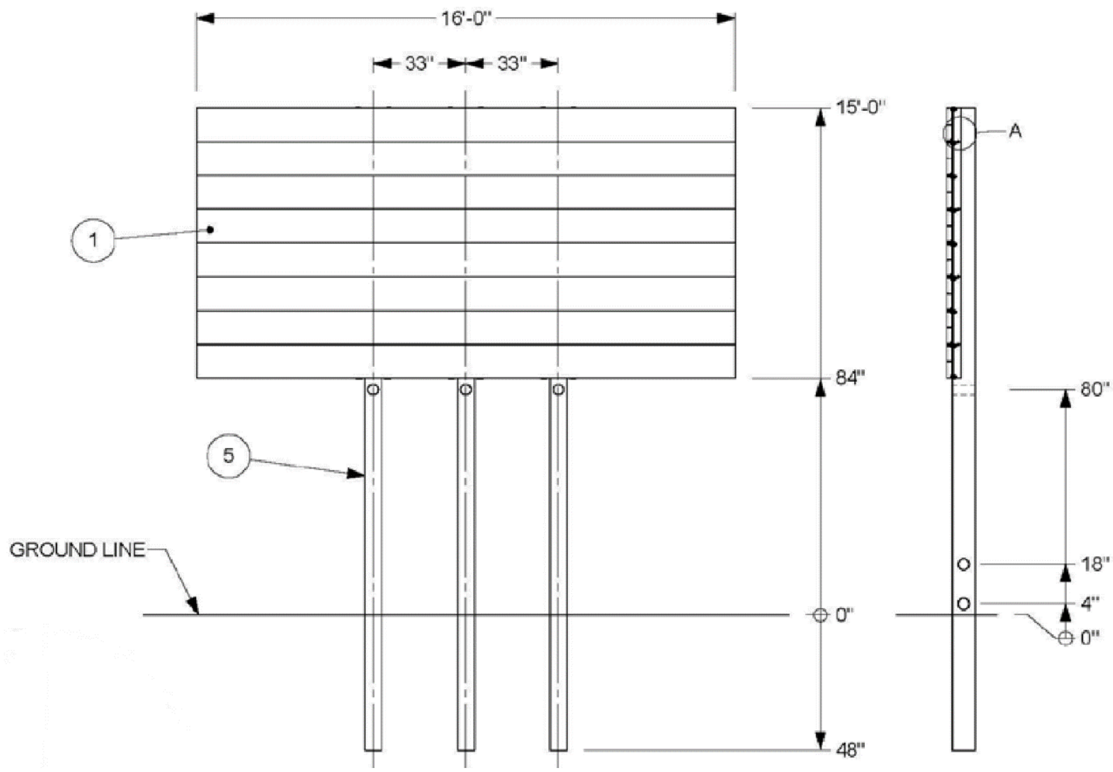


Figure 2-1. Details for Direct Embedded Wood Support Temporary Guide Sign System (*3*)

Figure 2-2. Direct Embedded Wood Support Temporary Guide Sign System 3-61 Test Vehicle Failure Damage (*3*)

After analyzing the failure, researchers proposed a design including a ¼-inch diameter cable to restrict the rotation of the support towards the vehicle upon impact. This support system was evaluated with *MASH* test 3-61 conditions at the 0-degree impact angle. The modification resulted in no occupant compartment intrusion and passed the evaluation criteria. Next, *MASH* test 3-62 at the 0-degree impact angle was conducted on the modified support system. The modified system also passed *MASH* test 3-62 evaluation criteria. Figure 2-3 shows a drawing of the successful modified design.

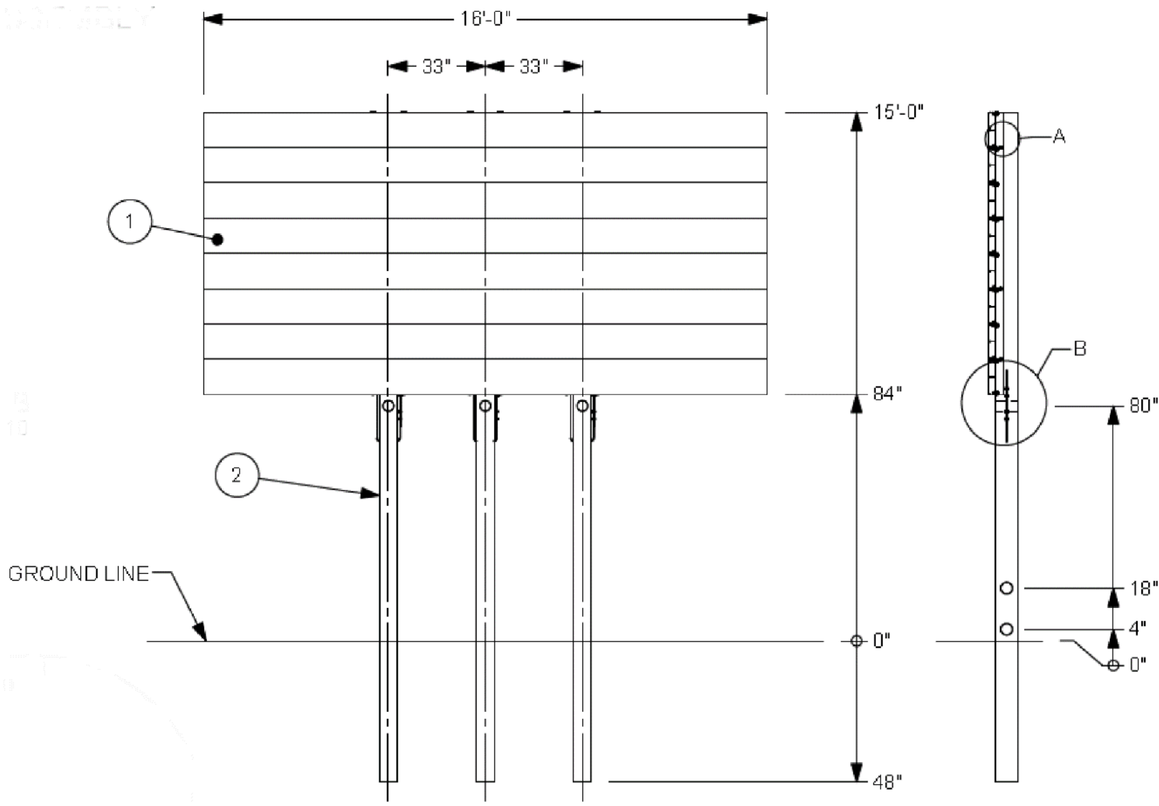


Figure 2-3. Details for Modified Direct Embedded Wood Support Temporary Guide Sign System (*3*)

The report subsequently discusses the design and testing of a direct embedded steel support temporary guide system. The intent of the testing was to verify that the slip base will properly activate without excessive movement when attached to a direct embedded steel foundation post without a concrete footing. Two W6x9 steel posts were used to support the same 128 square ft aluminum sign used in the wooden support crash-tests. The sign was mounted at a height of 7-ft from the ground. The posts were embedded 3.5 ft below grade. *MASH* test 3-60 was first conducted on the support system. After impact, the slip base caught the hood of the car, and caused the hood to be pushed back into the windshield, causing a crack in the lower left windshield. No holes or tears through the safety liner occurred, and the deformation was less than the 3-inch allowable threshold. Additionally, the OIV was also less than the preferred threshold. Therefore, the system passed the *MASH* evaluation criteria for test 3-60. Figure 2-4 shows a drawing of the successfully tested system.

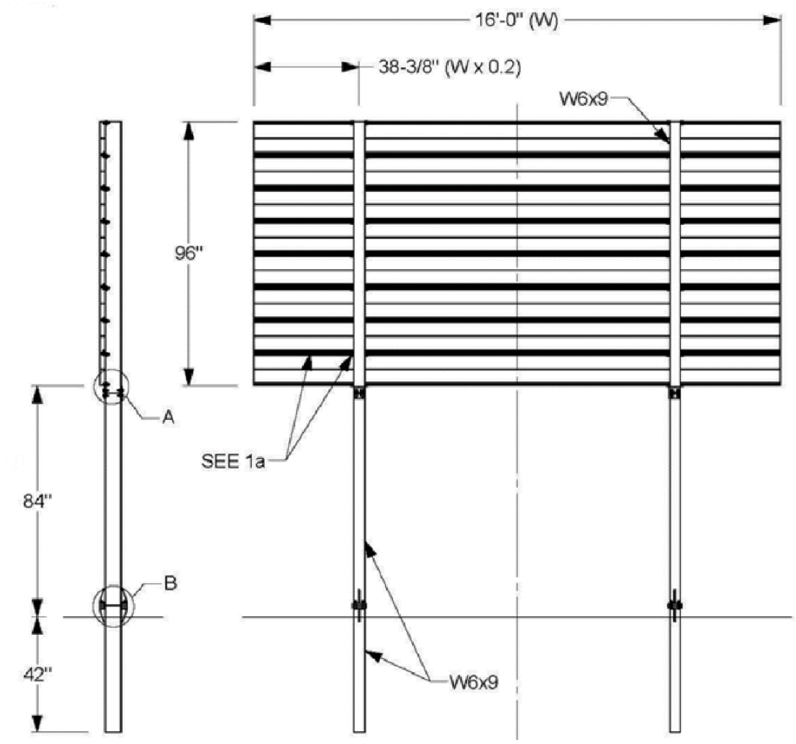


Figure 2-4. Details for Direct Embedded Steel Support Temporary Guide Sign System (*3*)

2.3. PERFORATED TENSION FUSE PLATE FOR BREAKAWAY ROADSIDE SIGNS (*4*)

Friction fuse plates were reported by maintenance engineers to cause signs to fall over in windstorms or after long periods of time. This undesirable behavior was attributed to the failure of the fuse plates. Consequently, the purpose of this research project was to improve the design details for breakaway roadside sign supports and reduce their associated maintenance costs. Specifically, the fuse plate was modified to be a perforated tension fuse plate, which does not rely on bolt penetration and friction to withstand wind loads. Figure 2-5 shows a drawing of the modified fuse plate, and Figure 2-6 shows the modified fuse plate installed on a sign support.

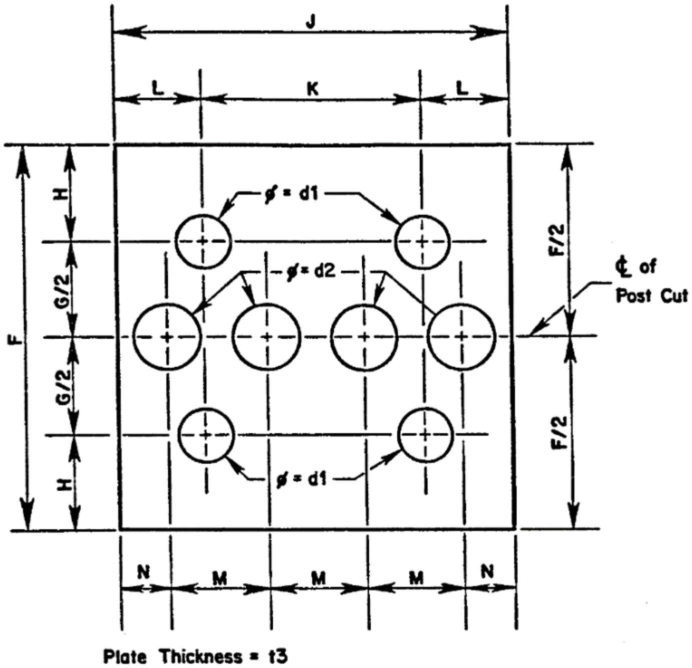


Figure 2-5. Details for Tension Fuse Plate (*4*)

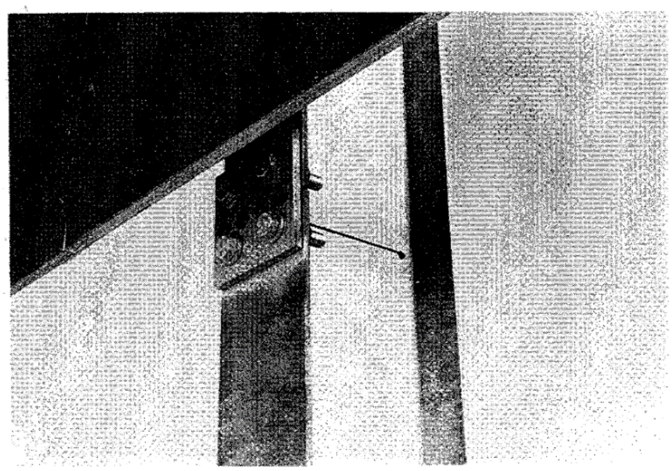


Figure 2-6. Tension Fuse Plate Installed on Sign Support (*4*)

A full-scale crash test was performed with the recommended modified fuse plate with a standard 8 ft tall by 16 ft wide sign support with two W8x18 steel posts. A 1975 Honda Civic was used as the test vehicle. The slip base activated, and the W8x18 post rotated away from the vehicle. The tension fuse plate did not break, but the lower wind clamp was pulled through the lower extruded wind beam. Figure 2-7 shows the test article after the crash test. The impact behavior was viewed as satisfactory, and the crash test was viewed as a success.

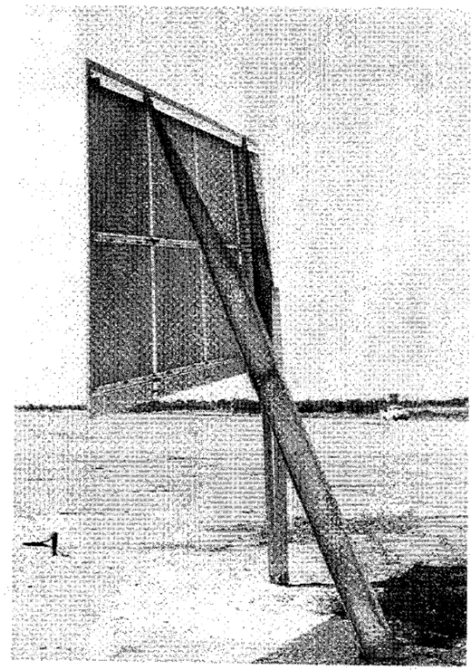


Figure 2-7. Sign Support Damages after Crash Test (*4*)

2.4. CRASH TESTS OF OMNIDIRECTIONAL SLIP-BASE SIGN SUPPORTS (*5*)

The objective of this research project was to determine the impact performance of a triangular, omnidirectional slip-base sign support with an all-direction upper post hinge. Details for the omnidirectional slip-base are shown below in Figure 2-8.

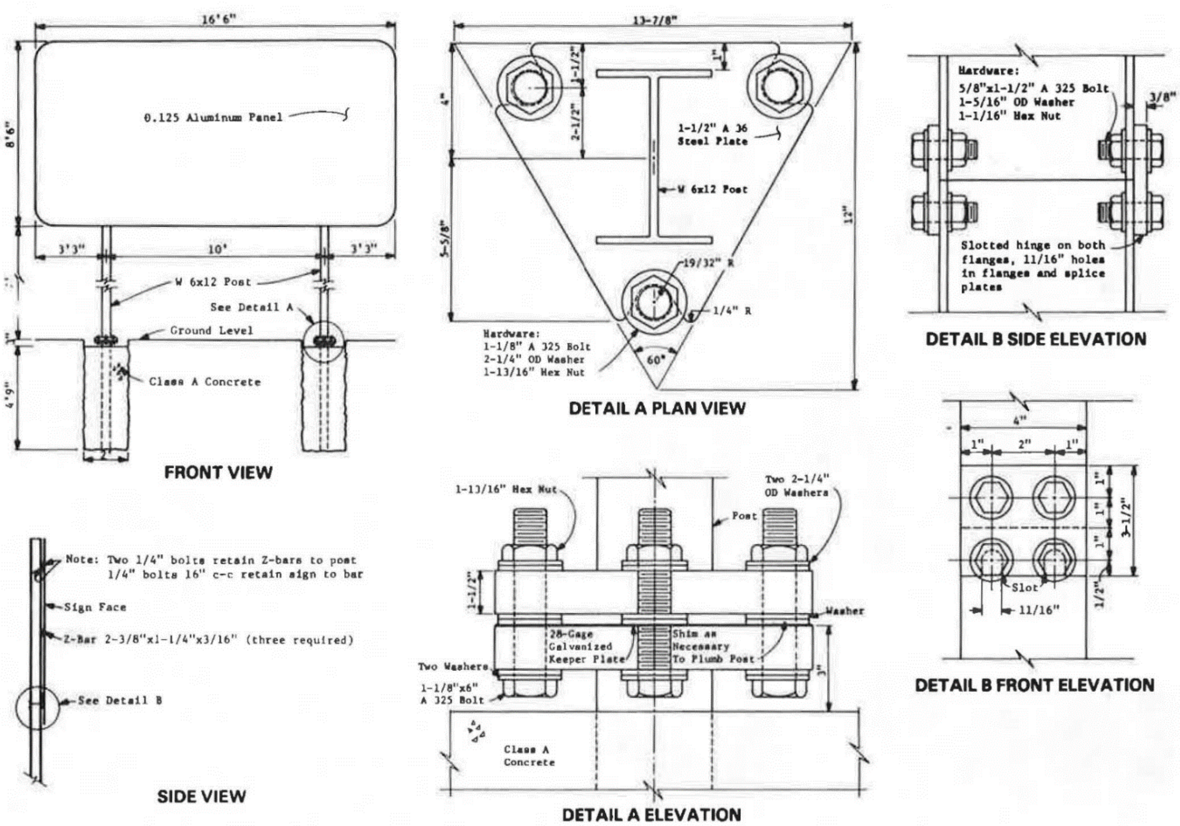


Figure 2-8. Sign Support Damages after Crash Test (*5*)

Four full-scale crash tests were conducted. The first test, Test 29, impacted the system at 90 degrees at a speed of 27.7 mph. The vehicle damage was limited to a 9-in deep, 21-in wide dent in the bumper, hood, and grill of the vehicle. The vehicle's trajectory path was also unaffected throughout the impact and exit of the system.

The second test, Test 30, impacted the system at 30 degrees at 21 mph. Vehicle damage was limited to a 9-in deep, 19-in wide dent in the bumper, grill, and hood of the vehicle.

The third test, Test 31, impacted the system at 30 degrees at a speed of 64.9 mph. The vehicle damage was limited to a 12-in deep, 28-in wide dent in the bumper, grill, and hood of the vehicle. During the test the intermediate post detached and flew downstream.

The final test, Test 32, modified the system and added a 0.25-in diameter cable to the top of the intermediate post and the bottom of the upper post to eliminate the intermediate post movement experienced in the previous high-speed test. The modified system was impacted at 90 degrees at 59.4 mph.

All four tests resulted in changes in momentum being less than the preferable 750 lb-s. Researchers made seven findings from the results of these tests:

1. The omnidirectional sign support used in testing met AASHTO criteria for momentum transfer (below 750 lb-s)

2. Vehicle damage was minimal across all four tests, with slower impact speeds having less damage.
3. Off-center impact testing at high speeds did not adversely affect vehicle trajectory or appurtenance performance.
4. The posts impacted by the vehicle bumper were dented and the flange ends were bent at the hinge.
5. Non-impacted posts sustained greater damage since they were bent and twisted when the sign panels fell.
6. Sign panels sustained bent lower left corners in each test once they impacted the ground.
7. The slotted splice plates on the non-impacted post did not develop enough resistance to maintain the sign in an upright position.

2.5. EVALUATION OF DUAL SUPPORT, TRIANGULAR SLIP-BASE SIGN INSTALLATIONS (*6*)

This report summarized the results of extruded aluminum sign panels up to 60 square feet, mounted on dual schedule 80 pipe supports with triangular slip bases. Figure 2-9 and Figure 2-10 show the test article evaluated through full-scale crash testing.

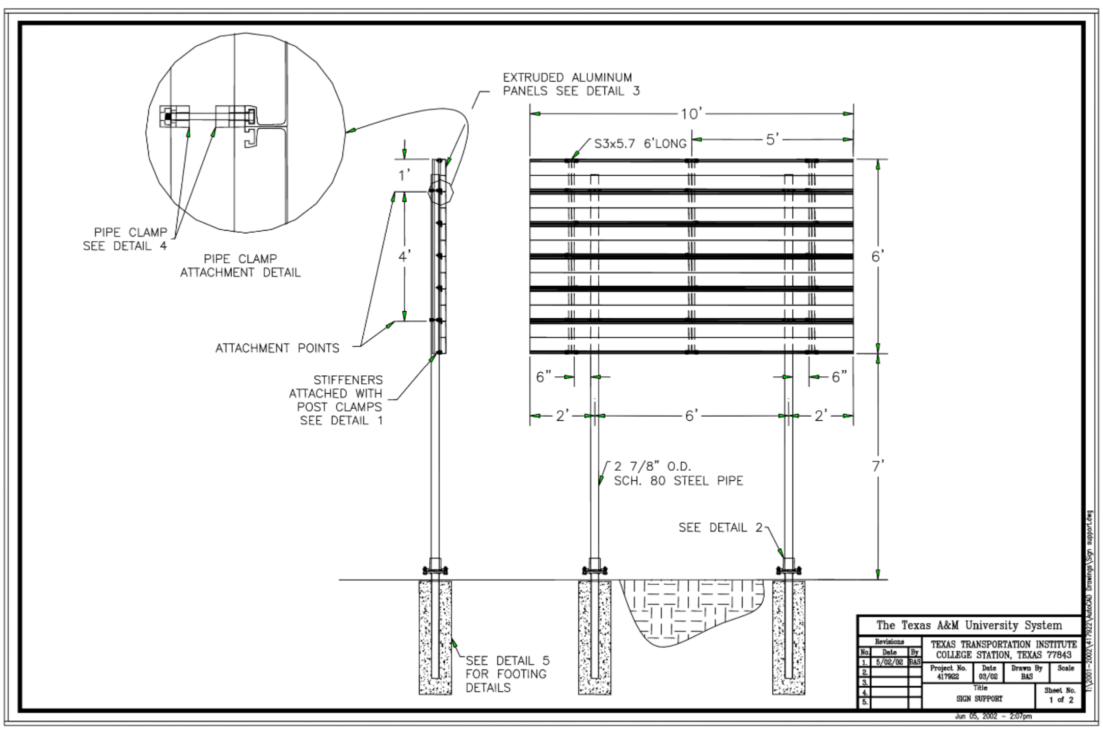


Figure 2-9. Details for Dual Sign Support (*6*)

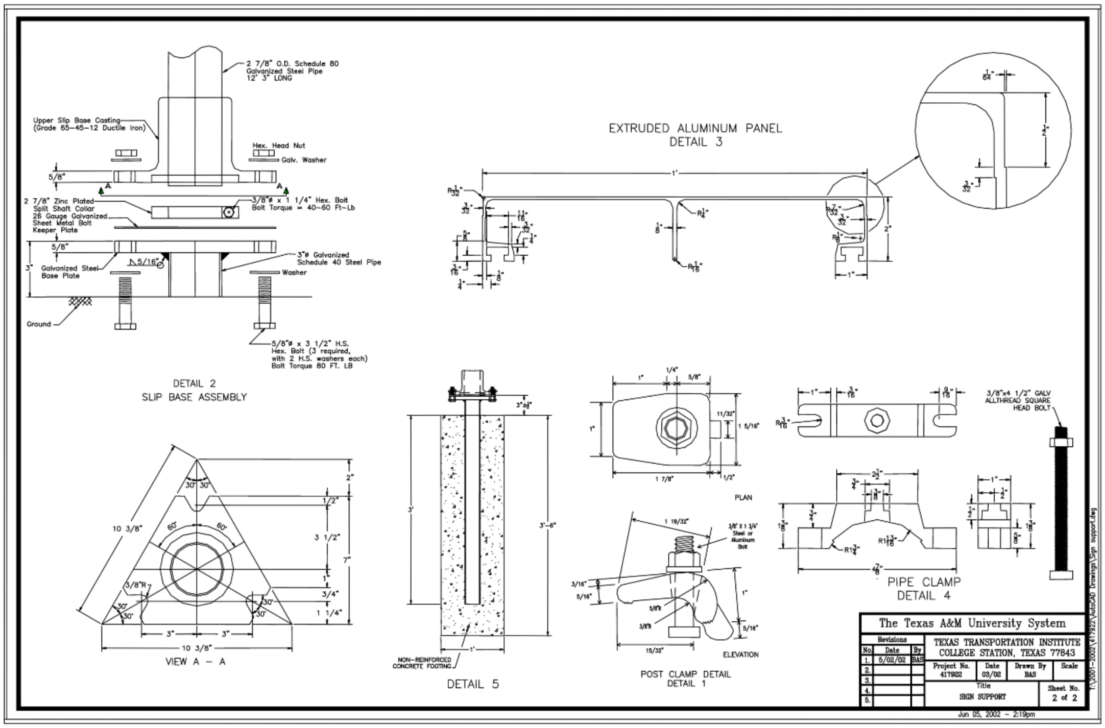


Figure 2-10. Details for Triangular Slip-Base (*6*)

The first test conducted on the system was National Cooperative Highway Research Program (NCHRP) Report 350 (*2)* Test 3-60. One of the dual support legs detached at the base and sign panel, and cracked the windshield. The results of this test were considered acceptable for passing testing criteria. The second test preformed on the system was NCHRP Report 350 Test 3-61. Similarly, one of the dual support legs detached, but no occupant compartment damage/deformation occurred. This test also passed the evaluation criteria.

2.6. DESIGN AND TESTING OF A DUAL SUPPORT BREAKAWAY SIGN (*7*)

Texas Transportation Institute improved a breakaway sign support design consisting of a steel perforated tension fuse plate. When the system was originally crash tested, the fuse plate failed to activate, but met the evaluation criteria. This Midwest Roadside Safety Facility project focused on improving the design and promoting the activation of the fuse plate. The details for the test article are shown in the three following figures.

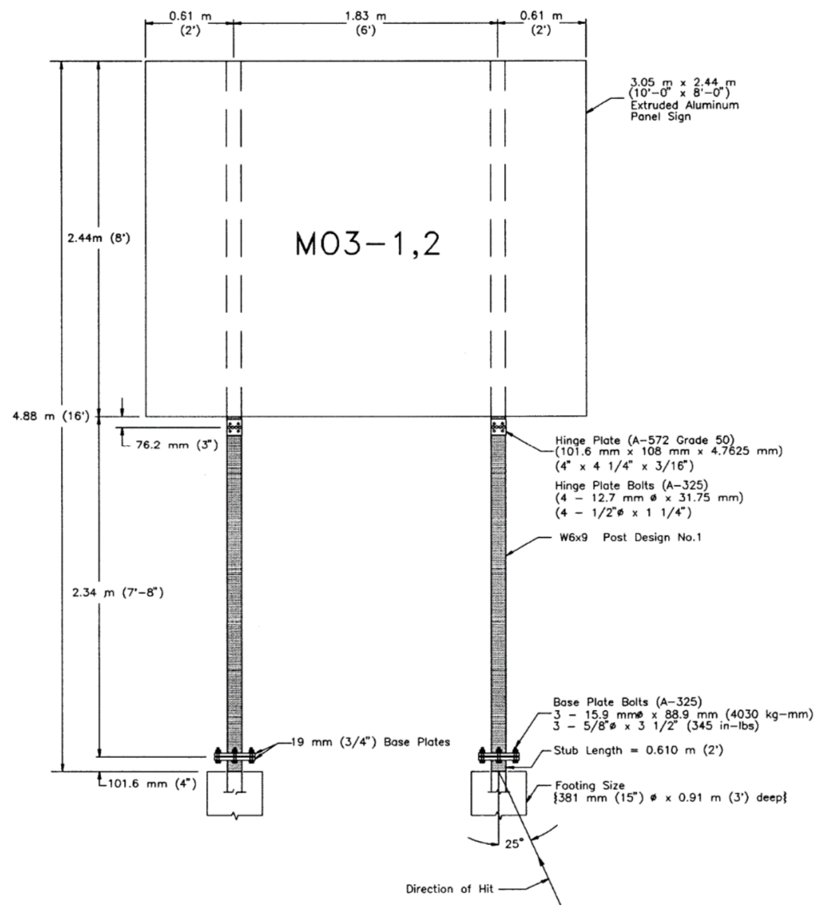


Figure 2-11. Details for Dual Support Breakaway Sign System (*7*)

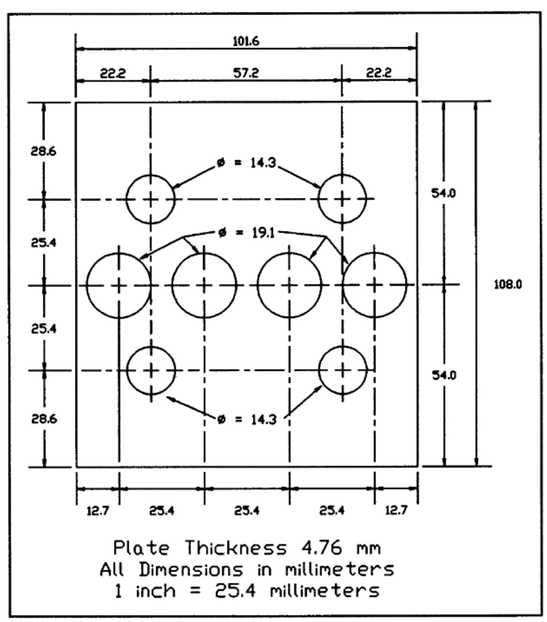


Figure 2-12. Details for Fuse Plate (*7*)

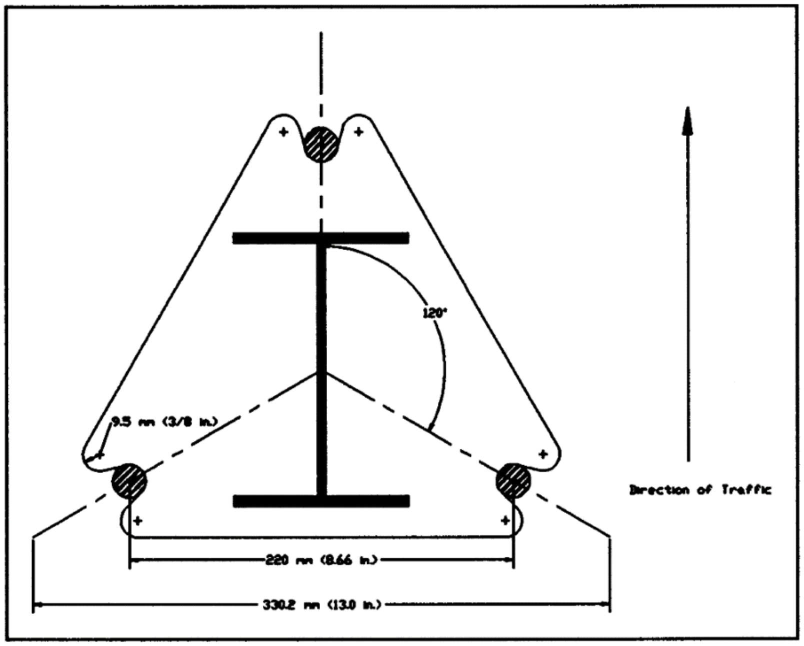


Figure 2-13. Details for Slip-Base (*7*)

Two crash tests were conducted on the new modified system. The first test included an impact at 25 degrees with a speed of 35.6 km/hr. The damage to the test vehicle was minimal, and it was able to be reused in the next test. The second test included an impact at 27 degrees at 92 km/hr. Both tests passed NCHRP Report 350 evaluation criteria. It was noted that additional research would need to be conducted to improve the wind load capacity of the design.

2.7. LITERATURE REVIEW CONCLUSIONS

The research team reviewed previous efforts to develop crashworthy support structures for larger signs. These projects provided insights to the crashworthy nature of design components and the importance of including wind load analysis into the overall design process. This review effort aided the research team in the subsequent tasks of this research project.

CHAPTER 3. STATE SURVEY

3.1. OVERVIEW

This survey was designed to gather information regarding multi-directional large sign support details found across the country. These details would guide the research team in selecting a test article design. The survey was administered online using Qualtrics and was sent to the Roadside Safety Pooled Fund Members. The survey received 13 total responses.

3.2. SURVEY QUESTIONS AND RESPONSES

Q1 – Does your state install large sign supports at locations exposed to both 0deg and 90deg impacts? Large Sign support assemblies are considered as any support that requires a minimum of two posts, employs wide flange or s shape steel posts, and utilizes fuse/fuse plates near the sign.

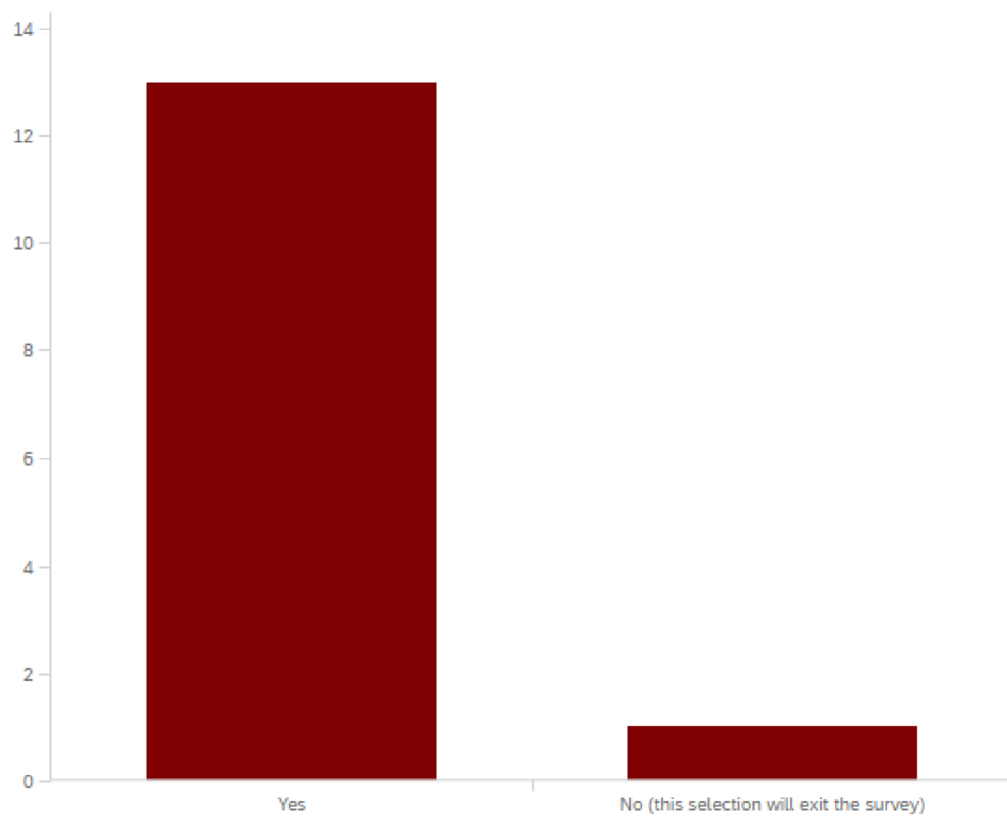
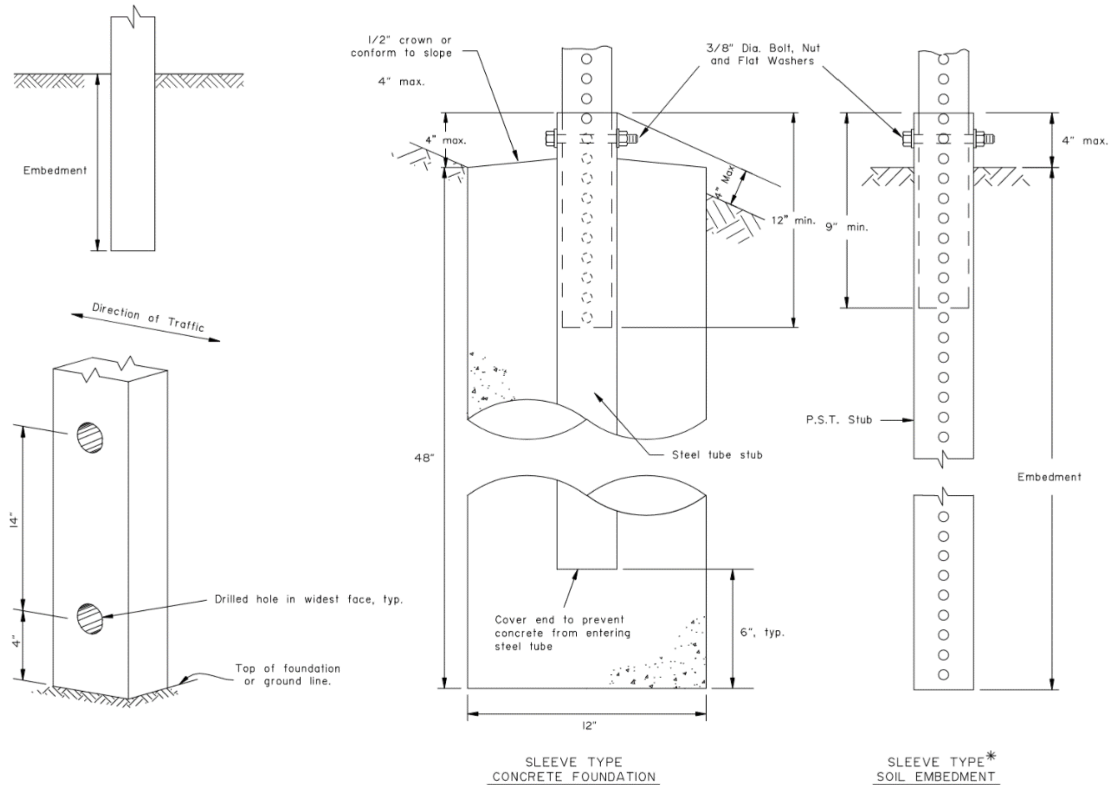


Figure 3-1. Question 2 Responses

Q2 – Please attach a link to or upload a standard detail sheet, or drawing.

S-30.05

SHEET | of |



GENERAL NOTES:

1. Sign shall be placed symmetrically around posts and refer to Standard Plan S-00 for sign framing details.
2. See plans for type of post, size and embedment type.
3. To maintain crashworthiness, install no more than the number of P.S.T.s or wood posts specified in the tables within 7' of each other.
4. Concrete shall be class B.
5. Do not use the supports on this drawing for multiple support signs if supports are separated by more than 7 feet.
6. Treat all field cuts and field drilled holes in wood posts in accordance with Section 730-2.04 of the Standard Specifications.

SIGN POST SPACING NOTES:

1. Install sign support in accordance with the table below, unless otherwise required by plans or specifications.
2. Exceptions:
   a. Usc onc post for all E5-I gore signs, regardless of width.
   b. Use one 2.5" P.S.T. for all STOP signs, with or without street name signs.
3. Supports placed within 7' of each other must be acceptable for that use. See tables below for the sizes of wood posts and P.S.T.s that may be used within 7'. See Manufacturer's documentation for breakaway couplings and tubes that may be used within 7'.
4. See Standard Plan S-31 for frangible couplings, hinges, and foundations for tube and W-shape sign supports.

WOOD SIGN POSTS			
SIZE	HOLE DIA.	EMBEDMENT*	NO. OF POSTS WITHIN 7 Ft. PATH
4"x4"	NONE	4'-1"	2
4"x6"	1 1/2"	5'-3"	2
6"x6"	1 1/2"	4'-9"	1
6"x8"	3"	4'-9"	1

* Embedment depth applies in both strong and weak soil.

WOOD POSTS

PERFORATED STEEL TUBES (P.S.T.)		
POST SIZE	Embedment Depth	No. of P.S.T.s permitted within 7 ft path
1 1/2" x 1 1/2"	4'-8"	2
1 3/4" x 1 3/4"	4'-6"	2
2" x 2"	4'-3"	2
2 1/4" x 2 1/4"	5'-0"	1
2 1/2" x 2 1/2"	4'-6"	1

* Use 3"x3"x3/16" Stub for 2 1/2"x2 1/2" PST Applications.

PERFORATED STEEL TUBE (PST) POSTS

TUBE SIGN POST SPACING								
Sign Width (feet)	No. of Posts	Distance Between Posts	Sign Overhang	Post Type				Notes
				P.S.T.	Wood	Steel Tube	W-Shape	
0.5 to 4.0	1	-	0.5W	X	X	X		See Note 2.
4.5 to 10.0	2	0.6W	0.2W	X	X	X		See Note 3.
10.5 to 11.0	2	6	Varies	X	X	X		See Note 3.
11.5 to 13.0	2	8	Varies				X	
13.5 to 20.0	2	0.6W	0.2W				X	
20.5 to 22.5	3	8	Varies				X	
23.0 to 29.5	3	0.35W	0.15W				X	
30.0 to 31.5	4	8	Varies				X	
32.0 to 40.0	4	0.25W	0.125W				X	

TUBE SIGN POST SPACING

Note: Drawing not to scale

State of Alaska DOT&PF
ALASKA STANDARD PLAN

LIGHT SIGN STRUCTURE
POST EMBEDMENT

Adopted as an Alaska Standard Plan by: Carolyn Morehouse
Carolyn Morehouse, P.E.
Chief Engineer

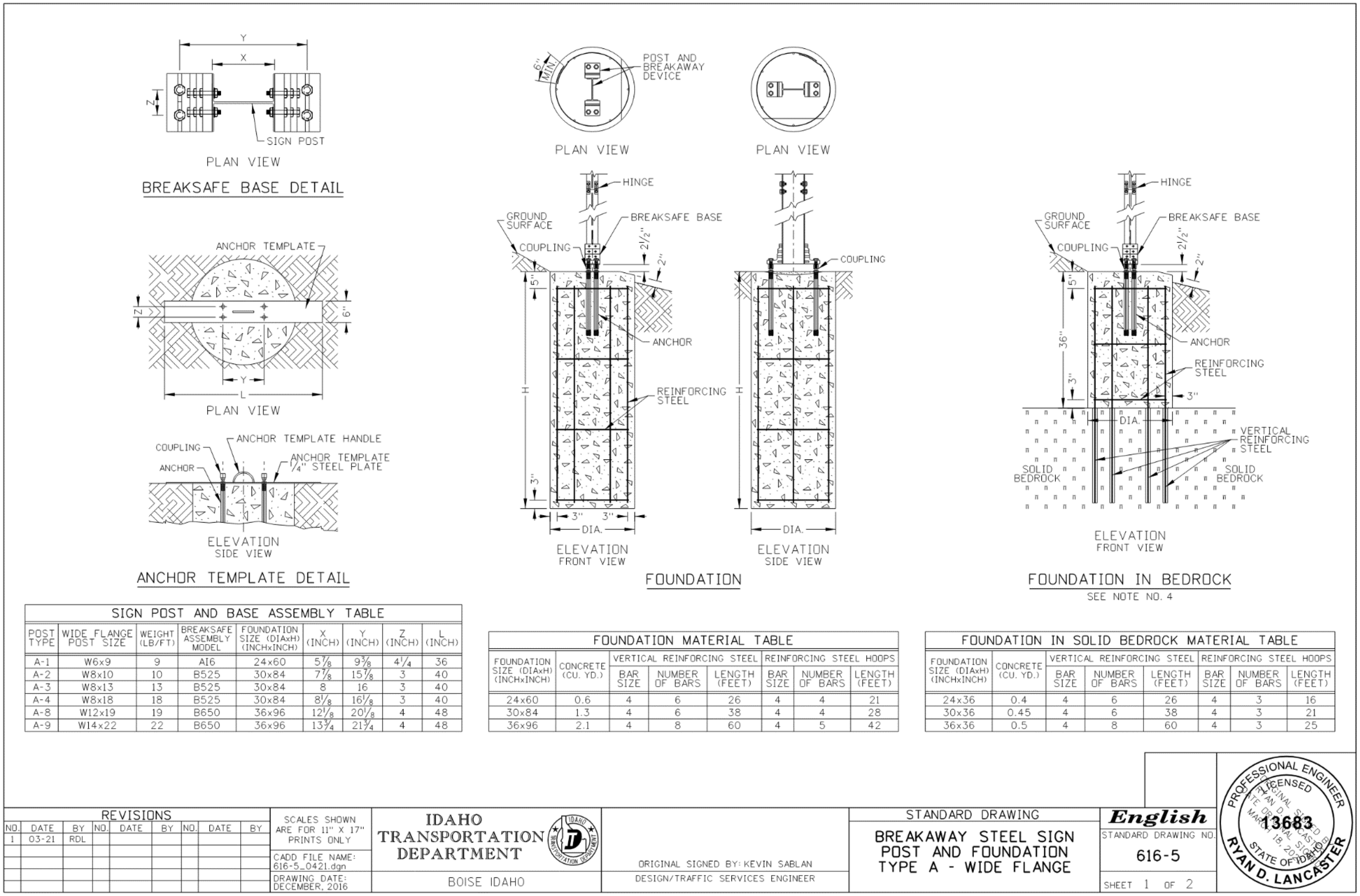
Adoption Date: 7/17/2020

Last Code and Stds. Review
By: WTH Date: 7/8/2020

Next Code and Standards Review date: 7/8/2030

S-30.05

Figure 3-2. Alaska's Response for Question 2.



SIGN POST AND BASE ASSEMBLY TABLE

POST TYPE	WIDE FLANGE POST SIZE	WEIGHT (LB/FT)	BREAKSAFE ASSEMBLY MODEL	FOUNDATION SIZE (DIAxH) (INCHxINCH)	X (INCH)	Y (INCH)	Z (INCH)	L (INCH)
A-1	W6x9	9	AI6	24x60	5 7/8	9 3/8	4 1/4	36
A-2	W8x10	10	B525	30x84	7 7/8	15 7/8	3	40
A-3	W8x13	13	B525	30x84	8	16	3	40
A-4	W8x18	18	B525	30x84	8 1/8	16 1/8	3	40
A-8	W12x19	19	B650	36x96	12 1/8	20 1/8	4	48
A-9	W14x22	22	B650	36x96	13 3/4	21 3/4	4	48

FOUNDATION MATERIAL TABLE

FOUNDATION SIZE (DIAxH) (INCHxINCH)	CONCRETE (CU. YD.)	VERTICAL REINFORCING STEEL			REINFORCING STEEL HOOPS		
		BAR SIZE	NUMBER OF BARS	LENGTH (FEET)	BAR SIZE	NUMBER OF BARS	LENGTH (FEET)
24x60	0.6	4	6	26	4	4	21
30x84	1.3	4	6	38	4	4	28
36x96	2.1	4	8	60	4	5	42

FOUNDATION IN SOLID BEDROCK MATERIAL TABLE

FOUNDATION SIZE (DIAxH) (INCHxINCH)	CONCRETE (CU. YD.)	VERTICAL REINFORCING STEEL			REINFORCING STEEL HOOPS		
		BAR SIZE	NUMBER OF BARS	LENGTH (FEET)	BAR SIZE	NUMBER OF BARS	LENGTH (FEET)
24x36	0.4	4	6	26	4	3	16
30x36	0.45	4	6	38	4	3	21
36x36	0.5	4	8	60	4	3	25

Figure 3-3. Idaho's Response for Question 2 (1/2).

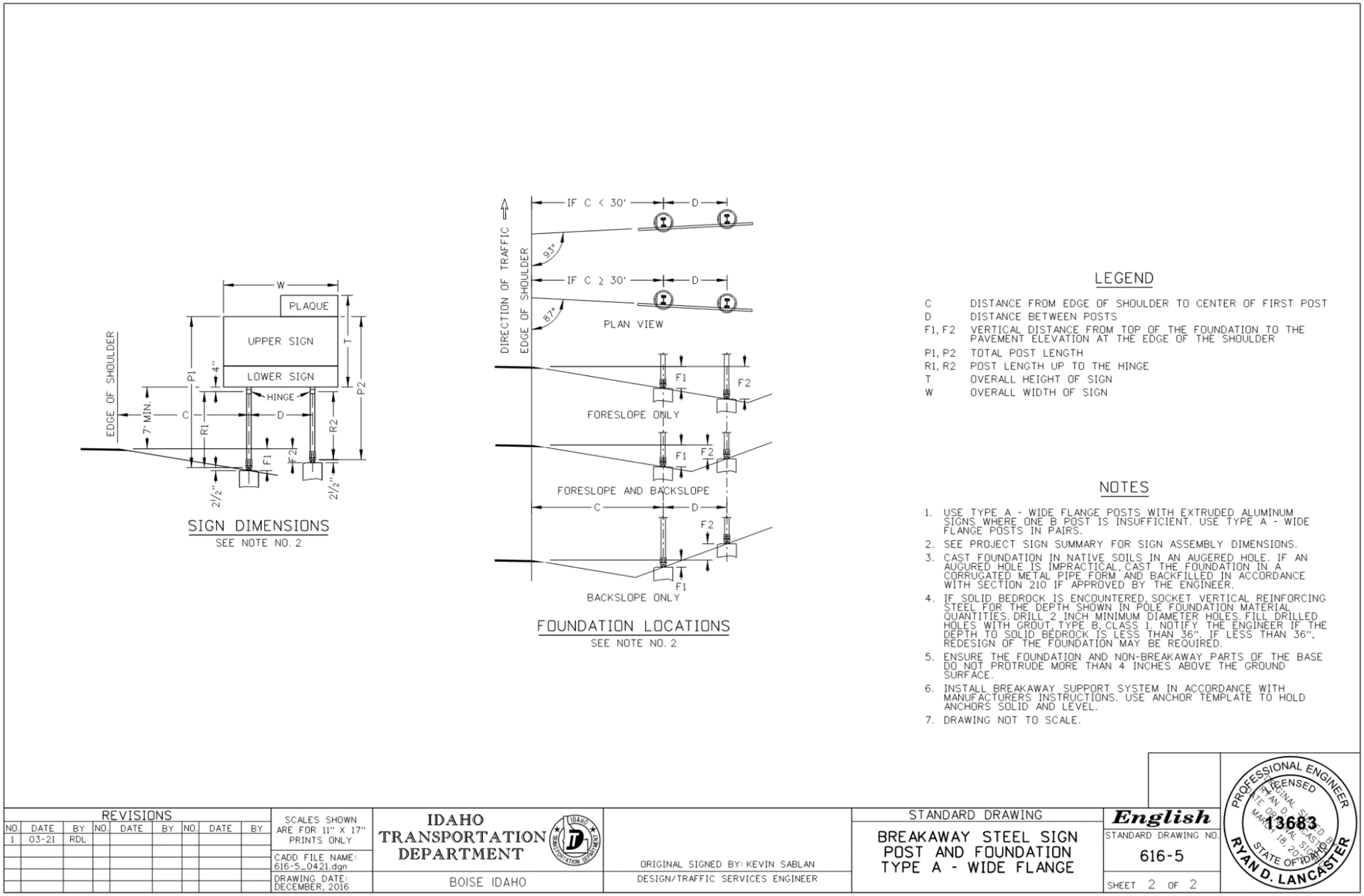


Figure 3-4. Idaho's Response for Question 2 (2/2).

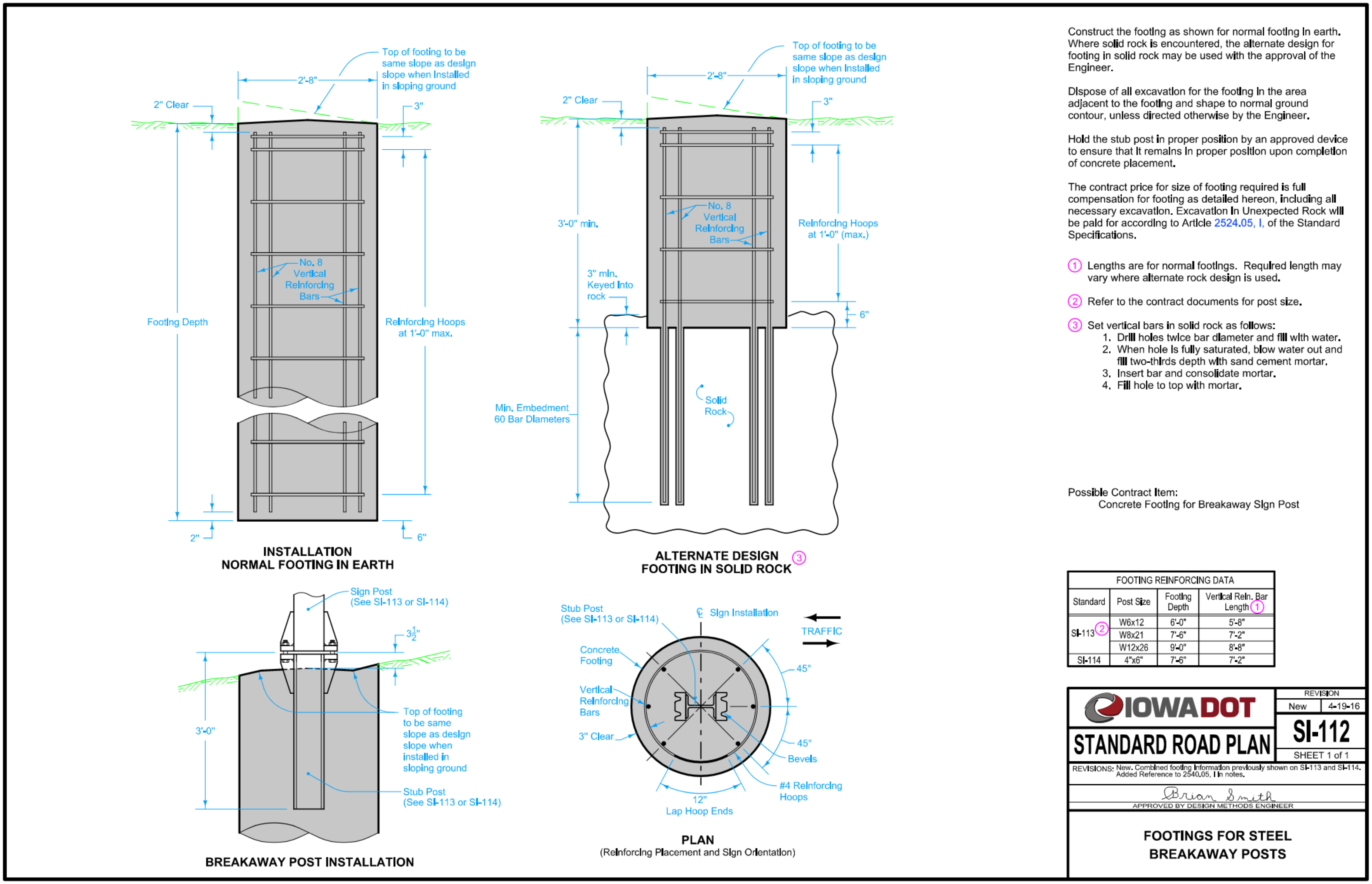
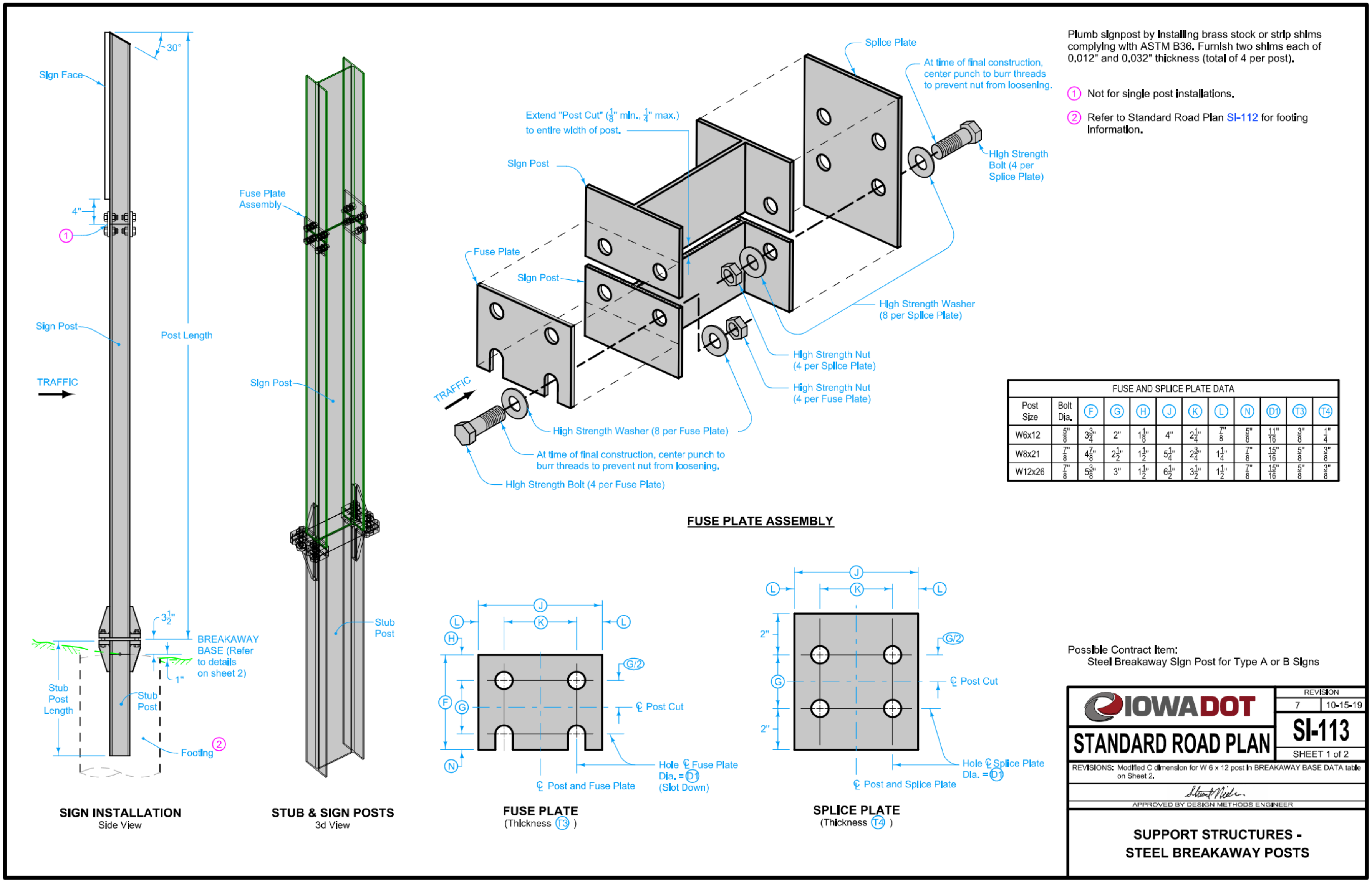


Figure 3-5. Iowa's Response for Question 2 (1/5).



FUSE AND SPLICE PLATE DATA

Post Size	Bolt Dia.	F	G	H	J	K	L	N	D1	T3	T4
W6x12	5/8"	3 3/4"	2"	1 1/8"	4"	2 1/4"	7/8"	5/8"	11/16"	3/8"	1/4"
W8x21	7/8"	4 7/8"	2 1/2"	1 1/2"	5 1/4"	2 3/4"	1 1/4"	7/8"	15/16"	5/8"	3/8"
W12x26	7/8"	5 3/8"	3"	1 1/2"	6 1/2"	3 1/2"	1 1/2"	7/8"	15/16"	5/8"	3/8"

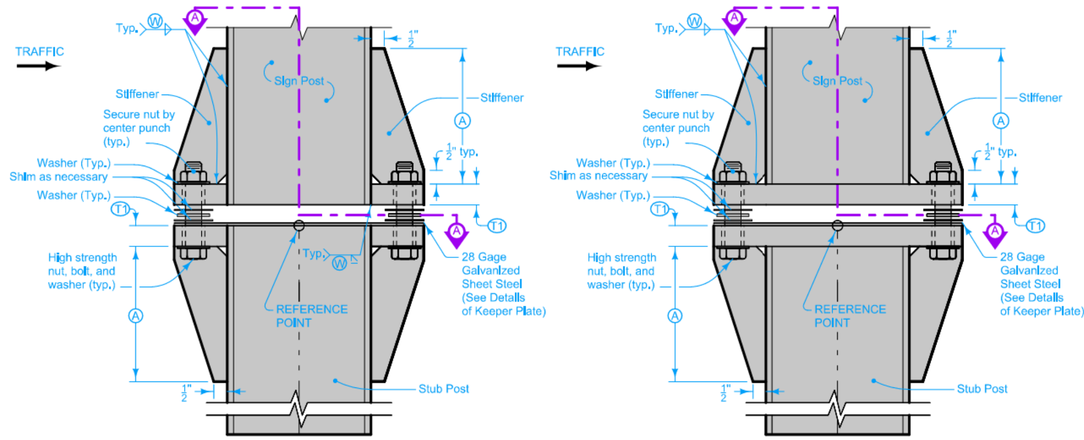
Figure 3-6. Iowa's Response for Question 2 (2/5)

The following Base Plate alternates are considered equivalent:

Alternate 1 - Weld base plates (2 each), to sides of signpost and stub post flanges.

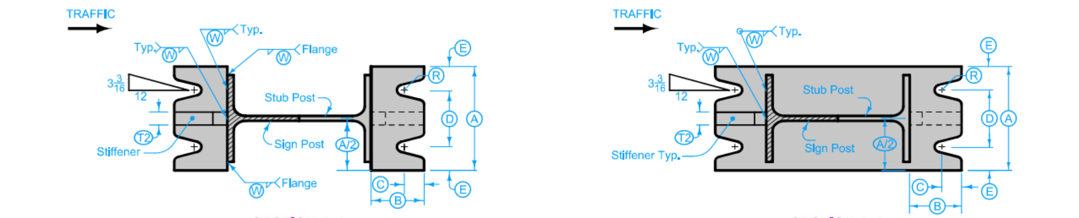
Alternate 2 - Weld base plate (1 each) to end of sign post and stub post. Properly match and align the bolt holes and notches in the stub post plate and the sign post plate as indicated herein.

Grind smooth all welds and galvanizing between Base Plates.



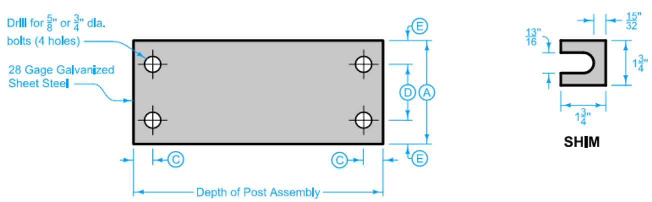
BREAKAWAY BASE
Side View
(Alternate 1)

BREAKAWAY BASE
Side View
(Alternate 2)



SECTION A-A
PLAN - BASE
(ALTERNATE 1)

SECTION A-A
PLAN - BASE
(ALTERNATE 2)



KEEPER PLATE

SHIM

BREAKAWAY BASE DATA

Post Size	Bolt Size & Torque	A	B	C	D	E	T1	T2	W	R
W 6 x 12	5/8" dia. x 2 3/4" Torque = 37.50 ft. lbs.	5"	2"	3/4"	2 3/4"	1 1/8"	3/4"	1/2"	1/4"	11/32"
W 8 x 21 W 12 x 26	3/4" dia. x 3 1/2" Torque = 62.50 ft. lbs.	6"	2 1/4"	7/8"	3 1/2"	1 1/4"	1"	3/4"	5/16"	13/32"

IOWADOT

STANDARD ROAD PLAN

REVISION 7 10-15-19

SI-113

SHEET 2 of 2

REVISIONS: Modified C dimension for W 6 x 12 post in BREAKAWAY BASE DATA table on Sheet 2.

APPROVED BY DESIGN METHODS ENGINEER

SUPPORT STRUCTURES - STEEL BREAKAWAY POSTS

Figure 3-7. Iowa's Response for Question 2 (3/5)

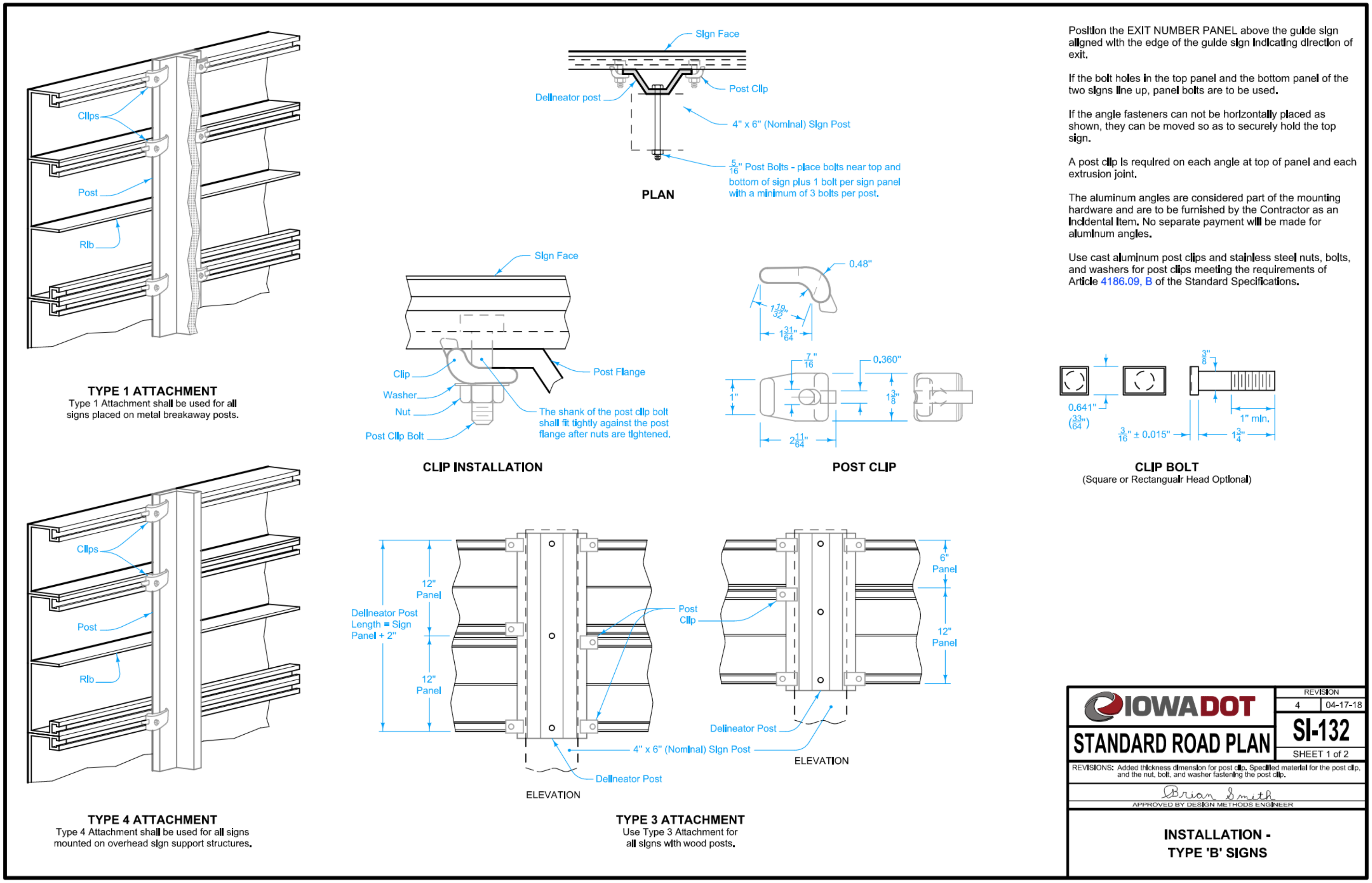


Figure 3-8. Iowa's Response for Question 2 (4/5).

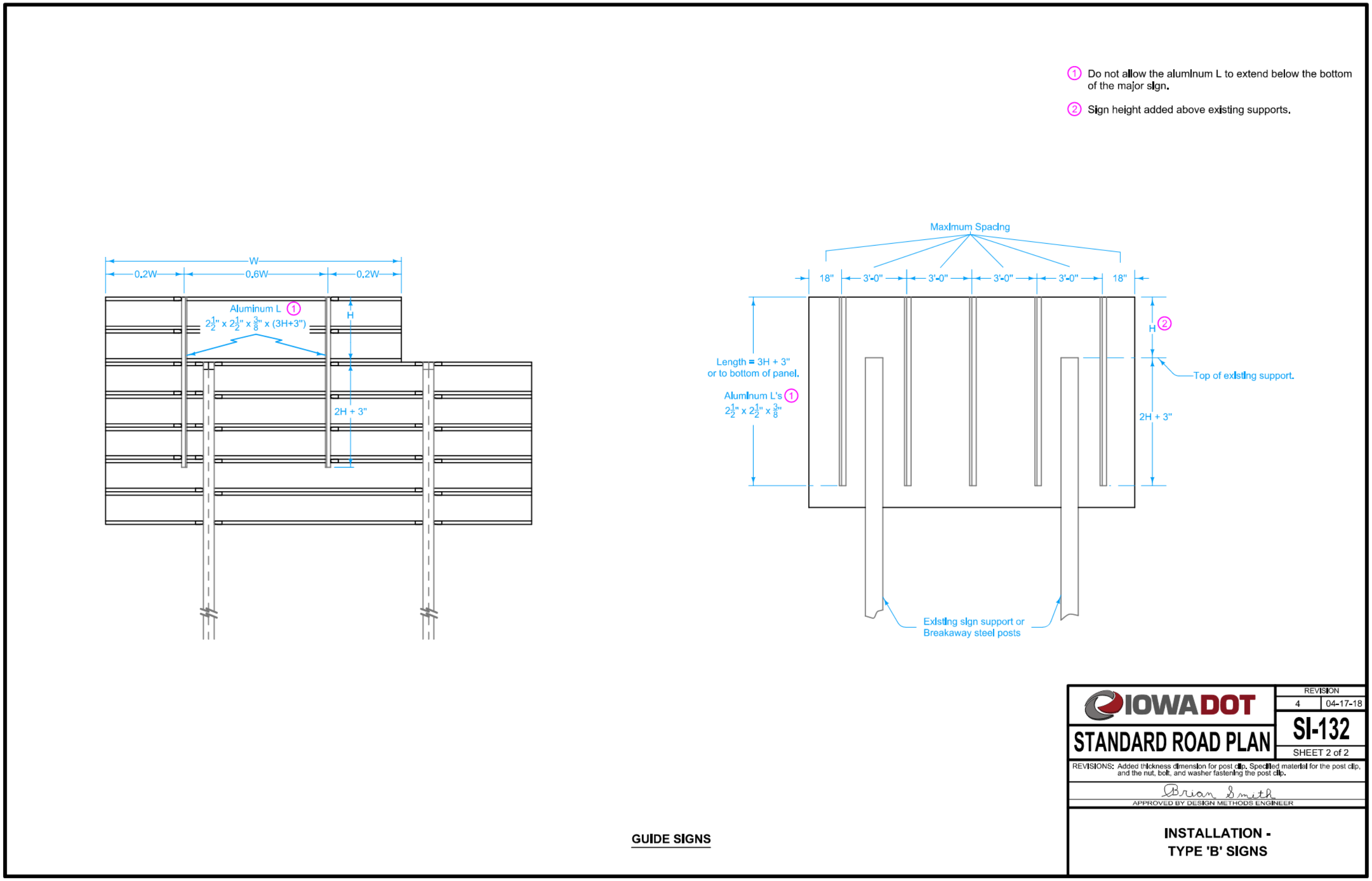
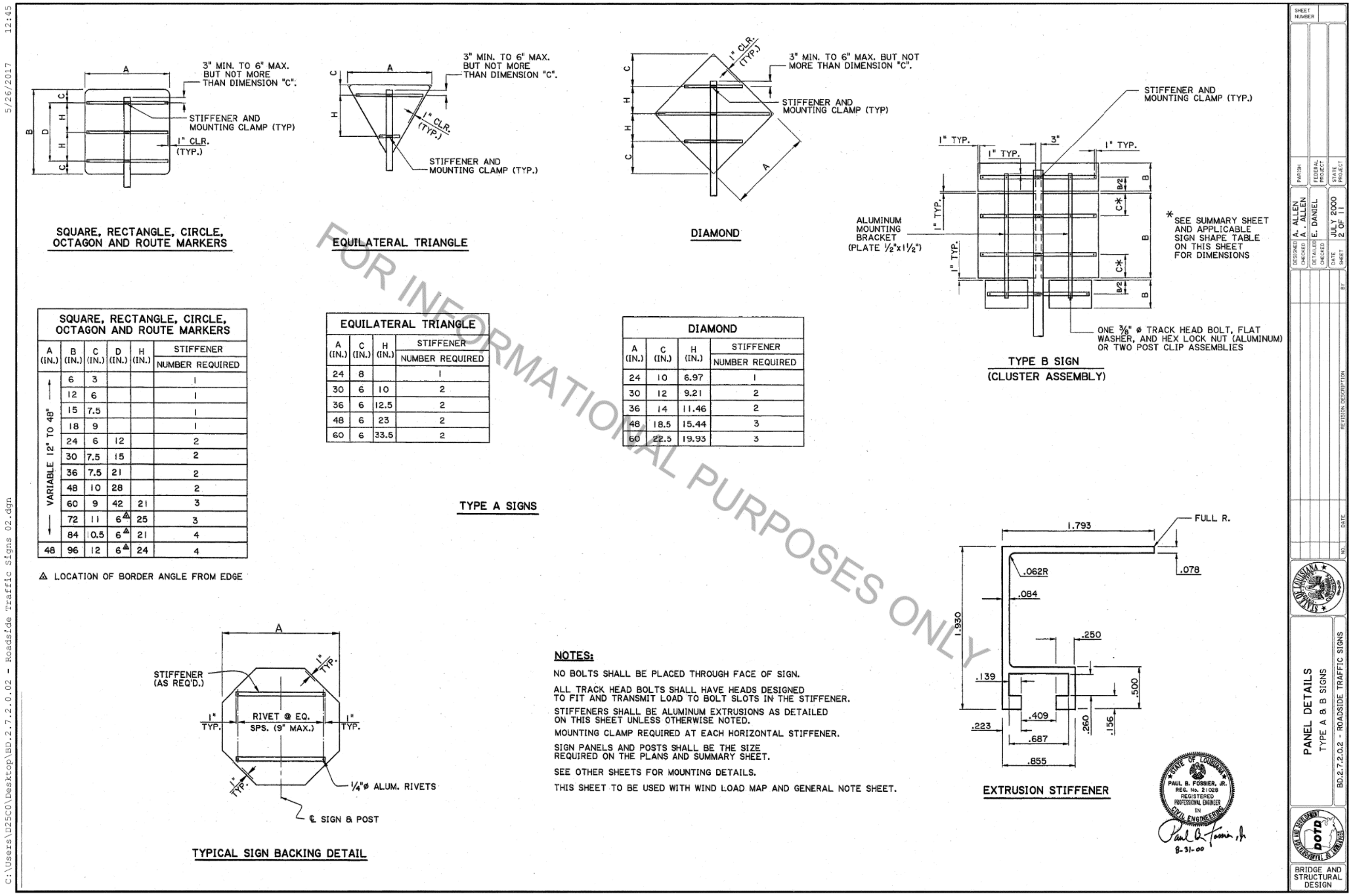


Figure 3-9. Iowa's Response for Question 2 (5/5).



SQUARE, RECTANGLE, CIRCLE, OCTAGON AND ROUTE MARKERS

A (IN.)	B (IN.)	C (IN.)	D (IN.)	H (IN.)	STIFFENER NUMBER REQUIRED
VARIABLE 12" TO 48"	6	3			1
	12	6			1
	15	7.5			1
	18	9			1
	24	6	12		2
	30	7.5	15		2
	36	7.5	21		2
	48	10	28		2
	60	9	42	21	3
	72	11	6△	25	3
	84	10.5	6△	21	4
48	96	12	6△	24	4

△ LOCATION OF BORDER ANGLE FROM EDGE

EQUILATERAL TRIANGLE

A (IN.)	C (IN.)	H (IN.)	STIFFENER NUMBER REQUIRED
24	8		1
30	6	10	2
36	6	12.5	2
48	6	23	2
60	6	33.5	2

DIAMOND

A (IN.)	C (IN.)	H (IN.)	STIFFENER NUMBER REQUIRED
24	10	6.97	1
30	12	9.21	2
36	14	11.46	2
48	18.5	15.44	3
60	22.5	19.93	3

Figure 3-10. Louisiana's Response for Question 2 (1/10).

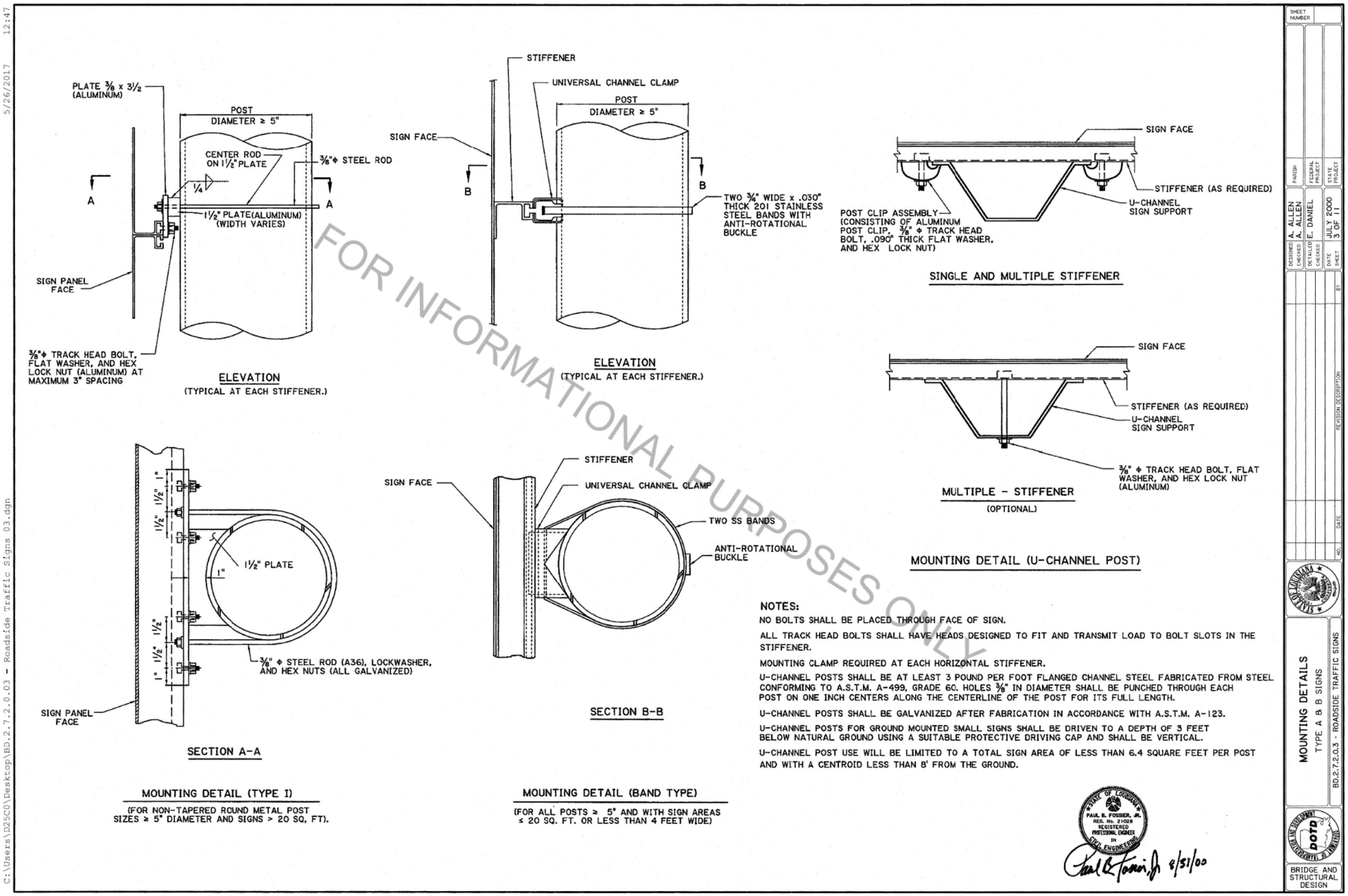


Figure 3-11. Louisiana's Response for Question 2 (2/10).

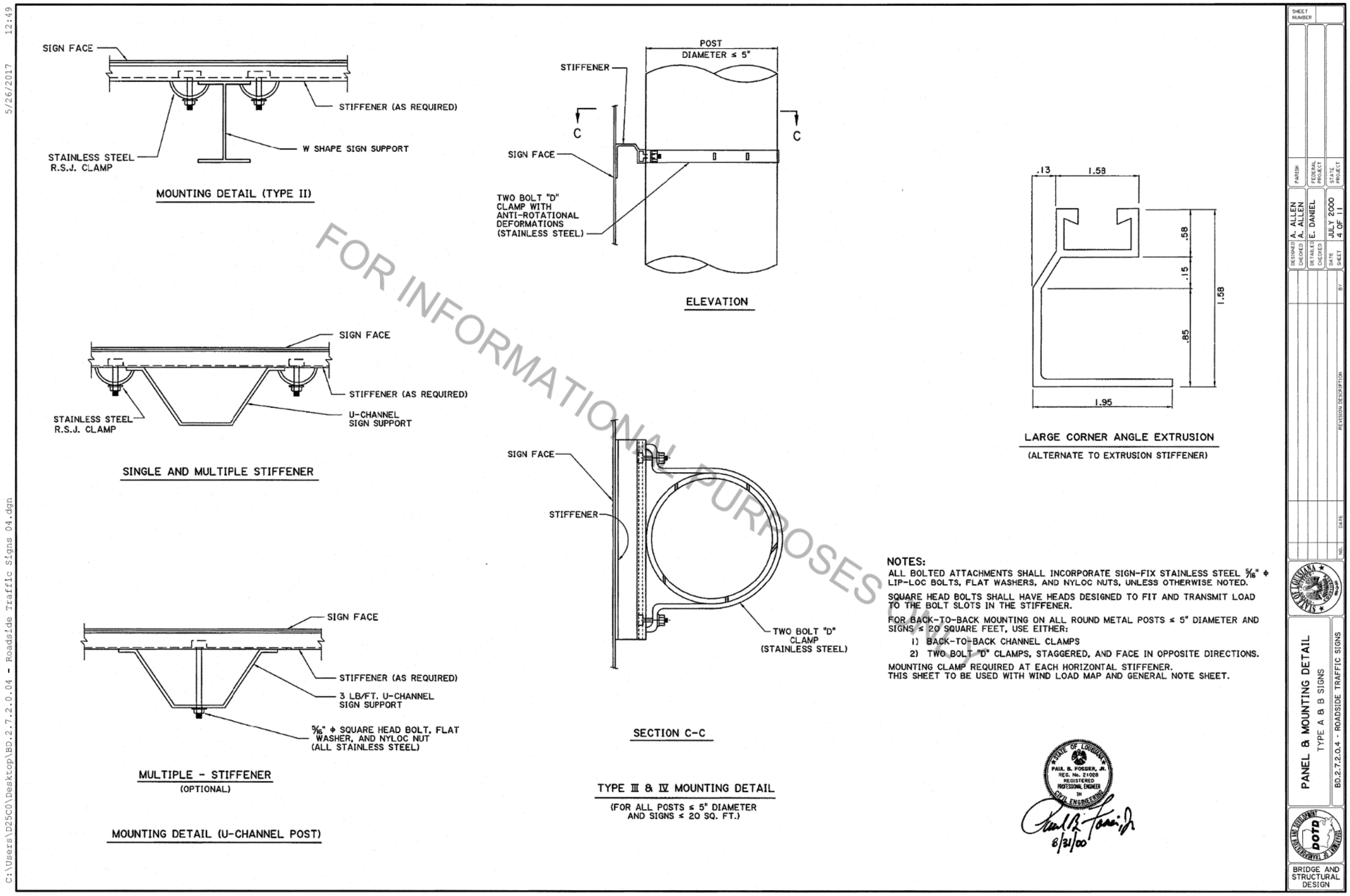


Figure 3-12. Louisiana's Response for Question 2 (3/10).

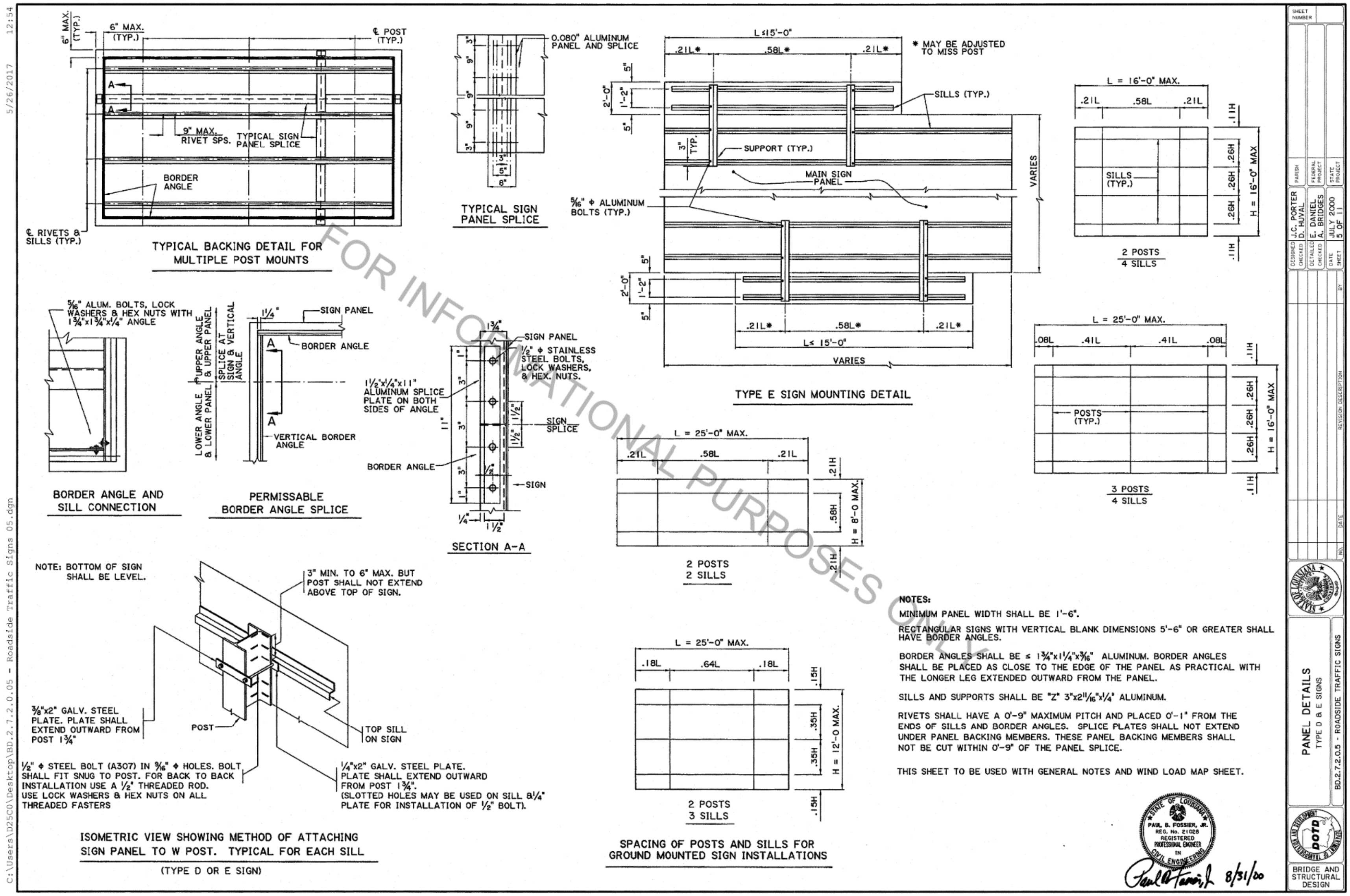


Figure 3-13. Louisiana's Response for Question 2 (4/10).

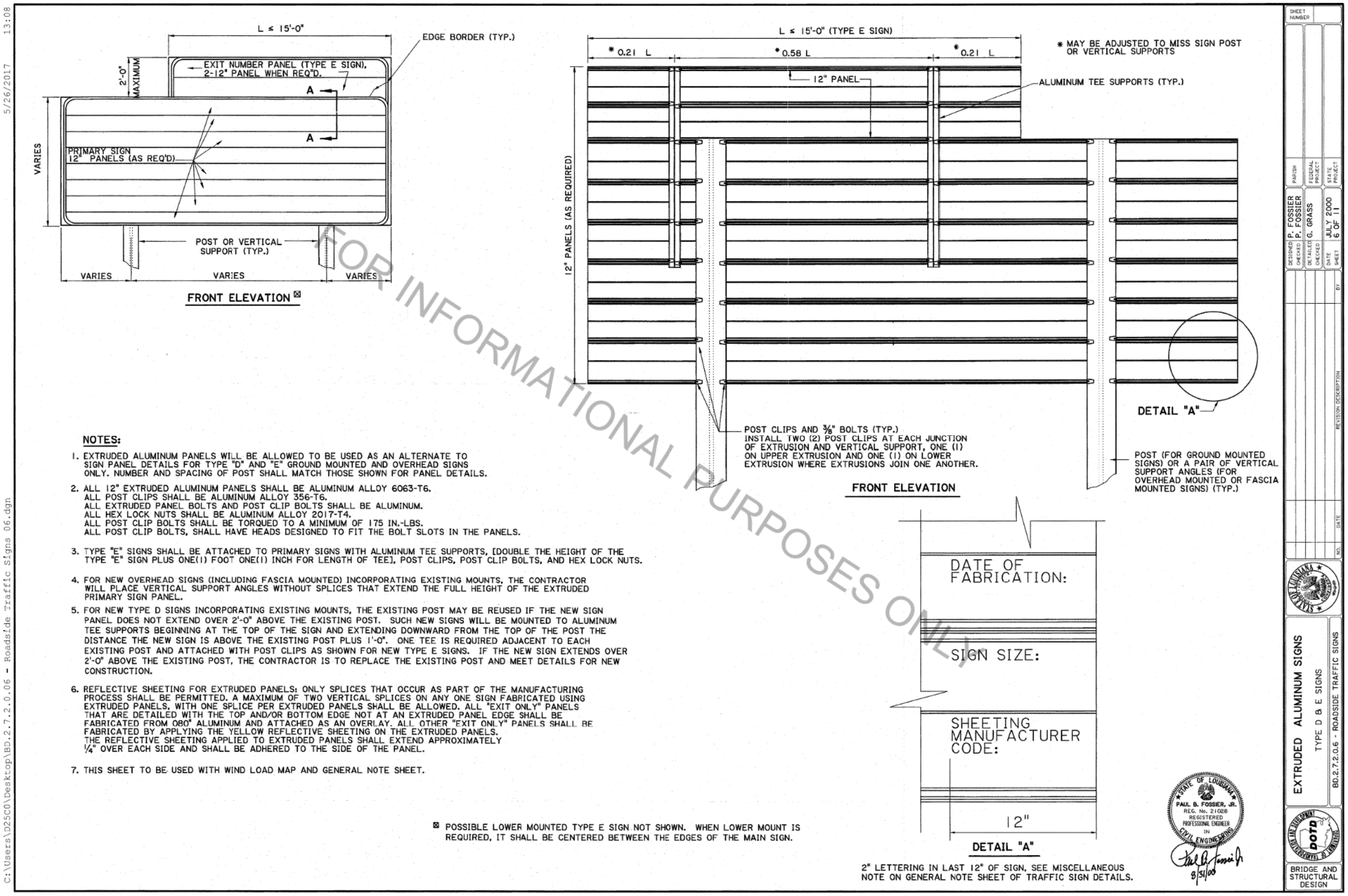


Figure 3-14. Louisiana's Response for Question 2 (5/10).

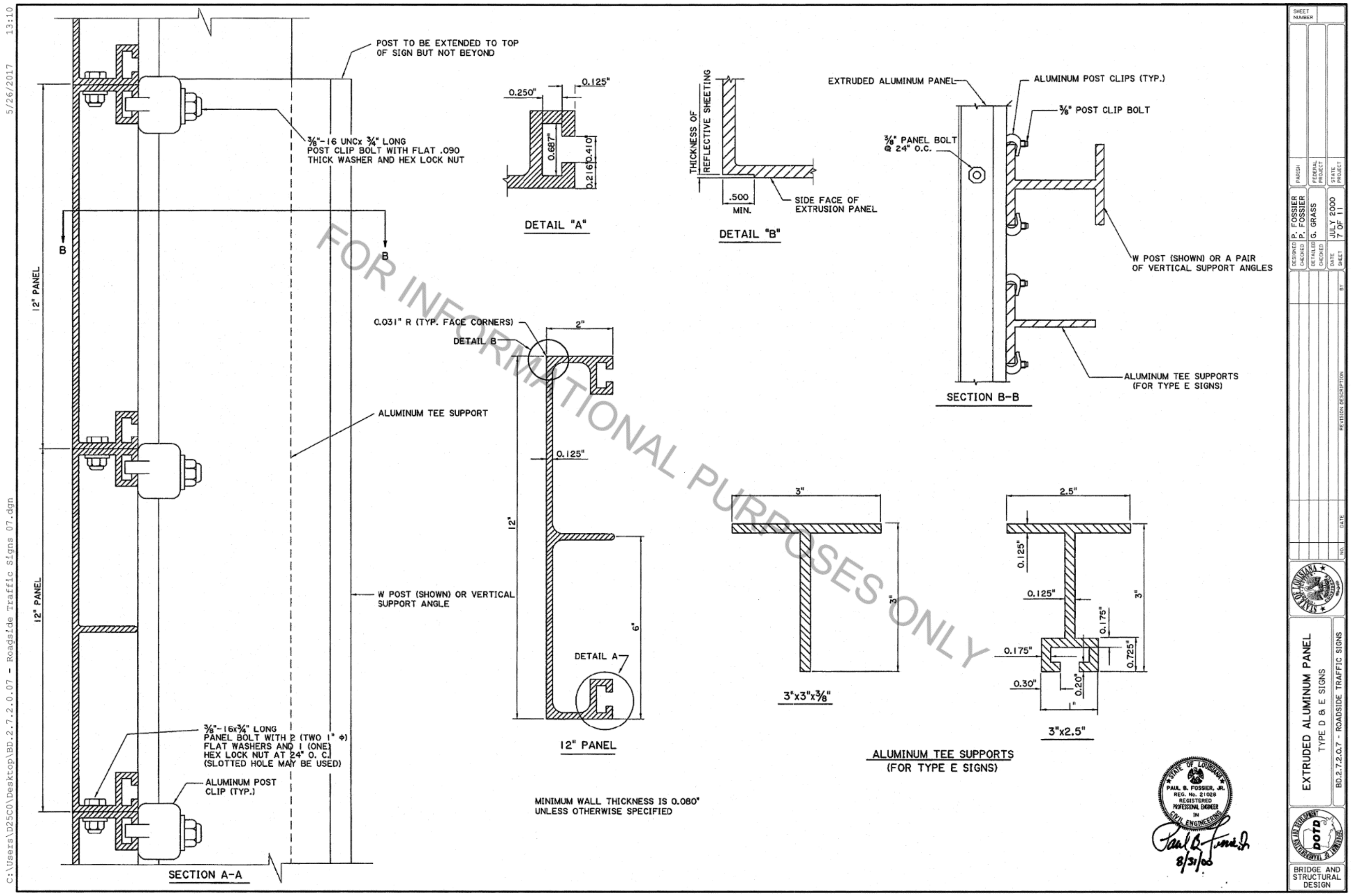


Figure 3-15. Louisiana's Response for Question 2 (6/10).

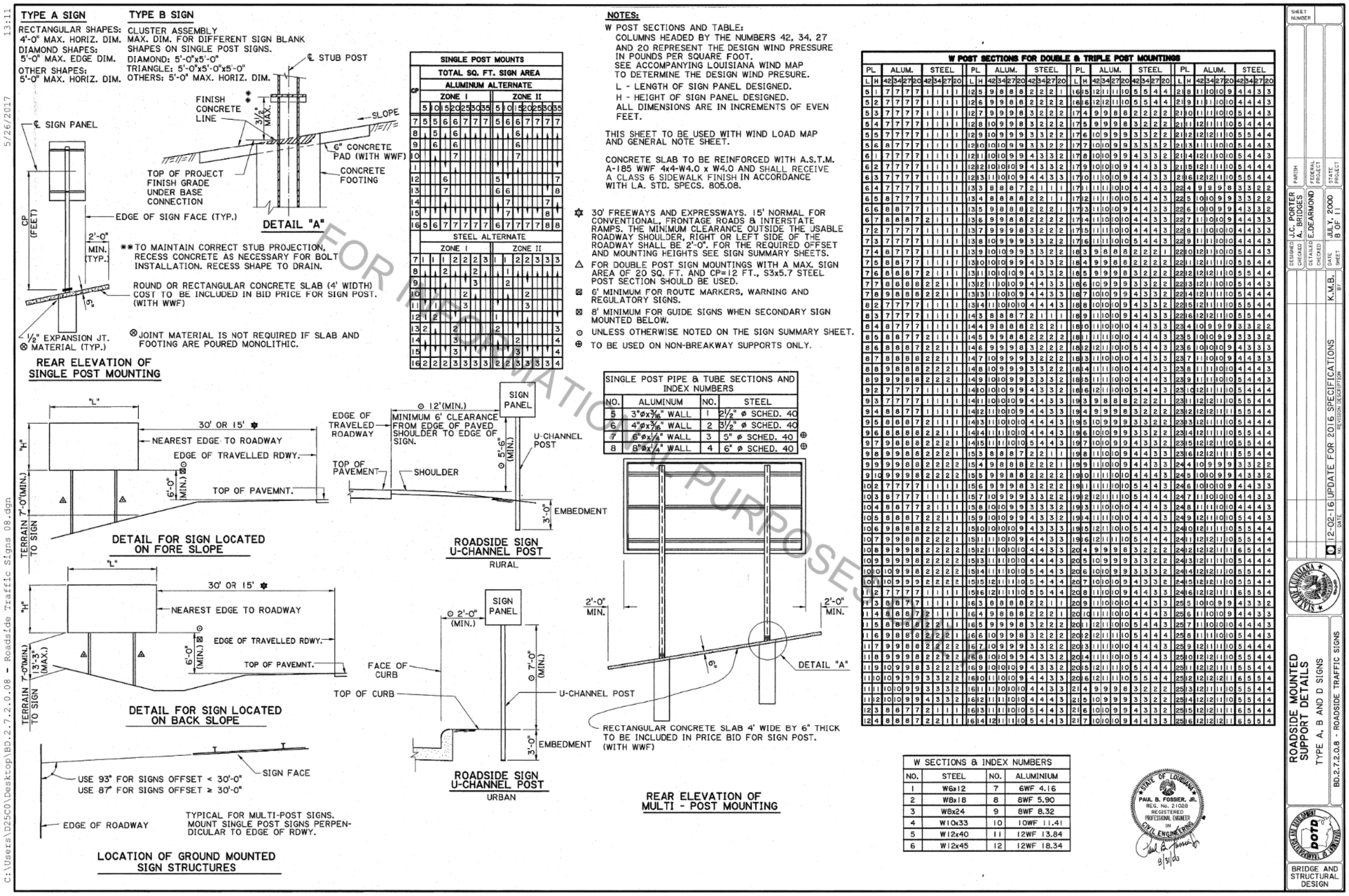


Figure 3-16. Louisiana's Response for Question 2 (7/10).

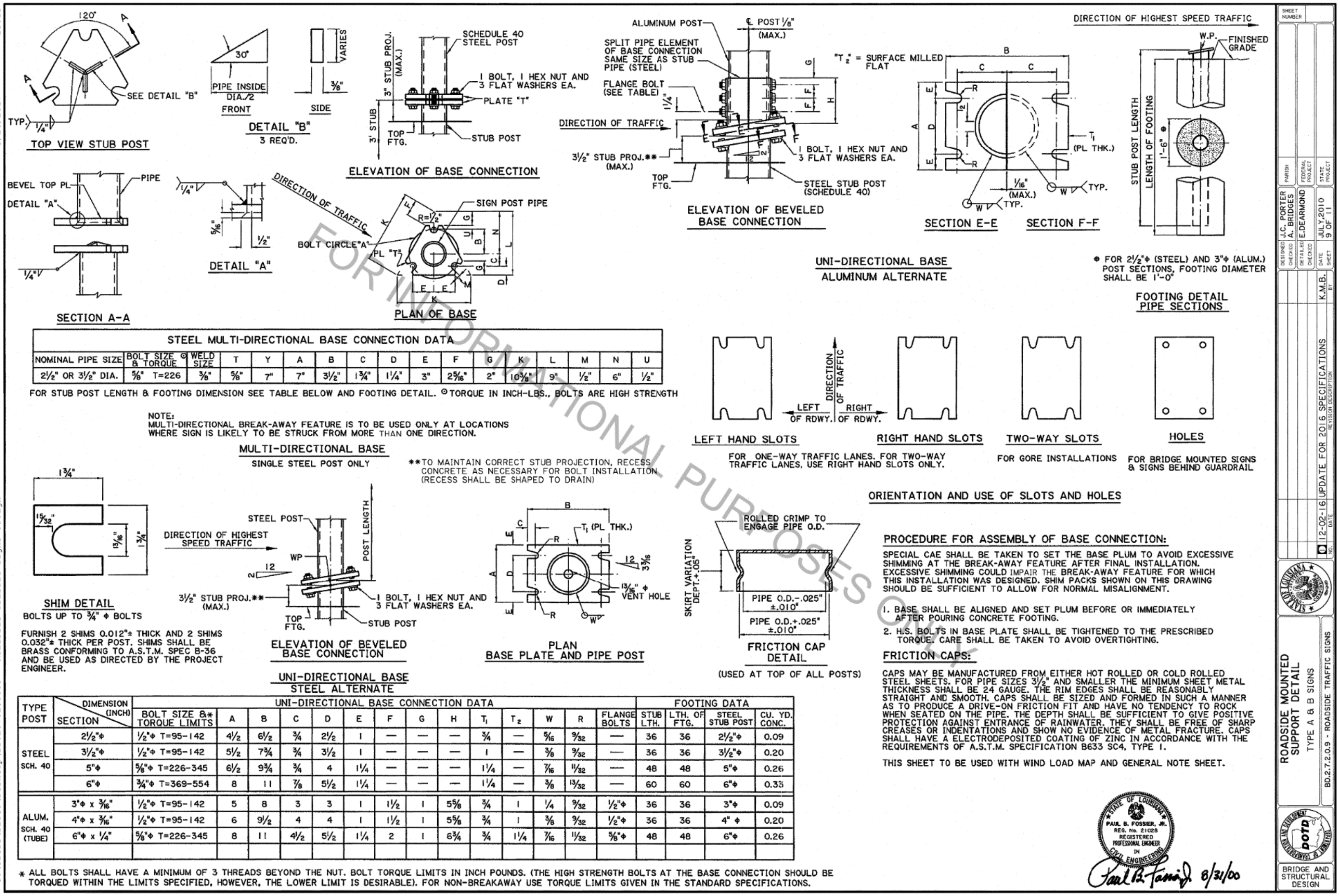
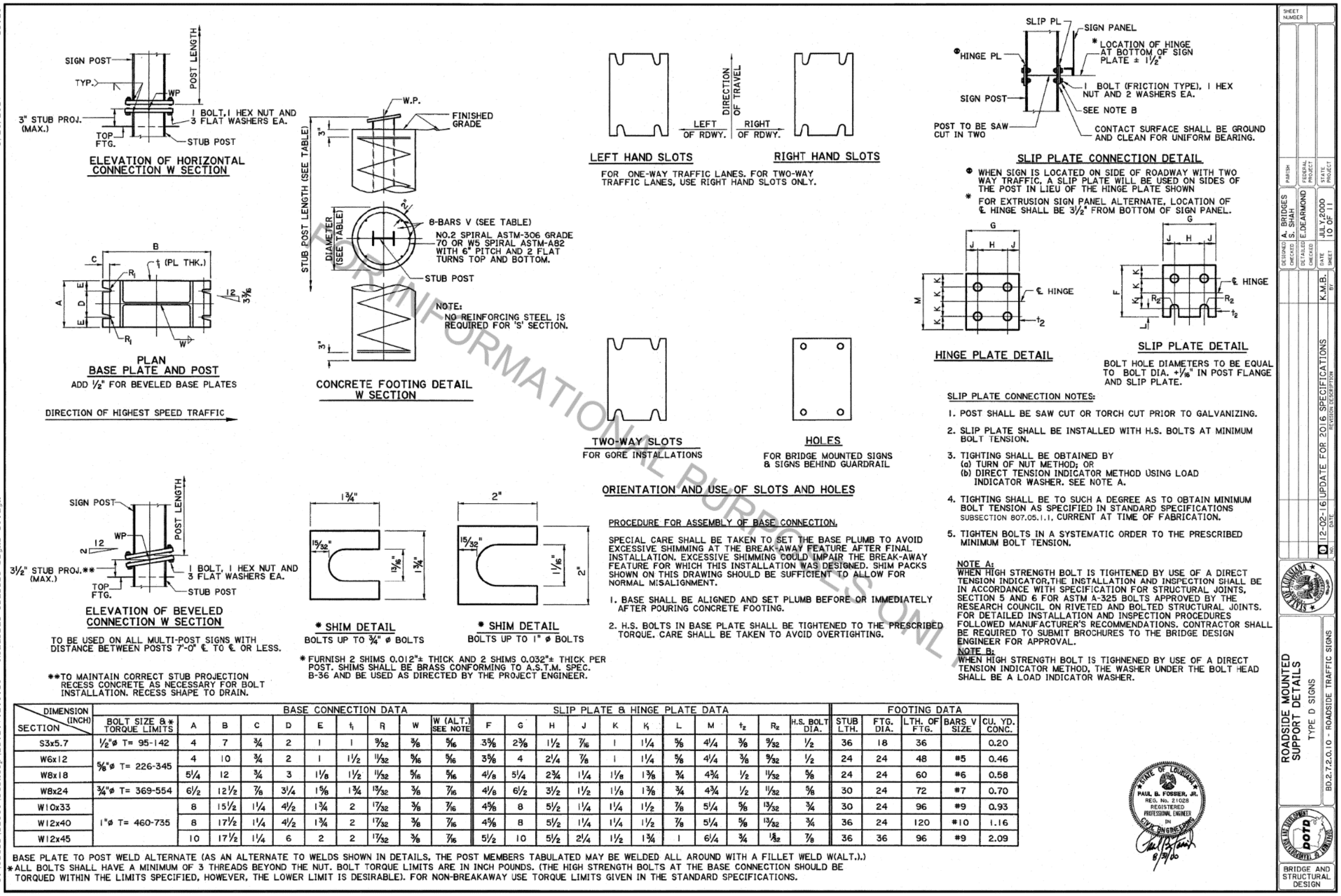


Figure 3-17. Louisiana's Response for Question 2 (8/10).



DIMENSION (INCH) / SECTION	BOLT SIZE & * TORQUE LIMITS	A	B	C	D	E	t_1	R_1	W	W (ALT.) SEE NOTE	F	G	H	J	K	K_1	L	M	t_2	R_2	H.S. BOLT DIA.	STUB LTH.	FTG. DIA.	LTH. OF FTG.	BARS V SIZE	CU. YD. CONC.
		BASE CONNECTION DATA									SLIP PLATE & HINGE PLATE DATA											FOOTING DATA				
S3x5.7	1/2"ø T= 95-142	4	7	3/4	2	1	1	9/32	3/8	5/16	3 5/8	2 3/8	1 1/2	7/16	1	1 1/4	5/8	4 1/4	3/8	9/32	1/2	36	18	36		0.20
W6x12	5/8"ø T= 226-345	4	10	3/4	2	1	1 1/2	11/32	5/16	5/16	3 5/8	4	2 1/4	7/8	1	1 1/4	5/8	4 1/4	3/8	9/32	1/2	24	24	48	#5	0.46
W8x18		5 1/4	12	3/4	3	1 1/8	1 1/2	11/32	5/16	5/16	4 1/8	5 1/4	2 3/4	1 1/4	1 1/8	1 3/8	3/4	4 3/4	1/2	11/32	5/8	24	24	60	#6	0.58
W8x24	3/4"ø T= 369-554	6 1/2	12 1/2	7/8	3 1/4	1 5/8	1 3/4	13/32	3/8	7/16	4 1/8	6 1/2	3 1/2	1 1/2	1 1/8	1 3/8	3/4	4 3/4	1/2	11/32	5/8	30	24	72	#7	0.70
W10x33	1"ø T= 460-735	8	15 1/2	1 1/4	4 1/2	1 3/4	2	17/32	3/8	7/16	4 5/8	8	5 1/2	1 1/4	1 1/4	1 1/2	7/8	5 1/4	5/8	13/32	3/4	30	24	96	#9	0.93
W12x40		8	17 1/2	1 1/4	4 1/2	1 3/4	2	17/32	3/8	7/16	4 5/8	8	5 1/2	1 1/4	1 1/4	1 1/2	7/8	5 1/4	5/8	13/32	3/4	36	24	120	#10	1.16
W12x45		10	17 1/2	1 1/4	6	2	2	17/32	3/8	7/16	5 1/2	10	5 1/2	2 1/4	1 1/2	1 3/4	1	6 1/4	3/4	15/32	7/8	36	36	96	#9	2.09

BASE PLATE TO POST WELD ALTERNATE (AS AN ALTERNATE TO WELDS SHOWN IN DETAILS, THE POST MEMBERS TABULATED MAY BE WELDED ALL AROUND WITH A FILLET WELD W(ALT.).)
*ALL BOLTS SHALL HAVE A MINIMUM OF 3 THREADS BEYOND THE NUT. BOLT TORQUE LIMITS ARE IN INCH POUNDS. (THE HIGH STRENGTH BOLTS AT THE BASE CONNECTION SHOULD BE TORQUED WITHIN THE LIMITS SPECIFIED, HOWEVER, THE LOWER LIMIT IS DESIRABLE). FOR NON-BREAKAWAY USE TORQUE LIMITS GIVEN IN THE STANDARD SPECIFICATIONS.

Figure 3-18. Louisiana's Response for Question 2 (9/10).

DIMENSION (INCH) / SECTION	BASE CONNECTION DATA: BOLT SIZE & * TORQUE LIMITS	A	B	C	D	E	F	G	H	t_1	t_2	R	W	FLANGE BOLT DIA.	SLIP PLATE & HINGE PLATE DATA: J	K	L	M	N	O	t_3	R_2	H.S. BOLT DIA.	FOOTING DATA: STUB LTH.	LTH. OF FTG.	BARS V SIZE	STEEL STUB POST	CU. YD. CONC.	ΔW (ALT.)
W6x4.16	1/2"ø T=95	4	3	2 3/8	2 1/4	7/8	2	1 1/8	6 1/4	3/4	3/8	9/32	1/4	1/2	4	2 1/4	7/8	4	1	3 5/8	3/8	9/32	1/2	24	48	#4	W6 x 12	0.46	5/16
W8x5.90		5 1/4	3	2 3/8	3	1 1/8	2	1 1/8	6 1/4	3/4	3/8	9/32	1/4	5/8	5 1/4	2 3/4	1 1/4	4 1/2	1 1/8	4 1/8	1/2	11/32	5/8	24	48	#5	W8 x 18	0.46	5/16
W8x8.32	5/8"ø T=226	6 1/2	3 1/2	2 3/4	4	1 1/4	2 1/2	1 1/4	7 1/2	3/4	1/2	11/32	5/16	5/8	6 1/2	3 1/2	1 1/2	4 1/2	1 1/8	4 1/8	1/2	11/32	5/8	30	60	#6	W8 x 24	0.58	7/16
W10x11.41		8	3 1/2	2 3/4	5	1 1/2	3	1 1/2	9	3/4	1/2	11/32	5/16	3/4	8	5 1/2	1 1/4	5	1 1/4	4 5/8	5/8	13/32	3/4	30	84	#7	W10 x 33	0.81	7/16
W12x13.84	3/4"ø T=369	8	4	3 1/8	5	1 1/2	3	1 3/4	9 1/2	1	5/8	13/32	5/16	7/8	8	5 1/2	1 1/4	5	1 1/4	4 5/8	5/8	13/32	3/4	36	96	#8	W12 x 40	0.93	
W12x18.34		10	4	3 1/8	6	2	3 1/2	2	11	1	5/8	13/32	5/16	1	10	5 1/2	2 1/4	6	1 1/2	5 1/2	3/4	15/32	7/8	36	108	#9	W12 x 45	1.05	

ΔBASE PLATE TO STUB POST WELD ALTERNATE (AS AN ALTERNATE TO WELDS SHOWN IN DETAILS, THE POST MEMBERS TABULATED MAY BE WELDED ALL AROUND WITH A FILLET WELD .

* ALL BOLTS SHALL HAVE A MINIMUM OF 3 THREADS BEYOND THE NUT. BOLT TORQUE LIMITS "-# LB.
FOR NON-BREAKAWAY USE TORQUE LIMITS GIVEN IN THE STANDARD SPECIFICATIONS.

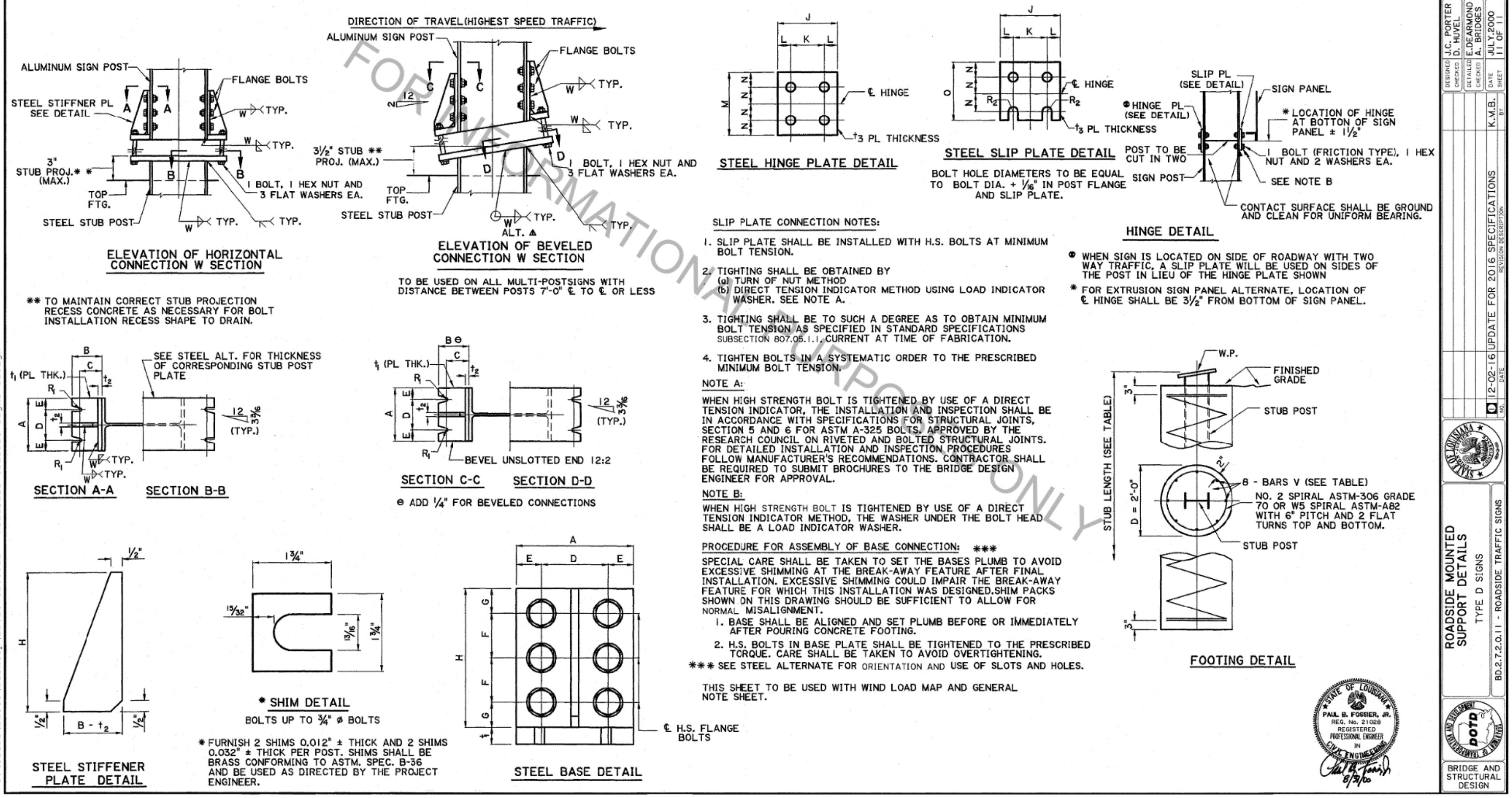


Figure 3-19. Louisiana's Response for Question 2 (10/10).

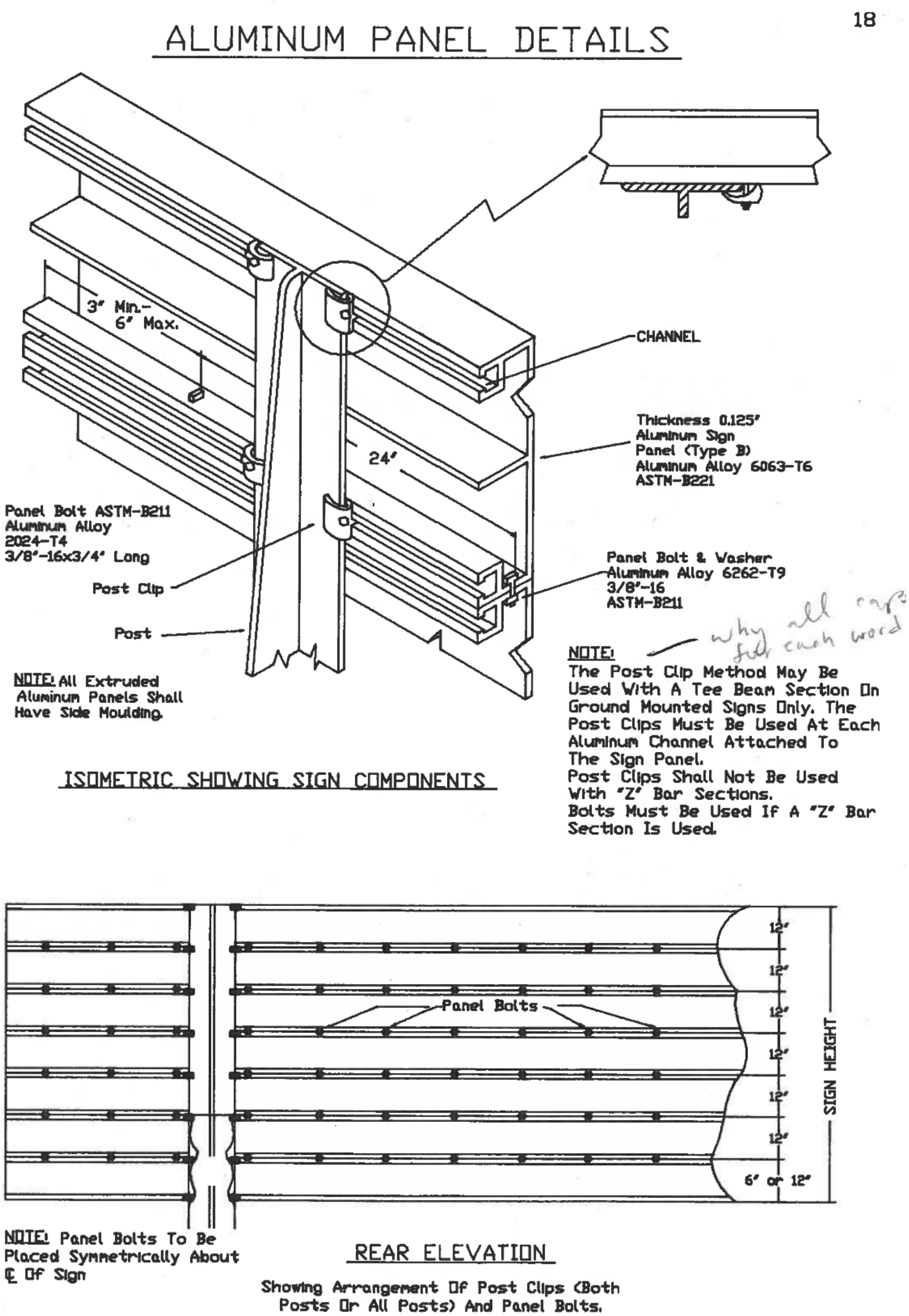


Figure 3-20. Massachusetts Response for Question 2 (1/11).

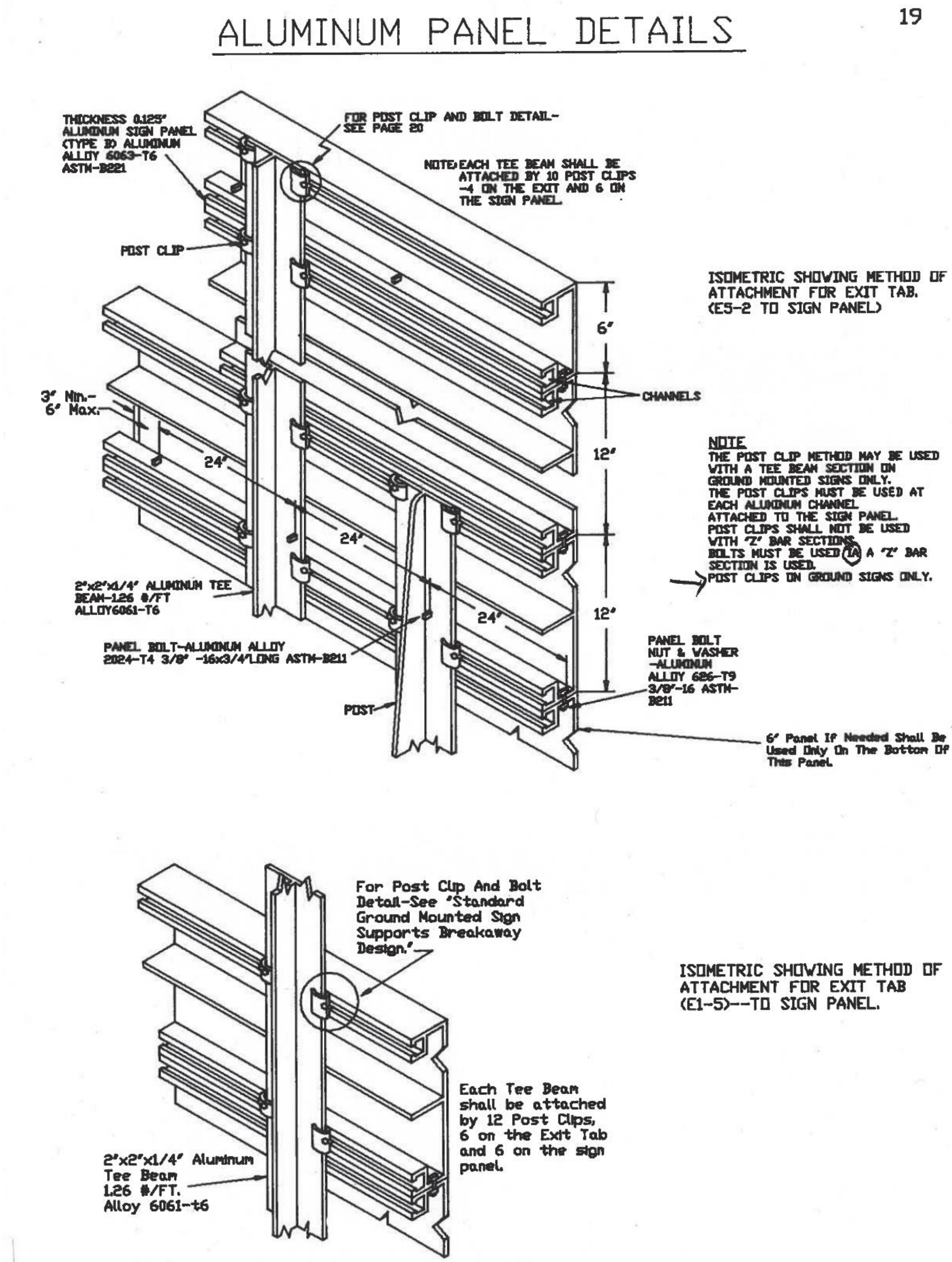


Figure 3-21. Massachusetts Response for Question 2 (2/11).

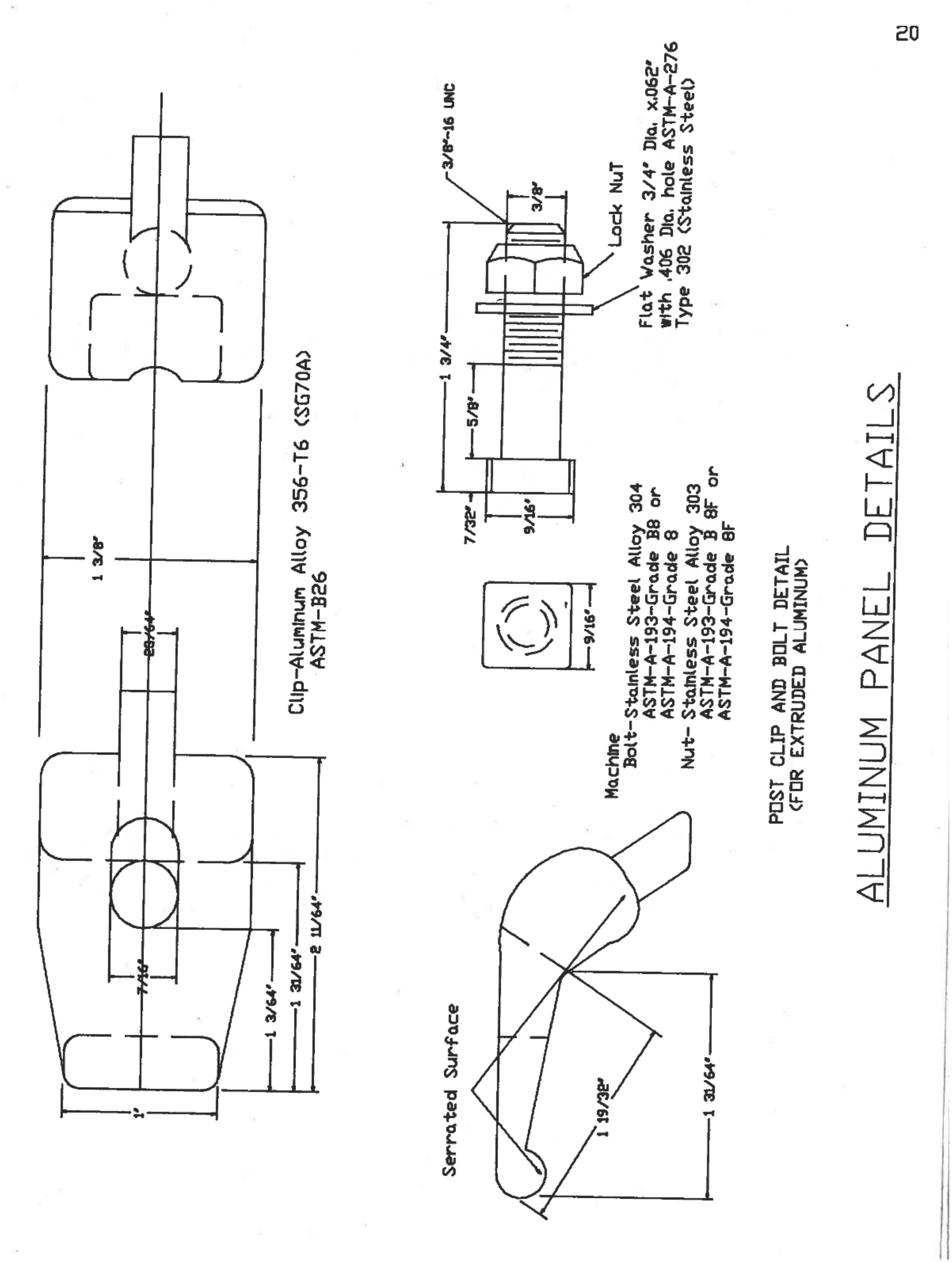


Figure 3-22. Massachusetts Response for Question 2 (3/11).

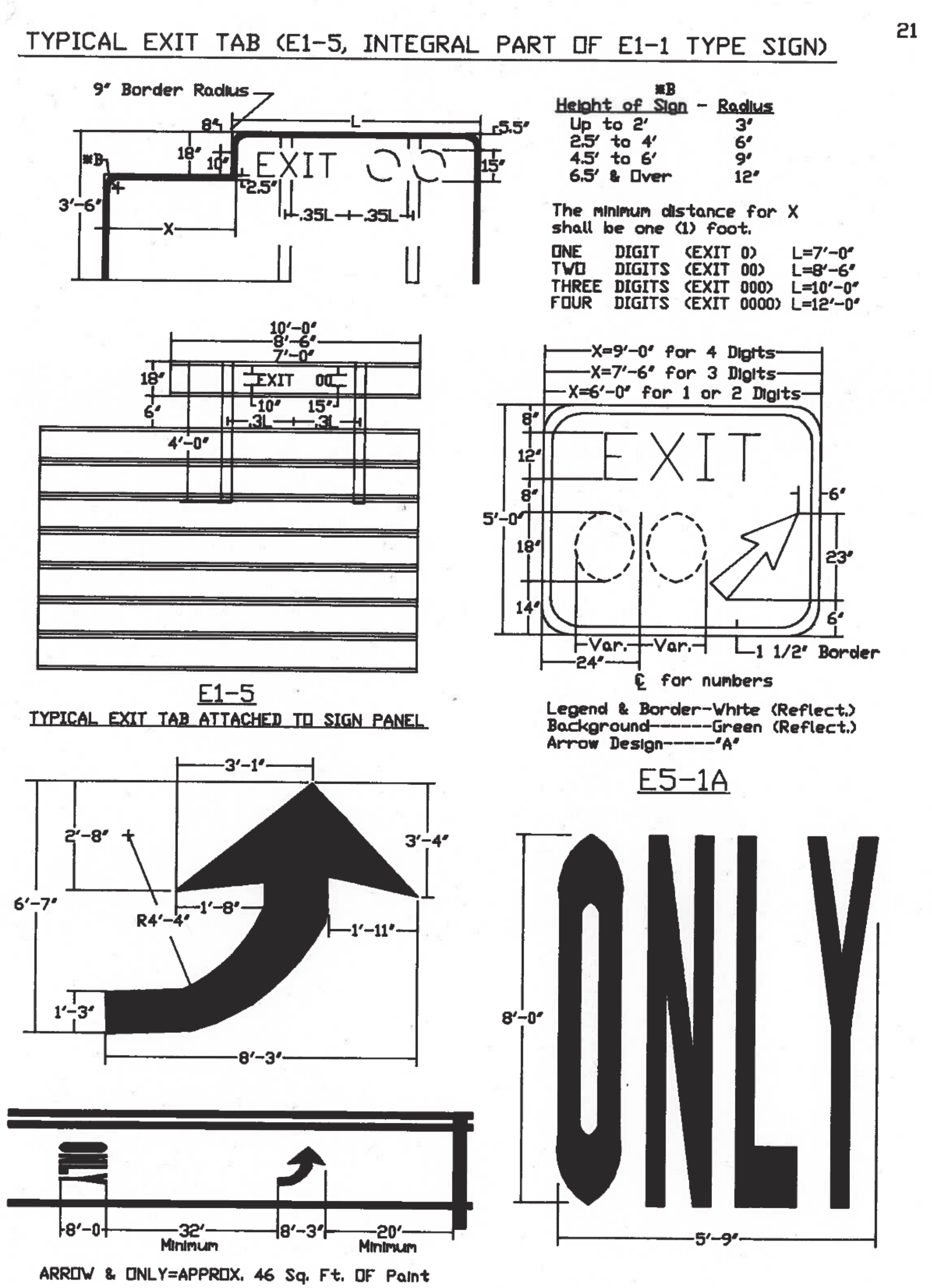


Figure 3-23. Massachusetts Response for Question 2 (4/11).

POST SIZE \ DIMENSION	BOLT SIZE & TORQUE	A	B	C	D	E	T_1	T_2	W	R
W6 X 12	5/8" × 3 1/4" With 1 3/4" Thread TORQUE 450"#	5"	2"	1 1/4"	2 3/4"	1 1/8"	3/4"	1/2"	1/4"	11/32"
W6 X 15										
W8 X 18										
W8 X 21										
W10 X 22	3/4" × 4" With 1 7/8" Thread TORQUE 750"#	6"	2 1/4"	1 3/8"	3 1/2"	1 1/4"	1"	3/4"	5/16"	13/32"
W10 X 26										
W12 X 26										
W12 X 30		8"	2 3/4"	1 5/8"	5 1/2"	1 1/4"	1"	3/4"	5/16"	17/32"
W12 X 40										
S 4 X 7.7	5/8" × 3 1/4" With 1 7/8" Thread TORQUE 200"#	SEE DETAIL								
S 5 X 10.0										

See Pages 29 & 30 for Base Plate Assembly

POST SIZE \ DIMENSION	F	G	H	J	K	L	N	D_1	T_3	BOLT DIA.	WT. OF EACH FUSE PL.
W6 X 12	3 3/4"	2"	1 1/8"	4"	2 1/4"	7/8"	5/8"	11/16"	3/8"	5/8"	1.60 #
W6 X 15	4 1/2"	2 1/2"	1 1/4"	6"	3 1/2"	1 1/4"	3/4"	13/16"	1/2"	3/4"	3.75 #
W8 X 18	4 1/2"	2 1/2"	1 1/4"	5 1/4"	2 3/4"	1 1/4"	3/4"	13/16"	1/2"	3/4"	3.27 #
W8 X 21	4 7/8"	2 1/2"	1 1/2"	5 1/4"	2 3/4"	1 1/4"	7/8"	15/16"	1/2"	7/8"	3.93 #
W10 X 22	5 3/8"	3"	1 1/2"	5 3/4"	2 3/4"	1 1/2"	7/8"	15/16"	1/2"	7/8"	4.75 #
W10 X 26	5 3/8"	3"	1 1/2"	5 3/4"	2 3/4"	1 1/2"	7/8"	15/16"	1/2"	7/8"	4.79 #
W12 X 26	5 3/8"	3"	1 1/2"	6 1/2"	3 1/2"	1 1/2"	7/8"	15/16"	1/2"	7/8"	5.42 #
W12 X 30	5 3/8"	3"	1 1/2"	6 1/2"	3 1/2"	1 1/2"	7/8"	15/16"	1/2"	7/8"	5.42 #
W12 X 40	5 7/8"	3"	1 1/2"	8"	5"	1 1/2"	1 3/8"	1 1/16"	1/2"	1"	6.12 #
S 4 X 7.7	3 1/8"	1 1/2"	1 1/8"	2 [illegible]	1 1/2"	9/16"	1/2"	9/16"	1/4"	1/2"	0.64 #
S 5 X 10.0	3 1/8"	1 1/2"	1 1/8"	2 [illegible]	1 1/2"	9/16"	1/2"	9/16"	1/4"	1/2"	0.64 #

See Page 27 For Fuse Plate Details

FOUNDATION DATA						* ALTERNATE	
POST SIZE \ DIMENSION	STUB LENGTH	STUB PROJ.	DR. SHAFT DIA.	BARS V SIZE	DEPHT CONC. SHAFT	DIA.	DEPTH
W6 X 12	2'-0"	3"	2'-0"	# 5	5'-6"	—	—
W6 X 15	2'-0"	3"	2'-0"	# 5	6'-6"	2'-3"	6'
W8 X 18	2'-6"	3"	2'-0"	# 6	7'-0"	2'-3"	6'
W8 X 21	2'-6"	3"	2'-0"	# 7	8'-0"	2'-6"	6'
W10 X 22	3'-0"	2 1/2"	2'-0"	# 8	9'-6"	2'-6"	6'
W10 X 26	3'-0"	2 1/2"	2'-0"	# 9	10'-0"	2'-6"	6'
W12 X 26	3'-0"	2 1/2"	2'-0"	# 10	11'-0"	3'-0"	6'
W12 X 30	3'-0"	2 1/2"	2'-0"	# 11	12'-0"	3'-0"	6'
W12 X 40	3'-0"	2 1/2"	2'-6"	# 10	12'-0"	3'-0"	6'
S 4 X 7.7	1'-6"	3 1/2"	1'-6"	# 5	4'-0"		
S 5 X 10.0	1'-6"	3 1/2"	1'-6"	# 5	5'-0"		

W 8 x 15 ?

See Page 22 For Foundation Details

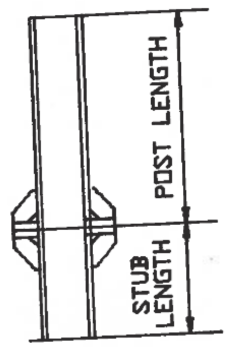
* IF ROCK, LEDGE OR WATER ENCOUNTERED, ALTERNATE FOOTINGS MAY BE EMPLOYED ONLY WITH THE WRITTEN APPROVAL OF THE ENGINEER.

Figure 3-24. Massachusetts Response for Question 2 (5/11).

POST WEIGHT DATA

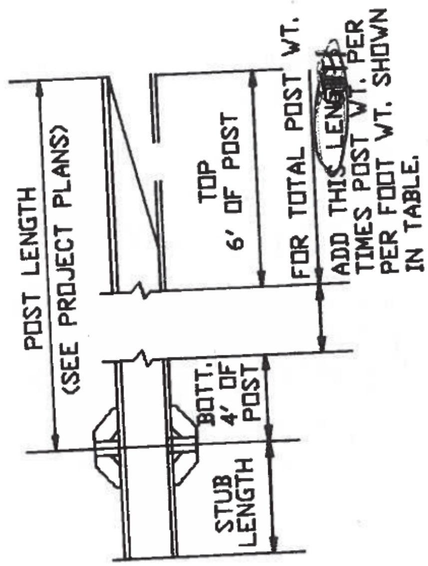
POST WEIGHT DATA	
POST SIZE*	WEIGHT
W6 x 12	158.4 LB.
S4 x 7.7	96.1 LB.
S5 x 10.0	122.6 LB.

* LAST FIGURES=POST WEIGHT PER FOOT.
NO TAPER



WEIGHT DATA IS THE WEIGHT OF ITEMS SHOWN FOR ONE POST-(INCLUDES 10' OF POST LENGTH, POST FOUNDATION STUB, RELATED BASE CONNECTION PLATES AND STIFFENERS, FRICTION FUSE PLATE AND ALL HIGH STRENGTH BOLTS, NUTS, AND WASHERS.)

FOR SIGNS HAVING A TOTAL AREA OVER 20 SQ. FT. TO 40 SQ. FT.



POST WEIGHT DATA	
POST SIZE*	WEIGHT
W6 x 12	128.4 LB.
W6 x 15	160.1 LB.
W8 x 18	197.2 LB.
W8 x 21	229.3 LB.
W10 x 22	259.6 LB.
W10 x 26	301.7 LB.
W12 x 26	302.3 LB.
W12 x 30	353.1 LB.
W12 x 40	460.6 LB.
S4 x 7.7	76.9 LB.
S5 x 10.0	97.6 LB.

* LAST FIGURES=POST WEIGHT PER FOOT.

WEIGHT DATA IS THE WEIGHT OF ITEMS SHOWN FOR ONE POST-(INCLUDES TOP 6' OF POST, BOTTOM 4' OF POST, POST FOUNDATION STUB, RELATED BASE CONNECTION PLATES AND STIFFENERS, FRICTION FUSE PLATES AND ALL HIGH STRENGTH BOLTS, NUTS, AND WASHERS.)

FOR SIGNS HAVING A TOTAL AREA OVER 40 SQ. FT.

Figure 3-25. Massachusetts Response for Question 2 (6/11).

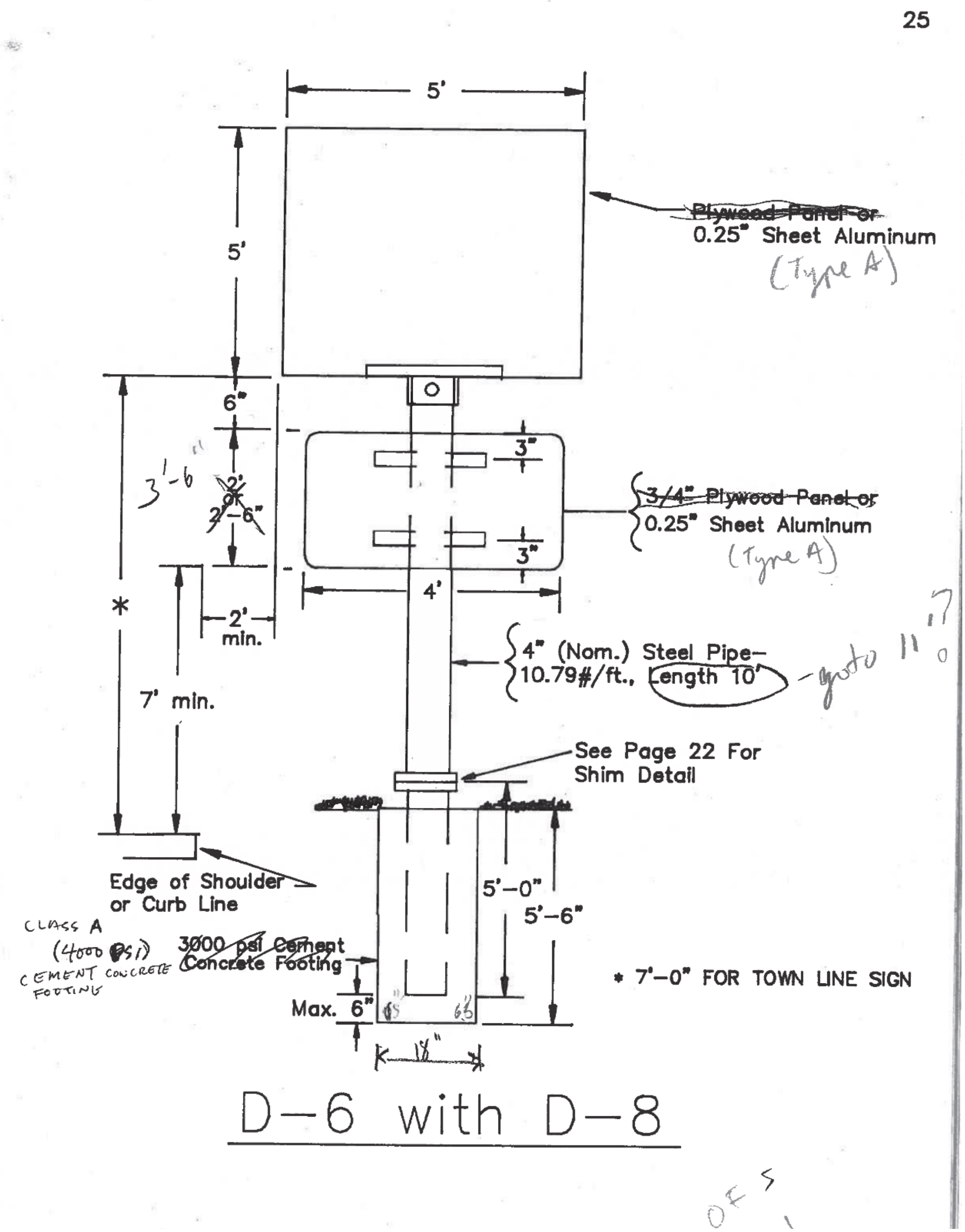
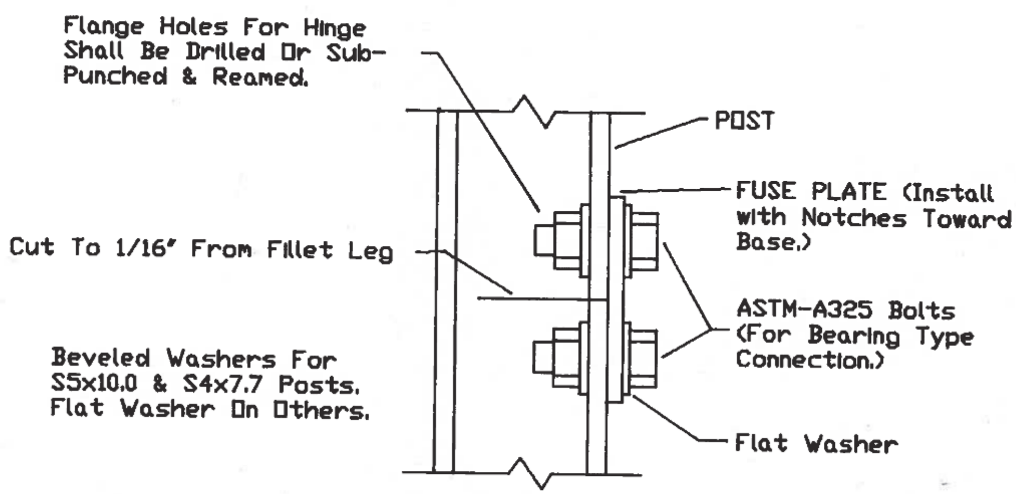


Figure 3-26. Massachusetts Response for Question 2 (7/11).



Field Note: All fuse plate bolts shall be 2 3/4" in length and have 2 1/4" of thread on the end of the bolt. All friction fuse bolts shall be tightened in the presence of the Department's representative in the field and in accordance with the requirements of Article 2.10.20, with a wrench calibrated daily at the Contractor's expense at the project site with a hydraulic bolt tension calibrator to obtain the following tension in each bolt.

	Bolt Size	Tension
Refer To Sheet 27 Fuse Plate Detail	1/2"	12,000 lbs.
	5/8"	19,000 lbs.
	3/4"	28,000 lbs.
	7/8"	36,000 lbs.

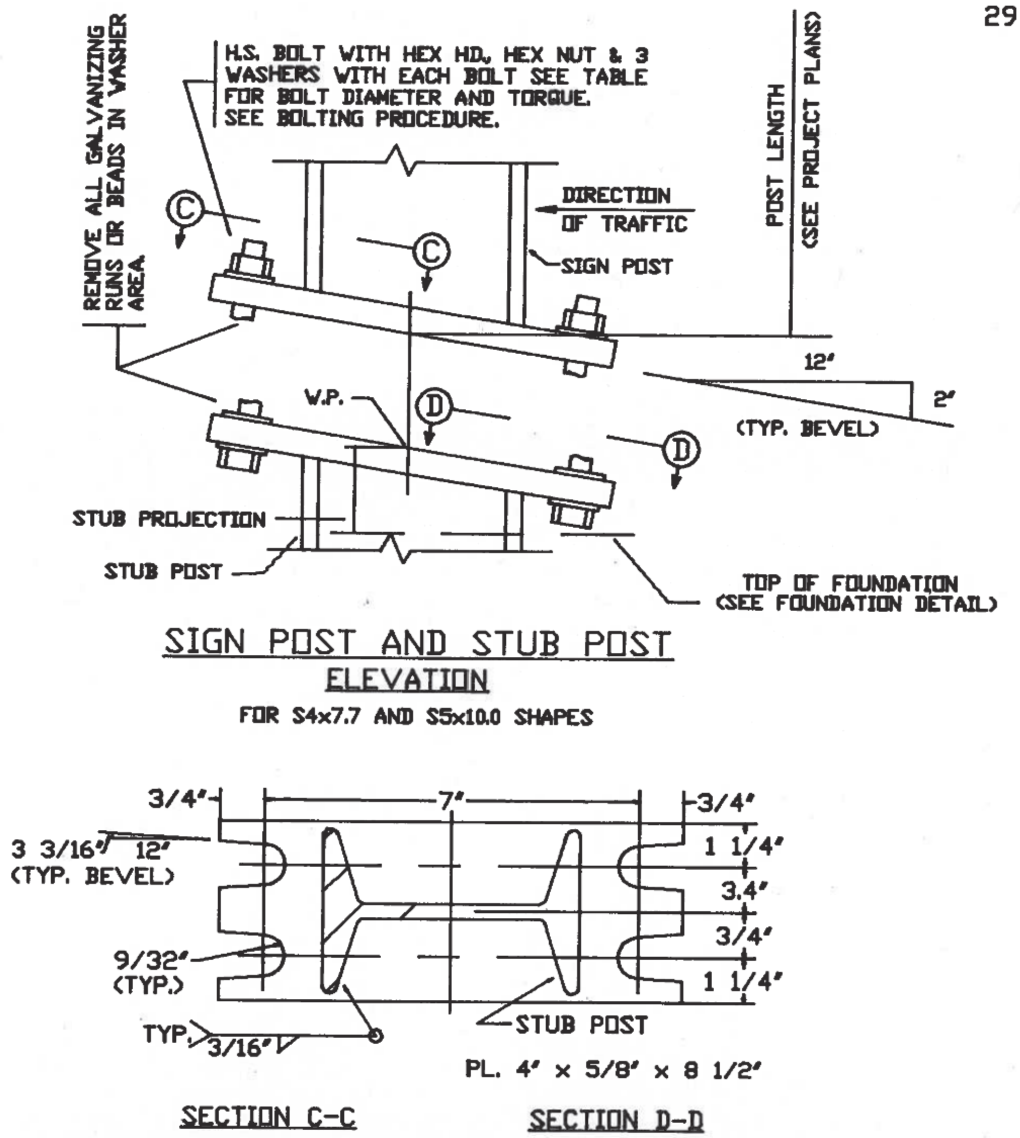
This installation procedure shall comprise the inspection required by the above mentioned specification. Fabricator shall assemble the signs in the shop with suitable erection bolts for shipment to the project whereupon said bolts shall be replaced with the specified hi-strength bolts and tested to the values shown above. Inspection shall be in accordance with the above mentioned Article 2.10.20 except that the inspection wrench shall be a torque wrench and that all bolts installed on the various fuse plates shall be inspected.

DETAIL "A" HINGE

28

Figure 3-27. Massachusetts Response for Question 2 (8/11).

29



SECTIONS SHOWN ARE FOR INSTALLATIONS ON THE RIGHT SHOULDER AND IN GORE. PLATE SLOT BEVELS ARE OPPOSITE HAND FROM THAT SHOWN FOR INSTALLATION ON LEFT SHOULDER.

PROCEDURE FOR ASSEMBLY OF BASE CONNECTION

1. ASSEMBLE POST TO STUB WITH BOLTS AND WITH ONE FLAT WASHER ON EACH BOLT BETWEEN PLATES.
2. SHIM AS REQUIRED TO PLUMB POST.
3. TIGHTEN ALL BOLTS THE MAXIMUM POSSIBLE WITH 12 TO 15" WRENCH TO BED WASHERS AND SHIMS AND TO CLEAN BOLT THREADS, THEN LOOSEN EACH BOLT IN TURN AND RETIGHTEN IN A SYSTEMATIC ORDER TO THE PRESCRIBED TORQUE. (SEE TABLE ON PAGE 22)
4. AFTER THE INITIAL TORQUING A SECOND NUT WILL BE USED TO INSURE THAT THE FIRST NUT WILL NOT BACK OFF.
5. THE CONTRACTOR TOGETHER WITH A DEPARTMENT INSPECTOR WILL RETURN TO THE SIGN FOR TWO INTERVALS OF 30± DAYS FOR THE PURPOSE OF MAINTAINING THE PRESCRIBED TORQUE.
6. IMMEDIATELY AFTER THE SECOND RE-TORQUING, THE TOP NUT SHALL BE REMOVED AND THE THREAD SHALL BE BURRED JUST ABOVE THE FIRST NUT USING A CENTER PUNCH, IN ORDER TO INSURE THAT THE PRESCRIBED TORQUE IS MAINTAINED.

Figure 3-28. Massachusetts Response for Question 2 (9/11).

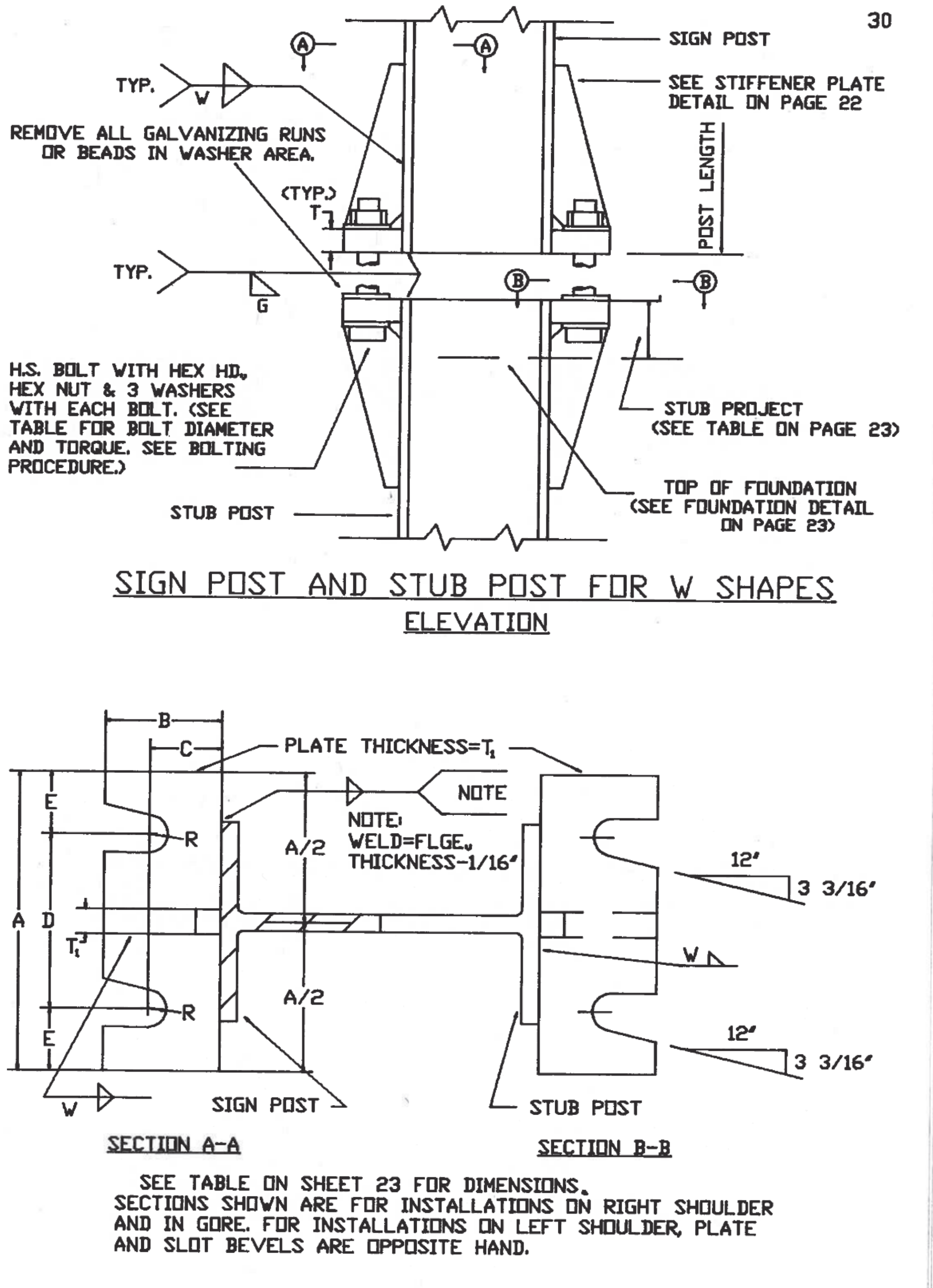
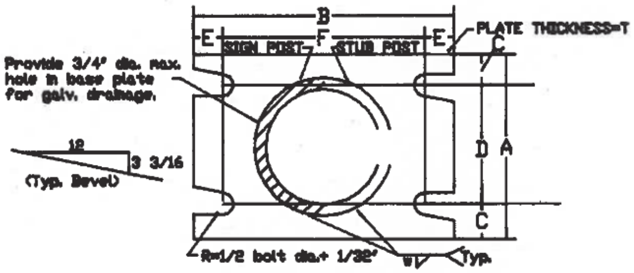
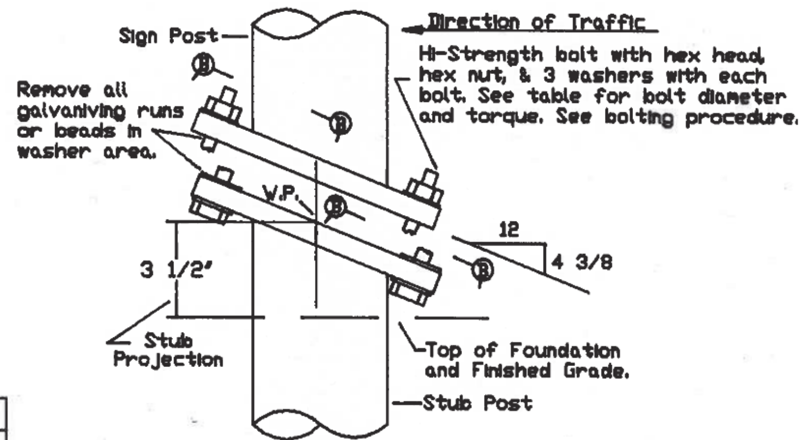


Figure 3-29. Massachusetts Response for Question 2 (10/11).



Section A-A Section B-B

Sections shown are for installations on right shoulder and in gore. Plate slot bevels are opposite hand from that shown for installations on left shoulder.



D6 & ~~DD6~~

SIGN POST AND STUB POST ELEVATION

BASE CONNECTION DATA TABLE									
Nom. Pipe Size Dimension	Bolt Size & Torque	A	B	C	D	E	F	T	W
4"	1/2" x 3" with 1/2" thread Torque 200 Ft. Lbs.	5 1/2"	7 3/4"	1"	3 1/2"	3/4"	6 1/4"	3/4"	3/8"
5"	5/8" x 3 3/8" with 1 3/4" thread Torque 450 Ft. Lbs.	6 1/2"	9 3/4"	1 1/4"	4"	7/8"	8"	1"	7/16"
~~6"~~		~~7 1/4"~~	~~10 1/2"~~	~~1 1/8"~~	~~4 1/2"~~	~~7/8"~~	~~8 3/4"~~	~~1"~~	~~7/16"~~

*Plates for base connection shall conform with the requirements of ASTM-A36.

whats this?

GENERAL NOTES

BREAKAWAY SIGN SUPPORTS SHALL CONFORM TO THE BREAKAWAY DESIGN SHOWN ON THE SHEETS FOR "GROUND MOUNTED SIGN SUPPORTS BREAKAWAY DESIGN FOR THE D-6 AND D-6 WITH D-8 SIGN OR SIGN ASSEMBLY" AND THE MASS. ~~DEPT. OF PUBLIC WORKS~~ Highway Dept "STANDARD SPECIFICATIONS FOR HIGHWAYS AND BRIDGES."

THE STEEL POSTS SHALL BE SEAMLESS STEEL PIPE AND SHALL CONFORM TO THE ASTM DESIGNATION A53.

ALL HIGH STRENGTH BOLTS, NUTS, AND WASHERS SHALL CONFORM TO ASTM-A325.

TIGHTEN THE HIGH STRENGTH BOLTS IN THE BASE PLATE CONNECTION ONLY TO THE TORQUE SHOWN IN THE TABLE. DO NOT OVERTIGHTEN.

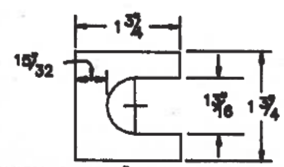
ALL BOLTS, OTHER THAN HIGH STRENGTH BOLTS SHALL CONFORM TO ASTM-A307 CLASS A.

ALL STEEL HARDWARE SHALL BE GALVANIZED AS PER ASTM-A153.

SEAMLESS STEEL PIPE AND BASE PLATES SHALL BE GALVANIZED AS PER ASTM-A123.

IN ALL CASES THE BOTTOM OF THE FOOTING SHALL BE PLACED TO THE DESIGN DEPTH.

THE LEGEND AND BORDER FOR D-6 SIGNS SHALL BE HIGH INTENSITY ENCAPSULATED LENSE.



FURNISH 2-.012"±THICK AND 2-.032"±THICK SHIMS PER POST. SHIMS SHALL BE FABRICATED FROM BRASS SHIM STOCK OR STRIP CONFORMING TO ASTM-B36

SHIM DETAIL

31

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Figure 3-30. Massachusetts Response for Question 2 (11/11).

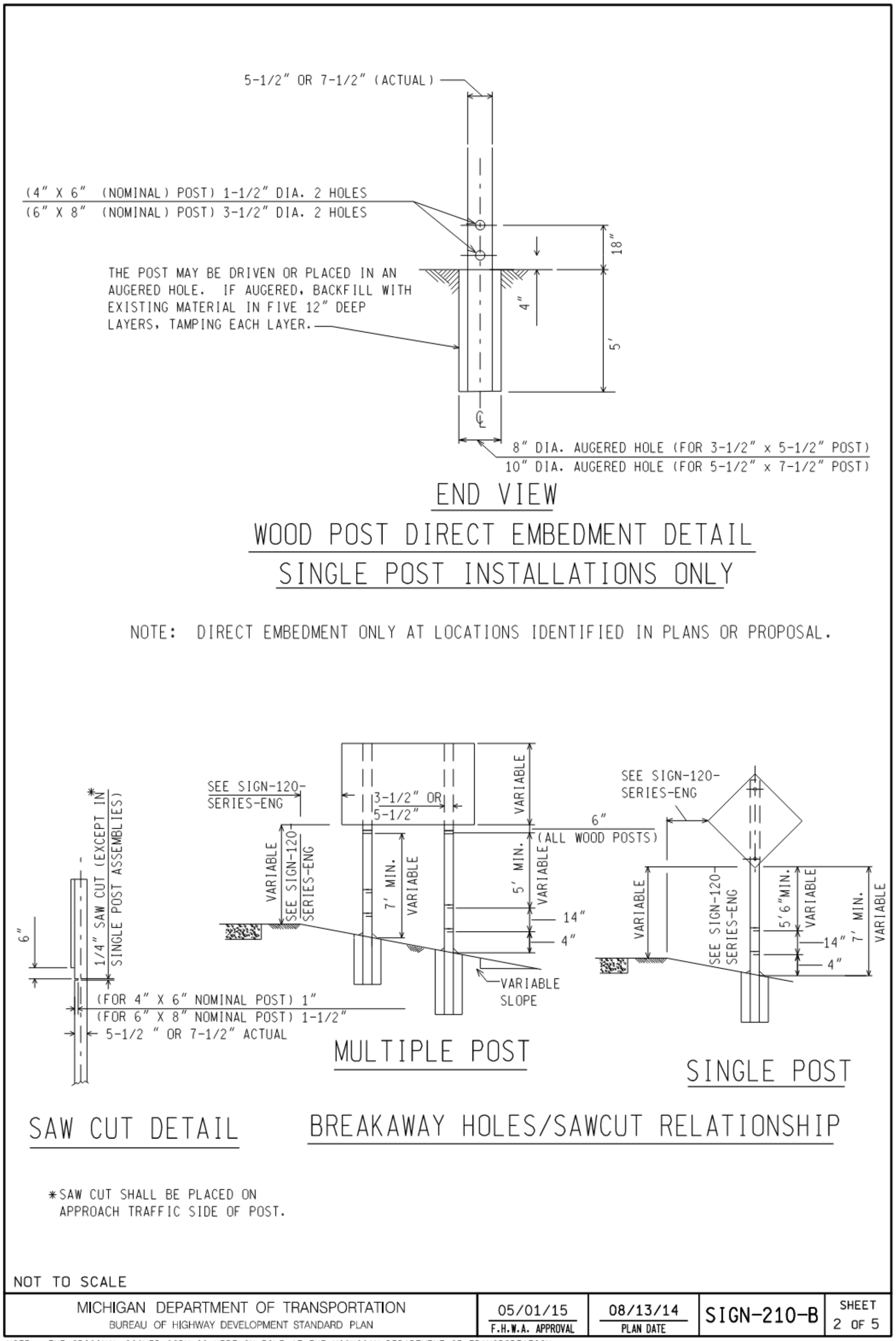


Figure 3-31. Michigan's Response for Question 2 (1/9).

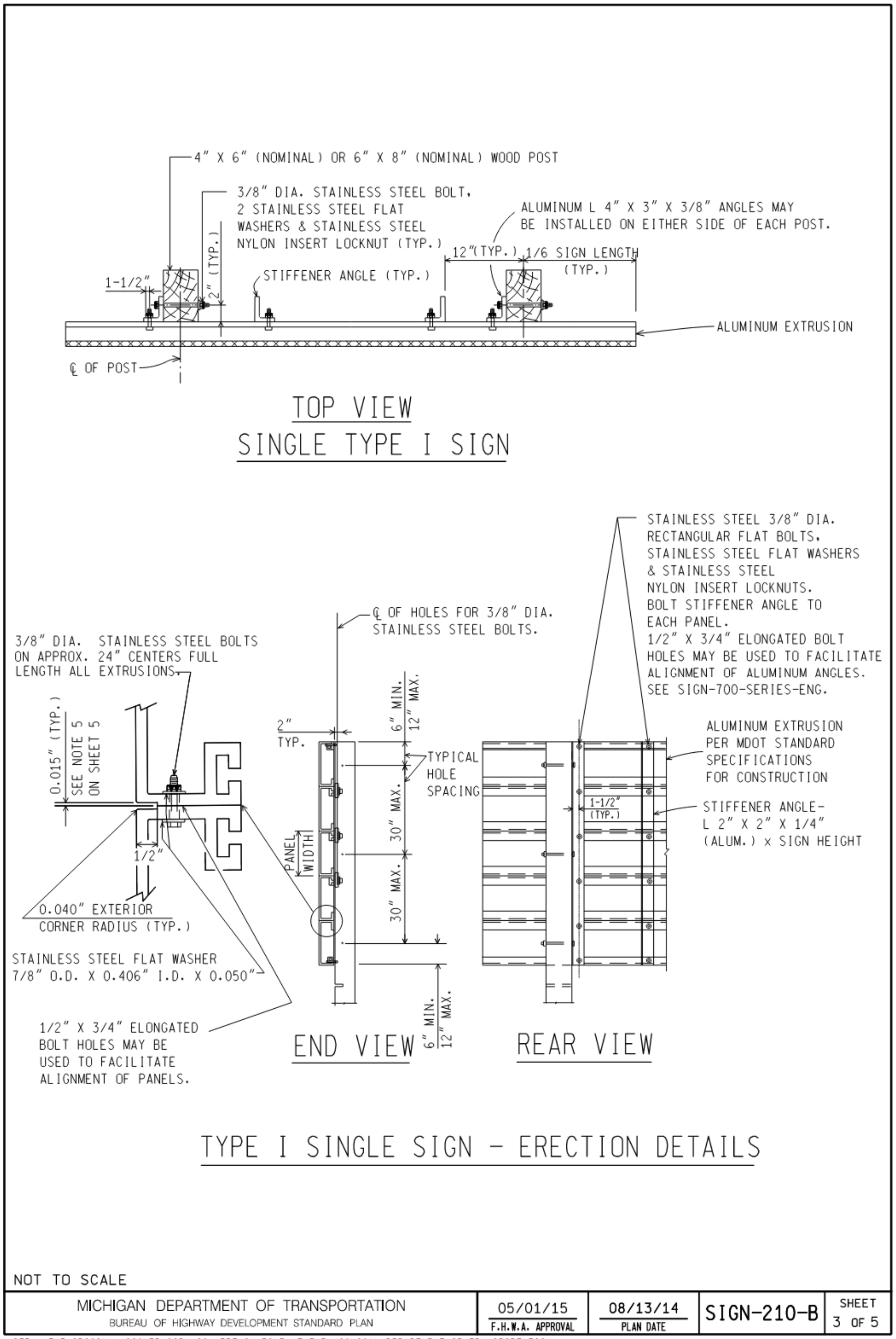


Figure 3-32. Michigan's Response for Question 2 (2/9).

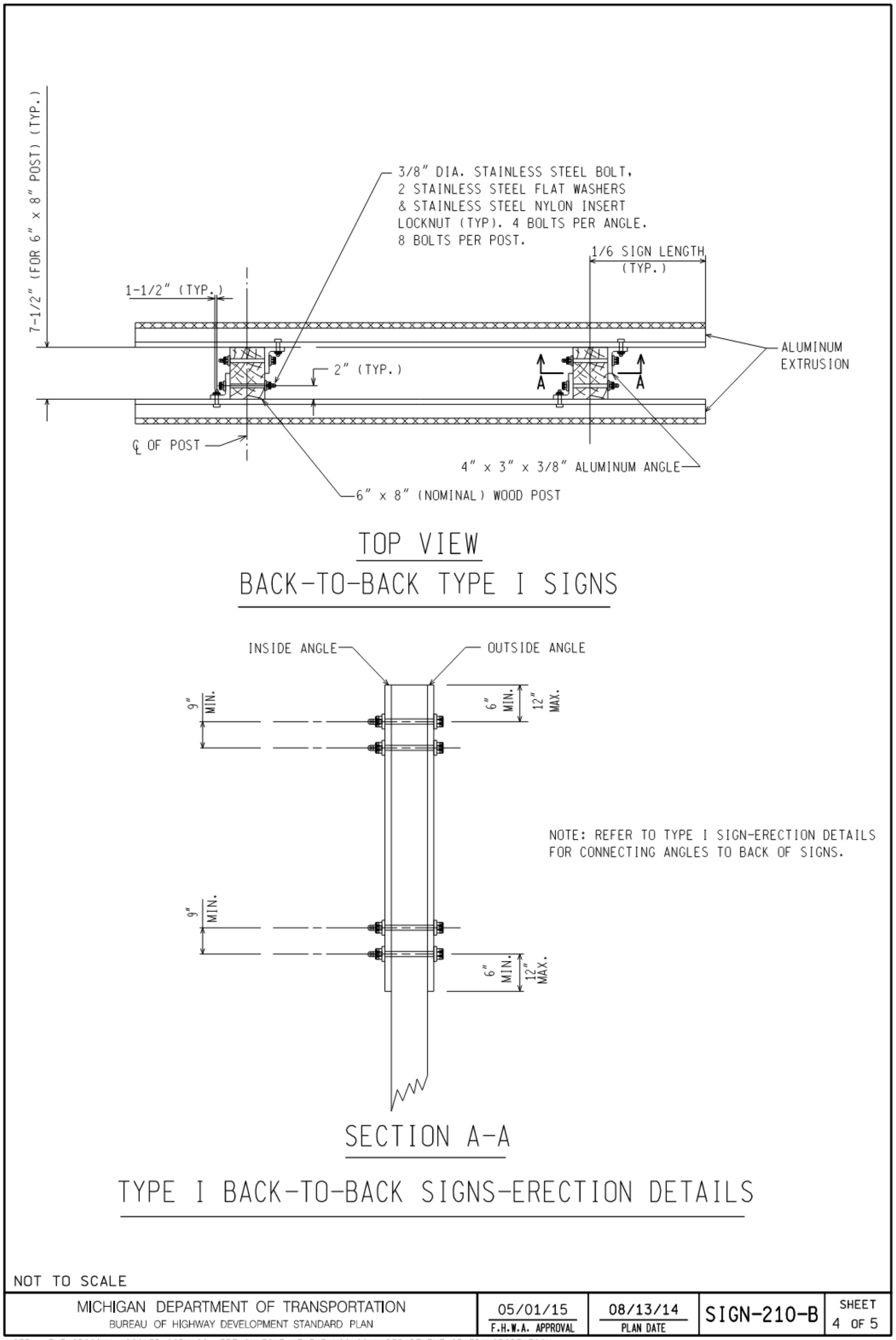
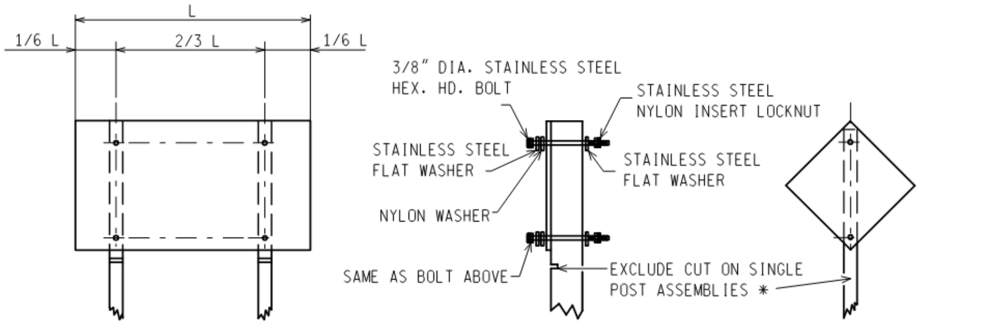


Figure 3-33. Michigan's Response for Question 2 (3/9).



* SAW CUT SHALL BE PLACED ON APPROACH TRAFFIC SIDE OF POST.

CONNECTION DETAIL

TYPES II & III SIGNS - ERECTION DETAILS

NOTES:

1. THE DRILLED BREAKAWAY HOLES ARE TO BE CAREFULLY CENTERED ON THE POSTS.
2. ALL CONCRETE FOUNDATIONS SHALL BE FINISHED AS SHOWN AND ANY SURPLUS MATERIAL SHALL BE COMPLETELY REMOVED FROM RIGHT-OF-WAY. SIGNS SHALL NOT BE ERECTED ON WOOD POSTS FOR A MINIMUM OF 24 HOURS AFTER PLACEMENT OF THE CONCRETE.
3. THE PAY ITEM "SIGN, TYPE ___" INCLUDES ALL ATTACHING DEVICES AND HARDWARE.
4. WOOD POSTS MAY BE DIRECTLY EMBEDDED ONLY AT THOSE LOCATIONS IDENTIFIED IN THE PLANS OR PROPOSAL.
5. A 0.500" WIDE X 0.015" DEEP GROOVE SHALL RUN THE ENTIRE LENGTH AT TOP AND BOTTOM OF ALL EXTRUDED ALUMINUM PANELS TO ACCOMMODATE OVERLAP SHEETING.
6. ALL STAINLESS STEEL BOLTS, NUTS, AND WASHERS SHALL BE MDOT STANDARDS SPECIFICATIONS FOR CONSTRUCTION.
7. FIELD DRILL ALUMINUM ANGLES AND WOOD POSTS.
8. ALL SIGNS SHALL BE ATTACHED SO THAT THE BOLTS ARE CENTERED HORIZONTALLY ON THE POSTS.

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	05/01/15 F.H.W.A. APPROVAL	08/13/14 PLAN DATE	SIGN-210-B	SHEET 5 OF 5

NOTE: THE ORIGINAL SIGNED COPY IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.

Figure 3-34. Michigan's Response for Question 2 (4/9).

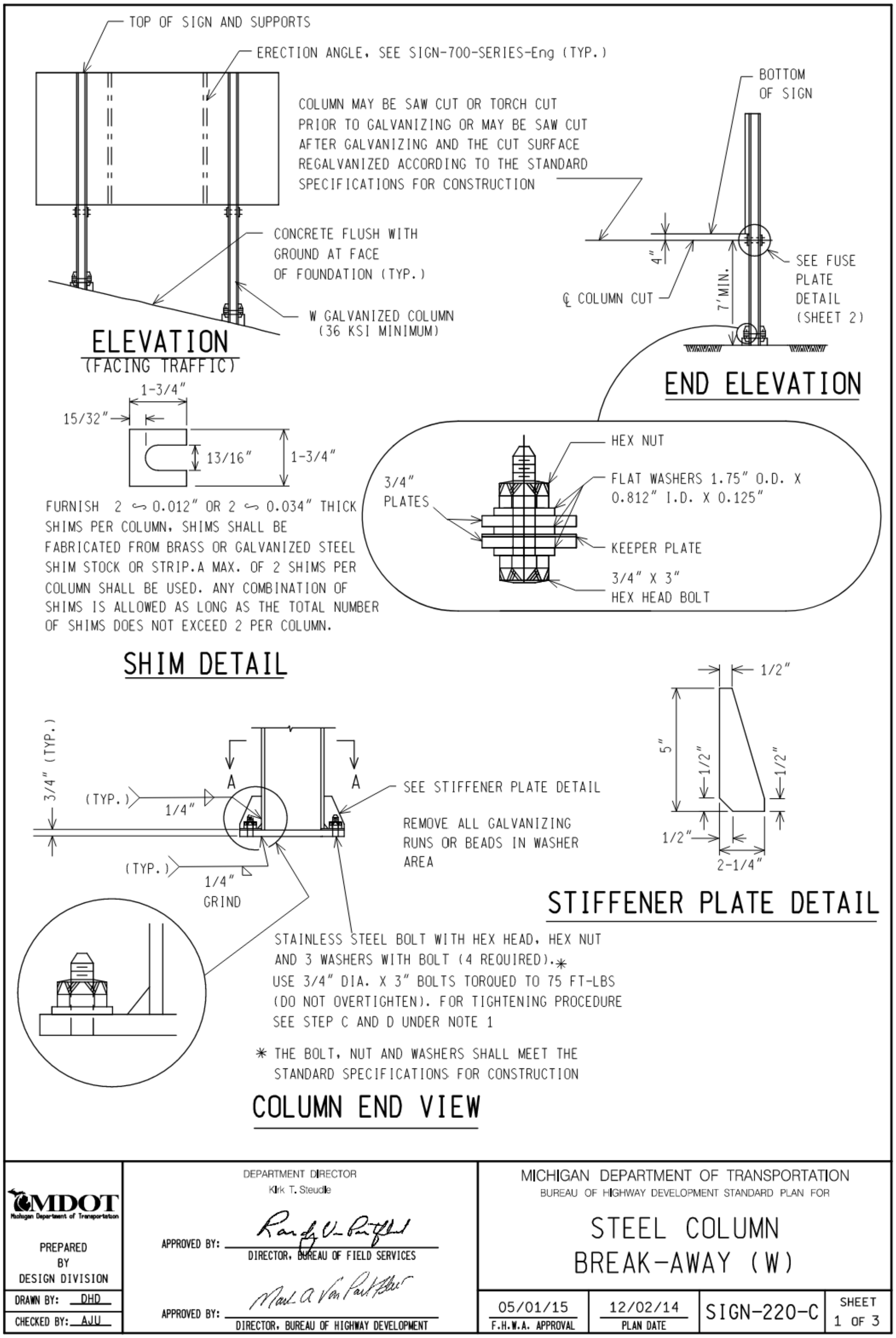
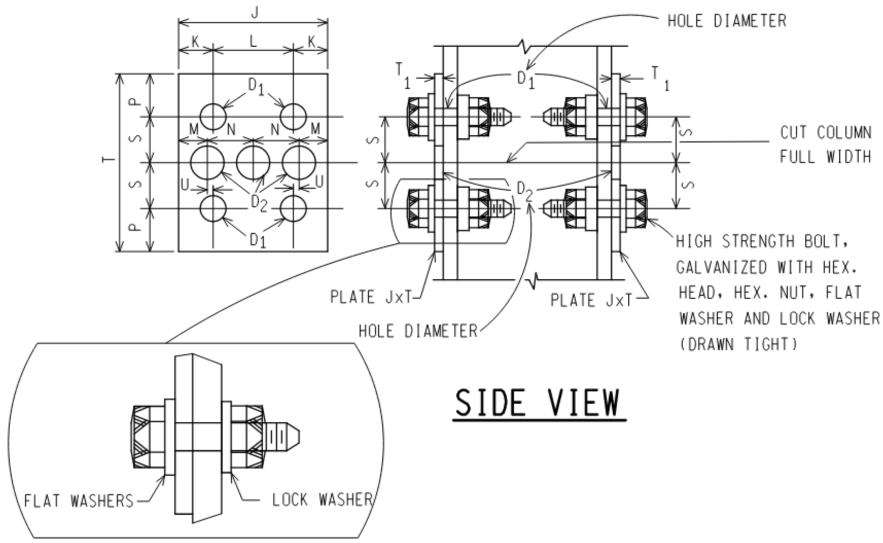


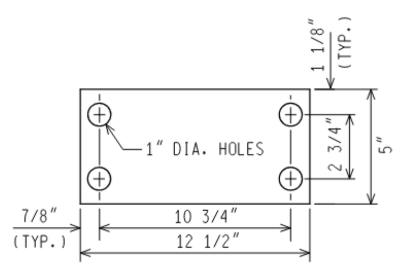
Figure 3-35. Michigan's Response for Question 2 (5/9).



SIDE VIEW

FUSE PLATE DETAILS

COLUMN SIZE	FUSE PLATE DIMENSIONS (inches)												
	J	K	L	M	N	P	S	T	U	T_1	D_1	D_2	BOLT SIZE
W8 x 13	4	7/8	2-1/4	25/32 ± 1/32	1-7/32 ± 1/32	1-1/4	1-1/4	5	3/32	1/4	13/16	7/8	3/4 DIA. X 1-3/4
W8 x 18	5-1/4	1-1/4	2-3/4	1 ± 1/32	1-5/8 ± 1/32	1-1/2	1-1/2	6	1/4	5/16	15/16	1-1/4	7/8 DIA. X 2



KEEPER PLATE DETAIL

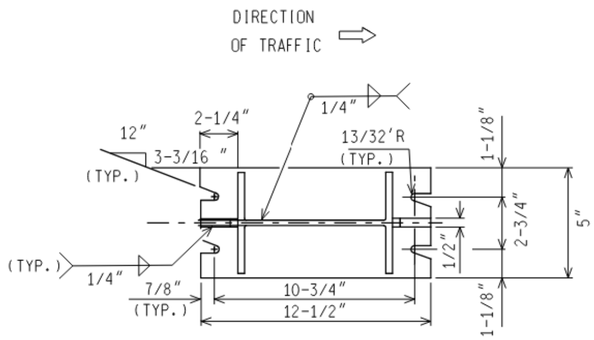
(28 GA GALVANIZED STEEL)

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	05/01/15 F.H.W.A. APPROVAL	12/02/14 PLAN DATE	SIGN-220-C	SHEET 2 OF 3

NOTE: THE ORIGINAL SIGNED COPY IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.

Figure 3-36. Michigan's Response for Question 2 (6/9).



SECTION A-A

SECTION SHOWN IS FOR INSTALLATION ON RIGHT SHOULDER AND IN GORE.
PLATE SLOT BEVELS ARE OPPOSITE HAND FROM THAT SHOWN FOR
INSTALLATIONS ON LEFT SHOULDER.

NOTES:

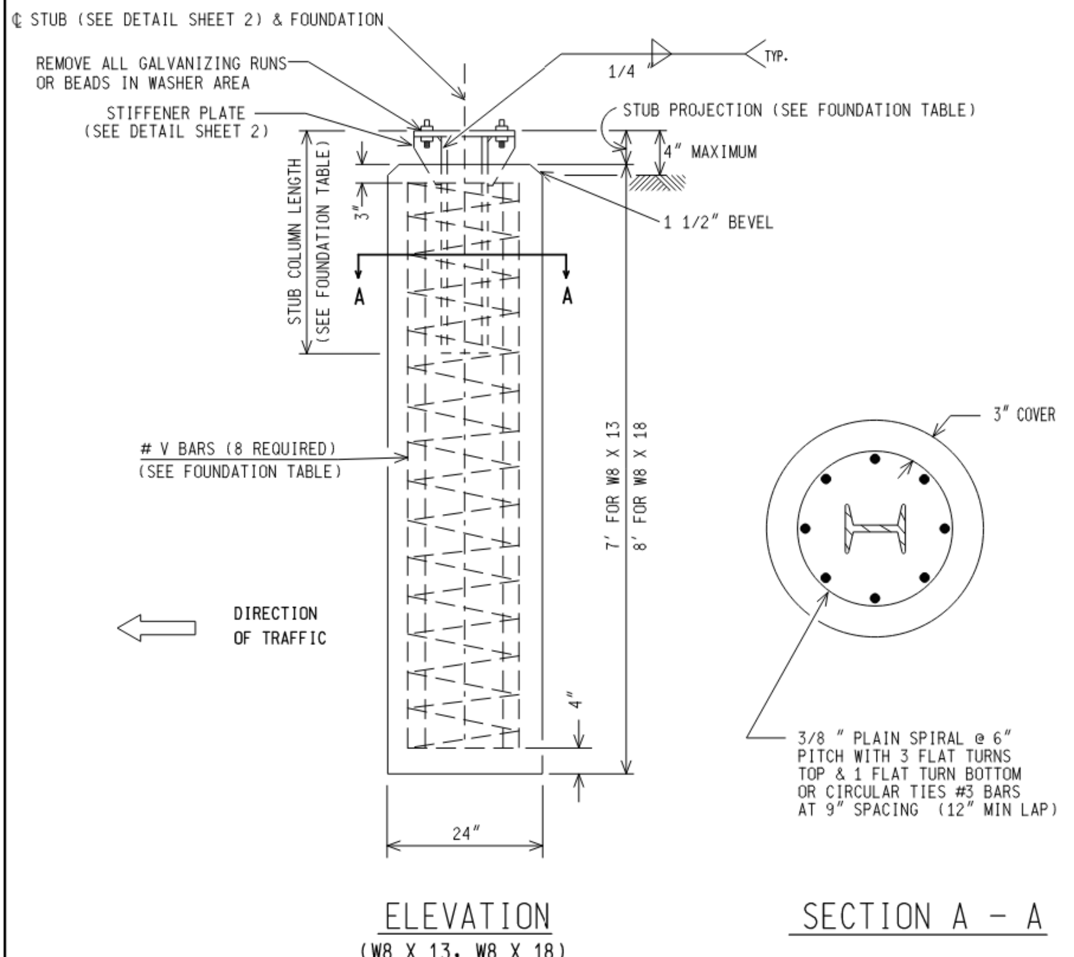
1. PROCEDURE FOR ASSEMBLY OF BASE CONNECTION:
   A. ASSEMBLE COLUMN TO STUB WITH BOLTS AND WITH ONE FLAT WASHER ON EACH BOLT BETWEEN PLATES.
   B. NUMBER OF SHIMS LIMITED TO TWO PER COLUMN.
   C. TIGHTEN BOLTS IN SYSTEMATIC ORDER TO THE PRESCRIBED TORQUE. DO NOT OVERTIGHTEN.
   D. LOOSEN EACH BOLT & RETIGHTEN TO PRESCRIBED TORQUE IN THE SAME ORDER AS INITIAL TIGHTENING, USE COLORED LOCTITE.
2. DESIGN CONFORMS WITH AASHTO SPECIFICATIONS FOR THE DESIGN AND CONSTRUCTION OF STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS.
3. MATERIALS AND FABRICATION PER MDOT STANDARD SPECIFICATIONS FOR CONSTRUCTION.
4. ALL HIGH STRENGTH NUTS SHALL BE OF SUCH CAPACITY AS TO DEVELOP THE BOLT STRENGTH
5. ALL STRUCTURAL STEEL SHALL BE GALVANIZED AFTER FABRICATION EXCEPT WHERE NOTED.
6. ALL CONTACT AREAS OF PLATES AND COLUMN FLANGES SHALL BE FREE OF GALVANIZING BEADS OR RUNS.
7. THE KEEPER PLATE SHALL BE FABRICATED FROM 28 GA GALVANIZED STEEL AND PLACED BETWEEN THE COLUMN AND STUB.
8. WHEN EXISTING STEEL COLUMN BREAKAWAY SUPPORTS ARE TO BE RETAINED, REPLACE BOLTS, WASHERS, NUTS AND KEEPER PLATE.

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	05/01/15 F.H.W.A. APPROVAL	12/02/14 PLAN DATE	SIGN-220-C	SHEET 3 OF 3

NOTE: THE ORIGINAL SIGNED COPY IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.

Figure 3-37. Michigan's Response for Question 2 (7/9).



FOUNDATION TABLE

COLUMN SIZE	STUB LENGTH	STUB PROJECTION	BAR SIZES (#V)	STUB WT. (lbs.)	RE-STEEL WT. (lbs.)	CONCRETE (cu. yd.)
W8 X 13	30″	3″	6	38.8	90.2	0.81
W8 X 18	30″	3″	7	51.3	136.0	0.93

MDOT
Michigan Department of Transportation

PREPARED BY DESIGN DIVISION

DRAWN BY: DHD
CHECKED BY: AJU

DEPARTMENT DIRECTOR
Kirk T. Steudle

APPROVED BY: DIRECTOR, BUREAU OF FIELD SERVICES

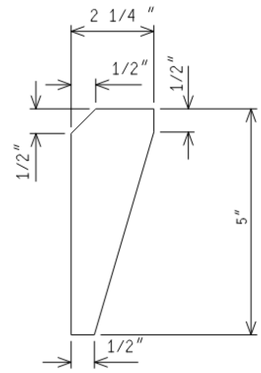
APPROVED BY: DIRECTOR, BUREAU OF HIGHWAY DEVELOPMENT

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR

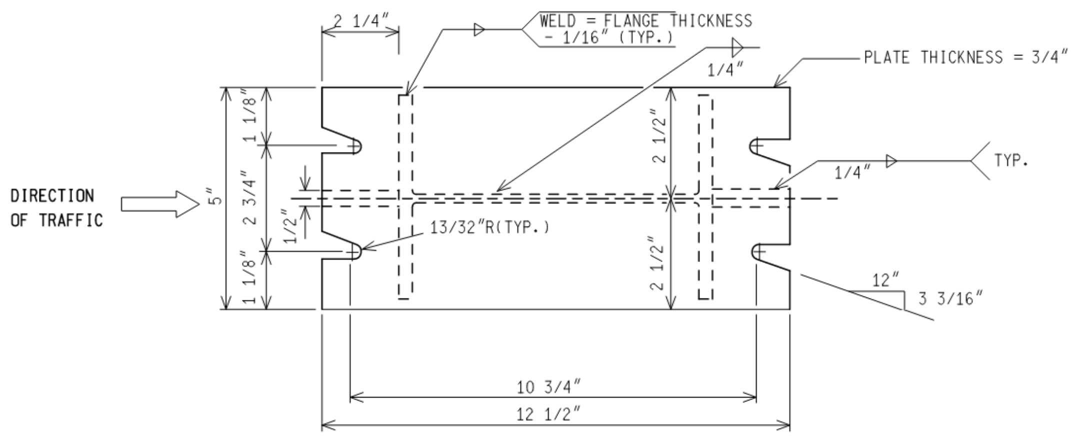
FOUNDATION
(BREAK-AWAY)

08/17/05	03/01/05	SIGN-230-A	SHEET 1 OF 2
F.H.W.A. APPROVAL	PLAN DATE		

Figure 3-38. Michigan's Response for Question 2 (8/9).



STIFFENER PLATE DETAIL



STUB DETAIL-TOP VIEW

PLATE SHOWN IN STUB DETAIL IS FOR INSTALLATION ON RIGHT SHOULDER OR IN GORE AREA.
PLATE SLOT BEVELS ARE OPPOSITE HAND FROM THAT SHOWN FOR INSTALLATION ON LEFT SHOULDER.

NOTES:

1. TOP OF FOUNDATION SHALL BE FLUSH WITH GROUND ON FLAT SLOPES. EDGE OF FOUNDATION NEAREST ROADWAY SHALL BE FLUSH WITH GROUND ON FILL SLOPES. EDGE OF FOUNDATION FARTHEST FROM ROADWAY SHALL BE FLUSH WITH GROUND ON CUT SLOPES.

2. BOLTS FOR CONNECTION OF COLUMN TO STUB ARE TO BE FURNISHED WITH COLUMN (SEE SIGN-220-SERIES-Eng).

3. CONCRETE SHALL BE USED AND PLACED AGAINST UNDISTURBED SOIL IN AN AUGERED HOLE. THE STEEL STUB SHALL BE HELD IN CORRECT POSITION WITH A TEMPLATE UNTIL THE CONCRETE HAS PROPERLY SET.

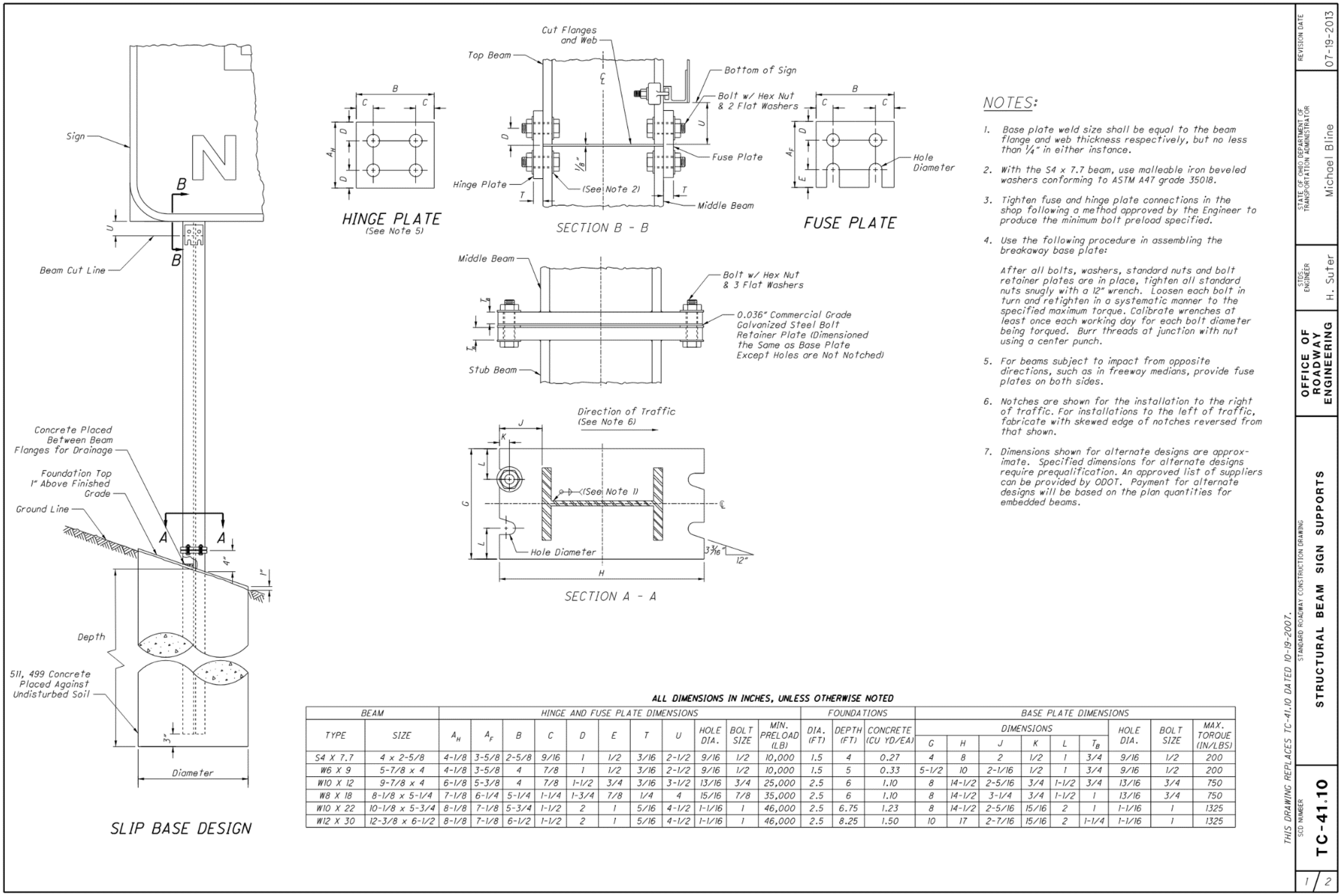
4. DEFORMED BARS, SPIRALS AND CONCRETE PER MDOT STANDARD SPECIFICATIONS FOR CONSTRUCTION.

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN	08/17/05 F.H.W.A. APPROVAL	03/01/05 PLAN DATE	SIGN-230-A	SHEET 2 OF 2

NOTE: THE ORIGINAL SIGNED COPY IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.

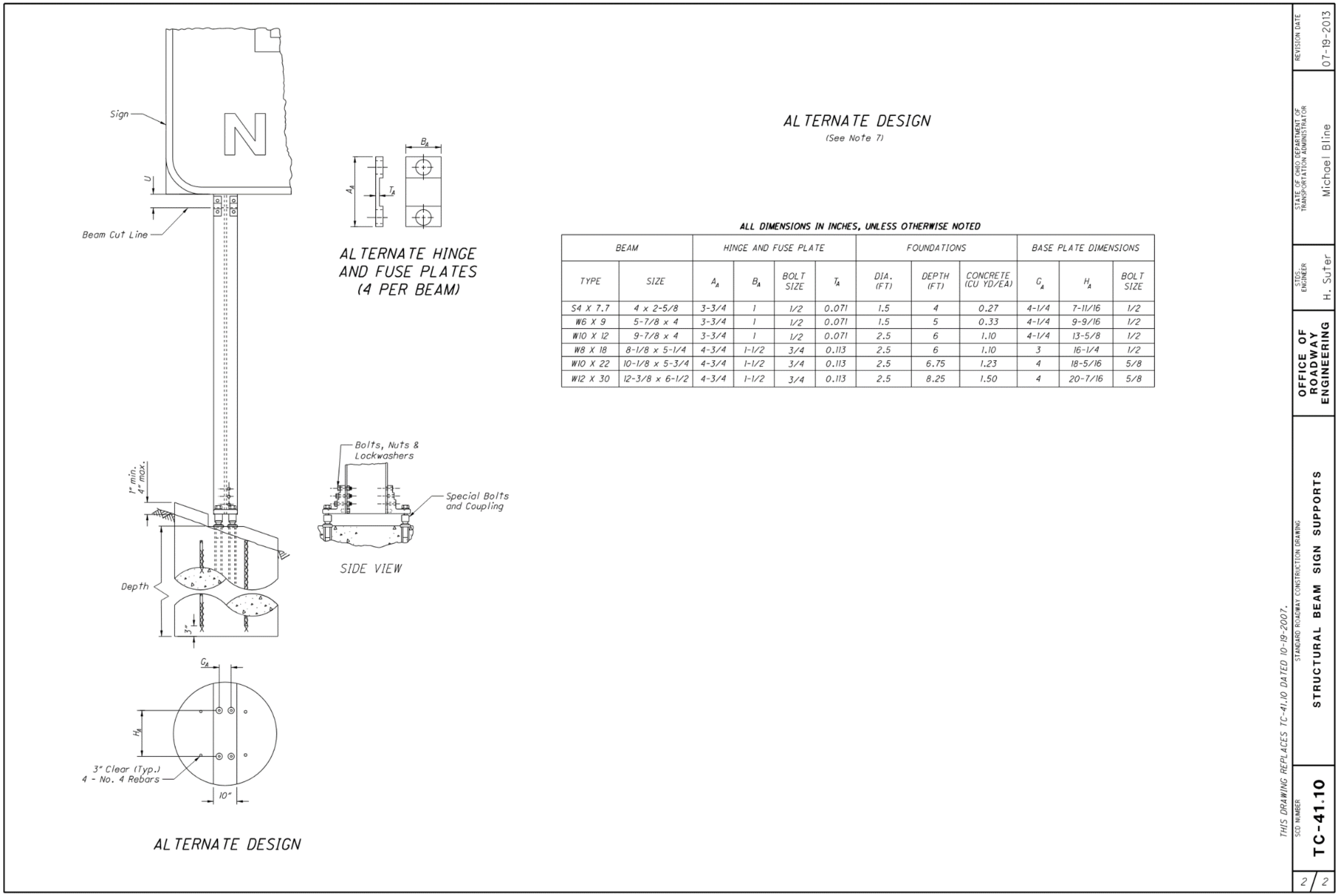
Figure 3-39. Michigan's Response for Question 2 (9/9).



ALL DIMENSIONS IN INCHES, UNLESS OTHERWISE NOTED

BEAM		HINGE AND FUSE PLATE DIMENSIONS											FOUNDATIONS			BASE PLATE DIMENSIONS								
TYPE	SIZE	A_H	A_F	B	C	D	E	T	U	HOLE DIA.	BOLT SIZE	MIN. PRELOAD (LB)	DIA. (FT)	DEPTH (FT)	CONCRETE (CU YD/EA)	DIMENSIONS G	H	J	K	L	T_B	HOLE DIA.	BOLT SIZE	MAX. TORQUE (IN/LBS)
S4 X 7.7	4 x 2-5/8	4-1/8	3-5/8	2-5/8	9/16	1	1/2	3/16	2-1/2	9/16	1/2	10,000	1.5	4	0.27	4	8	2	1/2	1	3/4	9/16	1/2	200
W6 X 9	5-7/8 x 4	4-1/8	3-5/8	4	7/8	1	1/2	3/16	2-1/2	9/16	1/2	10,000	1.5	5	0.33	5-1/2	10	2-1/16	1/2	1	3/4	9/16	1/2	200
W10 X 12	9-7/8 x 4	6-1/8	5-3/8	4	7/8	1-1/2	3/4	3/16	3-1/2	13/16	3/4	25,000	2.5	6	1.10	8	14-1/2	2-5/16	3/4	1-1/2	3/4	13/16	3/4	750
W8 X 18	8-1/8 x 5-1/4	7-1/8	6-1/4	5-1/4	1-1/4	1-3/4	7/8	1/4	4	15/16	7/8	35,000	2.5	6	1.10	8	14-1/2	3-1/4	3/4	1-1/2	1	13/16	3/4	750
W10 X 22	10-1/8 x 5-3/4	8-1/8	7-1/8	5-3/4	1-1/2	2	1	5/16	4-1/2	1-1/16	1	46,000	2.5	6.75	1.23	8	14-1/2	2-5/16	15/16	2	1	1-1/16	1	1325
W12 X 30	12-3/8 x 6-1/2	8-1/8	7-1/8	6-1/2	1-1/2	2	1	5/16	4-1/2	1-1/16	1	46,000	2.5	8.25	1.50	10	17	2-7/16	15/16	2	1-1/4	1-1/16	1	1325

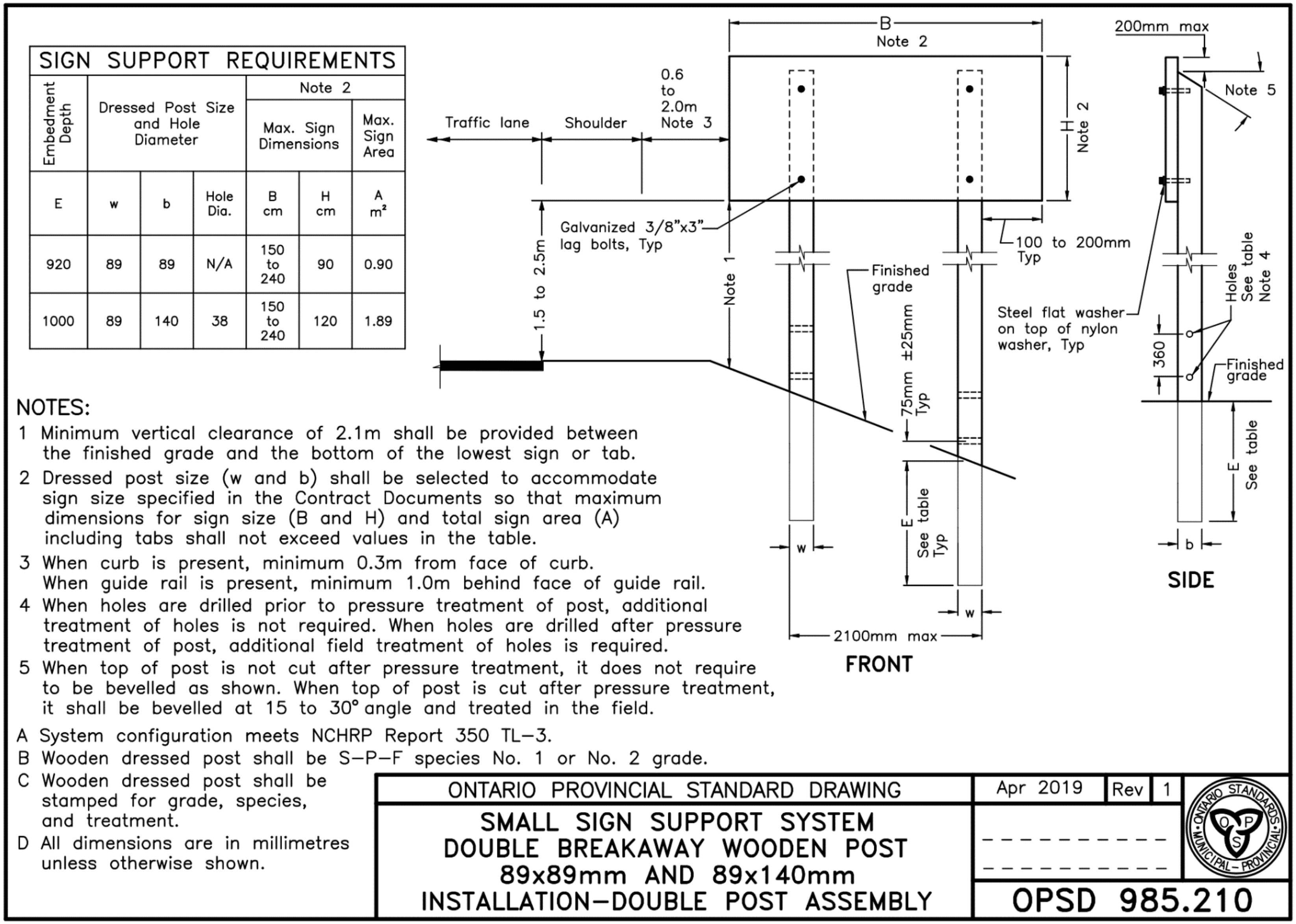
Figure 3-40. Ohio's Response for Question 2 (1/2).



ALL DIMENSIONS IN INCHES, UNLESS OTHERWISE NOTED

BEAM		HINGE AND FUSE PLATE				FOUNDATIONS			BASE PLATE DIMENSIONS		
TYPE	SIZE	A_A	B_A	BOLT SIZE	T_A	DIA. (FT)	DEPTH (FT)	CONCRETE (CU YD/EA)	G_A	H_A	BOLT SIZE
S4 X 7.7	4 x 2-5/8	3-3/4	1	1/2	0.071	1.5	4	0.27	4-1/4	7-11/16	1/2
W6 X 9	5-7/8 x 4	3-3/4	1	1/2	0.071	1.5	5	0.33	4-1/4	9-9/16	1/2
W10 X 12	9-7/8 x 4	3-3/4	1	1/2	0.071	2.5	6	1.10	4-1/4	13-5/8	1/2
W8 X 18	8-1/8 x 5-1/4	4-3/4	1-1/2	3/4	0.113	2.5	6	1.10	3	16-1/4	1/2
W10 X 22	10-1/8 x 5-3/4	4-3/4	1-1/2	3/4	0.113	2.5	6.75	1.23	4	18-5/16	5/8
W12 X 30	12-3/8 x 6-1/2	4-3/4	1-1/2	3/4	0.113	2.5	8.25	1.50	4	20-7/16	5/8

Figure 3-41. Ohio's Response for Question 2 (2/2).



SIGN SUPPORT REQUIREMENTS

Embedment Depth	Dressed Post Size and Hole Diameter			Note 2: Max. Sign Dimensions		Note 2: Max. Sign Area
E	w	b	Hole Dia.	B cm	H cm	A m^2
920	89	89	N/A	150 to 240	90	0.90
1000	89	140	38	150 to 240	120	1.89

NOTES:

1 Minimum vertical clearance of 2.1m shall be provided between the finished grade and the bottom of the lowest sign or tab.

2 Dressed post size (w and b) shall be selected to accommodate sign size specified in the Contract Documents so that maximum dimensions for sign size (B and H) and total sign area (A) including tabs shall not exceed values in the table.

3 When curb is present, minimum 0.3m from face of curb. When guide rail is present, minimum 1.0m behind face of guide rail.

4 When holes are drilled prior to pressure treatment of post, additional treatment of holes is not required. When holes are drilled after pressure treatment of post, additional field treatment of holes is required.

5 When top of post is not cut after pressure treatment, it does not require to be bevelled as shown. When top of post is cut after pressure treatment, it shall be bevelled at 15 to 30° angle and treated in the field.

A System configuration meets NCHRP Report 350 TL–3.

B Wooden dressed post shall be S–P–F species No. 1 or No. 2 grade.

C Wooden dressed post shall be stamped for grade, species, and treatment.

D All dimensions are in millimetres unless otherwise shown.

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SMALL SIGN SUPPORT SYSTEM
DOUBLE BREAKAWAY WOODEN POST
89x89mm AND 89x140mm
INSTALLATION–DOUBLE POST ASSEMBLY

OPSD 985.210

Figure 3-42. Ontario's Response for Question 2.

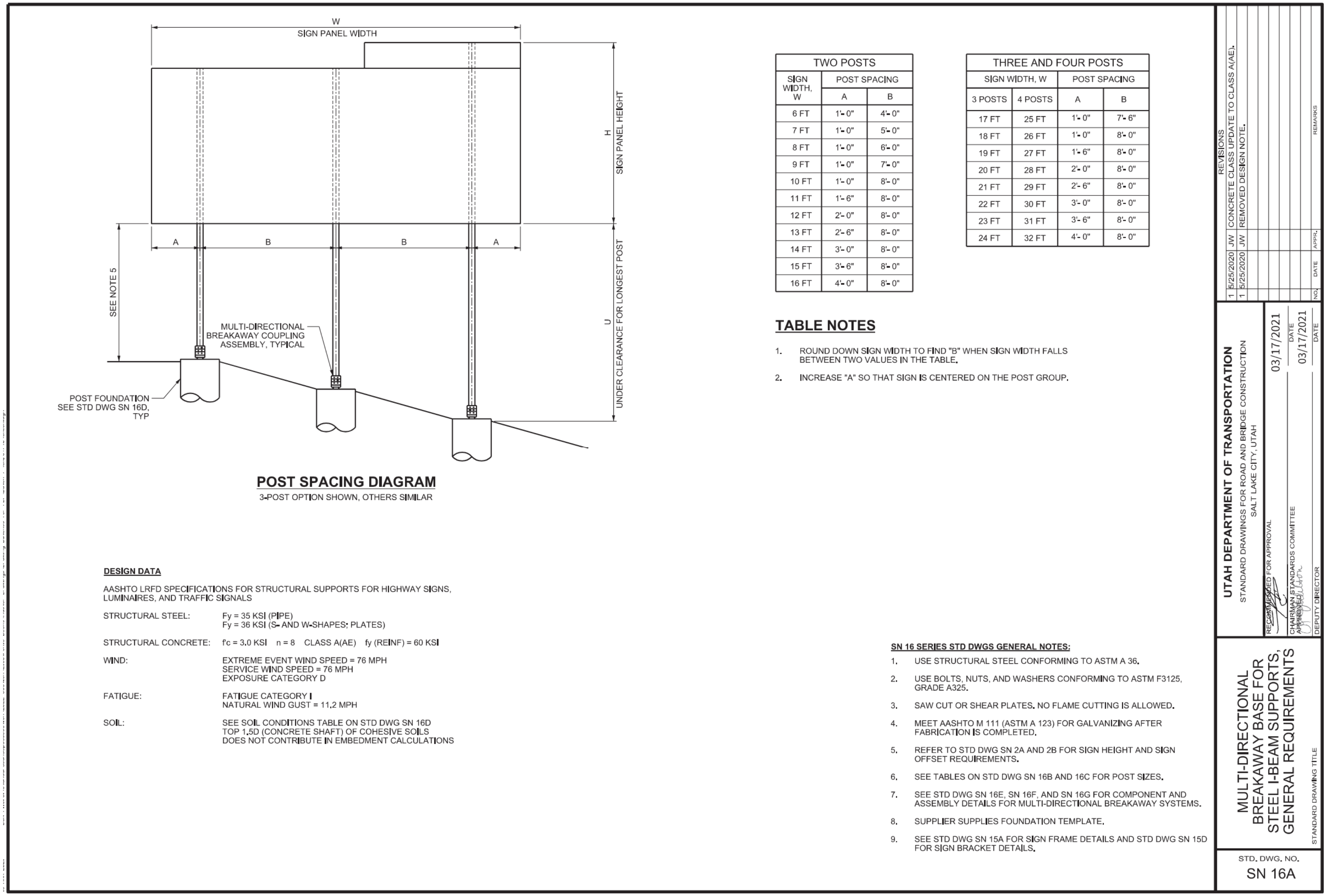


Figure 3-43. Utah's Response for Question 2 (1/11).

STEEL I-BEAM POST SELECTION TABLE - TWO POSTS

H	U	SIGN PANEL WIDTH, W										
		6'	7'	8'	9'	10'	11'	12'	13'	14'	15'	16'
4'	8'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9
	9'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9
	10'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9
	11'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12
	12'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 12
5'	8'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9
	9'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9
	10'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12
	11'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 12	W6 x 12	W6 x 16
	12'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16
6'	8'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12
	9'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 16
	10'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16
	11'	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W6 x 16
	12'	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18
7'	8'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16
	9'	W6 x 9	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16
	10'	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W6 x 16
	11'	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18
	12'	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18
8'	8'	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16
	9'	W6 x 9	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18
	10'	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18
	11'	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	12'	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18
9'	8'	W6 x 9	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18
	9'	W6 x 9	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18
	10'	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	11'	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	12'	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18
10'	8'	W6 x 12	W6 x 12	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18
	9'	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	10'	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	11'	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	12'	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21
11'	8'	W6 x 12	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	9'	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21
	10'	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21
	11'	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21
	12'	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W10 x 22	W10 x 22
12'	8'	W6 x 12	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21
	9'	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21
	10'	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W8 x 21
	11'	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W10 x 22	W10 x 22
	12'	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22
13'	8'	W6 x 16	W6 x 16	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W8 x 21
	9'	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W8 x 21	W10 x 22
	10'	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W8 x 21	W10 x 22	W10 x 22
	11'	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22
	12'	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22

STEEL I-BEAM POST SELECTION TABLE - TWO POSTS (CONTINUED)

H	U	SIGN PANEL WIDTH, W										
		6'	7'	8'	9'	10'	11'	12'	13'	14'	15'	16'
14'	8'	W6 x 16	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W8 x 21	W10 x 22	W10 x 22
	9'	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22
	10'	W8 x 18	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	11'	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	12'	W8 x 18	W8 x 18		W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26
15'	8'	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	9'	W8 x 18	W8 x 18	W8 x 18	W8 x 21	W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	10'	W8 x 18	W8 x 18		W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	11'	W8 x 18	W8 x 18		W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	12'	W8 x 18			W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26
16'	8'	W8 x 18	W8 x 18		W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	9'	W8 x 18	W8 x 18		W8 x 21	W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	10'	W8 x 18			W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	11'	W8 x 18			W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26
	12'				W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26
17'	8'	W8 x 18			W8 x 21	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	9'	W8 x 18			W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	10'	W8 x 18			W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26
	11'				W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	12'				W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26
18'	8'				W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26
	9'				W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26
	10'				W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	11'				W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	12'				W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26
19'	8'				W10 x 22	W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26
	9'				W10 x 22	W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	10'				W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	11'				W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	12'				W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30
20'	8'				W10 x 22	W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	9'				W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	10'				W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	11'				W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30
	12'				W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30	W14 x 30	W14 x 30
21'	8'				W10 x 22	W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	9'				W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30
	10'				W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30	W14 x 30
	11'				W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30	W14 x 30	W14 x 30
	12'				W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30	W14 x 30	W14 x 30	W14 x 30
22'	8'				W10 x 22	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30	W14 x 30
	9'				W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30	W14 x 30	W14 x 30
	10'				W12 x 26	W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30	W14 x 30	W14 x 30
	11'				W12 x 26	W12 x 26	W12 x 26	W12 x 26	W14 x 30	W14 x 30	W14 x 30	W14 x 30
	12'				W12 x 26	W12 x 26	W14 x 30	W14 x 30	W14 x 30	W14 x 30	W14 x 30	W14 x 30

SEE NOTE 2

NOTES:

1. SEE STD DWG SN 16A FOR GENERAL NOTES AND DESIGN DATA.
2. CONTACT UDOT CENTRAL TRAFFIC AND SAFETY FOR SIGN SIZES NOT LISTED IN STEEL I-BEAM POST SELECTION TABLE.

REVISIONS

NO.	DATE	APPR.	REMARKS
1	5/25/2020	JW	REMOVED POSTS FROM TABLE (CRASHWORTHINESS)
1	5/25/2020	JW	ADDED NOTE 2.

UTAH DEPARTMENT OF TRANSPORTATION
STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION
SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL 03/17/2021 DATE
CHAIRMAN STANDARDS COMMITTEE
APPROVED 03/17/2021 DATE
DEPUTY DIRECTOR DATE

MULTI-DIRECTIONAL BREAKAWAY BASE FOR STEEL I-BEAM SIGN SUPPORTS, TWO POSTS

STANDARD DRAWING TITLE

STD. DWG. NO.
SN 16B

Figure 3-44. Utah's Response for Question 2 (2/11).

STEEL I-BEAM POST SELECTION TABLE THREE OR FOUR POSTS					
H	U	SIGN PANEL WIDTH, W			
		17'	18' - 24'	25'	26' - 32'
4'	8'	W6 x 9	W6 x 9	W6 x 9	W6 x 9
	9'	W6 x 9	W6 x 9	W6 x 9	W6 x 9
	10'	W6 x 9	W6 x 9	W6 x 9	W6 x 9
	11'	W6 x 12	W6 x 12	W6 x 12	W6 x 12
	12'	W6 x 12	W6 x 12	W6 x 12	W6 x 12
5'	8'	W6 x 9	W6 x 9	W6 x 9	W6 x 9
	9'	W6 x 9	W6 x 12	W6 x 9	W6 x 12
	10'	W6 x 12	W6 x 12	W6 x 12	W6 x 12
	11'	W6 x 12	W6 x 16	W6 x 12	W6 x 16
	12'	W6 x 16	W6 x 16	W6 x 16	W6 x 16
6'	8'	W6 x 12	W6 x 12	W6 x 12	W6 x 12
	9'	W6 x 12	W6 x 16	W6 x 12	W6 x 16
	10'	W6 x 16	W6 x 16	W6 x 16	W6 x 16
	11'	W6 x 16	W8 x 18	W6 x 16	W8 x 18
	12'	W6 x 16	W8 x 18	W6 x 16	W8 x 18
7'	8'	W6 x 16	W6 x 16	W6 x 16	W6 x 16
	9'	W6 x 16	W6 x 16	W6 x 16	W6 x 16
	10'	W6 x 16	W6 x 16	W6 x 16	W6 x 16
	11'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	12'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
8'	8'	W6 x 16	W6 x 16	W6 x 16	W6 x 16
	9'	W6 x 16	W8 x 18	W6 x 16	W8 x 18
	10'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	11'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	12'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
9'	8'	W6 x 16	W8 x 18	W6 x 16	W8 x 18
	9'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	10'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	11'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	12'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
10'	8'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	9'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	10'	W8 x 18	W8 x 18	W8 x 18	W8 x 18
	11'	W8 x 18	W8 x 21	W8 x 18	W8 x 21
	12'	W8 x 21	W8 x 21	W8 x 21	W8 x 21
11'	8'	W8 x 18	W8 x 21	W8 x 18	W8 x 21
	9'	W8 x 21	W8 x 21	W8 x 21	W8 x 21
	10'	W8 x 21	W8 x 21	W8 x 21	W8 x 21
	11'	W8 x 21	W8 x 21	W8 x 21	W8 x 21
	12'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
12'	8'	W8 x 21	W8 x 21	W8 x 21	W8 x 21
	9'	W8 x 21	W8 x 21	W8 x 21	W8 x 21
	10'	W8 x 21	W8 x 21	W8 x 21	W8 x 21
	11'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	12'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
13'	8'	W8 x 21	W10 x 22	W8 x 21	W10 x 22
	9'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	10'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	11'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	12'	W10 x 22	W10 x 22	W10 x 22	W10 x 22

STEEL I-BEAM POST SELECTION TABLE THREE OR FOUR POSTS (CONTINUED)					
H	U	SIGN PANEL WIDTH, W			
		17'	18' - 24'	25'	26' - 32'
14'	8'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	9'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	10'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	11'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	12'	W10 x 22	W12 x 26	W10 x 22	W12 x 26
15'	8'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	9'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	10'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	11'	W10 x 22	W12 x 26	W10 x 22	W12 x 26
	12'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
16'	8'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	9'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	10'	W10 x 22	W12 x 26	W10 x 22	W12 x 26
	11'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	12'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
17'	8'	W10 x 22	W10 x 22	W10 x 22	W10 x 22
	9'	W10 x 22	W12 x 26	W10 x 22	W12 x 26
	10'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	11'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	12'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
18'	8'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	9'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	10'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	11'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	12'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
19'	8'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	9'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	10'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	11'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	12'	W12 x 26	W14 x 30	W12 x 26	W14 x 30
20'	8'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	9'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	10'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	11'	W12 x 26	W14 x 30	W12 x 26	W14 x 30
	12'	W14 x 30	W14 x 30	W14 x 30	W14 x 30
21'	8'	W12 x 26	W12 x 26	W12 x 26	W12 x 26
	9'	W12 x 26	W14 x 30	W12 x 26	W14 x 30
	10'	W14 x 30	W14 x 30	W14 x 30	W14 x 30
	11'	W14 x 30	W14 x 30	W14 x 30	W14 x 30
	12'	W14 x 30	W14 x 30	W14 x 30	W14 x 30
22'	8'	W14 x 30	W14 x 30	W14 x 30	W14 x 30
	9'	W14 x 30	W14 x 30	W14 x 30	W14 x 30
	10'	W14 x 30	W14 x 30	W14 x 30	W14 x 30
	11'	W14 x 30	W14 x 30	W14 x 30	W14 x 30
	12'	W14 x 30	W14 x 30	W14 x 30	W14 x 30

NOTES:

1. SEE STD DWG SN 16A FOR GENERAL NOTES AND DESIGN DATA.

REVISIONS

NO. DATE APPR. REMARKS

UTAH DEPARTMENT OF TRANSPORTATION

STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION

SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL 03/17/2021 DATE

CHAIRMAN STANDARDS COMMITTEE

APPROVED 03/17/2021 DATE

DEPUTY DIRECTOR

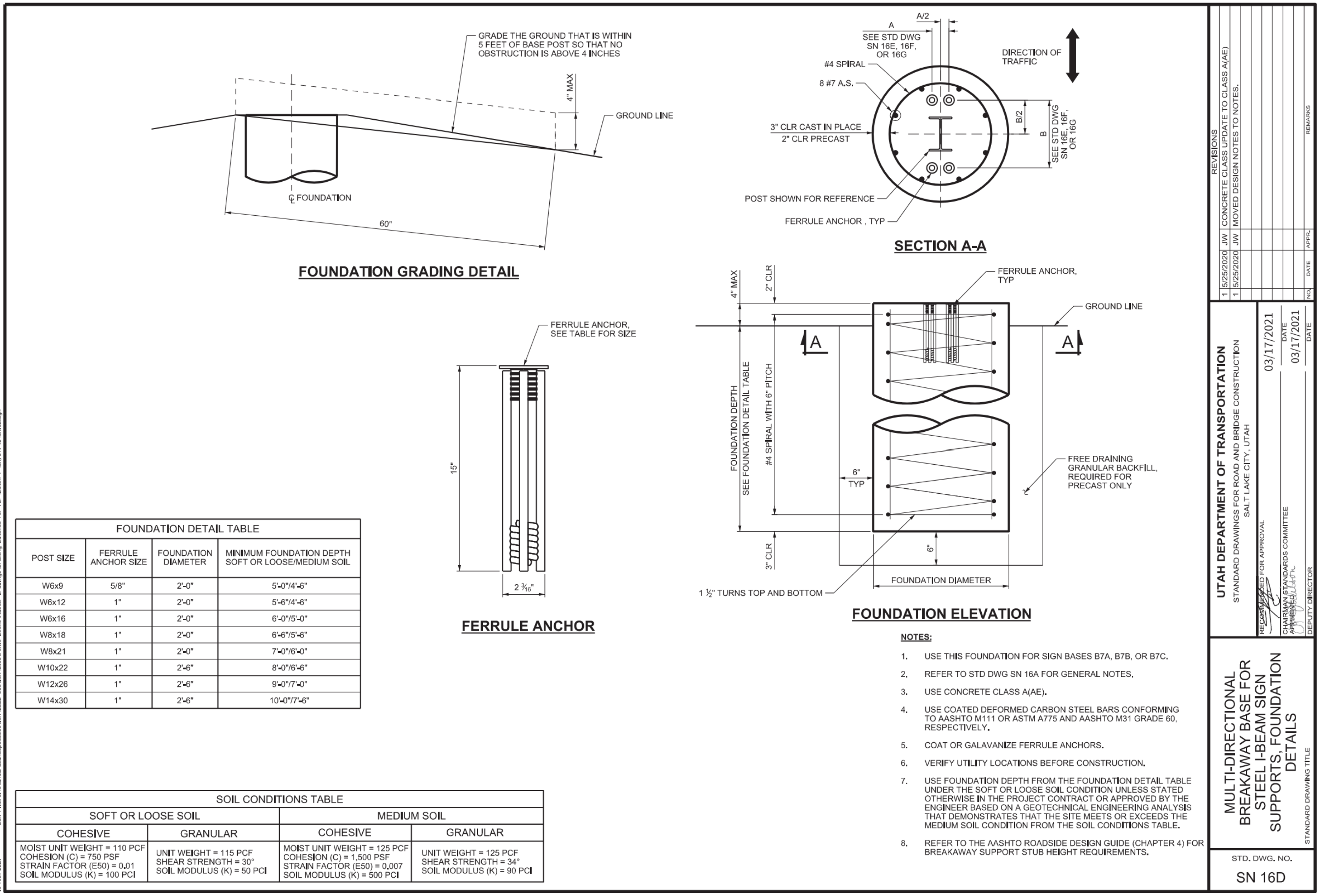
MULTI-DIRECTIONAL BREAKAWAY BASE FOR STEEL I-BEAM SIGN SUPPORTS, THREE AND FOUR POSTS

STANDARD DRAWING TITLE

STD. DWG. NO.

SN 16C

Figure 3-45. Utah's Response for Question 2 (3/11).



FOUNDATION DETAIL TABLE			
POST SIZE	FERRULE ANCHOR SIZE	FOUNDATION DIAMETER	MINIMUM FOUNDATION DEPTH SOFT OR LOOSE/MEDIUM SOIL
W6x9	5/8"	2'-0"	5'-0"/4'-6"
W6x12	1"	2'-0"	5'-6"/4'-6"
W6x16	1"	2'-0"	6'-0"/5'-0"
W8x18	1"	2'-0"	6'-6"/5'-6"
W8x21	1"	2'-0"	7'-0"/6'-0"
W10x22	1"	2'-6"	8'-0"/6'-6"
W12x26	1"	2'-6"	9'-0"/7'-0"
W14x30	1"	2'-6"	10'-0"/7'-6"

SOIL CONDITIONS TABLE			
SOFT OR LOOSE SOIL		MEDIUM SOIL	
COHESIVE	GRANULAR	COHESIVE	GRANULAR
MOIST UNIT WEIGHT = 110 PCF COHESION (C) = 750 PSF STRAIN FACTOR (E50) = 0.01 SOIL MODULUS (K) = 100 PCI	UNIT WEIGHT = 115 PCF SHEAR STRENGTH = 30° SOIL MODULUS (K) = 50 PCI	MOIST UNIT WEIGHT = 125 PCF COHESION (C) = 1,500 PSF STRAIN FACTOR (E50) = 0.007 SOIL MODULUS (K) = 500 PCI	UNIT WEIGHT = 125 PCF SHEAR STRENGTH = 34° SOIL MODULUS (K) = 90 PCI

NOTES:

1. USE THIS FOUNDATION FOR SIGN BASES B7A, B7B, OR B7C.
2. REFER TO STD DWG SN 16A FOR GENERAL NOTES.
3. USE CONCRETE CLASS A(AE).
4. USE COATED DEFORMED CARBON STEEL BARS CONFORMING TO AASHTO M111 OR ASTM A775 AND AASHTO M31 GRADE 60, RESPECTIVELY.
5. COAT OR GALAVANIZE FERRULE ANCHORS.
6. VERIFY UTILITY LOCATIONS BEFORE CONSTRUCTION.
7. USE FOUNDATION DEPTH FROM THE FOUNDATION DETAIL TABLE UNDER THE SOFT OR LOOSE SOIL CONDITION UNLESS STATED OTHERWISE IN THE PROJECT CONTRACT OR APPROVED BY THE ENGINEER BASED ON A GEOTECHNICAL ENGINEERING ANALYSIS THAT DEMONSTRATES THAT THE SITE MEETS OR EXCEEDS THE MEDIUM SOIL CONDITION FROM THE SOIL CONDITIONS TABLE.
8. REFER TO THE AASHTO ROADSIDE DESIGN GUIDE (CHAPTER 4) FOR BREAKAWAY SUPPORT STUB HEIGHT REQUIREMENTS.

Figure 3-46. Utah's Response for Question 2 (4/11).

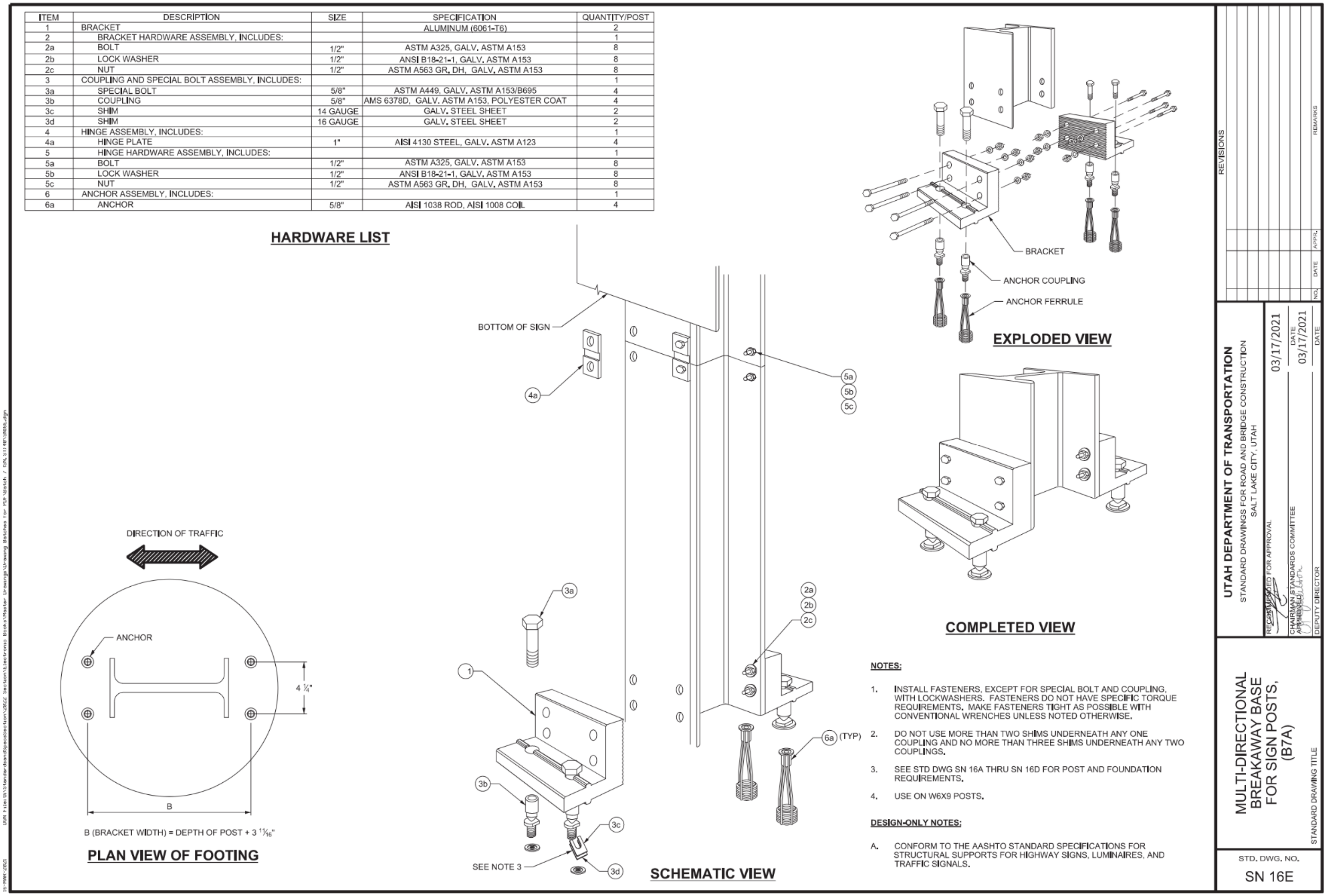
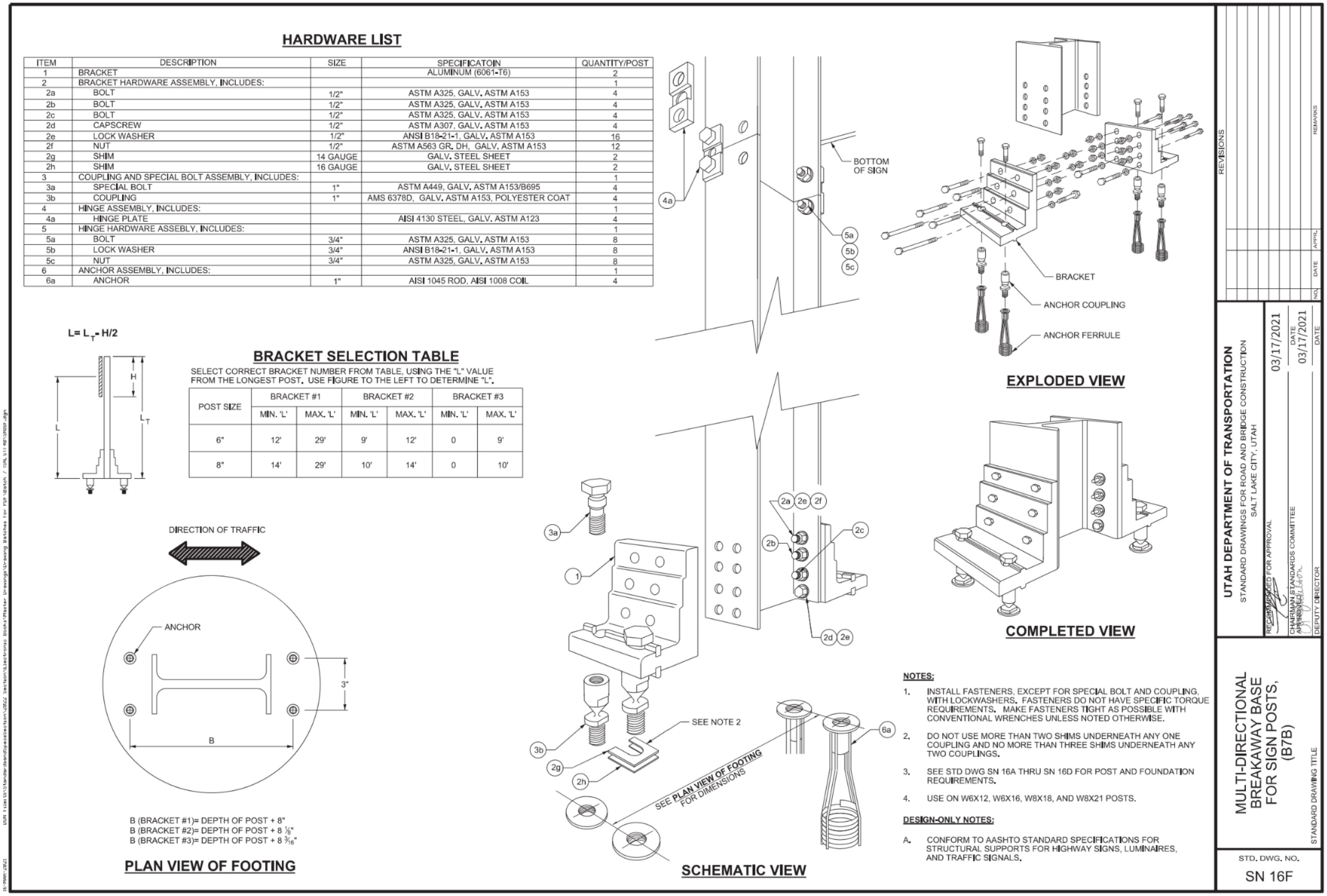


Figure 3-47. Utah's Response for Question 2 (5/11).



HARDWARE LIST

ITEM	DESCRIPTION	SIZE	SPECIFICATOIN	QUANTITY/POST
1	BRACKET		ALUMINUM (6061-T6)	2
2	BRACKET HARDWARE ASSEMBLY, INCLUDES:			1
2a	BOLT	1/2"	ASTM A325, GALV. ASTM A153	4
2b	BOLT	1/2"	ASTM A325, GALV. ASTM A153	4
2c	BOLT	1/2"	ASTM A325, GALV. ASTM A153	4
2d	CAPSCREW	1/2"	ASTM A307, GALV. ASTM A153	4
2e	LOCK WASHER	1/2"	ANSI B18-21-1, GALV. ASTM A153	16
2f	NUT	1/2"	ASTM A563 GR. DH, GALV. ASTM A153	12
2g	SHIM	14 GAUGE	GALV. STEEL SHEET	2
2h	SHIM	16 GAUGE	GALV. STEEL SHEET	2
3	COUPLING AND SPECIAL BOLT ASSEMBLY, INCLUDES:			1
3a	SPECIAL BOLT	1"	ASTM A449, GALV. ASTM A153/B695	4
3b	COUPLING	1"	AMS 6378D, GALV. ASTM A153, POLYESTER COAT	4
4	HINGE ASSEMBLY, INCLUDES:			1
4a	HINGE PLATE		AISI 4130 STEEL, GALV, ASTM A123	4
5	HINGE HARDWARE ASSEBLY, INCLUDES:			1
5a	BOLT	3/4"	ASTM A325, GALV. ASTM A153	8
5b	LOCK WASHER	3/4"	ANSI B18-21-1, GALV. ASTM A153	8
5c	NUT	3/4"	ASTM A325, GALV. ASTM A153	8
6	ANCHOR ASSEMBLY, INCLUDES:			1
6a	ANCHOR	1"	AISI 1045 ROD, AISI 1008 COIL	4

$L = L_T - H/2$

BRACKET SELECTION TABLE

SELECT CORRECT BRACKET NUMBER FROM TABLE, USING THE "L" VALUE FROM THE LONGEST POST. USE FIGURE TO THE LEFT TO DETERMINE "L".

POST SIZE	BRACKET #1		BRACKET #2		BRACKET #3	
	MIN. 'L'	MAX. 'L'	MIN. 'L'	MAX. 'L'	MIN. 'L'	MAX. 'L'
6"	12'	29'	9'	12'	0	9'
8"	14'	29'	10'	14'	0	10'

B (BRACKET #1)= DEPTH OF POST + 8"
B (BRACKET #2)= DEPTH OF POST + 8 ⅛"
B (BRACKET #3)= DEPTH OF POST + 8 3/16"

PLAN VIEW OF FOOTING

SCHEMATIC VIEW

EXPLODED VIEW

COMPLETED VIEW

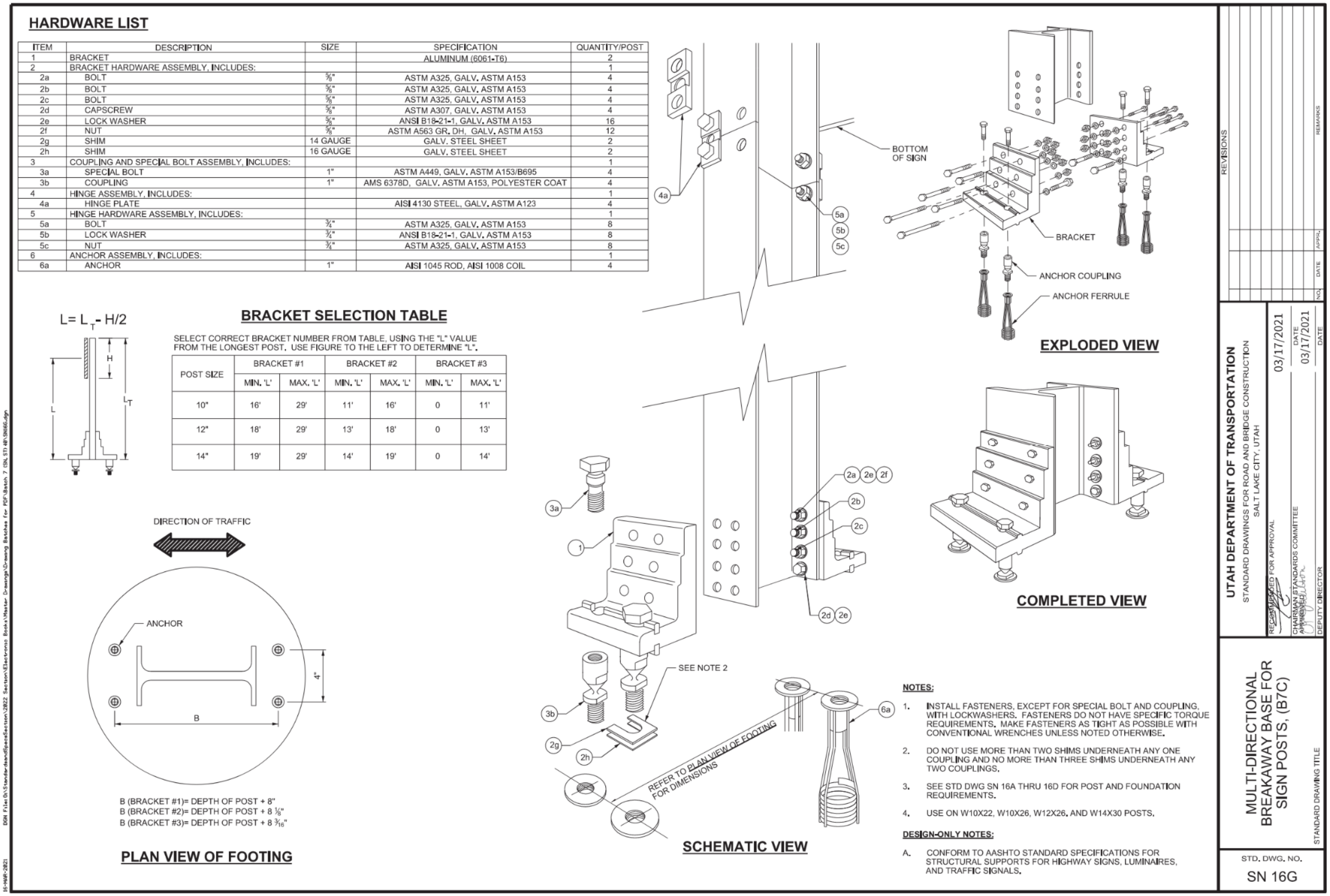
NOTES:

1. INSTALL FASTENERS, EXCEPT FOR SPECIAL BOLT AND COUPLING, WITH LOCKWASHERS. FASTENERS DO NOT HAVE SPECIFIC TORQUE REQUIREMENTS. MAKE FASTENERS TIGHT AS POSSIBLE WITH CONVENTIONAL WRENCHES UNLESS NOTED OTHERWISE.
2. DO NOT USE MORE THAN TWO SHIMS UNDERNEATH ANY ONE COUPLING AND NO MORE THAN THREE SHIMS UNDERNEATH ANY TWO COUPLINGS.
3. SEE STD DWG SN 16A THRU SN 16D FOR POST AND FOUNDATION REQUIREMENTS.
4. USE ON W6X12, W6X16, W8X18, AND W8X21 POSTS.

DESIGN-ONLY NOTES:

A. CONFORM TO AASHTO STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES, AND TRAFFIC SIGNALS.

Figure 3-48. Utah's Response for Question 2 (6/11).



HARDWARE LIST

ITEM	DESCRIPTION	SIZE	SPECIFICATION	QUANTITY/POST
1	BRACKET		ALUMINUM (6061-T6)	2
2	BRACKET HARDWARE ASSEMBLY, INCLUDES:			1
2a	BOLT	5/8"	ASTM A325, GALV. ASTM A153	4
2b	BOLT	5/8"	ASTM A325, GALV. ASTM A153	4
2c	BOLT	5/8"	ASTM A325, GALV. ASTM A153	4
2d	CAPSCREW	5/8"	ASTM A307, GALV. ASTM A153	4
2e	LOCK WASHER	5/8"	ANSI B18-21-1, GALV. ASTM A153	16
2f	NUT	5/8"	ASTM A563 GR. DH, GALV. ASTM A153	12
2g	SHIM	14 GAUGE	GALV. STEEL SHEET	2
2h	SHIM	16 GAUGE	GALV. STEEL SHEET	2
3	COUPLING AND SPECIAL BOLT ASSEMBLY, INCLUDES:			1
3a	SPECIAL BOLT	1"	ASTM A449, GALV. ASTM A153/B695	4
3b	COUPLING	1"	AMS 6378D, GALV. ASTM A153, POLYESTER COAT	4
4	HINGE ASSEMBLY, INCLUDES:			1
4a	HINGE PLATE		AISI 4130 STEEL, GALV. ASTM A123	4
5	HINGE HARDWARE ASSEMBLY, INCLUDES:			1
5a	BOLT	3/4"	ASTM A325, GALV. ASTM A153	8
5b	LOCK WASHER	3/4"	ANSI B18-21-1, GALV. ASTM A153	8
5c	NUT	3/4"	ASTM A325, GALV. ASTM A153	8
6	ANCHOR ASSEMBLY, INCLUDES:			1
6a	ANCHOR	1"	AISI 1045 ROD, AISI 1008 COIL	4

$L = L_T - H/2$

BRACKET SELECTION TABLE

SELECT CORRECT BRACKET NUMBER FROM TABLE, USING THE "L" VALUE FROM THE LONGEST POST. USE FIGURE TO THE LEFT TO DETERMINE "L".

POST SIZE	BRACKET #1		BRACKET #2		BRACKET #3	
	MIN. 'L'	MAX. 'L'	MIN. 'L'	MAX. 'L'	MIN. 'L'	MAX. 'L'
10"	16'	29'	11'	16'	0	11'
12"	18'	29'	13'	18'	0	13'
14"	19'	29'	14'	19'	0	14'

DIRECTION OF TRAFFIC

ANCHOR

B (BRACKET #1)= DEPTH OF POST + 8"
B (BRACKET #2)= DEPTH OF POST + 8 1/8"
B (BRACKET #3)= DEPTH OF POST + 8 3/16"

PLAN VIEW OF FOOTING

BOTTOM OF SIGN

BRACKET

ANCHOR COUPLING

ANCHOR FERRULE

EXPLODED VIEW

COMPLETED VIEW

SEE NOTE 2

REFER TO PLAN VIEW OF FOOTING FOR DIMENSIONS

SCHEMATIC VIEW

NOTES:

1. INSTALL FASTENERS, EXCEPT FOR SPECIAL BOLT AND COUPLING, WITH LOCKWASHERS. FASTENERS DO NOT HAVE SPECIFIC TORQUE REQUIREMENTS. MAKE FASTENERS AS TIGHT AS POSSIBLE WITH CONVENTIONAL WRENCHES UNLESS NOTED OTHERWISE.
2. DO NOT USE MORE THAN TWO SHIMS UNDERNEATH ANY ONE COUPLING AND NO MORE THAN THREE SHIMS UNDERNEATH ANY TWO COUPLINGS.
3. SEE STD DWG SN 16A THRU 16D FOR POST AND FOUNDATION REQUIREMENTS.
4. USE ON W10X22, W10X26, W12X26, AND W14X30 POSTS.

DESIGN-ONLY NOTES:

A. CONFORM TO AASHTO STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES, AND TRAFFIC SIGNALS.

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION
SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL 03/17/2021
CHAIRMAN STANDARDS COMMITTEE
APPROVED 03/17/2021
DEPUTY DIRECTOR

MULTI-DIRECTIONAL BREAKAWAY BASE FOR SIGN POSTS, (B7C)
STANDARD DRAWING TITLE

STD. DWG. NO.
SN 16G

Figure 3-49. Utah's Response for Question 2 (7/11).

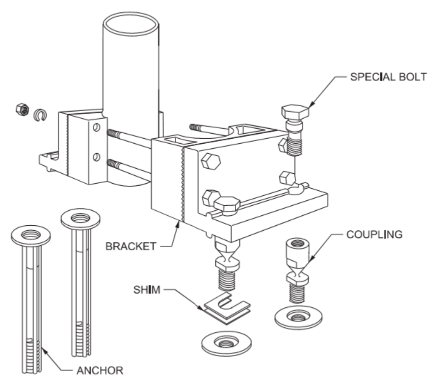
ROUND STEEL PIPE POST SELECTION GUIDE SINGLE POST APPLICATION

H (feet)	U (feet)	PANEL WIDTH, W (feet) 2'	3'	4'	5'
1'	7'	-	-	P3	P3
	8'	-	-	P3	P3
	9'	-	-	P3	P3
	10'	-	-	P3	P3
2'	7'	-	-	P3	P3
	8'	-	-	P3	P3
	9'	-	-	P3	P3.5
	10'	-	-	P3	P3.5
3'	7'	-	-	P3	P3.5
	8'	-	-	P3.5	P3.5
	9'	-	-	P3.5	P3.5
	10'	-	-	P3.5	P4
4'	7'	P3	P3.5	P3.5	P4
	8'	P3	P3.5	P3.5	P4
	9'	P3	P3.5	P4	P4
	10'	P3.5	P3.5	P4	P4.5
5'	7'	P3	P3.5	P4	P4
	8'	P3.5	P3.5	P4	P4.5
	9'	P3.5	P4	P4	P4.5
	10'	P3.5	P4	P4.5	P4.5
6'	7'	P3.5	P4	P4.5	P4.5
	8'	P3.5	P4	P4.5	P4.5-80
	9'	P3.5	P4	P4.5	P4.5-80
	10'	P3.5	P4.5	P4.5-80	P4.5-80
7'	7'	P3.5	P4	P4.5	P4.5-80
	8'	P3.5	P4.5	P4.5-80	P4.5-80
	9'	P4	P4.5	P4.5-80	P4.5-80
	10'	P4	P4.5	P4.5-80	-

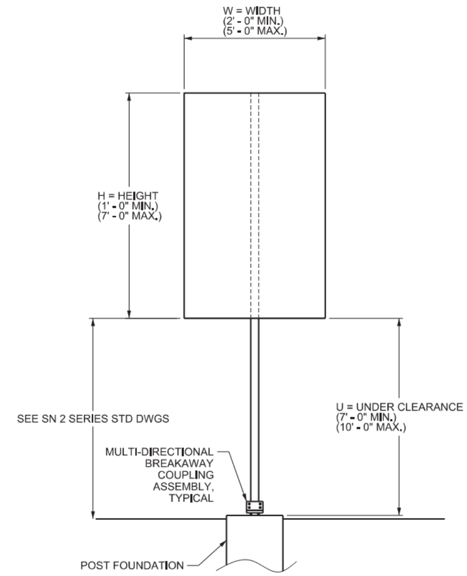
POST DETAIL CHART

POST TYPE	OUTSIDE DIAMETER	WALL THICKNESS	NOMINAL PIPE SIZE
P3.0	2.875"	0.203"	2.5" Sch. 40
P3.5	3.5"	0.216"	3" Sch. 40
P4.0	4.0"	0.226"	3.5" Sch. 40
P4.5	4.5"	0.237"	4" Sch. 40
P4.5-80	4.5"	0.337"	4" Sch. 80

ALL POST MATERIAL IN ACCORDANCE WITH ASTM A53, TYPE E STEEL PIPE, GALVANIZED TO MEET AASHTO M 232.



ROUND PIPE SIGN POST



SINGLE POST SIGN ELEVATION VIEW

NOTES:

1. DETERMINE THE SIGN DIMENSIONS AND POST HEIGHT REQUIREMENTS. SEE DIAGRAM, THIS SHEET.

   W = SIGN WIDTH (HORIZONTAL DIMENSION), INCLUDING SUPPLEMENTAL SIGN PANELS. ROUND UP TO NEAREST FOOT.

   H = SIGN DEPTH (VERTICAL DIMENSION), INCLUDING SUPPLEMENTAL SIGN PANELS. ROUND UP TO NEAREST FOOT.

   U = UNDER-PANEL HEIGHT (VERTICAL DIMENSION), MEASURED FROM THE TOP OF THE FOUNDATION TO THE BOTTOM OF THE SIGN PANEL. ROUND UP TO NEAREST FOOT.

2. ENTER THE POST SELECTION TABLE WITH THE REQUIRED W, AND H, AND DETERMINE THE APPROPRIATE POST SIZE, WITH THE DETAILS SHOWN IN THE TABLE.

REVISIONS | NO. | DATE | APPR. | REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION
SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL — DATE 03/17/2021
CHAIRMAN STANDARDS COMMITTEE
APPROVED — DATE 03/17/2021
DEPUTY DIRECTOR

MULTI-DIRECTIONAL BREAKAWAY BASE FOR ROUND AND SQUARE POST, (B7D)
STANDARD DRAWING TITLE

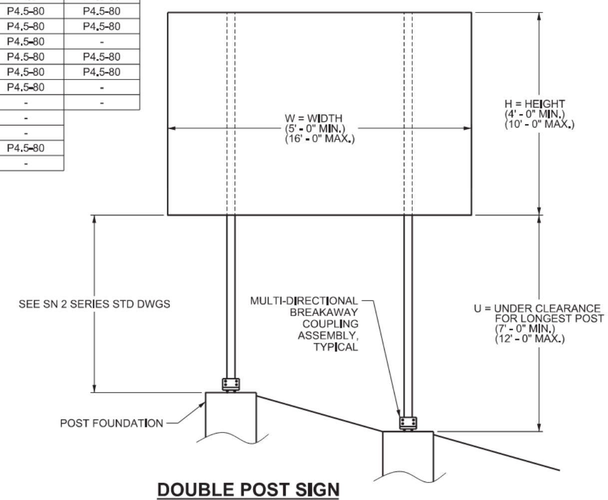
STD. DWG. NO.
SN 17A

16-MAR-2021

Figure 3-50. Utah's Response for Question 2 (8/11).

ROUND STEEL PIPE POST SELECTION GUIDE
DOUBLE POST APPLICATION

H (feet)	U (feet)	PANEL WIDTH, W (feet, round up to nearest foot) 5'	6'	7'	8'	9'	10'	11'	12'	13'	14'	15'	16'
4'	7'	P3	P3	P3.5	P3.5	P3.5	P3.5	P4	P4	P4	P4	P4.5	P4.5
	8'	P3	P3.5	P3.5	P3.5	P4	P4	P4	P4	P4.5	P4.5	P4.5	P4.5
	9'	P3	P3.5	P3.5	P3.5	P4	P4	P4	P4.5	P4.5	P4.5	P4.5	P4.5-80
	10'	P3.5	P3.5	P3.5	P4	P4	P4	P4.5	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80
	11'	P3.5	P3.5	P4	P4	P4	P4.5	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	P4.5-80
	12'	P3.5	P3.5	P4	P4	P4.5	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	P4.5-80	-
5'	7'	P3.5	P3.5	P3.5	P4	P4	P4	P4.5	P4.5	P4.5	P4.5	P4.5-80	P4.5-80
	8'	P3.5	P3.5	P3.5	P4	P4	P4.5	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	P4.5-80
	9'	P3.5	P3.5	P4	P4	P4.5	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	P4.5-80	-
	10'	P3.5	P4	P4	P4.5	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	P4.5-80	-	-
	11'	P3.5	P4	P4	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	P4.5-80	-	-	
	12'	P4	P4	P4	P4.5	P4.5-80	P4.5-80	P4.5-80	P4.5-80	-	-	-	
6'	7'	P3.5	P3.5	P4	P4	P4.5	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	P4.5-80	
	8'	P3.5	P4	P4	P4	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	-	-	
	9'	P3.5	P4	P4	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	-	-		
	10'	P4	P4	P4.5	P4.5	P4.5	P4.5-80	P4.5-80	-	-			
	11'	P4	P4	P4.5	P4.5	P4.5-80	P4.5-80	-	-	-			
	12'	P4	P4.5	P4.5	P4.5-80	P4.5-80	-	-	-				
7'	7'	P3.5	P4	P4	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80				
	8'	P4	P4	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	-				
	9'	P4	P4	P4.5	P4.5	P4.5-80	P4.5-80	-	-				
	10'	P4	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	-					
	11'	P4	P4.5	P4.5-80	P4.5-80	P4.5-80	-	-					
	12'	P4.5	P4.5	P4.5-80	P4.5-80	-	-	-					
8'	7'	P4	P4	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80					
	8'	P4	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	-					
	9'	P4.5	P4.5	P4.5-80	P4.5-80	P4.5-80	-	-					
	10'	P4.5	P4.5	P4.5-80	P4.5-80	-	-						
	11'	P4.5	P4.5-80	P4.5-80	-	-							
	12'	P4.5	P4.5-80	P4.5-80	-	-							
9'	7'	P4.5	P4.5	P4.5	P4.5-80	P4.5-80							
	8'	P4.5	P4.5	P4.5-80	P4.5-80	-							
	9'	P4.5	P4.5-80	P4.5-80	-	-							
	10'	P4.5	P4.5-80	P4.5-80	-								
	11'	P4.5-80	P4.5-80	-	-								
	12'	P4.5-80	-	-	-								
10'	7'	P4.5	P4.5-80	P4.5-80	P4.5-80								
	8'	P4.5	P4.5-80	P4.5-80	-								
	9'	P4.5-80	P4.5-80	-	-								
	10'	P4.5-80	-	-									
	11'	P4.5-80	-										
	12'	-											



DOUBLE POST SIGN ELEVATION VIEW

POST DETAIL CHART			
POST TYPE	OUTSIDE DIAMETER	WALL THICKNESS	NOMINAL PIPE SIZE
P3.0	2.875"	0.203"	2.5" Sch. 40
P3.5	3.5"	0.216"	3" Sch. 40
P4.0	4.0"	0.226"	3.5" Sch. 40
P4.5	4.5"	0.237"	4" Sch. 40
P4.5-80	4.5"	0.337"	4" Sch. 80

ALL POST MATERIAL ACCORDING TO ASTM A53 STEEL PIPE, GALVANIZED TO MEET AASHTO M 232.

NOTES:

1. DETERMINE THE SIGN DIMENSIONS AND POST HEIGHT REQUIREMENTS. SEE DIAGRAM, THIS SHEET.

   W = SIGN WIDTH (HORIZONTAL DIMENSION), INCLUDING SUPPLEMENTAL SIGN PANELS. ROUND UP TO NEAREST FOOT.

   H = SIGN DEPTH (VERTICAL DIMENSION), INCLUDING SUPPLEMENTAL SIGN PANELS. ROUND UP TO NEAREST FOOT.

   U = UNDER-PANEL HEIGHT (VERTICAL DIMENSION), MEASURED FROM THE TOP OF THE FOUNDATION TO THE BOTTOM OF THE SIGN PANEL AT THE TALLEST POST. ROUND UP TO NEAREST FOOT.

2. ENTER THE POST SELECTION TABLE WITH THE REQUIRED W, AND H, AND DETERMINE THE APPROPRIATE POST SIZE, WITH THE DETAILS SHOWN IN THE TABLE.

REVISIONS
NO. DATE APPR. REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION
SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL 03/17/2021
CHAIRMAN STANDARDS COMMITTEE DATE
APPROVED 03/17/2021
DEPUTY DIRECTOR DATE

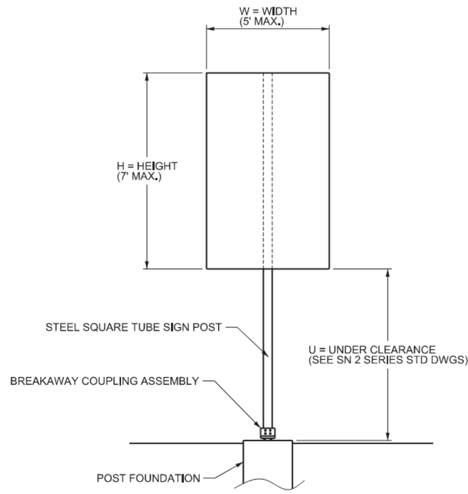
MULTI-DIRECTIONAL BREAKAWAY BASE FOR ROUND PIPE DOUBLE POST, (B7D)
STANDARD DRAWING TITLE

STD. DWG. NO.
SN 17B

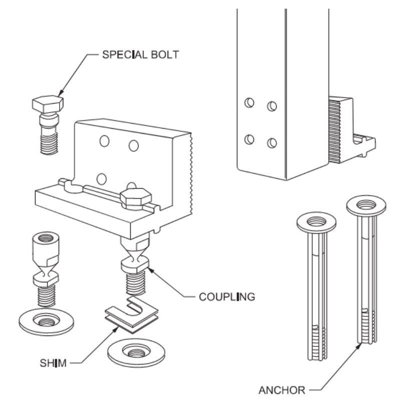
Figure 3-51. Utah's Response for Question 2 (9/11).

SQUARE STEEL TUBE POST SELECTION GUIDE
SINGLE POST APPLICATION

H (FEET)	U (FEET)	PANEL WIDTH, W (FEET) 2	3	4	5
1	7	-	-	4x4x3/16	4x4x3/16
	8	-	-	4x4x3/16	4x4x3/16
	9	-	-	4x4x3/16	4x4x3/16
	10	-	-	4x4x3/16	4x4x3/16
2	7	-	-	4x4x3/16	4x4x3/16
	8	-	-	4x4x3/16	4x4x3/16
	9	-	-	4x4x3/16	4x4x3/16
	10	-	-	4x4x3/16	4x4x3/16
3	7	-	-	4x4x3/16	4x4x3/16
	8	-	-	4x4x3/16	4x4x3/16
	9	-	-	4x4x3/16	4x4x3/16
	10	-	-	4x4x3/16	4x4x3/16
4	7	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	8	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	9	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	10	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
5	7	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	8	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	9	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	10	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
6	7	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	8	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	9	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	10	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
7	7	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	8	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	9	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4
	10	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4



SINGLE POST SIGN ELEVATION VIEW



SQUARE TUBE SIGN POST

POST DETAIL CHART			
POST TYPE	OUTSIDE DIMENSIONS	WALL THICKNESS	WEIGHT PER FOOT
4x4x3/16	4"x4"	0.1875"	9.42 lbs/ft
4x4x1/4	4"x4"	0.2500"	12.21 lbs/ft

ALL POST MATERIAL IN ACCORDANCE WITH ASTM A 500, GRADE B STEEL SQUARE TUBE, GALVANIZED TO MEET AASHTO M 232.

NOTES:

1. DETERMINE THE SIGN DIMENSIONS AND POST HEIGHT REQUIREMENTS. SEE DIAGRAM, THIS SHEET.

   W = SIGN WIDTH (HORIZONTAL DIMENSION), INCLUDING SUPPLEMENTAL SIGN PANELS. ROUND UP TO NEAREST FOOT.

   H = SIGN DEPTH (VERTICAL DIMENSION), INCLUDING SUPPLEMENTAL SIGN PANELS. ROUND UP TO NEAREST FOOT.

   U = UNDER-PANEL HEIGHT (VERTICAL DIMENSION), MEASURED FROM THE TOP OF THE FOUNDATION TO THE BOTTOM OF THE SIGN PANEL. ROUND UP TO NEAREST FOOT.

2. ENTER THE POST SELECTION TABLE WITH THE REQUIRED W, H, AND U, AND DETERMINE THE APPROPRIATE POST SIZE, WITH DETAILS SHOWN IN THE TABLE.

REVISIONS
NO. DATE APPR. REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION
SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL 03/17/2021
CHAIRMAN STANDARDS COMMITTEE DATE
APPROVED 03/17/2021
DEPUTY DIRECTOR DATE

MULTI-DIRECTIONAL BREAKAWAY COUPLING SYSTEM FOR SQUARE TUBE SIGN SUPPORTS SINGLE POST

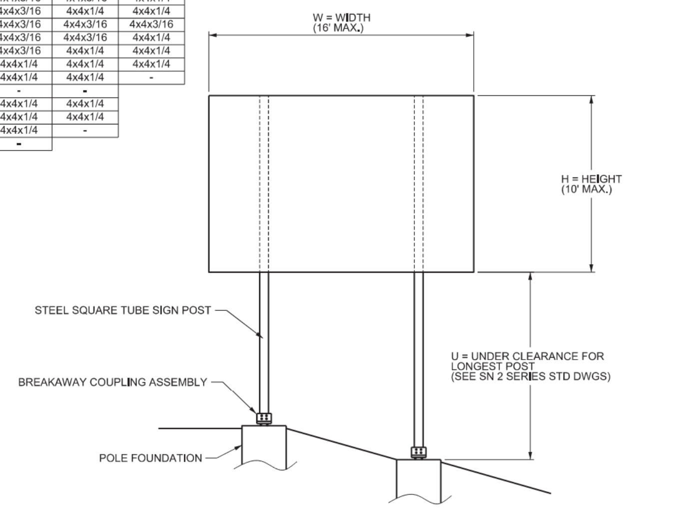
STANDARD DRAWING TITLE

STD. DWG. NO.
SN 17C

Figure 3-52. Utah's Response for Question 2 (10/11).

SQUARE STEEL TUBE POST SELECTION GUIDE
DOUBLE POST APPLICATION

H (FEET)	U (FEET)	PANEL WIDTH, W (FEET, ROUND UP TO NEAREST FOOT) 5	6	7	8	9	10	11	12	13	14	15	16
4	7	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	8	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	9	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	10	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	11	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4
	12	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4
5	7	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16
	8	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4
	9	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4
	10	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	4x4x1/4
	11	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	4x4x1/4	4x4x1/4	-
	12	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	4x4x1/4	-	-	
6	7	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	
	8	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	4x4x1/4	
	9	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	4x4x1/4	-	
	10	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	4x4x1/4	-		
	11	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	4x4x1/4	-			
	12	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	-				
7	7	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4				
	8	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4				
	9	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	-				
	10	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	-					
	11	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	-					
	12	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	-						
8	7	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16						
	8	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4						
	9	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4						
	10	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	-						
	11	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4	-							
	12	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4	-							
9	7	4x4x3/16	4x4x3/16	4x4x3/16	4x4x3/16								
	8	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4								
	9	4x4x3/16	4x4x3/16	4x4x3/16	4x4x1/4								
	10	4x4x3/16	4x4x3/16	4x4x1/4	4x4x1/4								
	11	4x4x3/16	4x4x1/4	4x4x1/4	-								
	12	4x4x1/4	4x4x1/4	-	-								
10	7	4x4x3/16	4x4x3/16	4x4x3/16									
	8	4x4x3/16	4x4x3/16	4x4x1/4									
	9	4x4x3/16	4x4x1/4	4x4x1/4									
	10	4x4x3/16	4x4x1/4	4x4x1/4									
	11	4x4x3/16	4x4x1/4	-									
	12	4x4x1/4	-										



DOUBLE POST SIGN ELEVATION VIEW

POST DETAIL CHART

POST TYPE	OUTSIDE DIMENSIONS	WALL THICKNESS	WEIGHT PER FOOT
4x4x$\frac{3}{16}$	4"x4"	0.1875"	9.42 lbs/ft
4x4x$\frac{1}{4}$	4"x4"	0.2500"	12.21 lbs/ft

ALL POST MATERIAL IN ACCORDANCE WITH ASTM A 500, GRADE B STEEL SQUARE TUBE, GALVANIZED TO MEET AASHTO M 232.

NOTES:

1. DETERMINE THE SIGN DIMENSIONS AND POST HEIGHT REQUIREMENTS. SEE DIAGRAM, THIS SHEET.

   W = SIGN WIDTH (HORIZONTAL DIMENSION), INCLUDING SUPPLEMENTAL SIGN PANELS. ROUND UP TO NEAREST FOOT.

   H = SIGN DEPTH (VERTICAL DIMENSION), INCLUDING SUPPLEMENTAL SIGN PANELS. ROUND UP TO NEAREST FOOT.

   U = UNDER-PANEL HEIGHT (VERTICAL DIMENSION), MEASURED FROM THE TOP OF THE FOUNDATION TO THE BOTTOM OF THE SIGN PANEL. ROUND UP TO NEAREST FOOT.

2. ENTER THE POST SELECTION TABLE WITH THE REQUIRED W, H, AND U, AND DETERMINE THE APPROPRIATE POST SIZE, WITH DETAILS SHOWN IN THE TABLE.

REVISIONS

NO.	DATE	APPR.	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION
SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL — 03/17/2021
CHAIRMAN STANDARDS COMMITTEE
APPROVED — DATE 03/17/2021
DEPUTY DIRECTOR — DATE

MULTI-DIRECTIONAL BREAKAWAY COUPLING SYSTEM FOR SQUARE TUBE SIGN SUPPORTS DOUBLE POST

STANDARD DRAWING TITLE

STD. DWG. NO.
SN 17D

Figure 3-53. Utah's Response for Question 2 (11/11).

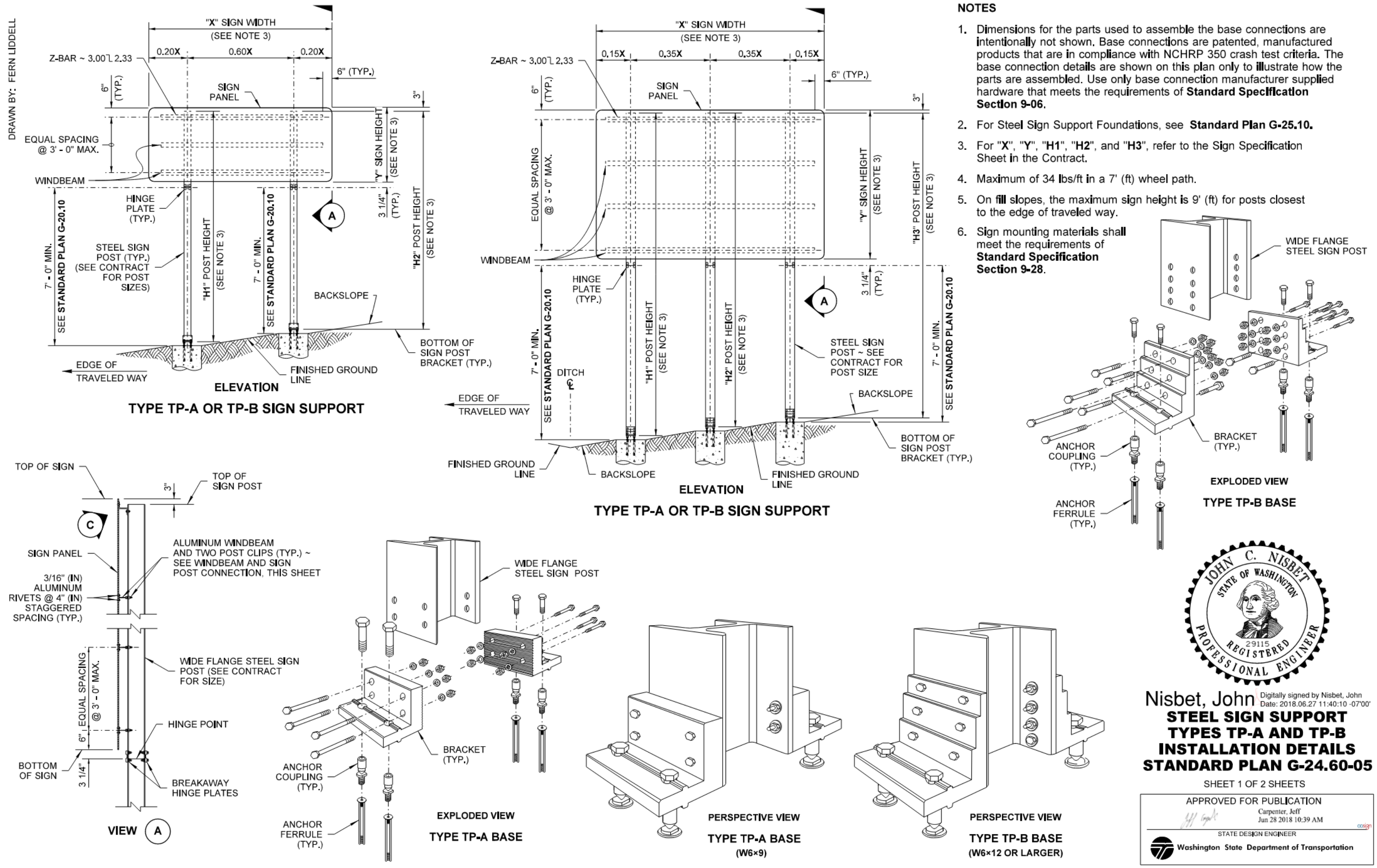


Figure 3-54. Washington's Response for Question 2 (1/2).

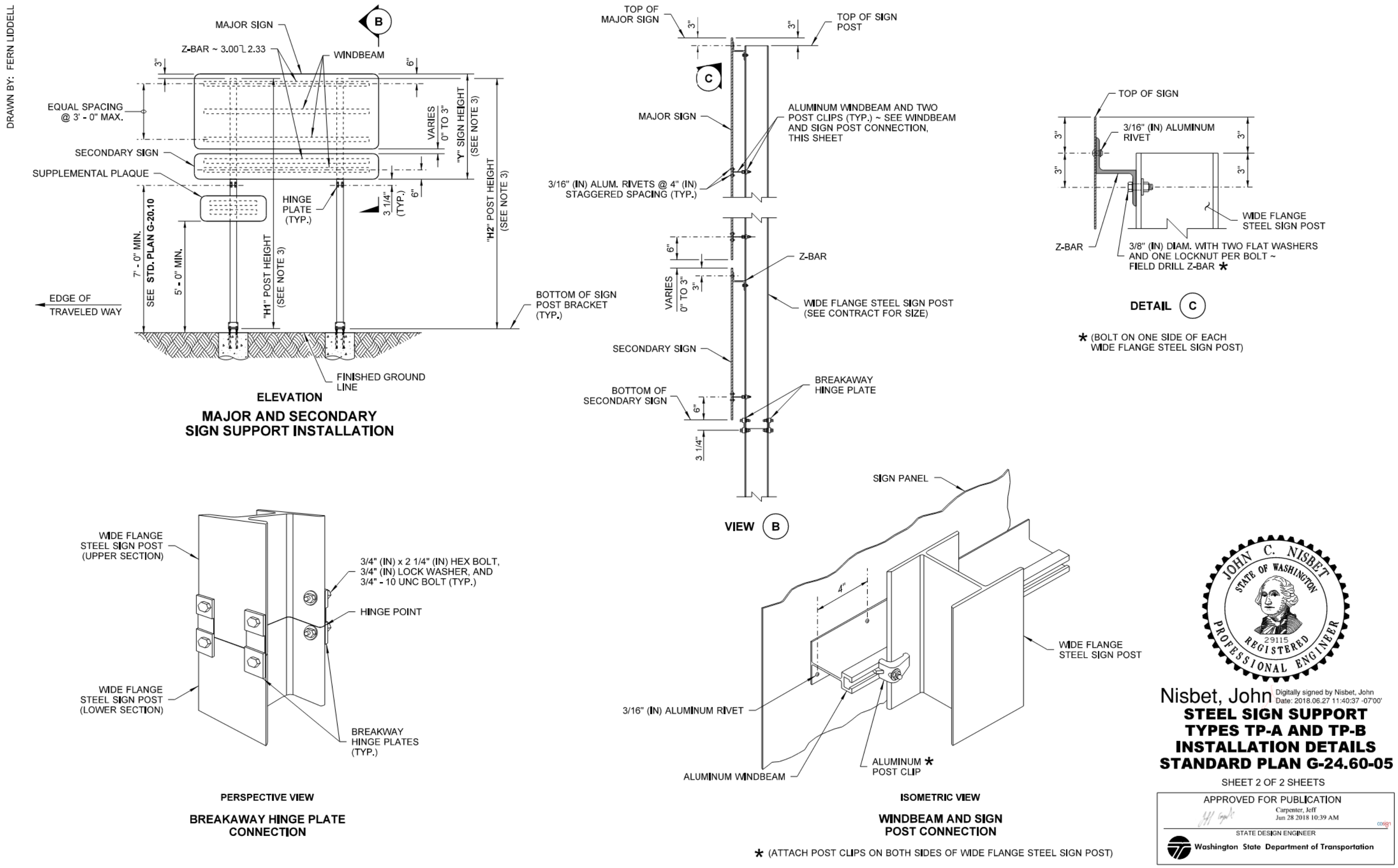
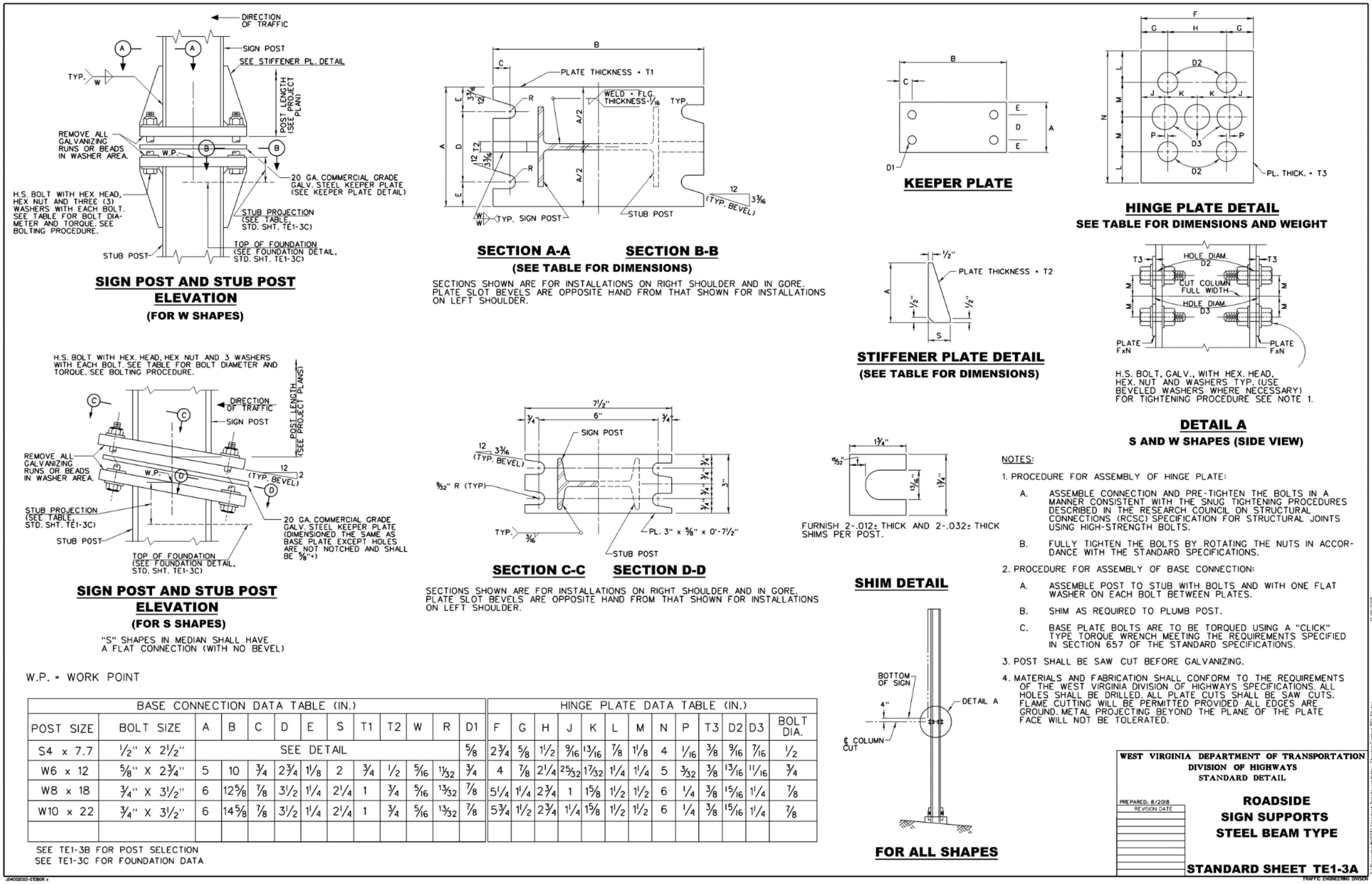


Figure 3-55. Washington's Response for Question 2 (2/2).



BASE CONNECTION DATA TABLE (IN.)

POST SIZE	BOLT SIZE	A	B	C	D	E	S	T1	T2	W	R	D1
S4 x 7.7	1/2" X 2 1/2"	SEE DETAIL										5/8
W6 x 12	5/8" X 2 3/4"	5	10	3/4	2 3/4	1 1/8	2	3/4	1/2	5/16	11/32	3/4
W8 x 18	3/4" X 3 1/2"	6	12 5/8	7/8	3 1/2	1 1/4	2 1/4	1	3/4	5/16	13/32	7/8
W10 x 22	3/4" X 3 1/2"	6	14 5/8	7/8	3 1/2	1 1/4	2 1/4	1	3/4	5/16	13/32	7/8

HINGE PLATE DATA TABLE (IN.)

POST SIZE	F	G	H	J	K	L	M	N	P	T3	D2	D3	BOLT DIA.
S4 x 7.7	2 3/4	5/8	1 1/2	9/16	13/16	7/8	1 1/8	4	1/16	3/8	9/16	7/16	1/2
W6 x 12	4	7/8	2 1/4	25/32	1 7/32	1 1/4	1 1/4	5	3/32	3/8	13/16	11/16	3/4
W8 x 18	5 1/4	1 1/4	2 3/4	1	1 5/8	1 1/2	1 1/2	6	1/4	3/8	15/16	1 1/4	7/8
W10 x 22	5 3/4	1 1/2	2 3/4	1 1/4	1 5/8	1 1/2	1 1/2	6	1/4	3/8	15/16	1 1/4	7/8

SEE TE1-3B FOR POST SELECTION
SEE TE1-3C FOR FOUNDATION DATA

Figure 3-56. West Virginia's Response for Question 2 (1/3).

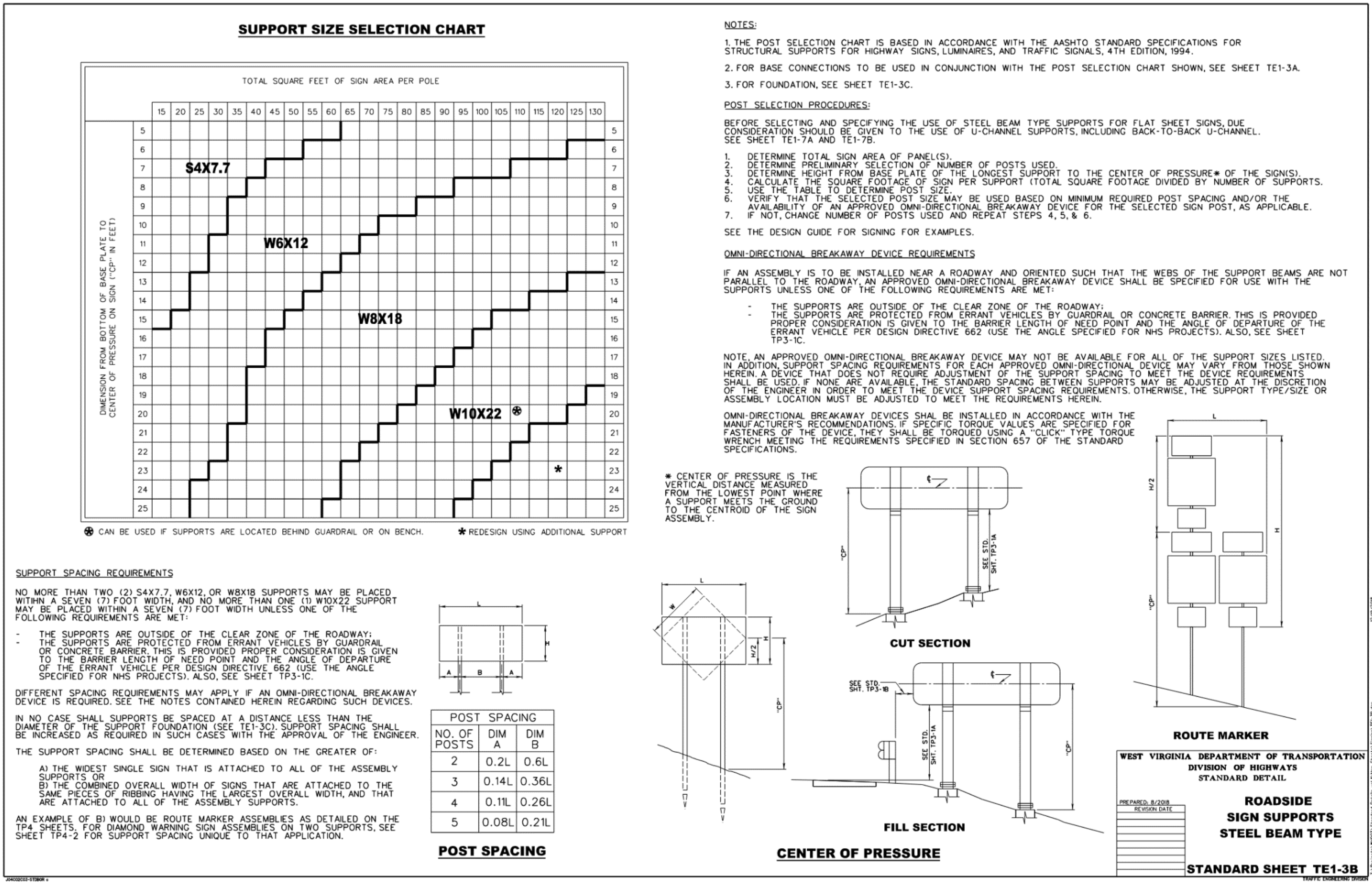
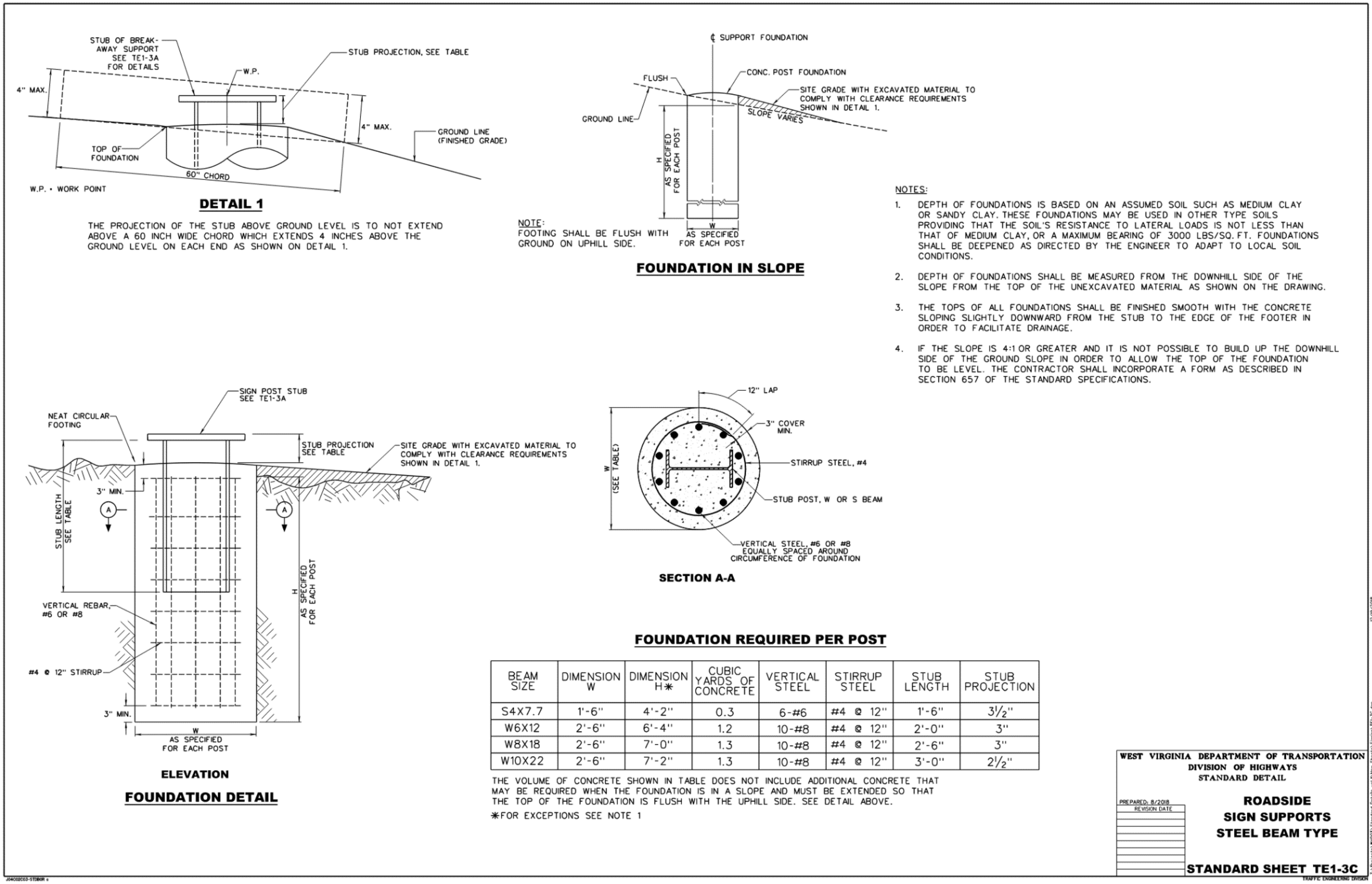


Figure 3-57. West Virginia's Response for Question 2 (2/3).



BEAM SIZE	DIMENSION W	DIMENSION H✳	CUBIC YARDS OF CONCRETE	VERTICAL STEEL	STIRRUP STEEL	STUB LENGTH	STUB PROJECTION
S4X7.7	1'-6"	4'-2"	0.3	6-#6	#4 @ 12"	1'-6"	3½"
W6X12	2'-6"	6'-4"	1.2	10-#8	#4 @ 12"	2'-0"	3"
W8X18	2'-6"	7'-0"	1.3	10-#8	#4 @ 12"	2'-6"	3"
W10X22	2'-6"	7'-2"	1.3	10-#8	#4 @ 12"	3'-0"	2½"

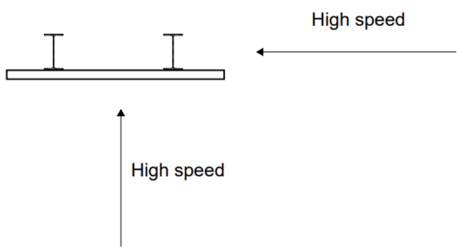
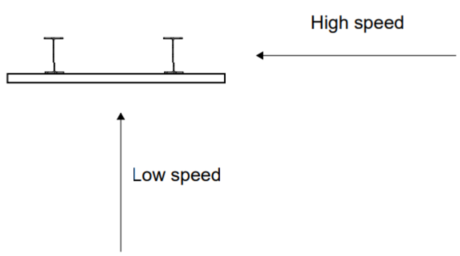
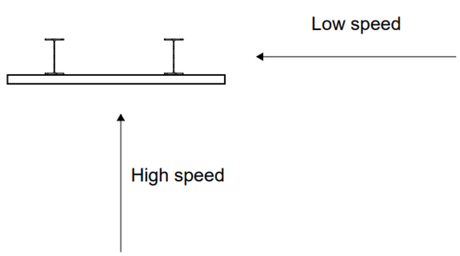
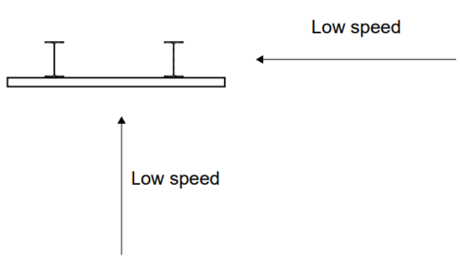
Figure 3-58. West Virginia's Response for Question 2 (3/3).

Q3 – Please select each of the following speed conditions that apply to the large sign support assemblies in your state. (Select all that apply)

High speed roadways are defined as above a posted 45mph speed limit.

Low speed roadways are defined as below or equal to a posted 45mph speed limit.

Table 3.1. Response Distribution for Question 3.

Case	Number of Responses
	**9**
	**7**
	**7**
	**8**

Q4 – Please enter the post sizes below that are used in these bidirectional applications. Next to each post size please indicate their prevalence in bidirectional applications. Please assign a value of "Most prevalent" to the post size used most prevalently in bidirectional applications. The values selected for other listed post sizes should be assigned to indicate its prevalence with respect to the post size assigned the value of "Most prevalent." *

For this question, the data was analyzed in order to rank the post sizes' prevalence. In order to do this, each prevalence ranking (Most prevalent, Frequently, Occasionally, Rarely) was assigned a numerical value (4, 3, 2, 1, respectively). Once assigned, the sum of these values was added to calculate the prevalence score number of given post sizes. The top three post sizes in order of prevalence are listed in the table below:

Table 3.2. Most Prevalent Post Sizes Determined from Question 4 Responses

Rank	Post Size	Prevalence Points Calculated
1	W6x12	13
2	W8x18	11
3	W6x9	7

Q5 – Do you have any other details or drawings to include in this survey? If not, please skip this page.

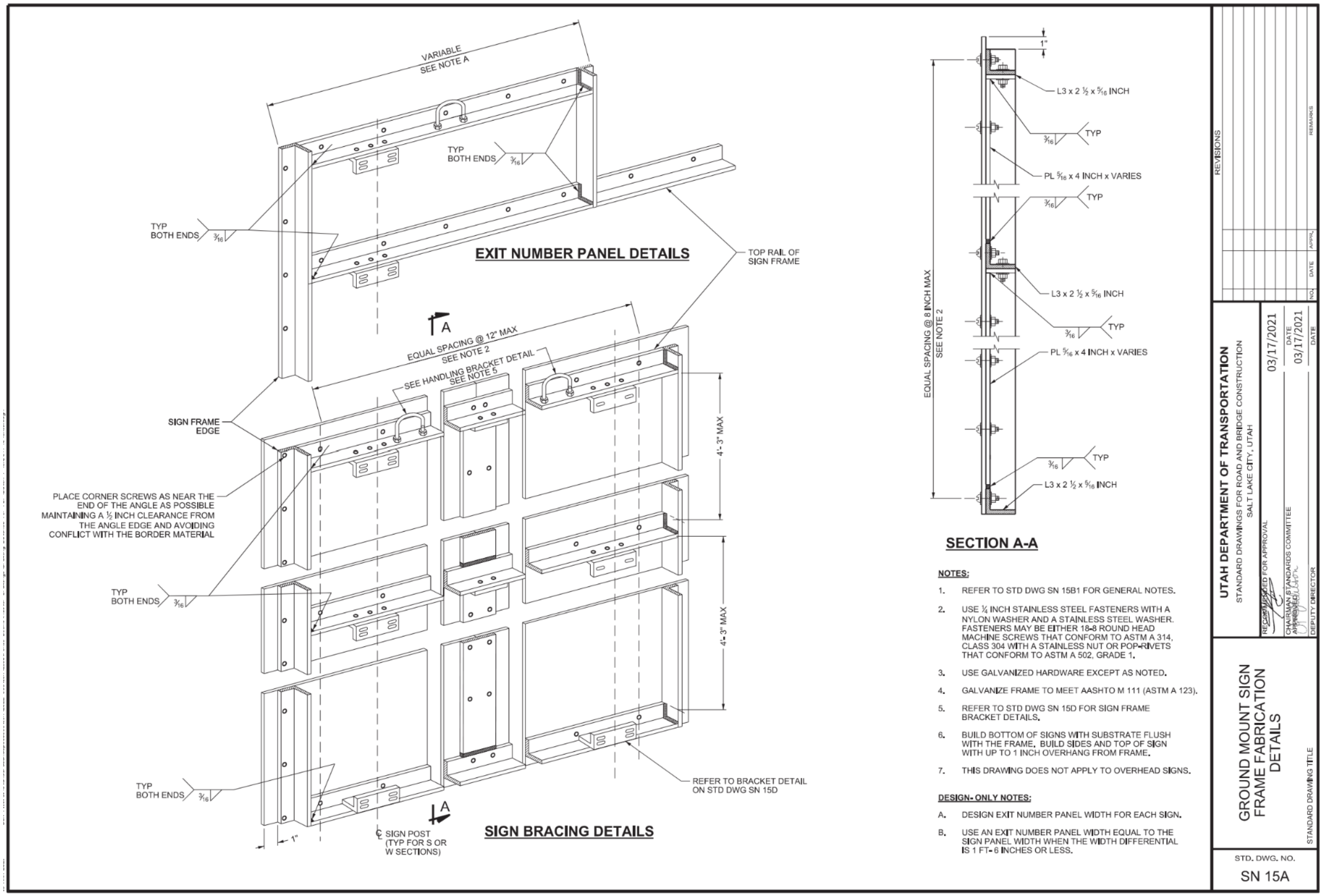
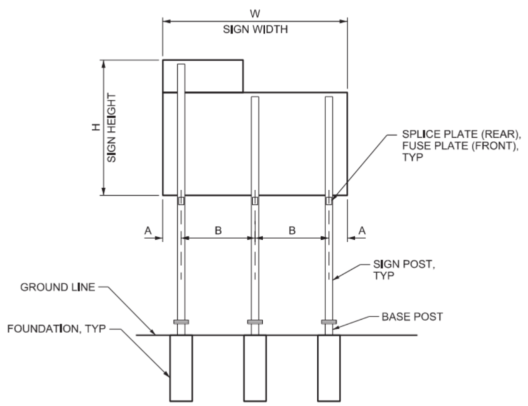


Figure 3-59: Utah's Response for Question 5 (1/7).



TYPICAL ELEVATION

TWO POSTS		
SIGN WIDTH, W	POST SPACING	
	A	B
6 FT	1'- 0"	4'- 0"
7 FT	1'- 0"	5'- 0"
8 FT	1'- 0"	6'- 0"
9 FT	1'- 0"	7'- 0"
10 FT	1'- 0"	8'- 0"
11 FT	1'- 6"	8'- 0"
12 FT	2'- 0"	8'- 0"
13 FT	2'- 6"	8'- 0"
14 FT	3'- 0"	8'- 0"
15 FT	3'- 6"	8'- 0"
16 FT	4'- 0"	8'- 0"

THREE AND FOUR POSTS			
SIGN WIDTH, W		POST SPACING	
3 POSTS	4 POSTS	A	B
17 FT	25 FT	1'- 0"	7'- 6"
18 FT	26 FT	1'- 0"	8'- 0"
19 FT	27 FT	1'- 6"	8'- 0"
20 FT	28 FT	2'- 0"	8'- 0"
21 FT	29 FT	2'- 6"	8'- 0"
22 FT	30 FT	3'- 0"	8'- 0"
23 FT	31 FT	3'- 6"	8'- 0"
24 FT	32 FT	4'- 0"	8'- 0"

TABLE NOTES

1. ROUND DOWN SIGN WIDTH TO FIND "B" WHEN SIGN WIDTH FALLS BETWEEN TWO VALUES IN THE TABLE.
2. INCREASE "A" SO THAT SIGN IS CENTERED ON THE POST GROUP.

DESIGN DATA

AASHTO LRFD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES, AND TRAFFIC SIGNALS, 1ST EDITION 2015

STRUCTURAL STEEL:	Fy = 35 KSI (PIPE) Fy = 36 KSI (S- AND W-SHAPES; PLATES)
STRUCTURAL CONCRETE:	f'c = 3.0 KSI n = 8 CLASS A(AE) fy (REINF) = 60 KSI
WIND:	EXTREME EVENT WIND SPEED = 76 MPH SERVICE WIND SPEED = 76 MPH EXPOSURE CATEGORY D
FATIGUE:	FATIGUE CATEGORY I NATURAL WIND GUST = 11.2 MPH
SOIL:	SEE SOIL CONDITIONS TABLE ON STD DWG SN 15B2 TOP 1.5D (CONCRETE SHAFT) OF COHESIVE SOILS DOES NOT CONTRIBUTE IN EMBEDMENT CALCULATIONS

SN 15 SERIES STD DWGS GENERAL NOTES:

1. USE STRUCTURAL STEEL CONFORMING TO ASTM A 53, GRADE B FOR PIPE (STANDARD WEIGHT) AND ASTM A 36 FOR S- AND W-SHAPES AND PLATES.
2. USE BOLTS, NUTS, AND WASHER CONFORMING TO ASTM F3125, GRADE A325.
3. USE A ¼ INCH FILLET WELD FOR MATERIAL LESS THAN OR EQUAL TO ¾ INCH. USE A 5/16 INCH FILLET WELD FOR MATERIAL GREATER THAN ¾ INCH.
4. SAW CUT OR SHEAR PLATES. NO FLAME CUTTING IS ALLOWED.
5. MEET AASHTO M 111 (ASTM A 123) FOR GALVANIZING AFTER FABRICATION IS COMPLETED.
6. REFER TO STD DWG SN 2A AND 2B FOR SIGN HEIGHT AND SIGN OFFSET REQUIREMENTS.

REVISIONS			
NO.	DATE	APPR.	REMARKS
1	5/25/2020	JW	CONCRETE CLASS UPDATE TO CLASS A(AE).
1	5/25/2020	JW	REMOVED REVISION NOTES AND DESIGN NOTE.

UTAH DEPARTMENT OF TRANSPORTATION
STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION
SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL 03/17/2021 DATE
CHAIRMAN STANDARDS COMMITTEE
APPROVED 03/17/2021
DEPUTY DIRECTOR DATE

FREEWAY SIGN
GENERAL REQUIREMENTS
STANDARD DRAWING TITLE

STD. DWG. NO.
SN 15B1

Figure 3-60: Utah's Response for Question 5 (2/7).

POST AND FOUNDATION TABLE

SIGN HEIGHT, H	ONE POST 3'-0"	ONE POST 4'-0"	ONE POST 5'-0"	TWO POSTS 6'-0"	TWO POSTS 7'-0"	TWO POSTS 8'-0"	TWO POSTS 9'-0"	TWO POSTS 10'-0"	TWO POSTS 11'-0"	TWO POSTS 12'-0"	TWO POSTS 13'-0"	TWO POSTS 14'-0"	TWO POSTS 15'-0"	TWO POSTS 16'-0"	THREE POSTS 17'-0"	THREE POSTS 18'-0" TO 24'-0"	FOUR POSTS 25'-0"	FOUR POSTS 26'-0" TO 32'-0"
1'-0"				S3 x 5.7 3'-9"/3'-6"	S3 x 5.7 3'-9"/3'-6"	S3 x 5.7 3'-9"/3'-6"	S3 x 5.7 3'-9"/3'-6"	S3 x 5.7 3'-9"/3'-6"	S3 x 5.7 3'-9"/3'-6"	S3 x 5.7 3'-9"/3'-9"	S3 x 5.7 3'-9"/3'-9"	S3 x 5.7 4'-0"/3'-9"	S3 x 5.7 4'-0"/3'-9"	S3 x 5.7 4'-0"/3'-9"	S3 x 5.7 4'-0"/4'-0"	S4 x 9.5 4'-0"/4'-0"	S3 x 5.7 4'-0"/4'-0"	S4 x 9.5 4'-0"/4'-0"
1'-6"				S3 x 5.7 3'-9"/3'-6"	S3 x 5.7 3'-9"/3'-6"	S3 x 5.7 3'-9"/3'-9"	S3 x 5.7 4'-0"/3'-9"	S3 x 5.7 4'-0"/3'-9"	S3 x 5.7 4'-0"/3'-9"	S3 x 5.7 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-0"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-0"/4'-0"	S4 x 9.5 4'-3"/4'-0"
2'-0"				S3 x 5.7 3'-9"/3'-9"	S3 x 5.7 4'-0"/3'-9"	S3 x 5.7 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-3"/3'-9"	S4 x 9.5 4'-3"/3'-9"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"
2'-6"				S3 x 5.7 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-3"/3'-9"	S4 x 9.5 4'-3"/3'-9"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-6"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S6 x 12.5 4'-6"/4'-0"
3'-0"	3" Ø 4'-0"/4'-0"	4" Ø 4'-0"/4'-0"	4" Ø 4'-3"/4'-0"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-0"/3'-9"	S4 x 9.5 4'-3"/3'-9"	S4 x 9.5 4'-3"/3'-9"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-3"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-3"
4'-0"	4" Ø 4'-0"/4'-0"	4" Ø 4'-3"/4'-0"	5" Ø 4'-6"/4'-0"	S4 x 9.5 4'-3"/3'-9"	S4 x 9.5 4'- 3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S4 x 9.5 4'-3"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"
5'-0"	4" Ø 4'-3"/4'-0"	5" Ø 4'-6"/4'-0"	5" Ø 4'-6"/4'-3"	S4 x 9.5 4'-3"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 5'-0"/4'-3"	S6 x 12.5 5'-0"/4'-6"	S6 x 12.5 5'-0"/4'-6"	S6 x 12.5 5'-0"/4'-6"	S6 x 12.5 5'-0"/4'-6"	S6 x 12.5 5'-0"/4'-6"	S6 x 12.5 5'-0"/4'-6"
6'-0"	5" Ø 4'-6"/4'-0"	5" Ø 4'-9"/4'-3"	6" Ø 4'-9"/4'-3"	S4 x 9.5 4'-6"/4'-0"	S6 x 12.5 4'-6"/4'-0"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 5'-0"/4'-3"	S6 x 12.5 5'-0"/4'-6"	S6 x 12.5 5'-0"/4'-6"	S6 x 17.25 5'-6"/4'-6"	S6 x 17.25 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-6"	S6 x 17.25 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-6"	S6 x 17.25 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-6"
7'-0"	5" Ø 4'-9"/4'-0"	6" Ø 5'-0"/4'-3"	6" Ø 5'-0"/4'-6"	S6 x 12.5 4'-9"/4'-0"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 5'-0"/4'-3"	S6 x 12.5 5'-0"/4'-3"	S6 x 12.5 5'-6"/4'-6"	S6 x 17.25 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-9"	S8 x 18.4 5'-6"/4'-9"	S8 x 18.4 5'-6"/4'-9"	S8 x 18.4 5'-6"/4'-9"	S8 x 18.4 5'-6"/4'-9"	S8 x 18.4 5'-6"/4'-9"
8'-0"	5" Ø 4'-9"/4'-3"	6" Ø 5'-0"/4'-3"	6" Ø 5'-6"/4'-6"	S6 x 12.5 4'-9"/4'-3"	S6 x 12.5 5'-0"/4'-3"	S6 x 12.5 5'-0"/4'-3"	S6 x 12.5 5'-6"/4'-6"	S6 x 17.25 5'-6"/4'-6"	S6 x 17.25 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"
9'-0"	6" Ø 5'-0"/4'-3"	6" Ø 5'-6"/4'-6"	8" Ø 5'-6"/4'-6"	S6 x 12.5 5'-0"/4'-3"	S6 x 12.5 5'-0"/4'-3"	S6 x 12.5 5'-6"/4'-6"	S6 x 17.25 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/5'-0"	W10 x 19 6'-0"/5'-0"	S8 x 18.4 6'-0"/5'-0"	W10 x 19 6'-0"/5'-0"	S8 x 18.4 6'-0"/5'-0"	W10 x 19 6'-0"/5'-0"
10'-0"	6" Ø 5'-6"/4'-3"	8" Ø 5'-6"/4'-6"	8" Ø 6'-0"/5'-0"	S6 x 12.5 5'-6"/4'-3"	S6 x 17.25 5'-6"/4'-6"	S6 x 17.25 5'-6"/4'-6"	S8 x 18.4 5'-6"/4'-6"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/5'-0"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-6"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-6"
11'-0"				S6 x 17.25 5'-6"/4'-6"	S6 x 17.25 5'-6"/4'-6"		S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/5'-0"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-6"	W10 x 22 6'-6"/5'-6"	W10 x 19 6'-6"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 19 6'-6"/5'-6"	W10 x 22 7'-0"/5'-6"
12'-0"				S6 x 17.25 5'-6"/4'-6"			S8 x 18.4 6'-0"/4'-9"	S8 x 18.4 6'-0"/4'-9"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"
13'-0"							S8 x 18.4 6'-6"/4'-9"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 26 7'-0"/5'-6"	W10 x 26 7'-0"/5'-6"	W10 x 26 7'-6"/5'-6"	W10 x 26 7'-0"/5'-6"	W10 x 26 7'-6"/5'-6"
14'-0"							W10 x 19 6'-6"/5'-0"	W10 x 19 6'-6"/5'-0"	W10 x 19 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 26 7'-6"/5'-6"	W10 x 26 7'-6"/6'-0"	W10 x 26 7'-6"/5'-6"	W10 x 30 7'-6"/6'-0"	W10 x 26 7'-6"/5'-6"	W10 x 30 7'-6"/6'-0"
15'-0"							W10 x 19 7'-0"/5'-0"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 22 7'-0"/5'-6"	W10 x 26 7'-6"/5'-6"	W10 x 26 7'-6"/5'-6"	W10 x 26 7'-6"/5'-6"	W10 x 30 7'-6"/6'-6"	W10 x 30 7'-6"/6'-0"	W10 x 30 8'-0"/6'-0"	W10 x 30 7'-6"/6'-0"	W10 x 30 8'-0"/6'-0"
16'-0"							W10 x 22 7'-0"/6'-0"	W10 x 22 7'-0"/6'-0"	W10 x 22 7'-6"/6'-0"	W10 x 26 7'-6"/6'-0"	W10 x 26 7'-6"/6'-0"	W10 x 30 7'-6"/6'-6"	W10 x 30 8'-0"/6'-6"	W10 x 30 8'-0"/6'-6"	W10 x 30 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"	W10 x 30 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"
17'-0"							W10 x 22 7'-0"/6'-0"	W10 x 22 7'-6"/6'-0"	W10 x 26 7'-6"/6'-0"	W10 x 26 7'-6"/6'-0"	W10 x 30 8'-0"/6'-6"	W10 x 30 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"
18'-0"							W10 x 22 7'-6"/6'-0"	W10 x 26 7'-6"/6'-0"	W10 x 26 7'-6"/6'-0"	W10 x 30 8'-0"/6'-6"	W10 x 30 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"
19'-0"							W10 x 26 7'-6"/6'-0"	W10 x 26 8'-0"/6'-0"	W10 x 30 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 45 8'-6"/7'-0"	W10 x 39 8'-6"/6'-6"	W10 x 45 8'-6"/7'-0"	W10 x 39 8'-6"/6'-6"	W10 x 45 8'-6"/7'-0"
20'-0"							W10 x 26 8'-0"/6'-0"	W10 x 30 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 45 9'-0"/7'-0"	W10 x 45 9'-0"/7'-0"	W10 x 45 9'-0"/7'-0"	W10 x 45 9'-0"/7'-0"	W10 x 45 9'-0"/7'-0"	W10 x 45 9'-0"/7'-0"
21'-0"							W10 x 30 8'-0"/6'-6"	W10 x 39 8'-0"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 45 9'-0"/7'-0"	W10 x 45 9'-0"/7'-0"	W10 x 49 9'-0"/7'-0"	W10 x 45 9'-0"/7'-0"	W10 x 49 9'-0"/7'-0"	W10 x 45 9'-0"/7'-0"	W10 x 49 9'-0"/7'-0"
22'-0"							W10 x 30 8'-0"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 8'-6"/6'-6"	W10 x 39 9'-0"/7'-0"	W10 x 45 9'-0"/7'-0"	W10 x 45 9'-0"/7'-0"	W10 x 49 9'-6"/7'-0"	W10 x 49 9'-6"/7'-0"	W10 x 49 9'-6"/7'-0"	W10 x 49 9'-6"/7'-0"	W10 x 49 9'-6"/7'-0"	W10 x 49 9'-6"/7'-0"

SEE NOTE 3

SEE NOTE 6

SEE NOTE 4

TABLE KEY

TOP VALUE:	PIPE DIAMETER (Ø) OR STRUCTURAL SHAPE
BOTTOM VALUE:	MINIMUM FOUNDATION EMBEDMENT - SOFT OR LOOSE SOIL/MEDIUM SOIL

SOIL CONDITIONS TABLE

SOFT OR LOOSE SOIL		MEDIUM SOIL	
COHESIVE	GRANULAR	COHESIVE	GRANULAR
MOIST UNIT WEIGHT = 110 PCF COHESION (C) = 750 PSF STRAIN FACTOR (E50) = 0.01 SOIL MODULUS (K) = 100 PCI	UNIT WEIGHT = 115 PCF SHEAR STRENGTH = 30° SOIL MODULUS (K) = 50 PCI	MOIST UNIT WEIGHT = 125 PCF COHESION (C) = 1,500 PSF STRAIN FACTOR (E50) = 0.007 SOIL MODULUS (K) = 500 PCI	UNIT WEIGHT = 125 PCF SHEAR STRENGTH = 34° SOIL MODULUS (K) = 90 PCI

NOTES:

1. SEE STD DWG SN 15B1 FOR GENERAL NOTES.
2. USE THE HIGHER VALUES WHEN SIGN HEIGHT OR WIDTH FALLS BETWEEN TWO VALUES.
3. USE OF Z-BAR IS PERMITTED FOR SIGN APPLICATIONS WITHIN NOTE 3 AREA. SEE STD DWG SN 8. DO NOT USE Z-BAR FOR MULTIPANEL SIGN APPLICATIONS.
4. USE SOLID POSTS (NON-BREAKAWAY) WITHIN NOTE 4 AREA. PLACE W10 X 39 AND LARGER POSTS BEHIND BARRIER AND OUTSIDE BARRIER LENGTH OF NEED.
5. USE EMBEDMENT VALUES FOR SOFT OR LOOSE SOIL CONDITIONS UNLESS OTHERWISE SHOWN.
6. CONTACT UDOT CENTRAL TRAFFIC AND SAFETY FOR SIGN SIZES NOT LISTED IN POST AND FOUNDATION TABLE.
7. USE FOUNDATION DEPTH FROM THE POST AND FOUNDATION TABLE UNDER THE SOFT OR LOOSE SOIL CONDITION UNLESS STATED OTHERWISE IN THE PROJECT CONTRACT OR APPROVED BY THE ENGINEER BASED ON A GEOTECHNICAL ENGINEERING ANALYSIS THAT DEMONSTRATES THAT THE SITE MEETS OR EXCEEDS THE MEDIUM SOIL CONDITION FROM THE SOIL CONDITIONS TABLE.
8. SOLID (NON-BREAKAWAY) POSTS SHOULD BE USED WHEN SIGN IS PROTECTED FROM VEHICLE IMPACTS BY PLACEMENT BEHIND BARRIER AND OUTSIDE THE LENGTH OF NEED.

REVISIONS

NO.	DATE	APPR.	REMARKS
1	2/22/18	CGW	ADDED MISSING NOTE 3 REFERENCE TO TABLE AND UPDATED NOTE 4.
2	2/28/19	JW	ADDED SOLID POST REQUIREMENT REFERENCE TO TABLE.
2	2/28/19	JW	ADDED NEW NOTE 4, RENUMBERED NOTE 4 TO 5.
3	5/25/20	JW	ADDED NOTE 6, REMOVED POSTS FROM TABLE FOR CRASHWORTHINESS.
3	5/25/20	JW	REMOVED DESIGN ONLY NOTE A, MOVED DESIGN ONLY NOTE B TO NOTES

UTAH DEPARTMENT OF TRANSPORTATION

STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION

SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL — 03/17/2021 DATE

CHAIRMAN STANDARDS COMMITTEE

APPROVED — 03/17/2021

DEPUTY DIRECTOR — DATE

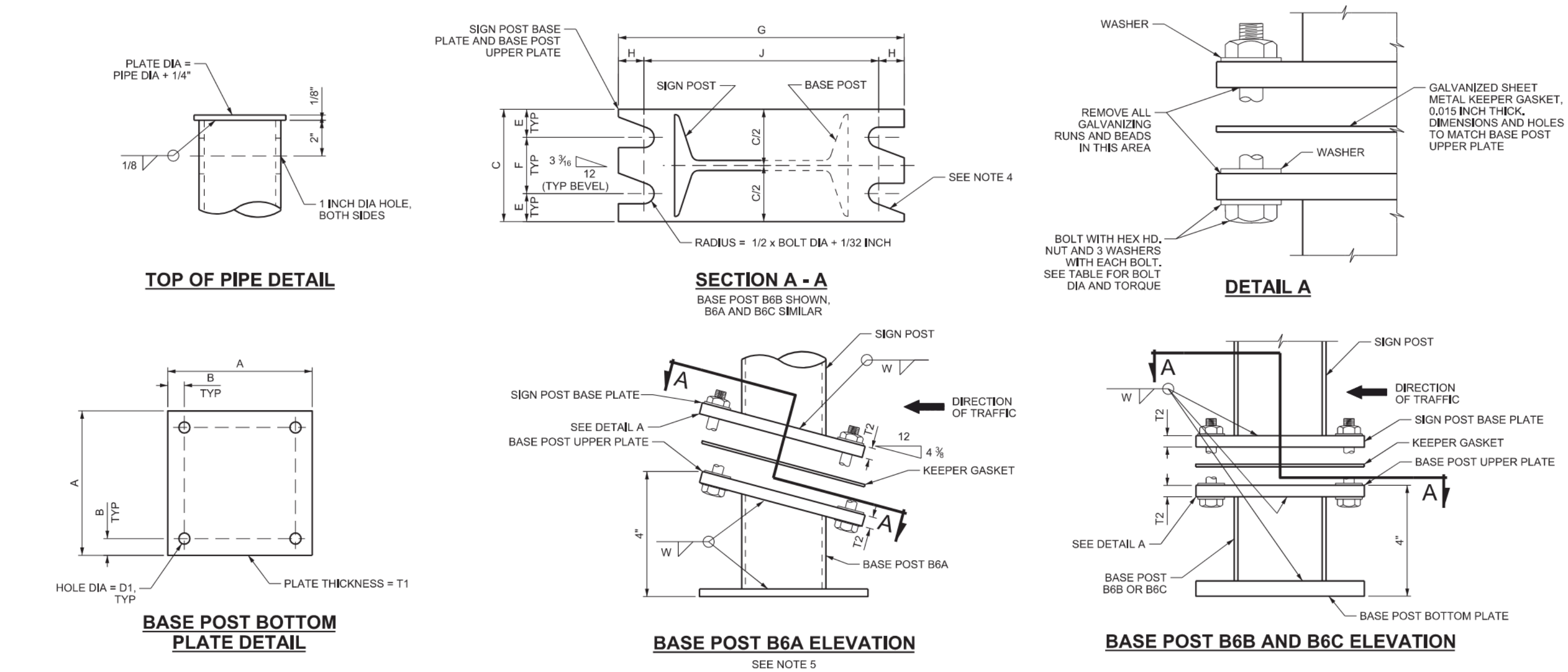
FREEWAY SIGN POST AND FOUNDATION REQUIREMENTS

STANDARD DRAWING TITLE

STD. DWG. NO.

SN 15B2

Figure 3-61: Utah's Response for Question 5 (3/7).



BASE CONNECTION TABLE

POST SIZE	BASE POST	BASE POST BOTTOM PLATE					BASE POST UPPER PLATE AND SIGN POST BASE PLATE								
		ANCHOR BOLT	A	B	D1	T1	BOLT SIZE AND TORQUE	C	E	F	G	H	J	T2	W
3" DIA STD PIPE	B6A	7/8" DIA x 2'- 6"	7 1/2"	1 1/2"	1"	3/4"	1/2" DIA x 2 1/2" 10 FT-LB TORQUE	4 1/2"	1"	2 1/2"	7 1/2"	3/4"	6"	3/4"	1/4"
4" DIA STD PIPE		7/8" DIA x 2'- 6"	8 1/2"	1 1/2"	1"	7/8"		5 1/2"	1"	3 1/2"	8 1/2"	3/4"	7"	3/4"	1/4"
5" DIA STD PIPE		7/8" DIA x 2'- 6"	10 1/2"	1 3/4"	1"	1"	5/8" DIA x 3 1/2" 24 FT-LB TORQUE	6 1/2"	1 1/4"	4"	10 1/4"	7/8"	8 1/2"	1"	1/4"
6" DIA STD PIPE			10 1/2"	1 3/4"	1"	1"		7 1/2"	1 1/4"	5"	11 1/2"	7/8"	9 3/4"	1"	5/16"
8" DIA STD PIPE		7/8" DIA x 2'- 6"	1'- 0 1/2"	2"	1"	1 1/4"		9 1/2"	1 1/4"	7"	1'- 2"	7/8"	1'- 0 1/4"	1"	5/16"
S3 x 5.7	B6B	7/8" DIA x 2'- 6"	7 1/2"	1 1/2"	1"	3/4"	1/2" DIA x 2 1/2" 10 FT-LB TORQUE	3"	3/4"	1 1/2"	7 1/2"	3/4"	6"	5/8"	3/16"
S4 x 9.5		7/8" DIA x 2'- 6"	8 1/2"	1 1/2"	1"	7/8"		3 1/2"	3/4"	2"	7 1/2"	3/4"	6"	5/8"	1/4"
S6 x 12.5		7/8" DIA x 2'- 6"	10 1/2"	1 3/4"	1"	1"	5/8" DIA x 3" 24 FT-LB TORQUE	4 1/2"	1 1/8"	2 1/4"	10"	3/4"	8 1/2"	3/4"	5/16"
S6 x 17.25		7/8" DIA x 2'- 6"	10 1/2"	1 3/4"	1"	1"		4 1/2"	1 1/8"	2 1/4"	10"	3/4"	8 1/2"	3/4"	5/16"
S8 x 18.4		7/8" DIA x 2'- 6"	1'- 0 1/2"	2"	1"	1 1/4"		5"	1 1/8"	2 3/4"	12"	3/4"	10 1/2"	3/4"	5/16"
W10 x 19	B6C	1 1/4" DIA x 2'- 6"	1'- 3"	2 1/4"	1 3/8"	1 3/4"	3/4" DIA x 3 1/2" 38 FT-LB TORQUE	6"	1 1/4"	3 1/2"	1'- 2 1/2"	7/8"	1'- 0 3/4"	1"	5/16"
W10 x 22		1 1/4" DIA x 2'- 6"	1'- 3"	2 1/4"	1 3/8"	1 3/4"		7"	1 1/2"	4"	1'- 3"	7/8"	1'- 1 1/4"	1"	5/16"
W10 x 26		1 1/4" DIA x 2'- 6"	1'- 3"	2 1/4"	1 3/8"	1 3/4"		7"	1 1/2"	4"	1'- 3"	7/8"	1'- 1 1/4"	1"	5/16"
W10 x 30		1 1/4" DIA x 2'- 6"	1'- 3"	2 1/4"	1 3/8"	1 3/4"	1" DIA x 3 1/2" 55 FT-LB TORQUE	7"	1 1/2"	4"	1'- 3"	7/8"	1'- 1 1/4"	1 1/8"	5/16"
W10 x 39		1 1/4" DIA x 2'- 6"	1'- 5 1/2"	2 1/2"	1 3/8"	1 3/4"		9"	1 3/4"	5 1/2"	1'- 3"	7/8"	1'- 1 1/4"	1 1/8"	5/16"
W10 x 45		1 1/4" DIA x 2'- 6"	1'- 5 1/2"	2 1/2"	1 3/8"	1 3/4"		9"	1 3/4"	5 1/2"	1'- 3"	7/8"	1'- 1 1/4"	1 1/8"	5/16"
W10 x 49		1 1/4" DIA x 2'- 6"	1'- 5 1/2"	2 1/2"	1 3/8"	1 3/4"		11"	1 3/4	7 1/2"	1'- 3"	7/8"	1'- 1 1/4"	1 1/8"	5/16"

NOTES:

1. REFER TO STD DWG SN 15B1 FOR GENERAL NOTES.
2. TIGHTEN BOLTS ONLY TO THE TORQUE LIMITS SHOWN IN THE TABLE. DO NOT OVER TIGHTEN.
3. USE THE SAME SHAPE FOR SIGN POST AND BASE POST.
4. BEVELS SHOWN IN SECTION A-A ARE FOR INSTALLATIONS ON RIGHT SHOULDER AND IN GORE. BEVELS ARE OPPOSITE HAND FROM THAT SHOWN FOR INSTALLATION ON LEFT SHOULDER.
5. USE BASE POST B6A FOR PIPE POST APPLICATIONS UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
6. USE ASTM F1554 STEEL FOR ANCHOR BOLTS. USE GRADE 36 UNLESS NOTED OTHERWISE. FULLY TORQUE ANCHOR BOLTS.

DESIGN-ONLY NOTES:

A. DO NOT USE INCLINE BASE WHERE THERE IS A POTENTIAL OF A BACKSIDE IMPACT.

REVISIONS

NO.	DATE	APPR.	REMARKS
1	2/28/2019	JW	MODIFIED PLATE AND BOLT DIMENSIONS.

UTAH DEPARTMENT OF TRANSPORTATION
STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION
SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL — DATE 03/17/2021
CHAIRMAN STANDARDS COMMITTEE
APPROVED — DATE 03/17/2021
DEPUTY DIRECTOR

FREEWAY SIGN BASE POST REQUIREMENTS (B6A, B6B, AND B6C)
STANDARD DRAWING TITLE

STD. DWG. NO.
SN 15C

Figure 3-62: Utah's Response for Question 5 (4/7).

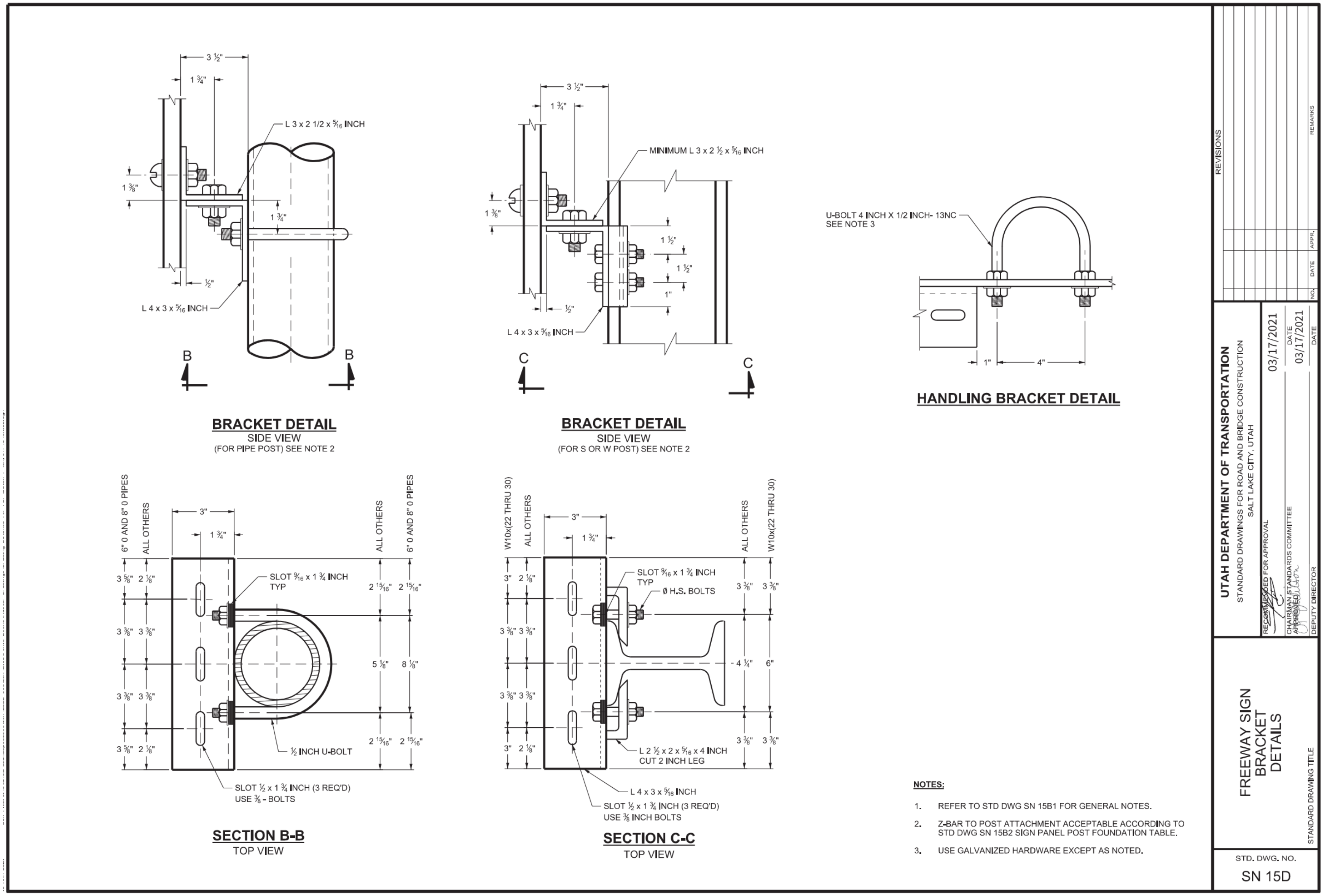


Figure 3-63: Utah's Response for Question 5 (5/7).

FUSE PLATE AND SPLICE PLATE TABLE												
POST SIZE	K	L	M	N	P	Q	R	S	D2	D3	T3	BOLT SIZE
S3 x 5.7	3 1/2"	2 1/4"	5/8"	2 3/8"	1 1/2"	7/16"	11/32"	9/16"	5/8"	3/8"	1/4"	1/2"
S4 x 9.5	4 1/4"	2 1/4"	1"	2 5/8"	1 1/2"	9/16"	15/32"	9/16"	5/8"	3/8"	5/16"	1/2"
S6 x 12.5	4 3/4"	2 1/2"	1 1/8"	4"	2"	1"	1/2"	1"	5/8"	3/4"	3/8"	1/2"
S6 x 17.25	4 3/4"	2 1/2"	1 1/8"	4"	2"	1"	1/2"	1"	3/4"	3/4"	3/8"	5/8"
S8 x 18.4	5"	2 1/2"	1 1/4"	5 1/4"	2 1/4"	1 1/2"	3/4"	1 1/4"	7/8"	1 1/8"	3/8"	3/4"
W10 x 19	6"	3"	1 1/2"	5 3/4"	2 1/4"	1 3/4"	13/16"	1 3/8"	7/8"	1 1/8"	3/8"	3/4"
W10 x 22	6"	3"	1 1/2"	5 3/4"	3 3/4"	1"	13/16"	1 3/8"	1"	1 1/8"	3/8"	7/8"
W10 x 26	6"	3"	1 1/2"	5 3/4"	3 3/4"	1"	13/16"	1 3/8"	1"	1 1/8"	1/2"	7/8"
W10 x 30	6"	3"	1 1/2"	5 3/4"	3 3/4"	1"	13/16"	1 3/8"	1"	1 1/8"	1/2"	7/8"
W10 x 39	USE SOLID (NON-BREAKAWAY) POSTS. PLACE W10 X 39 AND LARGER POSTS BEHIND BARRIER AND OUTSIDE BARRIER LENGTH OF NEED.											
W10 x 45												
W10 x 49												

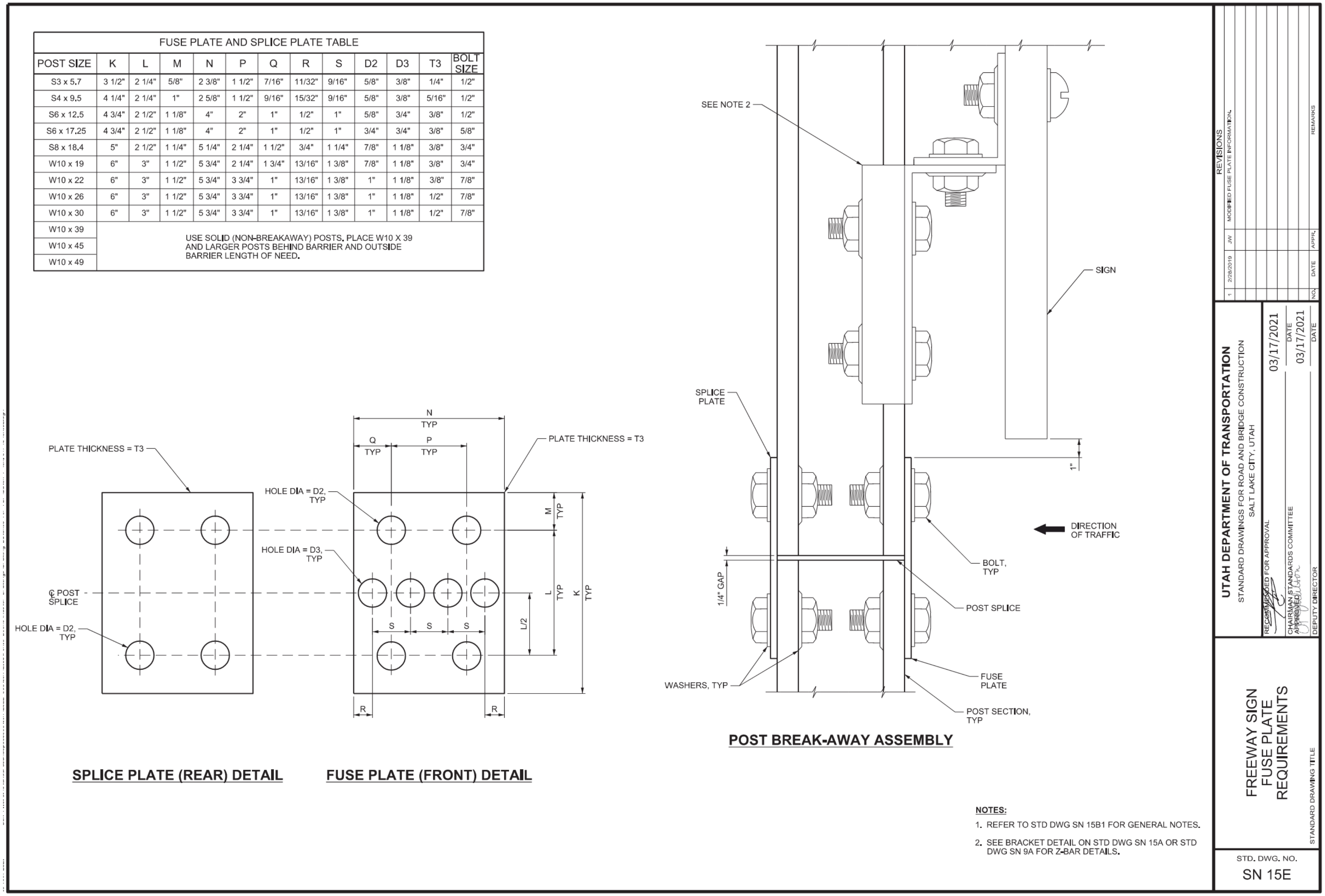


Figure 3-64: Utah's Response for Question 5 (6/7).

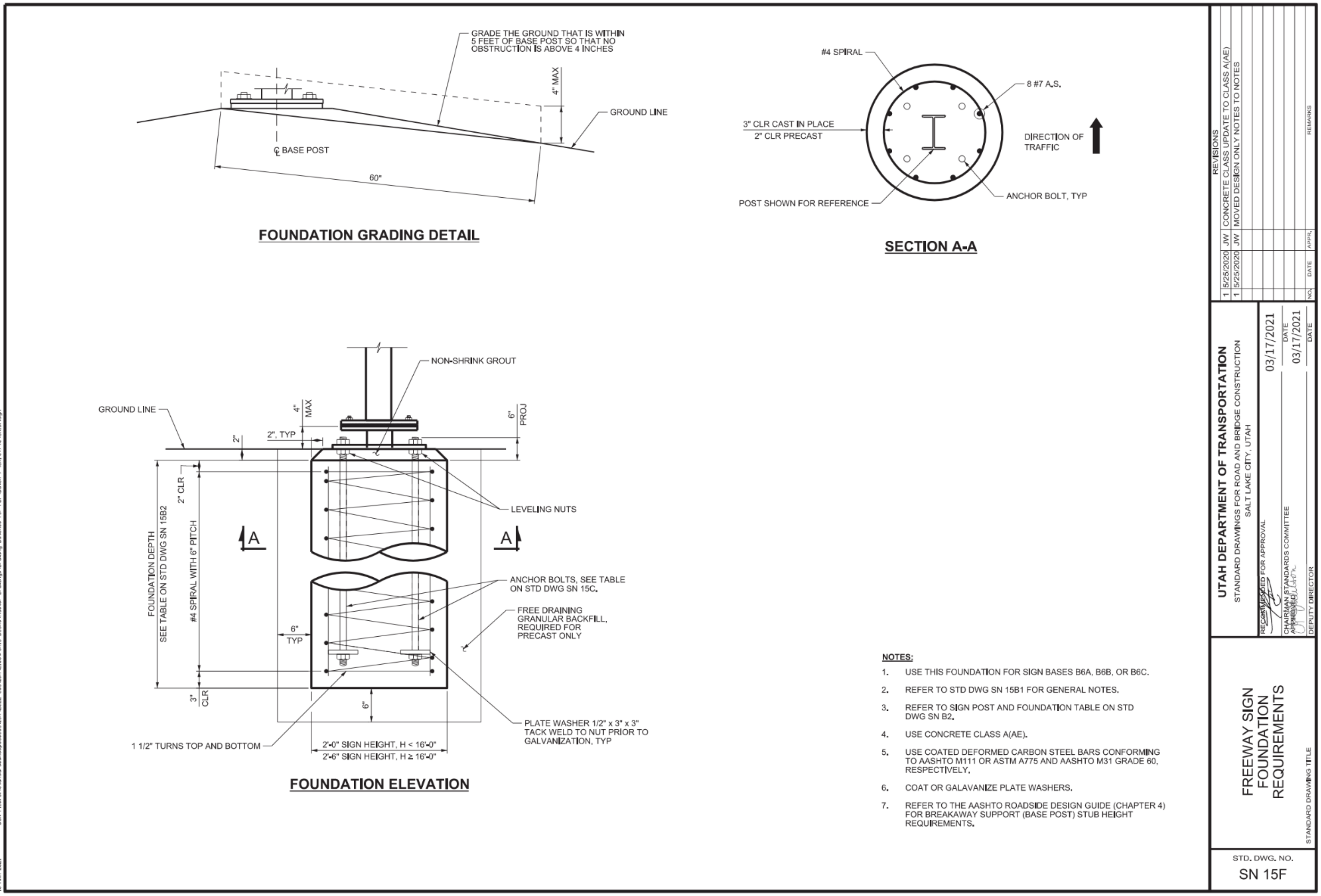
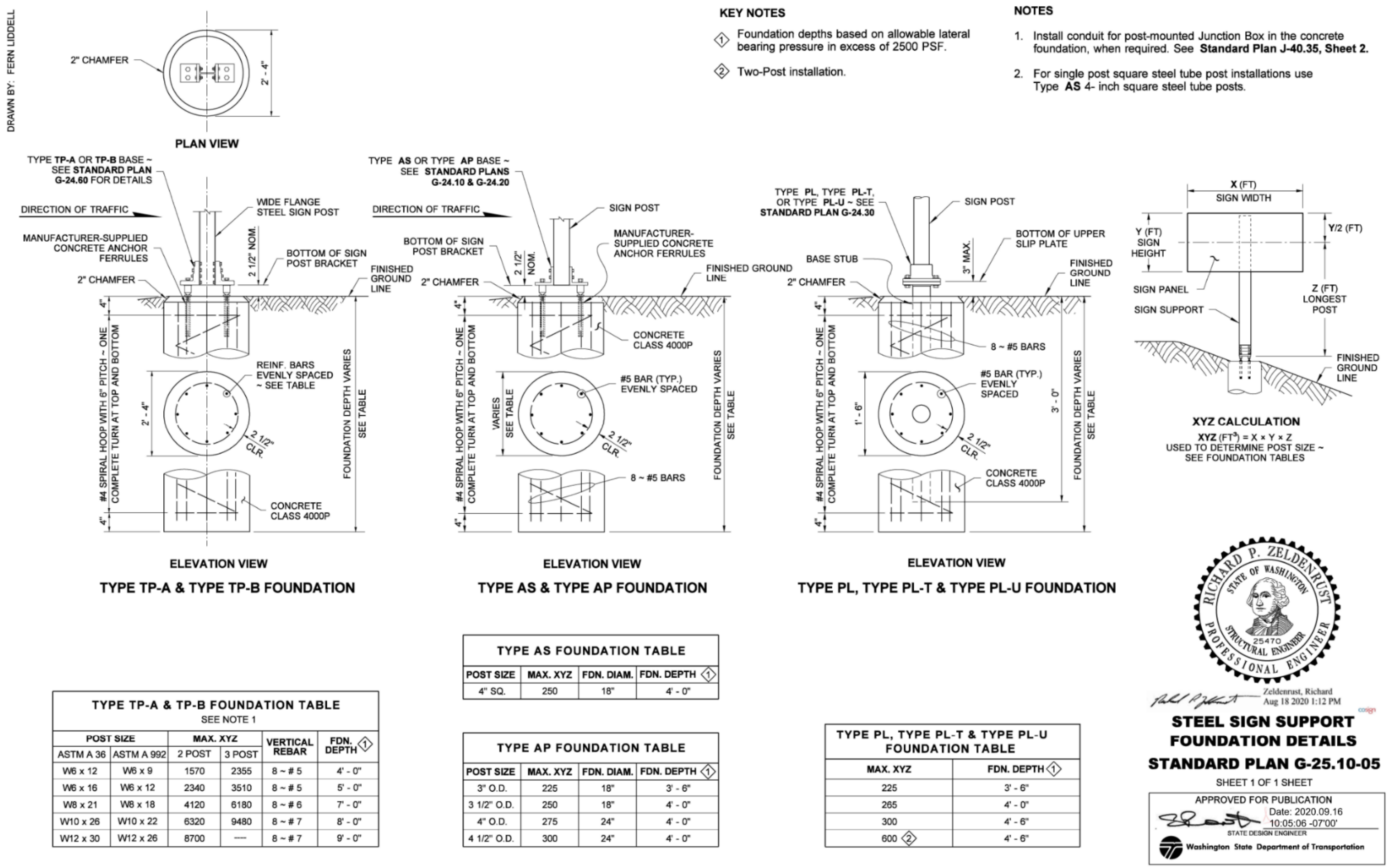


Figure 3-65: Utah's Response for Question 5 (7/7).



KEY NOTES

① Foundation depths based on allowable lateral bearing pressure in excess of 2500 PSF.

② Two-Post installation.

NOTES

1. Install conduit for post-mounted Junction Box in the concrete foundation, when required. See **Standard Plan J-40.35, Sheet 2.**
2. For single post square steel tube post installations use Type **AS** 4- inch square steel tube posts.

TYPE TP-A & TP-B FOUNDATION TABLE
SEE NOTE 1

POST SIZE		MAX. XYZ		VERTICAL REBAR	FDN. DEPTH ①
ASTM A 36	ASTM A 992	2 POST	3 POST		
W6 x 12	W6 x 9	1570	2355	8 ~ # 5	4' - 0"
W6 x 16	W6 x 12	2340	3510	8 ~ # 5	5' - 0"
W8 x 21	W8 x 18	4120	6180	8 ~ # 6	7' - 0"
W10 x 26	W10 x 22	6320	9480	8 ~ # 7	8' - 0"
W12 x 30	W12 x 26	8700	----	8 ~ # 7	9' - 0"

TYPE AS FOUNDATION TABLE

POST SIZE	MAX. XYZ	FDN. DIAM.	FDN. DEPTH ①
4" SQ.	250	18"	4' - 0"

TYPE AP FOUNDATION TABLE

POST SIZE	MAX. XYZ	FDN. DIAM.	FDN. DEPTH ①
3" O.D.	225	18"	3' - 6"
3 1/2" O.D.	250	18"	4' - 0"
4" O.D.	275	24"	4' - 0"
4 1/2" O.D.	300	24"	4' - 0"

TYPE PL, TYPE PL-T & TYPE PL-U FOUNDATION TABLE

MAX. XYZ	FDN. DEPTH ①
225	3' - 6"
265	4' - 0"
300	4' - 6"
600 ②	4' - 6"

Figure 3-66: Washington's Response for Question 5.

Q7 – Do you have any other information to share with the research team?

Table 3.3: State Responses for Question 7.

Louisiana	"We typically do not install W-beam beam posts in locations where they can be hit from multiple directions. In situations where this is possible (eg. Intersections or at the ends of off-ramps) the signs are usually not large so we typically use round pipe posts on multi-directional breakaway bases or square tube posts. The W-beam posts are typically used with larger signs installed along the shoulder, so we just use uni-directional breakaway base with those. That being said, it IS possible that we have some w-beam supports that are being used in multi-directional situations. But I would say this is rare and is not the intent of our standards."
Massachusetts	"For bi-directional signpost locations, the lip base is normally oriented towards the traffic direction that has the greatest exposure. This is normally based on traffic volumes, approach speeds, and the physical characteristics at the post location."
Michigan	"In Michigan, we use 3lbs. u-channel systems near intersections and if needed with utilize either 4x6 or 6x8 wood supports. Occasionally, a 4 lbs. PSST are utilized as well. We recognize that there is potential the wood support systems may not move forward as part of *MASH*. It will be interesting to see the information that is determined as part of this research."

CHAPTER 4. SYSTEM DETAILS

4.1. TEST ARTICLE AND INSTALLATION DETAILS

The Route Marker Assembly sign support design was adapted from typical details from West Virigina Department of Highways. For tests 616401-01 1-2, the Route Marker Assembly sign post assembly was 20 feet and 11 inches tall above grade. There were varying sized signs installed on the sign posts to form a large assembly of router marker and associated signs. From center to center the two sign posts were 39 inches apart. The sign posts had a fuse plate installed 96 inches above grade to the center of the breakaway plates, and the posts were mounted onto triangular slip bases. Figure 4-3 presents the overall information on the Route Marker Assembly with large sign supports, and Figure 4-4 thru Figure 4-7 provide photographs of the installation.

The guide sign support design was adapted from typical details from West Virigina Department of Highways. The guide sign for test 616401-01-3 was comprised of an extruded aluminum sign panel assembly measuring 5 feet tall and 15 feet long and fastened to two support posts placed 9 feet apart on center. The total height of the guide sign assembly was 13 feet 4 inches, with the same fuse plate and slip base designs used in tests 616401-01 1-4. A vertical stiffener was installed on the back of the extruded aluminum sign panels. Previous crash testing showed improvements to crashworthiness when sign panels were stiffened. The stiffener would minimize twisting of the sign panel, and therefore promote activation of the fuse plate. Figure 4-8 presents the overall information on the guide sign with large sign supports, and Figure 4-9 thru Figure 4-12 provide photographs of the installation.

After the test failure of 616401-01-3, the research team concluded that the fuse plate component of the sign could benefit from modifications. Video analysis showed a delayed activation of the fuse plate, allowing the sign panel to be pulled vertically downward and into the test vehicle. Therefore, the research team investigated improving the fuse plate's activation while simultaneously maintaining its wind load capacity.

When redesigning the fuse plate, the design team aimed to keep the plate's critical net cross-sectional area the same as the previous design. This would maintain the tensile capacity of the plate, and therefore, the wind load capacity of the design. The research team determined that decreasing the edge distance between the outer two holes would aid in the activation of the fuse plate in the 90 degree impact, but maintain its wind load capacity. Consequently, the hole pattern of the fuse plate was modified.

For test 616401-01-9, the installation was the same as test 616401-01-3, with the exception of the fuse plate, which had a modified hole pattern with the design intent of promoting activation with a 90 degree impact. Figure 4-13 presents the overall information on the guide sign with large sign supports, and Figure 4-14 thru Figure 4-17 provide photographs of the installation.

After the test failure of 616401-01-9, the research team concluded the design could be improved with a taller mounting height. With this design objective, the research team evaluated the increased mounting height's effect on the design's wind load capacity. The wind load capacities of the Route Marker Assembly and guide sign were analyzed using West Virginia's wind analysis design chart. The total sign area of both installation variations was calculated. The guide sign had a total area of 37.5 ft^2 (rounded to 40 ft^2) and the Route Marker Assembly had a total area of 39.4 ft^2 (rounded to 40 ft^2). Any separation between signs on the Route Marker Assembly were conservatively. The height of center of pressure was then determined for both sign variations (Route Marker Assembly and guide sign). The guide sign had a center of pressure height of 10 feet, 6 inches (rounded to 11 feet) and the Route Marker Assembly had a center of pressure of 14 feet, 3 ¾ inches (rounded to 15 feet).

Using the wind analysis chart, it was determined that the W6x12 posts maintained acceptable wind load capacities for the original center of pressure heights, as well as an increase of 1 foot in mounting height (which equates to a 1 foot increase in center of pressure height). Therefore, an increase in mounting height by 1 foot would not require a change in post size for the tested configurations. These findings are illustrated in Figure 4-1 and Figure 4-2, with the red indicating original as-tested design, and the blue representing an increase of 1 foot in mounting height.

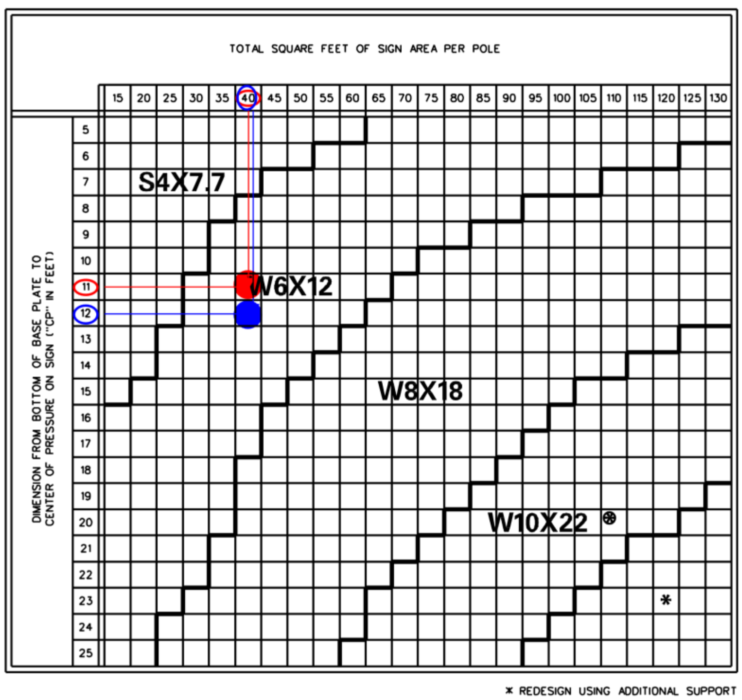


Figure 4-1: Post Size Required for Guide Sign at Various Mounting Heights.

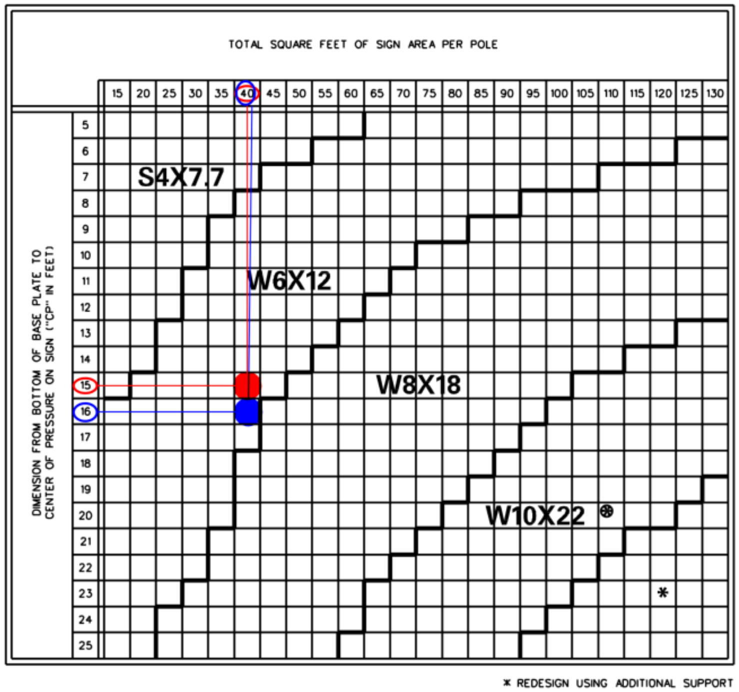


Figure 4-2: Post Size Required for Route Marker Assembly at Various Mounting Heights.

For test 616401-01-4, the length of the support posts below the sign panels was lengthened so that the center of the fuse plates were 9 feet (108 inches) above grade, and the overall height of the installation was 14 feet 4 inches. The fuse plate also utilized the modified hole pattern. All other details were the same as test 616401-01-3. Figure 4-18 presents the overall information on the guide sign with large sign supports, and Figure 4-19 thru Figure 4-22 provide photographs of the installation.

After the test failure of 616401-01-4, the research team concluded the design could be improved with another increase in mounting height. For test 616401-01-8, the length of the support posts below the sign panels was lengthened so that the center of the fuse plates were 10 feet (120 inches) above grade, and the overall height of the installation was 14 feet 4 inches. All other details were the same as test 616401-01-4. Figure 4-23 presents the overall information on the guide sign with large sign supports, and Figure 4-24 thru Figure 4-27 provide photographs of the installation.

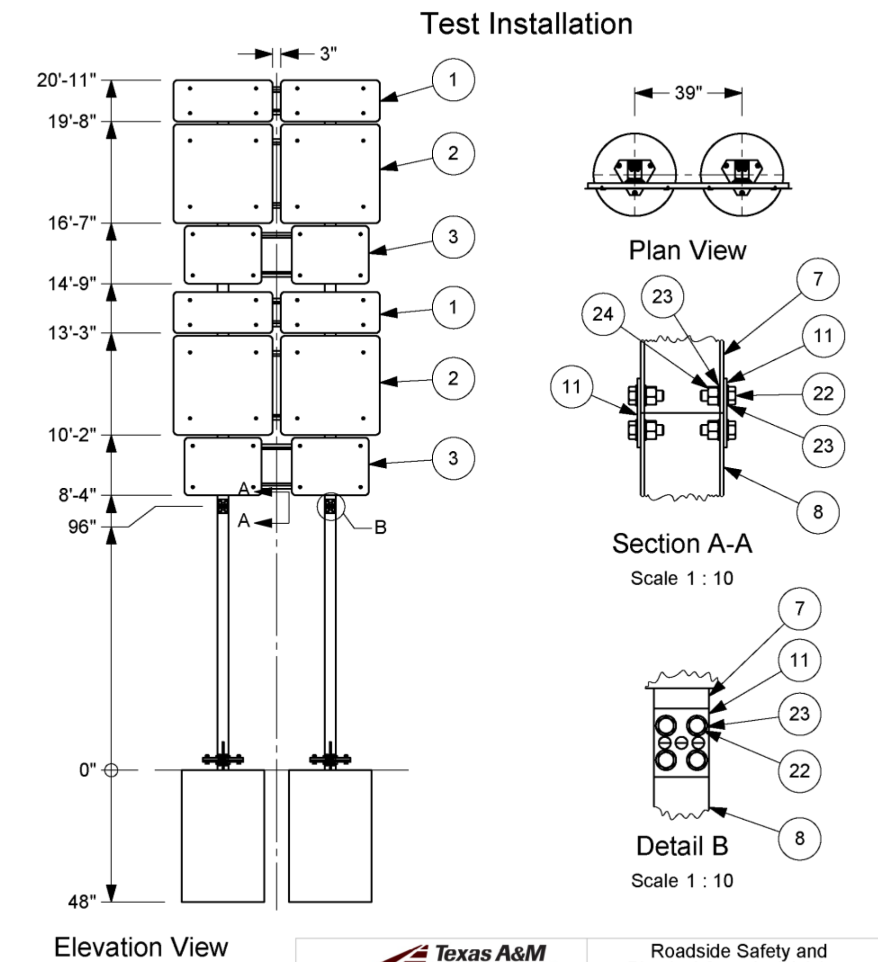
Appendix A provides further details on the Multi-directional Base Design for Large Sign Supports. Drawings and construction were provided by the Texas A&M Transportation Institute (TTI) Proving Ground.

4.2. DESIGN MODIFICATIONS DURING TESTS

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

#	Part Name	QTY.
1	15" x 36" x 0.0800 Sign Panel	4
2	36" x 36" x 0.0800 Sign Panel	4
3	21" x 28" x 0.0800 Sign Panel	4
4	73" Extruded Rib	8
5	65" Extruded Rib	4
6	Post Clamp	48
7	Top Section	2
8	Middle Section	2
9	Adapter Plate	4
10	Keeper Plate	2
11	Hinge Plate	4
12	Bolt, 5/16 x 7/8" hex	48
13	Nut, 5/16 hex A563	48
14	Washer, 5/16 F844	96
15	Washer, 5/16 lock	48
16	Bolt, 5/8 x 1 1/2" hex A325	16
17	Washer, 5/8 F436	16
18	Bolt, 3/8 x 1 3/4" square head	48
19	Washer, 3/8 F844	48
20	Washer, 3/8 lock	48
21	Nut, 3/8 hex	48
22	Bolt, 3/4 x 2" hex A325	16
23	Washer, 3/4 F436	44
24	Nut, 3/4 heavy hex A194	22
25	Bottom Section	2
26	Bolt, 3/4 x 2 3/4" hex	6
27	3,000 psi concrete	2
28	Rebar Ring, Ø1/2" x 24" OD	8
29	Ø1" x 42" rebar	20

1a. All steel components, including hardware, shall be galvanized.



Texas A&M Transportation Institute

Roadside Safety and Physical Security Division - Proving Ground

Project #616401-01 1-2 Route Marker		2022-10-28
Drawn by GES	Scale 1:50	Sheet 1 of 7 Test Installation

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Figure 4-3. Details of Route Marker Assembly with Large Sign Supports.

Figure 4-4. Impact Side of the Route Marker Assembly with Large Sign Supports prior to Testing.

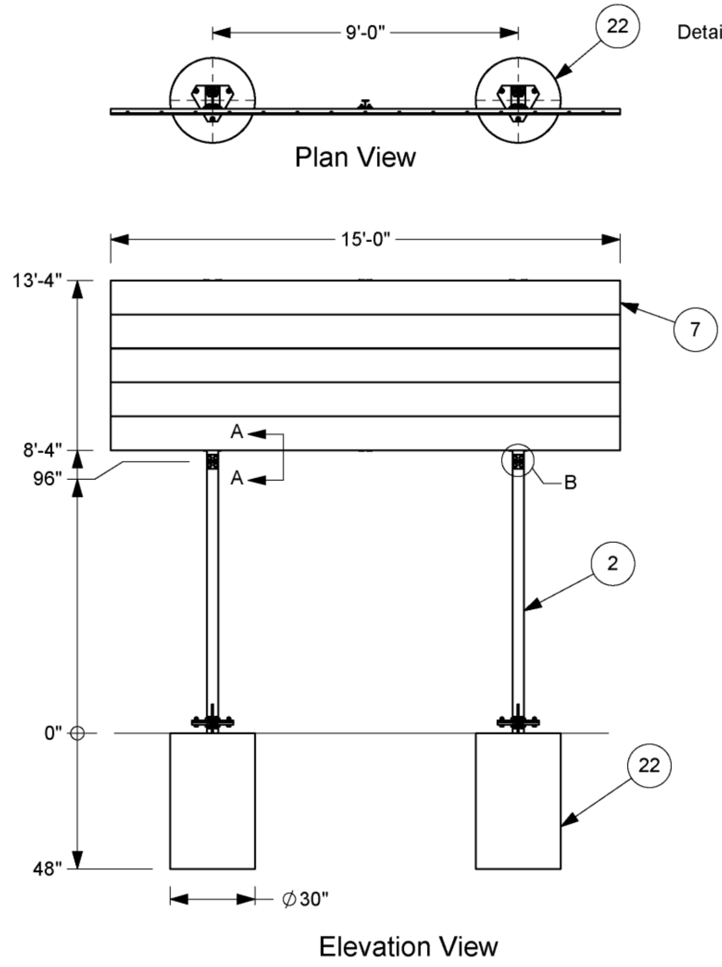
Figure 4-5. Back Side of the Route Marker Assembly with Large Sign Supports prior to Testing.

Figure 4-6. Fuse plate on the Route Marker Assembly with Large Sign Supports prior to Testing.

Figure 4-7. Slip Base on the Route Marker Assembly with Large Sign Supports prior to Testing.

Test Installation

Detail and Section views on next sheet



#	Part Name	QTY.
1	Bottom Section	2
2	Middle Section	2
3	Top Section	2
4	Adapter Plate	4
5	Keeper Plate	2
6	Hinge Plate	4
7	Aluminum Sign Panel, 12" x 180"	5
8	Stiffener	1
9	Post Clamp	24
10	Bolt, 3/8 x 1 3/4" square head	24
11	Bolt, 3/8 x 3/4" hex A307	28
12	Washer, 3/8 F844	80
13	Washer, 3/8 lock	24
14	Nut, 3/8 lock	28
15	Nut, 3/8 hex	24
16	Bolt, 5/8 x 1 1/2" hex A325	16
17	Washer, 5/8 F436	16
18	Bolt, 3/4 x 2" hex A325	16
19	Bolt, 3/4 x 2 3/4" hex A325	6
20	Washer, 3/4 F436	44
21	Nut, 3/4 heavy hex A194	22
22	3,000 psi concrete	2
23	Rebar Ring, Ø1/2" x 24" OD	8
24	Ø1" x 42" rebar	20

1a. All steel components shall be galvanized.

Texas A&M Transportation Institute

Roadside Safety and Physical Security Division - Proving Ground

Project #616401-01 Guide Sign | 2022-10-31

Drawn by GES | Scale 1:50 | Sheet 1 of 6 Test Installation

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Figure 4-8. Details of Guide Sign with Large Sign Supports for Test 616401-01-3.

Figure 4-9. Impact Side of the Guide Sign with Large Sign Supports prior to Test 616401-01-3.

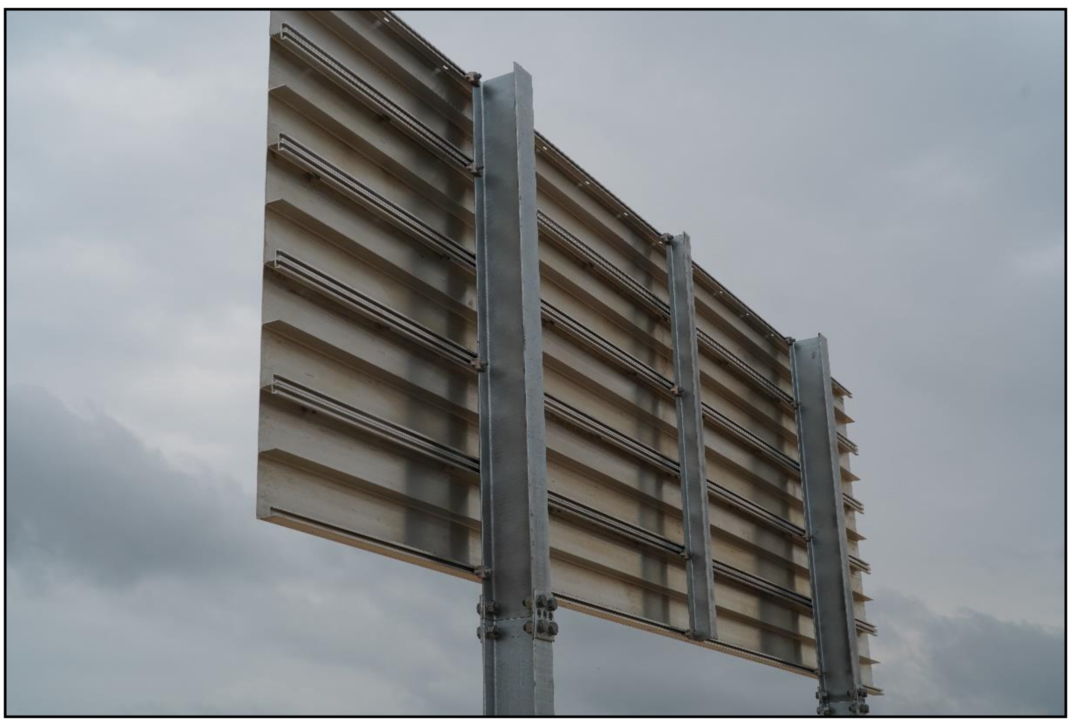


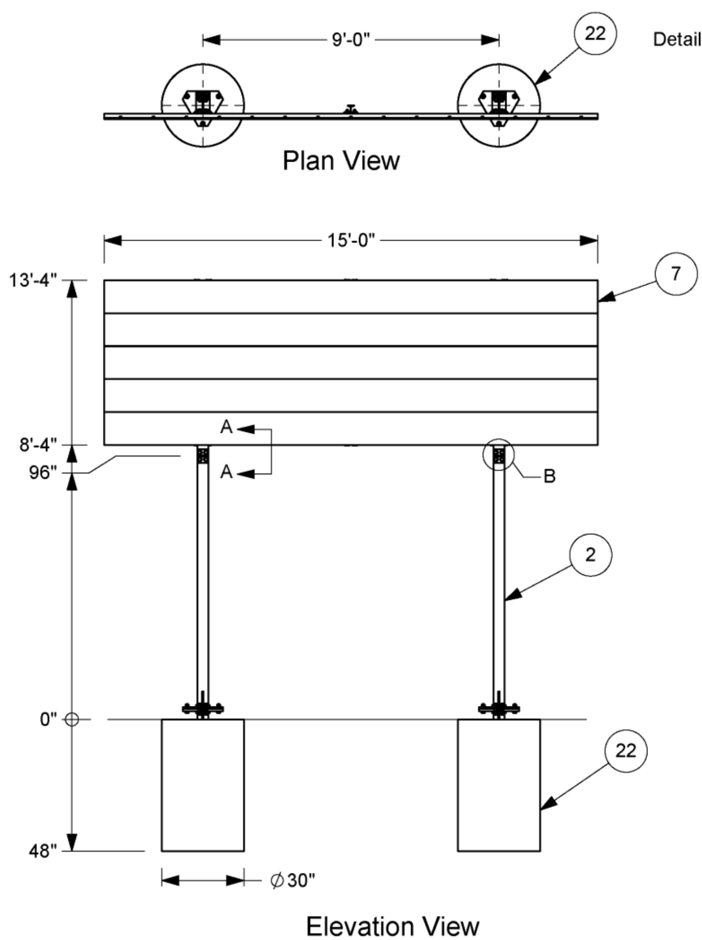
Figure 4-10. Back Side of the Guide Sign with Large Sign prior to Test 616401-01-3.


Figure 4-11. Fuse plate on the Guide Sign with Large Sign Supports prior to Test 616401-01-3.


Figure 4-12. Slip Base on the Guide Sign with Large Sign Supports prior to Test 616401-01-3.

Test Installation

Detail and Section views on next sheet



#	Part Name	QTY.
1	Bottom Section	2
2	Middle Section	2
3	Top Section	2
4	Adapter Plate	4
5	Keeper Plate	2
6	Hinge Plate	4
7	Aluminum Sign Panel, 12" x 180"	5
8	Stiffener	1
9	Post Clamp	24
10	Bolt, 3/8 x 1 3/4" square head	24
11	Bolt, 3/8 x 3/4" hex A307	28
12	Washer, 3/8 F844	80
13	Washer, 3/8 lock	24
14	Nut, 3/8 lock	28
15	Nut, 3/8 hex	24
16	Bolt, 5/8 x 1 1/2" hex A325	16
17	Washer, 5/8 F436	16
18	Bolt, 3/4 x 2" hex A325	16
19	Bolt, 3/4 x 2 3/4" hex A325	6
20	Washer, 3/4 F436	44
21	Nut, 3/4 heavy hex A194	22
22	3,000 psi concrete	2
23	Rebar Ring, Ø1/2" x 24" OD	8
24	Ø1" x 42" rebar	20

1a. All steel components shall be galvanized.

Texas A&M Transportation Institute

Roadside Safety and Physical Security Division - Proving Ground

Project #616401-01 Guide Sign		2023-07-25
Drawn by GES	Scale 1:50	Sheet 1 of 6 Test Installation

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Figure 4-13. Details of Guide Sign with Large Sign Supports for Test 616401-01-9.

Figure 4-14. Impact Side of the Guide Sign with Large Sign Supports prior to Test 616401-01-9.

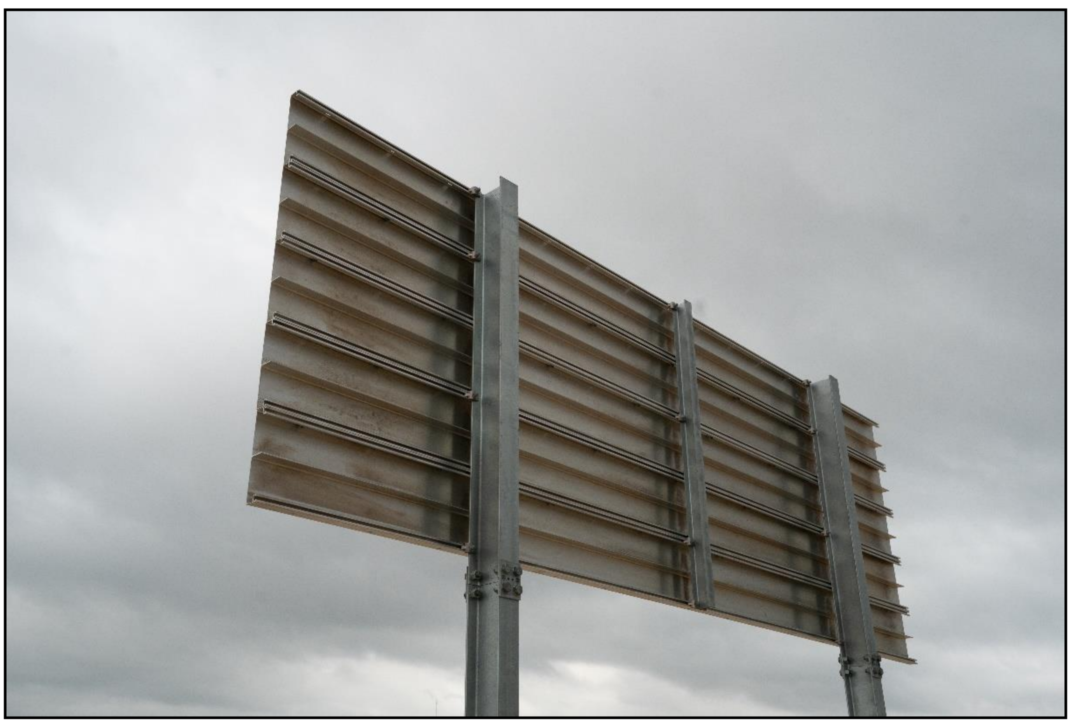


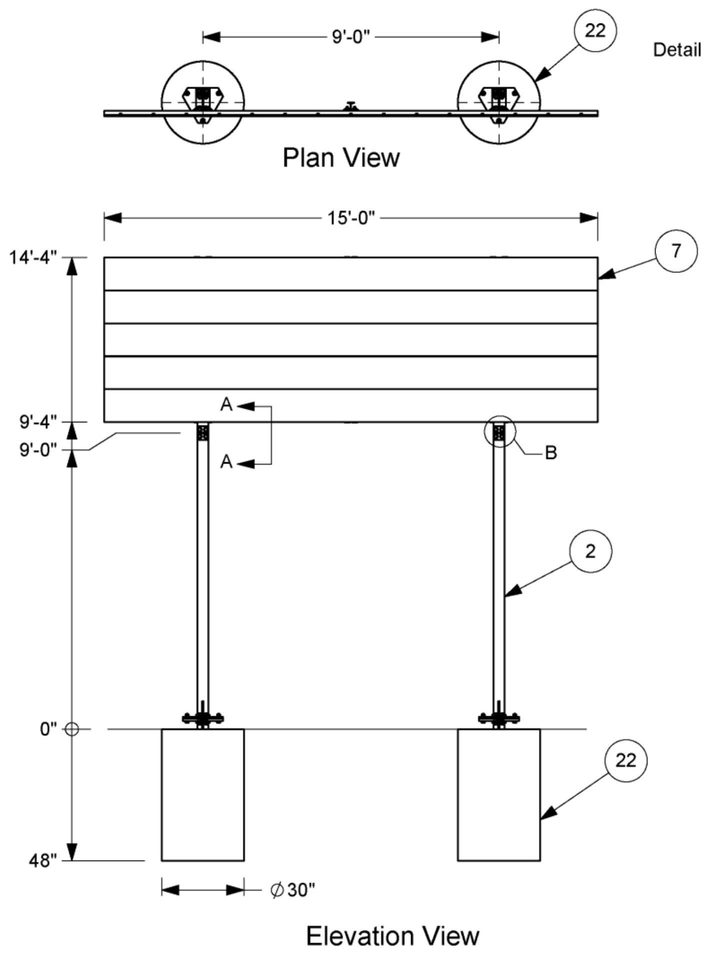
Figure 4-15. Back Side of the Guide Sign with Large Sign Supports prior to Test 616401-01-9.

Figure 4-16. Fuse plate on the Guide Sign with Large Sign Supports prior to Test 616401-01-9.

Figure 4-17. Slip Base on the Guide Sign with Large Sign Supports prior to Test 616401-01-9.

Test Installation

Detail and Section views on next sheet



#	Part Name	QTY.
1	Bottom Section	2
2	Middle Section	2
3	Top Section	2
4	Adapter Plate	4
5	Keeper Plate	2
6	Hinge Plate	4
7	Aluminum Sign Panel, 12" x 180"	5
8	Stiffener	1
9	Post Clamp	24
10	Bolt, 3/8 x 1 3/4" square head	24
11	Bolt, 3/8 x 3/4" hex A307	28
12	Washer, 3/8 F844	80
13	Washer, 3/8 lock	24
14	Nut, 3/8 lock	28
15	Nut, 3/8 hex	24
16	Bolt, 5/8 x 1 1/2" hex A325	16
17	Washer, 5/8 F436	16
18	Bolt, 3/4 x 2" hex A325	16
19	Bolt, 3/4 x 2 3/4" hex A325	6
20	Washer, 3/4 F436	44
21	Nut, 3/4 heavy hex A194	22
22	3,000 psi concrete	2
23	Rebar Ring, Ø1/2" x 24" OD	8
24	Ø1" x 42" rebar	20

1a. All steel components shall be galvanized.

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Roadside Safety and Physical Security Division - Proving Ground

Project #616401-01 Guide Sign | 2023-10-04

Drawn by GES | Scale 1:50 | Sheet 1 of 6 Test Installation

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Figure 4-18. Details of Guide Sign with Large Sign Supports for Test 616401-01-4.

Figure 4-19. Impact Side of the Guide Sign with Large Sign Supports prior to Test 616401-01-4.

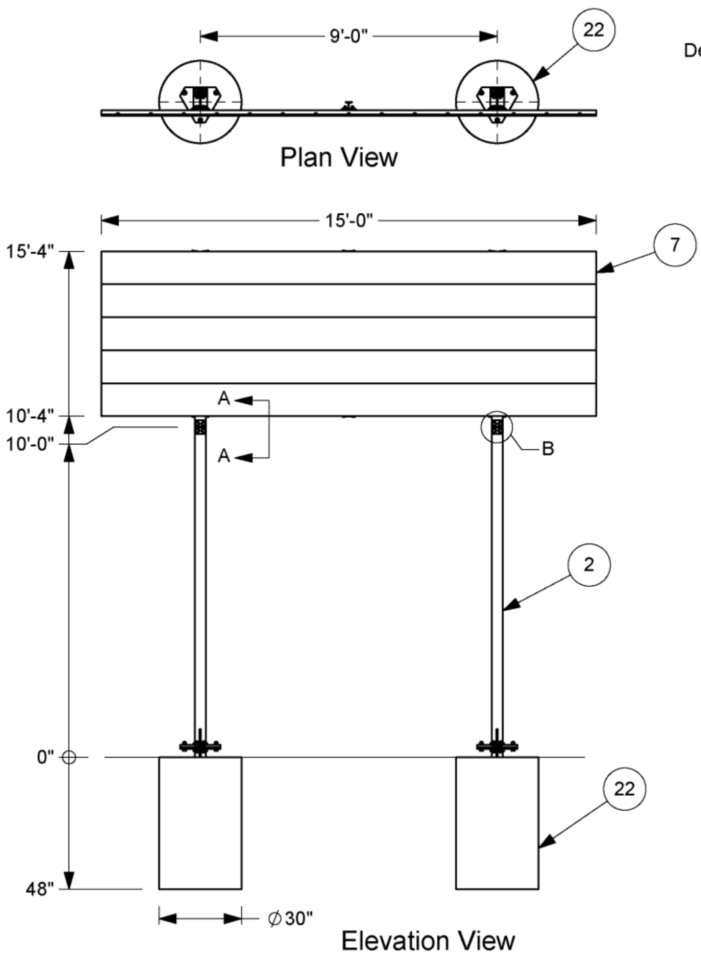
Figure 4-20. Back Side of the Guide Sign with Large Sign Supports prior to Test 616401-01-4.

Figure 4-21. Fuse plate on the Guide Sign with Large Sign Supports prior to Test 616401-01-4.

Figure 4-22. Slip Base on the Guide Sign with Large Sign Supports prior to Test 616401-01-4.

Test Installation

Detail and Section views on next sheet



#	Part Name	QTY.
1	Bottom Section	2
2	Middle Section	2
3	Top Section	2
4	Adapter Plate	4
5	Keeper Plate	2
6	Hinge Plate	4
7	Aluminum Sign Panel, 12" x 180"	5
8	Stiffener	1
9	Post Clamp	24
10	Bolt, 3/8 x 1 3/4" square head	24
11	Bolt, 3/8 x 3/4" hex A307	28
12	Washer, 3/8 F844	80
13	Washer, 3/8 lock	24
14	Nut, 3/8 lock	28
15	Nut, 3/8 hex	24
16	Bolt, 5/8 x 1 1/2" hex A325	16
17	Washer, 5/8 F436	16
18	Bolt, 3/4 x 2" hex A325	16
19	Bolt, 3/4 x 2 3/4" hex A325	6
20	Washer, 3/4 F436	44
21	Nut, 3/4 heavy hex A194	22
22	3,000 psi concrete	2
23	Rebar Ring, Ø1/2" x 24" OD	8
24	Ø1" x 42" rebar	20

1a. All steel components shall be galvanized.

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Roadside Safety and Physical Security Division - Proving Ground

Project #616401-01 Guide Sign | 2024-02-23

Drawn by GES | Scale 1:50 | Sheet 1 of 6 Test Installation

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Figure 4-23. Details of Guide Sign with Large Sign Supports for Test 616401-01-8.

Figure 4-24. Impact Side of the Guide Sign with Large Sign Supports prior to Test 616401-01-8.

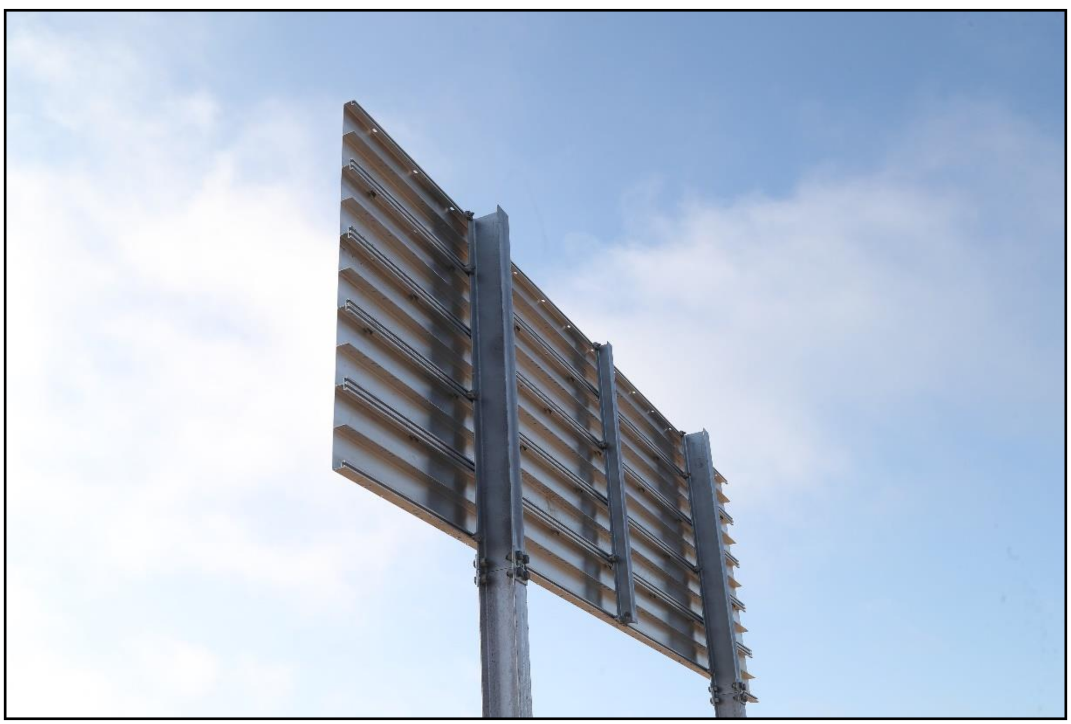


Figure 4-25. Back Side of the Guide Sign with Large Sign Supports prior to Test 616401-01-8.

Figure 4-26. Fuse plate on the Guide Sign with Large Sign Supports prior to Test 616401-01-8.

Figure 4-27. Slip Base on the Guide Sign with Large Sign Supports prior to Test 616401-01-8.

4.3. MATERIAL SPECIFICATIONS

Appendix B provides material certification documents for the materials used to install/construct the Multi-directional Base Design for Large Sign Supports. Table 4.1 shows the average compressive strengths of the concrete.

Table 4.1. Concrete Strength.

Location	Design Strength	Avg. Strength	Age	Detailed Location
Footers for tests 616401-01 1-3	3000 psi	3843 psi	39 days	100% of Footers
Footers for tests 616401-01-4&8	3000 psi	4077 psi	47 days	100% of Replacement Footers
Footers for test 616401-01-9	3000 psi	3655 psi	17 days	100% of Replacement Footers

CHAPTER 5. TEST REQUIREMENTS AND EVALUATION CRITERIA

5.1. CRASH TEST PERFORMED/MATRIX

Table 5.1 shows the test conditions and evaluation criteria for *MASH* TL-3 for Support Structures. The target critical impact points (CIPs) for each test were determined using the information provided in *MASH* Section 2.2.4. Figure 5-1 shows the target CIP for *MASH* TL-3 tests on the Multi-directional Base Design for Large Sign Supports.

Table 5.1. Test Conditions and Evaluation Criteria Specified for *MASH* TL-3 Support Structures.

Test Designation	Test Vehicle	Impact Speed	Impact Angle	Evaluation Criteria
3-60	1100C	19 mi/h	0º-25° or 90°	B, D, F, H, I, N
3-61	1100C	62 mi/h	0º-25° or 90°	B, D, F, H, I, N
3-62	2270P	62 mi/h	0º-25° or 90°	B, D, F, H, I, N

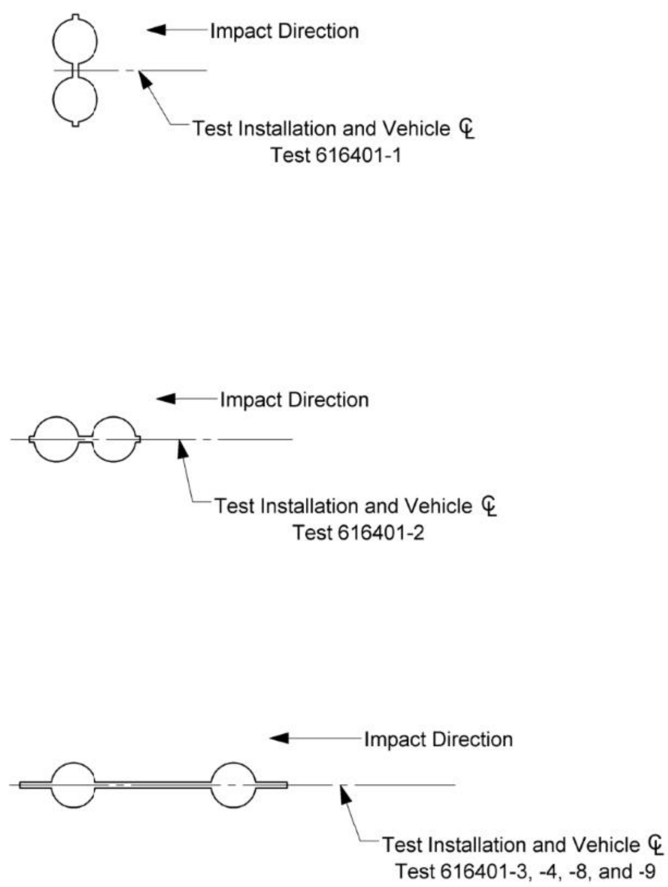


Figure 5-1. Target CIP for *MASH* TL-3 Tests on Multi-directional Base Design for Large Sign Supports.

The crash tests and data analysis procedures were in accordance with guidelines presented in *MASH*. Chapter 6 presents brief descriptions of these procedures.

5.2. EVALUATION CRITERIA

The appropriate safety evaluation criteria from Tables 2-5 and 5-1 of *MASH* were used to evaluate the crash tests reported herein. Table 5.1 lists the test conditions and evaluation criteria required for *MASH* TL-3, and Table 5.2 provides detailed information on the evaluation criteria.

Table 5.2. Evaluation Criteria Required for *MASH* Testing.

Evaluation Factors	Evaluation Criteria
B.	The test article should readily activate in a predictable manner by breaking away, fracturing, or yielding.
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 10 ft/s, or maximum allowable value of 16 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.
N.	Vehicle trajectory behind the test article is acceptable.

CHAPTER 6. TEST CONDITIONS

6.1. TEST FACILITY

The full-scale crash tests reported herein were 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 tests were 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 a 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. For this soil embedded testing, sections of the concrete apron were removed, and the concrete footings were installed within soil.

6.2. VEHICLE TOW AND GUIDANCE SYSTEM

For the testing utilizing the 1100C and 2270P vehicles, each vehicle 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. For test 616401-01-1, a 1:1 speed ratio between the test and tow vehicle existed with this system. For all other tests, 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.

6.3. DATA ACQUISITION SYSTEMS

6.3.1. Vehicle Instrumentation and Data Processing

Each 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 *MASH* recommended version of 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 ENDEVCOÒ 2901 precision primary vibration standard. This standard and its support instruments are checked annually and receive a calibration traceable to the International System of Units (SI). Measurement Uncertainties have been determined for critical parameters involved in this testing, and are available upon request by the Sponsor.

TRAP uses the DAS-captured data to compute the occupant to vehicle contact impact velocities, time of occupant to vehicle contact 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. Measurement Uncertainties have been determined for critical parameters involved in this testing, and are available upon request by the Sponsor.

6.3.2. Anthropomorphic Dummy Instrumentation

An Alderson Research Laboratories Hybrid II, 50th percentile male anthropomorphic dummy, restrained with lap and shoulder belts, was placed in the front seat on the passenger side of the 1100C vehicle. The dummy was not instrumented.

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

6.3.3. Photographic Instrumentation Data Processing

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

- One placed with a field of view perpendicular to the impact path and in-line with the point of impact
- One placed downstream from the impact point at an oblique angle to the impact path

A flashbulb on the impacting vehicle was activated by a pressure-sensitive tape switch to indicate the instant of contact with the test article. 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 each test vehicle and the installation before and after the test.

CHAPTER 7. *MASH* TEST 3-60 (CRASH TEST 616401-01-1)

7.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 7.1 for details of *MASH* impact conditions for this test and Table 7.2 for the exit parameters. Figure 7-1 and Figure 7-2 depict the target impact setup.

Table 7.1. Impact Conditions for *MASH TEST 3-60,* Crash Test 616401-01-1.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	19 mi/h	±2.5 mi/h	18.8 mi/h
Impact Angle	0°	±1.5°	0°
Kinetic Energy	34 kip-ft	≤34 kip-ft	29.1 kip-ft
Impact Location	Centerline of the vehicle aligned with the centerline of sign	±6 inches	Centerline of the vehicle aligned with the centerline of sign

Table 7.2. Exit Parameters for *MASH TEST 3-60,* Crash Test 616401-01-1.

Exit Parameter	Measured
Speed	14.4mi/h
Brakes applied post impact	>5 seconds
Vehicle at rest position	187 ft downstream of impact point In line relative to the impact path
Comments:	Vehicle remained upright and stable

Figure 7-1. Route Marker Assembly Sign with Large Sign Supports /Test Vehicle Geometrics for Test 616401-01-1.

Figure 7-2. Route Marker Assembly Sign with Large Sign Supports /Test Vehicle Impact Location 616401-01-1.

7.2. WEATHER CONDITIONS

Table 7.3 provides the weather conditions for 616401-01-1.

Table 7.3. Weather Conditions 616401-01-1.

Date of Test	2023-05-04
Wind Speed	8 mi/h
Wind Direction	83°
Temperature	72 °F
Relative Humidity	86 %
Vehicle Traveling	170°

7.3. TEST VEHICLE

Figure 7-3 and Figure 7-4 show the 2019 Nissan Versa used for the crash test. Table 7.4 shows the vehicle measurements. Figure C.1 in Appendix C.1 gives additional dimensions and information on the vehicle.

Figure 7-3. Impact Side of Test Vehicle before Test 616401-01-1.

Figure 7-4. Rear of the Test Vehicle before Test 616401-01-1.

Table 7.4. Vehicle Measurements for Test 616401-01-1.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	165 lb
Inertial Mass	2420 lb	±55 lb	2464 lb
Gross Static[a] Mass	2585 lb	±55 lb	2629 lb
Wheelbase	98 inches	±5 inches	102.4 inches
Front Overhang	35 inches	±4 inches	32.5 inches
Overall Length	169 inches	±8 inches	175.4 inches
Overall Width	65 inches	±3 inches	66.7 inches
Hood Height	28 inches	±4 inches	30.5 inches
Track Width[b]	59 inches	±2 inches	58.4 inches
CG aft of Front Axle[c]	39 inches	±4 inches	41.5 inches
CG above Ground[c,d]	N/A inches	N/A inches	N/A inches

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.

7.4. TEST DESCRIPTION

Table 7.5 lists events that occurred during Test 616401-01-1. Figures C.4 and C.5 in Appendix C.2 present sequential photographs during the test.

Table 7.5. Events during Test 616401-01-1.

Time	Events
0.0000 s	Vehicle impacted the installation
0.0190 s	Right (passenger side) support base released
0.0240 s	Left (driver side) support base released
0.6920 s	Sign contacted roof of car

7.5. DAMAGE TO TEST INSTALLATION

The sign released at the slip base and remained on top of the car. The second from the bottom through the fourth from the bottom stiffeners were deformed. Figure 7-5 and Figure 7-6 show the damage to the Route Marker Assembly Sign with Large Sign Supports.

Figure 7-5. Route Marker Assembly Sign with Large Sign Supports after Test 616401-01-1.

Figure 7-6. Footers for the Route Marker Assembly Sign with Large Sign Supports after Test 616401-01-1.

7.6. DAMAGE TO TEST VEHICLE

Figure 7-7 through Figure 7-9 show the damage sustained by the vehicle. and Figure 7-10 shows the interior of the test vehicle. Table 7.6 and Table 7.7 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 7-7. Impact Side of Test Vehicle after Test 616401-01-1.

Figure 7-8. Rear of Test Vehicle after Test 616401-01-1.

Figure 7-9. Test Vehicle Windshield Damage after Test 616401-01-1.

Figure 7-10. Interior Roof of Test Vehicle after Test 616401-01-1.

Table 7.6. Occupant Compartment Deformation 616401-01-1.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	2.5 inches
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 lateral inches	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 7.7. Exterior Vehicle Damage 616401-01-1.

Side Windows	Side windows remained intact
Maximum Exterior Deformation	2.5 inches in the top plane at the roof of the vehicle
VDS	12FC1
CDC	12FCHW1
Fuel Tank Damage	None
Description of Damage to Vehicle:	The windshield had a 2-inch wide× 1.5-inch long orbital fracture on the driver's side at the top, and a 2.5-inch wide × 2-inch long orbital fracture in the middle at the top, but neither had a hole. The roof had a 2-inch dent in the front and a 2.5-inch dent at the rear. The bumper cover was fractured, and the back glass shattered due to the flexing of the roof and the weight of the sign on the glass, but there was no penetration of the test article into the occupant compartment. The rear spoiler was released from the vehicle, and there were two small dents on the trunk lid.

7.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 7.8. 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 7.8. Occupant Risk Factors for Test 616401-01-1.

Test Parameter	Specification [a]	Measured	Time
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	5.8 ft/s	0.3631 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	0.3 ft/s	0.3631 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	1.6 g	0.6878 - 0.6978 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	0.8 g	0.6916 - 0.7016 seconds
Theoretical Head Impact Velocity (THIV)	N/A	1.8 m/s	0.3631 seconds on front of interior
Acceleration Severity Index	N/A	0.4	0.7850 - 0.8350 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-3.3 g	0.0053 - 0.0553 seconds
50-ms MA Lateral	N/A	-0.4 g	0.7330 - 0.7830 seconds
50-ms MA Vertical	N/A	-3.9 g	0.7593 - 0.8093 seconds
Roll	≤75°	1.8°	1.7065 seconds
Pitch	≤75°	3.2°	1.8961 seconds
Yaw	N/A	0.7°	2.0000 seconds

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

7.8. TEST SUMMARY

Figure 5.11 summarizes the results of *MASH* Test 616401-01-1. The Route Marker Assembly sign met the *MASH* criteria for *MASH* test 3-60.

0.000 s

0.300 s

0.600 s

0.900 s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-60
Project No.:	616401-01-1
Test Date:	2023-05-04

TEST ARTICLE	
Type:	Support Structures
Name:	Route Marker Assembly Sign with Large Sign Supports
Length:	22 feet and 11 inches
Key Materials:	Aluminum signs, steel posts, steel slip bases, concrete footings
Soil Type and Condition:	Native Soil, dry

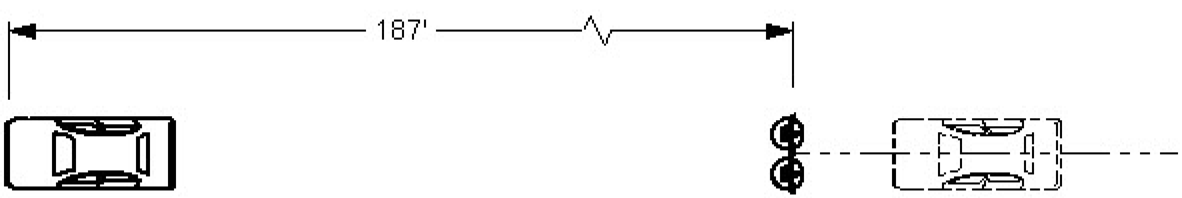
TEST VEHICLE	
Type/Designation:	1100C
Year, Make and Model:	2019 Nissan Versa
Inertial Mass:	2464 lb
Dummy Mass:	165 lb
Gross Static Mass:	2629 lb

IMPACT CONDITIONS	
Impact Speed:	18.8 mi/h
Impact Angle:	0°
Impact Location:	Centerline of the vehicle aligned with the centerline of sign
Kinetic Energy:	29.1 kip-ft

EXIT CONDITIONS	
Exit Speed:	14.4mi/h
Stopping Distance:	187 ft downstream In line

VEHICLE DAMAGE	
VDS:	12FC1
CDC:	12FCHW1
Max Exterior Deformation:	2.5 inches
Max Occupant Compartment Deformation:	2.5 inches in the roof

Occupant Risk Values	
Long. OIV	5.8 ft/s
Lat. OIV	0.3 ft/s
Long. Ridedown	1.6 g
Lat. Ridedown	0.8 g
THIV	1.8 m/s
ASI	0.4
Max 50-ms Long.	-3.3 g
Max 50-ms Lat.	-0.4 g
Max 50-ms Vert.	-3.9 g
Max Roll	1.8°
Max Pitch	3.2°
Max Yaw	0.7°



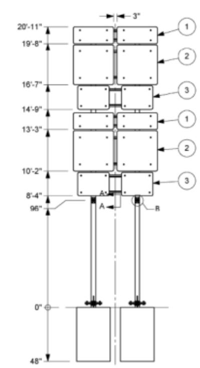


Figure 7-11. Summary of Results for *MASH* Test 3-60 on Route Marker Assembly Sign with Large Sign Supports.

CHAPTER 8. *MASH* TEST 3-61 (CRASH TEST 616401-01-2)

8.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 8.1 for details of *MASH* impact conditions for this test and Table 8.2 for the exit parameters. Figure 8-1 and Figure 8-2 depict the target impact setup.

Table 8.1. Impact Conditions for *MASH* TEST 3-61, Crash Test 616401-01-2.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	62 mi/h	±2.5 mi/h	62.8 mi/h
Impact Angle	90°	±1.5°	90°
Kinetic Energy	288 kip-ft	≥288 kip-ft	320 kip-ft
Impact Location	Centerline of the vehicle aligned with the centerline of the sign posts	±6 inches	Centerline of the vehicle aligned with the centerline of the sign posts

Table 8.2. Exit Parameters for *MASH* TEST 3-61, Crash Test 616401-01-2.

Exit Parameter	Measured
Speed	54.3mi/h
Brakes applied post impact	1.9 seconds
Vehicle at rest position	236 ft downstream of impact point 2 ft to the left
Comments:	Vehicle remained upright and stable

Figure 8-1. Route Marker Assembly Sign with Large Sign Supports /Test Vehicle Geometrics for Test 616401-01-2.

Figure 8-2. Route Marker Assembly Sign with Large Sign Supports /Test Vehicle Impact Location 616401-01-2.

8.2. WEATHER CONDITIONS

Table 8.3 provides the weather conditions for 616401-01-2.

Table 8.3. Weather Conditions 616401-01-2.

Date of Test	2023-05-04
Wind Speed	10 mi/h
Wind Direction	81°
Temperature	74 °F
Relative Humidity	88 %
Vehicle Traveling	170°

8.3. TEST VEHICLE

Figure 8-3 and Figure 8-4 show the 2018 Nissan Versa used for the crash test. Table 8.4 shows the vehicle measurements. Figure D.1 in Appendix D.1 gives additional dimensions and information on the vehicle.

Figure 8-3. Impact Side of the Test Vehicle before Test 616401-01-2.

Figure 8-4. Rear of the Test Vehicle before Test 616401-01-2.

Table 8.4. Vehicle Measurements 616401-01-2.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	165 lb
Inertial Mass	2420 lb	±55 lb	2427 lb
Gross Static[a] Mass	2585 lb	±55 lb	2592 lb
Wheelbase	98 inches	±5 inches	102.4 inches
Front Overhang	35 inches	±4 inches	32.5 inches
Overall Length	169 inches	±8 inches	175.4 inches
Overall Width	65 inches	±3 inches	66.7 inches
Hood Height	28 inches	±4 inches	30.5 inches
Track Width[b]	59 inches	±2 inches	58.4 inches
CG aft of Front Axle[c]	39 inches	±4 inches	42.7 inches
CG above Ground[c,d]	N/A inches	N/A inches	N/A inches

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.

8.4. TEST DESCRIPTION

Table 8.5 lists events that occurred during Test 616401-01-2. Figures D.4 and D.5 in Appendix D.2 present sequential photographs during the test.

Table 8.5. Events during Test 616401-01-2.

Time (s)	Events
0.0000 s	Vehicle impacted the installation
0.0150 s	The impact support base released
0.0440 s	The downstream support released

8.5. DAMAGE TO TEST INSTALLATION

The impact sign post came rest at 138 feet downstream, and the downstream post at 8 feet downstream of impact. The two small signs on stiffeners stopped at 25 feet downstream and 9 feet to the right of impact. The rest of the signs came to rest 36 feet downstream. Figure 8-5 and Figure 8-6 show the damage to the Route Marker Assembly Sign with Large Sign Supports.

Figure 8-5. Route Marker Assembly Sign with Large Sign Supports after Test 616401-01-2.

Figure 8-6. Footers for the Route Marker Assembly Sign with Large Sign Supports after Test 616401-01-2.

8.6. DAMAGE TO TEST VEHICLE

Figure 8-7 through Figure 8-9 show the damage sustained by the vehicle. Figure 8-10 shows the interior of the test vehicle. Table 8.6 and Table 8.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures D.2 and D.3 in Appendix D.1 provide exterior crush and occupant compartment measurements.

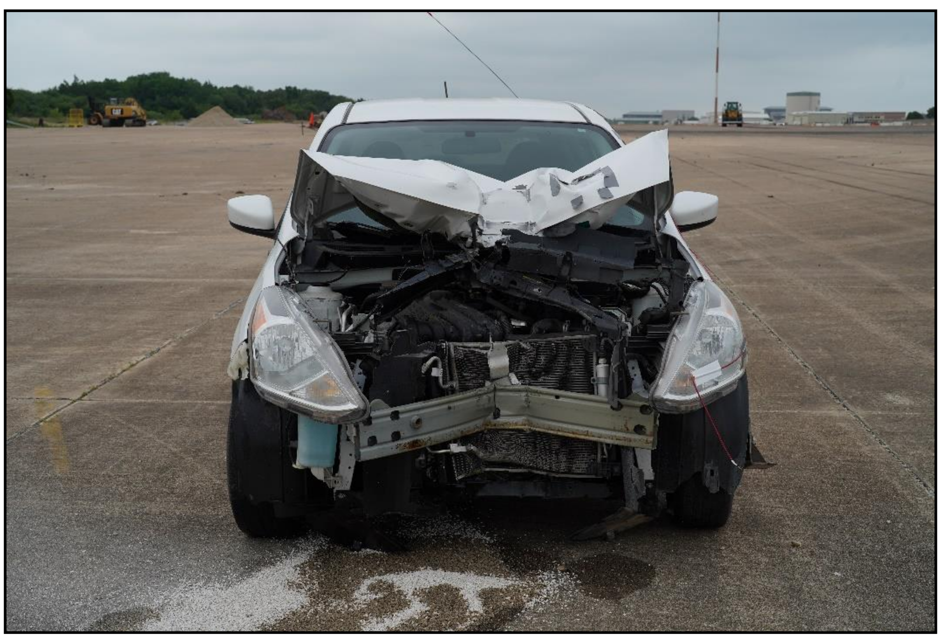


Figure 8-7. Impact Side of Test Vehicle after Test 616401-01-2.

Figure 8-8. Rear of the Test Vehicle after Test 616401-01-2.

Figure 8-9. Roof of the Test Vehicle after Test 616401-01-2.

Figure 8-10. Interior of Test Vehicle on after Test 616401-01-2.

Table 8.6. Occupant Compartment Deformation 616401-01-2.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	0 inches
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 8.7. Exterior Vehicle Damage 616401-01-2.

Side Windows	Side windows remained intact
Maximum Exterior Deformation	16 inches in the front plane at the front bumper
VDS	12FC6
CDC	12FCMN5
Fuel Tank Damage	None
Description of Damage to Vehicle:	There were fractures in the lower left corner of the windshield. Exterior deformation of the front bumper, grill, and hood pushed the fan into the engine, and the radiator was damaged.

8.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 8.8. Figure D.6 in Appendix D.3 shows the vehicle angular displacements, and Figures D.7 through D.9 in Appendix D.4 show acceleration versus time traces.

Table 8.8. Occupant Risk Factors for Test 616401-01-2.

Test Parameter	***Specification*** [a]	Measured	Time
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	10.4 ft/s	0.2284 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	0.0 ft/s	0.2284 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	0.8 g	0.2438 - 0.2538 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	0.5 g	0.2335 - 0.2435 seconds
Theoretical Head Impact Velocity (THIV)	N/A	3.2 m/s	0.2291 seconds on front of interior
Acceleration Severity Index	N/A	0.4	0.0299 - 0.0799 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-5.3 g	0.0229 - 0.0729 seconds
50-ms MA Lateral	N/A	0.8 g	0.0717 - 0.1217 seconds
50-ms MA Vertical	N/A	-4.3 g	0.0325 - 0.0825 seconds
Roll	≤75°	0.8°	1.4999 seconds
Pitch	≤75°	7.8°	1.4989 seconds
Yaw	N/A	7.7°	1.4999 seconds

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

8.8. TEST SUMMARY

Figure 6.11 summarizes the results of *MASH* Test 616401-01-2. The Route Marker Assembly sign met the *MASH* criteria for *MASH* test 3-61.

0.000 s

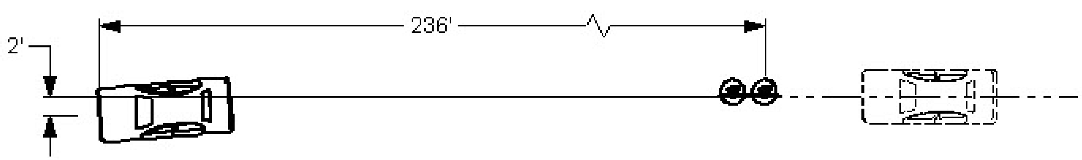
0.100 s

0.200 s

0.300 s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-61
Project No.:	616401-01-2
Test Date:	2023-05-04
TEST ARTICLE	
Type:	Support Structures
Name:	Route Marker Assembly Sign with Large Sign Supports
Length:	22 feet and 11 inches
Key Materials:	Aluminum signs, steel posts, steel slip bases, concrete footings
Soil Type and Condition:	Native Soil, dry
TEST VEHICLE	
Type/Designation:	1100C
Year, Make and Model:	2018 Nissan Versa
Inertial Mass:	2427 lb
Dummy Mass:	165 lb
Gross Static Mass:	2592 lb
IMPACT CONDITIONS	
Impact Speed:	62.8 mi/h
Impact Angle:	90°
Impact Location:	Centerline of the vehicle aligned with the centerline of the sign posts
Kinetic Energy:	320 kip-ft

EXIT CONDITIONS	
Exit Speed:	54.3mi/h
Stopping Distance:	236 ft downstream 2 ft to the left side
VEHICLE DAMAGE	
VDS:	12FC6
CDC:	12FCMN5
Max Exterior Deformation:	16 inches
Max Occupant Compartment Deformation:	No occupant compartment deformation
Occupant Risk Values	
Long. OIV	10.4 ft/s
Lat. OIV	0.0 ft/s
Long. Ridedown	0.8 g
Lat. Ridedown	0.5 g
THIV	3.2 m/s
ASI	0.4
Max 50-ms Long.	-5.3 g
Max 50-ms Lat.	0.8 g
Max 50-ms Vert.	-4.3 g
Max Roll	0.8°
Max Pitch	7.8°
Max Yaw	7.7°



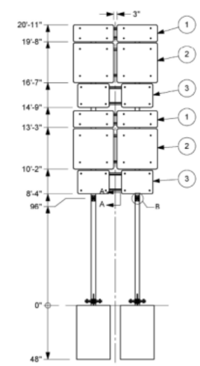


Figure 8-11. Summary of Results for *MASH* Test 3-61 on Route Marker Assembly Sign with Large Sign Supports.

CHAPTER 9. *MASH* TEST 3-62 (CRASH TEST 616401-01-3)

9.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 9.1 for details of *MASH* impact conditions for this test and Table 9.2 for the exit parameters. Figure 9-1 and Figure 9-2 depict the target impact setup.

Table 9.1. Impact Conditions for *MASH* TEST 3-62, Crash Test 616401-01-3.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	62 mi/h	±2.5 mi/h	62.9 mi/h
Impact Angle	90°	±1.5°	90°
Kinetic Energy	594 kip-ft	≥594 kip-ft	664.2 kip-ft
Impact Location	Centerline of the vehicle aligned with the centerline of the sign posts	±6 inches	Centerline of the vehicle aligned with the centerline of the sign posts

Table 9.2. Exit Parameters for *MASH* TEST 3-62, Crash Test 616401-01-3.

Exit Parameter	Measured
Speed	55.1 mi/h
Brakes applied post impact	1.6 seconds
Vehicle at rest position	265 ft downstream of impact point 2 ft to the left
Comments:	Vehicle remained upright and stable

Figure 9-1. Guide Sign with Large Sign Supports /Test Vehicle Geometrics for Test 616401-01-3.

Figure 9-2. Guide Sign with Large Sign Supports /Test Vehicle Impact Location 616401-01-3.

9.2. WEATHER CONDITIONS

Table 9.3 provides the weather conditions for 616401-01-3.

Table 9.3. Weather Conditions 616401-01-3.

Date of Test	2023-05-04
Wind Speed	5 mi/h
Wind Direction	57°
Temperature	80 °F
Relative Humidity	79 %
Vehicle Traveling	170°

9.3. TEST VEHICLE

Figure 9-3 and Figure 9-4 show the 2017 RAM 1500 used for the crash test. Table 9.4 shows the vehicle measurements. Figure E.1 in Appendix E.1 gives additional dimensions and information on the vehicle.

Figure 9-3. Impact Side of Test Vehicle before Test 616401-01-3.

Figure 9-4. Rear of the Test Vehicle before Test 616401-01-3.

Table 9.4. Vehicle Measurements 616401-01-3.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	N/A
Inertial Mass	5000 lb	±110 lb	5022 lb
Gross Static[a] Mass	5000 lb	±110 lb	5022 lb
Wheelbase	148 inches	±12 inches	140.5 inches
Front Overhang	39 inches	±3 inches	40 inches
Overall Length	237 inches	±13 inches	227.5 inches
Overall Width	78 inches	±2 inches	78.5 inches
Hood Height	43 inches	±4 inches	46 inches
Track Width[b]	67 inches	±1.5 inches	68.3 inches
CG aft of Front Axle[c]	63 inches	±4 inches	61.6 inches
CG above Ground[c,d]	28 inches	≥28 inches	28.5 inches

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.

9.4. TEST DESCRIPTION

Table 9.5 lists events that occurred during Test 616401-01-3. Figures E.4 and E.5 in Appendix E.2 present sequential photographs during the test.

Table 9.5. Events during Test 616401-01-3.

Time (s)	Events
0.0000 s	Vehicle impacted the installation
0.0070 s	The impact support post base released
0.0940 s	Front lower corner of sign impacted roof
0.1290 s	The downstream support post base released

9.5. DAMAGE TO TEST INSTALLATION

The post assemblies released from the sign panel assembly, and the sign panel assembly came to rest 95 feet downstream and 35 feet to the left of impact. The upper support posts released from the lower support posts, with one upper post coming to rest 45 feet downstream and 4 feet to the right of impact. The second upper post stopped at 137 feet downstream and 6 feet to the right. One lower post came to rest 265 feet downstream and 45 feet to the right of impact. The second lower post stopped at 358 feet downstream and 17 feet to the left. The downstream slip base bent downstream and was raised 1.5 inches above the installed height on impact side. Figure 9-5 and Figure 9-6 show the damage to the Guide Sign with Large Sign Supports.

Figure 9-5. Guide Sign with Large Sign Supports at Impact Location after Test 616401-01-3.

Figure 9-6. Footer for the Guide Sign with Large Sign Supports after Test 616401-01-3.

9.6. DAMAGE TO TEST VEHICLE

Figure 9-7 through Figure 9-9 show the damage sustained by the vehicle. Figure 9-10 shows the interior of the test vehicle. Table 9.6 and Table 9.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures E.2 and E.3 in Appendix E.1 provide exterior crush and occupant compartment measurements.

Figure 9-7. Impact Side of Test Vehicle after Test 616401-01-3.

Figure 9-8. Rear of the Test Vehicle after Test 616401-01-3.

Figure 9-9. Roof of the Test Vehicle after Test 616401-01-3.

Figure 9-10. Interior of Test Vehicle after Test 616401-01-3.

Table 9.6. Occupant Compartment Deformation 616401-01-3.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	6.5 inches
Windshield	≤3.0 inches	5 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 9.7. Exterior Vehicle Damage 616401-01-3.

Side Windows	Side windows remained intact
Maximum Exterior Deformation	15 inches in the front plane at the front bumper
VDS	12FC5
CDC	12FCHW5
Fuel Tank Damage	None
Description of Damage to Vehicle:	There were multiple tears on the exterior of the vehicle. The hood had a 3-inch wide × 19-inch long tear. The roof had a 1-inch wide× 10-inch long tear in the center near the front, a 1-inch wide × 2-inch long tear on the front right near the center, a 2-inch wide × 7-inch long tear on the front left near the center, and 5.5-inch wide × 17-inch long rip near the rear. The front bumper released from the vehicle, and the grill and radiator were fractured and deformed, which caused the fan to push into the engine block. The right and left headlights released from the vehicle, and the hood latch released, resulting in the hood flying into the windshield. The windshield was severely fractured and deformed 5 inches into occupant compartment, and the rear windshield was shattered.

9.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 9.8. Figure E.6 in Appendix E.3 shows the vehicle angular displacements, and Figures E.7 through E.9 in Appendix E.4 show acceleration versus time traces.

Table 9.8. Occupant Risk Factors for Test 616401-01-3.

Test Parameter	***Specification*** [a]	**Measured**	**Time**
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	10.9 ft/s	0.2923 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	1.2 ft/s	0.2923 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	0.9 g	0.2923 - 0.3023 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	1.1 g	0.3728 - 0.3828 seconds
Theoretical Head Impact Velocity (THIV)	N/A	3.4 m/s	0.2925 seconds on front of interior
Acceleration Severity Index	N/A	0.3	0.1312 - 0.1812 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-3.2 g	0.0999 - 0.1499 seconds
50-ms MA Lateral	N/A	-0.7 g	0.3060 - 0.3560 seconds
50-ms MA Vertical	N/A	-2 g	0.1401 - 0.1901 seconds
Roll	≤75°	2.4°	1.4453 seconds
Pitch	≤75°	3.8°	0.3674 seconds
Yaw	N/A	3.4°	1.5000 seconds

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

9.8. TEST SUMMARY

Figure 9-11 summarizes the results of *MASH* Test 616401-01-3. Due to the 6.5 inch deformation in the roof exceeding the *MASH* limit of 4 inches, and the penetration of the test article through the roof, the guide sign with large sign supports failed to meet *MASH* Criteria D for *MASH* test 3-62.


0.000 s

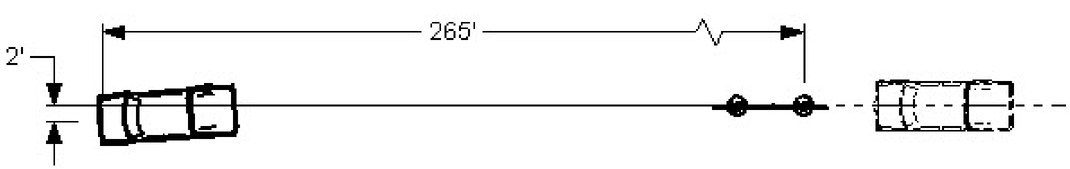

0.100


0.200 s


0.300 s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-62
Project No.:	616401-01-3
Test Date:	2023-05-04
TEST ARTICLE	
Type:	Support Structures
Name:	Guide Sign with Large Sign Supports
Length:	13 feet 4 inches
Key Materials:	Aluminum signs, steel posts, steel slip bases, concrete footings
Soil Type and Condition:	Native Soil, dry
TEST VEHICLE	
Type/Designation:	2270P
Year, Make and Model:	2017 RAM 1500
Inertial Mass:	5022 lb
Dummy Mass:	N/A
Gross Static Mass:	5022 lb
IMPACT CONDITIONS	
Impact Speed:	62.9 mi/h
Impact Angle:	90°
Impact Location:	Centerline of the vehicle aligned with the centerline of the sign posts
Kinetic Energy:	664.2 kip-ft

EXIT CONDITIONS	
Exit Speed:	55.1mi/h
Stopping Distance:	265 ft downstream left ft to the 2 side
VEHICLE DAMAGE	
VDS:	12FC5
CDC:	12FCHW5
Max Exterior Deformation:	15 inches
Max Occupant Compartment Deformation:	6.5 inches in the roof
Occupant Risk Values	
Long. OIV	10.9 ft/s
Lat. OIV	1.2 ft/s
Long. Ridedown	0.9 g
Lat. Ridedown	1.1 g
THIV	3.4 m/s
ASI	0.3
Max 50-ms Long.	-3.2 g
Max 50-ms Lat.	-0.7 g
Max 50-ms Vert.	-2 g
Max Roll	2.4°
Max Pitch	3.8°
Max Yaw	3.4°



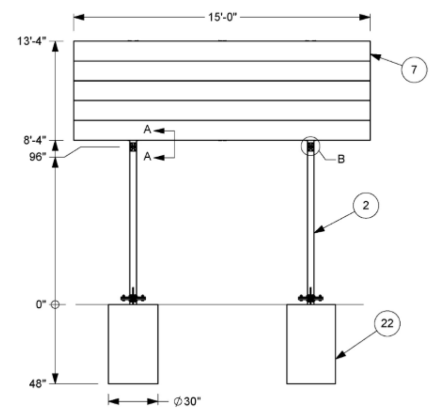


Figure 9-11. Summary of Results for *MASH* Test 3-62 on Guide Sign with Large Sign Supports.

CHAPTER 10. *MASH* TEST 3-62 (CRASH TEST 616401-01-9)

10.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 10.1 for details of *MASH* impact conditions for this test and Table 10.2 for the exit parameters. Figure 10-1 and Figure 10-2 depict the target impact setup.

Table 10.1. Impact Conditions for *MASH* TEST 3-62, Crash Test 616401-01-9.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	62 mi/h	±2.5 mi/h	63.2 mi/h
Impact Angle	90°	±1.5°	90°
Kinetic Energy	594 kip-ft	≥594 kip-ft	670.6 kip-ft
Impact Location	Centerline of the vehicle aligned with the centerline of the sign posts	±6 inches	Centerline of the vehicle aligned with the centerline of the sign post

Table 10.2. Exit Parameters for *MASH* TEST 3-62, Crash Test 616401-01-9.

Exit Parameter	Measured
Speed	54.4mi/h
Brakes applied post impact	1.5 seconds
Vehicle at rest position	279 ft downstream of impact point 9 ft to the left
Comments:	Vehicle remained upright and stable

Figure 10-1. Guide Sign with Large Sign Supports /Test Vehicle Geometrics for Test 616401-01-9.

Figure 10-2. Guide Sign with Large Sign Supports /Test Vehicle Impact Location 616401-01-9.

10.2. WEATHER CONDITIONS

Table 10.3 provides the weather conditions for 616401-01-9.

Table 10.3. Weather Conditions 616401-01-9.

Date of Test	2023-09-25
Wind Speed	6 mi/h
Wind Direction	100°
Temperature	78 °F
Relative Humidity	91 %
Vehicle Traveling	170°

10.3. TEST VEHICLE

Figure 10-3 and Figure 10-4 show the 2017 RAM 1500 used for the crash test. Table 10.4 shows the vehicle measurements. Figure H.1 in Appendix H.1 gives additional dimensions and information on the vehicle.

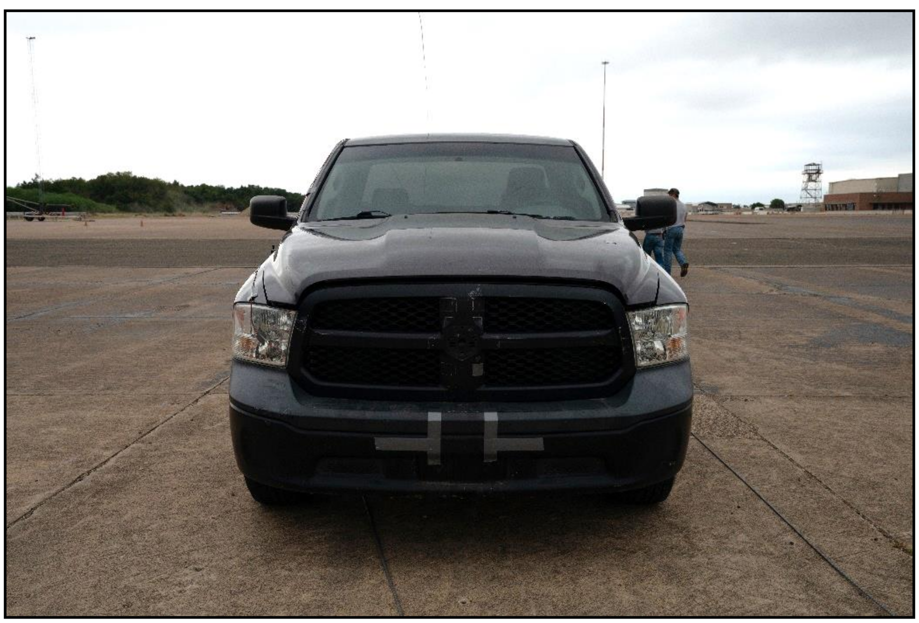


Figure 10-3. Impact Side of Test Vehicle before Test 616401-01-9.

Figure 10-4. Rear of the Test Vehicle before Test 616401-01-9.

Table 10.4. Vehicle Measurements 616401-01-9.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	N/A
Inertial Mass	5000 lb	±110 lb	5022 lb
Gross Static[a] Mass	5000 lb	±110 lb	5022 lb
Wheelbase	148 inches	±12 inches	140.5 inches
Front Overhang	39 inches	±3 inches	40 inches
Overall Length	237 inches	±13 inches	227.5 inches
Overall Width	78 inches	±2 inches	78.5 inches
Hood Height	43 inches	±4 inches	46 inches
Track Width[b]	67 inches	±1.5 inches	68.3 inches
CG aft of Front Axle[c]	63 inches	±4 inches	61.2 inches
CG above Ground[c,d]	28 inches	28 inches	28.4 inches

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.

10.4. TEST DESCRIPTION

Table 10.5 lists events that occurred during Test 616401-01-9. Figures H.4 and H.5 in Appendix H.2 present sequential photographs during the test.

Table 10.5. Events during Test 616401-01-9.

Time (s)	Events
0.0000 s	Vehicle impacted the installation
0.0050 s	The impact support post base began to release
0.0890 s	The impact support post contacted the downstream support post approximately 50 inches up from base
0.0940 s	The downstream support post base began to bend
0.1310 s	The downstream support post base began to release
0.3140 s	Vehicle exited the impact site at 55.4 mi/h with the downstream lower support post trapped under the vehicle

10.5. DAMAGE TO TEST INSTALLATION

The downstream footer was cracked, and the soil around it was disturbed. The upstream anchor bolt and the fuse plate did not release from the impact footer, and the downstream footer was bent downstream. The sign panel assembly and downstream upper support posts came to rest 32 feet downstream and 8 feet to the right. The lower downstream support post stopped at 188 feet downstream and 3 feet to the left. The lower impact support post came to rest 376 feet downstream. This post was deformed in the middle with tearing and scuffing. Figure 10-5 and Figure 10-6 show the damage to the Guide Sign with Large Sign Supports.

Figure 10-5. Guide Sign with Large Sign Supports at Impact Location after Test 616401-01-9.

Figure 10-6. Footer for the Guide Sign with Large Sign after Test 616401-01-9.

10.6. DAMAGE TO TEST VEHICLE

Figure 10-7 through Figure 10-10 show the damage sustained by the vehicle. Figure 10-11 shows the interior of the test vehicle. Table 10.6 and

Table 10.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures H.2 and H.3 in Appendix H.1 provide exterior crush and occupant compartment measurements.

Figure 10-7. Impact Side of Test Vehicle after Test 616401-01-9.

Figure 10-8. Roof of the Test Vehicle after Test 616401-01-9.

Figure 10-9. Detail of Roof Damage on the Test Vehicle after Test 616401-01-9.

Figure 10-10. Test Vehicle Windshield Damage after Test 616401-01-9.

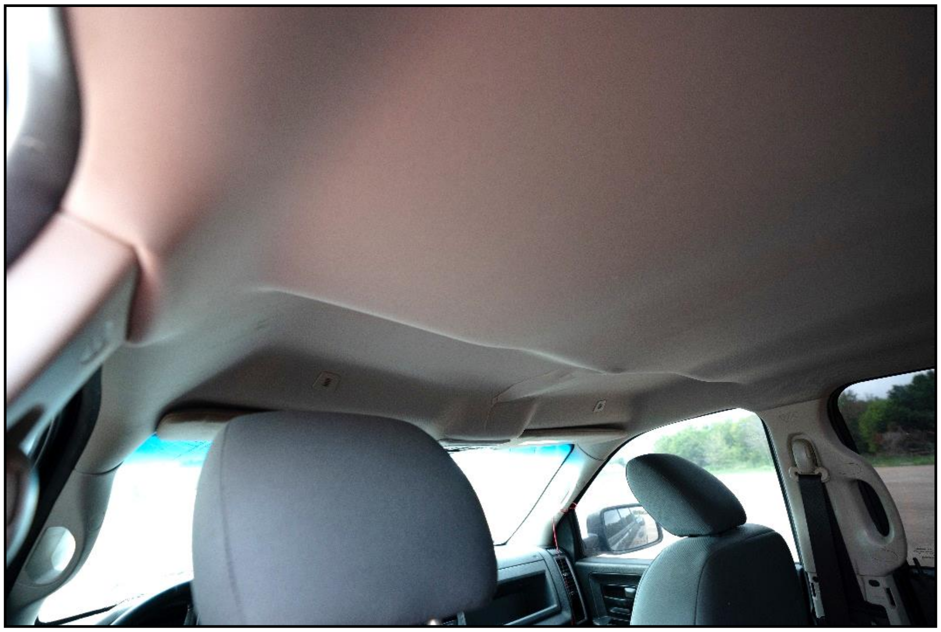


Figure 10-11. Interior of the Test Vehicle after Test 616401-01-9.

Table 10.6. Occupant Compartment Deformation 616401-01-9.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	2 inches
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 10.7. Exterior Vehicle Damage 616401-01-9.

Side Windows	Side windows remained intact
Maximum Exterior Deformation	9 inches in the front plane at the front bumper
VDS	12FC5
CDC	12FCAW3
Fuel Tank Damage	None
Description of Damage to Vehicle:	The windshield had a 3-inch wide × 1.5-inch long tear on the lower left side 5 inches from its base near the center along with a 1 inch deformation in the windshield. There were multiple tears on the exterior of the vehicle. The roof had a 1.3-inch wide × 19-inch long tear 25 inches from the front of the windshield and 21 inches across from the left front door, an 18-inch wide × 1.5-inch long tear 24 inches from front of windshield 25 inches across from left front door, and a 7-inch wide × 1.3-inch long tear at the rear 17 inches away from left rear door. The bumper, grill, hood, radiator, and support were damaged, and the bumper frame and mounting brackets were bent. Both headlights were fractured, and the oil pan and drive shaft were dented.

10.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 10.8. Figure H.6 in Appendix H.3 shows the vehicle angular displacements, and Figures H.7 through H.9 in Appendix H.4 show acceleration versus time traces.

Table 10.8. Occupant Risk Factors for Test 616401-01-9.

Test Parameter	***Specification*** [a]	**Measured**	**Time**
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	12.7 ft/s	0.2706 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	0.2 ft/s	0.2706 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	6.9 g	0.6964 - 0.7064 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	0.8 g	0.7166 - 0.7266 seconds
Theoretical Head Impact Velocity (THIV)	N/A	3.9 m/s	0.2706 seconds on front of interior
Acceleration Severity Index	N/A	0.4	0.1601 - 0.2101 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-3.7 g	0.1097 - 0.1597 seconds
50-ms MA Lateral	N/A	0.5 g	0.8789 - 0.9289 seconds
50-ms MA Vertical	N/A	-3.8 g	0.1372 - 0.1872 seconds
Roll	≤75°	1.4°	0.2344 seconds
Pitch	≤75°	4.8°	0.2812 seconds
Yaw	N/A	2.7°	0.9962 seconds

a. Values in italics are the preferred *MASH* values

10.8. TEST SUMMARY

Figure 10-12 summarizes the results of *MASH* Test 616401-01-9. Due to the penetration of the installation into the roof the guide sign with large sign supports failed to meet *MASH* Criteria D for *MASH* test 3-62.


0.000 s

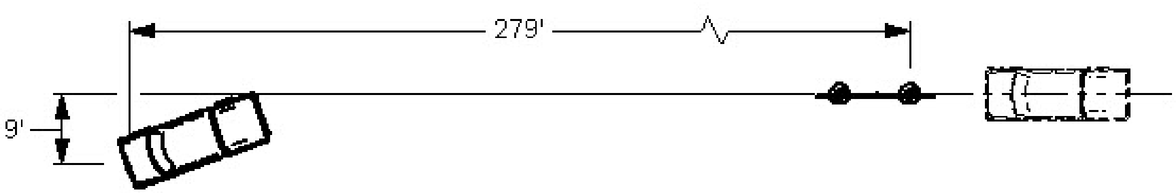

0.200 s


0.400 s


0.600 s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-62
Project No.:	616401-01-9
Test Date:	2023-09-25
TEST ARTICLE	
Type:	Support Structures
Name:	Guide Sign with Large Sign Supports
Length:	13 feet 4 inches
Key Materials:	Aluminum signs, steel posts, steel slip bases, concrete footings
Soil Type and Condition:	Native Soil, dry
TEST VEHICLE	
Type/Designation:	2270P
Year, Make and Model:	2017 RAM 1500
Inertial Mass:	5022 lb
Dummy Mass:	N/A
Gross Static Mass:	5022 lb
IMPACT CONDITIONS	
Impact Speed:	63.2 mi/h
Impact Angle:	90°
Impact Location:	Centerline of the vehicle aligned with the centerline of the sign post
Kinetic Energy:	670.6 kip-ft

EXIT CONDITIONS	
Exit Speed:	54.4mi/h
Stopping Distance:	279 ft downstream 9 ft to the left side
VEHICLE DAMAGE	
VDS:	12FC5
CDC:	12FCAW3
Max Exterior Deformation:	9 inches
Max Occupant Compartment Deformation:	2 inches in the roof
Occupant Risk Values	
Long. OIV	12.7 ft/s
Lat. OIV	0.2 ft/s
Long. Ridedown	6.9 g
Lat. Ridedown	0.8 g
THIV	3.9 m/s
ASI	0.4
Max 50-ms Long.	-3.7 g
Max 50-ms Lat.	0.5 g
Max 50-ms Vert.	-3.8 g
Max Roll	1.4°
Max Pitch	4.8°
Max Yaw	2.7°



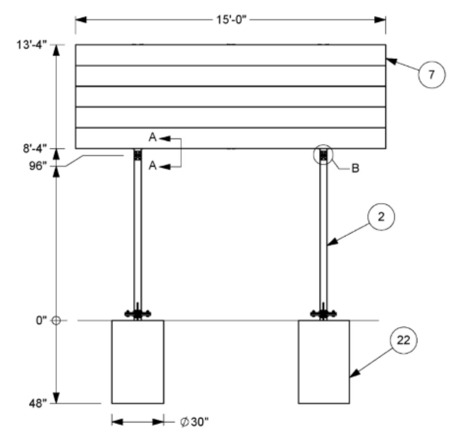


Figure 10-12. Summary of Results for *MASH* Test 3-62 on Guide Sign with Large Sign Supports.

CHAPTER 11. *MASH* TEST 3-62 (CRASH TEST 616401-01-4)

11.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 11.1 for details of *MASH* impact conditions for this test and Table 11.2 for the exit parameters. Figure 11-1 and Figure 11-2 depict the target impact setup.

Table 11.1. Impact Conditions for *MASH* TEST 3-62, Crash Test 616401-01-4.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	62 mi/h	±2.5 mi/h	62.0 mi/h
Impact Angle	90°	±1.5°	90°
Kinetic Energy	594 kip-ft	≥594 kip-ft	645.5 kip-ft
Impact Location	Centerline of the vehicle aligned with the centerline of the sign posts	±6 inches	Centerline of the vehicle aligned with the centerline of the sign posts

Table 11.2. Exit Parameters for *MASH* TEST 3-62, Crash Test 616401-01-4.

Exit Parameter	Measured
Speed	51.5 mi/h
Brakes applied post impact	2.2 seconds
Vehicle at rest position	279 ft downstream of impact point 9 ft to the left
Comments:	Vehicle remained upright and stable

Figure 11-1. Guide Sign with Large Sign Supports /Test Vehicle Geometrics for Test 616401-01-4.

Figure 11-2. Guide Sign with Large Sign Supports /Test Vehicle Impact Location 616401-01-4.

11.2. WEATHER CONDITIONS

Table 11.3 provides the weather conditions for 616401-01-4.

Table 11.3. Weather Conditions 616401-01-4.

Date of Test	2023-11-29
Wind Speed	2 mi/h
Wind Direction	173°
Temperature	50 °F
Relative Humidity	77 %
Vehicle Traveling	170°

11.3. TEST VEHICLE

Figure 11-3 and Figure 11-4 show the 2017 RAM 1500 used for the crash test. Table 11.4 shows the vehicle measurements. Figure F.1 in Appendix F.1 gives additional dimensions and information on the vehicle.

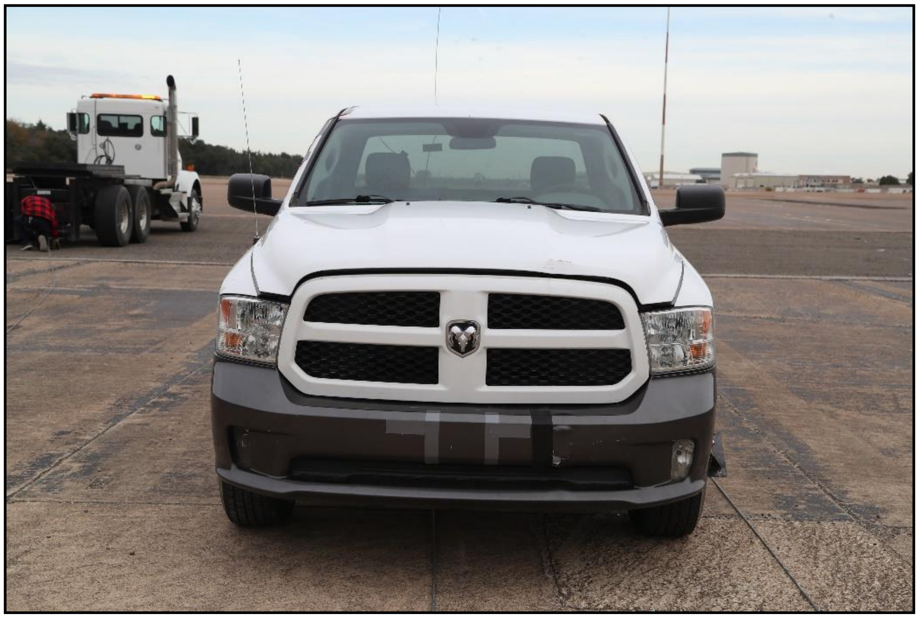


Figure 11-3. Impact Side of Test Vehicle before Test 616401-01-4.

Figure 11-4. Rear of the Test Vehicle before Test 616401-01-4.

Table 11.4. Vehicle Measurements 616401-01-4.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	N/A
Inertial Mass	5000 lb	±110 lb	5023 lb
Gross Static[a] Mass	5000 lb	±110 lb	5023 lb
Wheelbase	148 inches	±12 inches	140.5 inches
Front Overhang	39 inches	±3 inches	40 inches
Overall Length	237 inches	±13 inches	227.5 inches
Overall Width	78 inches	±2 inches	78.5 inches
Hood Height	43 inches	±4 inches	46 inches
Track Width[b]	67 inches	±1.5 inches	68.3 inches
CG aft of Front Axle[c]	63 inches	±4 inches	61.3 inches
CG above Ground[c,d]	28 inches	28 inches	28.6 inches

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.

11.4. TEST DESCRIPTION

Table 11.5 lists events that occurred during Test 616401-01-4. Figures F.4 and F.5 in Appendix F.2 present sequential photographs during the test.

Table 11.5. Events during Test 616401-01-4.

Time (s)	Events
0.0000 s	Vehicle impacted the installation
0.0070 s	The impact support post base began to release
0.0290 s	The impact support post fuse plate began to fracture
0.0840 s	The downstream support post fuse plate began to break
0.1360 s	The downstream support post base began to release
0.1730 s	The top of the impact support post impacted roof

11.5. DAMAGE TO TEST INSTALLATION

The lower impact support post came to rest 252 feet downstream and 25 feet to the right from impact. The lower downstream support post came to rest 312 feet downstream and 10 feet to the right. The lower downstream support post had a 10 inch bend 36 inches above the base with both impact side flanges torn. The upper impact support post released from the sign assembly and landed beneath the sign assembly 26 feet downstream and 3 feet right relative to impact. The downstream concrete had a 1-inch gap between the concrete and the soil on the impact side and the base was bent downstream. Figure 11-5 and Figure 11-6 show the damage to the Guide Sign with Large Sign Supports.

Figure 11-5. Guide Sign with Large Sign Supports at Impact Location after Test 616401-01-4.

Figure 11-6. Downstream Footer for the Guide Sign with Large Sign Supports after Test 616401-01-4.

11.6. DAMAGE TO TEST VEHICLE

Figure 11-7 through Figure 11-9 show the damage sustained by the vehicle. Figure 11-10 shows the interior of the test vehicle. Table 11.6 and Table 11.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures F.2 and F.3 in Appendix F.1 provide exterior crush and occupant compartment measurements.

Figure 11-7. Impact Side of Test Vehicle after Test 616401-01-4.

Figure 11-8. Rear of the Test Vehicle after Test 616401-01-4.

Figure 11-9. Roof of the Test Vehicle after Test 616401-01-4.

Figure 11-10. Interior of the Test Vehicle after Test 616401-01-4.

Table 11.6. Occupant Compartment Deformation 616401-01-4.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	1.3 inches
Windshield	≤3.0 inches	3 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 11.7. Exterior Vehicle Damage 616401-01-4.

Side Windows	Side windows remained intact
Maximum Exterior Deformation	13 inches in the front plane above the bumper
VDS	12FC3
CDC	12FCHW3
Fuel Tank Damage	None
Description of Damage to Vehicle:	The roof was damaged, with a 30-inch long × 30-inch wide × 1.3-inch deep dent, a 5-inch long × 0.8-inch wide tear 8 inches from the left rear door and 22 inches from the back of the cab, a 3.3-inch long × 0.8-inch wide tear 13 inches from the left rear door and 19 inches from the back of the cab, and a 5-inch long × 1-inch wide tear in the roof at the brake light, which was shattered. The headlights and tailgate released from the vehicle. The bumper, grill, radiator, and supports were deformed, causing the fan to push into the motor. The hood released from the latch and flew into the windshield, fracturing it and causing a deformation with a maximum depth of 3 inches.

11.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 11.8. Figure F.6 in Appendix F.3 shows the vehicle angular displacements, and Figures F.7 through F.9 in Appendix F.4 show acceleration versus time traces.

Table 11.8. Occupant Risk Factors for Test 616401-01-4.

Test Parameter	***Specification*** [a]	**Measured**	**Time**
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	12.4 ft/s	0.2776 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	1.3 ft/s	0.2776 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	3 g	0.2981 - 0.3081 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	1.5 g	1.4366 - 1.4466 seconds
Theoretical Head Impact Velocity (THIV)	N/A	3.8 m/s	0.2777 seconds on front of interior
Acceleration Severity Index	N/A	0.4	0.1854 - 0.2354 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-3.6 g	0.1358 - 0.1858 seconds
50-ms MA Lateral	N/A	-0.7 g	1.8334 - 1.8834 seconds
50-ms MA Vertical	N/A	-3.1 g	0.1752 - 0.2252 seconds
Roll	≤75°	7.2°	1.5751 seconds
Pitch	≤75°	7.2°	1.6510 seconds
Yaw	N/A	2.5°	2.0999 seconds

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

11.8. TEST SUMMARY

Figure 11-11 summarizes the results of *MASH* Test 616401-01-4. Due to the penetration of the post into the vehicle's roof, the guide sign with large sign supports failed to meet evaluation criteria D for *MASH* test 3-62.

0.000 s

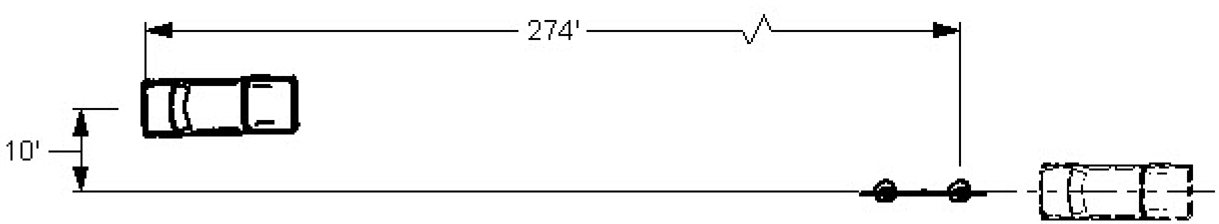
0.150 s

0.300 s

0.450 s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-62
Project No.:	616401-01-4
Test Date:	2023-11-29
TEST ARTICLE	
Type:	Support Structures
Name:	Guide Sign with Large Sign Supports
Length:	14 feet 4 inches
Key Materials:	Aluminum signs, steel posts, steel slip bases, concrete footings
Soil Type and Condition:	Native Soil, dry
TEST VEHICLE	
Type/Designation:	2270P
Year, Make and Model:	2017 RAM 1500
Inertial Mass:	5023 lb
Dummy Mass:	N/A
Gross Static Mass:	5023 lb
IMPACT CONDITIONS	
Impact Speed:	62.0 mi/h
Impact Angle:	90°
Impact Location:	Centerline of the vehicle aligned with the centerline of the sign posts
Kinetic Energy:	645.5 kip-ft

EXIT CONDITIONS	
Exit Speed:	51.5mi/h
Stopping Distance:	279 ft downstream 9 ft to the left side
VEHICLE DAMAGE	
VDS:	12FC3
CDC:	12FCHW3
Max Exterior Deformation:	13 inches
Max Occupant Compartment Deformation:	3 inches in the windshield
Occupant Risk Values	
Long. OIV	12.4 ft/s
Lat. OIV	1.3 ft/s
Long. Ridedown	3 g
Lat. Ridedown	1.5 g
THIV	3.8 m/s
ASI	0.4
Max 50-ms Long.	-3.6 g
Max 50-ms Lat.	-0.7 g
Max 50-ms Vert.	-3.1 g
Max Roll	7.2°
Max Pitch	7.2°
Max Yaw	2.5°



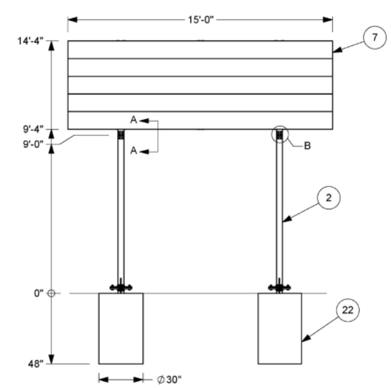


Figure 11-11. Summary of Results for *MASH* Test 3-62 on Guide Sign with Large Sign Supports.

CHAPTER 12. *MASH* TEST 3-62 (CRASH TEST 616401-01-8)

12.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 12.1 for details of *MASH* impact conditions for this test and Table 12.2 for the exit parameters. Figure 12-1 and Figure 12-2 depict the target impact setup.

Table 12.1. Impact Conditions for *MASH* TEST 3-62, Crash Test 616401-01-8.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	62 mi/h	±2.5 mi/h	62.0 mi/h
Impact Angle	90°	±1.5°	90°
Kinetic Energy	594 kip-ft	≥594 kip-ft	646.9 kip-ft
Impact Location	Centerline of the vehicle aligned with the centerline of the sign posts	±6 inches	Centerline of the vehicle aligned with the centerline of the sign posts

Table 12.2. Exit Parameters for *MASH* TEST 3-62, Crash Test 616401-01-8.

Exit Parameter	Measured
Speed	53.8mi/h
Brakes applied post impact	1.6 seconds
Vehicle at rest position	275 ft downstream of impact point 2 ft to the left
Comments:	Vehicle remained upright and stable

Figure 12-1. Guide Sign with Large Sign Supports /Test Vehicle Geometrics for Test 616401-01-8.

Figure 12-2. Guide Sign with Large Sign Supports /Test Vehicle Impact Location 616401-01-8.

12.2. WEATHER CONDITIONS

Table 12.3 provides the weather conditions for 616401-01-8.

Table 12.3. Weather Conditions 616401-01-8.

Date of Test	2024-03-22
Wind Speed	11 mi/h
Wind Direction	221°
Temperature	57 °F
Relative Humidity	96 %
Vehicle Traveling	170°

12.3. TEST VEHICLE

Figure 12-3 and Figure 12-4 show the 2019 RAM 1500 used for the crash test. Table 12.4 shows the vehicle measurements. Figure G.1 in Appendix G.1 gives additional dimensions and information on the vehicle.

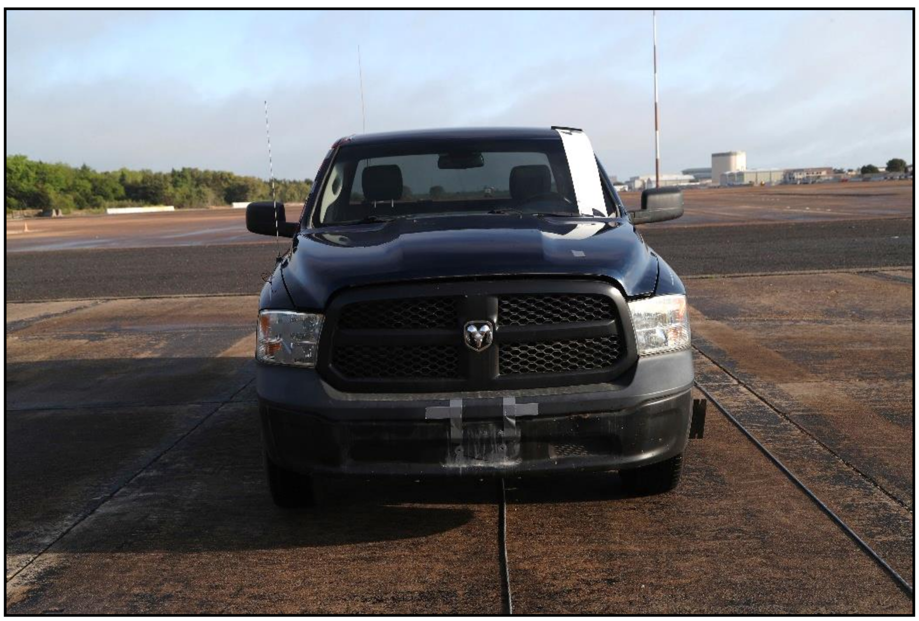


Figure 12-3. Front of Test Vehicle before Test 616401-01-8.

Figure 12-4. Rear of the Test Vehicle before Test 616401-01-8.

Table 12.4. Vehicle Measurements 616401-01-8.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	N/A
Inertial Mass	5000 lb	±110 lb	5034 lb
Gross Static[a] Mass	5000 lb	±110 lb	5034 lb
Wheelbase	148 inches	±12 inches	140.5 inches
Front Overhang	39 inches	±3 inches	40.3 inches
Overall Length	237 inches	±13 inches	229 inches
Overall Width	78 inches	±2 inches	78.5 inches
Hood Height	43 inches	±4 inches	46 inches
Track Width[b]	67 inches	±1.5 inches	68.3 inches
CG aft of Front Axle[c]	63 inches	±4 inches	60 inches
CG above Ground[c,d]	28 inches	≥28 inches	28.6 inches

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.

12.4. TEST DESCRIPTION

Table 12.5 lists events that occurred during Test 616401-01-8. Figures G.4 and G.5 in Appendix G.2 present sequential photographs during the test.

Table 12.5. Events during Test 616401-01-8.

Time (s)	Events
0.0000 s	Vehicle impacted the installation
0.0010 s	The impact support post base began to release
0.0390 s	The impact support post fuse plate began to break
0.0870 s	Base of the impact support post contacted the downstream support post
0.0890 s	Base of the downstream support post began to bend at grade
0.1290 s	The downstream support post base began to release
0.3290 s	The downstream support post contacted the impact support post and the roof of vehicle

12.5. DAMAGE TO TEST INSTALLATION

Both support posts released from the footers and the sign panel assembly, with one landing 435 feet downstream from impact and the other landing 390 feet downstream of impact. The sign landed at the downstream footer, which was leaning downstream, with the impact side 3 inches above the installed height. Figure 12-5 and Figure 12-6 show the damage to the Guide Sign with Large Sign Supports.

Figure 12-5. Guide Sign with Large Sign Supports at Impact Location after Test 616401-01-8.

Figure 12-6. Footer for the Guide Sign with Large Sign Supports after Test 616401-01-8.

12.6. DAMAGE TO TEST VEHICLE

Figure 12-7 through Figure 12-10 show the damage sustained by the vehicle. Figure 12-11 shows the interior of the test vehicle. Table 12.6 and Table 12.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures G.2 and G.3 in Appendix G.1 provide exterior crush and occupant compartment measurements.

Figure 12-7. Impact Side of Test Vehicle after Test 616401-01-8.

Figure 12-8. Rear of the Test Vehicle after Test 616401-01-8.

Figure 12-9. Test Vehicle Windshield Damage after Test 616401-01-8.

Figure 12-10. Roof of the Test Vehicle after Test 616401-01-8.

Figure 12-11. Interior of the Test Vehicle after Test 616401-01-8.

Table 12.6. Occupant Compartment Deformation 616401-01-8.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	5.3 inches
Windshield	≤3.0 inches	3.5 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 12.7. Exterior Vehicle Damage 616401-01-8.

Side Windows	Side windows remained intact
Maximum Exterior Deformation	21 in the front plane at the front bumper
VDS	12FC5
CDC	12FCAW4
Fuel Tank Damage	None
Description of Damage to Vehicle:	The bumper, grill, radiator, and supports were deformed, causing the fan to push into the motor. The headlights released from the vehicle, and the hood released from its latch. The hood also had two large tears and was deformed. The windshield was fractured with a 3.5 inch deep deformation at the top along with torn laminate. The roof had a 5.25 inch deep deformation in the front center. The top brake light was fractured, the back glass shattered, and the tailgate was dented.

12.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 12.8. Figure G.6 in Appendix G.3 shows the vehicle angular displacements, and Figures G.7 through G.9 in Appendix G.4 show acceleration versus time traces.

Table 12.8. Occupant Risk Factors for Test 616401-01-8.

Test Parameter	***Specification*** [a]	**Measured**	**Time**
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	11.8 ft/s	0.2741 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	1.3 ft/s	0.2741 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	1.9 g	0.3471 - 0.3571 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	1.1 g	1.1455 - 1.1555 seconds
Theoretical Head Impact Velocity (THIV)	N/A	3.6 m/s	0.2743 seconds on front of interior
Acceleration Severity Index	N/A	0.5	0.1402 - 0.1902 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-4.5 g	0.1261 - 0.1761 seconds
50-ms MA Lateral	N/A	-0.5 g	0.2905 - 0.3405 seconds
50-ms MA Vertical	N/A	1.8 g	0.2210 - 0.2710 seconds
Roll	≤75°	1.2°	0.2876 seconds
Pitch	≤75°	3.2°	0.3079 seconds
Yaw	N/A	2°	1.4965 seconds

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

12.8. TEST SUMMARY

Figure 12-12 summarizes the results of *MASH* Test 616401-01-8. Due to the 5.3-inch roof deformation exceeding the *MASH* limit of 4 inches, the guide sign with large sign supports failed to meet evaluation criteria D for *MASH* test 3-62.

0.000 s

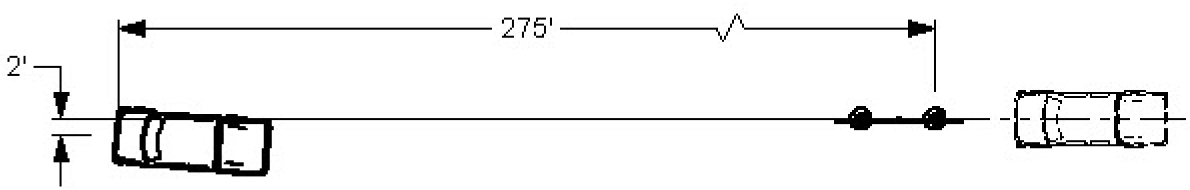
0.150 s

0.300 s

0.450 s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-62
Project No.:	616401-01-8
Test Date:	2024-03-22
TEST ARTICLE	
Type:	Support Structures
Name:	Guide Sign with Large Sign Supports
Length:	15 feet 4 inches
Key Materials:	Aluminum signs, steel posts, steel slip bases, concrete footings
Soil Type and Condition:	Native Soil, dry
TEST VEHICLE	
Type/Designation:	2270P
Year, Make and Model:	2019 RAM 1500
Inertial Mass:	5034 lb
Dummy Mass:	N/A
Gross Static Mass:	5034 lb
IMPACT CONDITIONS	
Impact Speed:	62.0 mi/h
Impact Angle:	90°
Impact Location:	Centerline of the vehicle aligned with the centerline of the sign posts
Kinetic Energy:	646.9 kip-ft

EXIT CONDITIONS	
Exit Speed:	53.8mi/h
Stopping Distance:	275 ft downstream 2 ft to the left side
VEHICLE DAMAGE	
VDS:	12FC5
CDC:	12FCAW4
Max Exterior Deformation:	21 inches
Max Occupant Compartment Deformation:	5.3 inches in the roof
Occupant Risk Values	
Long. OIV	11.8 ft/s
Lat. OIV	1.3 ft/s
Long. Ridedown	1.9 g
Lat. Ridedown	1.1 g
THIV	3.6 m/s
ASI	0.5
Max 50-ms Long.	-4.5 g
Max 50-ms Lat.	-0.5 g
Max 50-ms Vert.	1.8 g
Max Roll	1.2°
Max Pitch	3.2°
Max Yaw	2°



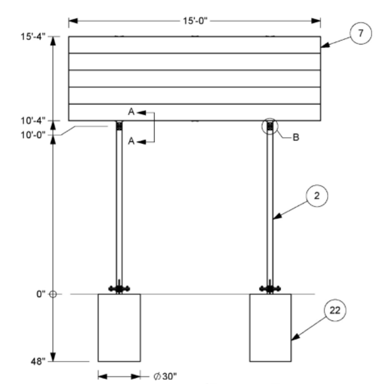


Figure 12-12. Summary of Results for *MASH* Test 3-62 on Guide Sign with Large Sign Supports.

CHAPTER 13. CONCLUSIONS, AND FUTURE RESEARCH RECOMMENDATIONS

13.1. TESTING RESULTS

The crash tests reported herein were performed in accordance with *MASH* TL-3 on various designs of the Multi-directional Base Design for Large Sign Supports

Table 13.1 shows that the guide sign support structure design did not meet the *MASH* performance criteria for support structures. Table 13.1 also shows that the Route Marker Assembly support structure design met the *MASH* performance criteria for test 3-60 at 0 degrees and test 3-61 at 90 degrees.

Table 13.1. Assessment Summary for *MASH* TL-3 Tests on Multi-directional Base Design for Large Sign Supports.

Evaluation Criteria	**Description**	**Test 616401-01-1** (*MASH* Test 3-60)	**Test 616401-01-2** (*MASH* Test 3-61)	**Test 616401-01-3** (*MASH* Test 3-62)	**Test 616401-01-4** (*MASH* Test 3-62)	**Test 616401-01-8** (*MASH* Test 3-62)	**Test 616401-01-9** (*MASH* Test 3-62)
B	Test Article Broke Away, Fractured, Yielded	S	S	S	S	S	S
D	No Penetration into Occupant Compartment	S	S	FAIL	FAIL	FAIL	FAIL
F	Roll and Pitch Limit	S	S	S	S	S	S
H	OIV Threshold	S	S	S	S	S	S
I	Ridedown Threshold	S	S	S	S	S	S
N	Vehicle Trajectory Behind Test Article Acceptable	S	S	S	S	S	S
Overall	Evaluation	Pass	Pass	Fail	Fail	Fail	Fail

Note: S = Satisfactory; N/A = Not Applicable.
[1] See Table 5.2 for details

13.2. CONCLUSIONS AND FUTURE RESEARCH RECOMMENDATIONS

The research team evaluated two designs for larger sign supports, one for a large route marker assembly and one for a guide sign. These two systems were designed to be crash tested with two impact angles, 0 degrees and 90 degrees. After a failure in *MASH* test 3-72 at 90 degrees on the guide sign system, the research team modified the fuse plate design to promote activation. This modified design also failed to meet *MASH* evaluation criteria. Subsequent crash tests evaluated the effectiveness of increasing the mounting height of the sign. These new designs were crash tested according to *MASH* test 3-72 criteria, and all failed to meet *MASH* evaluation criteria.

The research team recommends future research to investigate a modified design which limits the airborne trajectory of the posts and sign panel. This may include further modifications to the fuse plate, a restraint mechanism on the posts, raising the height of the fuse plate but retaining the mounting height of the sign, or other design changes.

REFERENCES

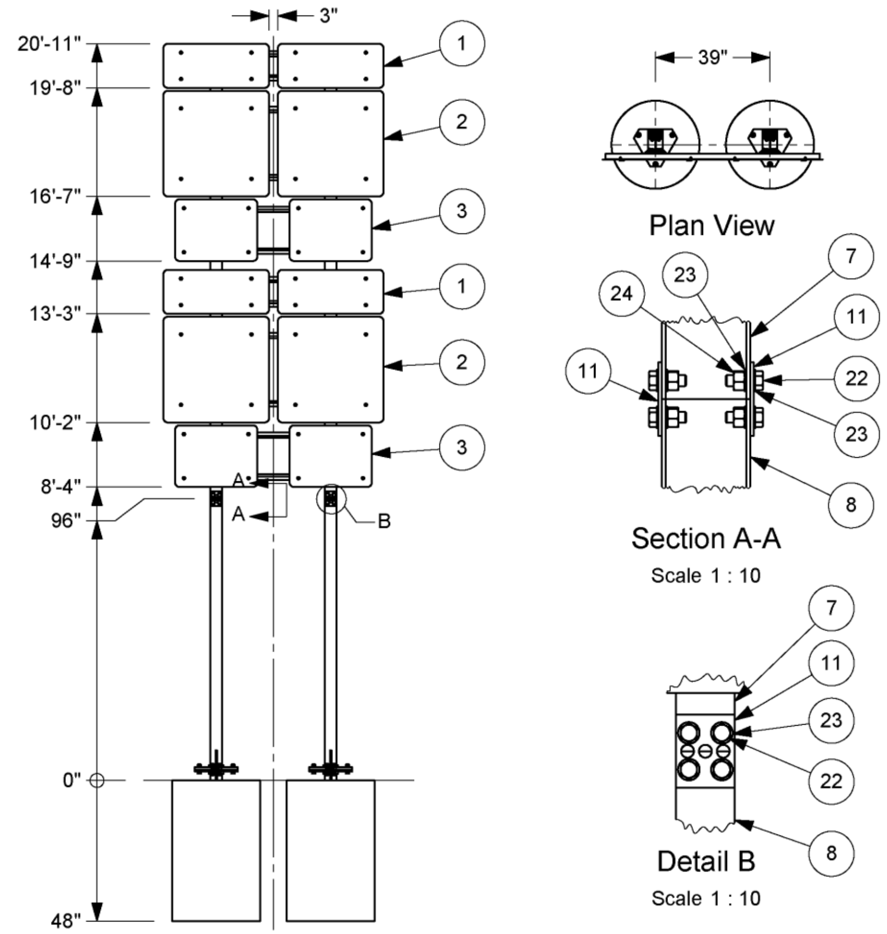
1. AASHTO. *Manual for Assessing Safety Hardware*, Second Edition. American Association of State Highway and Transportation Officials, Washington, DC, 2016.
2. Ross Jr., H.E., Sicking, D.L., Zimmer, R.A., and Michie*,* J.D.*, "Recommended Procedures for the Safety Performance Evaluation of Highway Features,"* NCHRP Report 350, Transportation Research Board, Washington,
3. Bligh, R.P., Arrington, D.R., and Menges, W.L., *Temporary Large Guide Signs*, Texas Transportation Institute, College Station, TX, 2014.
4. Hirsch, T.J., Fairbanks, W.L., Arnold, A., Perforated Tension Fuse Plate for Breakaway Roadside Signs, Texas Transportation Institute, College Station, TX, 1984.
5. Hahn, K.C. and Bryden, J.E., *Crash Tests of Omni-directional Slip-Base Sign Supports*, Engineering Research and Development Bureau, New York State Department of Transportation, Albany, NY, 1981.
6. Bligh, R.P., Alberson, D.C., Menges, W.L., and Haug, R.R., Evaluation of Dual Support, Triangular Slip-Base Sign Installations, Texas Transportation Institute, College Station, TX, 2002.
7. Paulsen, G.W., Pfeifer, B.G., Holloway, J.C., and Reid, J.D., *Design and Testing of a Dual Support Breakaway Sign,* Midwest Roadside Safety Facility, Lincoln, NE, 1995.
8.

APPENDIX A. DETAILS OF MULTI-DIRECTIONAL BASE DESIGN FOR LARGE SIGN SUPPORTS

A.1. DETAILS OF THE ROUTE MARKER ASSEMBLY SIGN ON LARGE SUPPORT POSTS FOR CRASH TESTS 616401-01-1-2

#	Part Name	QTY.
1	15" x 36" x 0.0800 Sign Panel	4
2	36" x 36" x 0.0800 Sign Panel	4
3	21" x 28" x 0.0800 Sign Panel	4
4	73" Extruded Rib	8
5	65" Extruded Rib	4
6	Post Clamp	48
7	Top Section	2
8	Middle Section	2
9	Adapter Plate	4
10	Keeper Plate	2
11	Hinge Plate	4
12	Bolt, 5/16 x 7/8" hex	48
13	Nut, 5/16 hex A563	48
14	Washer, 5/16 F844	96
15	Washer, 5/16 lock	48
16	Bolt, 5/8 x 1 1/2" hex A325	16
17	Washer, 5/8 F436	16
18	Bolt, 3/8 x 1 3/4" square head	48
19	Washer, 3/8 F844	48
20	Washer, 3/8 lock	48
21	Nut, 3/8 hex	48
22	Bolt, 3/4 x 2" hex A325	16
23	Washer, 3/4 F436	44
24	Nut, 3/4 heavy hex A194	22
25	Bottom Section	2
26	Bolt, 3/4 x 2 3/4" hex	6
27	3,000 psi concrete	2
28	Rebar Ring, Ø1/2" x 24" OD	8
29	Ø1" x 42" rebar	20

Test Installation



Elevation View

1a. All steel components, including hardware, shall be galvanized.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 1-2 Route Marker		2022-10-28
Drawn by GES	Scale 1:50	Sheet 1 of 7 Test Installation

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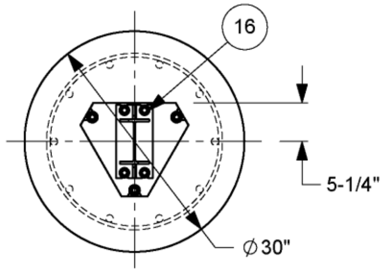
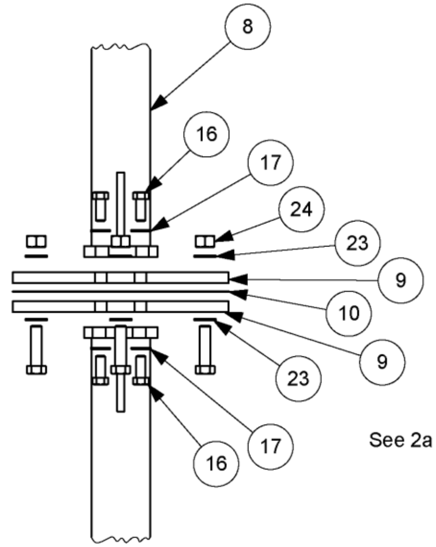
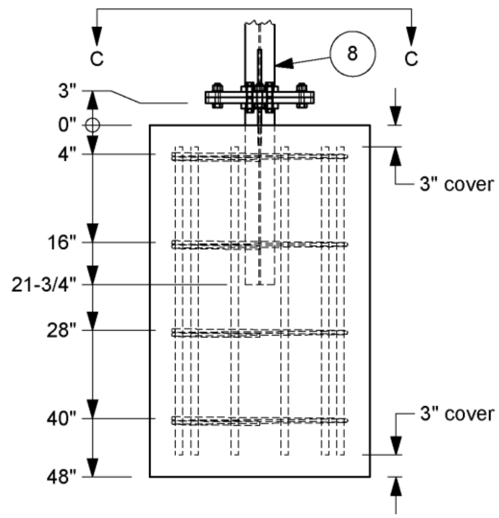
Foundation and Slip Base



Section C-C



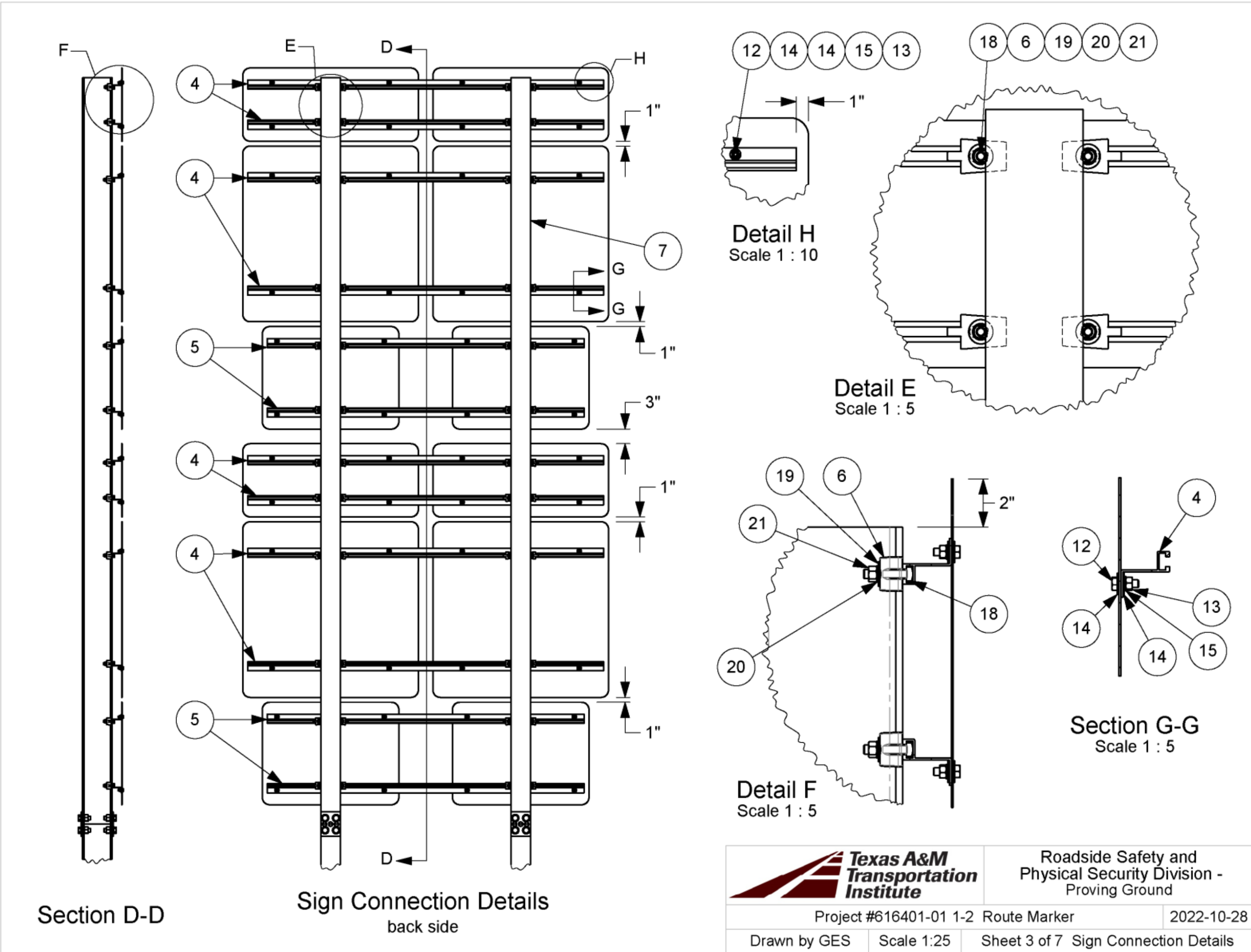
Slip Base Parts



Foundation

2a. Torque Triangular Slip Base bolts to 60 ft/lbs.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 1-2 Route Marker		2022-10-28
Drawn by GES	Scale 1:20	Sheet 2 of 7 Foundation and Slip Base



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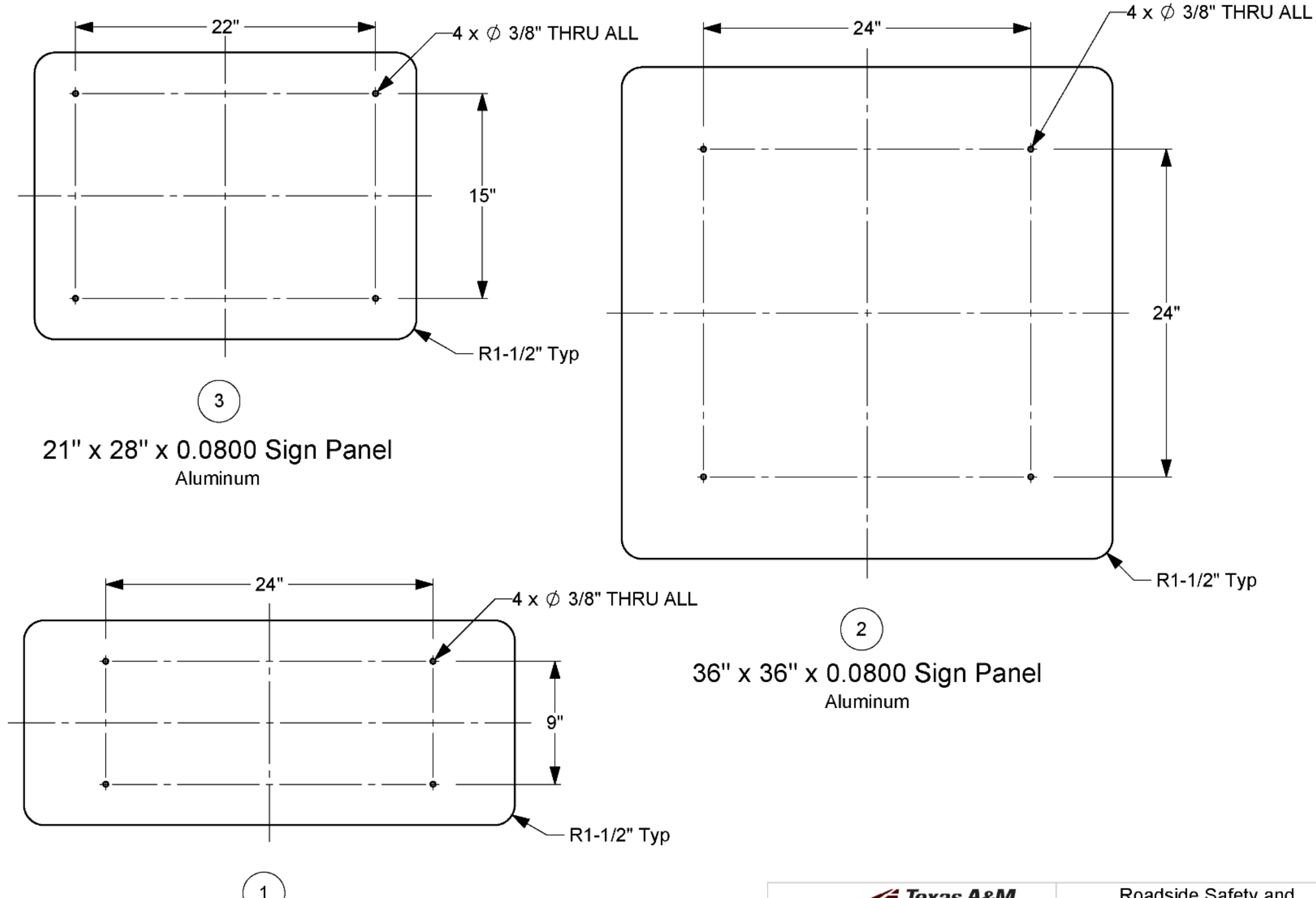

21" x 28" x 0.0800 Sign Panel
Aluminum

36" x 36" x 0.0800 Sign Panel
Aluminum

15" x 36" x 0.0800 Sign Panel
Aluminum

Texas A&M Transportation Institute

Roadside Safety and Physical Security Division - Proving Ground

Project #616401-01 1-2 Route Marker		2022-10-28
Drawn by GES	Scale 1:10	Sheet 4 of 7 Sign Panels

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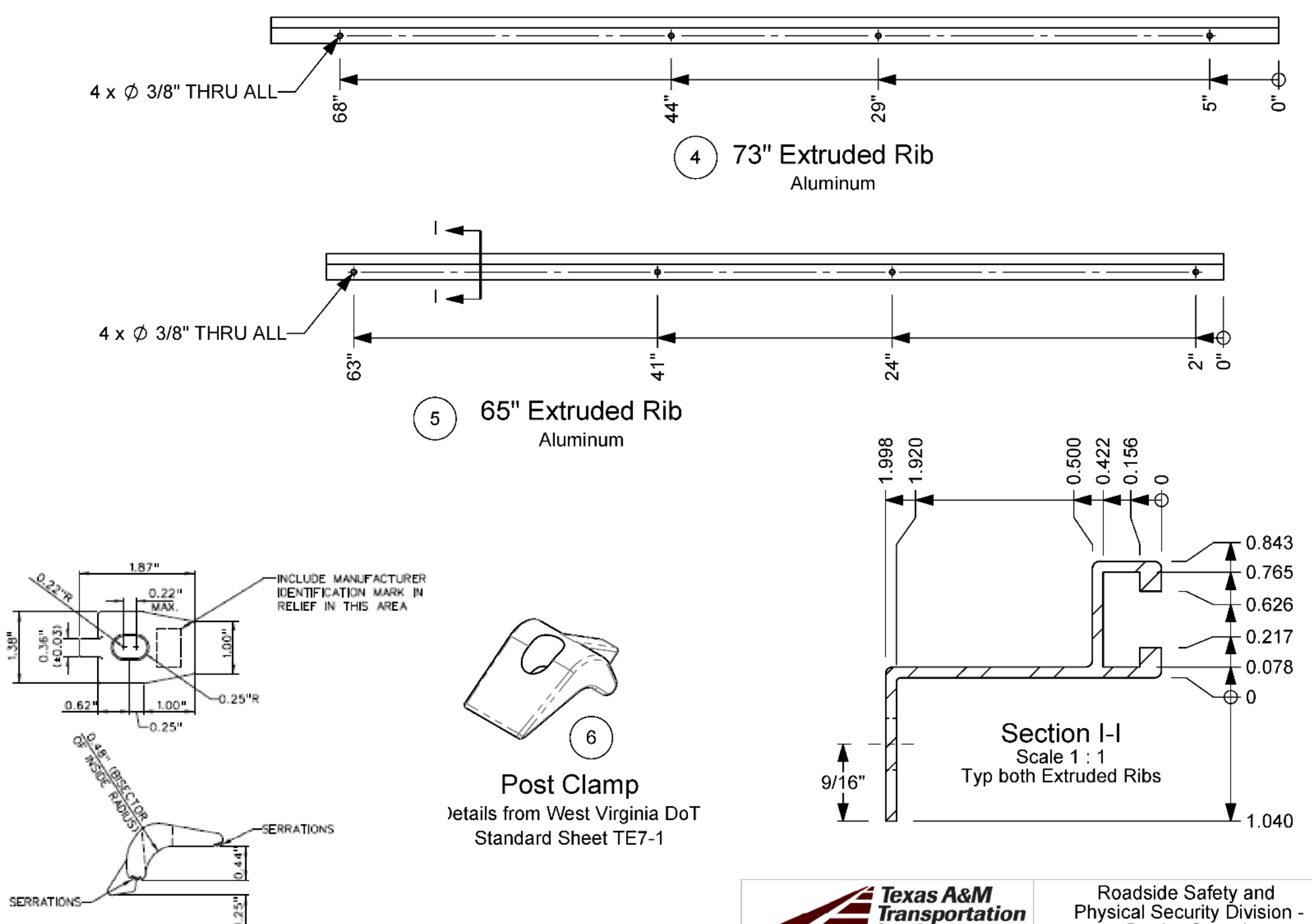
Ribs and Post Clamp



(TOLERANCE = +0.10, -0.03, EXCEPT AS NOTED)

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 1-2 Route Marker		2022-10-28
Drawn by GES	Scale 1:10	Sheet 5 of 7 Ribs and Post Clamp

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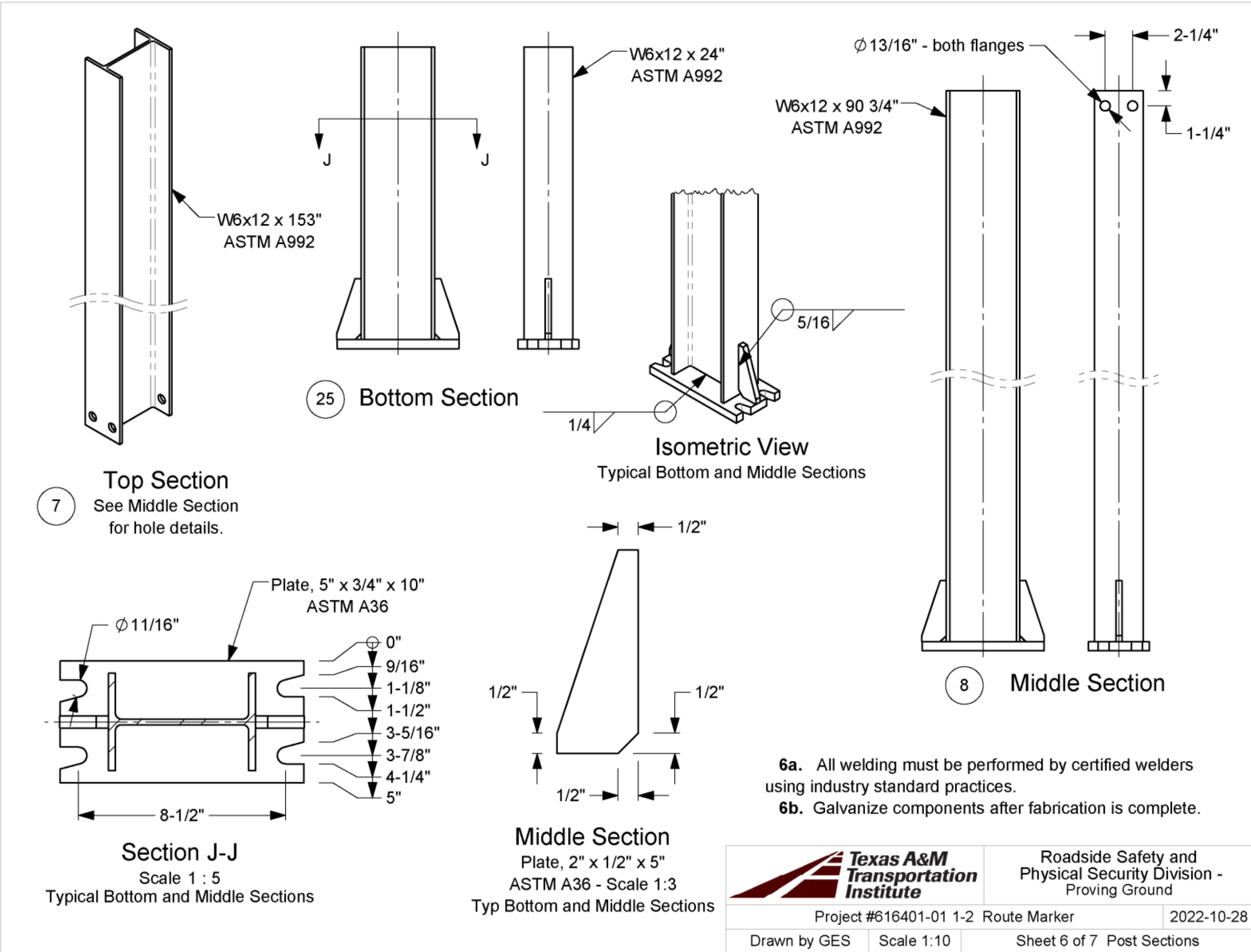

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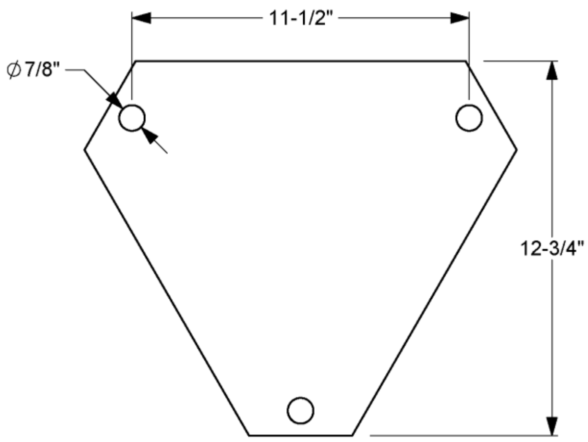
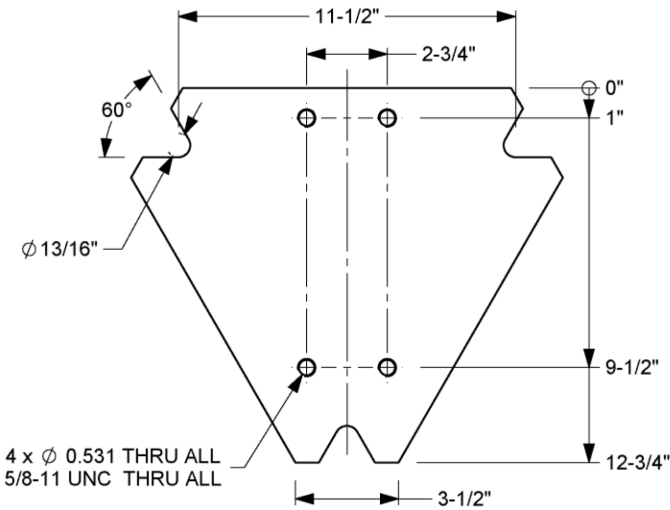
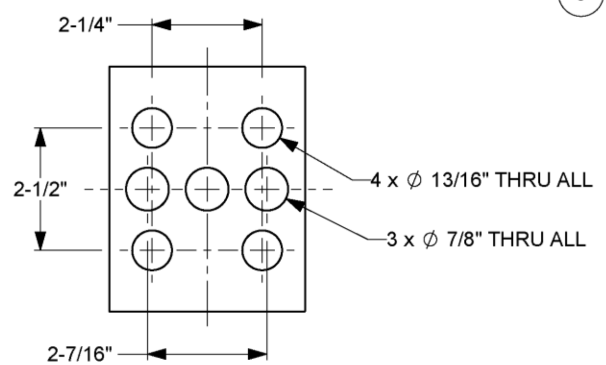


10 Keeper Plate
26 gauge Plate
See Adapter Plate for other dimensions



9 Adapter Plate
3/4" thick
ASTM A572 Grade 50



11 Hinge Plate
Plate, 4" x 1/4" x 5"
ASTM A36 - Scale 1:3

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 1-2 Route Marker		2022-10-28
Drawn by GES	Scale 1:5	Sheet 7 of 7 Assorted Parts

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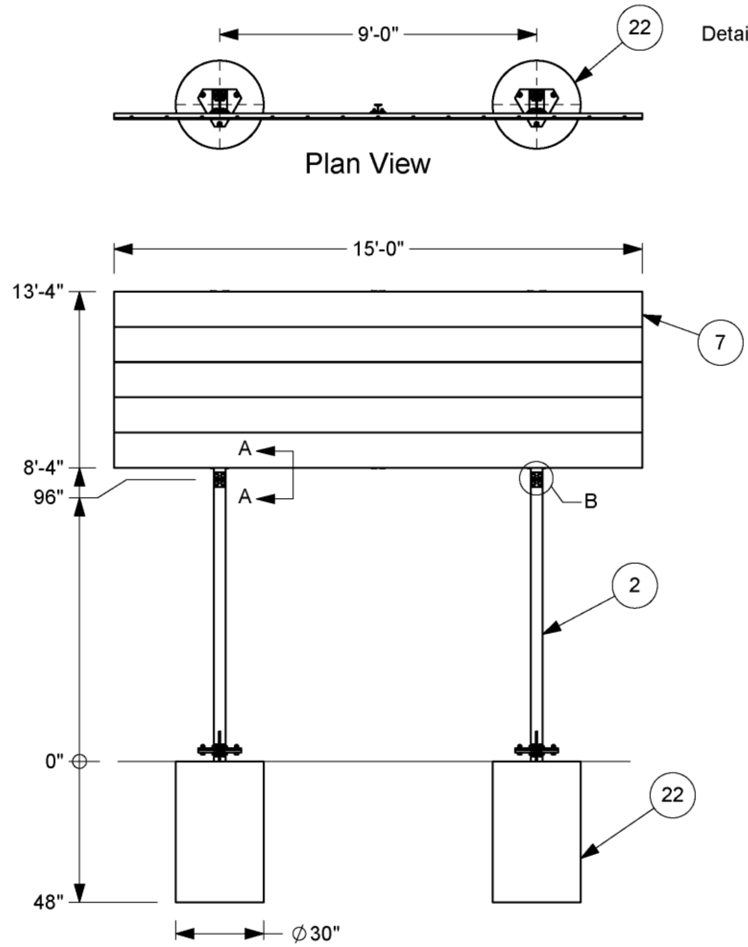
A.2. DETAILS OF THE GUIDE SIGN ON LARGE SUPPORT POSTS FOR CRASH TEST 616401-01-3

Test Installation

Detail and Section views on next sheet



Elevation View

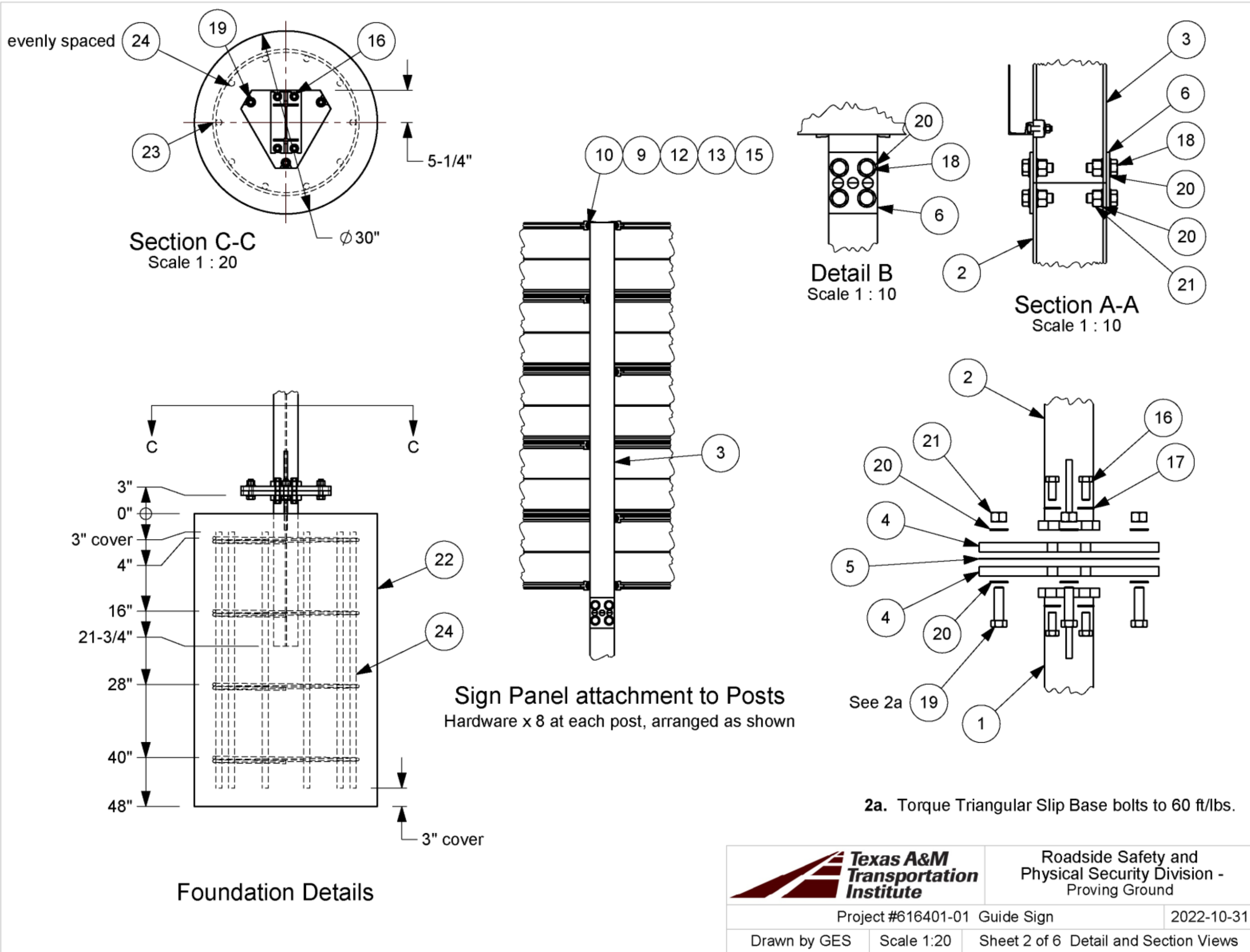
#	Part Name	QTY.
1	Bottom Section	2
2	Middle Section	2
3	Top Section	2
4	Adapter Plate	4
5	Keeper Plate	2
6	Hinge Plate	4
7	Aluminum Sign Panel, 12" x 180"	5
8	Stiffener	1
9	Post Clamp	24
10	Bolt, 3/8 x 1 3/4" square head	24
11	Bolt, 3/8 x 3/4" hex A307	28
12	Washer, 3/8 F844	80
13	Washer, 3/8 lock	24
14	Nut, 3/8 lock	28
15	Nut, 3/8 hex	24
16	Bolt, 5/8 x 1 1/2" hex A325	16
17	Washer, 5/8 F436	16
18	Bolt, 3/4 x 2" hex A325	16
19	Bolt, 3/4 x 2 3/4" hex A325	6
20	Washer, 3/4 F436	44
21	Nut, 3/4 heavy hex A194	22
22	3,000 psi concrete	2
23	Rebar Ring, Ø1/2" x 24" OD	8
24	Ø1" x 42" rebar	20

1a. All steel components shall be galvanized.

Texas A&M Transportation Institute

Roadside Safety and Physical Security Division - Proving Ground

Project #616401-01 Guide Sign		2022-10-31
Drawn by GES	Scale 1:50	Sheet 1 of 6 Test Installation



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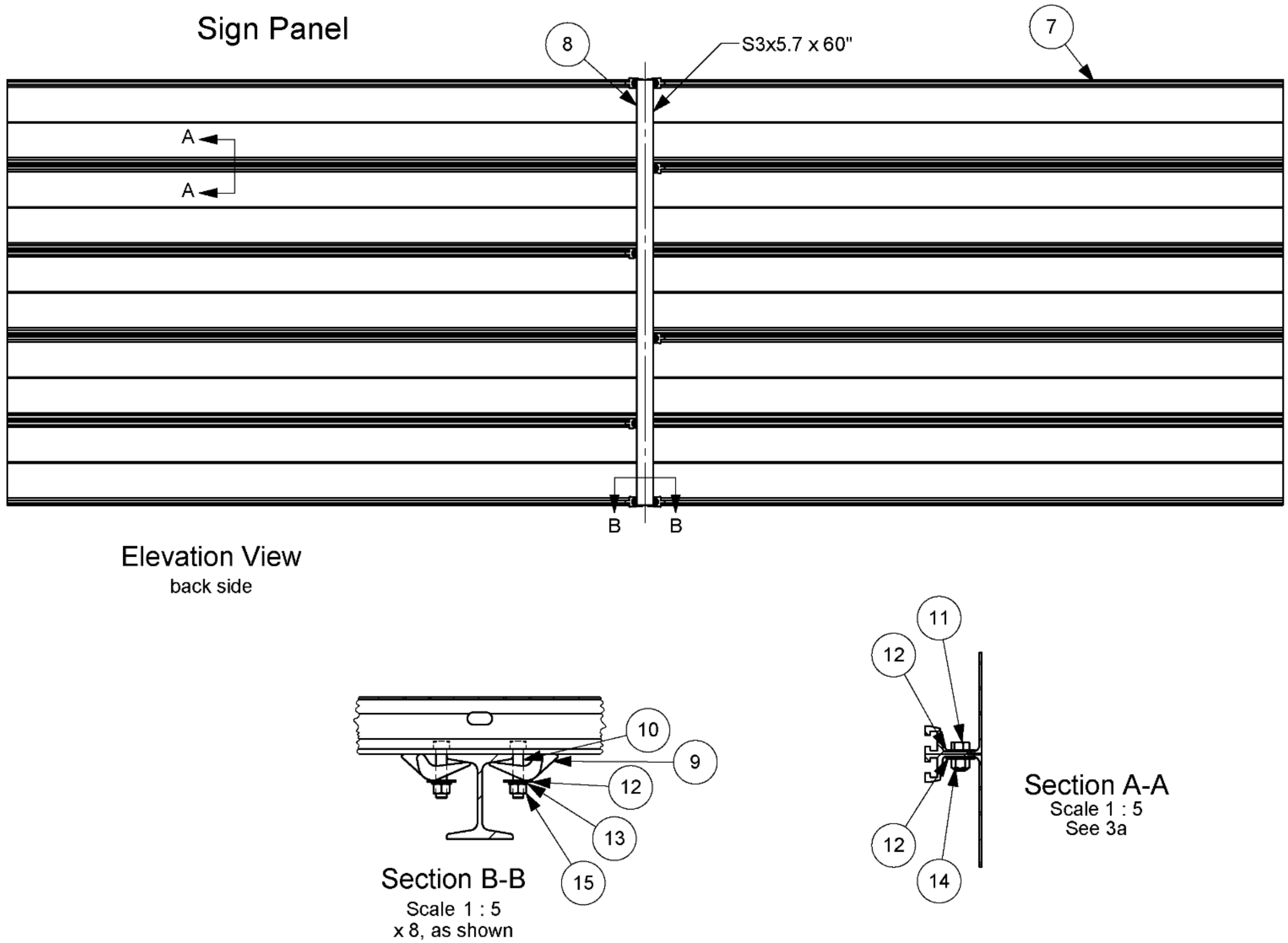
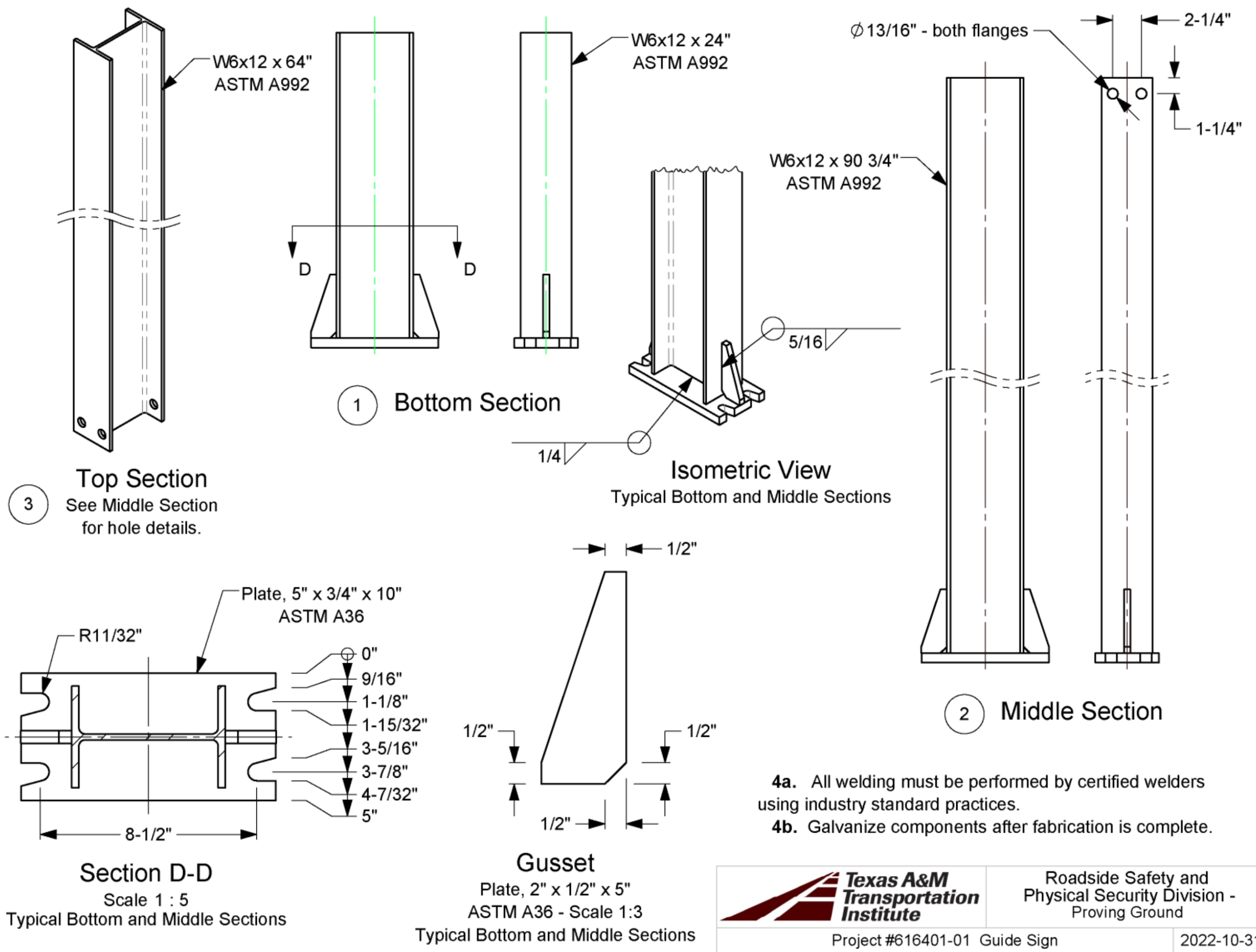
Sign Panel



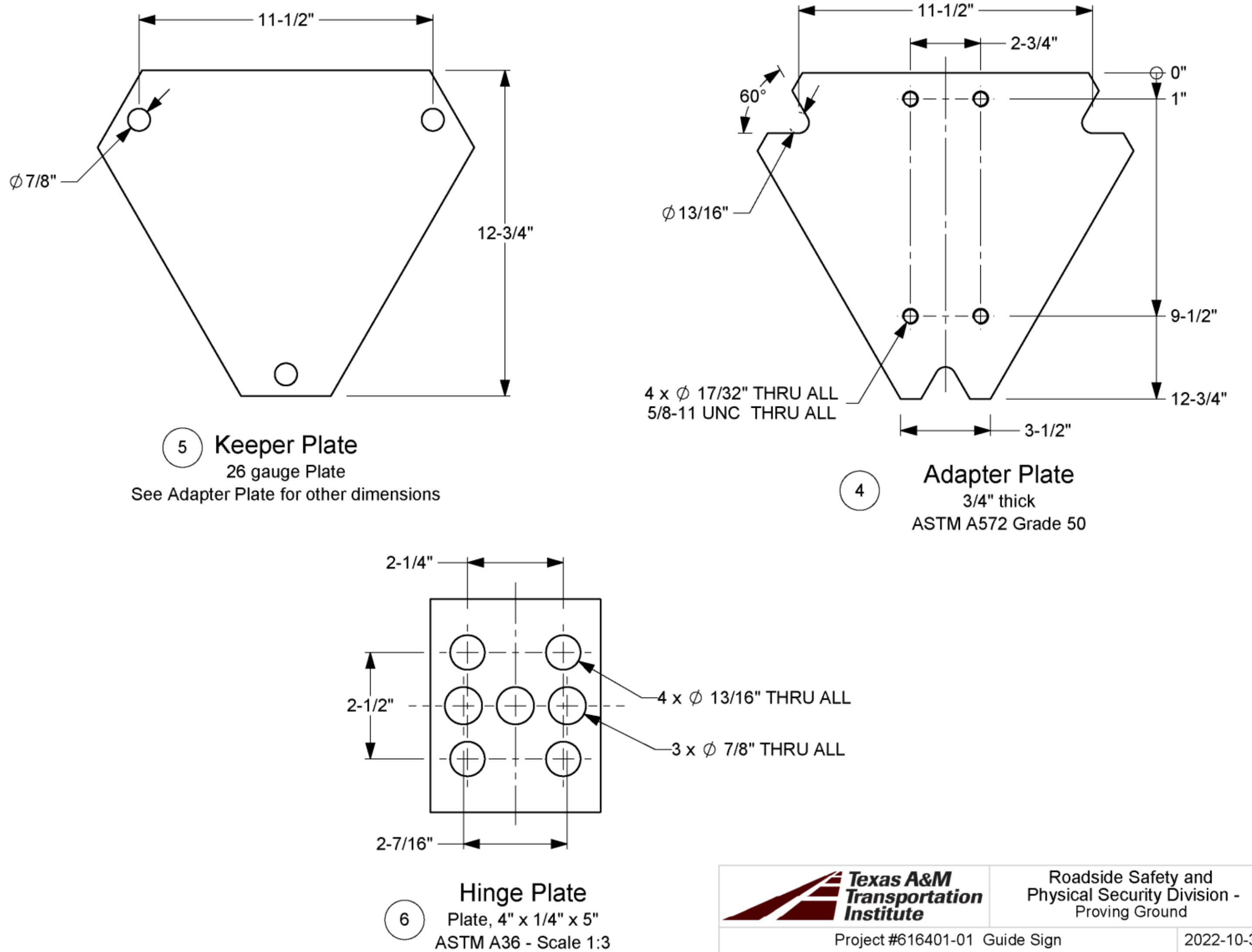
3a. Stitch Bolts spaced at 24" horizontally, staggered 12" on alternating joints.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2022-10-31
Drawn by GES	Scale 1:20	Sheet 3 of 6 Sign Panel



4a. All welding must be performed by certified welders using industry standard practices.
4b. Galvanize components after fabrication is complete.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2022-10-31
Drawn by GES	Scale 1:10	Sheet 4 of 6 Post Sections



Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2022-10-31
Drawn by GES	Scale 1:5	Sheet 5 of 6 Assorted Parts-1

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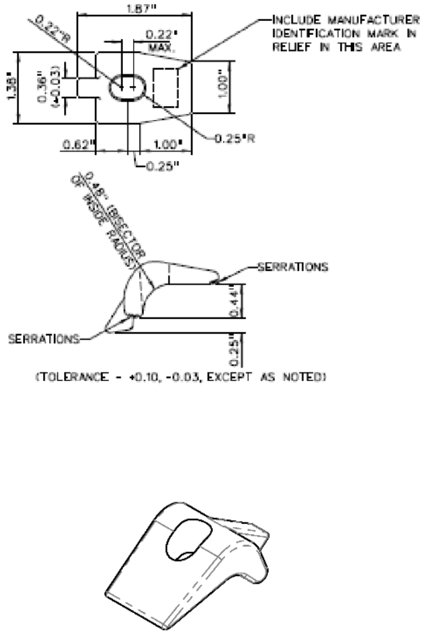
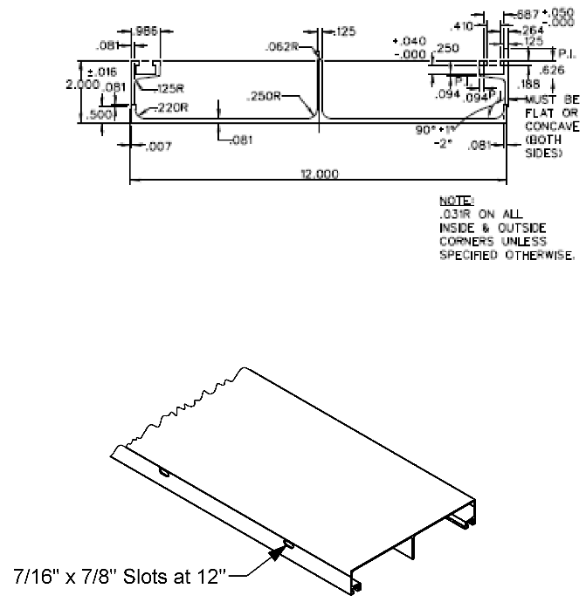


9

Post Clamp

Details from West Virginia DoT Standard Sheet TE7-1.



7

Aluminum Sign Panel, 12" x 180"

Details from West Virginia DoT Standard Sheet TE7-1.

Texas A&M Transportation Institute

Roadside Safety and Physical Security Division - Proving Ground

Project #616401-01 Guide Sign | 2022-10-31

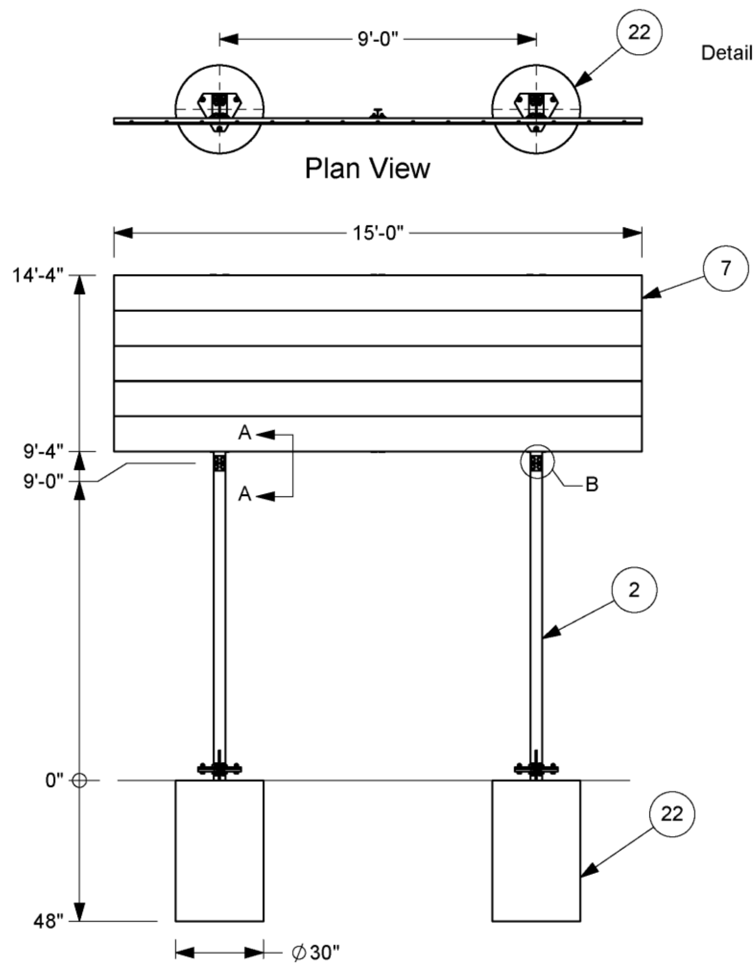
Drawn by GES | Scale 1:2 | Sheet 6 of 6 Assorted Parts-2

S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\first design\616401-01 Guide Sign Drawing

A.3. DETAILS OF THE GUIDE SIGN ON LARGE SUPPORT POSTS FOR CRASH TEST 616401-01-4

Test Installation

Detail and Section views on next sheet

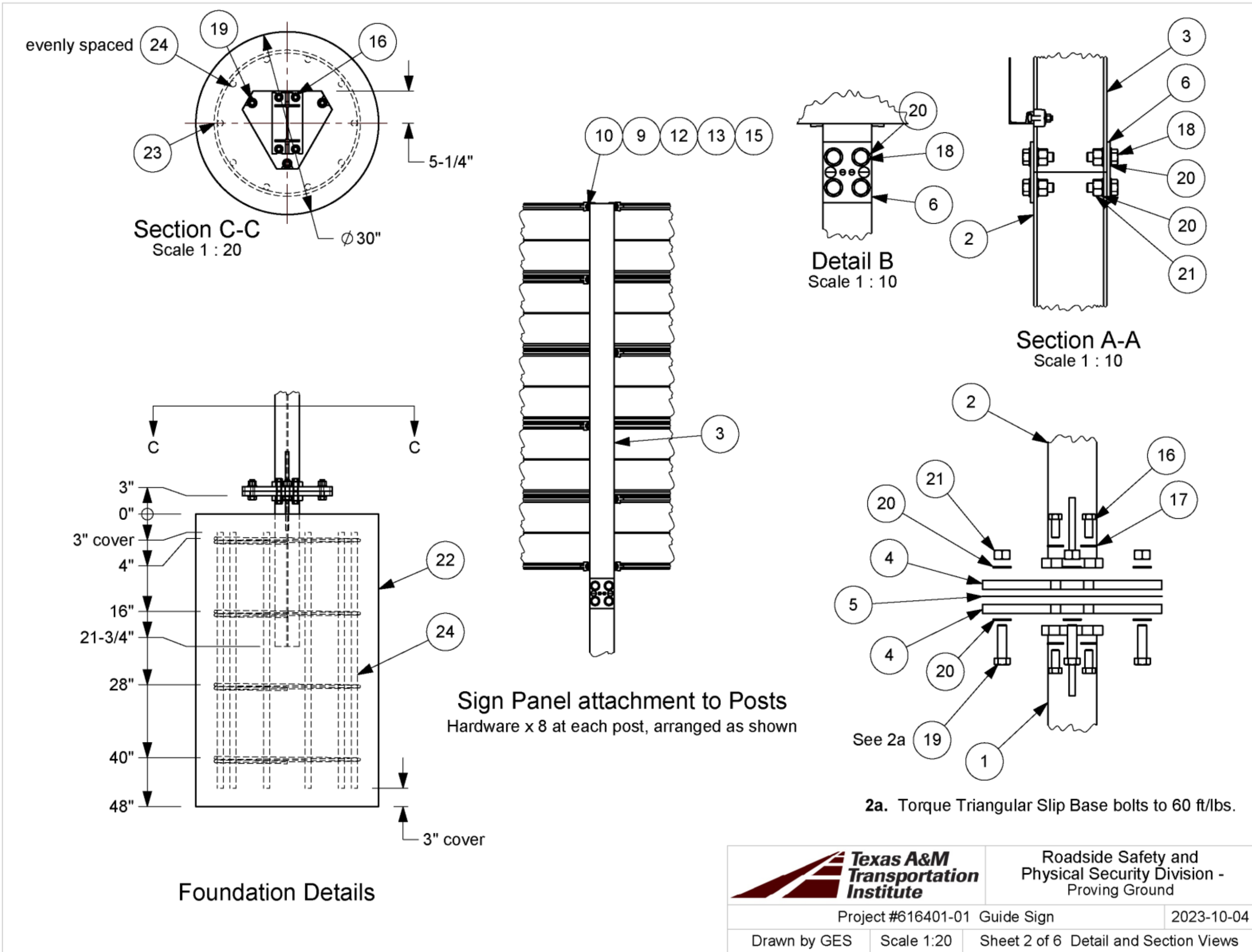


Elevation View

#	Part Name	QTY.
1	Bottom Section	2
2	Middle Section	2
3	Top Section	2
4	Adapter Plate	4
5	Keeper Plate	2
6	Hinge Plate	4
7	Aluminum Sign Panel, 12" x 180"	5
8	Stiffener	1
9	Post Clamp	24
10	Bolt, 3/8 x 1 3/4" square head	24
11	Bolt, 3/8 x 3/4" hex A307	28
12	Washer, 3/8 F844	80
13	Washer, 3/8 lock	24
14	Nut, 3/8 lock	28
15	Nut, 3/8 hex	24
16	Bolt, 5/8 x 1 1/2" hex A325	16
17	Washer, 5/8 F436	16
18	Bolt, 3/4 x 2" hex A325	16
19	Bolt, 3/4 x 2 3/4" hex A325	6
20	Washer, 3/4 F436	44
21	Nut, 3/4 heavy hex A194	22
22	3,000 psi concrete	2
23	Rebar Ring, Ø1/2" x 24" OD	8
24	Ø1" x 42" rebar	20

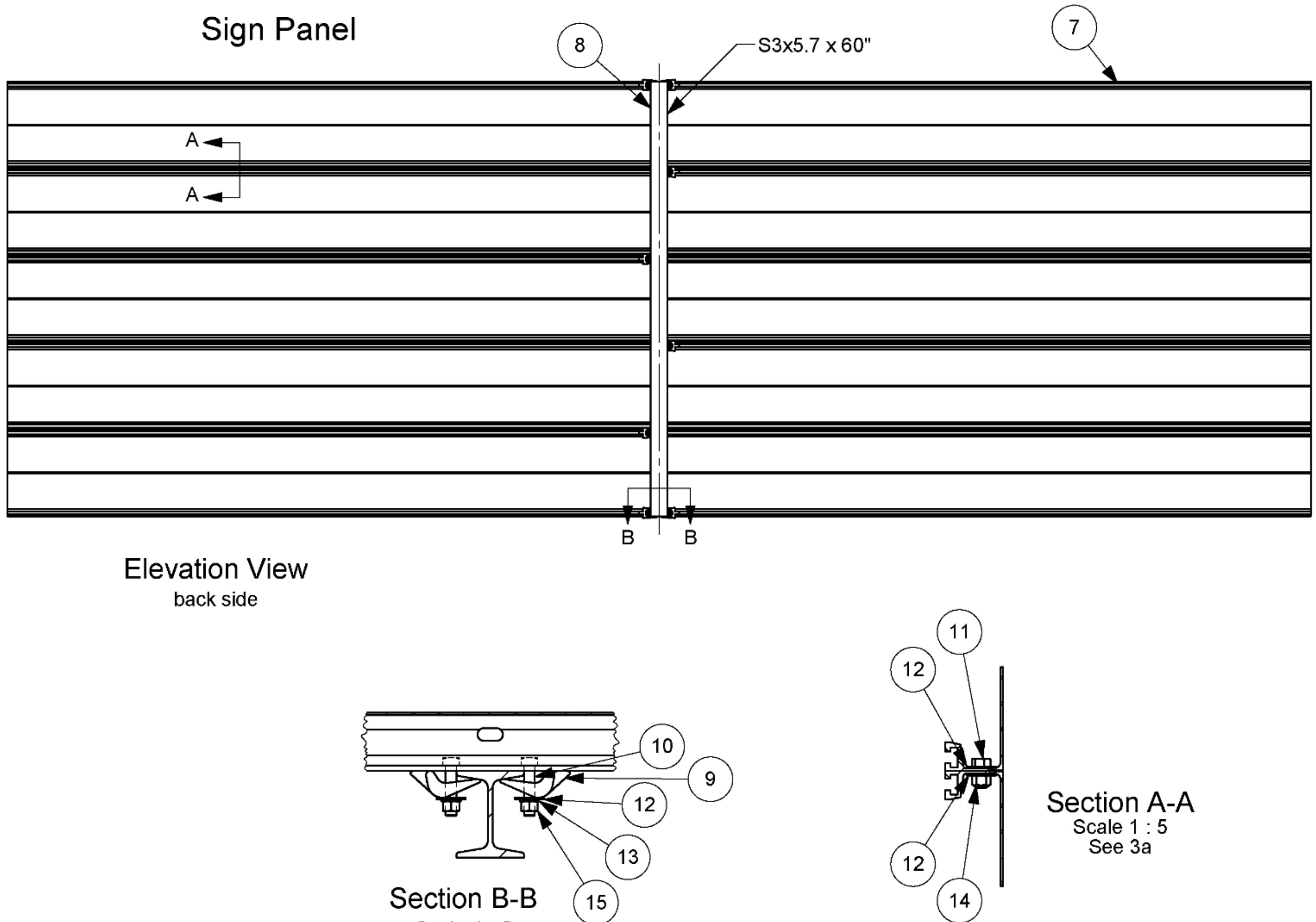
1a. All steel components shall be galvanized.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2023-10-04
Drawn by GES	Scale 1:50	Sheet 1 of 6 Test Installation



S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\2023-10-04 (12" taller)\616401-01 Guide Sign Drawing

Sign Panel



Elevation View
back side

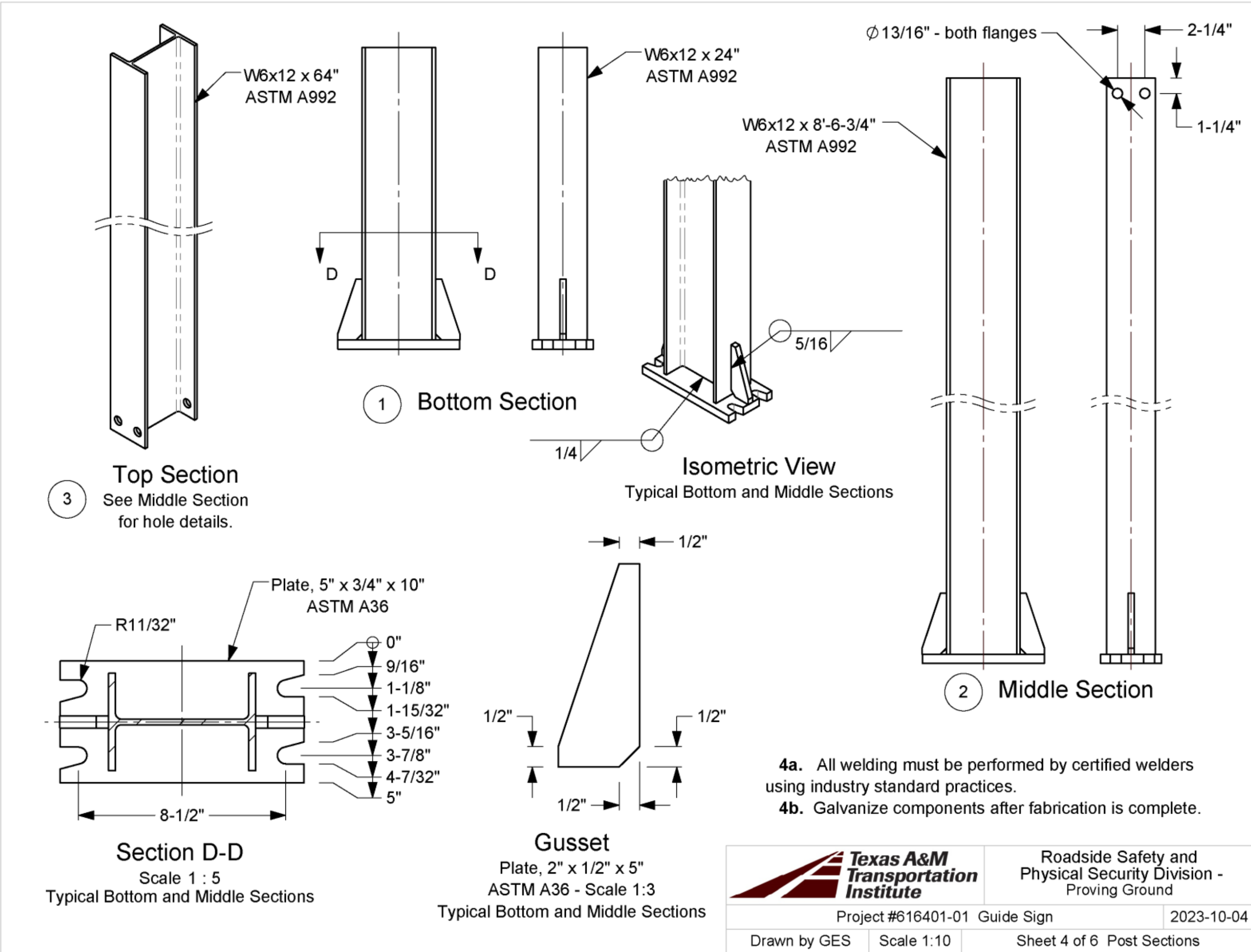
Section B-B
Scale 1 : 5
x 8, as shown

Section A-A
Scale 1 : 5
See 3a

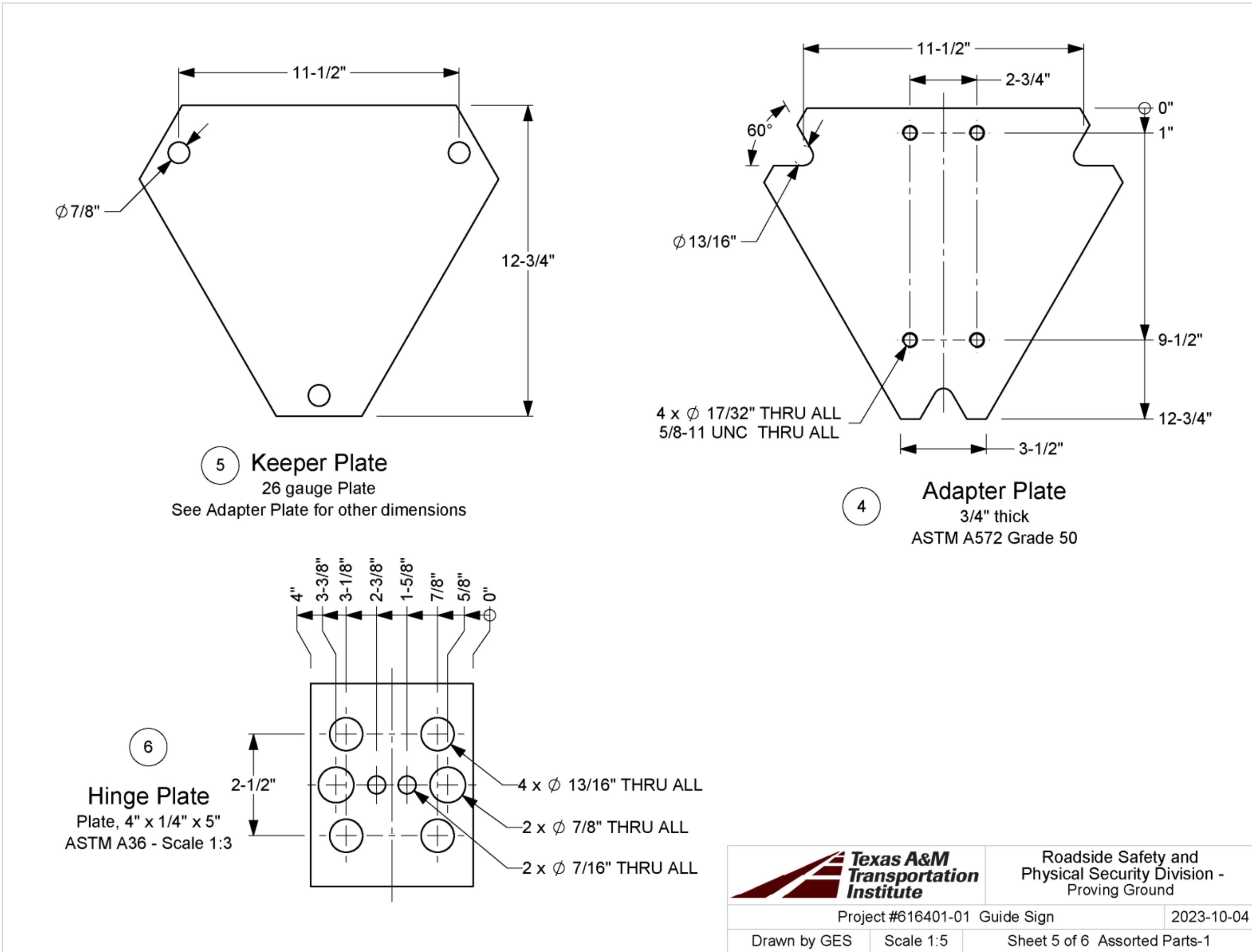
3a. Stitch Bolts spaced at 24" horizontally, staggered 12" on alternating joints.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2023-10-04
Drawn by GES	Scale 1:20	Sheet 3 of 6 Sign Panel

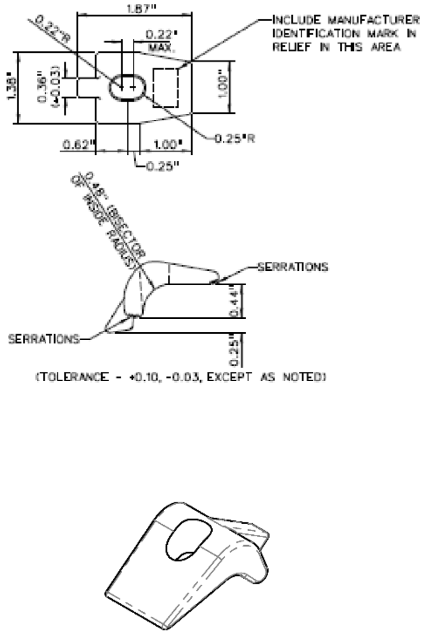
S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\2023-10-04 (12" taller)\616401-01 Guide Sign Drawing



S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\2023-10-04 (12" taller)\616401-01 Guide Sign Drawing



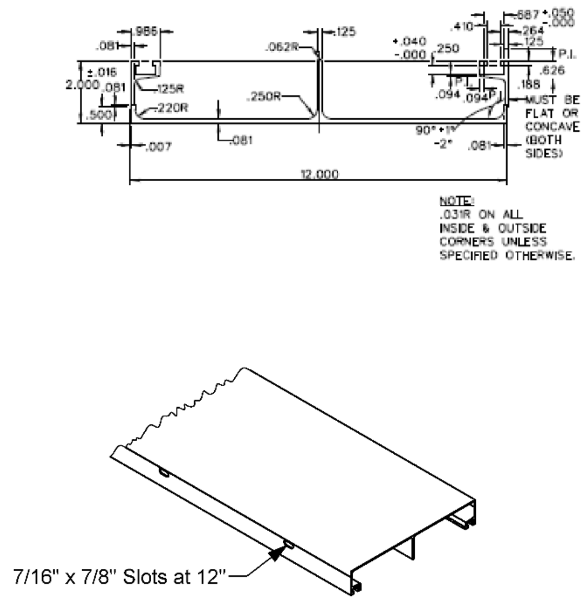
S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\2023-10-04 (12" taller)\616401-01 Guide Sign Drawing



9

Post Clamp

Details from West Virginia DoT Standard Sheet TE7-1.



7

Aluminum Sign Panel, 12" x 180"

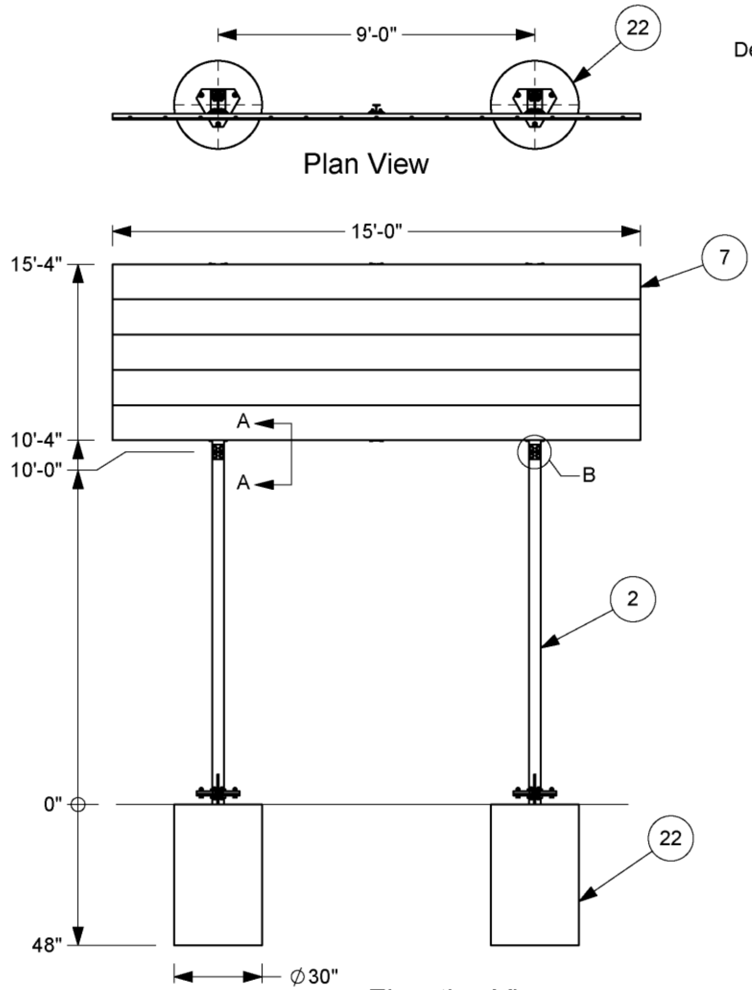
Details from West Virginia DoT Standard Sheet TE7-1.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2023-10-04
Drawn by GES	Scale 1:2	Sheet 6 of 6 Assorted Parts-2

A.4. DETAILS OF THE GUIDE SIGN ON LARGE SUPPORT POSTS FOR CRASH TEST 616401-01-8

Test Installation

Detail and Section views on next sheet



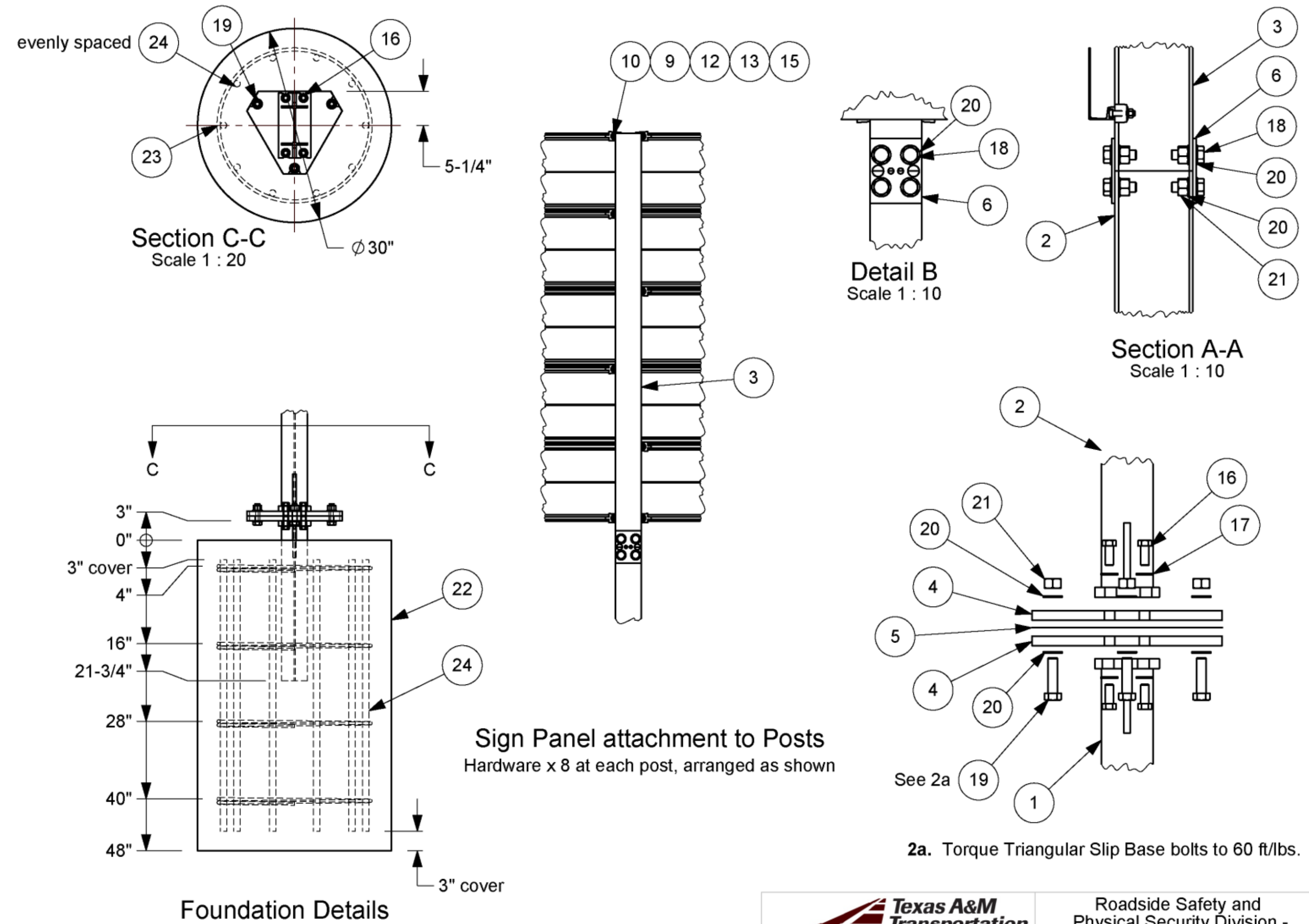
Elevation View

#	Part Name	QTY.
1	Bottom Section	2
2	Middle Section	2
3	Top Section	2
4	Adapter Plate	4
5	Keeper Plate	2
6	Hinge Plate	4
7	Aluminum Sign Panel, 12" x 180"	5
8	Stiffener	1
9	Post Clamp	24
10	Bolt, 3/8 x 1 3/4" square head	24
11	Bolt, 3/8 x 3/4" hex A307	28
12	Washer, 3/8 F844	80
13	Washer, 3/8 lock	24
14	Nut, 3/8 lock	28
15	Nut, 3/8 hex	24
16	Bolt, 5/8 x 1 1/2" hex A325	16
17	Washer, 5/8 F436	16
18	Bolt, 3/4 x 2" hex A325	16
19	Bolt, 3/4 x 2 3/4" hex A325	6
20	Washer, 3/4 F436	44
21	Nut, 3/4 heavy hex A194	22
22	3,000 psi concrete	2
23	Rebar Ring, Ø1/2" x 24" OD	8
24	Ø1" x 42" rebar	20

1a. All steel components shall be galvanized.

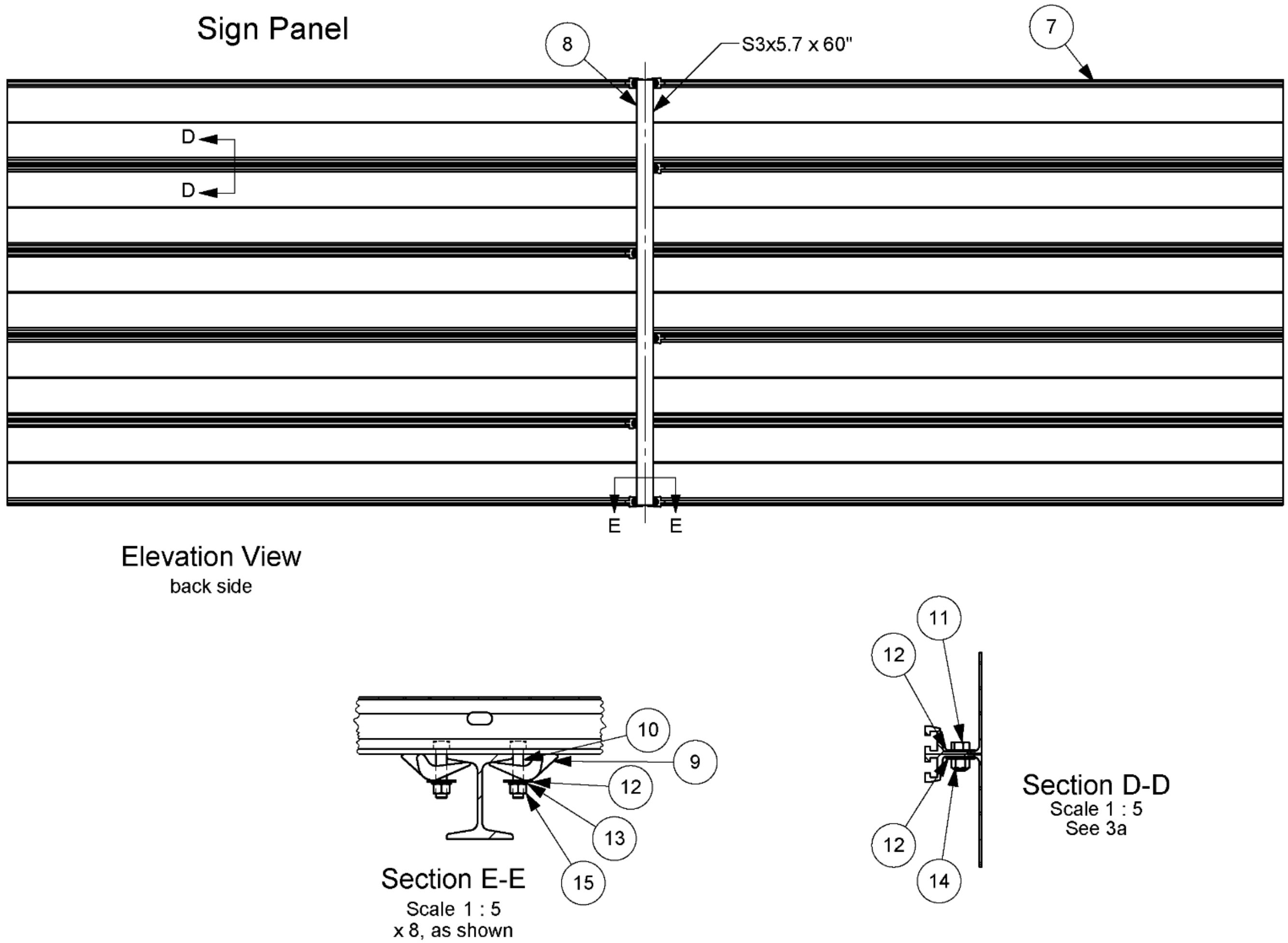
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2024-02-23
Drawn by GES	Scale 1:50	Sheet 1 of 6 Test Installation

S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\2024-02-22 (10' tall)\616401-01 Guide Sign Drawing, 2024-03-01 7.4-01



Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground
Project #616401-01 Guide Sign	2024-02-23
Drawn by GES · Scale 1:20	Sheet 2 of 6 Detail and Section Views

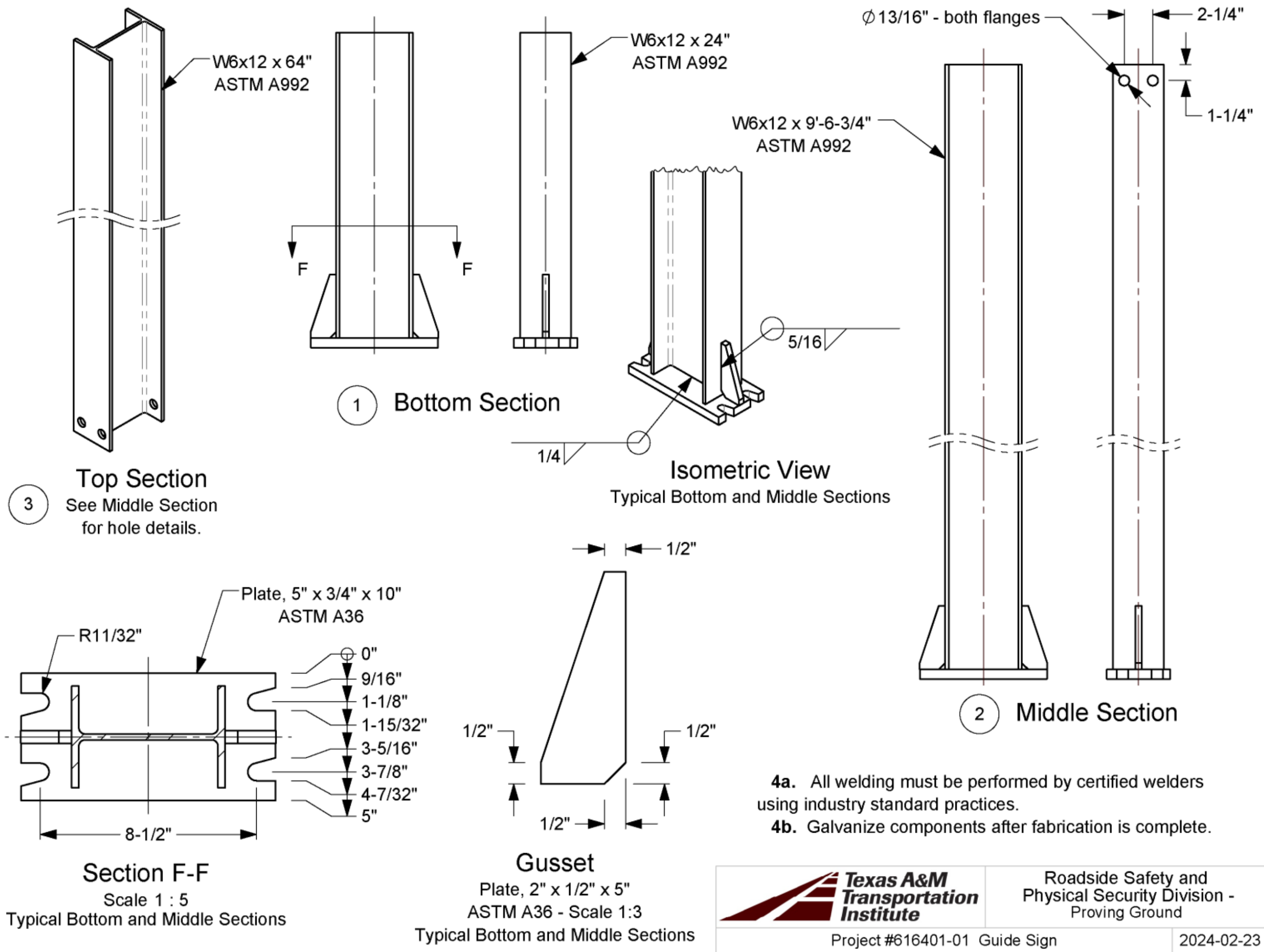
S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\2024-02-22 (10' tall)\616401-01 Guide Sign Drawing, 2024-03-01 7.4-01



3a. Stitch Bolts spaced at 24" horizontally, staggered 12" on alternating joints.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2024-02-23
Drawn by GES	Scale 1:20	Sheet 3 of 6 Sign Panel

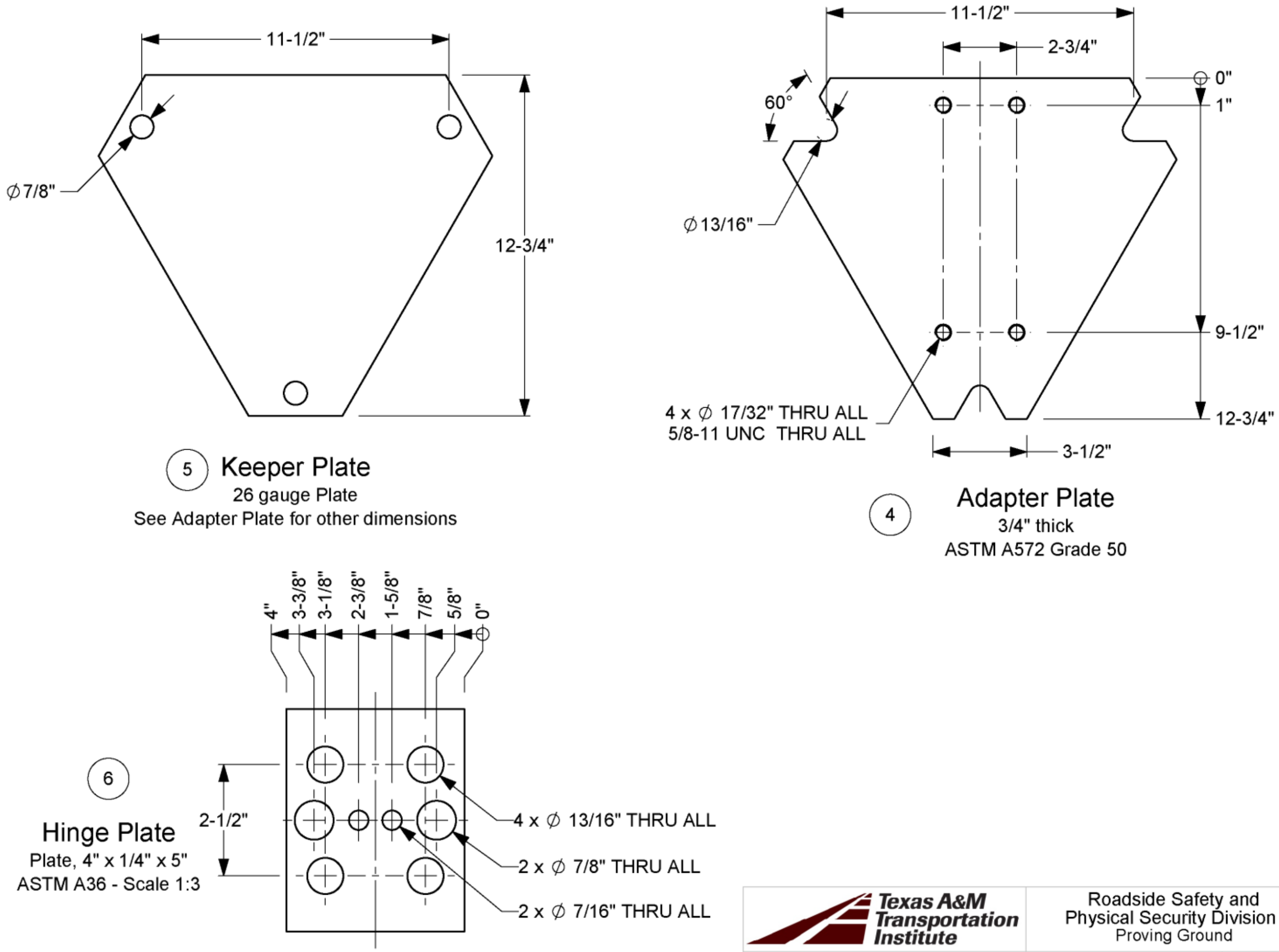
S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\2024-02-22 (10' tall)\616401-01 Guide Sign Drawing, 2024-03-01 7.4-01



4a. All welding must be performed by certified welders using industry standard practices.
4b. Galvanize components after fabrication is complete.

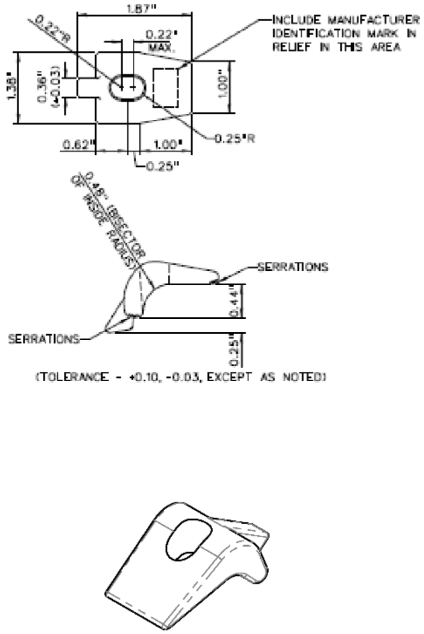
Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground
Project #616401-01 Guide Sign		2024-02-23
Drawn by GES	Scale 1:10	Sheet 4 of 6 Post Sections

S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\2024-02-22 (10' tall)\616401-01 Guide Sign Drawing, 2024-03-01 7.4-01



Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2024-02-23
Drawn by GES	Scale 1:5	Sheet 5 of 6 Assorted Parts-1

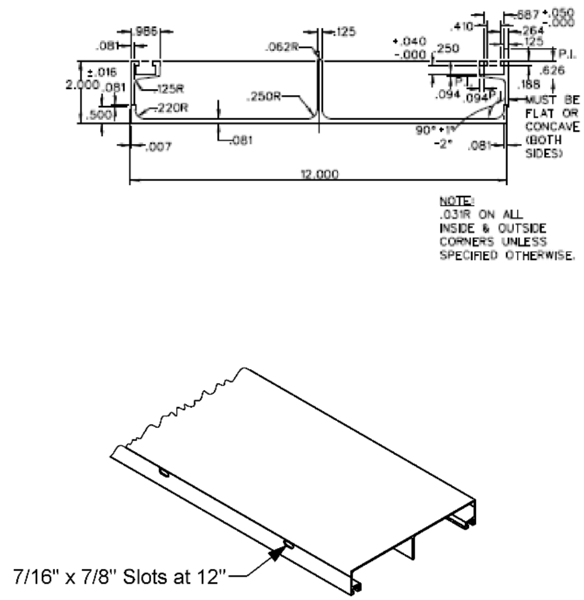
S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\2024-02-22 (10' tall)\616401-01 Guide Sign Drawing, 2024-03-01 7.4-01



9

Post Clamp

Details from West Virginia DoT Standard Sheet TE7-1.



7

Aluminum Sign Panel, 12" x 180"

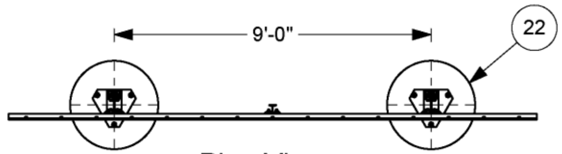
Details from West Virginia DoT Standard Sheet TE7-1.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2024-02-23
Drawn by GES	Scale 1:2	Sheet 6 of 6 Assorted Parts-2

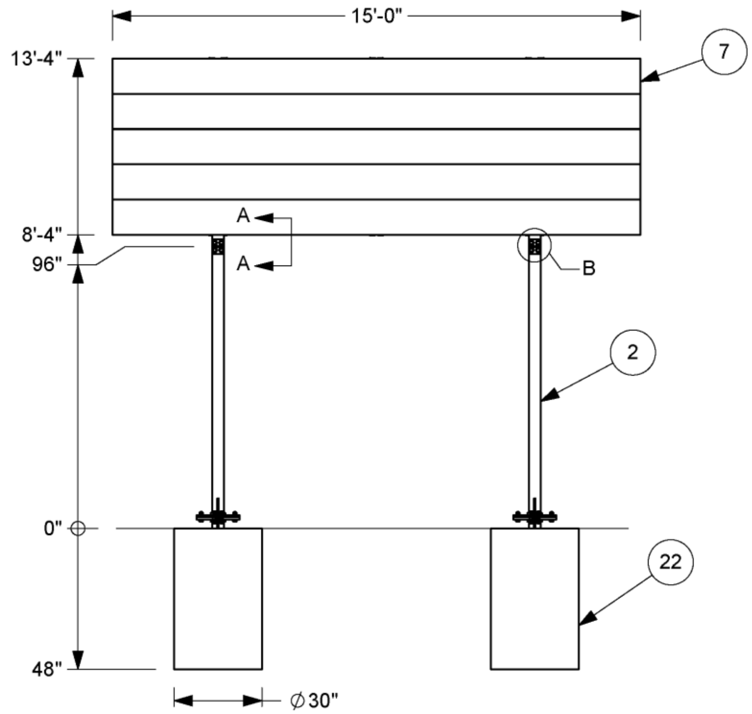
A.5. DETAILS OF THE GUIDE SIGN ON LARGE SUPPORT POSTS FOR CRASH TEST 616401-01-9

Test Installation

Detail and Section views on next sheet



Plan View



Elevation View

#	Part Name	QTY.
1	Bottom Section	2
2	Middle Section	2
3	Top Section	2
4	Adapter Plate	4
5	Keeper Plate	2
6	Hinge Plate	4
7	Aluminum Sign Panel, 12" x 180"	5
8	Stiffener	1
9	Post Clamp	24
10	Bolt, 3/8 x 1 3/4" square head	24
11	Bolt, 3/8 x 3/4" hex A307	28
12	Washer, 3/8 F844	80
13	Washer, 3/8 lock	24
14	Nut, 3/8 lock	28
15	Nut, 3/8 hex	24
16	Bolt, 5/8 x 1 1/2" hex A325	16
17	Washer, 5/8 F436	16
18	Bolt, 3/4 x 2" hex A325	16
19	Bolt, 3/4 x 2 3/4" hex A325	6
20	Washer, 3/4 F436	44
21	Nut, 3/4 heavy hex A194	22
22	3,000 psi concrete	2
23	Rebar Ring, Ø1/2" x 24" OD	8
24	Ø1" x 42" rebar	20

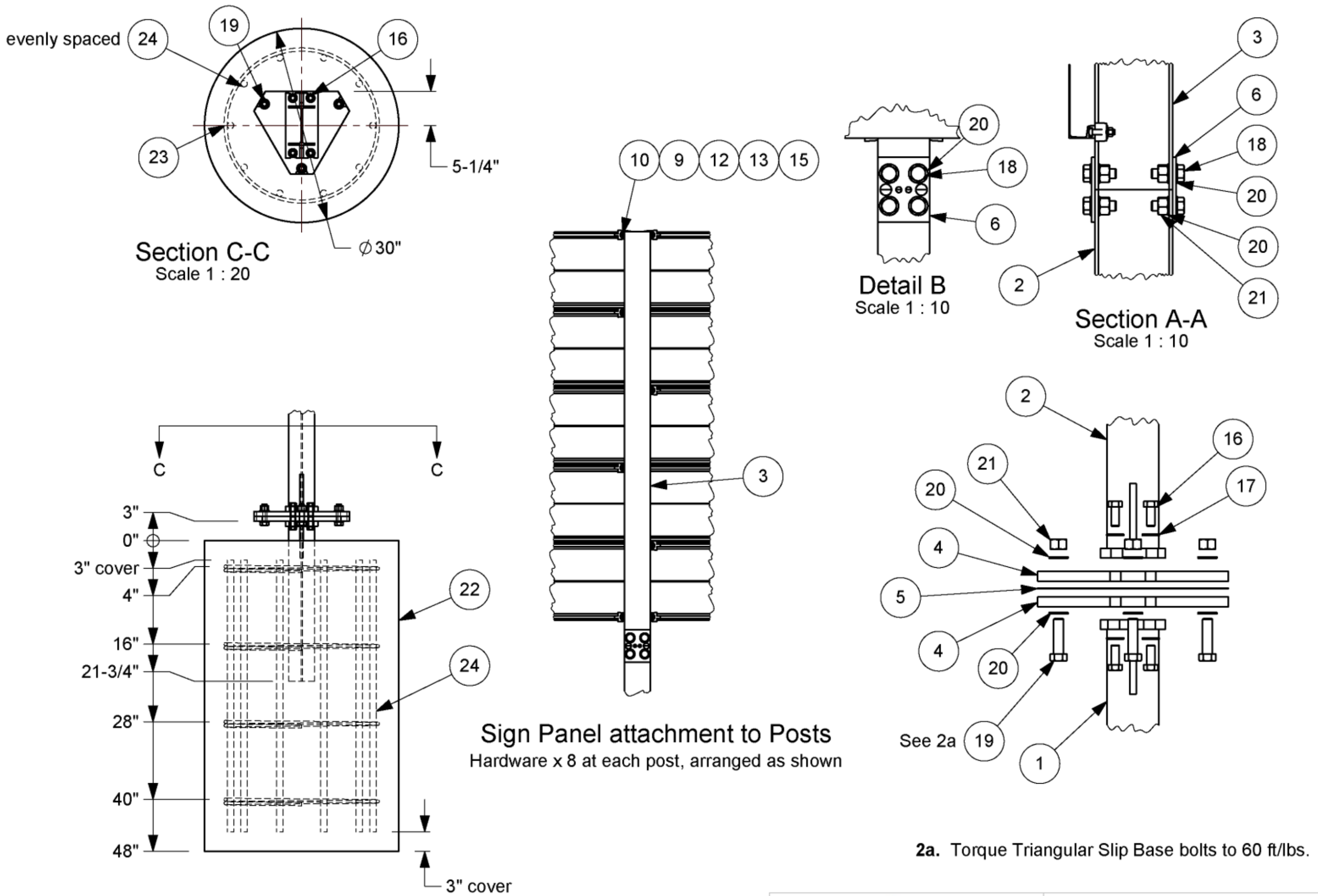
1a. All steel components shall be galvanized.

Texas A&M Transportation Institute

Roadside Safety and Physical Security Division - Proving Ground

Project #616401-01 Guide Sign		2023-07-25
Drawn by GES	Scale 1:50	Sheet 1 of 6 Test Installation

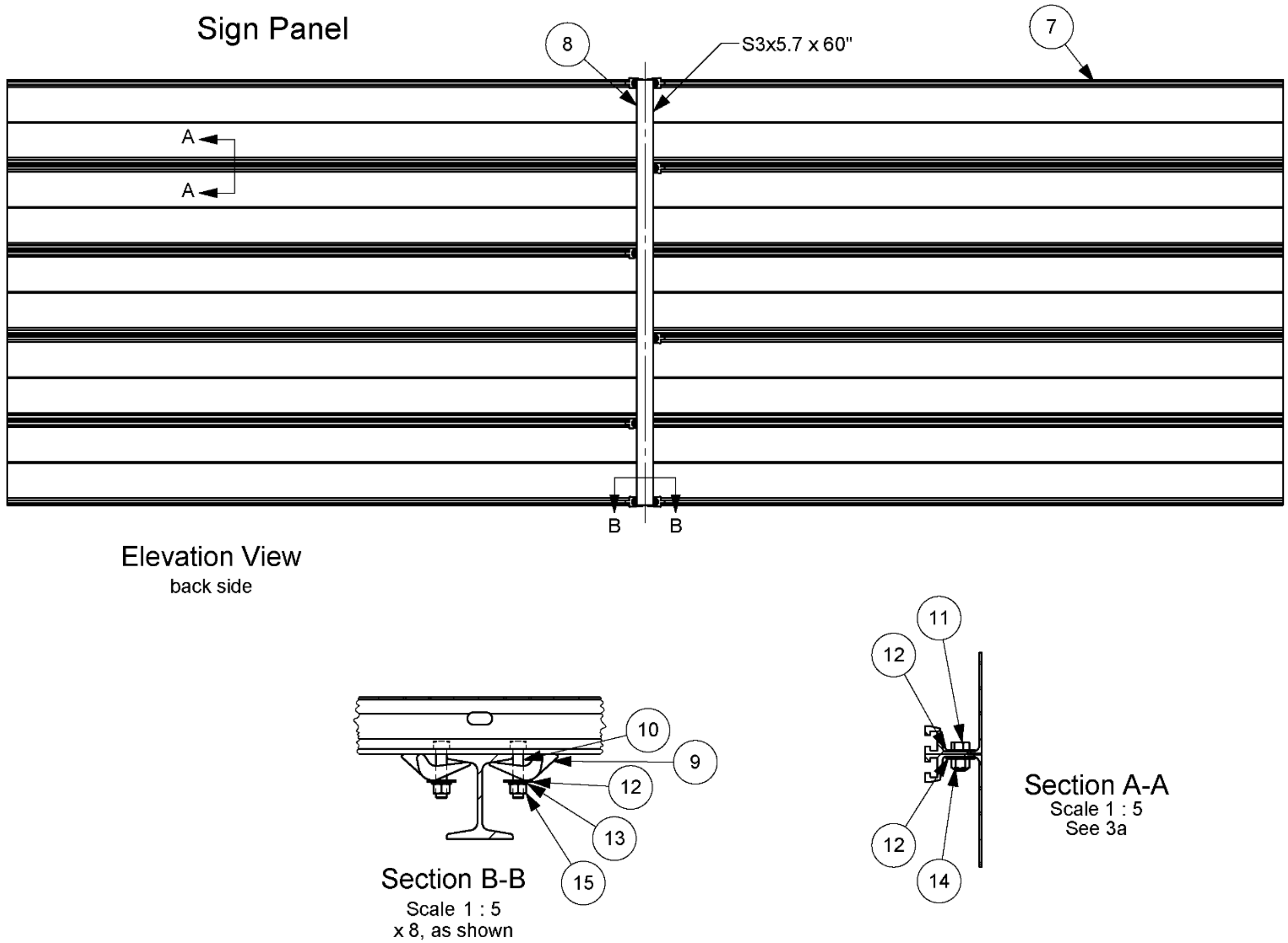
S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\new hinge plate\616401-01 Guide Sign Drawing



Foundation Details

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
	Project #616401-01 Guide Sign	2023-07-25
Drawn by GES	Scale 1:20	Sheet 2 of 6 Detail and Section Views

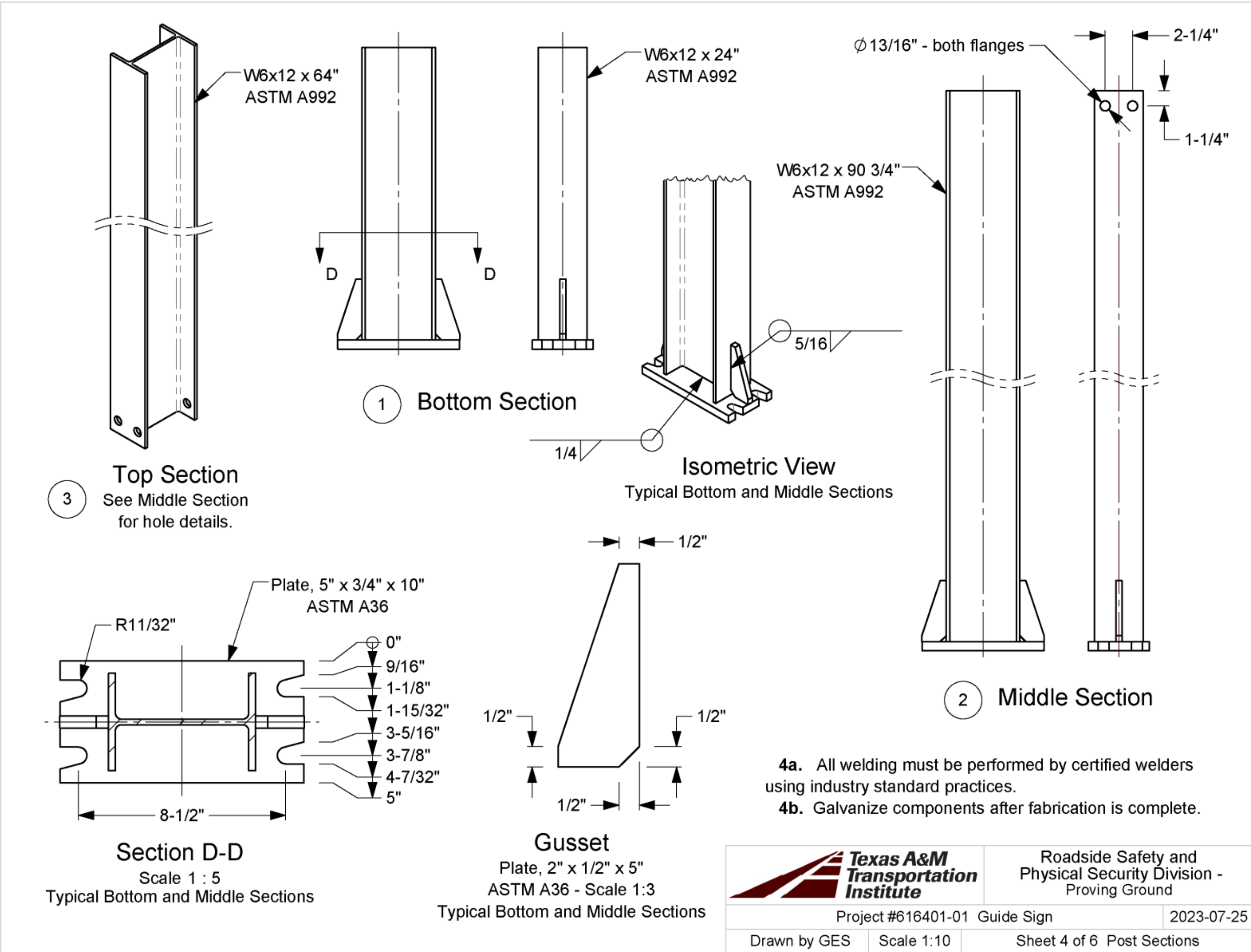
Sign Panel



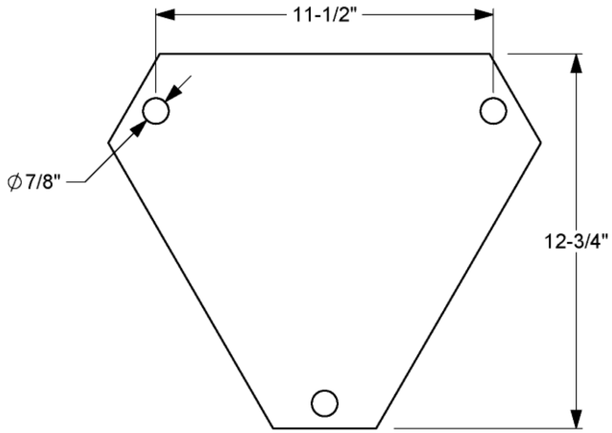
3a. Stitch Bolts spaced at 24" horizontally, staggered 12" on alternating joints.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2023-07-25
Drawn by GES	Scale 1:20	Sheet 3 of 6 Sign Panel

S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\new hinge plate\616401-01 Guide Sign Drawing



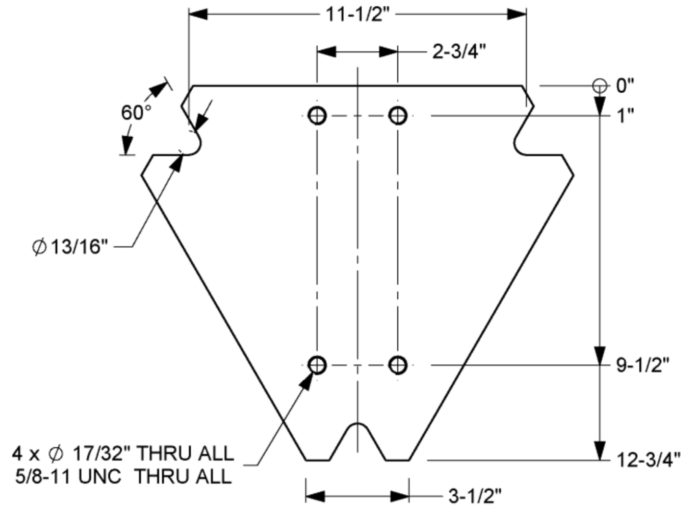
S:\Accreditation-17025-2017\EIR-000 Project Files\616401-01 - Multi-direction Sign - Kovar\Drafting, 616401-01\guide sign\new hinge plate\616401-01 Guide Sign Drawing



5 Keeper Plate

26 gauge Plate

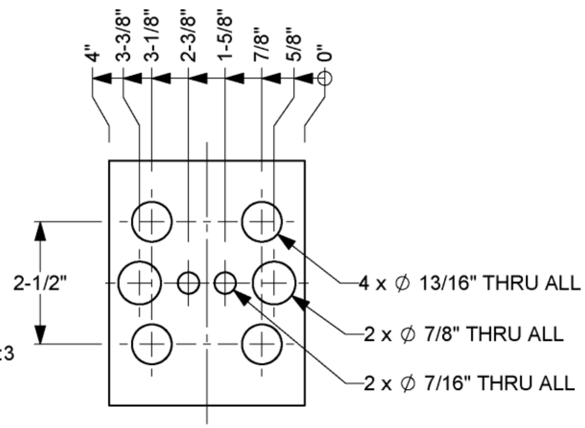
See Adapter Plate for other dimensions



4 Adapter Plate

3/4" thick

ASTM A572 Grade 50

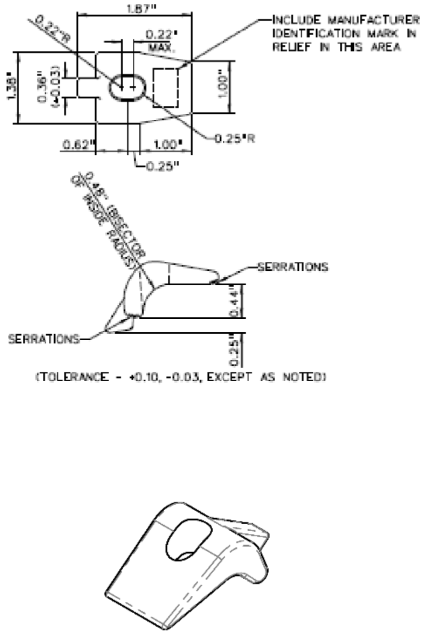


6 Hinge Plate

Plate, 4" x 1/4" x 5"

ASTM A36 - Scale 1:3

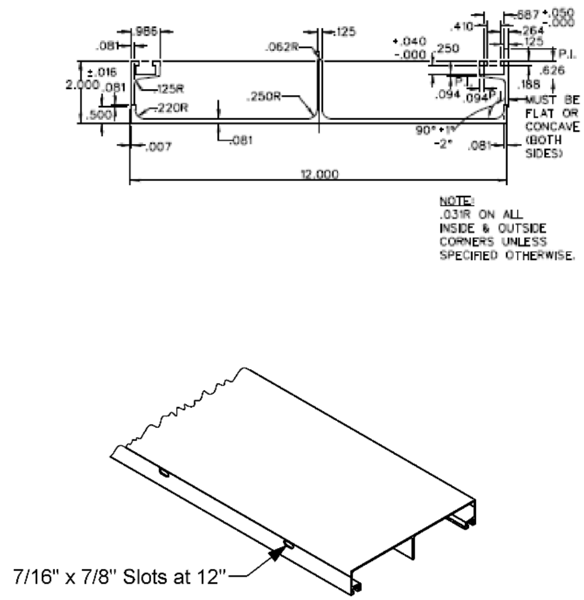
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2023-07-25
Drawn by GES	Scale 1:5	Sheet 5 of 6 Assorted Parts-1



9

Post Clamp

Details from West Virginia DoT Standard Sheet TE7-1.



7

Aluminum Sign Panel, 12" x 180"

Details from West Virginia DoT Standard Sheet TE7-1.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616401-01 Guide Sign		2023-07-25
Drawn by GES	Scale 1:2	Sheet 6 of 6 Assorted Parts-2

APPENDIX B. SUPPORTING CERTIFICATION DOCUMENTS

Triple S

CERTIFICATE OF ANALYSIS

Besheret STEEL PROCESSING

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

July 11, 2023

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

	Heat	Tag	Pcs	LBS
HOT ROLLED PLATE A36/SA36 0.2500" x 60" x 120"	2A5263	38442E	10	5,107

Part PL36TML1460
Conform To ASTM-A36-.246-.258 7/1/2019

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

Chemical Composition

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# 616401
Item #1

A36 Plate
1/4 x 60 x 120

7/3/2023	01:25 PM		1

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: 616401-01 **Casting Date:** 3/31/2023 **Mix Design (psi):** 3000

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	chrisburns130	148107	100% of Footers

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

TEXCRETE
Redi-mix Concrete Company

148107

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

TEXCRETE

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

5222 Sandy Point RD.
Bryan, Tx 77807

17534 SH 6 South
College Station, TX 77845

18935 Circle Lake Dr.
Pinehurst, TX 77362

TEXAS A&M TRANSPORTATIO
RELLIS CAMPUS, BRYAN TX

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

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
9:00	FN93020050	7.00	7.00	PO#	CHRIS BURNS130		77509
DATE	PROJECT	LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
3/31/23	TTIRELL	7.00	7.00			5.00 in	75715

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
7.00 yd	FN930200500	COM,3000,BLND,5"		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
908	927	928			
FINISH UNLOADING	LEFT JOB	ARRIVED AT PLANT	ON SITE TESTING		
			TESTING LAB: TERRACON GESSNER CME	OTHER	
	TESTED		AIR	CYLINDERS	
	☐ YES ☐ NO				

Tax
Prev. AMT
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:

10 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 ______

148107

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0268
Service Date: 03/31/23
Report Date: 04/26/23
Task: PO# 616401

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: 3,000 psi @ 28 days

Mix ID: FN930200500
Supplier: Texcrete
Batch Time: 0900 **Plant:**
Truck No.: Burns130 **Ticket No.:** 75715

Sample Information
Sample Date: 03/31/23 **Sample Time:** 1015
Sampled By: Alexander Dunigan, P.E.
Weather Conditions:
Accumulative Yards: 7/7 **Batch Size (cy):** 7
Placement Method:
Water Added Before (gal):
Water Added After (gal):
Sample Location: Footer on East End
Placement Location: Footers
Sample Description: 6-inch diameter cylinders

Field Test Data

Test	Result	Specification
Air Content (%):		
Concrete Temp. (F):		
Ambient Temp. (F):		
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		05/09/23	39 F	111,320	3,940	2	TJT
1	B	Good	6.00	28.27		05/09/23	39 F	106,270	3,760	2	TJT
1	C	Good	6.00	28.27		05/09/23	39 F	108,350	3,830	2	TJT
1	D		6.00	28.27		05/26/23	56 F				

Initial Cure: Outside **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.: Alexander Dunigan, P.E. **Start/Stop:** 1000-1100
Reported To:
Contractor:
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

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: 616401-01 **Casting Date:** 10/12/2023 **Mix Design (psi):** 3000

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	Alvarez,Ines3	84281	100% of Replacement Footer

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

TEXCRETE
Redi-mix Concrete Company

179146

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 INTORELLIS ENTRANCE, STAY STRAIGHTALL THE WAY DOWN TO THE GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
9:37	FN93020050	3.00	3.00	PO# 616401	ALVAREZ, INES3		86090
DATE	PROJECT	LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
10/12/23	TTIRELL	3.00	3.00			5.00 in	84281

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
3.00 yd	FN930200500	30,5,457,.55		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

Tax
Prev. AMT
Ticket Total

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
949	1003				

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. 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 RELEASErelieving 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_20 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____________

179146

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0283
Service Date: 10/12/23
Report Date: 11/28/23
Task: PO# 616401

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: 4,000 psi @ 28 days

Mix ID: FN930200500
Supplier: Texcrete
Batch Time: 0937 **Plant:**
Truck No.: Ines3 **Ticket No.:** 84281

Sample Information

Sample Date: 10/12/23 **Sample Time:** 1012
Sampled By: Daniel Calvo
Weather Conditions: Cloudy
Accumulative Yards: 3.00/3.00 **Batch Size (cy):** 3
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: Pier Diagonally SW 1200' from 7th St
Placement Location: Pier across IODP SW of 7th St
Sample Description: 6-inch diameter cylinders

Field Test Data

Test	Result	Specification
Slump (in):	2 1/4	
Air Content (%):	2.1	
Concrete Temp. (F):	85	
Ambient Temp. (F):	67	
Plastic Unit Wt. (pcf):	147.3	
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	11/28/23	47 F	115,390	4,080	2	DD
1	B	Good	6.00	28.27	10/13/23	11/28/23	47 F	117,470	4,160	2	DD
1	C	Good	6.00	28.27	10/13/23	11/28/23	47 F	112,910	3,990	2	DD
1	D				10/13/23		Hold				

Initial Cure: Outside Plastic Lids **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.: Daniel Calvo
Reported To:
Contractor: MBC Management
Report Distribution:
(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

Start/Stop: 0900-1200

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

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

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: 616401-01 **Casting Date:** 3/1/2024 **Mix Design (psi):** 3000

Name of Technician Taking Sample: Terracon

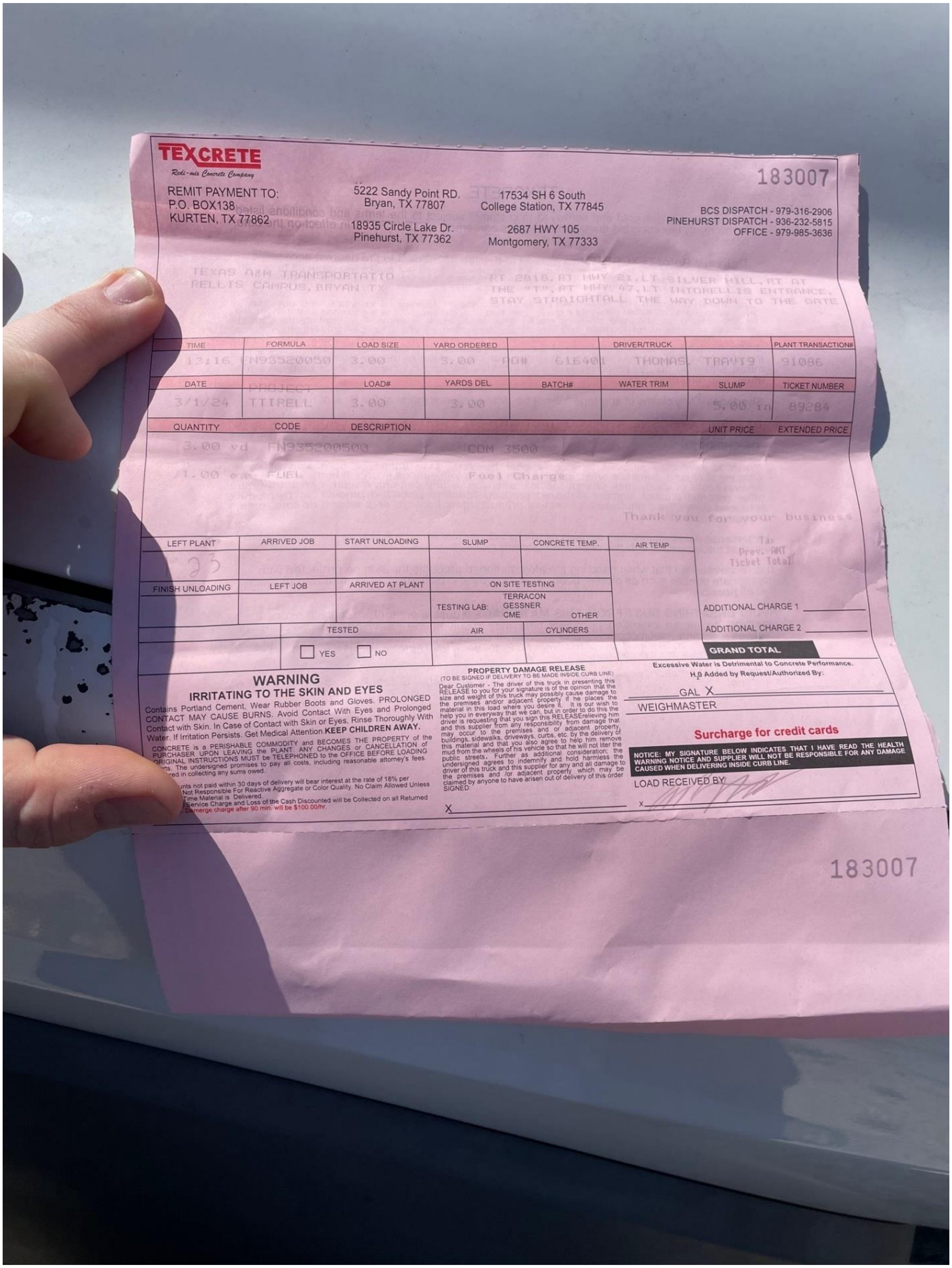
Name of Technician Breaking Sample: Terracon

Signature of Technician Taking Sample: Terracon

Signature of Technician Breaking Sample: Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	Thomas TravT9	89284	100% of Replacement Footer

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



TEXCRETE
Redi-mix Concrete Company

183007

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 INTORELLIS ENTRANCE.
STAY STRAIGHTALL THE WAY DOWN TO THE GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
13:16	FN93520050	3.00	3.00	PO# 616401	THOMAS, TRAVI9		91086

DATE	PROJECT	LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
3/1/24	TTIRELL	3.00	3.00			5.00 in	89284

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
3.00 yd	FN935200500	COM 3500		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

Tax
Prev. AMT
Ticket Total

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
23					

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 ...rts. The undersigned promises to pay all costs, including reasonable attorney's fees ...red in collecting any sums owed.

...unts not paid within 30 days of delivery will bear interest at the rate of 18% per ... Not Responsible For Reactive Aggregate or Color Quality. No Claim Allowed Unless ... Time Material is Delivered. ... Service Charge and Loss of the Cash Discounted will be Collected on all Returned ... 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

183007

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0289
Service Date: 03/01/24
Report Date: 03/19/24
Task: PO# 616401-01

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 @ 28 days

Mix ID: FN35200500
Supplier: Texcrete
Batch Time: 1313 **Plant:** Bryan
Truck No.: 1 **Ticket No.:** 89284

Sample Information
Sample Date: 03/01/24 **Sample Time:** 1414
Sampled By: Keaon Griffin
Weather Conditions: Sunny, Light wind
Accumulative Yards: 3/3 **Batch Size (cy):** 3
Placement Method: Chute
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: Foundation guard rail
Placement Location: Foundation guard rail
Sample Description: 6-inch diameter cylinders

Field Test Data

Test	Result	Specification
Slump (in):	5 1/2	
Air Content (%):	2.0	
Concrete Temp. (F):	75	
Ambient Temp. (F):	65	
Plastic Unit Wt. (pcf):	143.3	
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		03/18/24	17 F	103,140	3,650	3	AGV
1	B	Good	6.00	28.27		03/18/24	17 F	103,520	3,660	3	AGV
1	C						Hold				
1	D						Hold				

Initial Cure: Onsite Cooler **Final Cure:** Field Cured

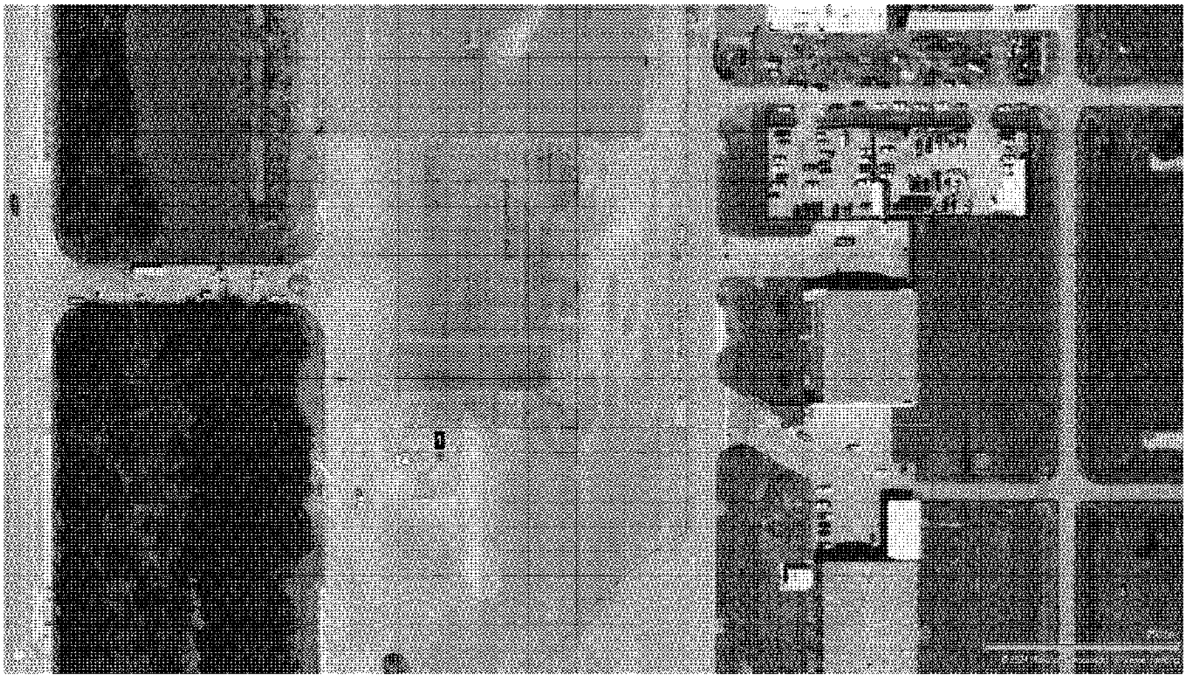
Comments: **F = Field Cured**
Note: Reported air content does not include Aggregate Correction Factor (ACF).

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.: Keaon Griffin
Start/Stop: 1200-1530
Reported To: Bill with TTI
Contractor:
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



Test

Retested / Accepted

Deviation

terracon

6198 Imperial Loop
College Station, TX 77845-5765
979-846-3767
terracon.com

Riverside Campus

Concrete Compressive Strength Test

Exhibit
A-1

Report Number:	Service Date:	Employee:	Scale:
A1171057.0289	03/01/2024	Griffin, Keaon	Refer to Drawing

Photo Log

Report Number: A1171057.0289
Service Date: 03/01/24
Report Date: 03/19/24
Task: PO# 616401-01

Terracon

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

(P1) Cylinder Storage

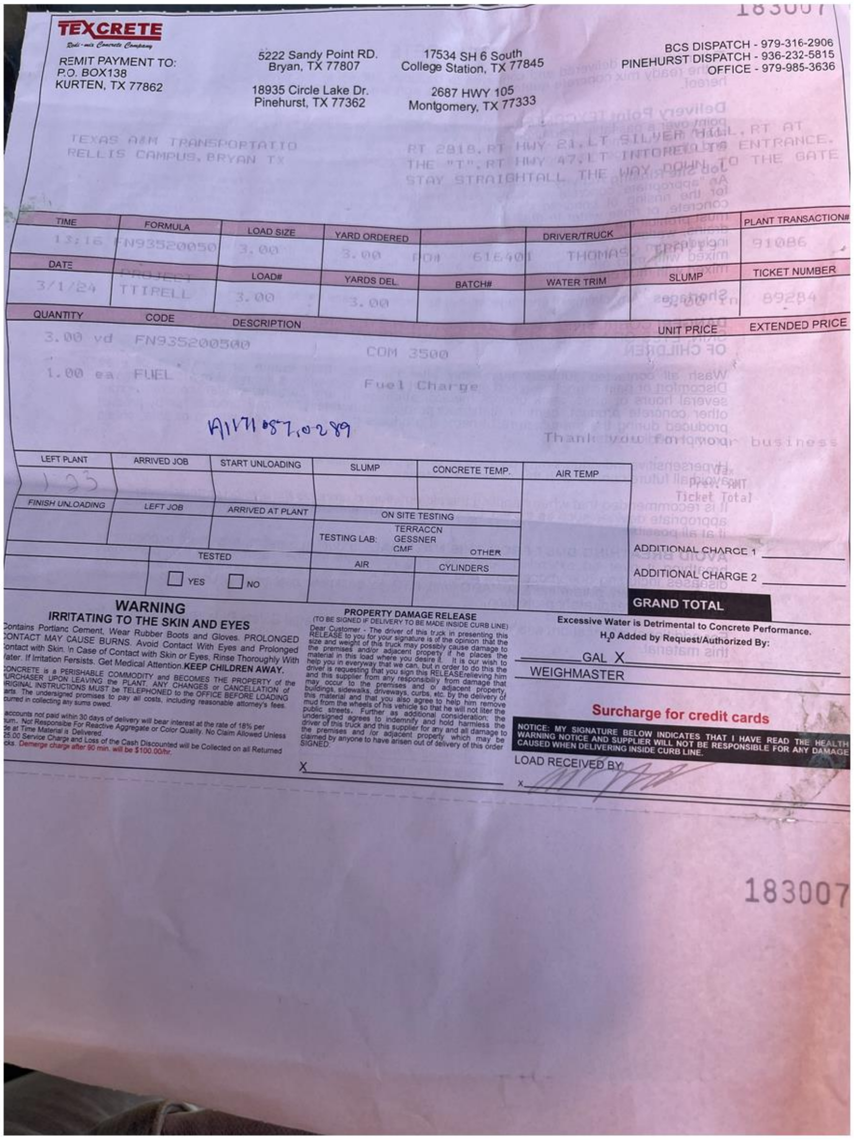
Photo Log

Report Number:	A1171057.0289
Service Date:	03/01/24
Report Date:	03/19/24
Task:	PO# 616401-01

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

(P2) Placement Location

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



(P3) Ticket

APPENDIX C. *MASH* TEST 3-60 (CRASH TEST 616401-01-1)

C.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2023-05-04 Test No.: 616401-01-1 VIN No.: 3NICN7AP6KL810468

Year: 2019 Make: Nissan Model: Versa

Tire Inflation Pressure: 36 PSI Odometer: 92331 Tire Size: P185/65R15

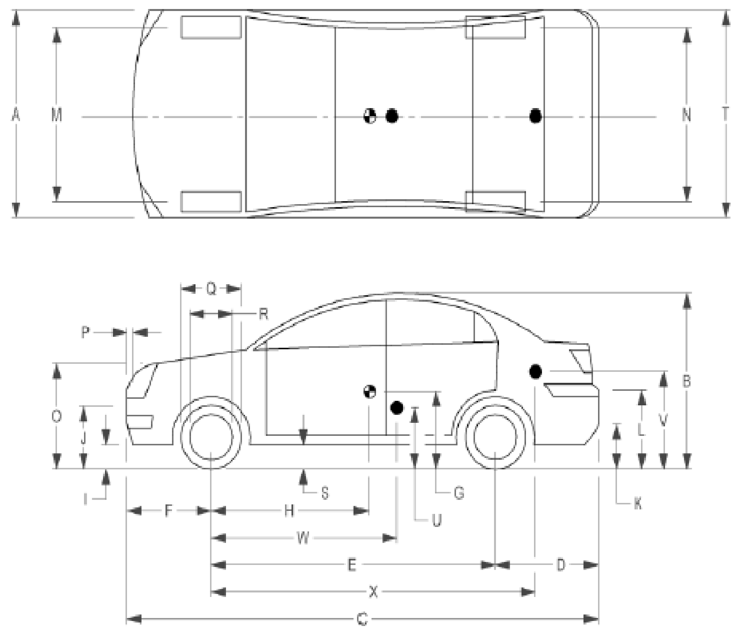
Describe any damage to the vehicle prior to test: None

● Denotes accelerometer location.

NOTES: None

Engine Type: 4 CYL
Engine CID: 1.6 L
Transmission Type:
☑ Auto or ☐ Manual
☑ FWD ☐ RWD ☐ 4WD
Optional Equipment:
None

Dummy Data:
Type: 50th Percentile Male
Mass: 165 lb
Seat Position: PASSENGER'S SIDE



Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G	0.00	L	26.00	Q	24.00	V	21.25
C	175.40	H	41.48	M	58.30	R	16.25	W	41.50
D	40.50	I	7.00	N	58.50	S	7.50	X	79.75
E	102.40	J	22.50	O	30.50	T	64.50		

Wheel Center Ht Front 11.50 Wheel Center Ht Rear 11.50 W-H 0.02

RANGE LIMIT: A = 65 ±3 inches; C = 169 ±8 inches; E = 98 ±5 inches; F = 35 ±4 inches; H = 39 ±4 inches; O (Top of Radiator Support) = 28 ±4 inches (M+N)/2 = 59 ±2 inches; W-H < 2 inches or use MASH Paragraph A4.3.2

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	1750	M_{front}	1439	1465	1550
Back	1687	M_{rear}	996	999	1079
Total	3389	M_{Total}	2435	2464	2629

Allowable TIM = 2420 lb ±55 lb | Allowable GSM = 2585 lb ± 55 lb

Mass Distribution:
lb LF: 722 RF: 743 LR: 543 RR: 456

Figure C.1. Vehicle Properties for Test 616401-01-1.

Date:	2023-05-04	Test No.:	616401-01-1	VIN No.:	3NICN7AP6KL810468
Year:	2019	Make:	Nissan	Model:	Versa

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	-	-	-	-	-	-	-	-	-	-	-
	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.

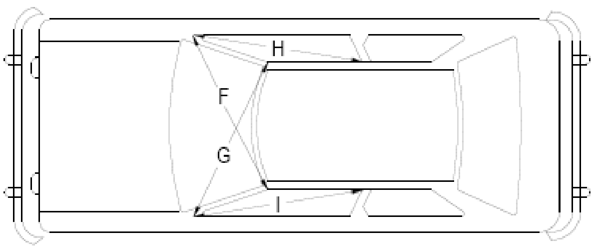
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

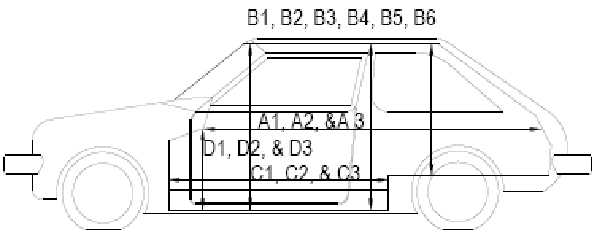
***Measure and document on the vehicle diagram the location of the maximum crush.

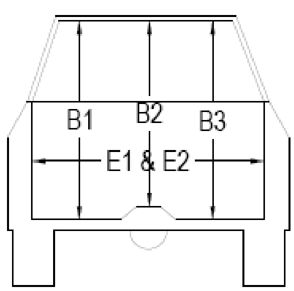
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure C.2. Exterior Crush Measurements for Test 616401-01-1.

Date:	2023-05-04	Test No.:	616401-01-1	VIN No.:	3NICN7AP6KL810468
Year:	2019	Make:	Nissan	Model:	Versa







OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	67.50	67.50	0.00
A2	67.25	67.25	0.00
A3	67.75	67.75	0.00
B1	40.50	39.50	-1.00
B2	39.00	37.00	-2.00
B3	40.50	39.50	-1.00
B4	36.25	35.75	-0.50
B5	36.00	33.50	-2.50
B6	36.25	35.25	-1.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	9.50	9.50	0.00
D2	0.00	0.00	0.00
D3	9.50	9.50	0.00
E1	51.50	51.50	0.00
E2	51.00	51.00	0.00
F	51.00	51.00	0.00
G	51.00	51.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	51.00	51.00	0.00

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

Figure C.3. Occupant Compartment Measurements for Test 616401-01-1.

C.2. SEQUENTIAL PHOTOGRAPHS

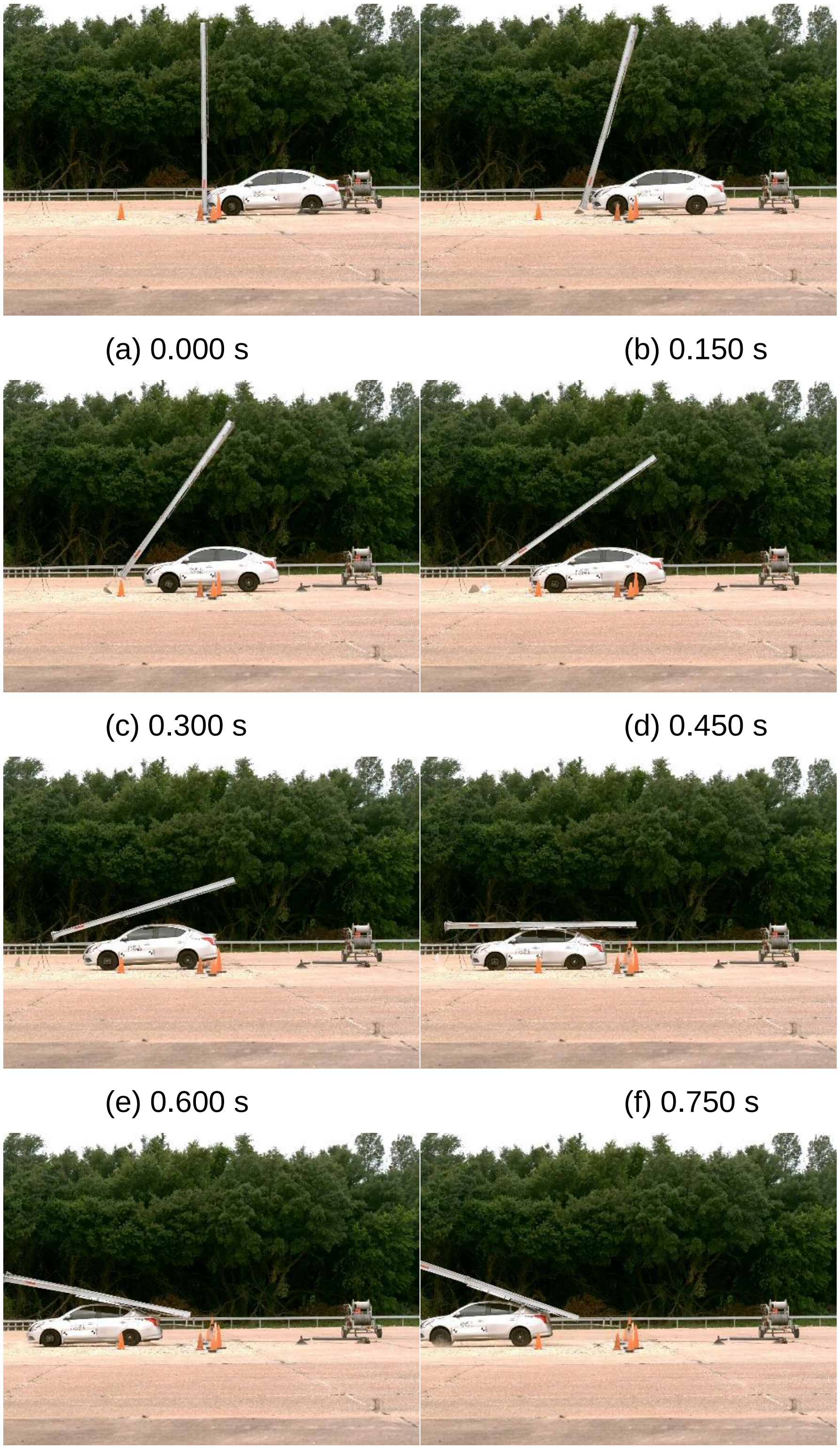
(a) 0.000 s (b) 0.150 s

(c) 0.300 s (d) 0.450 s

(e) 0.600 s (f) 0.750 s

(g) 0.900 s (h) 1.050 s

Figure C.4. Sequential Photographs for Test 616401-01-1 (Oblique Views).



(a) 0.000 s (b) 0.150 s

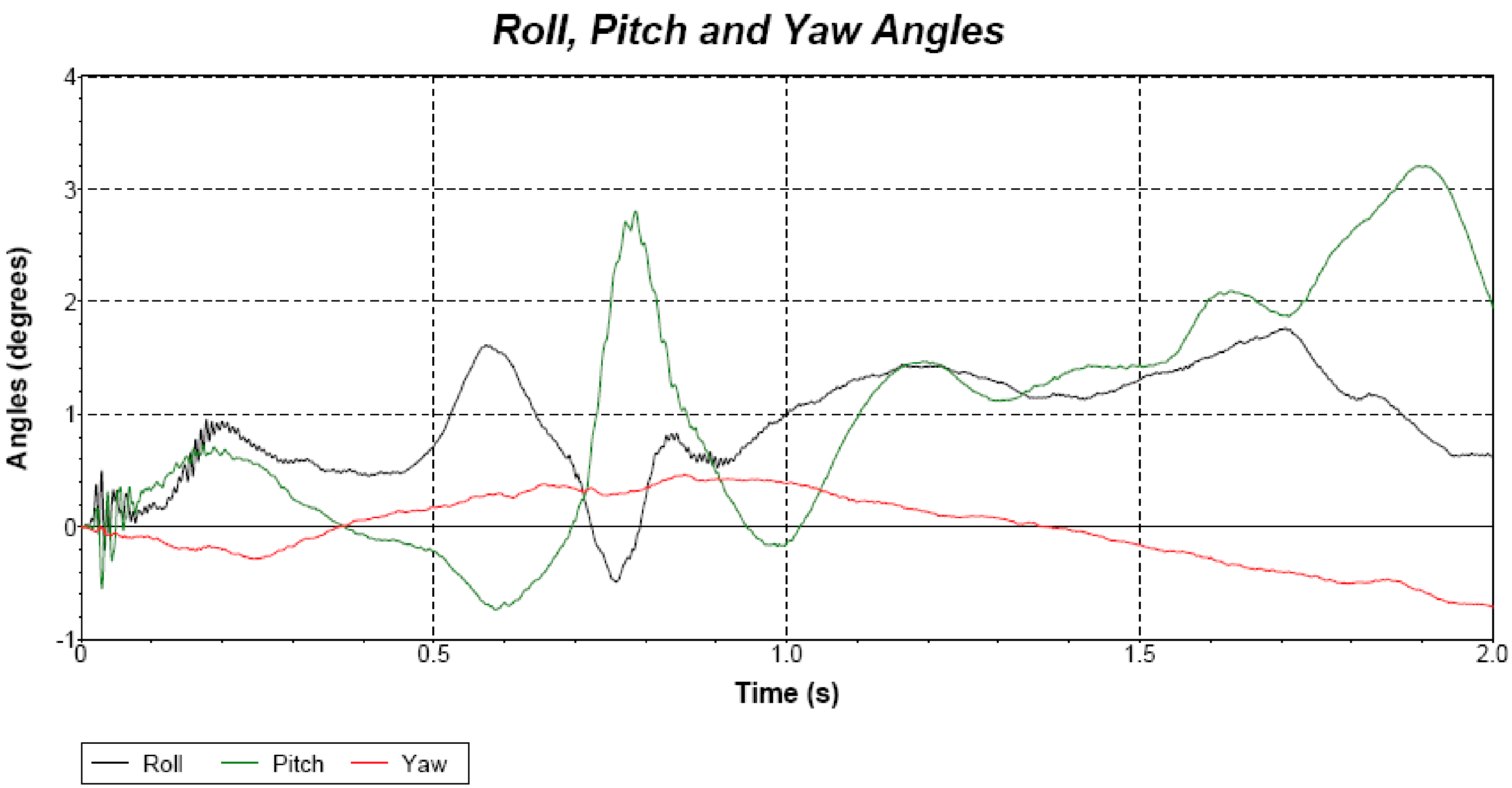
(c) 0.300 s (d) 0.450 s

(e) 0.600 s (f) 0.750 s

(g) 0.900 s (h) 1.050 s

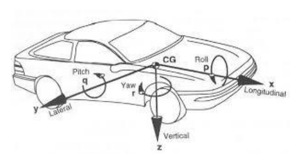
Figure C.5. Sequential Photographs for Test 616401-01-1 (Right Angle Views).

C.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

1. Yaw.
2. Pitch.
3. Roll



Test Number: 616401-01-1
Test Standard Test Number: *MASH* Test 3-60
Test Article: Route Marker
Test Vehicle: 2019 Nissan Versa
Inertial Mass: 2464 lbs
Gross Mass: 2629 lbs
Impact Speed: 18.8 mi/h
Impact Angle: 0°

Figure C.6. Vehicle Angular Displacements for Test 616401-01-1.

C.4. VEHICLE ACCELERATIONS

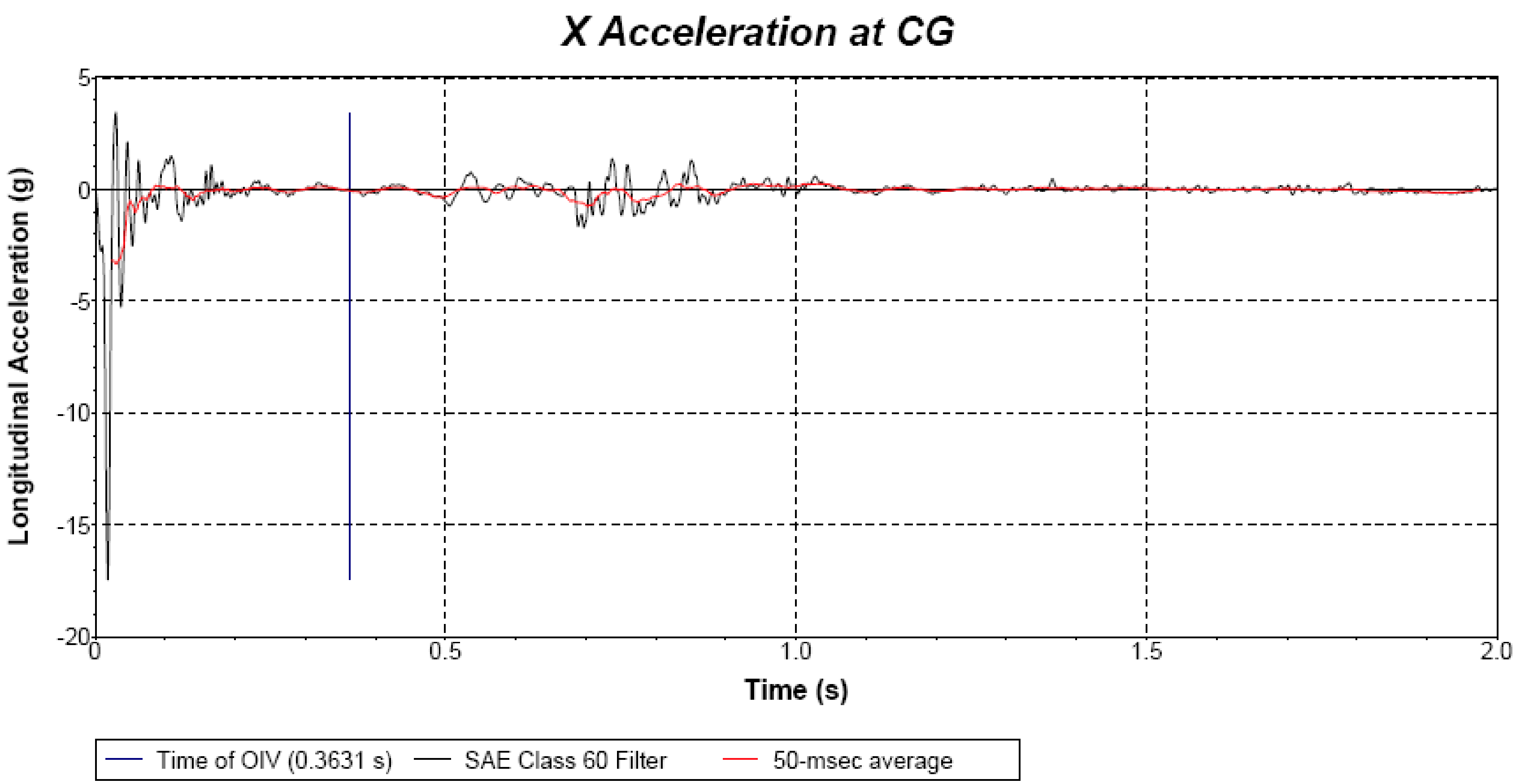


Figure C.7. Vehicle Longitudinal Accelerometer Trace for Test 616401-01-1 (Accelerometer Located at Center of Gravity).

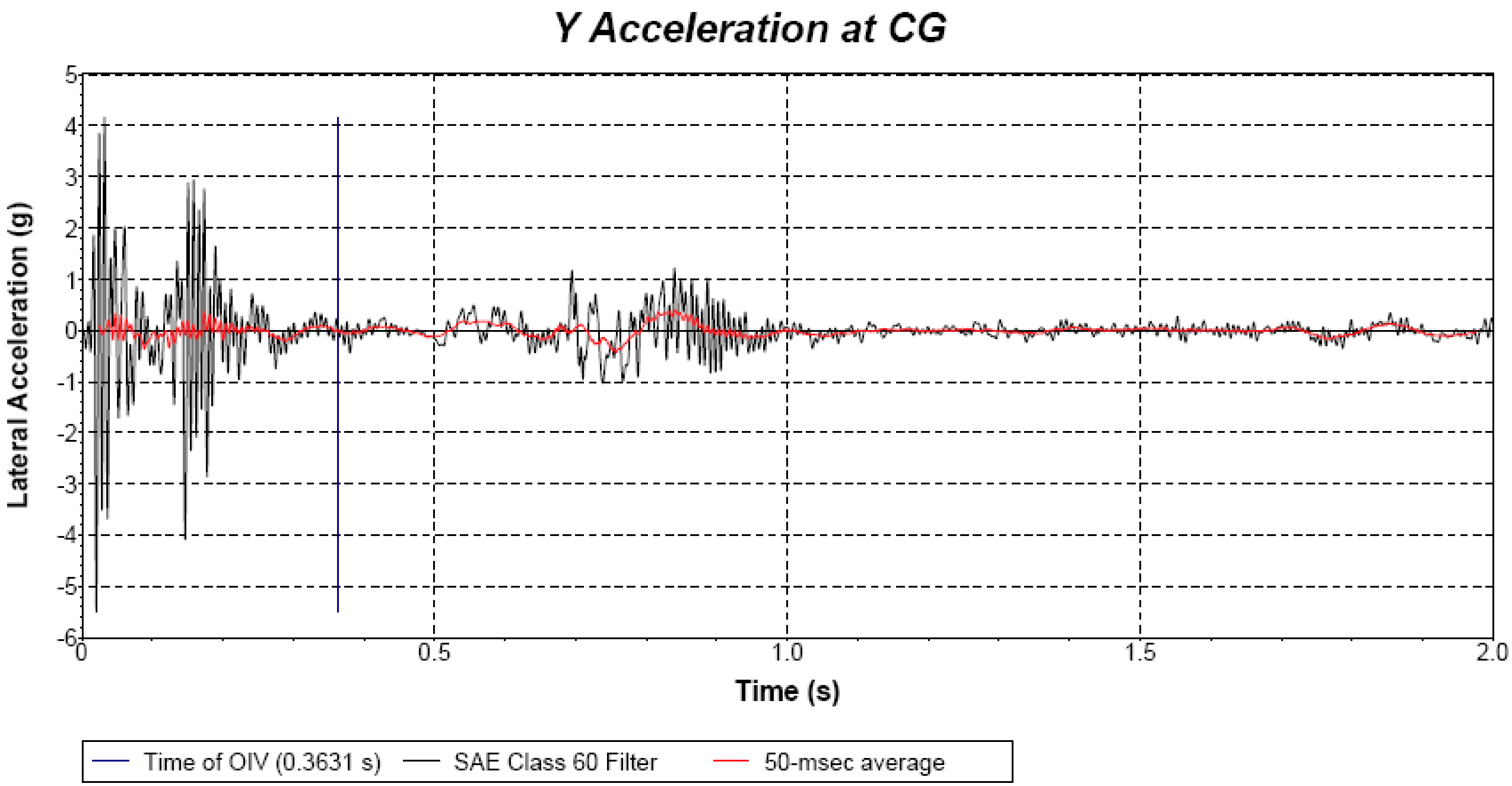


Figure C.8. Vehicle Lateral Accelerometer Trace for Test 616401-01-1 (Accelerometer Located at Center of Gravity).

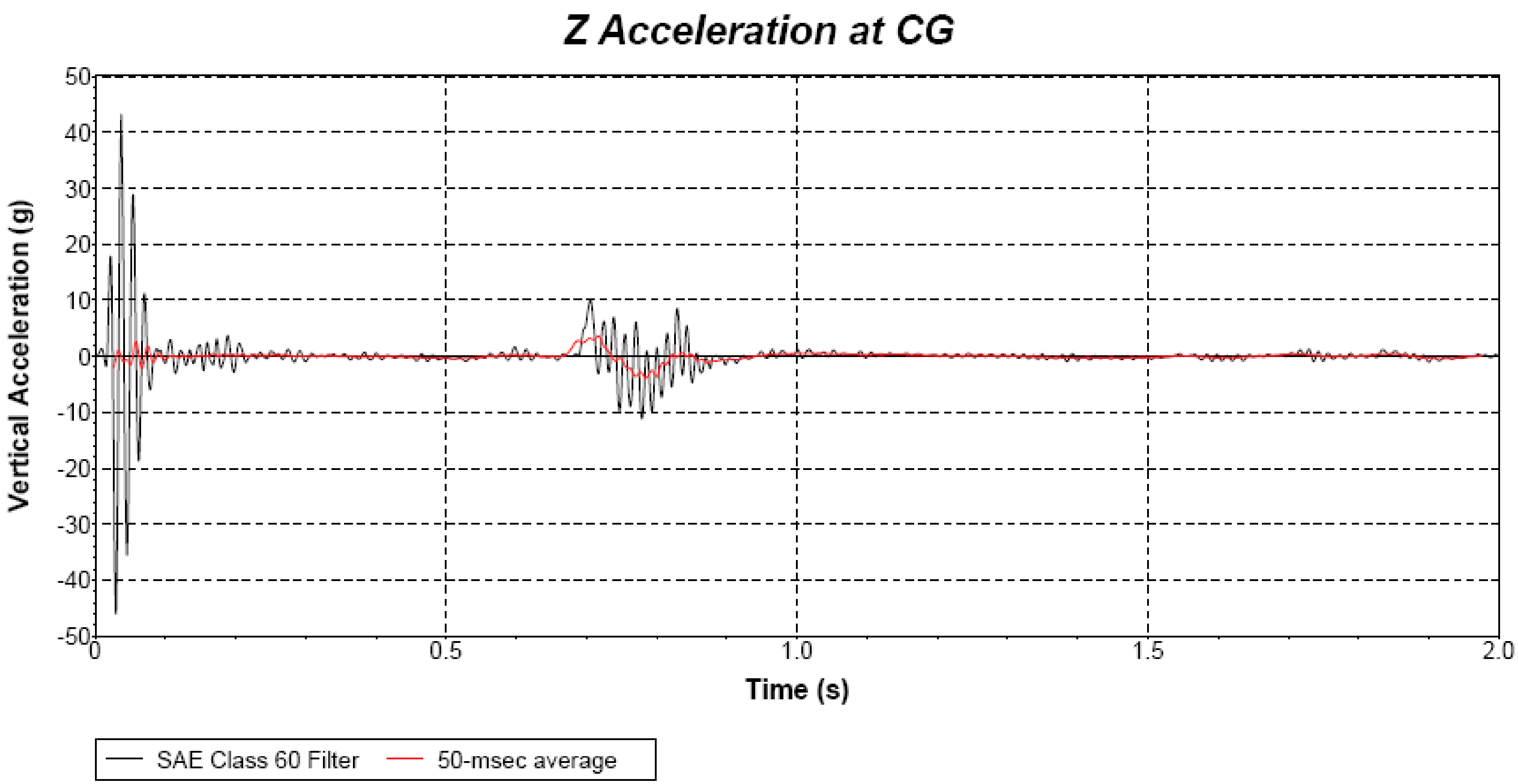


Figure C.9. Vehicle Vertical Accelerometer Trace for Test 616401-01-1 (Accelerometer Located at Center of Gravity).

APPENDIX D. *MASH* TEST 3-61 (CRASH TEST 616401-01-2)

D.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2023-05-04 Test No.: 616401-01-2 VIN No.: 3NICN7AP3JL867631

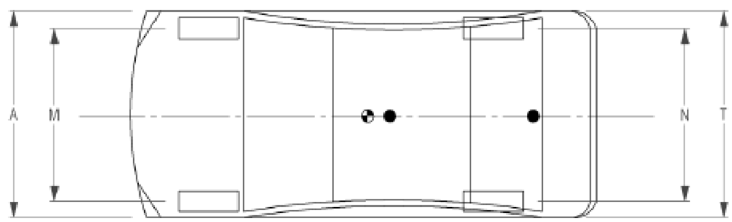
Year: 2018 Make: Nissan Model: Versa

Tire Inflation Pressure: 36 PSI Odometer: 103459 Tire Size: P185/65R15

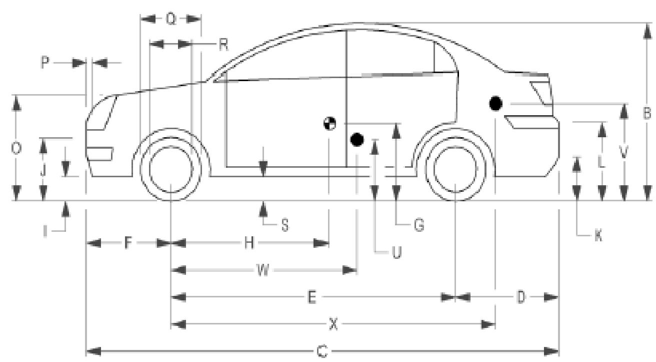
Describe any damage to the vehicle prior to test: None

● Denotes accelerometer location.

NOTES: None



Engine Type: 4 CYL
Engine CID: 1.6 L
Transmission Type:
☐ Auto or ☑ Manual
☑ FWD ☐ RWD ☐ 4WD
Optional Equipment:
None



Dummy Data:
Type: 50th Percentile Male
Mass: 165 lb
Seat Position: PASSENGER SIDE

Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G	0.00	L	26.00	Q	24.00	V	21.25
C	175.40	H	42.70	M	58.30	R	16.25	W	42.50
D	40.50	I	7.00	N	58.50	S	7.50	X	79.75
E	102.40	J	22.50	O	30.50	T	64.50		

Wheel Center Ht Front 11.50 Wheel Center Ht Rear 11.50 W-H -0.20

RANGE LIMIT: A = 65 ±3 inches; C = 169 ±8 inches; E = 98 ±5 inches; F = 35 ±4 inches; H = 39 ±4 inches; O (Top of Radiator Support) = 28 ±4 inches (M+N)/2 = 59 ±2 inches; W-H < 2 inches or use MASH Paragraph A4.3.2

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	1750	M_{front}	1393	1414	1499
Back	1687	M_{rear}	943	1013	1093
Total	3389	M_{Total}	2336	2427	2592

Allowable TIM = 2420 lb ±55 lb | Allowable GSM = 2585 lb ± 55 lb

Mass Distribution:
lb LF: 712 RF: 702 LR: 507 RR: 506

Figure D.1. Vehicle Properties for Test 616401-01-2.

Date:	2023-05-04	Test No.:	616401-01-2	VIN No.:	3NICN7AP3JL867631
Year:	2018	Make:	Nissan	Model:	Versa

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 Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
1	AT FRONT BUMPER	10	16	5	-	-	-	-	-	-	0
	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.

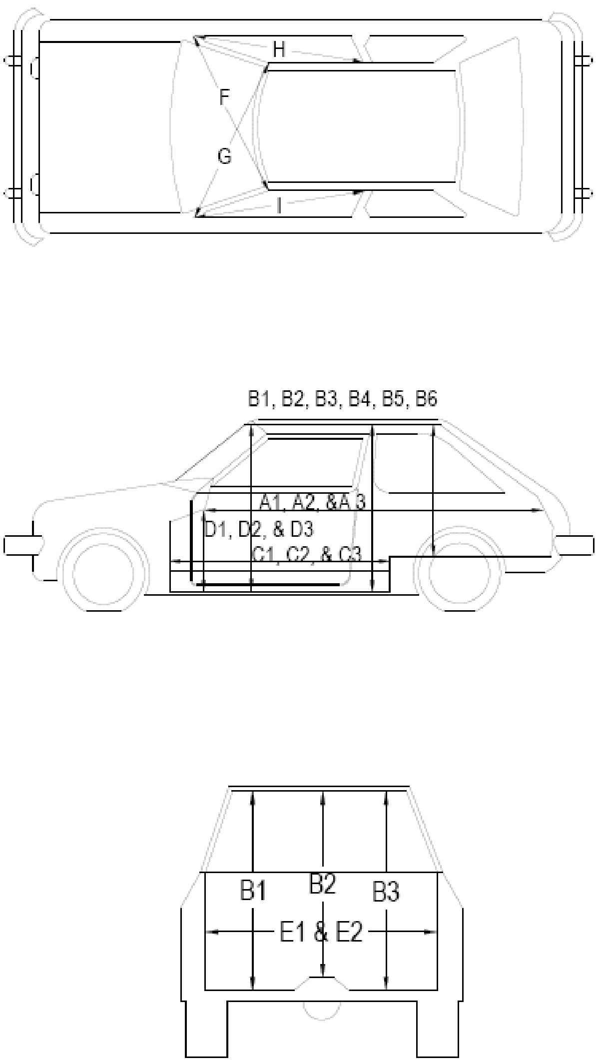
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

***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 D.2. Exterior Crush Measurements for Test 616401-01-2.

Date:	2023-05-04	Test No.:	616401-01-2	VIN No.:	3NICN7AP3JL867631
Year:	2018	Make:	Nissan	Model:	Versa



OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	67.50	67.50	0.00
A2	67.25	67.25	0.00
A3	67.75	67.75	0.00
B1	40.50	40.50	0.00
B2	39.00	39.00	0.00
B3	40.50	40.50	0.00
B4	36.25	36.25	0.00
B5	36.00	36.00	0.00
B6	36.25	36.25	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	9.50	9.50	0.00
D2	0.00	0.00	0.00
D3	9.50	9.50	0.00
E1	51.50	51.50	0.00
E2	51.00	51.00	0.00
F	51.00	51.00	0.00
G	51.00	51.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	51.00	51.00	0.00

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

Figure D.3. Occupant Compartment Measurements for Test 616401-01-2.

D.2. SEQUENTIAL PHOTOGRAPHS

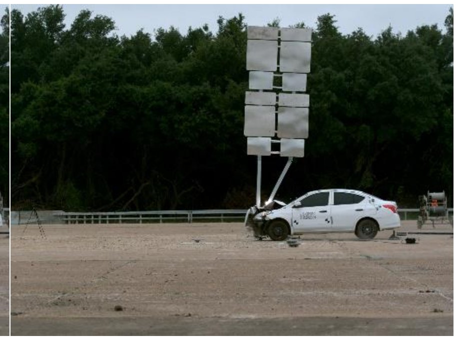
(a) 0.000 s (b) 0.050 s

(c) 0.100 s (d) 0.150 s

(e) 0.200 s (f) 0.250 s

(g) 0.300 s (h) 0.350 s

Figure D.4. Sequential Photographs for Test 616401-01-2 (Oblique Views).

(a) 0.000 s (b) 0.050 s

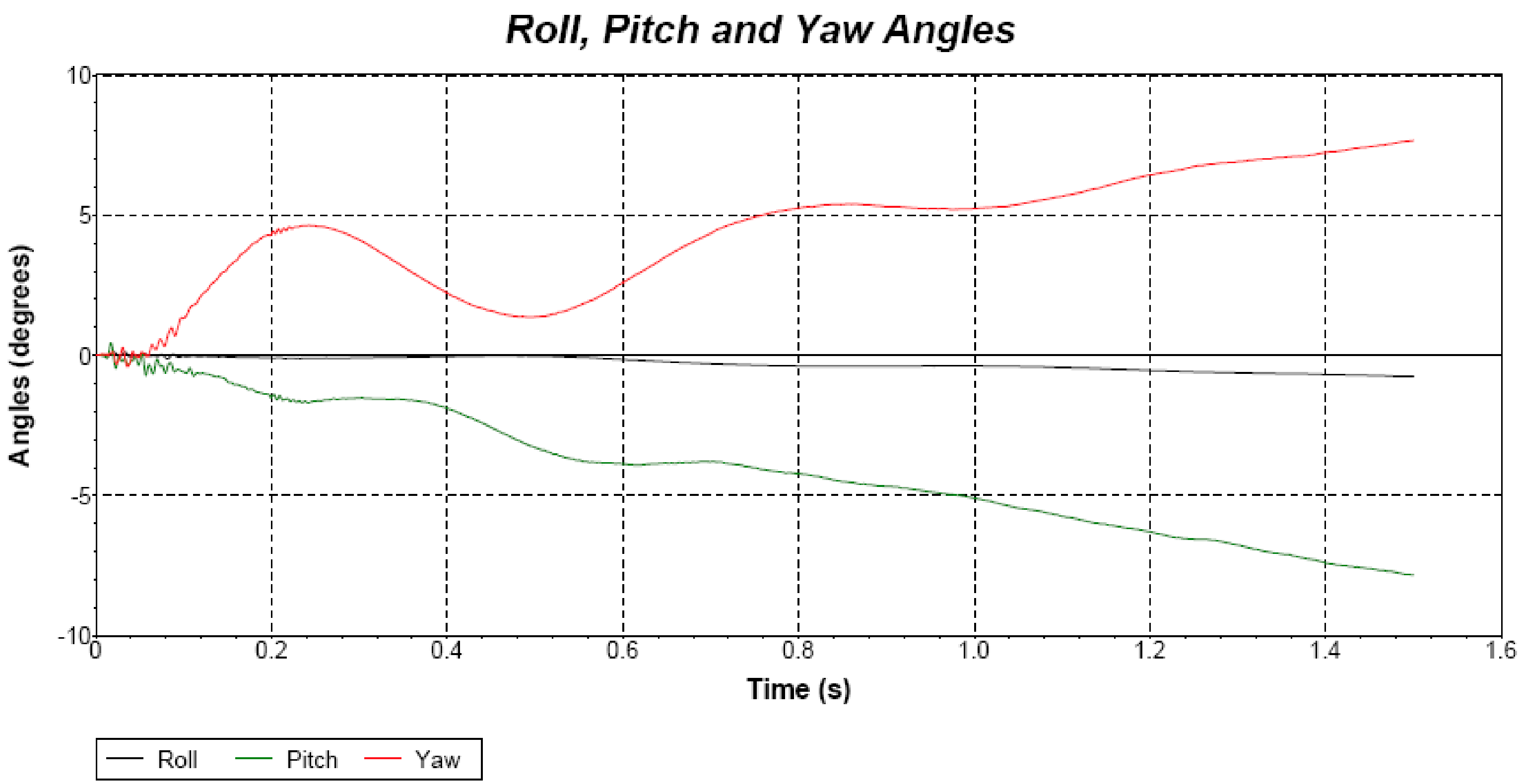

(c) 0.100 s (d) 0.150 s


(e) 0.200 s (f) 0.250 s


(g) 0.300 s (h) 0.350 s

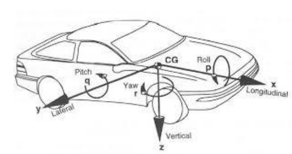
Figure D.5. Sequential Photographs for Test 616401-01-2 (Right Angle Views).

D.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

4. Yaw.
5. Pitch.
6. Roll.



Test Number: 616401-01-2
Test Standard Test Number: *MASH* Test 3-61
Test Article: Route Marker
Test Vehicle: 2018 Nissan Versa
Inertial Mass: 2427 lbs
Gross Mass: 2592 lbs
Impact Speed: 62.8 mi/h
Impact Angle: 90°

Figure D.6. Vehicle Angular Displacements for Test 616401-01-2.

D.4. VEHICLE ACCELERATIONS

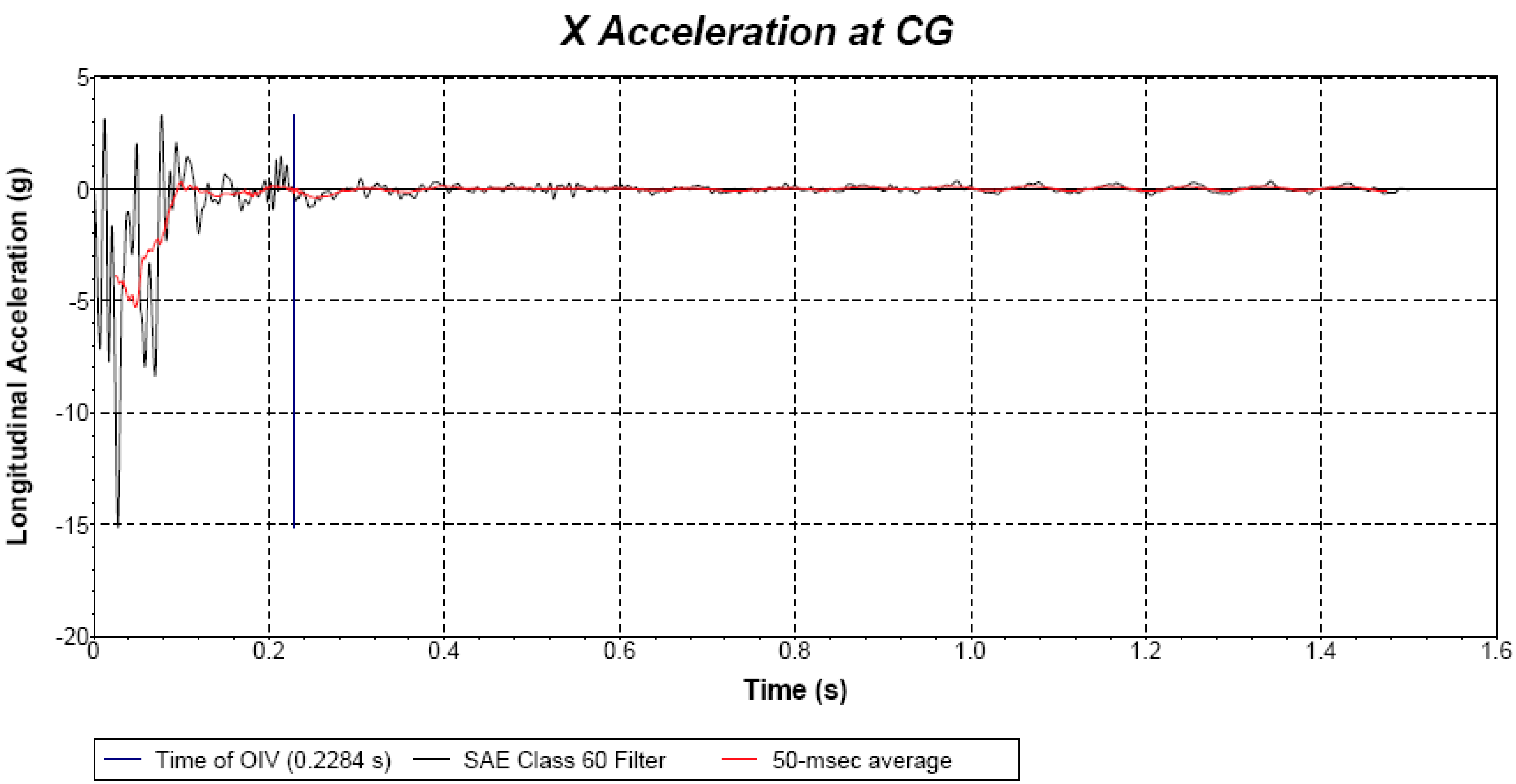


Figure D.7. Vehicle Longitudinal Accelerometer Trace for Test 616401-01-2 (Accelerometer Located at Center of Gravity).

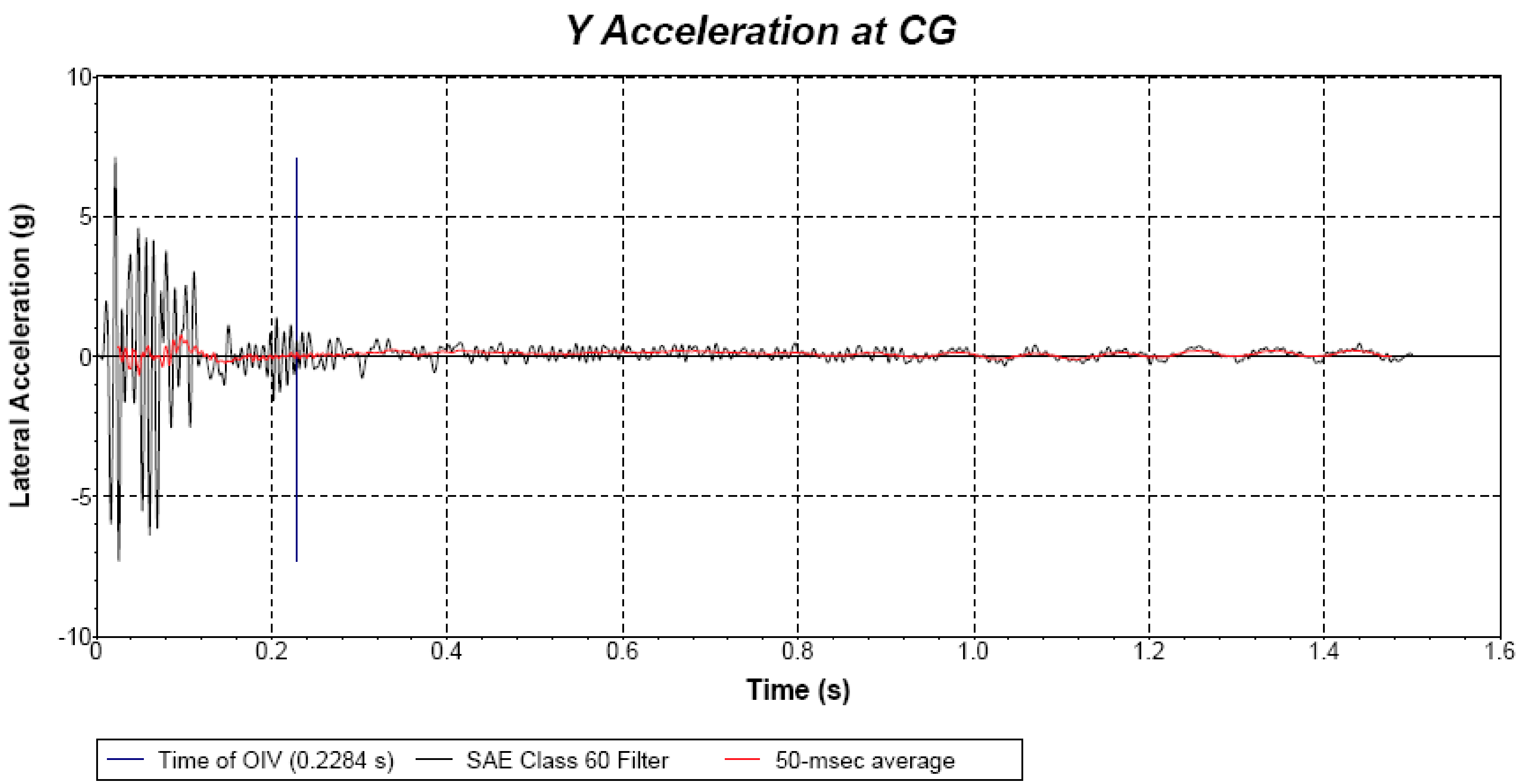


Figure D.8. Vehicle Lateral Accelerometer Trace for Test 616401-01-2 (Accelerometer Located at Center of Gravity).

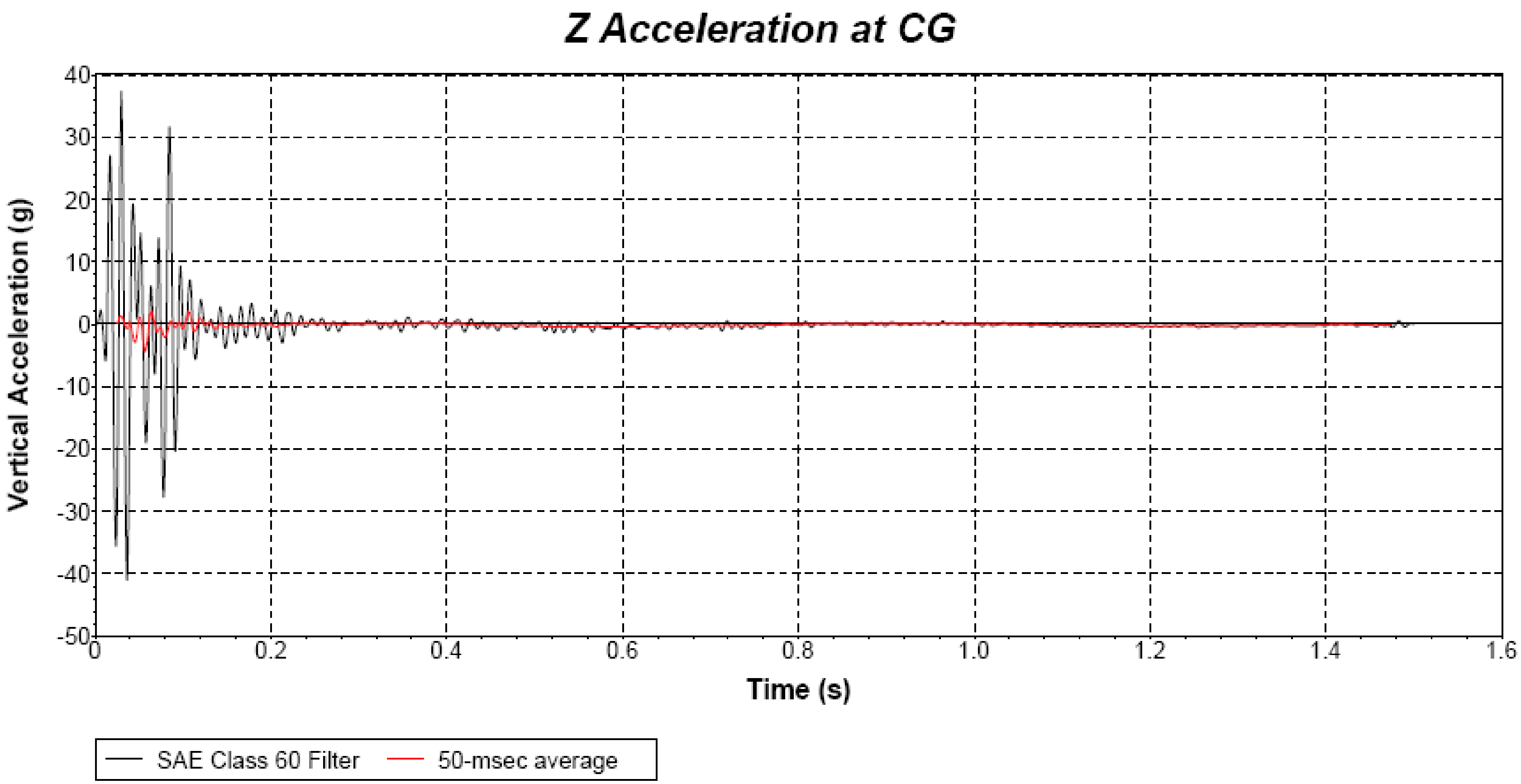


Figure D.9. Vehicle Vertical Accelerometer Trace for Test 616401-01-2 (Accelerometer Located at Center of Gravity).

APPENDIX E. *MASH* TEST 3-62 (CRASH TEST 616401-01-3)

E.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2023-05-04 Test No.: 616401-01-3 VIN No.: 1CRR6FT9HS791640

Year: 2017 Make: RAM Model: 1500

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

Tread Type: Highway Odometer: 127722

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

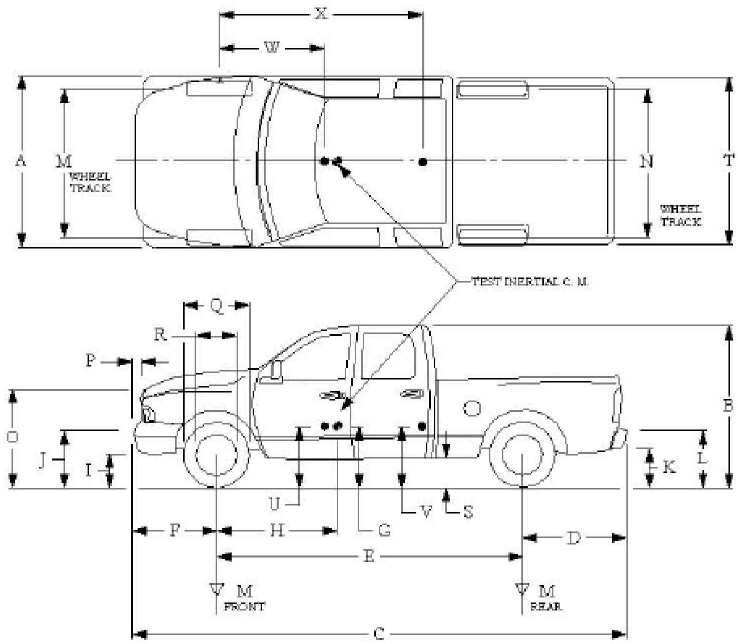
NOTES: None

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	28.50	L	30.00	Q	30.50	V	30.25
C	227.50	H	61.63	M	68.50	R	18.00	W	61.50
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}	2920	2819	0
Back	3900	M_{rear}	2078	2203	0
Total	6700	M_{Total}	4998	5022	5022

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

Mass Distribution:
lb LF: 1420 RF: 1399 LR: 1108 RR: 1095

Figure E.1. Vehicle Properties for Test 616401-01-3.

Date:	2023-05-04	Test No.:	616401-01-3	VIN No.:	1CRR6FT9HS791640
Year:	2017	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 Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
1	AT FRONT BUMPER	20	15	5	-	-	-	-	-	-	0
	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.

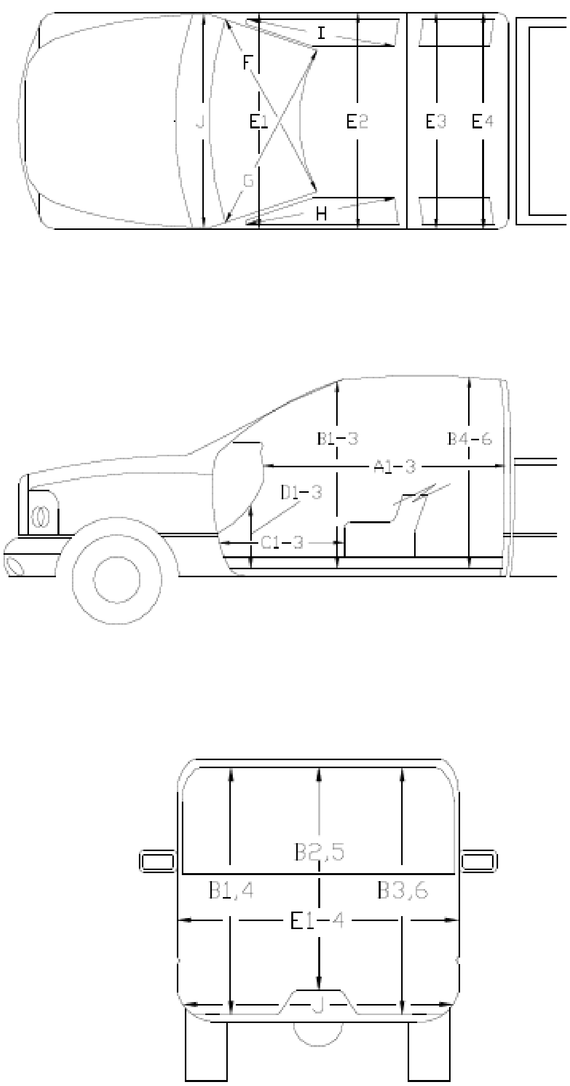
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

***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 E.2. Exterior Crush Measurements for Test 616401-01-3.

Date:	2023-05-04	Test No.:	616401-01-3	VIN No.:	1CRR6FT9HS791640
Year:	2017	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	65.00	0.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	43.00	-2.00
B2	38.00	35.00	-3.00
B3	45.00	43.00	-2.00
B4	39.50	33.00	-6.50
B5	43.00	36.50	-6.50
B6	39.50	35.00	-4.50
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	11.50	0.00
E1	58.50	58.50	0.00
E2	63.50	63.50	0.00
E3	63.50	63.50	0.00
E4	63.50	63.50	0.00
F	59.00	59.00	0.00
G	59.00	59.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	25.00	25.00	0.00

Figure E.3. Occupant Compartment Measurements for Test 616401-01-3.

E.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.050 s

(c) 0.100 s (d) 0.150 s

(e) 0.200 s (f) 0.250 s

(g) 0.300 s (h) 0.350 s

Figure E.4. Sequential Photographs for Test 616401-01-3 (Oblique Views).


(a) 0.000 s (b) 0.050 s

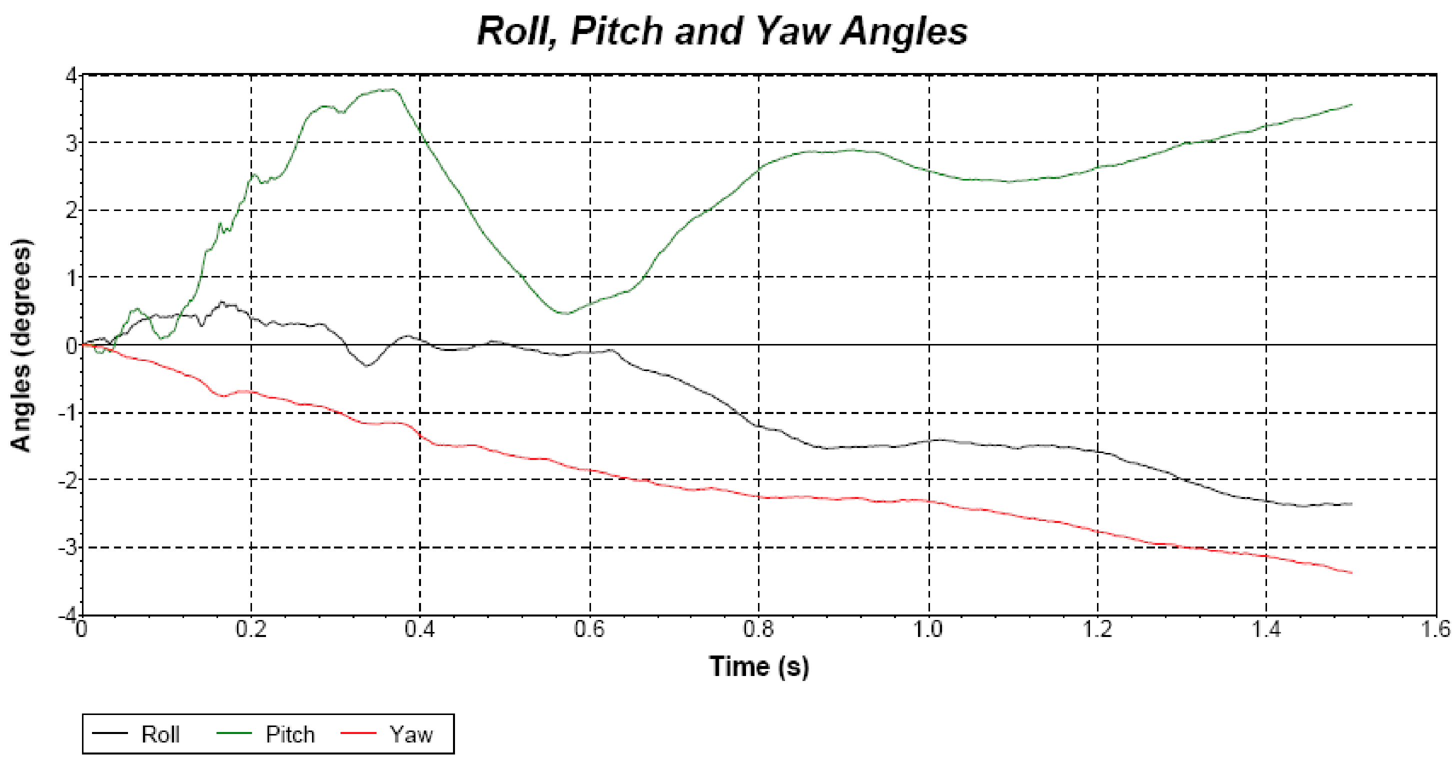

(c) 0.100 s (d) 0.150 s


(e) 0.200 s (f) 0.250 s


(g) 0.300 s (h) 0.350 s

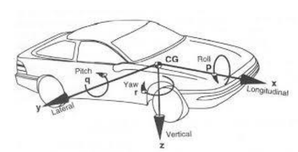
Figure E.5. Sequential Photographs for Test 616401-01-3 (Right Angle Views).

E.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

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



Test Number: 616401-01-3
Test Standard Test Number: *MASH* Test 3-62
Test Article: Guide Sign
Test Vehicle: 2017 RAM 1500
Inertial Mass: 5022 lbs
Gross Mass: 5022 lbs
Impact Speed: 62.9 mi/h
Impact Angle: 90°

Figure E.6. Vehicle Angular Displacements for Test 616401-01-3.

E.4. VEHICLE ACCELERATIONS

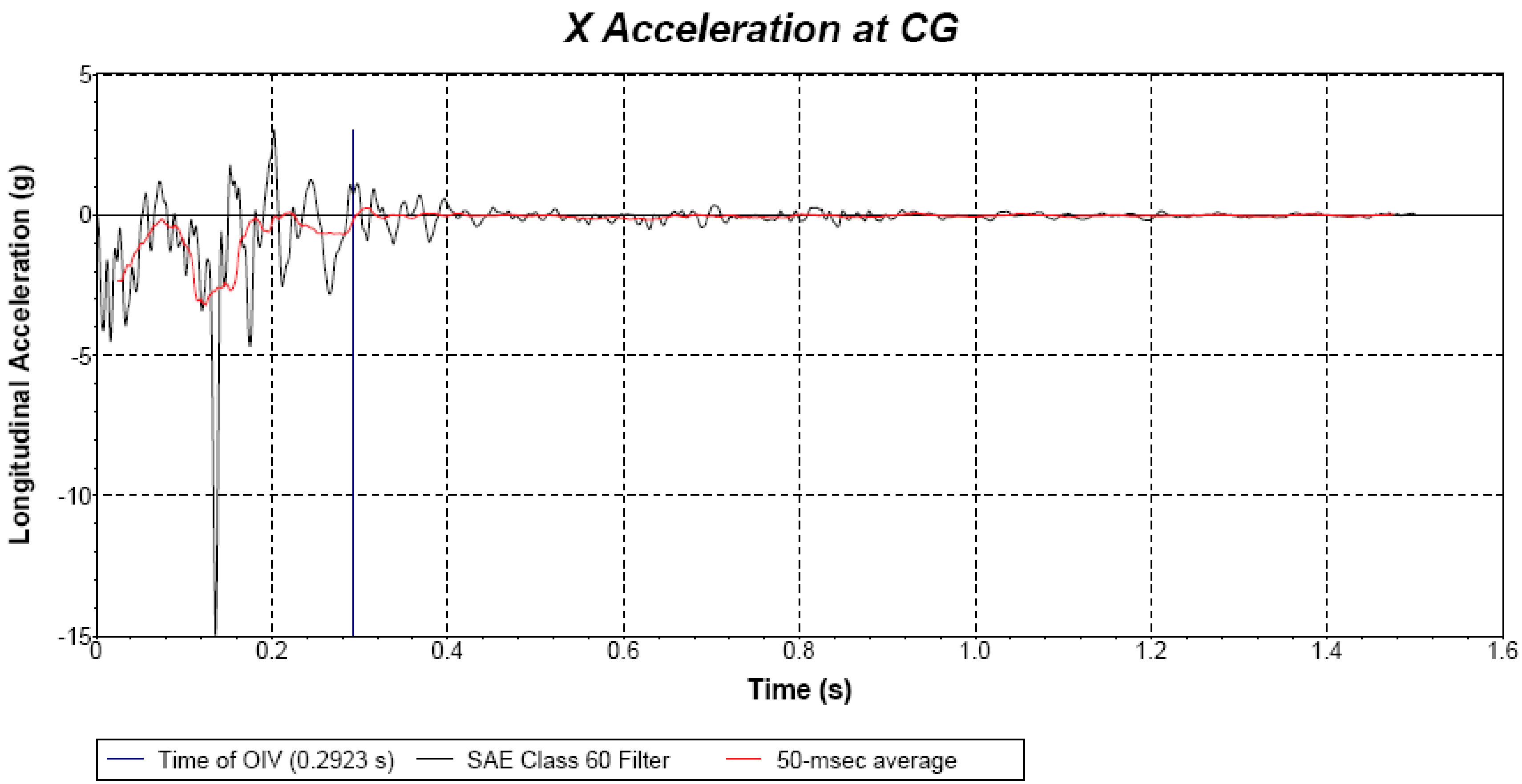


Figure E.7. Vehicle Longitudinal Accelerometer Trace for Test 616401-01-3 (Accelerometer Located at Center of Gravity).

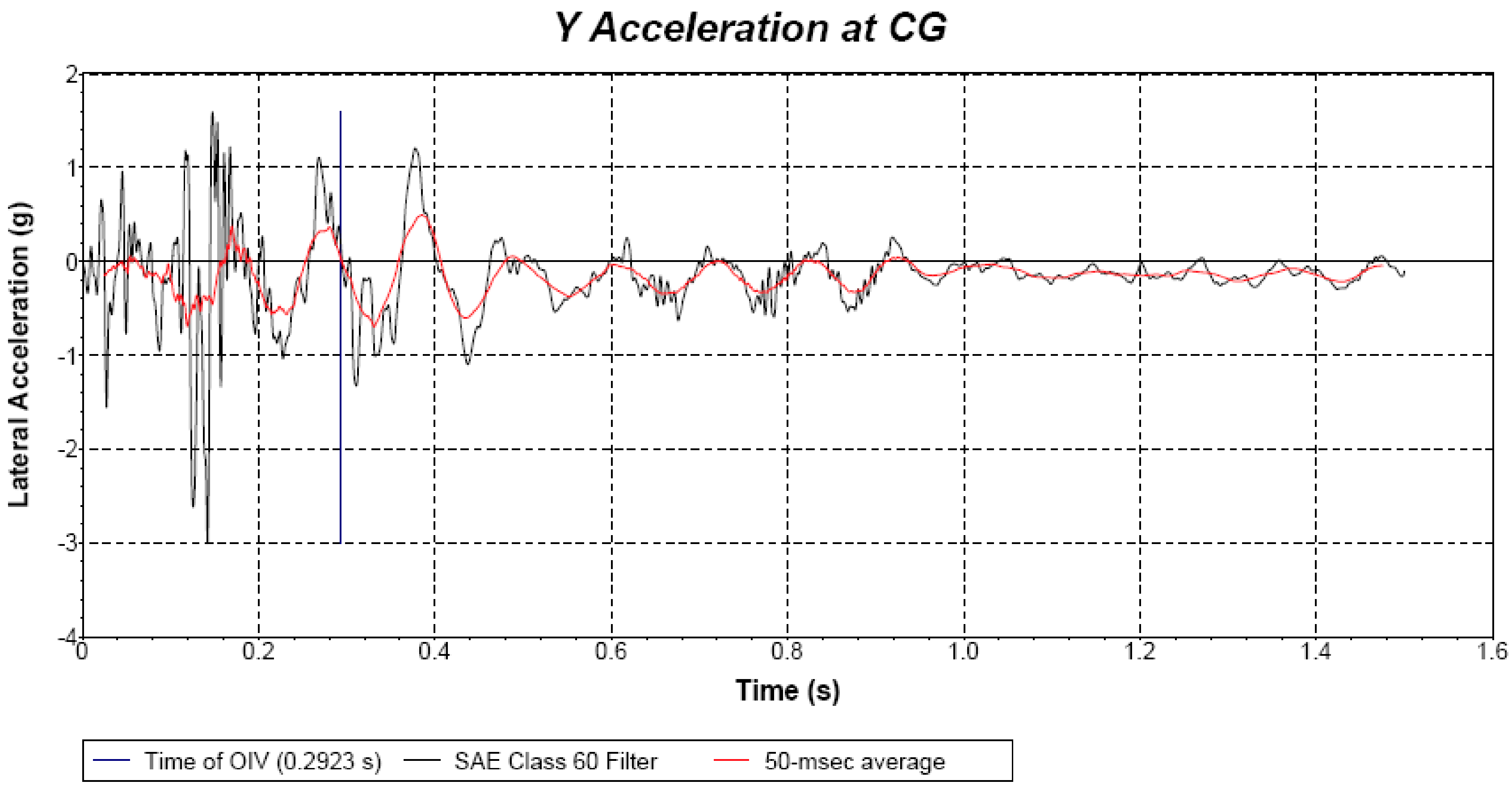


Figure E.8. Vehicle Lateral Accelerometer Trace for Test 616401-01-3 (Accelerometer Located at Center of Gravity).

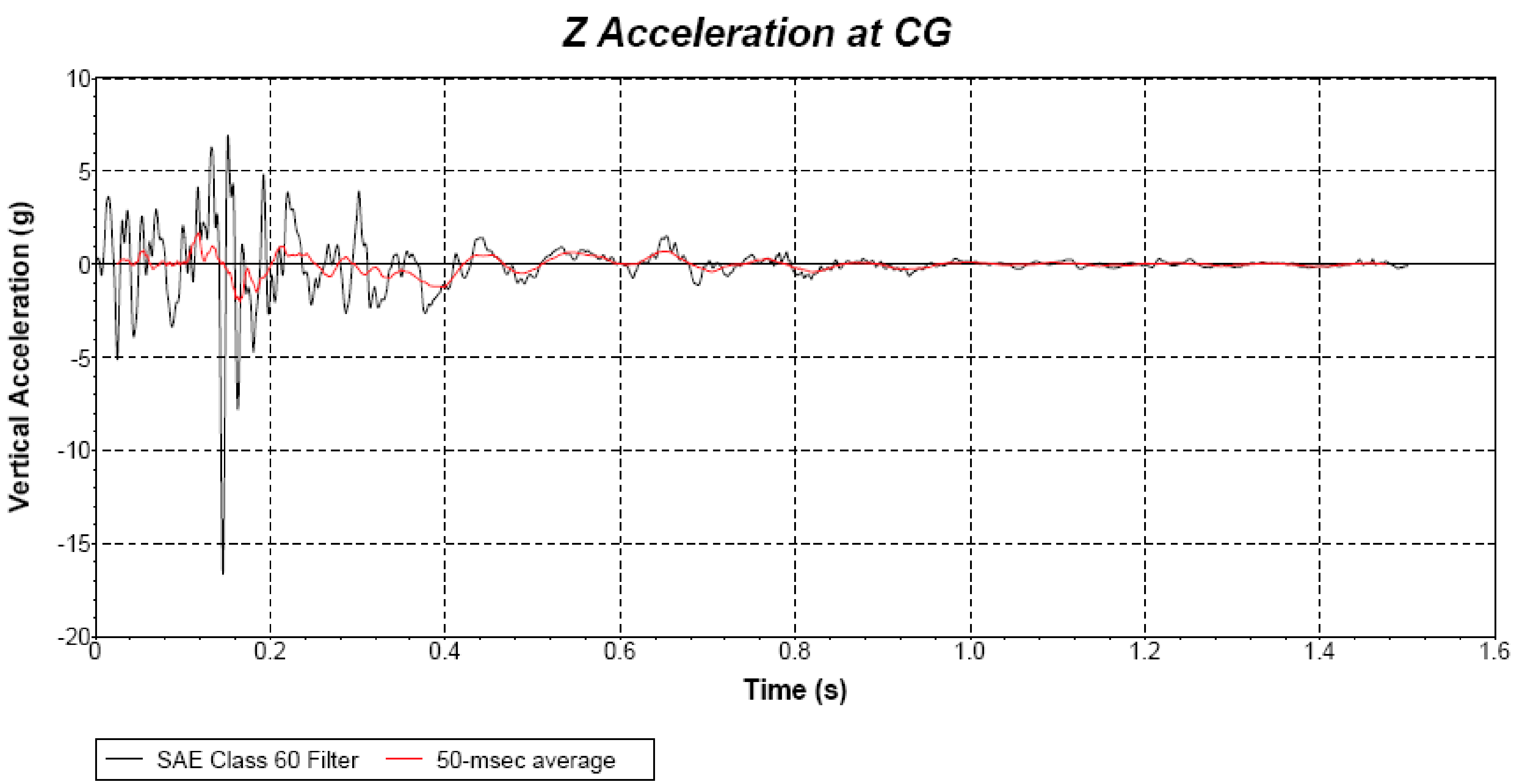


Figure E.9. Vehicle Vertical Accelerometer Trace for Test 616401-01-3 (Accelerometer Located at Center of Gravity).

APPENDIX F. *MASH* TEST 3-62 (CRASH TEST 616401-01-9)

F.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2023-09-25 Test No.: 616401-01-9 VIN No.: 1C6RR6FT3HS561270

Year: 2017 Make: RAM Model: 1500

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

Tread Type: Highway Odometer: 146015

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

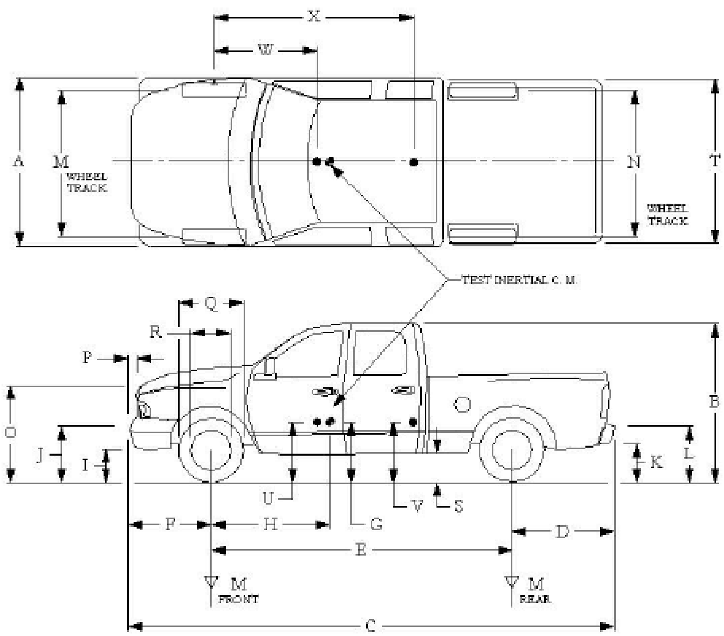
NOTES: None

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	28.37	L	30.00	Q	30.50	V	30.25
C	227.50	H	61.20	M	68.50	R	18.00	W	61.00
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}	2920	2834	2834
Back	3900	M_{rear}	2014	2188	2188
Total	6700	M_{Total}	4934	5022	5022

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

Mass Distribution:
lb LF: 1464 RF: 1370 LR: 1060 RR: 1128

Figure F.1. Vehicle Properties for Test 616401-01-9.

Date:	2023-09-25	Test No.:	616401-01-9	VIN No.:	1C6RR6FT3HS561270
Year:	2017	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	18	17	9	-	-	-	-	-	-	-
2	AT HOOD	45	21	7	-	-	-	-	-	-	-
	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.

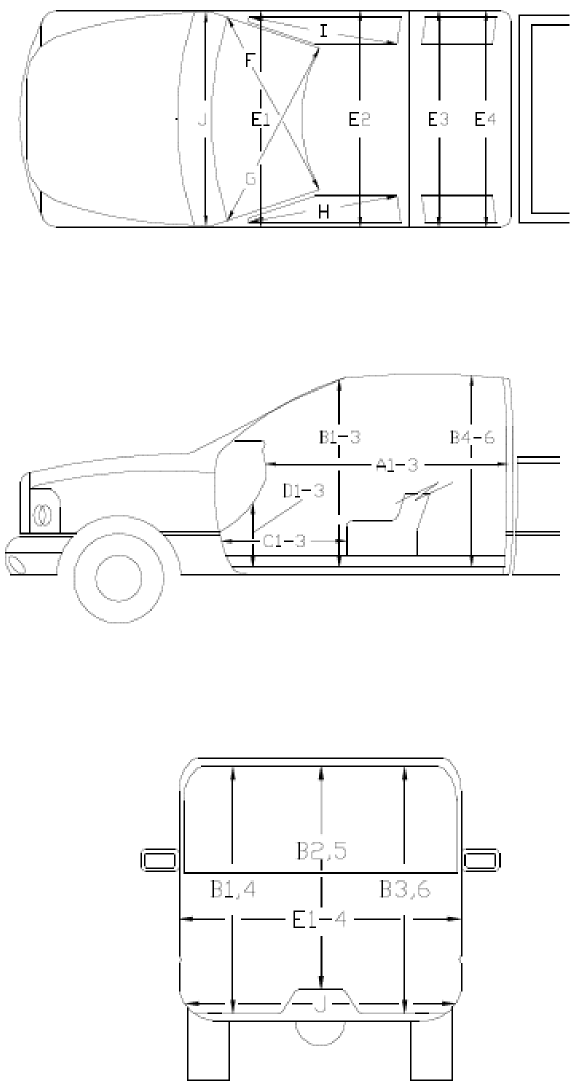
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

***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 F.2. Exterior Crush Measurements for Test 616401-01-9.

Date:	2023-09-25	Test No.:	616401-01-9	VIN No.:	1C6RR6FT3HS561270
Year:	2017	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	65.00	0.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	43.50	-1.50
B2	38.00	36.00	-2.00
B3	45.00	43.50	-1.50
B4	39.50	38.75	-0.75
B5	43.00	41.75	-1.25
B6	39.50	39.00	-0.50
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	11.50	0.00
E1	58.50	58.50	0.00
E2	63.50	63.50	0.00
E3	63.50	63.50	0.00
E4	63.50	63.50	0.00
F	59.00	59.00	0.00
G	59.00	59.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	25.00	25.00	0.00

Figure F.3. Occupant Compartment Measurements for Test 616401-01-9.

F.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.500 s (f) 0.600 s

(g) 0.700 s (h) 0.800 s

Figure F.4. Sequential Photographs for Test 616401-01-9 (Oblique Views).

(a) 0.000 s (b) 0.100 s

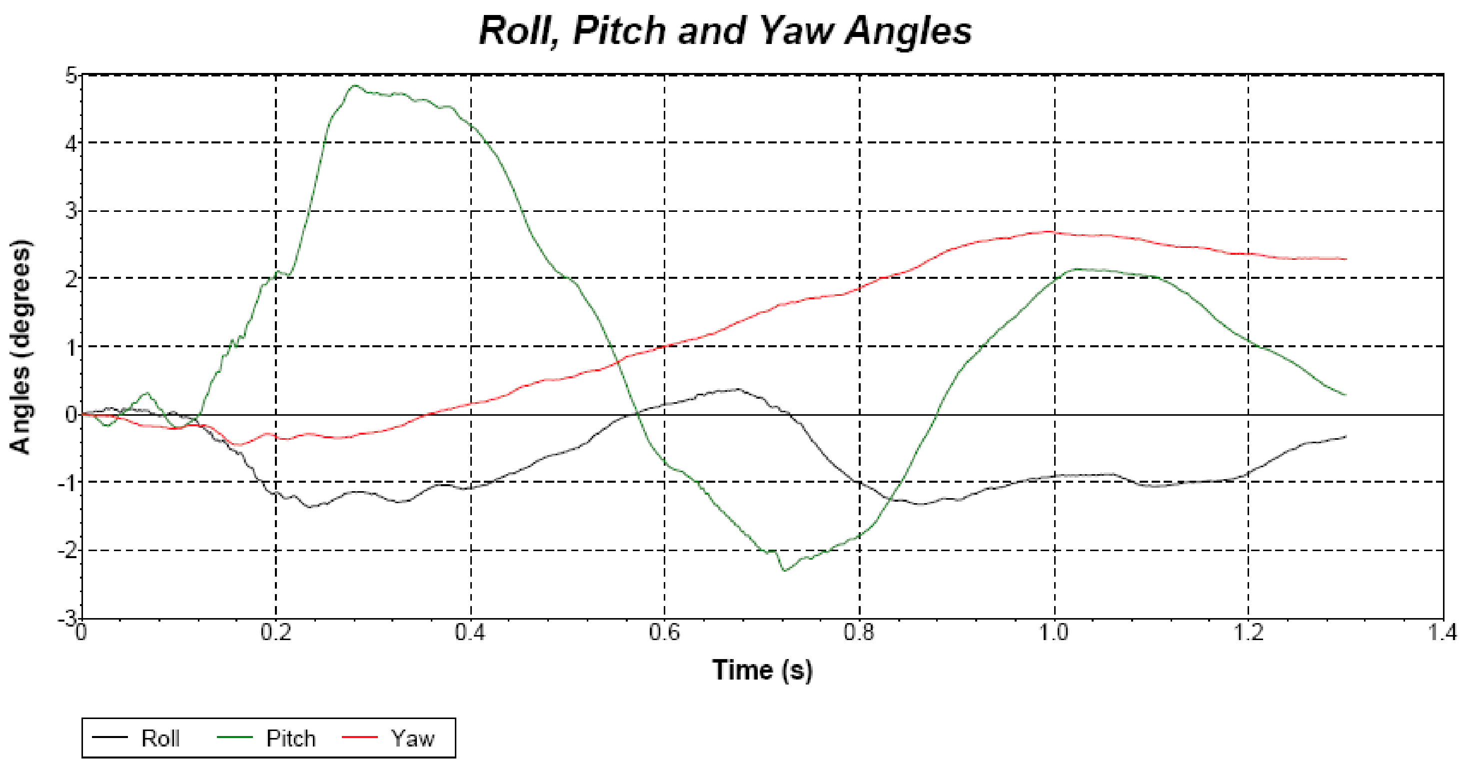
(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

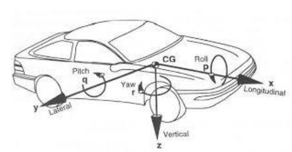
Figure F.5. Sequential Photographs for Test 616401-01-9 (Right Angle Views).

F.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

4. Yaw.
5. Pitch.
6. Roll.



Test Number: 616401-01-9
Test Standard Test Number: *MASH* Test 3-62
Test Article: Guide Sign
Test Vehicle: 2017 RAM 1500
Inertial Mass: 5022 lbs
Gross Mass: 5022 lbs
Impact Speed: 63.2 mi/h
Impact Angle: 90°

Figure F.6. Vehicle Angular Displacements for Test 616401-01-9.

F.4. VEHICLE ACCELERATIONS

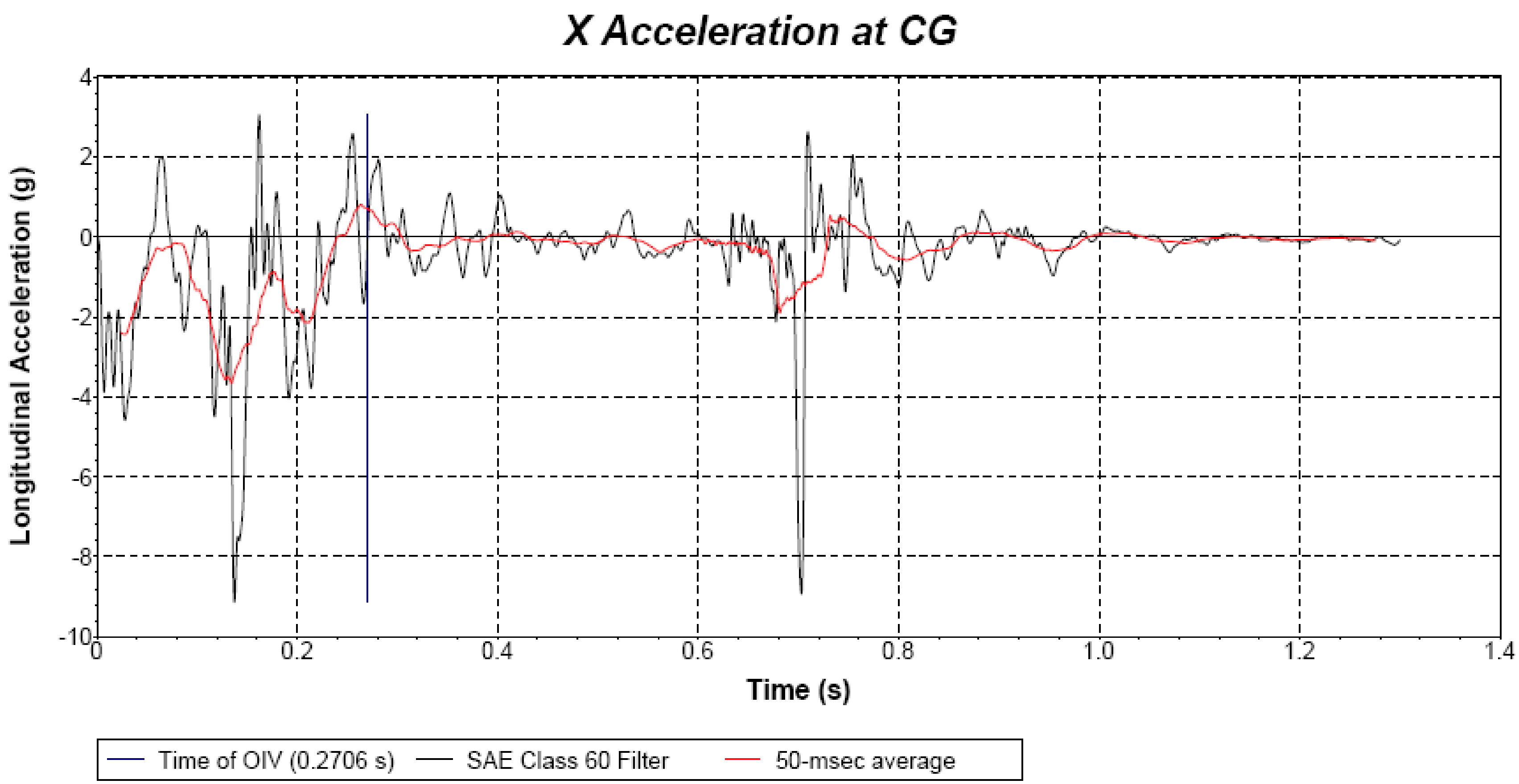


Figure F.7. Vehicle Longitudinal Accelerometer Trace for Test 616401-01-9 (Accelerometer Located at Center of Gravity).

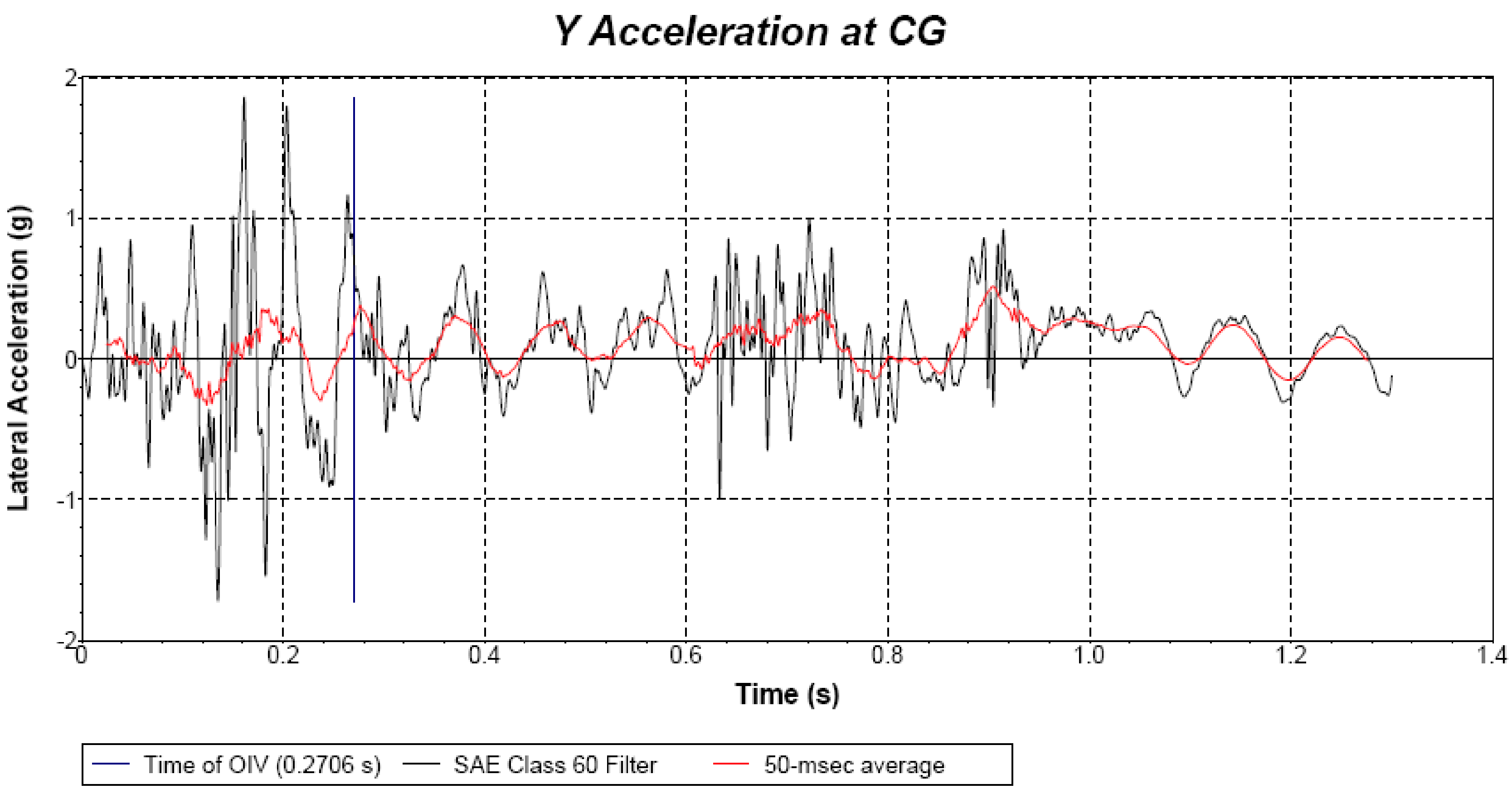


Figure F.8. Vehicle Lateral Accelerometer Trace for Test 616401-01-9 (Accelerometer Located at Center of Gravity).

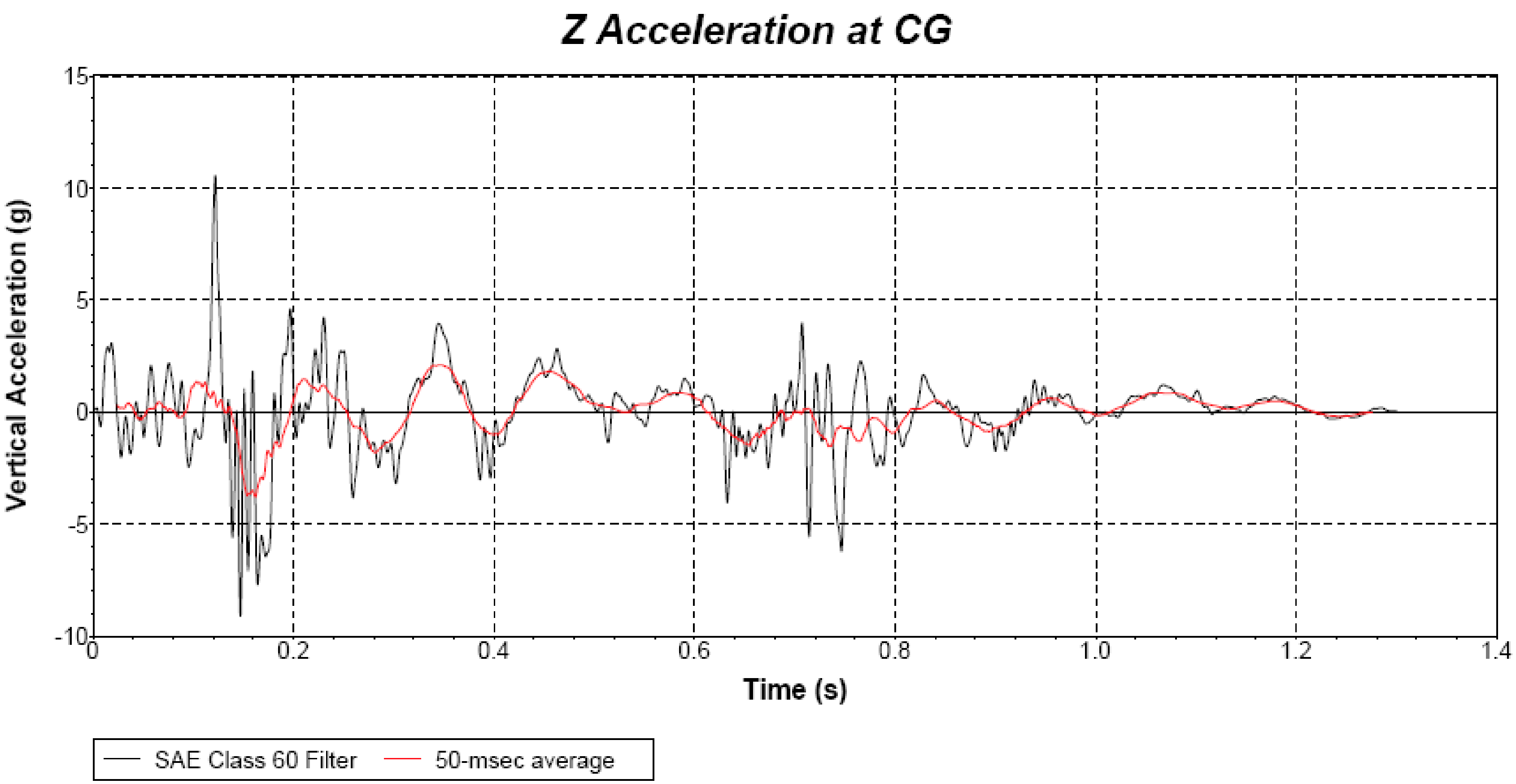


Figure F.9. Vehicle Vertical Accelerometer Trace for Test 616401-01-9 (Accelerometer Located at Center of Gravity).

APPENDIX G. *MASH* TEST 3-62 (CRASH TEST 616401-01-4)

G.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2023-11-29 Test No.: 616401-01-4 VIN No.: 1C6RR6FT5HS855799

Year: 2017 Make: RAM Model: 1500

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

Tread Type: Highway Odometer: 102203

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

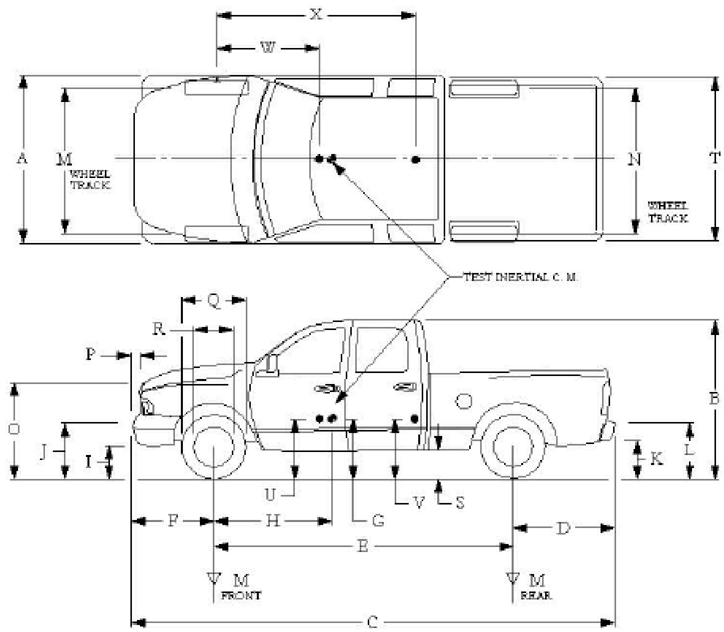
NOTES: None

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	28.60	L	30.00	Q	30.50	V	30.25
C	227.50	H	61.31	M	68.50	R	18.00	W	61.25
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}	2903	2831	2831
Back	3900	M_{rear}	2066	2192	2192
Total	6700	M_{Total}	4969	5023	5023

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

Mass Distribution:
lb LF: 1478 RF: 1353 LR: 1072 RR: 1120

Figure G.1. Vehicle Properties for Test 616401-01-4.

Date:	2023-11-29	Test No.:	616401-01-4	VIN No.:	1C6RR6FT5HS855799
Year:	2017	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 Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
1	ABOVE BUMPER	26	13	12	-	-	-	-	-	-	-
	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.

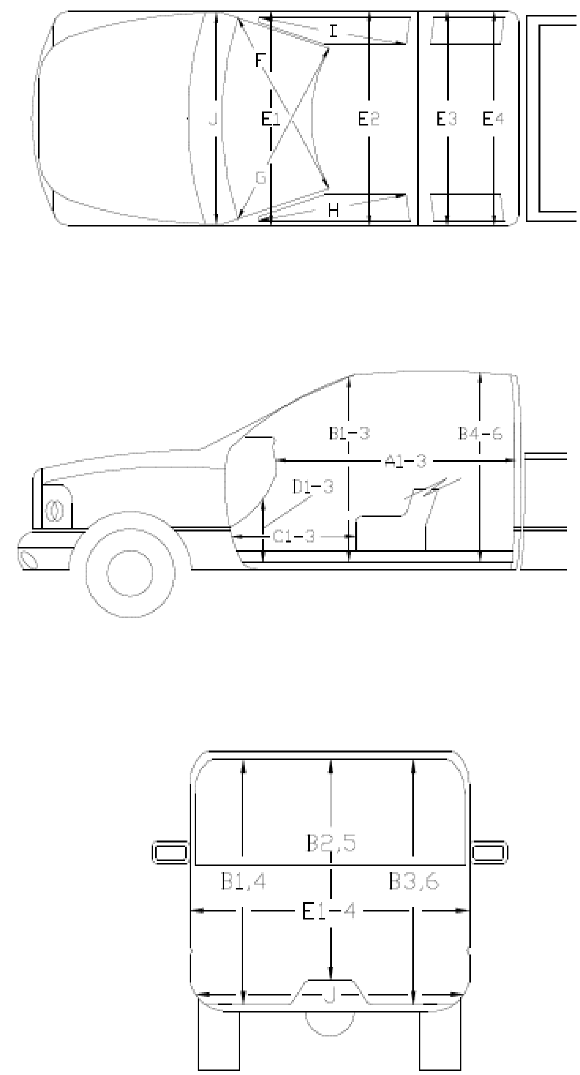
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

***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 G.2. Exterior Crush Measurements for Test 616401-01-4.

Date:	2023-11-29	Test No.:	616401-01-4	VIN No.:	1C6RR6FT5HS855799
Year:	2017	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	65.00	0.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	45.00	0.00
B2	38.00	38.00	0.00
B3	45.00	45.00	0.00
B4	39.50	38.25	-1.25
B5	43.00	42.75	-0.25
B6	39.50	39.50	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	11.50	0.00
E1	58.50	58.50	0.00
E2	63.50	63.50	0.00
E3	63.50	63.50	0.00
E4	63.50	63.50	0.00
F	59.00	59.00	0.00
G	59.00	59.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	25.00	25.00	0.00

Figure G.3. Occupant Compartment Measurements for Test 616401-01-4.

G.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.075 s

(c) 0.150 s (d) 0.225 s

(e) 0.300 s (f) 0.375 s

(g) 0.450 s (h) 0.525 s

Figure G.4. Sequential Photographs for Test 616401-01-4 (Oblique Views).


(a) 0.000 s (b) 0.075 s

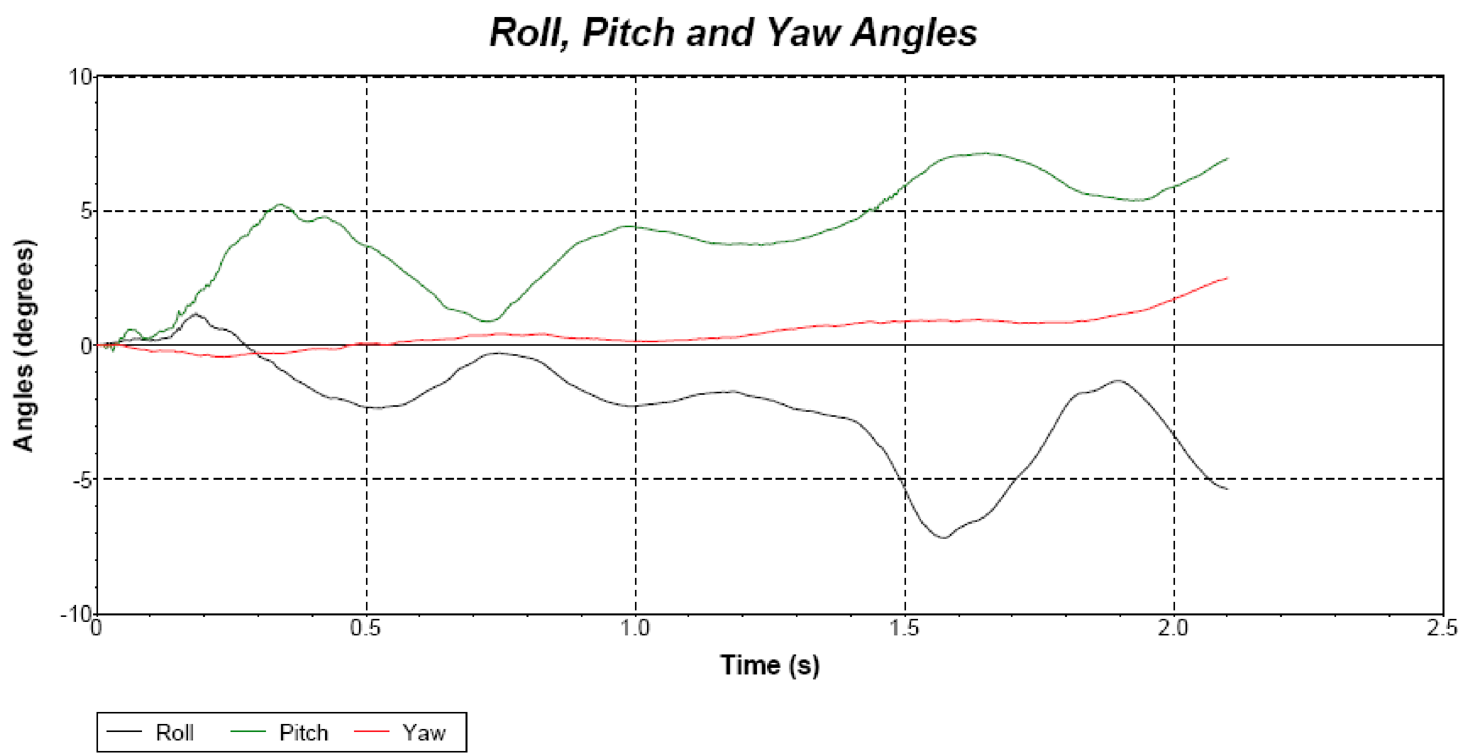

(c) 0.150 s (d) 0.225 s


(e) 0.300 s (f) 0.375 s


(g) 0.450 s (h) 0.525 s

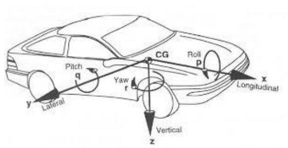
Figure G.5. Sequential Photographs for Test 616401-01-4 (Right Angle Views).

G.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

7. Yaw.
8. Pitch.
9. Roll.



Test Number: 616401-01-4
Test Standard Test Number: *MASH* Test 3-62
Test Article: Guide Sign
Test Vehicle: 2017 RAM 1500
Inertial Mass: 5023 lbs
Gross Mass: 5023 lbs
Impact Speed: 62.0 mi/h
Impact Angle: 90°

Figure G.6. Vehicle Angular Displacements for Test 616401-01-4.

G.4. VEHICLE ACCELERATIONS

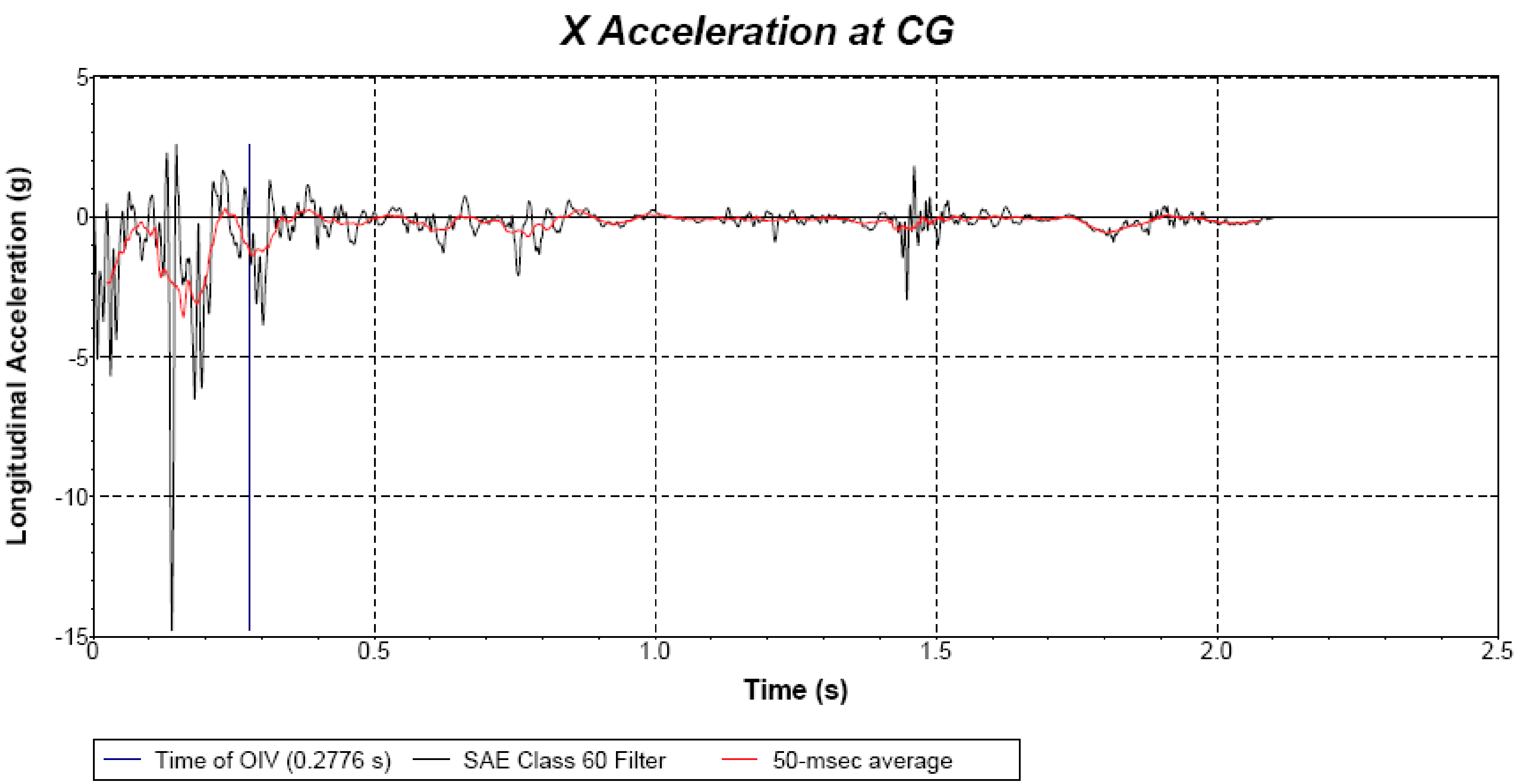


Figure G.7. Vehicle Longitudinal Accelerometer Trace for Test 616401-01-4 (Accelerometer Located at Center of Gravity).

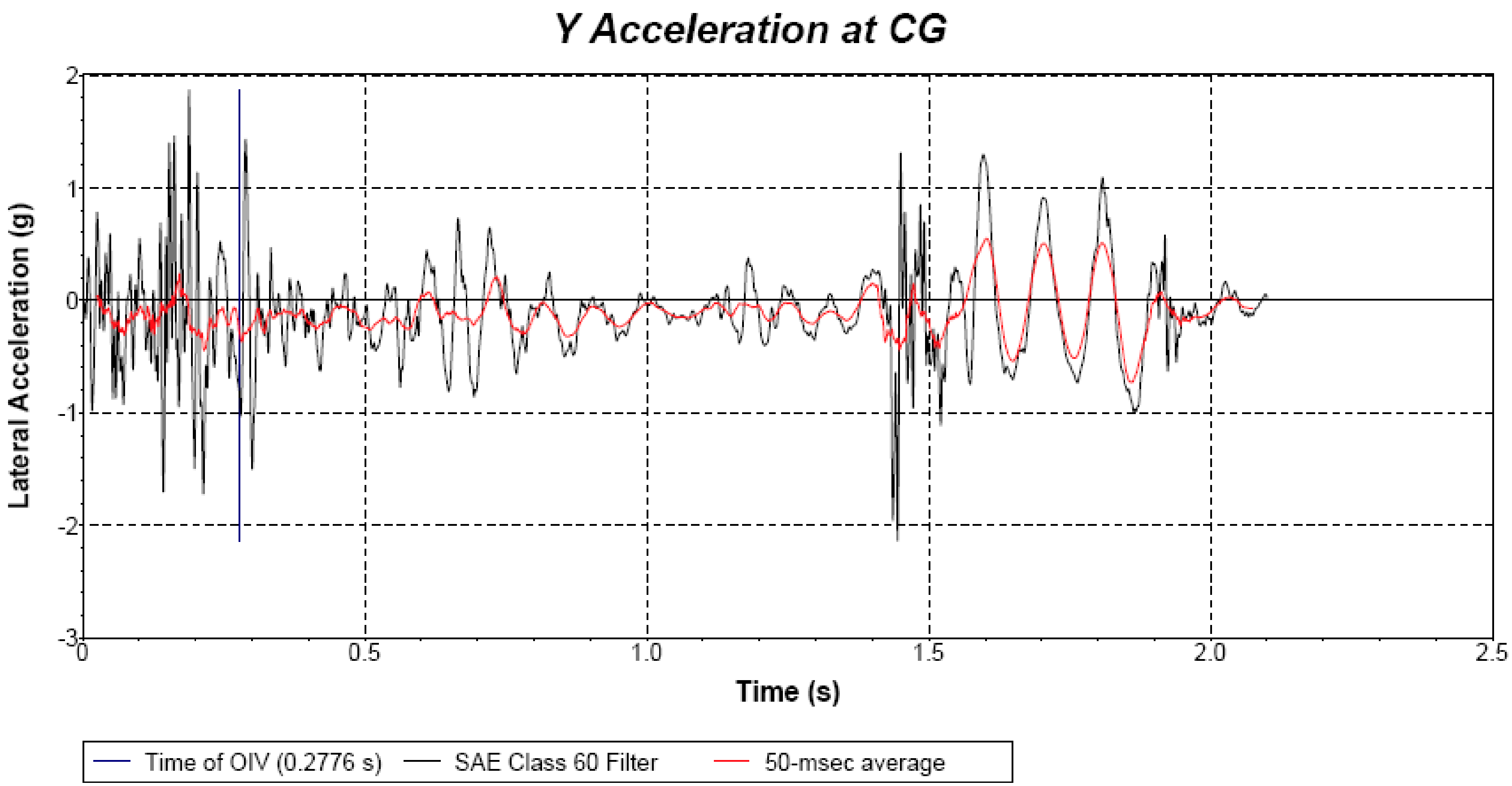


Figure G.8. Vehicle Lateral Accelerometer Trace for Test 616401-01-4 (Accelerometer Located at Center of Gravity).

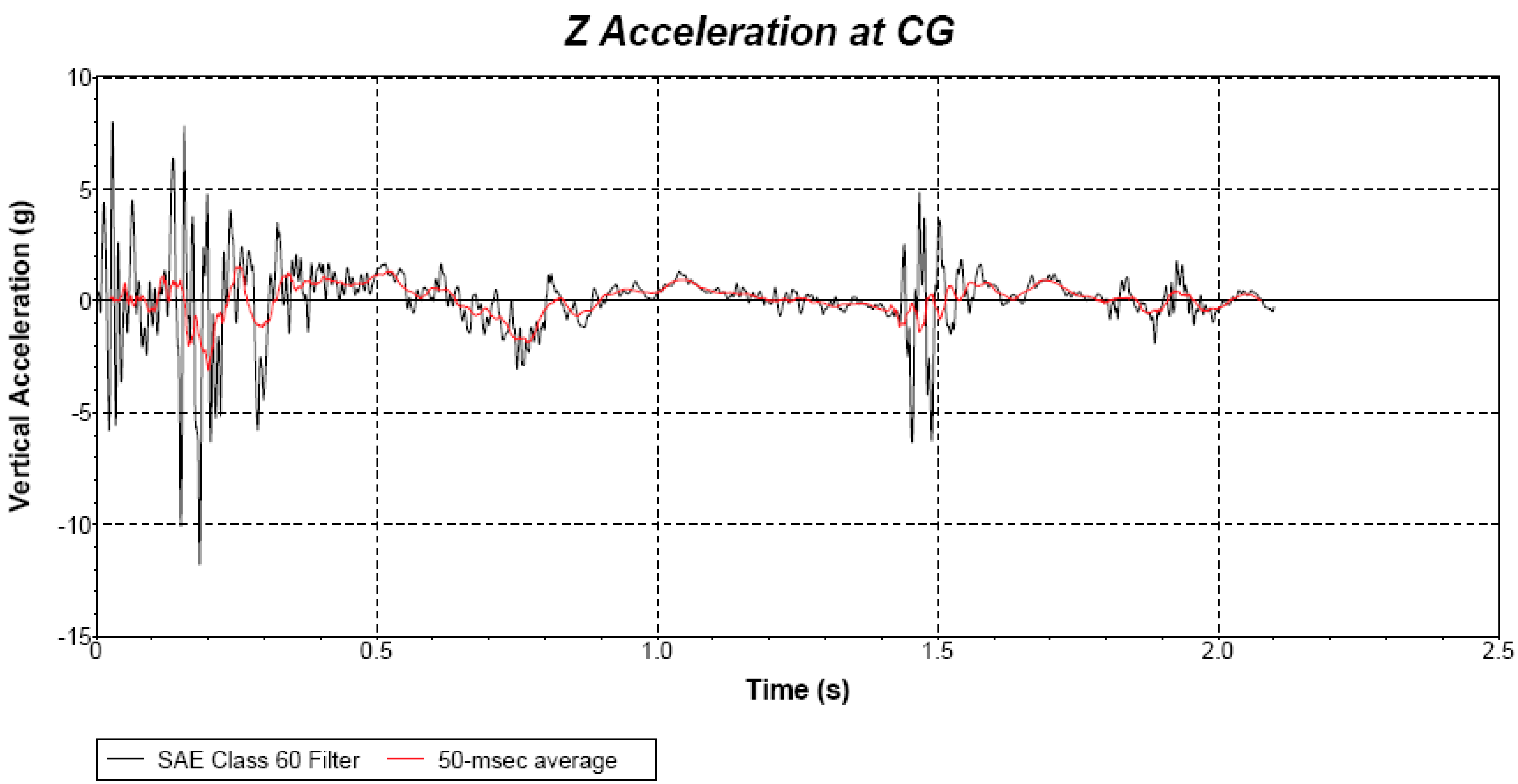


Figure G.9. Vehicle Vertical Accelerometer Trace for Test 616401-01-4 (Accelerometer Located at Center of Gravity).

APPENDIX H. *MASH* TEST 3-62 (CRASH TEST 616401-01-8)

H.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2024-03-22 Test No.: 616401-01-8 VIN No.: 1C6RR6FT5KS733919

Year: 2019 Make: RAM Model: 1500

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

Tread Type: Highway Odometer: 93339

Note any damage to the vehicle prior to test: DENT IN BED ON PASSENGER SIDE

● Denotes accelerometer location.

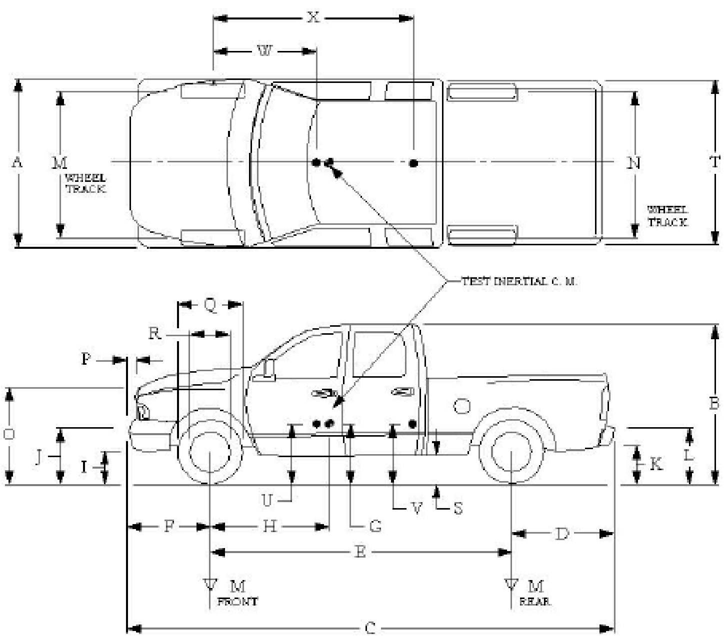
NOTES: None

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	40.25	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	229.00	H	59.92	M	68.50	R	18.00	W	60.00
D	48.25	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}	2977	2887	2887
Back	3900	M_{rear}	2090	2147	2147
Total	6700	M_{Total}	5067	5034	5034

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

Mass Distribution:
lb LF: 1457 RF: 1430 LR: 1087 RR: 1060

Figure H.1. Vehicle Properties for Test 616401-01-8.

Date:	2024-03-22	Test No.:	616401-01-8	VIN No.:	1C6RR6FT5KS733919
Year:	2019	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 Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
1	AT FRONT BUMPER	20	21	7	-	-	-	-	-	-	0
	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.

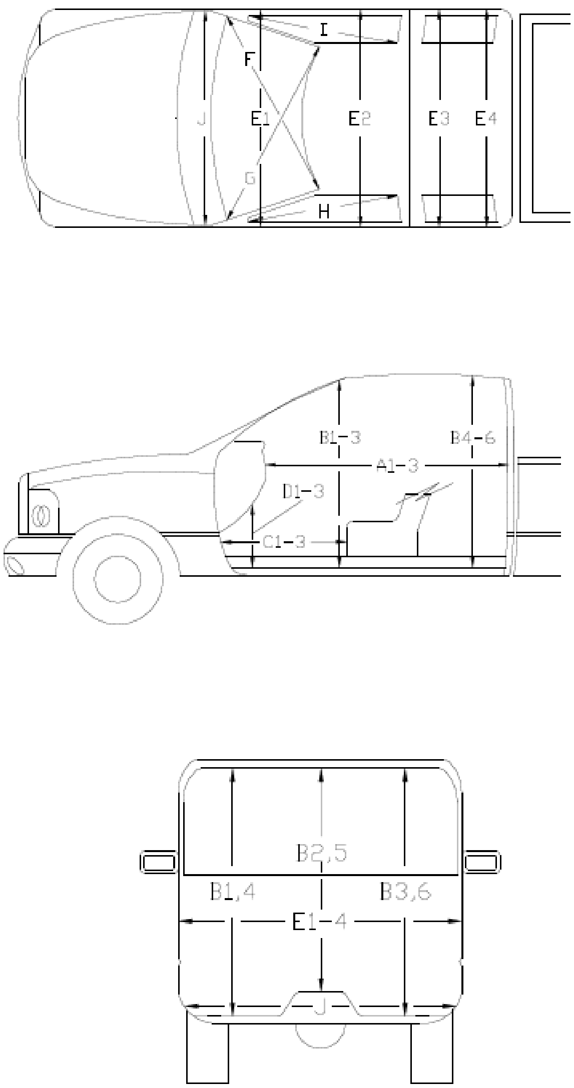
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

***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 H.2. Exterior Crush Measurements for Test 616401-01-8.

Date:	2024-03-22	Test No.:	616401-01-8	VIN No.:	1C6RR6FT5KS733919
Year:	2019	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	65.00	0.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	44.25	-0.75
B2	38.00	33.50	-4.50
B3	45.00	44.25	-0.75
B4	39.50	38.00	-1.50
B5	43.00	37.75	-5.25
B6	39.50	37.75	-1.75
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	11.50	0.00
E1	58.50	58.50	0.00
E2	63.50	63.50	0.00
E3	63.50	63.50	0.00
E4	63.50	63.50	0.00
F	59.00	59.00	0.00
G	59.00	59.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	25.00	25.00	0.00

Figure H.3. Occupant Compartment Measurements for Test 616401-01-8.

H.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.075 s

(c) 0.150 s (d) 0.225 s

(e) 0.300 s (f) 0.375 s

(g) 0.450 s (h) 0.525 s

Figure H.4. Sequential Photographs for Test 616401-01-8 (Oblique Views).


(a) 0.000 s (b) 0.075 s

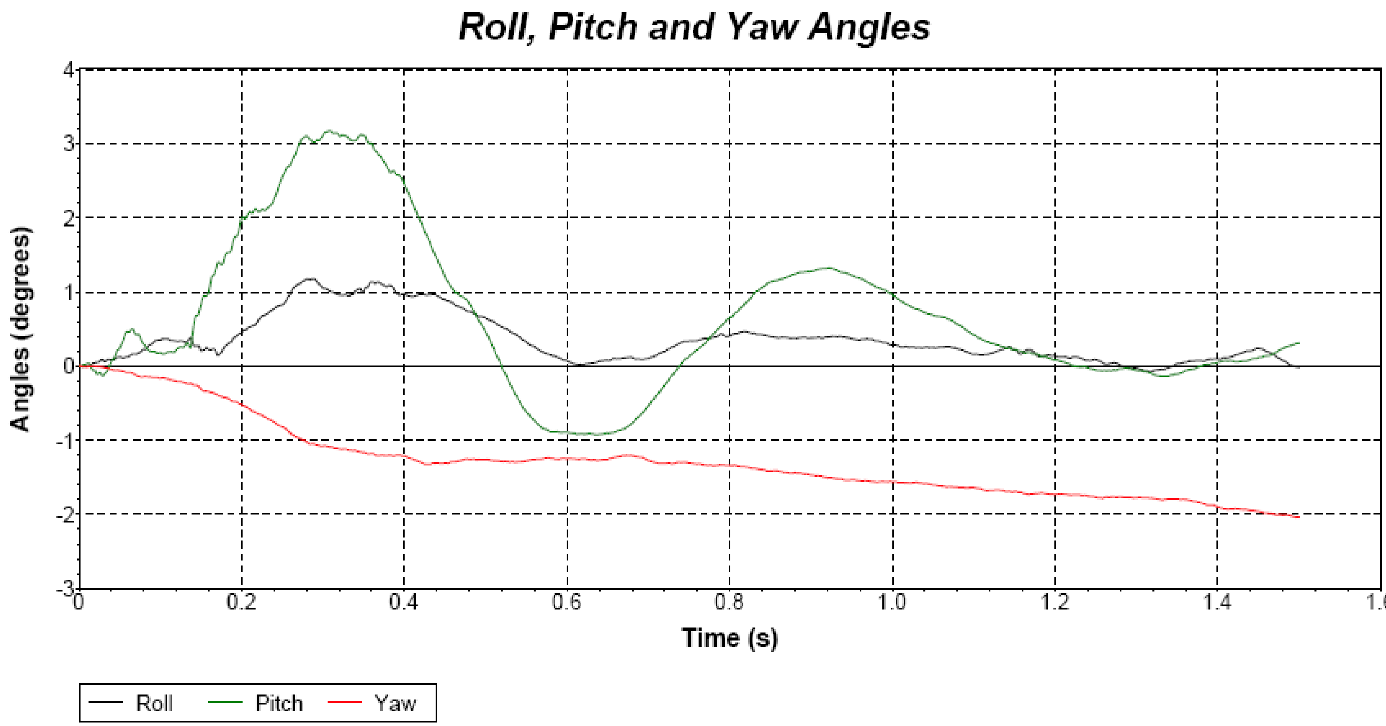

(c) 0.150 s (d) 0.225 s


(e) 0.300 s (f) 0.375 s


(g) 0.450 s (h) 0.525 s

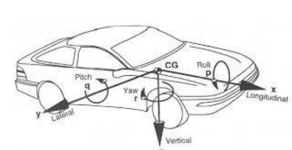
Figure H.5. Sequential Photographs for Test 616401-01-8 (Right Angle Views).

H.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

10. Yaw.
11. Pitch.
12. Roll.



Test Number: 616401-01-8
Test Standard Test Number: *MASH* Test 3-62
Test Article: Guide Sign
Test Vehicle: 2019 RAM 1500
Inertial Mass: 5034 lbs
Gross Mass: 5034 lbs
Impact Speed: 62.0 mi/h
Impact Angle: 90°

Figure H.6. Vehicle Angular Displacements for Test 616401-01-8.

H.4. VEHICLE ACCELERATIONS

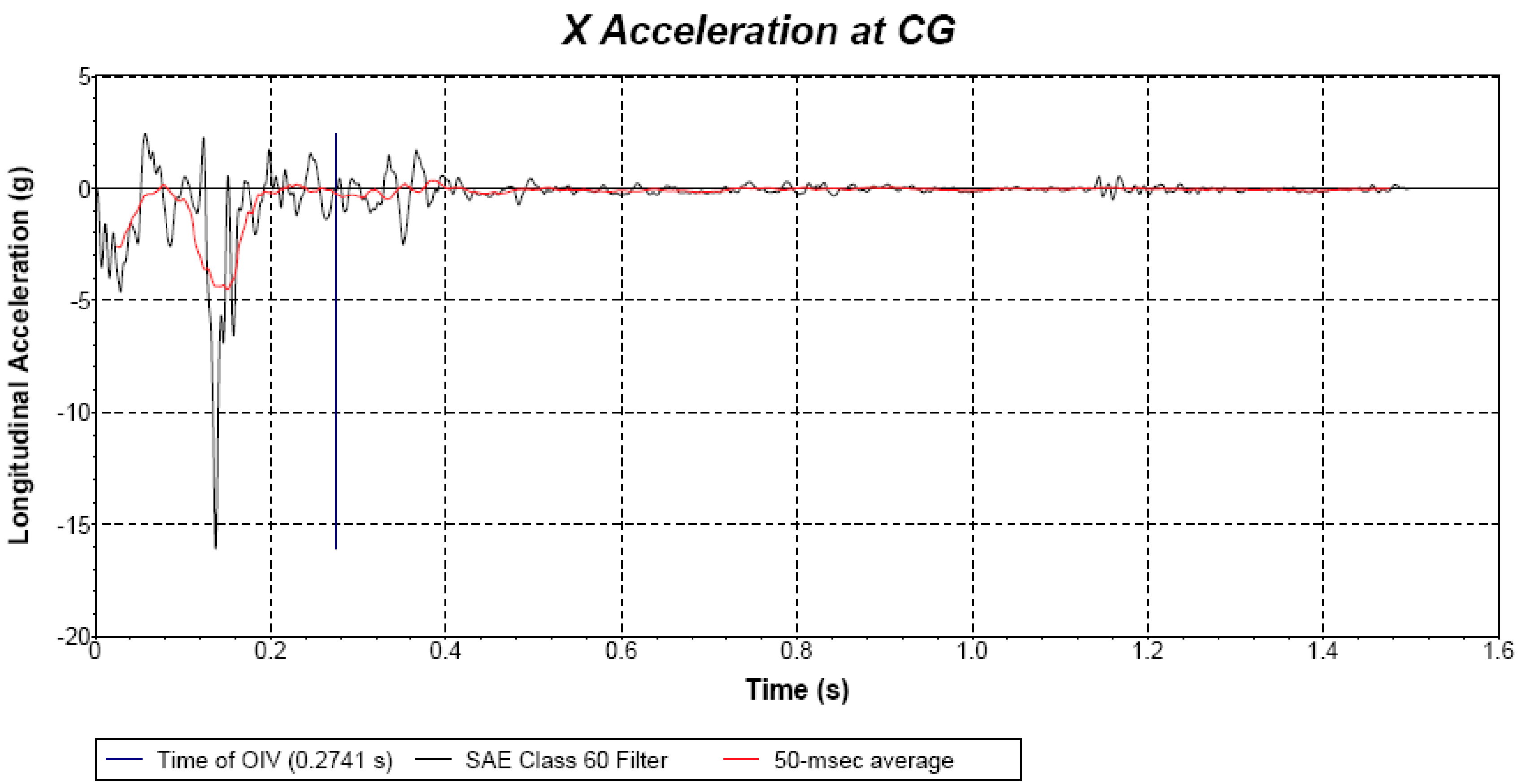


Figure H.7. Vehicle Longitudinal Accelerometer Trace for Test 616401-01-8 (Accelerometer Located at Center of Gravity).

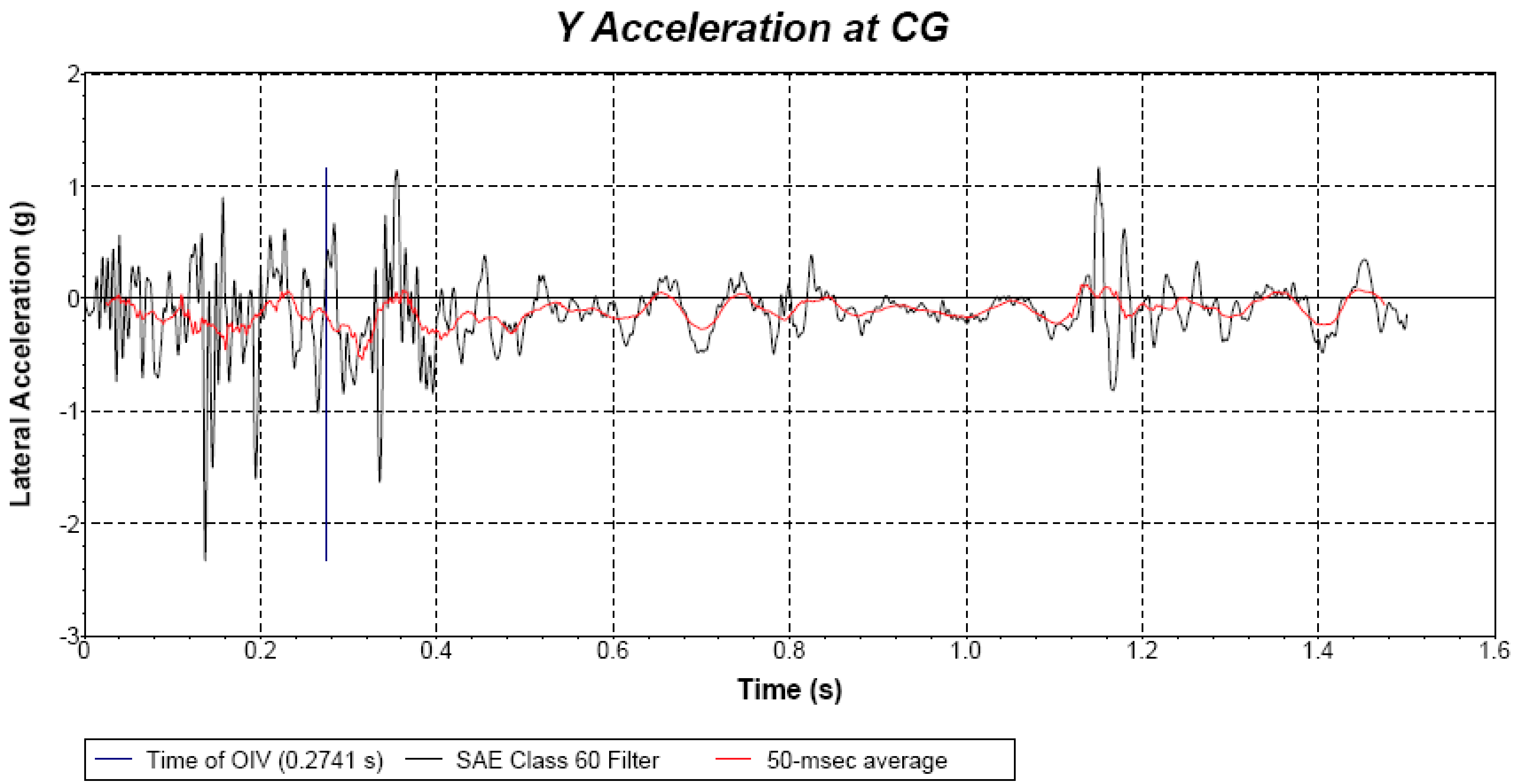


Figure H.8. Vehicle Lateral Accelerometer Trace for Test 616401-01-8 (Accelerometer Located at Center of Gravity).

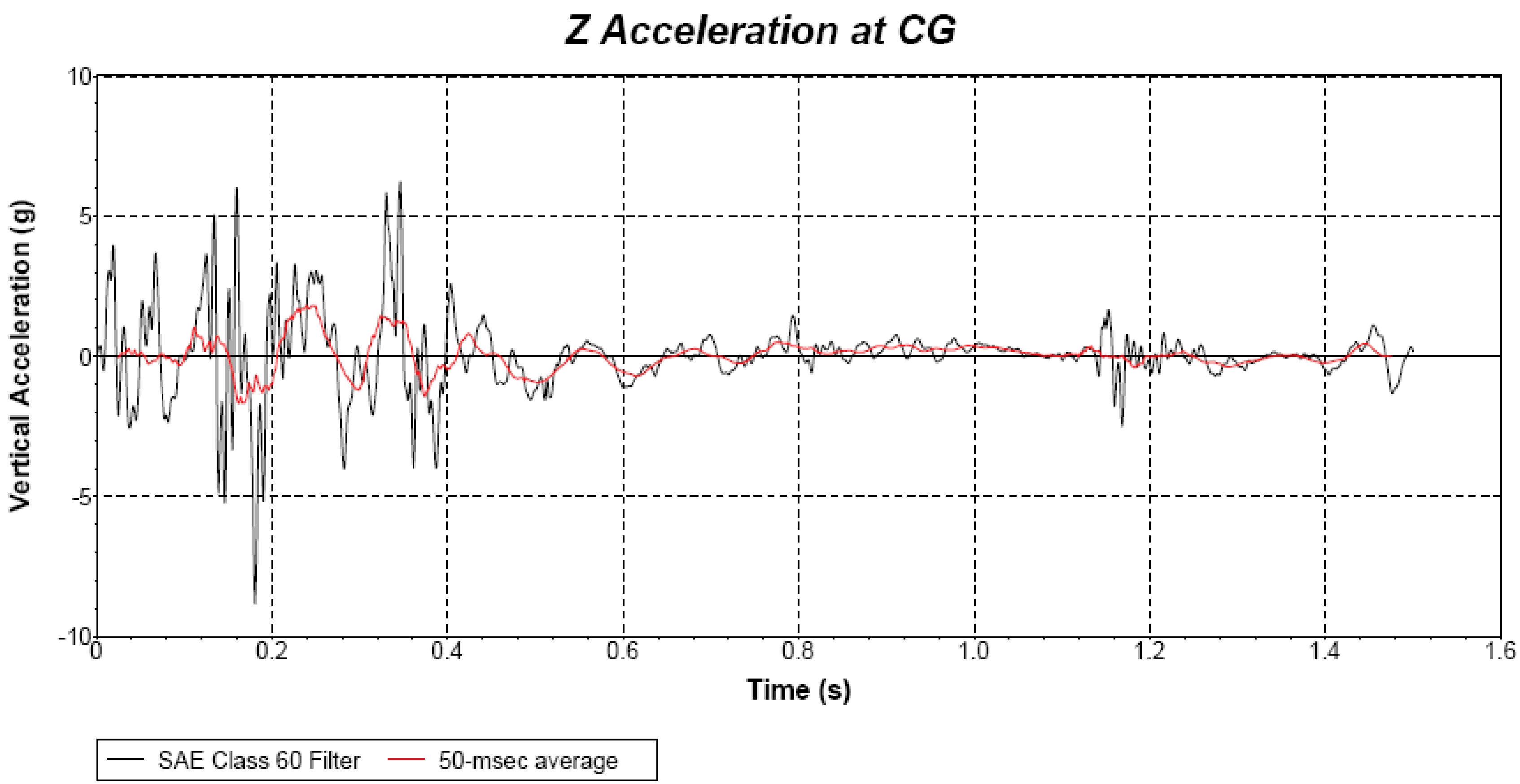


Figure H.9. Vehicle Vertical Accelerometer Trace for Test 616401-01-8 (Accelerometer Located at Center of Gravity).