Texas A&M Transportation Institute
PROVING GROUND

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MASH EVALUATION OF SQUARE TUBE SLIP BASE SIGN SUPPORT SYSTEMS

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16. Abstract

The purpose of the tests reported herein was to assess the performance of the 3 × 3 and the 8 × 8 Square Tube Slip Base Sign Support Systems according to the safety-performance evaluation guidelines included in the second edition of the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*) (*1*). The crash tests performed for the 3 × 3 Square Tube Slip Base Sign Support System were:

1. ***MASH* Test 3-61:** An 1100C vehicle weighing 2420 lb impacting the Support Structures while travelling at 62 mi/h and 0 degrees.
2. ***MASH* Test 3-62:** A 2270P vehicle weighing 5000 lb impacting the Support Structures while traveling at 62 mi/h and 0 degrees.

The crash test performed for the 8 × 8 Square Tube Slip Base Sign Support System was:

3. ***MASH* Test 3-60:** A 1100C vehicle weighing 2420 lb impacting the Support Structures while traveling at 19 mi/h and 0 degrees.

This report provides details on the Square Tube Slip Base Sign Support Systems, the crash tests and results, and the performance assessment of the Square Tube Slip Base Sign Support Systems for *MASH* TL-3 Support Structures evaluation criteria.

The 8 x 8 Square Tube Slip Base Sign Support System met the performance criteria for *MASH* Test 3-60. The 3x3 Square Tube Slip Base Sign Support System did meet the performance criteria for *MASH* Test 3-61, but did not meet the performance criteria for *MASH* Test 3-62. The top part of the sign support contacted the roof of the pickup truck vehicle and induced a tear in the roof. This behavior was determined to be penetration of the occupant compartment, resulting in failure of *MASH* Criterion D.

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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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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

Many breakaway sign support systems were developed and investigated according to Test Level 3 (TL-3) criteria per previous NCHRP Report 350 standard requirements (*1*). Previous testing and evaluation may also have included pendulum or bogie vehicle impact testing. Some of these breakaway sign support systems have not been evaluated according to the safety-performance evaluation guidelines included in the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*), Second Edition (*2*).

One specific system that required MASH evaluation was a square tube sign support with a triangular slip base breakaway system. Previous impacting testing was performed to evaluate 3-inch x 3-inch and 8-inch x 8-inch square tube sign supports with a multidirectional slip base breakaway system (*3*,*4*). Both systems were impacted by an 1850 lb bogie vehicle at speeds of 22 mi/h and 62 mi/h. Both systems were found to meet the performance criteria for NCHRP Report 350.

The purpose of the tests reported herein was to assess the performance of the Square Tube Slip Base Sign Support System according to AASHTO *MASH* (*2*). The crash tests were performed in accordance with *MASH* TL-3.

CHAPTER 2.
ENGINEERING ANALYSIS

There are many possible configurations of a sign support system. This includes variations in sign area and type, post size, triangular slip base, and mounting height. As such, it is not feasible to evaluate every possible configuration of a sign support system with full-scale crash testing. An alternative approach considered for this project consisted of identifying and evaluating the critical (i.e., worst case) sign support configuration for full-scale crash testing. If the critical sign support configuration performed satisfactorily in the full-scale crash testing, then the other less critical configurations would be considered satisfactory.

2.1. STATE STANDARD DETAILS

A review of state DOT standard details was performed to identify states that use square tube sign support systems. This review was focused on member states of the Roadside Safety Pooled Fund.

A total of eight states were identified that use square tube sign support systems for roadside applications. This usage was limited to solid structural square tube sign support systems and did not include states that use perforated square steel tube (PSST) sign support systems. The types of breakaway systems used with square tube sign support systems included slip base and frangible couplings. For this project, sign support systems with a triangular slip base were the primary focus. The range in post size varied from 3-inch x 3-inch to 8-inch x 8-inch square tube posts. Standard mounting height for these systems was 7 ft. The required sign panel area depends on the sign application, additional plaques/panels, and sign panel substrate (e.g., wood, aluminum sheet, extruded aluminum).

2.2. CRITICAL CONFIGURATION

A critical sign support configuration was determined for the square tube sign support systems. The critical sign support configuration was determined for each MASH test. The primary MASH evaluation factors considered when determining the critical sign support configuration were occupant impact velocity, potential for occupant compartment penetration, and occupant compartment deformation.

A sign support system with the largest post size and largest sign support area was identified as the critical configuration for the low speed small car vehicle impact (i.e., MASH Test 3-60). The combination of the large post and large sign support area resulted in the heaviest configuration. This configuration was considered the most critical for two primary reasons. First, it will require the greatest breakaway force to release the slip base, resulting in the highest occupant impact velocity. Second, the large sign support area would create the most contact with the roof and/or windshield of the vehicle. After reviewing standard post sizes and sign support areas, an 8x8 post with a 15 ft (width) x 7 ft (height) sign panel was identified as the critical sign support configuration for MASH Test 3-60. The sign panel was comprised of extruded aluminum with a horizontal cross brace for additional support.

A sign support system with the smallest post size and smallest sign support area was identified as the critical configuration for the high speed small car vehicle and pickup truck vehicle impacts (i.e., MASH Tests 3-61 and 3-62). This configuration was the most critical for two primary reasons. First, the combination of small post and small sign support resulted in the lowest system center of gravity. The center of gravity is the point at which the post rotates after release of the breakaway system. A lower center of gravity increases the likelihood of secondary contact with the vehicle roof or windshield. A higher center of gravity may allow the post to rotate over the vehicle without any secondary contact. Second, the small post and sign support area would produce a higher rotational velocity after release of the breakaway system. As a result, any secondary contact would impart greater energy to the vehicle, potentially causing increased roof or windshield deformation. After reviewing standard post sizes and sign support areas, a 3x3 square tube post with a 4 ft (width) x 5 ft (height) sign panel was identified as the critical sign support configuration for MASH Tests 3-61 and 3-62. The sign panel was comprised of aluminum sheeting.

2.3. ENGINEERING ANALYSIS

Prior to performing full-scale crash testing, an analysis program was used to evaluate the performance of the critical sign support configurations for MASH TL-3. The analysis program was previously developed under NCHRP Report 318 to analyze the behavior of breakaway supports for impacts with vehicles (*5*). The analysis program estimates the change in vehicular velocity resulting from impact with the breakaway support system and estimates the post-impact trajectory of the breakaway support system. This allows for the prediction of secondary contact of the breakaway support system with the vehicle roof or windshield. The equations used in the analysis program are based on the conservation of energy and the conservation of linear and angular momentum.

Figure 2.1 through Figure 2.3 show the predicted secondary contact for the three test impacts. For Test 3-60, secondary impact is predicted on the roof of the small car vehicle. The large sign panel contacts across the entire vehicle roof. Predicted change in velocity of the vehicle was below the MASH occupant impact velocity limit. For Test 3-61, secondary impact is predicted on the trunk of the small car vehicle. There is no occupant compartment deformation requirement for this location of the vehicle. For Test 3-62, secondary impact is predicted on the back edge of the roof of the pickup truck. The analysis program cannot predict the amount of roof deformation. Full-scale crash testing was needed to confirm the performance of the sign support systems for MASH TL-3.

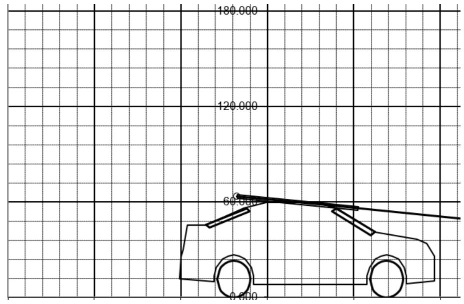


Figure 2.1. Test 3-60 Predicted Secondary Contact.

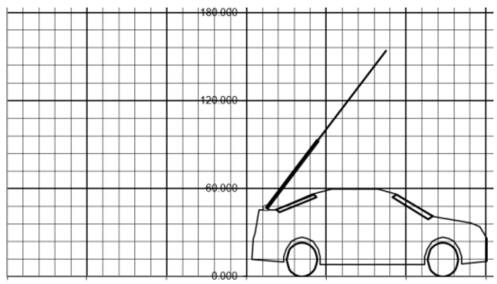


Figure 2.2. Test 3-61 Predicted Secondary Contact.

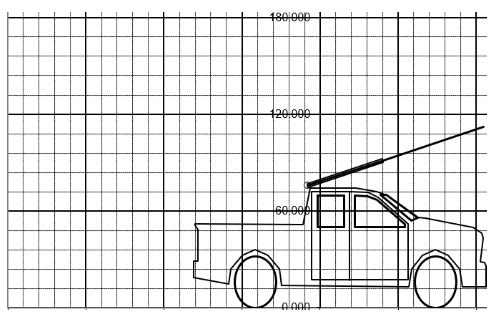


Figure 2.3. Test 3-62 Predicted Secondary Contact.

CHAPTER 3.
TEST REQUIREMENTS AND EVALUATION CRITERIA

3.1. CRASH TEST PERFORMED/MATRIX

Table 3.1 shows the test conditions and evaluation criteria for *MASH* TL-3 for Support Structures.

Table 3.1. Test Conditions and Evaluation Criteria Specified for *MASH* TL-3 Support Structures.

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

The crash tests and data analysis procedures were in accordance with guidelines presented in *MASH*. Chapter 4 presents brief descriptions of these procedures.

3.2. 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 3.1 lists the test conditions and evaluation criteria required for *MASH* TL-3, and Table 3.2 provides detailed information on the evaluation criteria.

Table 3.2. 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.
C.	Acceptable test article performance may be by redirection, controlled penetration, or controlled stopping of the vehicle.
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 4.
TEST CONDITIONS

4.1. 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 3100-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 on 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 installation was embedded within soil.

4.2. VEHICLE TOW AND GUIDANCE SYSTEM

Each test 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. 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.

4.3. DATA ACQUISITION SYSTEMS

4.3.1. 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 ENDEVCO 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. The data from the vehicle-mounted accelerometers are collected and filtered with an SAE Class 180 low-pass digital filter. Various filters to enhance readability are used for plotting acceleration versus time curves for the longitudinal, lateral, and vertical directions 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.

4.3.2. 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 impact 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.

4.3.3. Photographic Instrumentation Data Processing

Photographic coverage of each test included 2 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 Square Tube Slip Base Sign Support System. 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 5.
3 × 3 SQUARE TUBE SLIP BASE SYSTEM DETAILS

5.1. TEST ARTICLE AND INSTALLATION DETAILS

The test installation consisted of a 48-inch wide x 60-inch tall aluminum sign panel, mounted with its bottom edge 7 feet above grade. It was mounted on a 3-inch square steel tube post with a triangular slip base connection at 4 inches above grade. The stub was made of 3-inch square tube and secured in a reinforced concrete foundation.

Figure 5.1 presents the overall information on the 3 × 3 Square Tube Slip Base Sign Support System, and Figure 5.2 thru Figure 5.5 provide photographs of the installation. Appendix A provides further details on the 3 × 3 Square Tube Slip Base Sign Support System. Drawings were provided by the Texas A&M Transportation Institute (TTI) Proving Ground, and construction was performed by TTI Proving Ground personnel.

5.2. DESIGN MODIFICATIONS DURING TESTS

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

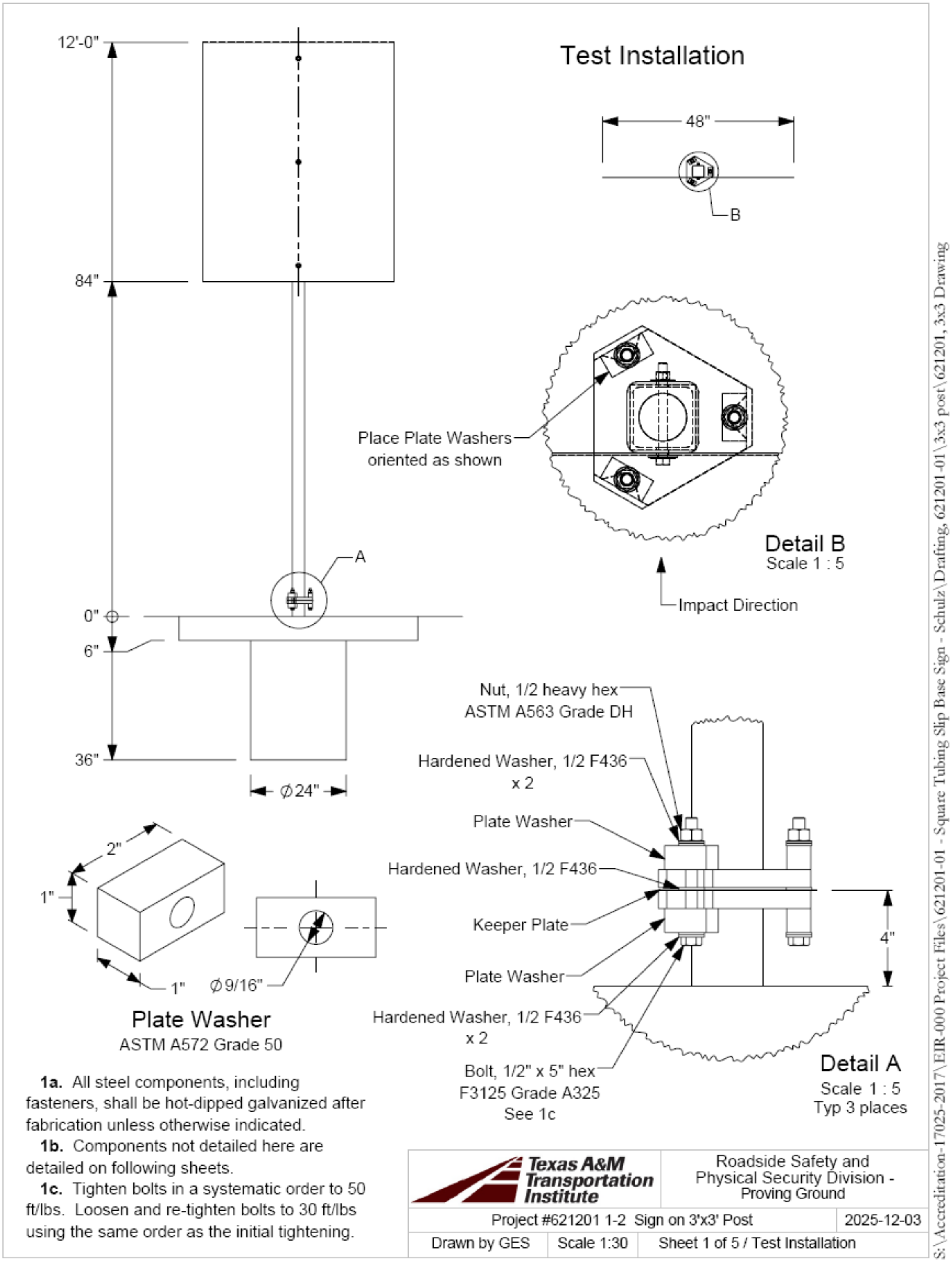


Figure 5.1. Details of 3 × 3 Square Tube Slip Base Sign Support System.

Figure 5.2. 3 × 3 Square Tube Slip Base Sign Support System prior to Testing.

Figure 5.3. Right Angle View of the 3 × 3 Square Tube Slip Base Sign Support System prior to Testing.

Figure 5.4. Sign Panel Assembly prior to Testing.

Figure 5.5. Slip Base Assembly prior to Testing.

5.3. MATERIAL SPECIFICATIONS

Appendix F provides material certification documents for the materials used to install/construct the 3 × 3 and 8 × 8 Square Tube Slip Base Sign Support System. Table 5.1 shows the average compressive strengths of the concrete on the day of the test 2026-03-09.

Table 5.1. Concrete Strength.

Location	Design Strength (psi)	Avg. Strength (psi)	Age (days)
Footers	3000	3400	17

CHAPTER 6.
MASH TEST 3-61 (CRASH TEST 621201-01-1)

6.1. CRITICAL IMPACT ANGLE LOCATION

The Critical Impact Angle (CIA) for this test was centerline of the vehicle aligned 16.75 inches from the centerline of the installation towards the driver's side at 0 degrees. The target CIA for this test was determined using the information provided in *MASH* Section 2.2.4. Figure 6.1 shows the target CIA for test 621201-01-1. Figure 6.2 and Figure 6.3 depict the vehicle at the CIA prior to test 621201-01-1.

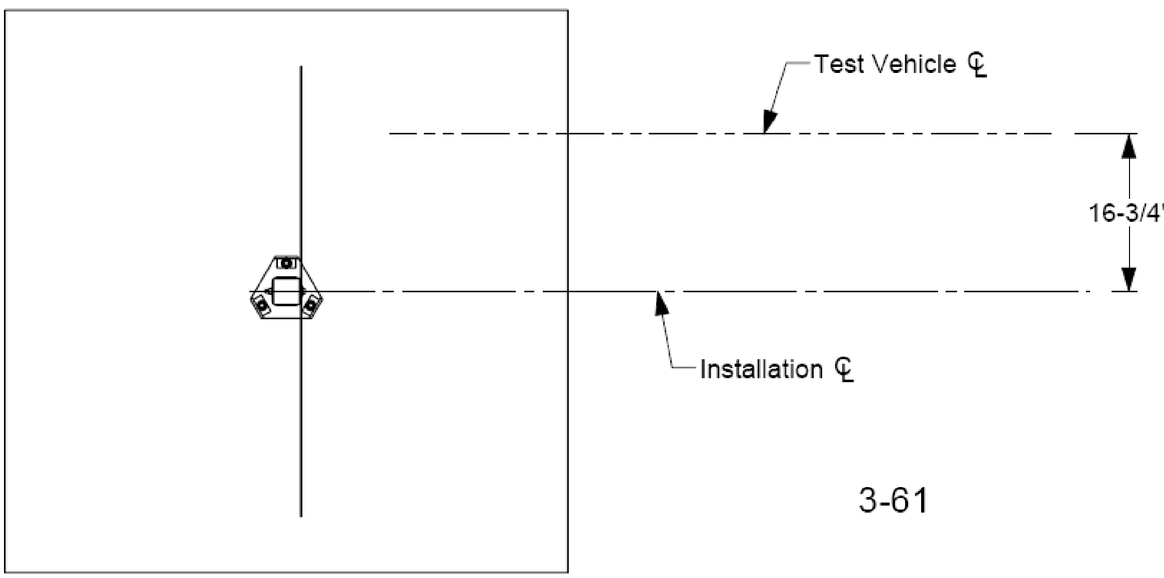


Figure 6.1. Target CIA for *MASH* Test 3-61 on the 3 × 3 Square Tube Slip Base Sign Support System.

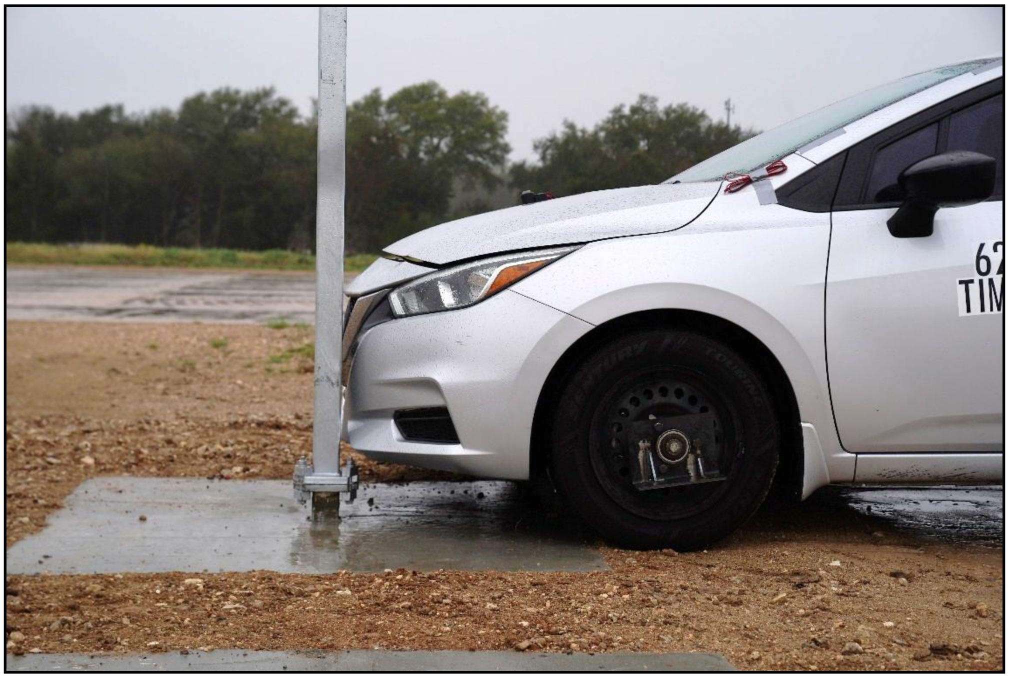


Figure 6.2. 3 × 3 Square Tube Slip Base Sign Support System/Test Vehicle Geometrics for Test 621201-01-1.

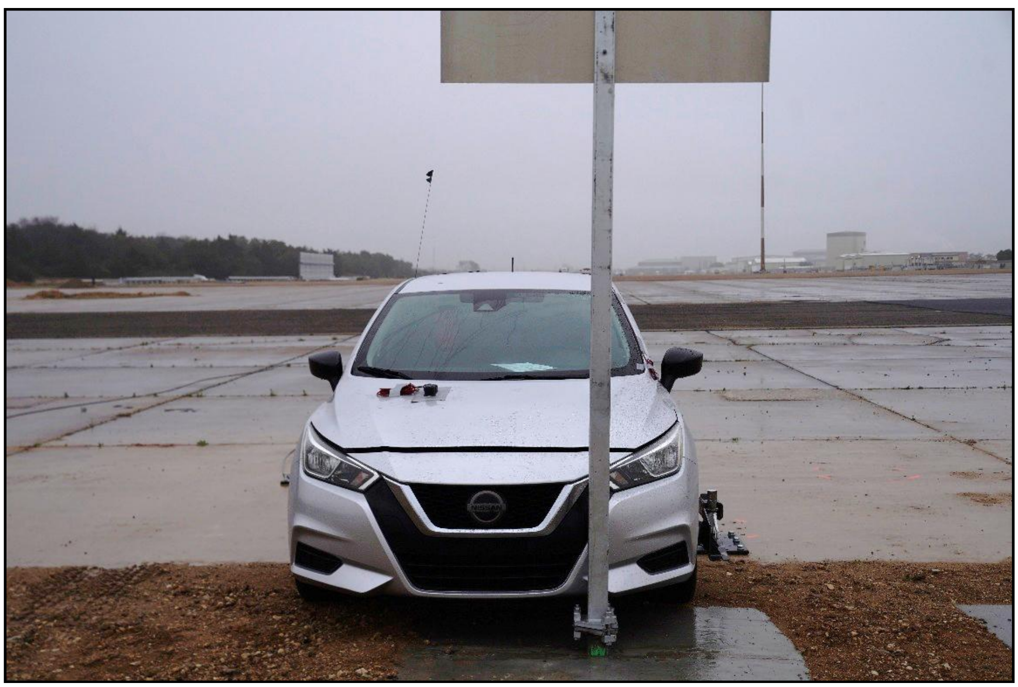


Figure 6.3. 3 × 3 Square Tube Slip Base Sign Support System/Test Vehicle Impact Location for Test 621201-01-1.

6.2. TEST VEHICLE DETAILS PRIOR TO IMPACT

Table 6.1 shows the vehicle measurements. Figure 6.4 and Figure 6.5 show the 2020 Nissan Versa used for the crash test. Figure B.1 in Appendix B.1 gives additional dimensions and information on the vehicle.

Table 6.1. Vehicle Measurements for Test 621201-01-1.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a] (lb)	165	N/A	165
Inertial Mass (lb)	2420	-55 / +120	2520
Gross Static[a] Mass (lb)	2585	-55 / +120	2685
Wheelbase (inches)	100	±5	102.4
Front Overhang (inches)	35	±4	32.5
Overall Length (inches)	171	±8	175.4
Overall Width (inches)	67	±3	66.7
Hood Height (inches)	28	±4	30.5
Track Width[b] (inches)	59	±2	58.4
CG aft of Front Axle[c] (inches)	39	±4	38.5
CG above Ground[c,d] (inches)	N/A	N/A	N/A

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.

Figure 6.4. Front of Test Vehicle before Test 621201-01-1.

Figure 6.5. Rear of Test Vehicle before Test 621201-01-1.

6.3. TEST DESCRIPTION

6.3.1. Weather Conditions

Table 6.2 provides the weather conditions for test 621201-01-1. Values for wind direction and vehicle travel are in reference to the degrees on a compass, with North being 0 degrees.

Table 6.2. Weather Conditions for Test 621201-01-1.

Date of Test	2026-03-09
Wind Speed	3 mi/h
Wind Direction	146°
Temperature	69°F
Relative Humidity	97 %
Vehicle Traveling	170 °

6.3.2. Test Events

Table 6.3 lists events that occurred during Test 621201-01-1. The figures in Appendix B.2 present sequential photographs during the test.

Table 6.3. Events during Test 621201-01-1.

Time (seconds)	Events
0.0000	Vehicle impacted the installation
0.0060	Slip Base began to release
0.0090	Slip Base fully released

6.4. TEST ACTUAL IMPACT CONDITIONS

Table 6.4 lists the details of the *MASH* impact conditions for this test and Table 6.5 lists the exit parameters.

Table 6.4. Impact Conditions for *MASH* TEST 3-61, Crash Test 621201-01-1.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	62	±2.5	61.98
Impact Angle (°)	0	±1.5	0.0
Kinetic Energy (kip-ft)	288	≥288	323.6
Impact Location	Centerline of the vehicle aligned 16.75 inches from the centerline of the installation towards the driver's side	±6 inches	Centerline of the vehicle aligned 16.75 inches from the centerline of the installation towards the driver's side

Table 6.5. Exit Parameters for *MASH* TEST 3-61, Crash Test 621201-01-1.

Exit Parameter	Measured
Speed	61.1mi/h
Brakes applied post impact	1.75 seconds
Vehicle at rest position	322 ft downstream of impact point 12 ft to the right of impact
Comments:	Vehicle remained upright and stable.

6.5. DAMAGE TO TEST INSTALLATION

The sign support assembly released from the base and came to rest 30 feet downstream from impact. Bolts from the base landed 75 feet, 135 feet, and 450 feet downstream from impact. Figure 6.6 and Figure 6.7 show the damage to the 3 × 3 Square Tube Slip Base Sign Support System.

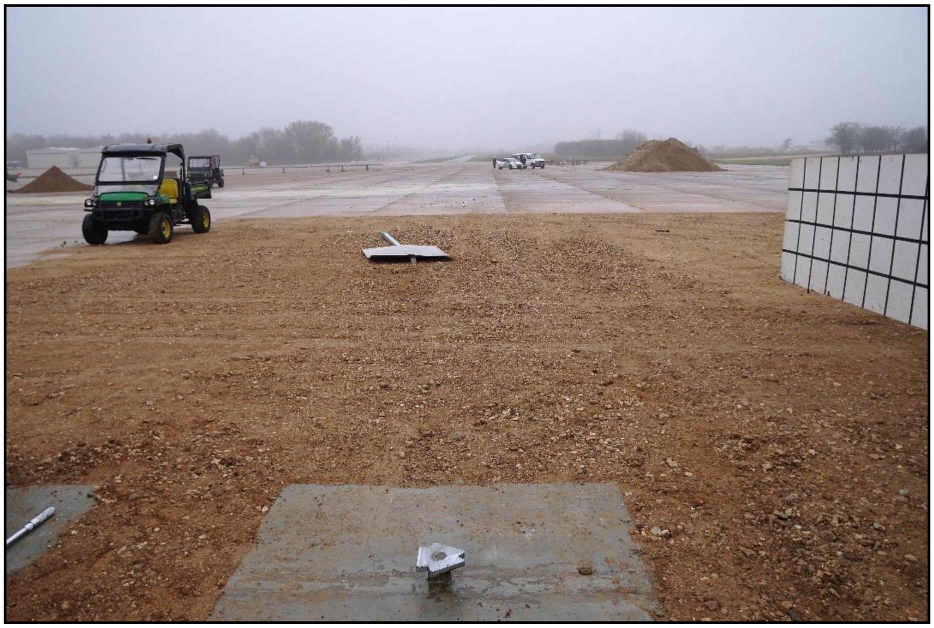


Figure 6.6. 3 × 3 Square Tube Slip Base Sign Support System at Impact Location after Test 621201-01-1.

Figure 6.7. 3 × 3 Square Tube Slip Base Sign Support System at Resting Position after Test 621201-01-1.

6.6. DAMAGE TO TEST VEHICLE

Figure 6.8 and Figure 6.9 show the damage sustained by the vehicle. Table 6.6 and Table 6.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figure B.2 and Figure B.3 in Appendix B.1 provide exterior crush and occupant compartment measurements.

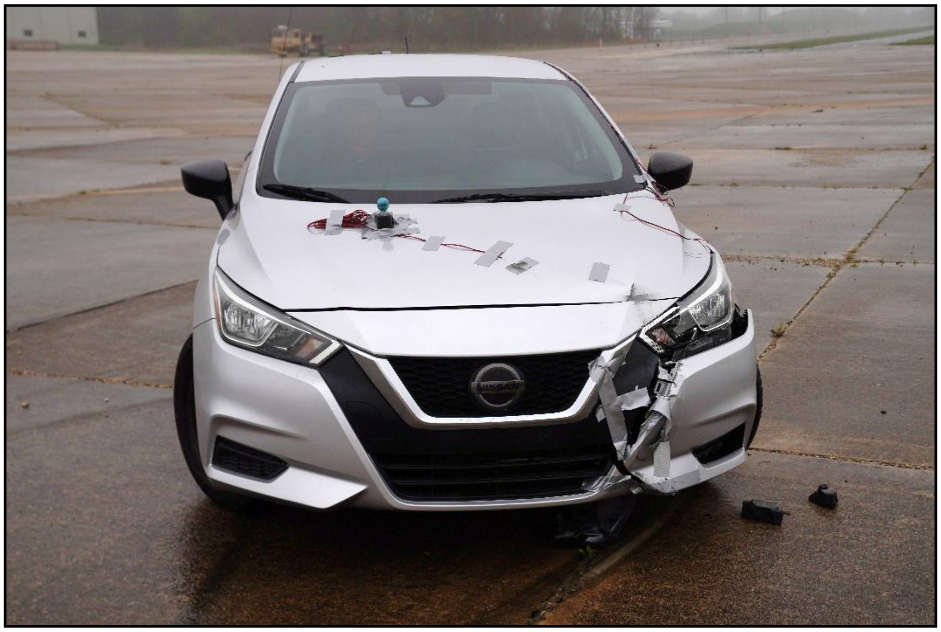


Figure 6.8. Impact Side of Test Vehicle after Test 621201-01-1.

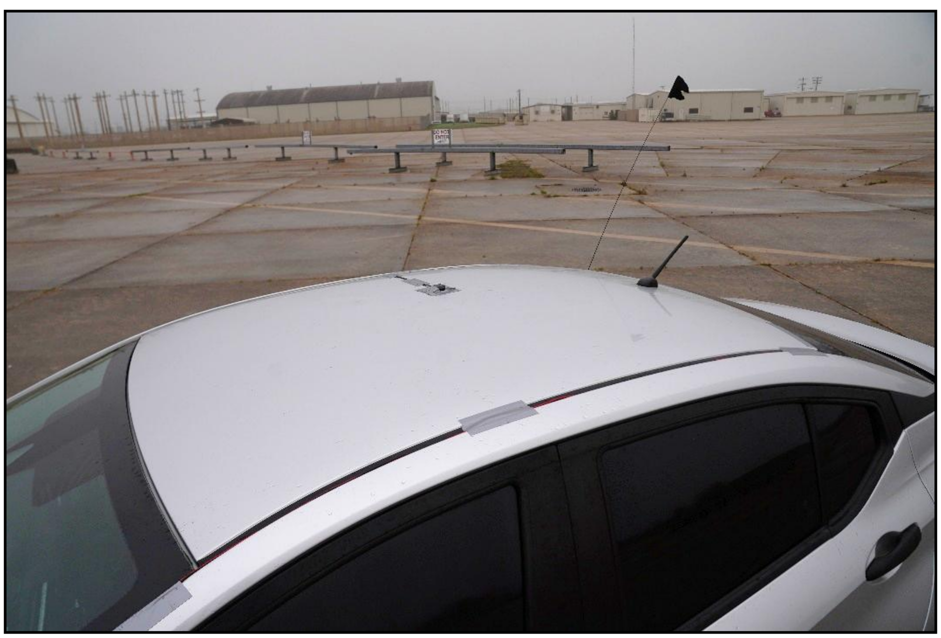


Figure 6.9. Roof of Test Vehicle after Test 621201-01-1.

Table 6.6. Occupant Compartment Deformation for Test 621201-01-1.

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

Table 6.7. Exterior Vehicle Damage for Test 621201-01-1.

Test Parameter	Details
Side Windows	The side windows remained intact
Maximum Exterior Deformation	3 inches in the front bumper
VDS	12FL1
CDC	12FLEN1
Fuel Tank Damage	None
Description of Damage to Vehicle:	The left side of the front bumper and hood were deformed. The clips that were holding the bumper on the left side, and the left headlight both fractured.

6.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 6.8. Figure B.6 in Appendix B.3 shows the vehicle angular displacements, and Figure B.7 through Figure B.9 in Appendix B.4 show acceleration versus time traces.

Table 6.8. Occupant Risk Factors for Test 621201-01-1.

Test Parameter	Specification[a]	Measured	Time
OIV, Longitudinal (ft/s)	≤16.0 *≤10.0*	0.9	1.3366 seconds on front of interior
OIV, Lateral (ft/s)	N/A	0.3	1.3366 seconds on front of interior
Ridedown, Longitudinal (g)	≤20.49 *≤15.0*	0.9	2.0339 - 2.0439 seconds
Ridedown, Lateral (g)	≤20.49 *≤15.0*	0.5	1.5465 - 1.5565 seconds
Theoretical Head Impact Velocity (THIV) (m/s)	N/A	0.3	1.3223 seconds on front of interior
Acceleration Severity Index	N/A	0.1	0.0048 - 0.0548 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal (g)	N/A	-1.1	0.0000 - 0.0500 seconds
50-ms MA Lateral (g)	N/A	-0.6	0.0188 - 0.0688 seconds
50-ms MA Vertical (g)	N/A	-1.8	0.0258 - 0.0758 seconds
Roll (°)	≤75	1.0	0.2478 seconds
Pitch (°)	≤75	0.6	0.7336 seconds
Yaw (°)	N/A	0.9	0.3054 seconds

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

Note: N/A = Not Applicable

6.8. TEST SUMMARY

Figure 6.10 summarizes the results of *MASH* Test 3-61.


0.000 s

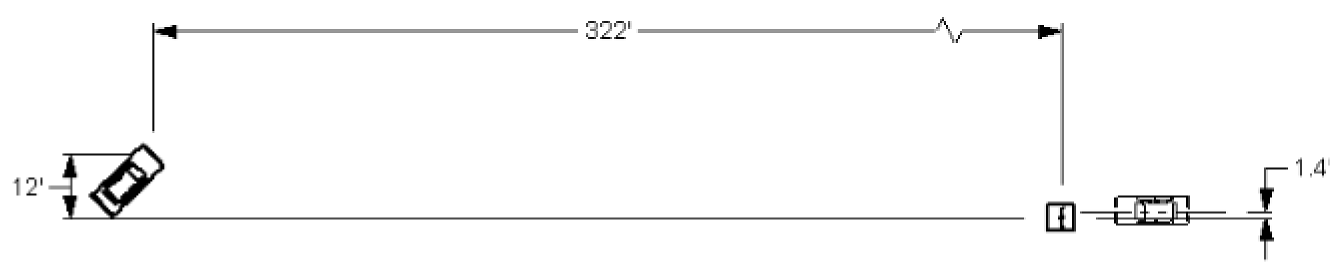

0.1000 s


0.2000 s


0.3000s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-61
Project No.:	621201-01-1
Test Date:	2026-03-09
TEST ARTICLE	
Type:	Support Structures
Name:	3 × 3 Square Tube Slip Base Sign Support System
Length:	12 feet
Key Materials:	Steel tube post, aluminum sign panel
Soil Type and Condition:	native soil, concrete footer
TEST VEHICLE	
Type/Designation:	1100C
Year, Make and Model:	2020 Nissan Versa
Inertial Mass:	2520 lb
Dummy Mass:	165 lb
Gross Static Mass:	2685 lb
IMPACT CONDITIONS	
Impact Speed:	61.98 mi/h
Impact Angle:	0.0°
Impact Location:	Centerline of the vehicle aligned 16.75 inches from the centerline of the installation towards the driver's side
Kinetic Energy:	323.6 kip-ft

EXIT CONDITIONS	
Exit Speed:	61.1 mi/h
Stopping Distance:	322 ft downstream 12 ft to the right of impact
VEHICLE DAMAGE	
VDS:	12FL1
CDC:	12FLEN1
Max Exterior Deformation:	3 inches in the front bumper
Max Occupant Compartment Deformation:	No occupant compartment deformation
OCCUPANT RISK VALUES	
Longitudinal OIV:	0.9 ft/s
Lateral OIV:	0.3 ft/s
Longitudinal Ridedown:	0.9 g
Lateral Ridedown:	0.5 g
THIV:	0.3 m/s
ASI:	0.1
Max 50ms Longitudinal:	-1.1 g
Max 50ms Lateral:	-0.6 g
Max 50ms Vertical:	-1.8 g
Max Roll:	1.0°
Max Pitch:	0.6°
Max Yaw:	0.9°



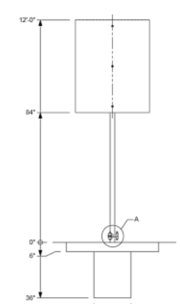


Figure 6.10. Summary of Results for *MASH* Test 3-61 on 3 × 3 Square Tube Slip Base Sign Support System.

CHAPTER 7.
MASH TEST 3-62 (CRASH TEST 621201-01-2)

7.1. CRITICAL IMPACT ANGLE LOCATION

The Critical Impact Angle (CIA) for this test was centerline of the vehicle aligned 13 inches from the centerline of the installation towards the driver's side at 0 degrees. The target CIA for this test was determined using the information provided in *MASH* Section 2.2.4. Figure 7.1 shows the target CIA for test 621201-01-2. Figure 7.2 and Figure 7.3 depict the vehicle at the CIA prior to test 621201-01-2.

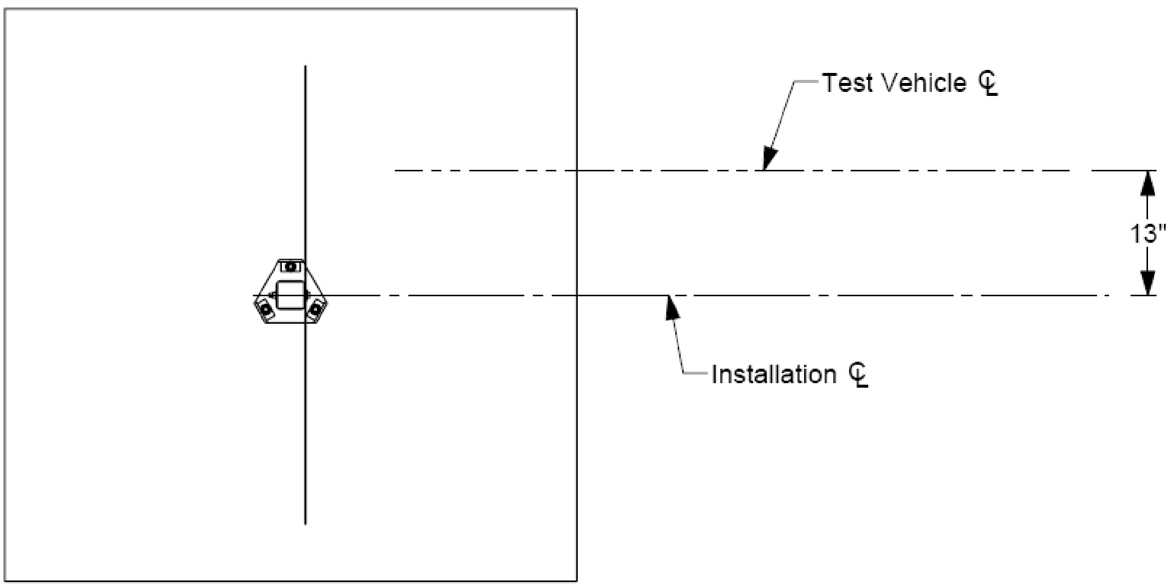


Figure 7.1. Target CIA for *MASH* Test 3-62 on 3 × 3 Square Tube Slip Base Sign Support System.

Figure 7.2. 3 × 3 Square Tube Slip Base Sign Support System/Test Vehicle Geometrics for Test 621201-01-2.

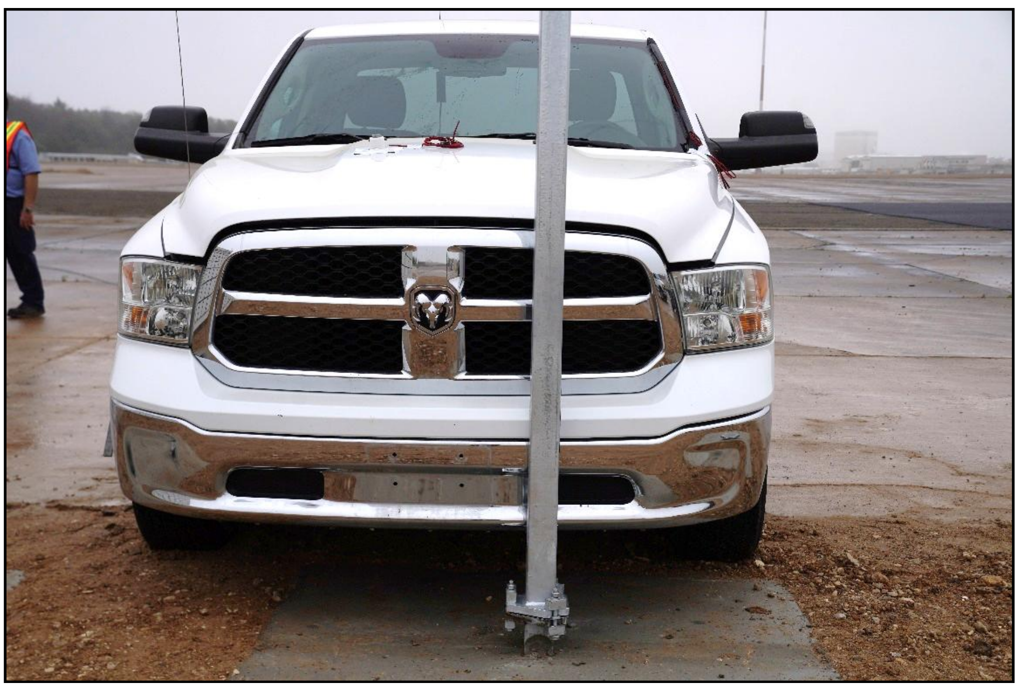


Figure 7.3. 3 × 3 Square Tube Slip Base Sign Support System/Test Vehicle Impact Location 621201-01-2.

7.2. TEST VEHICLE DETAILS PRIOR TO IMPACT

Table 7.1 shows the vehicle measurements. Figure 7.4 and Figure 7.5 show the 2021 RAM 1500 used for the crash test. Figure C.1 in Appendix C.1 gives additional dimensions and information on the vehicle.

Table 7.1. Vehicle Measurements for Test 621201-01-2.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a] (lb)	165	N/A	N/A
Inertial Mass (lb)	5000	±110	5053
Gross Static[a] Mass (lb)	5000	±110	5053
Wheelbase (inches)	148	±12	140.5
Front Overhang (inches)	39	±3	40
Overall Length (inches)	237	±13	227.5
Overall Width (inches)	81	±2.5	78.5
Hood Height (inches)	43	±4	46
Track Width[b] (inches)	68	±1.5	68.3
CG aft of Front Axle[c] (inches)	63	±4	61.6
CG above Ground[c,d] (inches)	≥28	N/A	28.5

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.

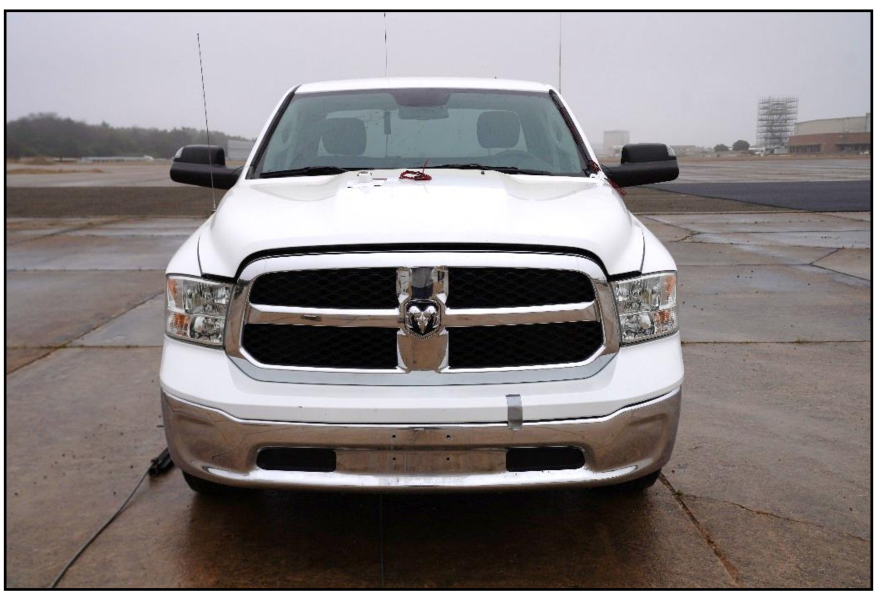


Figure 7.4. Impact Side of Test Vehicle before Test 621201-01-2.

Figure 7.5. Opposite Impact Side of Test Vehicle before Test 621201-01-2.

7.3. TEST DESCRIPTION

7.3.1. Weather Conditions

Table 7.2 provides the weather conditions for test 621201-01-2. Values for wind direction and vehicle travel are in reference to the degrees on a compass, with North being 0 degrees.

Table 7.2. Weather Conditions for Test 621201-01-2.

Date of Test	2026-03-09
Wind Speed	4 mi/h
Wind Direction	146°
Temperature	69°F
Relative Humidity	98 %
Vehicle Traveling	170 °

7.3.2. Test Events

Table 7.3 lists events that occurred during Test 621201-01-2. The figures in Appendix C.2 present sequential photographs during the test.

Table 7.3. Events during Test 621201-01-2.

Time (seconds)	Events
0.0000	Vehicle impacted the installation
0.0030	Slip Base began to release
0.0090	Slip Base fully released
0.1150	Top of sign began to impact rear portion of roof
0.1730	Sign no longer in contact with roof.

7.4. TEST ACTUAL IMPACT CONDITIONS

Table 7.4 lists the details of the *MASH* impact conditions for this test and Table 7.5 lists the exit parameters.

Table 7.4. Impact Conditions for *MASH* TEST 3-62, Crash Test 621201-01-2.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	62	±2.5	61.72
Impact Angle (°)	0	±1.5	0.0
Kinetic Energy (kip-ft)	594	≥594	643.5
Impact Location	Centerline of the vehicle aligned 13 inches from the centerline of the installation towards the driver's side	±6 inches	Centerline of the vehicle aligned 13 inches from the centerline of the installation towards the driver's side

Table 7.5. Exit Parameters for *MASH* TEST 3-62, Crash Test 621201-01-2.

Exit Parameter	Measured
Speed	59.9 mi/h
Brakes applied post impact	2.1 seconds
Vehicle at rest position	345 ft downstream of impact point 7 ft to the left of impact
Comments:	Vehicle remained upright and stable.

7.5. DAMAGE TO TEST INSTALLATION

The sign support assembly released from the base and came to rest 160 feet downstream from impact. One bolt from the base stayed at impact, and the other two landed 8 and 140 feet downstream from impact. Figure 7.6 and Figure 7.7 show the damage to the 3 × 3 Square Tube Slip Base Sign Support System.

Figure 7.6. 3 × 3 Square Tube Slip Base Sign Support System at Impact Location after Test 621201-01-2.

Figure 7.7. 3 × 3 Square Tube Slip Base Sign Support System at Resting Position after Test 621201-01-2.

7.6. DAMAGE TO TEST VEHICLE

Figure 7.8 and Figure 7.9 show the damage sustained by the vehicle. Figure 7.10 and Figure 7.11 show the interior of the test vehicle. Table 7.6 and Table 7.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figure C.2 and Figure C.3 in Appendix C.1 provide exterior crush and occupant compartment measurements.

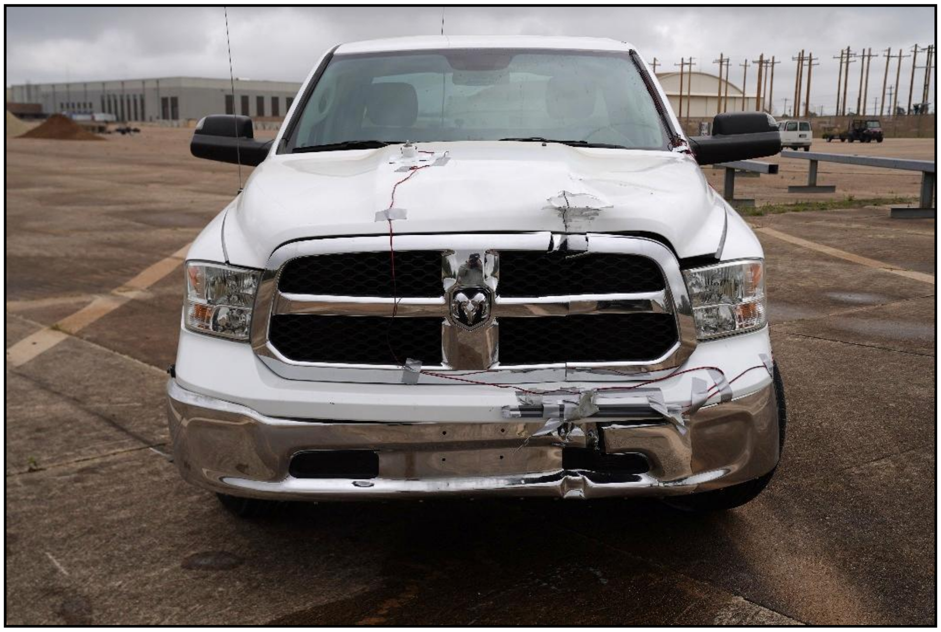


Figure 7.8. Impact Side of Test Vehicle after Test 621201-01-2.

Figure 7.9. Rear Impact Side of Test Vehicle after Test 621201-01-2.

Figure 7.10. Overall Interior of Test Vehicle after Test 621201-01-2.

Figure 7.11. Interior of Test Vehicle on Impact Side after Test 621201-01-2.

Table 7.6. Occupant Compartment Deformation for Test 621201-01-2.

Test Parameter	Specification (inches)	Measured (inches)
Roof	≤4.0	3.3
Windshield	≤3.0	0.0
A and B Pillars	≤5.0 overall/≤3.0 lateral	0.0
Foot Well/Toe Pan	≤9.0	0.0
Floor Pan/Transmission Tunnel	≤12.0	0.0
Side Front Panel	≤12.0	0.0
Front Door (above Seat)	≤9.0	0.0
Front Door (below Seat)	≤12.0	0.0

Table 7.7. Exterior Vehicle Damage for Test 621201-01-2.

Test Parameter	Details
Side Windows	The side windows remained intact
Maximum Exterior Deformation	7.5 inches in the front bumper
VDS	12FL2
CDC	12FLAN1
Fuel Tank Damage	None
Description of Damage to Vehicle:	The left side of the front bumper, grill, hood, and roof were deformed. The roof had a 45 inch long x 48 inch wide dent along with a 2.5 inch long x 0.4 inch wide tear.

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 Figure C.7 through Figure C.9 in Appendix C.4 show acceleration versus time traces.

Table 7.8. Occupant Risk Factors for Test 621201-01-2.

Test Parameter	Specification [a]	Measured	Time
OIV, Longitudinal (ft/s)	≤16.0 *≤10.0*	1.0	0.7652 seconds on left side of interior
OIV, Lateral (ft/s)	N/A	2.9	0.7652 seconds on left side of interior
Ridedown, Longitudinal (g)	≤20.49 *≤15.0*	0.9	2.4038 - 2.4138 seconds
Ridedown, Lateral (g)	≤20.49 *≤15.0*	0.5	1.8038 - 1.8138 seconds
Theoretical Head Impact Velocity (THIV) (m/s)	N/A	0.9	0.7662 seconds on left side of interior
Acceleration Severity Index	N/A	0.2	0.1659 - 0.2159 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal (g)	N/A	-0.9	0.0988 - 0.1488 seconds
50-ms MA Lateral (g)	N/A	0.4	0.1024 - 0.1524 seconds
50-ms MA Vertical (g)	N/A	-2.2	0.1403 - 0.1903 seconds
Roll (°)	≤75	0.9	0.2487 seconds
Pitch (°)	≤75	1.2	0.2672 seconds
Yaw (°)	N/A	0.6	0.3735 seconds

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

Note: N/A = Not Applicable

7.8. DISCUSSION

After initial vehicle impact and release of the slip base system, the upper part of the sign support system with the post and sign panel rotated and contacted the roof of the pickup truck. This contact induced a tear in the roof structure (Figure 7.9). Review of the high-speed video did not clearly identify which component of the sign support system caused the tear. However, based on the tear location relative to the contact area, the tear was believed to have been caused by either the bolt head near the top of the sign panel or the top edge of the sign post. The roof tear was assessed as occupant compartment penetration by the test article, resulting in failure of *MASH* Criterion D.

7.9. TEST SUMMARY

Figure 7.12 summarizes the results of *MASH* Test 3-62.

0.000 s

0.1000 s

0.2000 s

0.3000s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-62
Project No.:	621201-01-2
Test Date:	2026-03-09
TEST ARTICLE	
Type:	Support Structures
Name:	3 × 3 Square Tube Slip Base Sign Support System
Length:	12 feet
Key Materials:	Steel tube post, aluminum sign panel
Soil Type and Condition:	native soil, concrete footer
TEST VEHICLE	
Type/Designation:	2270P
Year, Make and Model:	2021 RAM 1500
Inertial Mass:	5053 lb
Dummy Mass:	N/A lb
Gross Static Mass:	5053 lb
IMPACT CONDITIONS	
Impact Speed:	61.72 mi/h
Impact Angle:	0.0°
Impact Location:	Centerline of the vehicle aligned 13 inches from the centerline of the installation towards the driver's side
Kinetic Energy:	643.5 kip-ft

EXIT CONDITIONS	
Exit Speed:	59.9mi/h
Stopping Distance:	345 ft downstream 7 ft to the left of impact
VEHICLE DAMAGE	
VDS:	12FL2
CDC:	12FLAN1
Max Exterior Deformation:	7.5 inches in the front bumper
Max Occupant Compartment Deformation:	3.3 inches in the roof
OCCUPANT RISK VALUES	
Longitudinal OIV:	1.0 ft/s
Lateral OIV:	2.9 ft/s
Longitudinal Ridedown:	0.9 g
Lateral Ridedown:	0.5 g
THIV:	0.9 m/s
ASI:	0.2
Max 50ms Longitudinal:	-0.9 g
Max 50ms Lateral:	0.4 g
Max 50ms Vertical:	-2.2 g
Max Roll:	0.9°
Max Pitch:	1.2°
Max Yaw:	0.6°

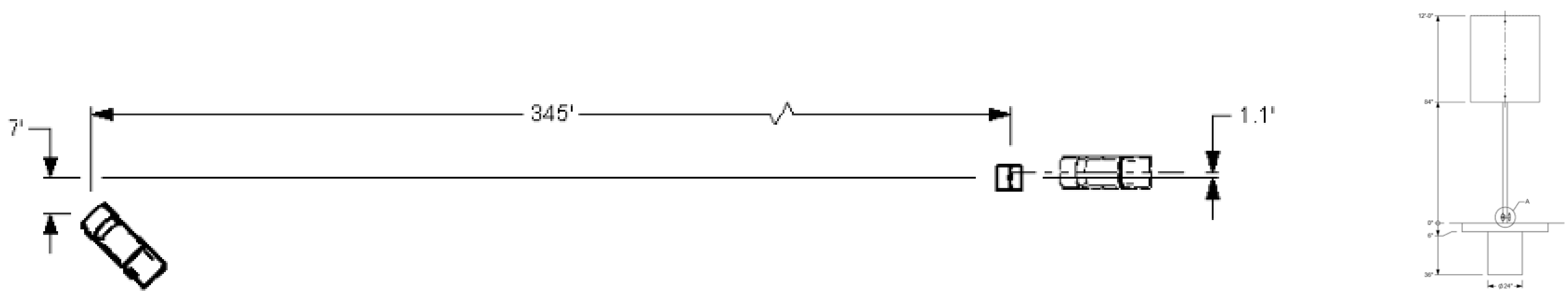


Figure 7.12. Summary of Results for *MASH* Test 3-62 on 3 × 3 Square Tube Slip Base Sign Support System.

CHAPTER 8.

8 × 8 SQUARE TUBE SLIP BASE SYSTEM DETAILS

8.1. TEST ARTICLE AND INSTALLATION DETAILS

The test installation consisted of a 15 feet wide x 7 feet tall sign assembly made of 12-inch-wide extruded aluminum panels, mounted with its bottom edge 7 feet above grade. It was mounted on an 8-inch square steel tube post with a triangular slip base connection at 4 inches above grade. The stub was made the same material as the post and secured in a reinforced concrete foundation.

Figure 8.1 presents the overall information on the 8 × 8 Square Tube Slip Base Sign Support System, and Figure 8.2 thru Figure 8.4 provide photographs of the installation. Appendix D provides further details on the 8 × 8 Square Tube Slip Base Sign Support System. Drawings were provided by the Texas A&M Transportation Institute (TTI) Proving Ground, and construction was performed by TTI Proving Ground personnel.

8.2. DESIGN MODIFICATIONS DURING TESTS

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

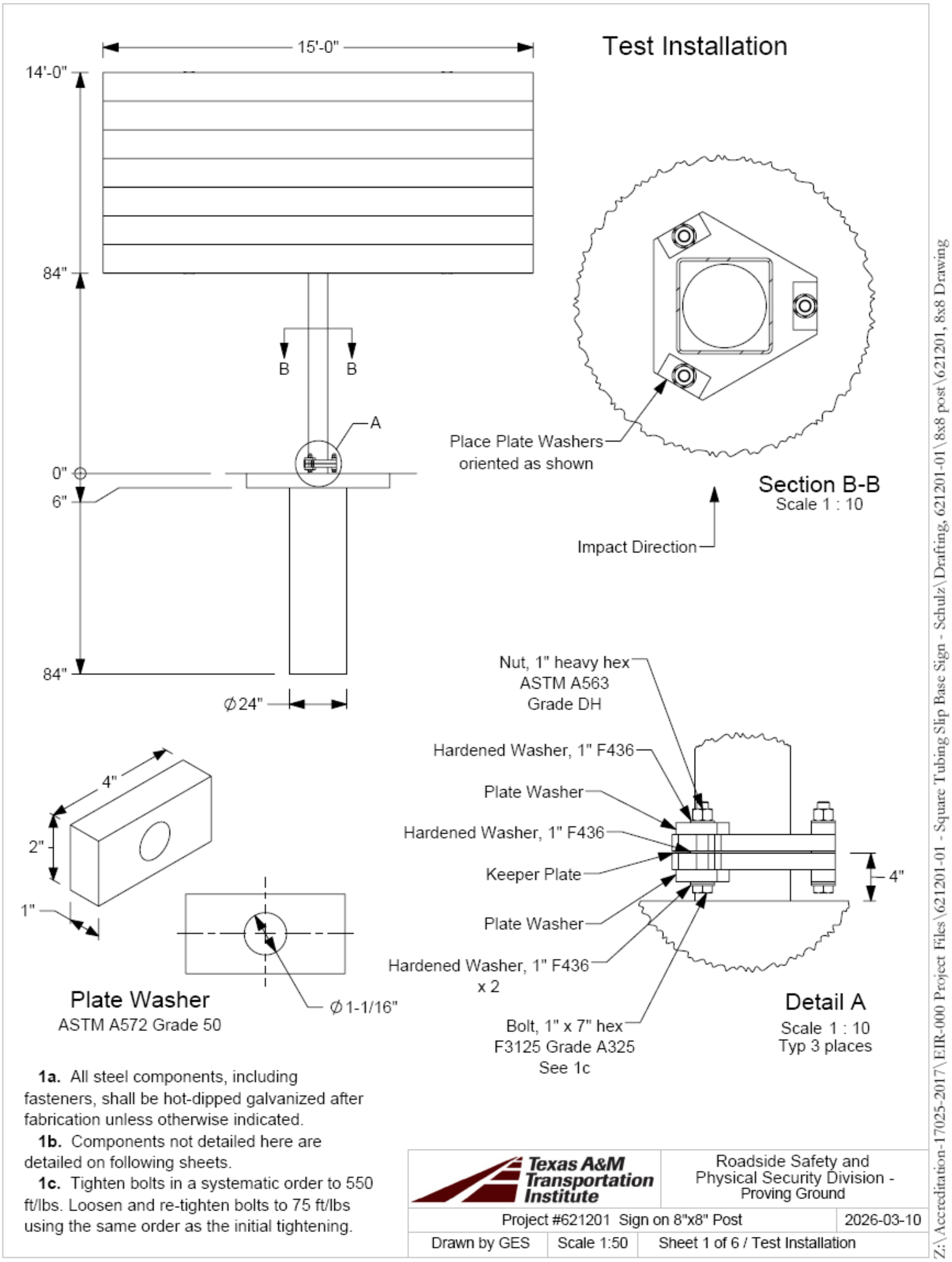


Figure 8.1. Details of 8 × 8 Square Tube Slip Base Sign Support System.

Figure 8.2. 8 × 8 Square Tube Slip Base Sign Support System prior to Testing.

Figure 8.3. 8 × 8 Square Tube Slip Base Sign Support System Base prior to Testing.

Figure 8.4. Right Angle View of the 8 × 8 Square Tube Slip Base Sign Support System prior to Testing.

CHAPTER 9.

MASH TEST 3-60 (CRASH TEST 621201-01-3)

9.1. CRITICAL IMPACT ANGLE LOCATION

The Critical Impact Angle (CIA) for this test was centerline of the vehicle aligned 16.75 inches from the centerline of the installation towards the driver's side at 0 degrees. The target CIA for this test was determined using the information provided in *MASH* Section 2.2.4. Figure 9.1 shows the target CIA for test 621201-01-3. Figure 9.2 and Figure 9.3 depict the vehicle at the CIA prior to test 621201-01-3.

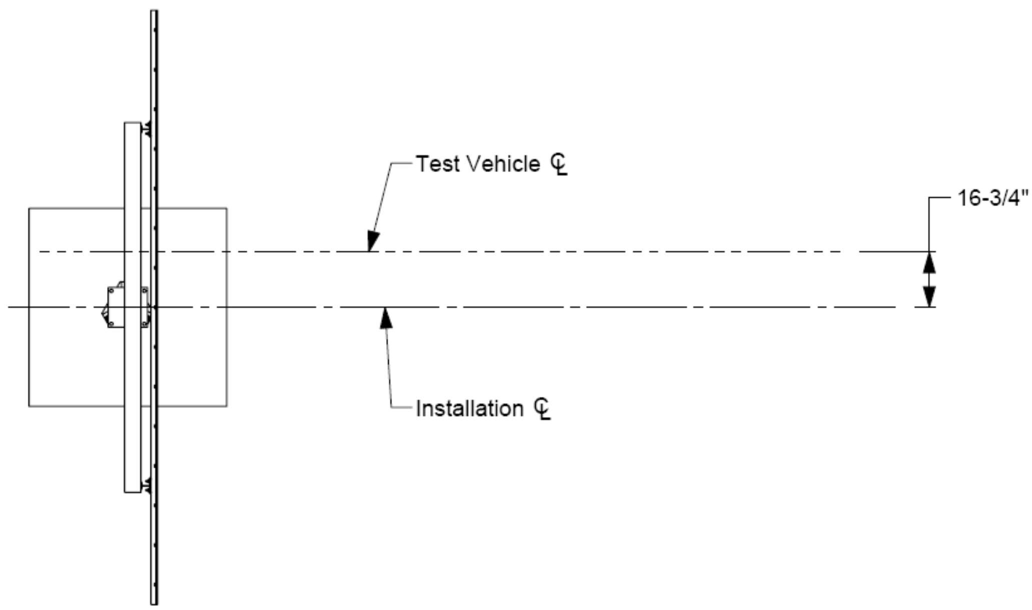


Figure 9.1. Target CIA for *MASH* Test 3-60 on 8 × 8 Square Tube Slip Base Sign Support System.

Figure 9.2. 8 × 8 Square Tube Slip Base Sign Support System/Test Vehicle Geometrics for Test 621201-01-3.

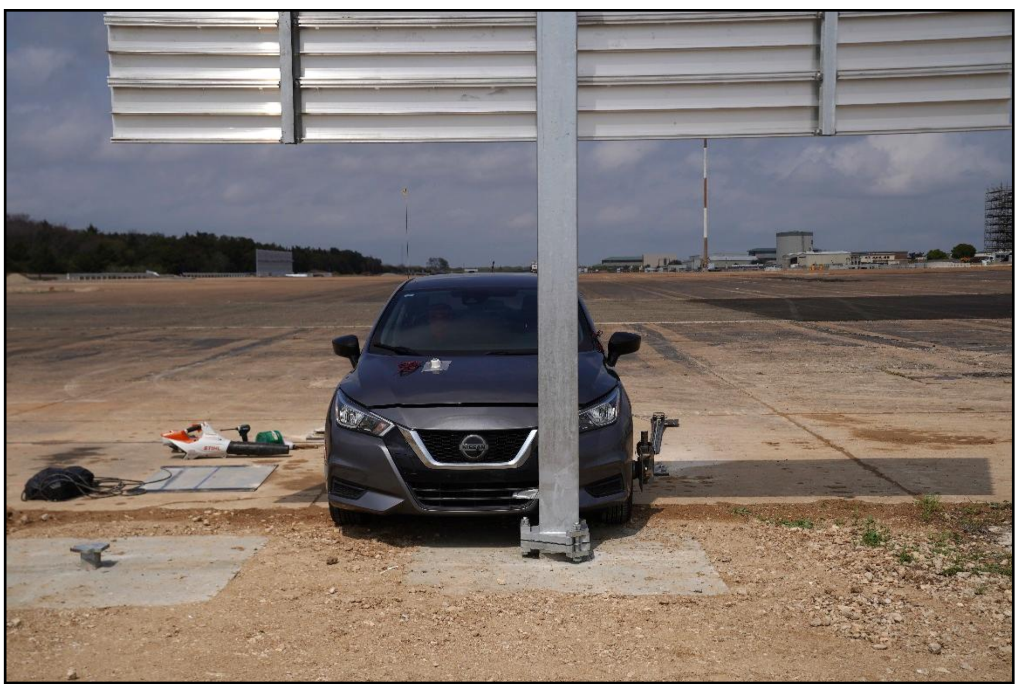


Figure 9.3. 8 × 8 Square Tube Slip Base Sign Support System/Test Vehicle Impact Location 621201-01-3.

9.2. TEST VEHICLE DETAILS PRIOR TO IMPACT

Table 9.1 shows the vehicle measurements. Figure 9.4 and Figure 9.5 show the 2020 Nissan Versa used for the crash test. Figure E.1 in Appendix E.1 gives additional dimensions and information on the vehicle.

Table 9.1. Vehicle Measurements for Test 621201-01-3.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a] (lb)	165	N/A	165
Inertial Mass (lb)	2420	-55 / +120	2509
Gross Static[a] Mass (lb)	2585	-55 / +120	2674
Wheelbase (inches)	100	±5	102.4
Front Overhang (inches)	35	±4	32.5
Overall Length (inches)	171	±8	175.4
Overall Width (inches)	67	±3	66.7
Hood Height (inches)	28	±4	30.5
Track Width[b] (inches)	59	±2	58.4
CG aft of Front Axle[c] (inches)	39	±4	38.4
CG above Ground[c,d] (inches)	N/A	N/A	N/A

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.

Figure 9.4. Impact Side of Test Vehicle before Test 621201-01-3.

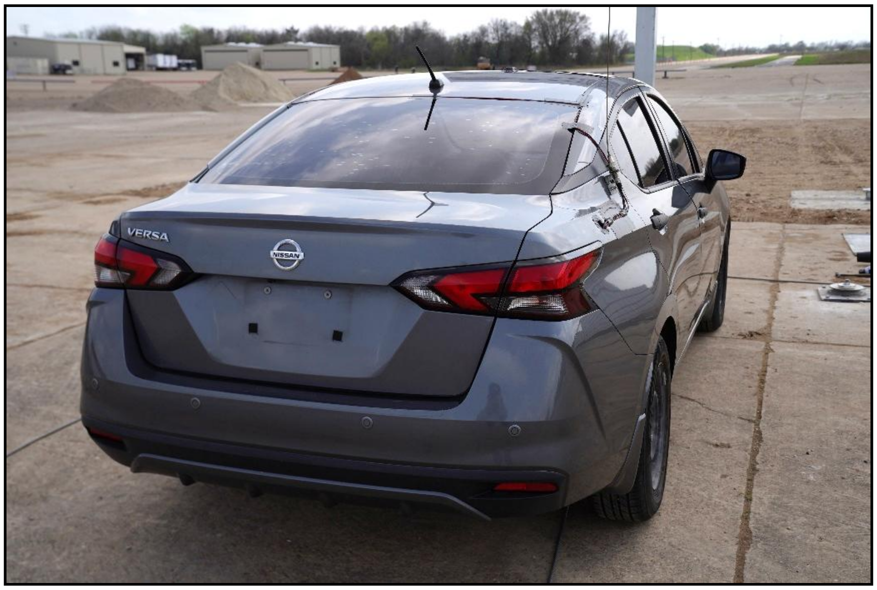


Figure 9.5. Opposite Impact Side of Test Vehicle before Test 621201-01-3.

9.3. TEST DESCRIPTION

9.3.1. Weather Conditions

Table 9.2 provides the weather conditions for test 621201-01-3. Values for wind direction and vehicle travel are in reference to the degrees on a compass, with North being 0 degrees.

Table 9.2. Weather Conditions for Test 621201-01-3.

Date of Test	2026-03-09
Wind Speed	15 mi/h
Wind Direction	186°
Temperature	81°F
Relative Humidity	77 %
Vehicle Traveling	170 °

9.3.2. Test Events

Table 9.3 lists events that occurred during Test 621201-01-3. The figures in Appendix E.2 present sequential photographs during the test.

Table 9.3. Events during Test 621201-01-3.

Time (seconds)	Events
0.0000	Vehicle impacted the installation
0.0200	Slip Base began to release
0.0430	Slip Base fully released
0.4840	Sign began to impact rear portion of roof
0.7260	Sign no longer in contact with vehicle

9.4. TEST ACTUAL IMPACT CONDITIONS

Table 9.4 lists the details of the *MASH* impact conditions for this test and Table 9.5 lists the exit parameters.

Table 9.4. Impact Conditions for *MASH* TEST 3-60, Crash Test 621201-01-3.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	19	±2.5	19.04
Impact Angle (°)	0	±1.5	0.0
Kinetic Energy (kip-ft)	34	≤34	30.4
Impact Location	Centerline of the vehicle aligned 16.75 inches from the centerline of the installation towards the driver's side	±6 inches	Centerline of the vehicle aligned 16.75 inches from the centerline of the installation towards the driver's side

Table 9.5. Exit Parameters for *MASH* TEST 3-60, Crash Test 621201-01-3.

Exit Parameter	Measured
Speed	15.8 mi/h
Brakes applied post impact	3.5 seconds
Vehicle at rest position	80 ft downstream of impact point In-line ft to the
Comments:	Vehicle remained upright and stable.

9.5. DAMAGE TO TEST INSTALLATION

The sign support assembly released from the base and came to rest 6 feet downstream from impact. One bolt from the base was missing, and the other two landed 3 and 60 feet downstream from impact. Figure 9.6 and Figure 9.7 show the damage to the 8 × 8 Square Tube Slip Base Sign Support System.

Figure 9.6. 8 × 8 Square Tube Slip Base Sign Support System at Impact Location after Test 621201-01-3.

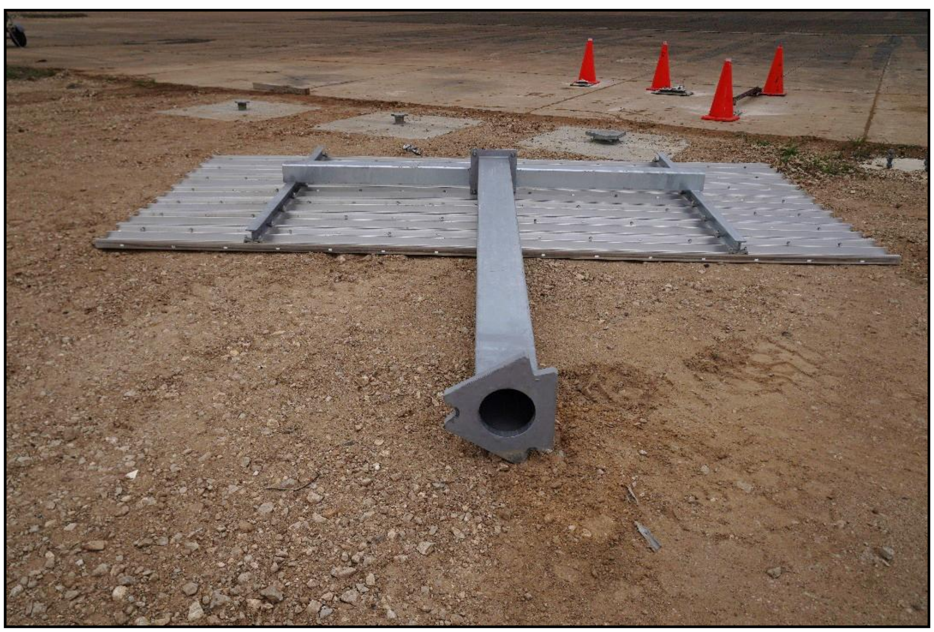


Figure 9.7. 8 × 8 Square Tube Slip Base Sign Support System at Resting Position after Test 621201-01-3.

9.6. DAMAGE TO TEST VEHICLE

Figure 9.8 and Figure 9.9 show the damage sustained by the vehicle. Figure 9.10 and Figure 9.11 show the interior of the test vehicle. Table 9.6 and Table 9.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figure E.2 and Figure E.3 in Appendix E.1 provide exterior crush and occupant compartment measurements.

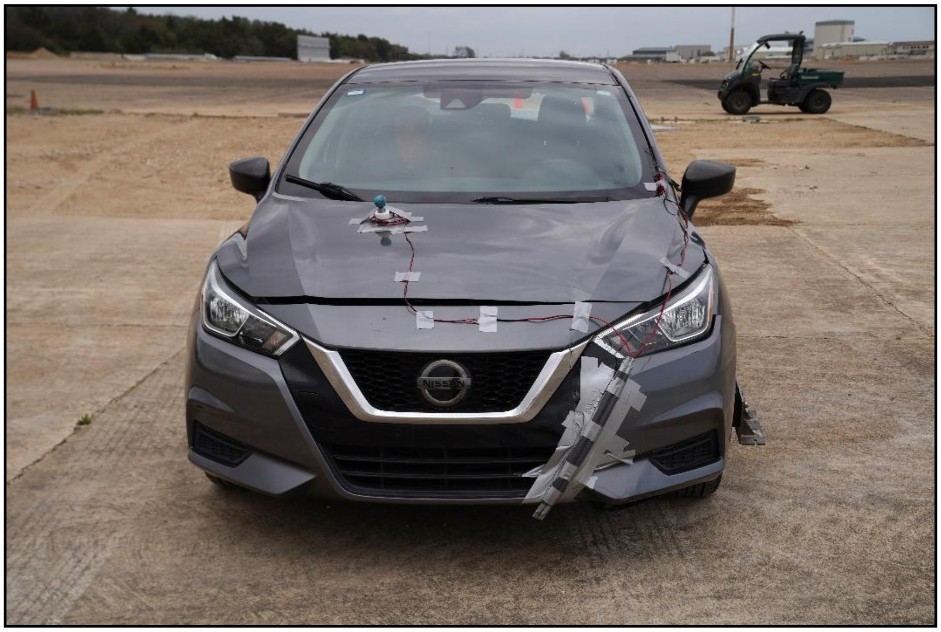


Figure 9.8. Impact Side of Test Vehicle after Test 621201-01-3.

Figure 9.9. Rear Impact Side of Test Vehicle after Test 621201-01-3.

Figure 9.10. Overall Interior of Test Vehicle after Test 621201-01-3.

Figure 9.11. Interior of Test Vehicle on Impact Side after Test 621201-01-3.

Table 9.6. Occupant Compartment Deformation for Test 621201-01-3.

Test Parameter	Specification (inches)	Measured (inches)
Roof	≤4.0	1.8
Windshield	≤3.0	0.0
A and B Pillars	≤5.0 overall/≤3.0 lateral	0.0
Foot Well/Toe Pan	≤9.0	0.0
Floor Pan/Transmission Tunnel	≤12.0	0.0
Side Front Panel	≤12.0	0.0
Front Door (above Seat)	≤9.0	0.0
Front Door (below Seat)	≤12.0	0.0

Table 9.7. Exterior Vehicle Damage for Test 621201-01-3.

Test Parameter	Details
Side Windows	The side windows remained intact
Maximum Exterior Deformation	2.3 inches in the roof
VDS	12FL1
CDC	12FLAN1
Fuel Tank Damage	None
Description of Damage to Vehicle:	The left side of the front bumper, grill, hood, roof, and trunk were deformed. The back window was shattered by contact with the sign, but there was no penetration or potential for penetration of the test article into the occupant compartment.

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 Figure E.7 through Figure E.9 in Appendix E.4 show acceleration versus time traces.

Table 9.8. Occupant Risk Factors for Test 621201-01-3.

Test Parameter	Specification [a]	Measured	Time
OIV, Longitudinal (ft/s)	≤16.0 *≤10.0*	4.6	0.4947 seconds on front of interior
OIV, Lateral (ft/s)	N/A	2.4	0.4947 seconds on front of interior
Ridedown, Longitudinal (g)	≤20.49 *≤15.0*	1.0	0.5889 - 0.5989 seconds
Ridedown, Lateral (g)	≤20.49 *≤15.0*	2.3	0.4954 - 0.5054 seconds
Theoretical Head Impact Velocity (THIV) (m/s)	N/A	1.6	0.4946 seconds on front of interior
Acceleration Severity Index	N/A	0.2	0.0176 - 0.0676 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal (g)	N/A	-2.2	0.0006 - 0.0506 seconds
50-ms MA Lateral (g)	N/A	-0.7	0.6547 - 0.7047 seconds
50-ms MA Vertical (g)	N/A	-1.9	0.5609 - 0.6109 seconds
Roll (°)	≤75	2.1	0.6793 seconds
Pitch (°)	≤75	2.7	0.5937 seconds
Yaw (°)	N/A	1.4	1.9787 seconds

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

Note: N/A = Not Applicable

9.8. TEST SUMMARY

Figure 9.12 summarizes the results of *MASH* Test 3-60.

0.000 s

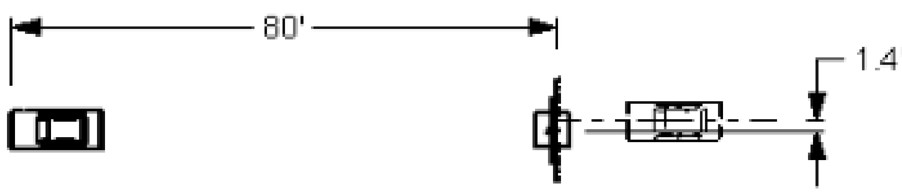
0.2000 s

0.4000 s

0.6000s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-60
Project No.:	621201-01-3
Test Date:	2026-03-09
TEST ARTICLE	
Type:	Support Structures
Name:	8 × 8 Square Tube Slip Base Sign Support System
Length:	12 feet
Key Materials:	Steel tube post, aluminum sign panel
Soil Type and Condition:	native soil, concrete footer
TEST VEHICLE	
Type/Designation:	1100C
Year, Make and Model:	2020 Nissan Versa
Inertial Mass:	2509 lb
Dummy Mass:	165 lb
Gross Static Mass:	2674 lb
IMPACT CONDITIONS	
Impact Speed:	19.04 mi/h
Impact Angle:	0.0°
Impact Location:	Centerline of the vehicle aligned 16.75 inches from the centerline of the installation towards the driver's side
Kinetic Energy:	30.4 kip-ft

EXIT CONDITIONS	
Exit Speed:	15.8 mi/h
Stopping Distance:	80 ft downstream In-line ft to the side
VEHICLE DAMAGE	
VDS:	12FL1
CDC:	12FLAN1
Max Exterior Deformation:	1.8 inches in the roof
Max Occupant Compartment Deformation:	1.8 inches in the roof
OCCUPANT RISK VALUES	
Longitudinal OIV:	4.6 ft/s
Lateral OIV:	2.4 ft/s
Longitudinal Ridedown:	1.0 g
Lateral Ridedown:	2.3 g
THIV:	1.6 m/s
ASI:	0.2
Max 50ms Longitudinal:	-2.2 g
Max 50ms Lateral:	-0.7 g
Max 50ms Vertical:	-1.9 g
Max Roll:	2.1°
Max Pitch:	2.7°
Max Yaw:	1.4°



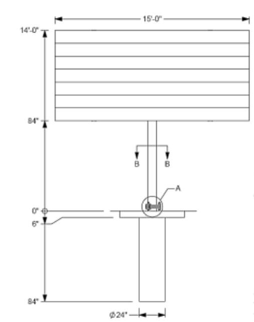


Figure 9.12. Summary of Results for *MASH* Test 3-60 on 8 × 8 Square Tube Slip Base Sign Support System.

CHAPTER 10.

POST-TEST ENGINEERING ANALYSIS*

An approach was taken to test and evaluate a range of square tube post and sign panel configurations through full-scale crash testing. A 3-inch x 3-inch post with a 4 ft x 5 ft sign panel and an 8-inch x 8-inch post with a 15 ft x 7 ft sign panel were identified as the lower and upper bounds of possible sign support configurations with a square tube post and triangular slip base breakaway system.

The configuration with an 8-inch x 8-inch post and 15 ft x 7 ft sign area indicated satisfactory performance for *MASH* Test 3-60. The configuration with a 3-inch x 3-inch post and 4 ft x 5 ft sign area indicated satisfactory performance for *MASH* Test 3-61 and unsatisfactory performance for *MASH* Test 3-62. The sign support contacted the roof of the pickup truck vehicle and induced a small tear in the roof structure.

The 3-inch x 3-inch post with a 4 ft x 5 ft sign area was selected as the critical configuration for the lightest post and smallest sign support area. This combination essentially resulted in the lowest center of gravity among possible configurations. A lower center of gravity increases the likelihood of secondary contact with the vehicle. Other configurations may indicate improved crashworthy performance for *MASH* Test 3-62. Sign support systems with a higher rotation point (i.e., center of gravity) will have an increased chance of rotating over the vehicle and not having secondary contact.

Full-scale crash testing of alternative configurations for *MASH* Test 3-62 would allow for crashworthy evaluation of square tube posts and sign panel areas larger than the 3-inch x 3-inch post and 4 ft x 5 ft sign area. Until such testing can be performed, an alternative approach was considered that used the engineering analysis program described in Chapter 2 to evaluate alternative sign support configurations. This engineering analysis program allows for prediction of secondary contact between the sign support system and vehicle. While not a substitute for full-scale crash testing, this program can provide useful analysis of square tube sign support systems and their crashworthy performance.

10.1. ENGINEERING ANALYSIS VALIDATION

Prior to evaluating additional configurations, updates were made to the engineering analysis program described in Chapter 2 to improve its predictive capabilities for secondary

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

contact with the vehicle. The results from the three full-scale crash tests were used for comparison with the engineering analysis program outputs described in Chapter 2. To improve the performance of the analysis program three updates were made:

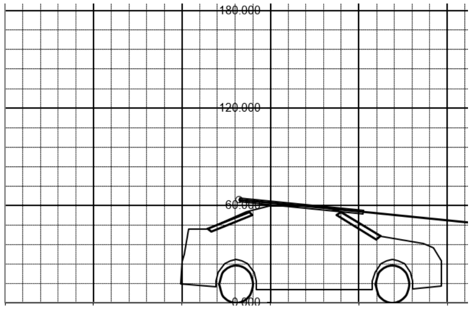
1. Decreased slip base activation force from 38,000 lbs to 30,000 lbs.
2. Reduced coefficient of restitution from 0.25 to 0.2.
3. Increased bumper impact height for the pickup truck vehicle from 26 inches to 40 inches.

As shown in Figure 7.2, the initial contact point between the bumper and the post was approximately 26 inches above the ground. The remainder of the pickup truck's front profile extended vertically above this point with a small offset from the post. Following initial contact between the truck and the post, the post rotated slightly and engaged the upper portion of the vehicle's front profile near the hood (Figure 10.1). This interaction was believed to affect the trajectory of the sign support system. The increase in bumper impact height in the analysis program was intended to capture this observed behavior.

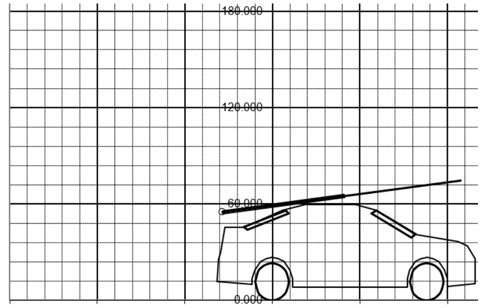
Figure 10.1. Engagement of Pickup Truck Hood with Post.

After making the updates, new outputs from the engineering analysis program were generated. These new outputs were the predicted secondary contact locations of the sign support system with the vehicle, if applicable.

Figure 10.2 shows the original analysis secondary contact prediction, the updated analysis secondary contact prediction, and the full-scale crash test secondary contact locations. After updating a few of the analysis program parameters, the predicted secondary contact location closely matched the full-scale crash test results.

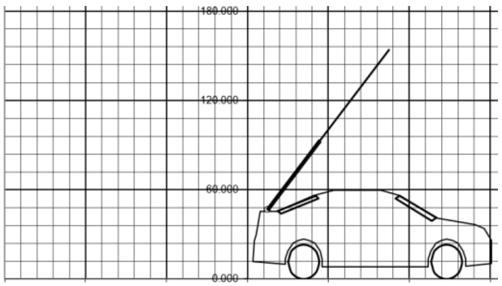


(a) *MASH* Test 3-60 – Original Analysis

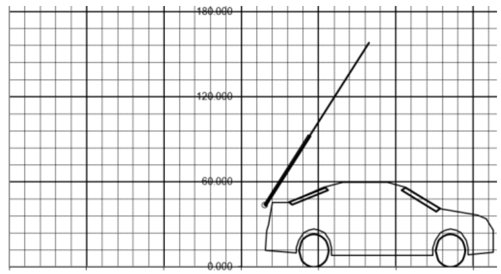


(b) *MASH* Test 3-60 – Updated Analysis

(c) *MASH* Test 3-60 – Full-Scale Crash Test

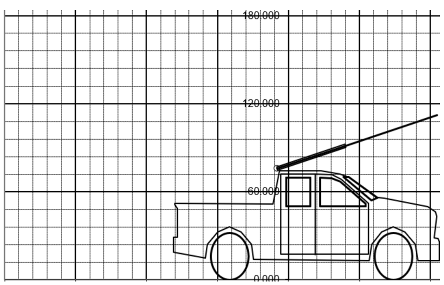


(d) *MASH* Test 3-61 – Original Analysis

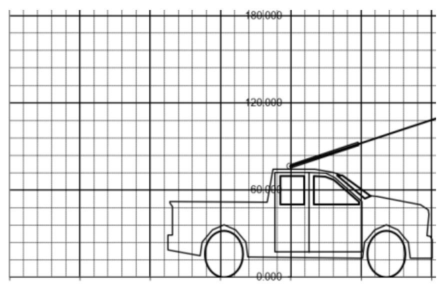


(e) *MASH* Test 3-61 – Updated Analysis

(f) *MASH* Test 3-61 – Full-Scale Crash Test



(g) *MASH* Test 3-62 – Original Analysis



(h) *MASH* Test 3-62 – Updated Analysis

(i) *MASH* Test 3-62 – Full-Scale Crash Test

Figure 10.2. Comparison of Engineering Analysis Results with Full-Scale Crash Tests.

10.2. ADDITIONAL SIGN SUPPORT CONFIGURATIONS EVALUATION

An engineering analysis program was used to evaluate the crashworthy performance of additional sign support configurations. This analysis included the updated parameters described in the previous section which demonstrated good agreement with the secondary contact outcomes observed in the full-scale crash tests (Figure 10.2). Full-scale crash testing is recommended to confirm the results and recommendations presented in this section.

The first sign support system analyzed was the 8-inch x 8-inch square tube post with a 15 ft x 7 ft sign panel area tested and evaluated according to *MASH* Test 3-60 (see Chapter 9). This system was analyzed with the engineering analysis program for *MASH* Test 3-61 and *MASH* Test 3-62 impact conditions. Figure 10.3 and Figure 10.4 show the output from the engineering analysis program for *MASH* Tests 3-61 and 3-62. No secondary contact was predicted and the sign support system rotated over the vehicle. Thus, this system indicated satisfactory performance for *MASH* TL-3 based on the engineering analysis program results.

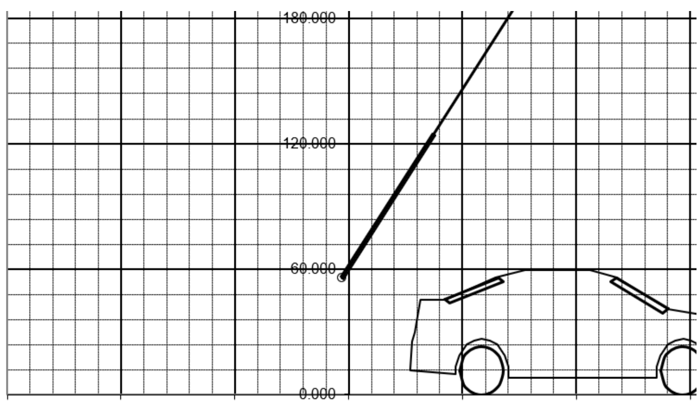


Figure 10.3. *MASH* Test 3-61 Predicted Sign Support System Rotation over Vehicle.

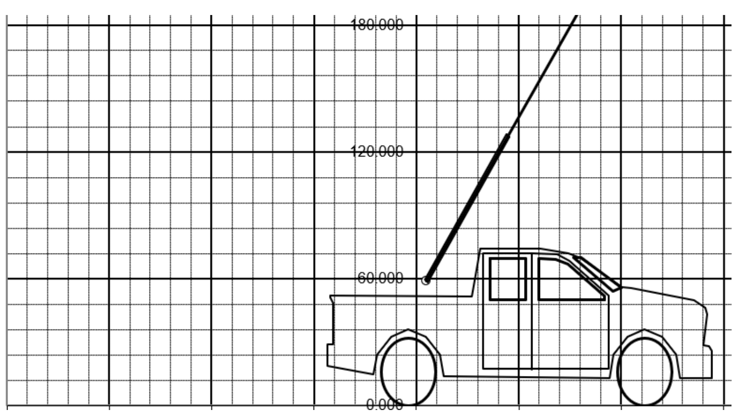


Figure 10.4. *MASH* Test 3-62 Predicted Sign Support System Rotation over Vehicle.

Analysis of additional sign support systems was performed to identify other systems that may indicate satisfactory crashworthy performance. As the full-scale crash tests indicated satisfactory performance for the critical worst-case sign support configurations for *MASH* Tests 3-60 and 3-61, the engineering analysis program was only used to evaluate additional sign support systems for *MASH* Test 3-62 crashworthy performance. Any systems identified that perform acceptably for *MASH* Test 3-62 would be expected to perform acceptably for *MASH* Tests 3-60 and 3-61. In addition to evaluating crashworthy performance, structural loading of the sign support systems due to wind loading was also considered. Systems that indicate satisfactory crashworthy performance may produce wind load demands that exceed structural capacity; therefore, such systems would not be recommended for use.

The first series of analyses evaluated sign panel configurations areas with a minimum 10 ft width, for which the H-Brace assembly would be required. A second series of analyses evaluated sign panel configurations with a maximum width of 9 ft, for which the H-Brace assembly would not be required. The inclusion or omission of the H-Brace assembly affects the overall center of gravity of the system.

Table 10.1 summarizes the sign support systems that were predicted to prevent secondary contact with the pickup truck vehicle by rotating over the vehicle. These systems utilized an H-Brace assembly due to their sign panel width of 10 ft or greater. The information in the table is presented as a function of square tube post size, sign panel height, and the minimum sign panel width required to avoid secondary contact. The minimum sign panel widths were applicable for sign panel heights of 6 ft and 7 ft. Sign panel heights less than 6 ft resulted in secondary contact with the pickup truck vehicle. Sign panel heights greater than or equal to 8 ft will be acceptable with a minimum width of 10 ft. However, as the sign panel areas increase, wind loading demands also increase and may require the use of larger square tube posts. The 3-inch × 3-inch and 4-inch × 4-inch square tube posts did not provide any sign panel configurations that both demonstrated satisfactory crashworthy performance and satisfied wind loading requirements.

Table 10.2 summarizes other sign support systems that were predicted to prevent secondary contact with the pickup truck by rotating over the vehicle. These systems did not utilize an H-Brace assembly as they had sign panel widths less than 10 ft. The information in the table is presented as a function of square tube post size, sign panel height, and the minimum sign panel width required to avoid secondary contact. The minimum sign panel widths were applicable for sign panel heights of 7 ft, 8 ft, and 9 ft. Sign panel configurations with heights less than 6 ft resulted in secondary contact with the vehicle or total areas that would result in wind loads exceeding post structural capacity.

Table 10.1. Minimum Sign Panel Assembly Width with H-Brace Assembly.

Post Size	Sign Panel Height	
	6 ft	**7 ft**
5-in. x 5-in.	10 ft	10 ft
6-in. x 6-in.	12 ft	10 ft
7-in. x 7-in.	13 ft	10 ft
8-in. x 8-in.	14 ft	10 ft

Table 10.2. Minimum Sign Panel Assembly Width without H-Brace Assembly.

Post Size	Sign Panel Height		
	7 ft	**8 ft**	**9 ft**
3-in. x 3-in.	—	3 ft	3 ft
4-in. x 4-in.	—	3 ft	3 ft
5-in. x 5-in.	6 ft	3 ft	3 ft
6-in. x 6-in.	7 ft	4 ft	3 ft
7-in. x 7-in.	9 ft	5 ft	3 ft
8-in. x 8-in.	--	6 ft	3 ft

— = Post structural capacity not sufficient for wind loads.
-- = No configuration less than 10 ft indicated satisfactory crashworthy performance.

These results are presented based on the predicted performance of the sign support systems utilizing an engineering analysis program. Full-scale crash testing is recommended to confirm the results of the engineering analysis program. The crash test presented in Chapter 7 evaluated a 3-inch x 3-inch post with a 4 ft x 5 ft sign panel and no H-Brace assembly. The sign substrate used in the full-scale crash testing was thin aluminum sheeting. A recommended alternative for full-scale crash testing to confirm the results presented in this section would be a 5-inch x 5-inch post with a 6 ft x 7 ft sign panel. The sign panel would be without an H-Brace assembly and would be comprised of extruded aluminum panels.

The engineering analysis results and recommendations presented in this section are based on some components specific to Oregon DOT (e.g., H-Brace assembly). Other DOTs may use modified sign panel attachment components based on the square tube size and sign panel size. The key sign support system parameter that indicated satisfactory performance in the engineering analysis program for *MASH* Test 3-62 was the sign support system center of gravity. Systems presented in Table 10.1 and Table 10.2 all had a center of gravity of 104 inches (measured from groundline) or greater. Thus, other sign support systems that are similar in key features (e.g., post type, sign panel type, breakaway system type, etc.) and have a center of gravity of 104 inches or greater would be expected to perform similarly. The addition of weight near the top of the sign support system could be used as an alternative means of raising the center of gravity to the minimum required height of 104 inches, in lieu of increasing the sign panel height.

CHAPTER 11.

SUMMARY AND CONCLUSIONS

The crash tests reported herein were performed in accordance with *MASH* TL-3, which involves three tests on the Square Tube Slip Base Sign Support System. *MASH* Test 3-60 was performed on a Square Tube Slip Base Sign Support System with an 8-inch x 8-inch post and 15 ft x 7 ft sign panel. *MASH* Tests 3-61 and 3-62 were performed on a Square Tube Slip Base Sign Support System with a 3-inch x 3-inch post and 4 ft x 5 ft sign panel.

Table 11.1 shows that the Square Tube Slip Base Sign Support System failed to meet the performance criteria for *MASH* TL-3 Support Structures. Specifically, the 3x3 square tube slip base sign support system failed to meet the performance criteria for *MASH* Test 3-62. The upper portion of the sign support contacted the roof of the pickup truck, resulting in a tear in the roof panel. The damage was determined to constitute penetration of the occupant compartment and therefore resulted in failure of *MASH* Criterion D.

Table 11.1. Assessment Summary for *MASH* TL-3 Tests on Square Tube Slip Base Sign Support System.

Evaluation Criteria	**Description**[1]	**Test 621201-01-1** (*MASH* Test 3-61)	**Test 621201-01-2** (*MASH* Test 3-62)	**Test 621201-01-3** (*MASH* Test 3-60)
B	Test Article Broke Away, Fractured, Yielded	S	S	S
D	Occupant Compartment Penetration and Deformation Limits	S	FAIL	S
F	Roll and Pitch Limit	S	S	S
H	OIV Threshold	S	S	S
I	Ridedown Threshold	S	S	S
N	Vehicle Trajectory Behind Test Article Acceptable	S	S	S
Overall Evaluation		Pass	Fail	Pass

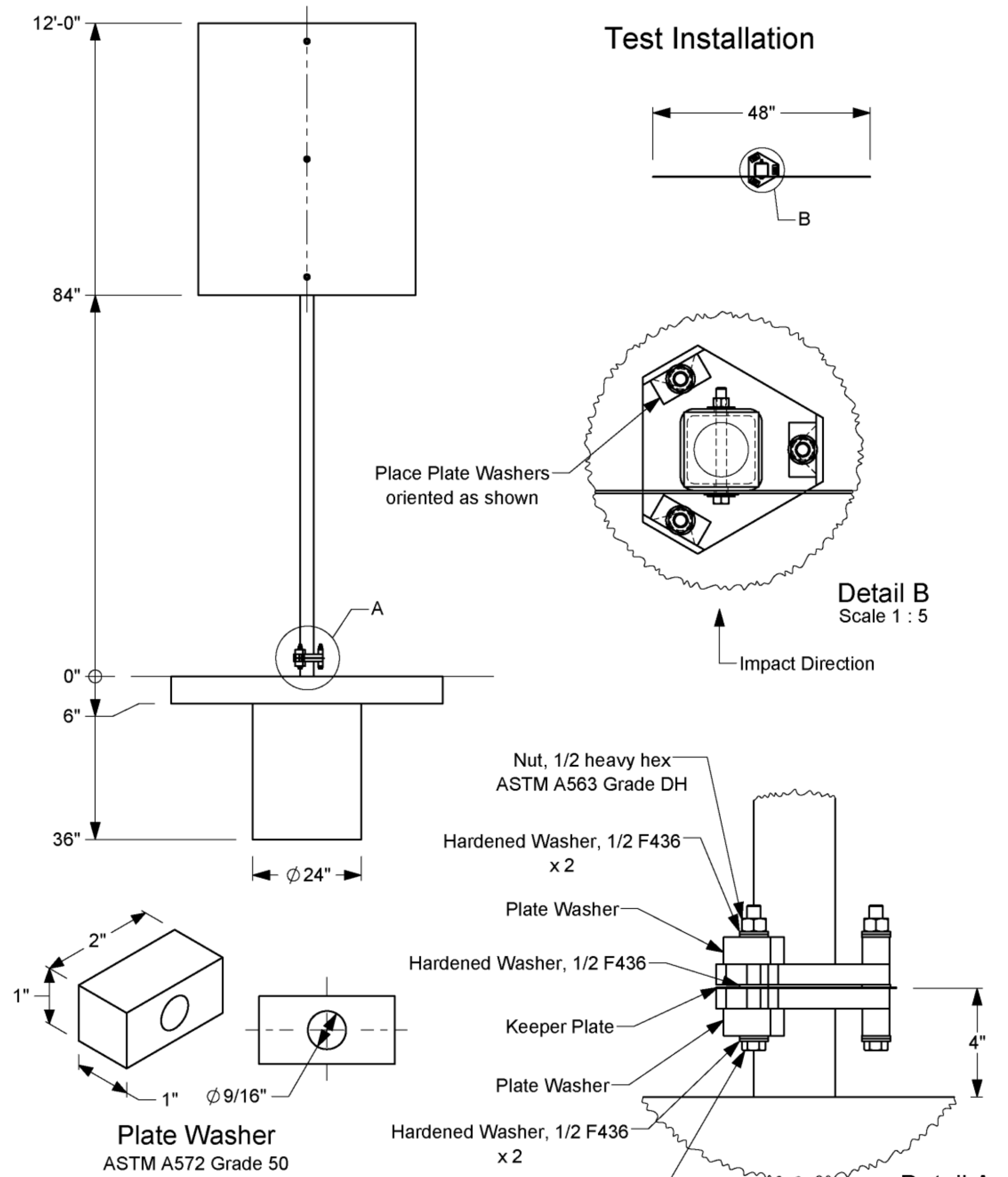
Note: S = Satisfactory; N/A = Not Applicable.
[1] See Table 3.2 for details

REFERENCES

1. Ross, H.E., Sicking, D.L., Zimmer, R.A., and Michie, J.D. *Recommended Procedures for the Safety Performance Evaluation of High Features.* National Cooperative Highway Research Program Report 350, Transportation Research Board, National Research Council, Washington, DC, 1993.
2. AASHTO. *Manual for Assessing Safety Hardware*, Second Edition. American Association of State Highway and Transportation Officials, Washington, DC, 2016.
3. Ghanoudi, M.K., and Brown, C.M. *Testing of a Modified Oregon Multidirectional Slip-Base Sign Support, Foil Test Numbers: 95F007 and 95F009.* Report No. FHWA-RD-97-048. MiTech Incorporated, Rockville, MD, 1997.
4. Brown, C.M. *Safety Performance Testing of a Modified Oregon Multidirectional Slip-Base Sign Support: Foil Test Numbers 98F002 and 98F004.* Report No. FHWA-RD-98-111. MiTech Incorporated, Rockville, MD, 1998.
5. Ross, H.E., Perera, H.S., Sicking, D.L., and Bligh, R.P. *Roadside Safety Design for Small Vehicles.* National Cooperative Highway Research Program (NCHRP) Report No. 318. Washington, DC, 1989.

APPENDIX A.

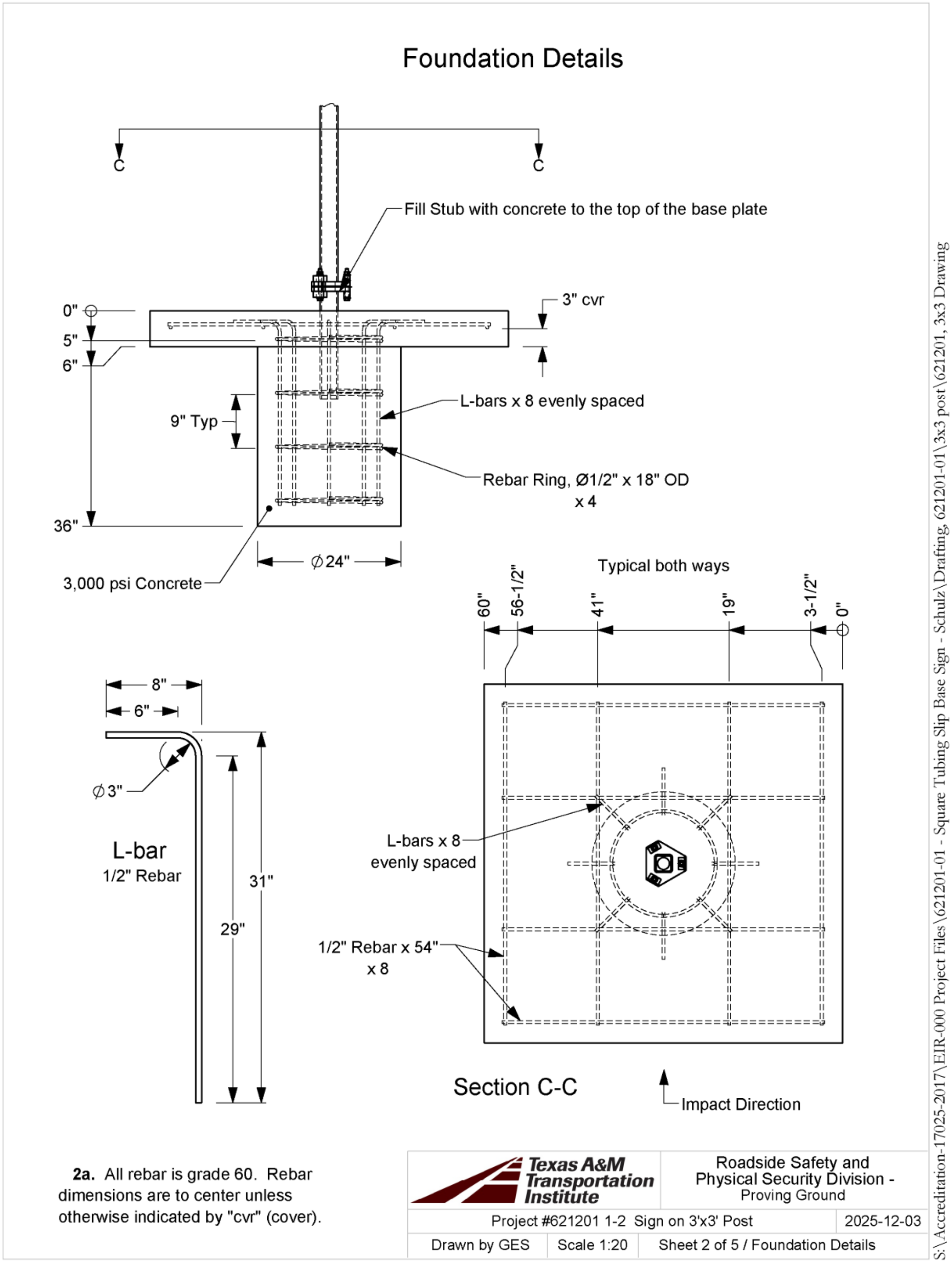
DETAILS OF THE 3 × 3 SQUARE TUBE SLIP BASE SIGN SUPPORT SYSTEM



1a. All steel components, including fasteners, shall be hot-dipped galvanized after fabrication unless otherwise indicated.
1b. Components not detailed here are detailed on following sheets.
1c. Tighten bolts in a systematic order to 50 ft/lbs. Loosen and re-tighten bolts to 30 ft/lbs using the same order as the initial tightening.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #621201 1-2 Sign on 3'x3' Post		2025-12-03
Drawn by GES	Scale 1:30	Sheet 1 of 5 / Test Installation

S:\Accreditation-17025-2017\EIR-000 Project Files\621201-01 - Square Tubing Slip Base Sign - Schulz\Drafting, 621201-01\3x3 post\621201, 3x3 Drawing


Foundation Details
C
C
Fill Stub with concrete to the top of the base plate
0"
5"
6"
3" cvr
9" Typ
L-bars x 8 evenly spaced
Rebar Ring, Ø1/2" x 18" OD
x 4
36"
3,000 psi Concrete
Ø24"
Typical both ways
60"
56-1/2"
41"
19"
3-1/2"
0"
8"
6"
Ø3"
L-bar
1/2" Rebar
31"
29"
L-bars x 8
evenly spaced
1/2" Rebar x 54"
x 8
Section C-C
Impact Direction
2a. All rebar is grade 60. Rebar dimensions are to center unless otherwise indicated by "cvr" (cover).
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #621201 1-2 Sign on 3'x3' Post
2025-12-03
Drawn by GES
Scale 1:20
Sheet 2 of 5 / Foundation Details
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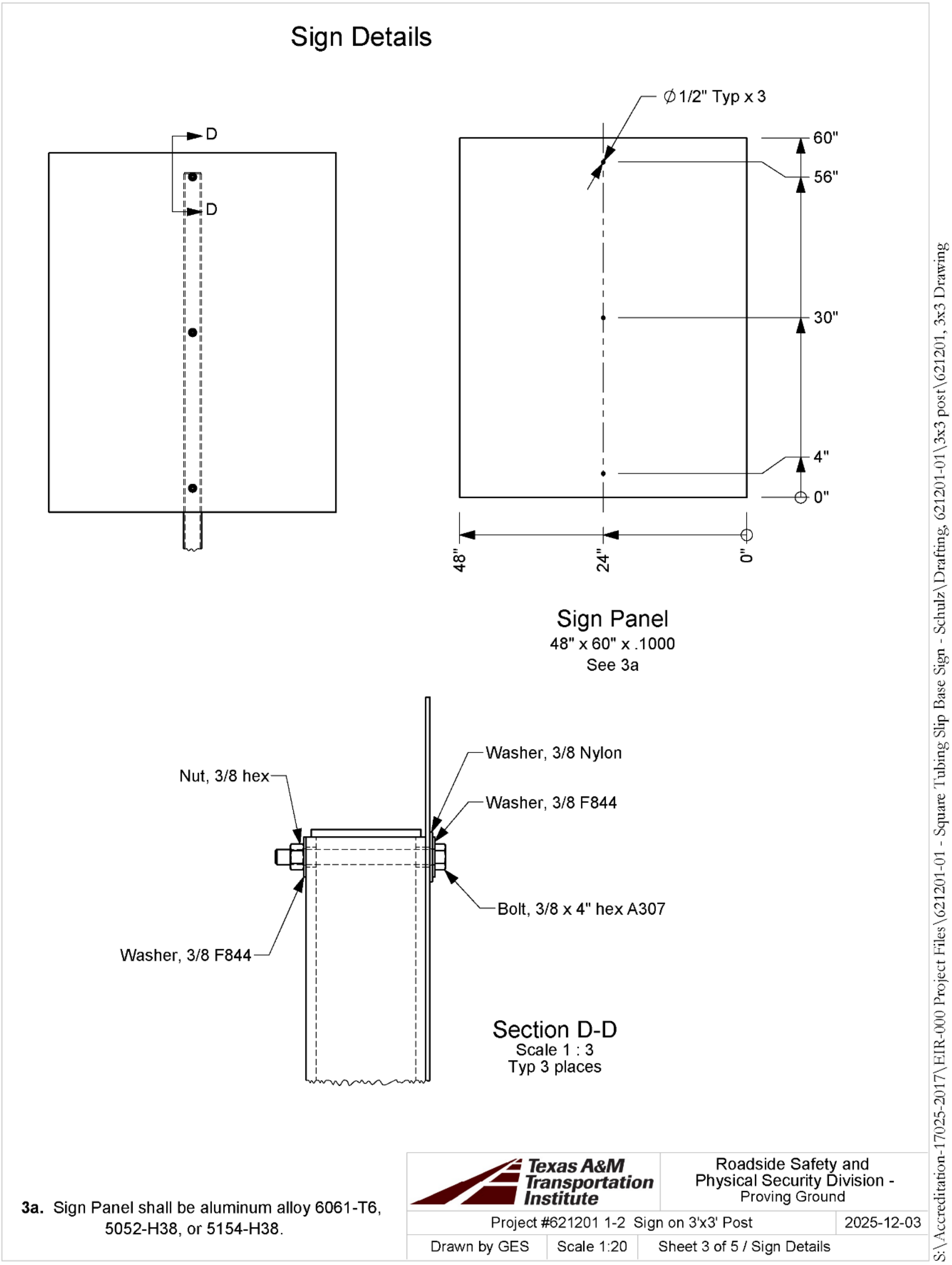

Sign Details
D
D
∅ 1/2" Typ x 3
60"
56"
30"
4"
0"
48"
24"
0"
Sign Panel
48" x 60" x .1000
See 3a
Washer, 3/8 Nylon
Nut, 3/8 hex
Washer, 3/8 F844
Bolt, 3/8 x 4" hex A307
Washer, 3/8 F844
Section D-D
Scale 1 : 3
Typ 3 places
3a. Sign Panel shall be aluminum alloy 6061-T6, 5052-H38, or 5154-H38.
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #621201 1-2 Sign on 3'x3' Post
2025-12-03
Drawn by GES
Scale 1:20
Sheet 3 of 5 / Sign Details
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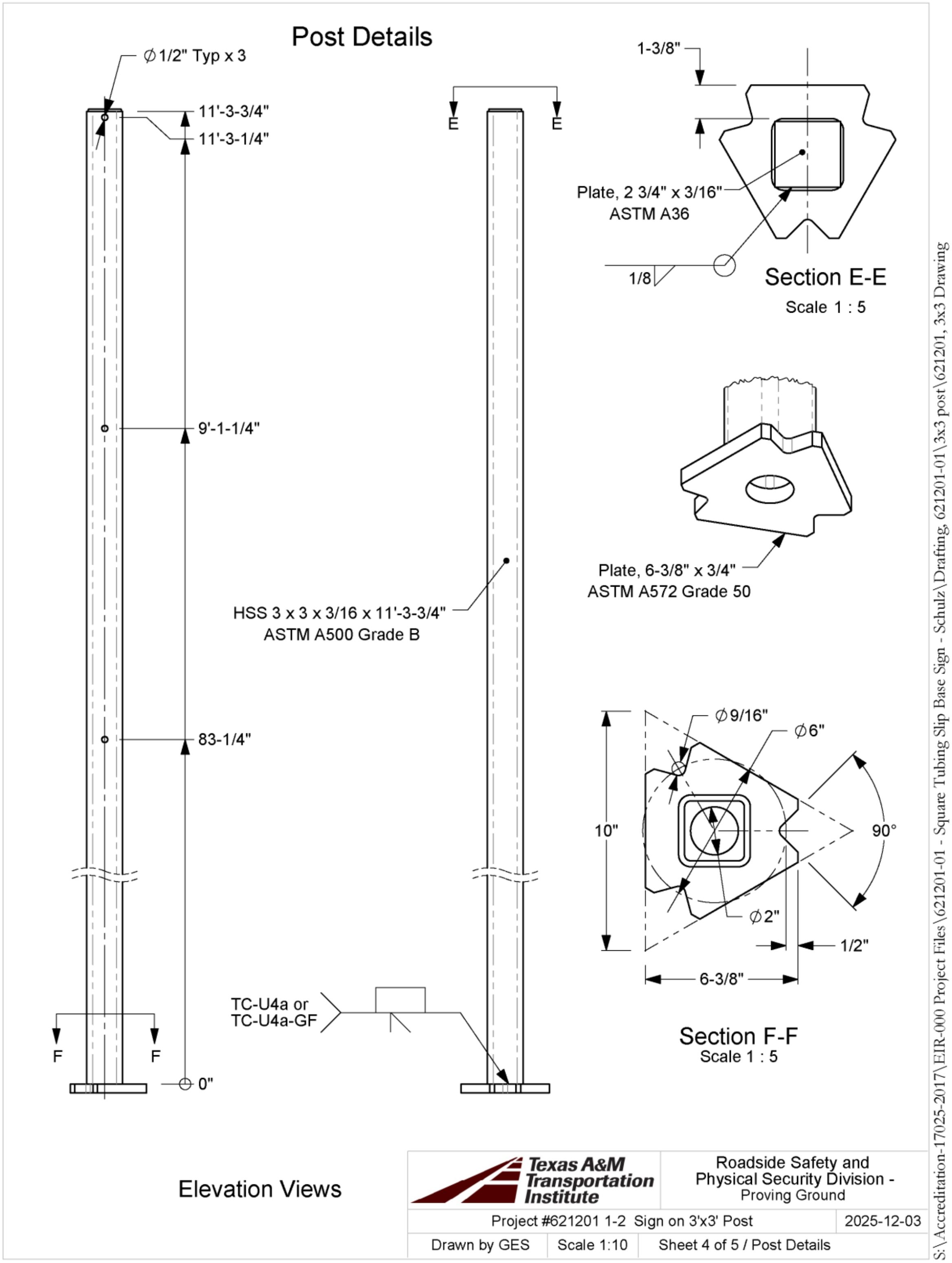
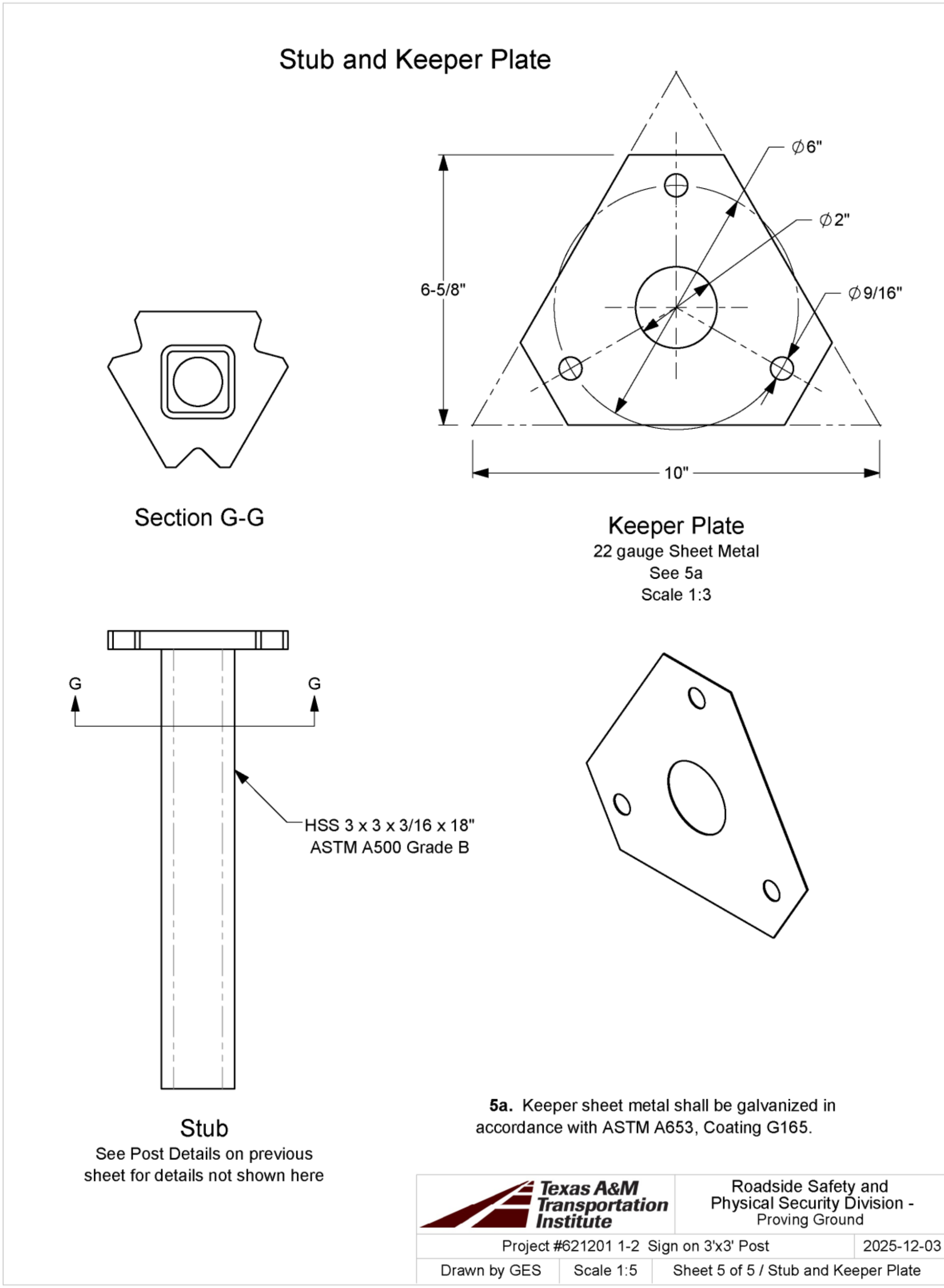

Post Details
∅1/2" Typ x 3
11'-3-3/4"
11'-3-1/4"
9'-1-1/4"
83-1/4"
0"
F
F
E
E
HSS 3 x 3 x 3/16 x 11'-3-3/4"
ASTM A500 Grade B
TC-U4a or
TC-U4a-GF
1-3/8"
Plate, 2 3/4" x 3/16"
ASTM A36
1/8
Section E-E
Scale 1 : 5
Plate, 6-3/8" x 3/4"
ASTM A572 Grade 50
∅9/16"
∅6"
10"
90°
∅2"
1/2"
6-3/8"
Section F-F
Scale 1 : 5
Elevation Views
Texas A&M Transportation Institute
Roadside Safety and
Physical Security Division -
Proving Ground
Project #621201 1-2 Sign on 3'x3' Post
2025-12-03
Drawn by GES
Scale 1:10
Sheet 4 of 5 / Post Details
S:\Accreditation-17025-2017\EIR-000 Project Files\621201-01 - Square Tubing Slip Base Sign - Schulz\Drafting, 621201-01\3x3 post\621201, 3x3 Drawing



S:\Accreditation-17025-2017\EIR-000 Project Files\621201-01 - Square Tubing Slip Base Sign - Schulz\Drafting, 621201-01\3x3 post\621201, 3x3 Drawing

APPENDIX B.

MASH TEST 3-61 (CRASH TEST 621201-01-1)

B.1. VEHICLE PROPERTIES AND INFORMATION

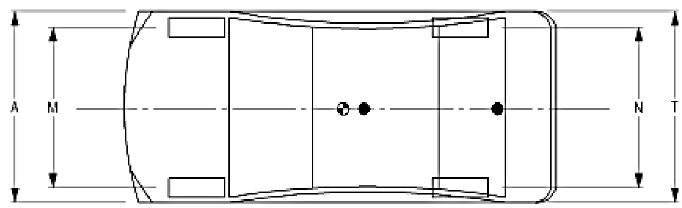
Date: 2026-03-09 | Test No.: 621201-01-1 | VIN No.: 3N1CN8DV4LL881508

Year: 2020 | Make: Nissan | Model: Versa

Tire Inflation Pressure: 36 PSI | Odometer: 88,263 | Tire Size: P185/65R15

Describe any damage to the vehicle prior to test: None

● Denotes accelerometer location.

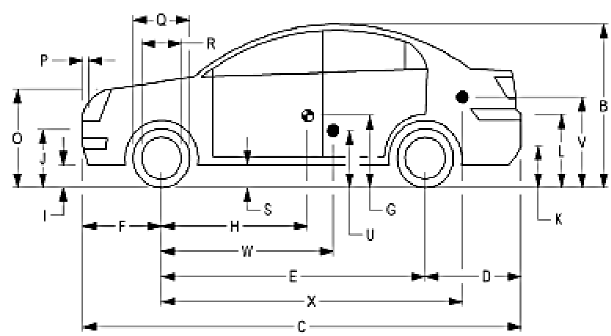


NOTES: None

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:

Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G		L	26.00	Q	24.00	V	21.25
C	175.40	H	38.50	M	58.30	R	16.25	W	
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 -38.50

RANGE LIMIT: A = 67 ±3 inches; C = 171 ±8 inches; E = 100 ±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}	1584	1577	
Back	1687	M_{rear}	1014	943	
Total	3389	M_{Total}	2598	2520	0

Allowable TIM = 2420 lb -55 lb / +120 lb | Allowable GSM = 2585 lb -55 lb / +120 lb

Mass Distribution:
lb LF: 846 RF: 731 LR: 457 RR: 486

Figure B.1. Vehicle Properties for Test 621201-01-1.

Date:	2026-03-09	Test No.:	621201-01-1	VIN No.:	3N1CN8DV4LL881508
Year:	2020	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	AFB	-18	-3	-67							-15
2	ABOVE HOOD	-9.5	-2								-17
	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.

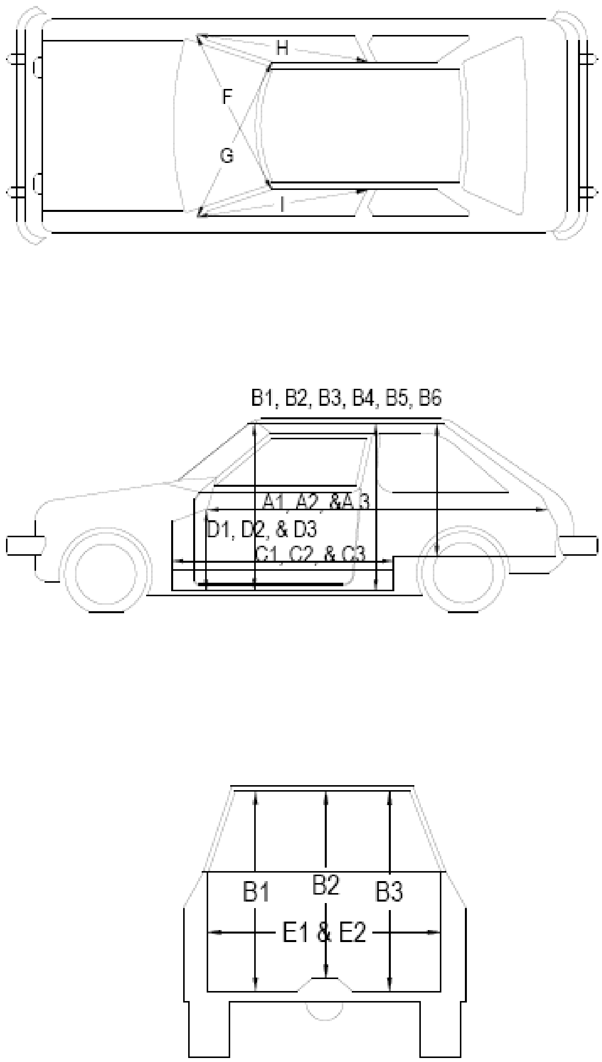
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

***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 B.2. Exterior Crush Measurements for Test 621201-01-1.

Date:	2026-03-09	Test No.:	621201-01-1	VIN No.:	3N1CN8DV4LL881508
Year:	2020	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 B.3. Occupant Compartment Measurements for Test 621201-01-1.

B.2. SEQUENTIAL PHOTOGRAPHS

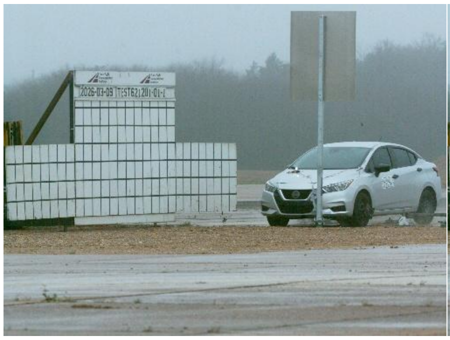
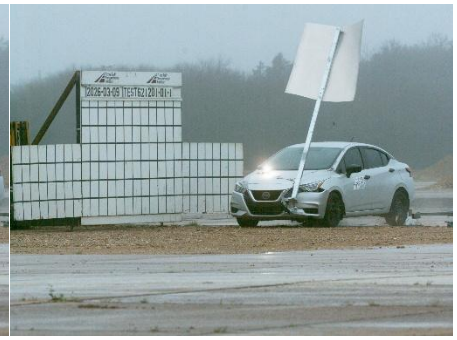

(a) 0.000 s (b) 0.0500 s


(c) 0.1000 s (d) 0.1500 s


(e) 0.2000 s (f) 0.2500 s

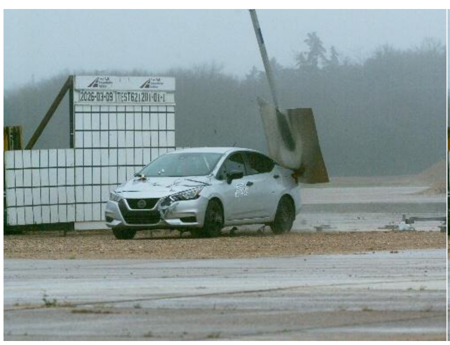
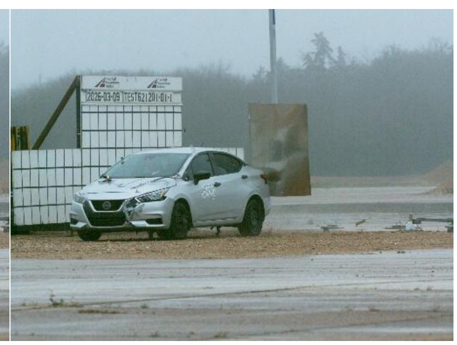

(g) 0.3000 s (h) 0.3500 s

Figure B.4. Sequential Photographs for Test 621201-01-1 (Right Angle Views).

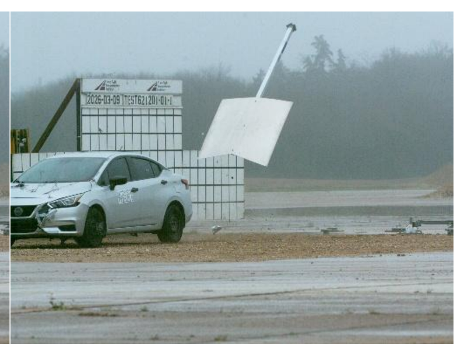



(a) 0.000 s (b) 0.0500 s


(c) 0.1000 s (d) 0.1500 s

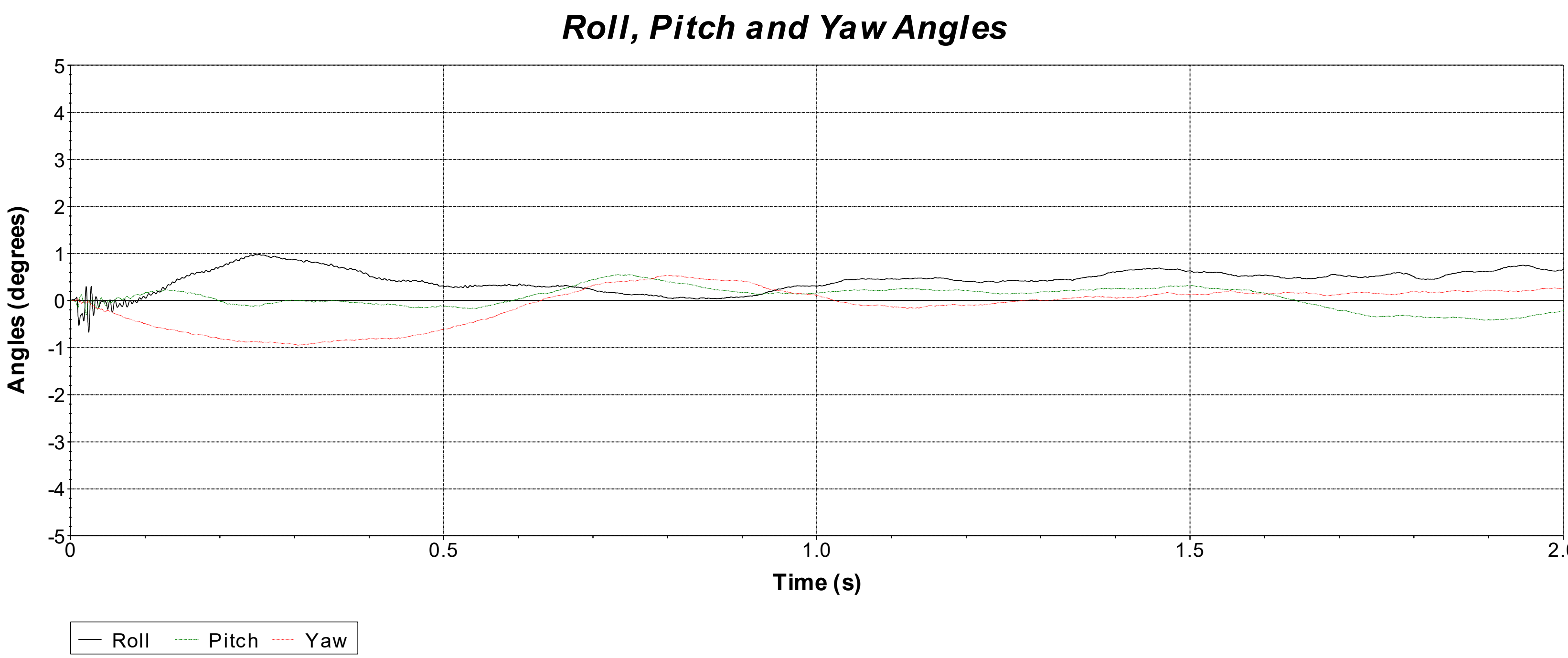
(e) 0.2000 s (f) 0.2500 s

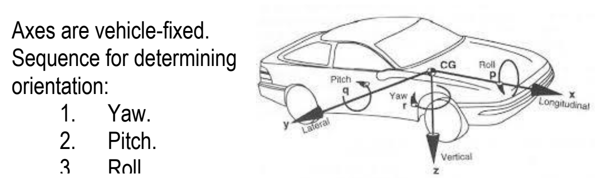



(g) 0.3000 s (h) 0.3500 s

Figure B.5. Sequential Photographs for Test 621201-01-1 (Downstream Oblique Views).

B.3. VEHICLE ANGULAR DISPLACEMENTS





Test Number: 621201-01-1
Test Standard Test Number: *MASH* Test 3-61
Test Article: 3 × 3 Square Tube Slip Base Sign Support System
Test Vehicle: 2020 Nissan Versa
Inertial Mass: 2520 lbs
Gross Mass: 2685 lbs
Impact Speed: 61.98 mi/h
Impact Angle: 0.0°

Figure B.6. Vehicle Angular Displacements for Test 621201-01-1.

B.4. VEHICLE ACCELERATIONS

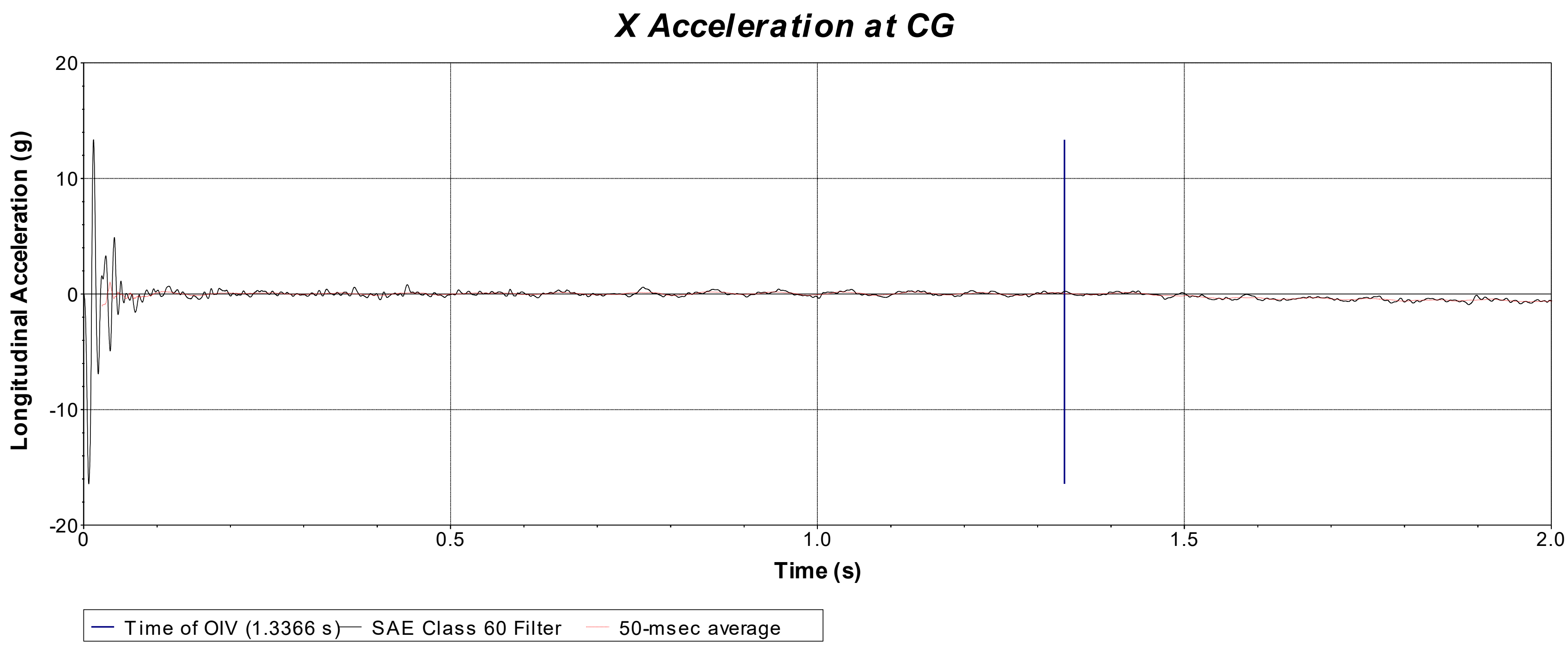


Figure B.7. Vehicle Longitudinal Accelerometer Trace for Test 621201-01-1 (Accelerometer Located at Center of Gravity).

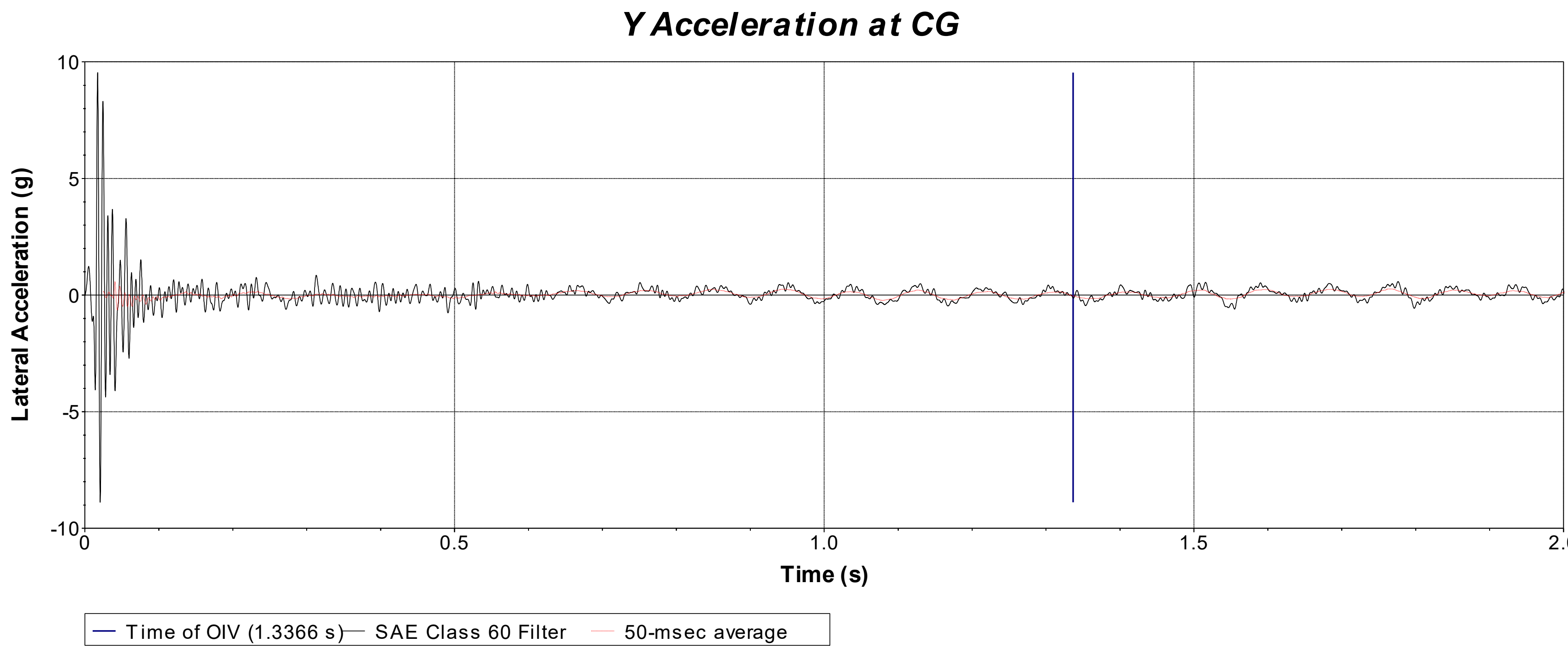


Figure B.8. Vehicle Lateral Accelerometer Trace for Test 621201-01-1 (Accelerometer Located at Center of Gravity).

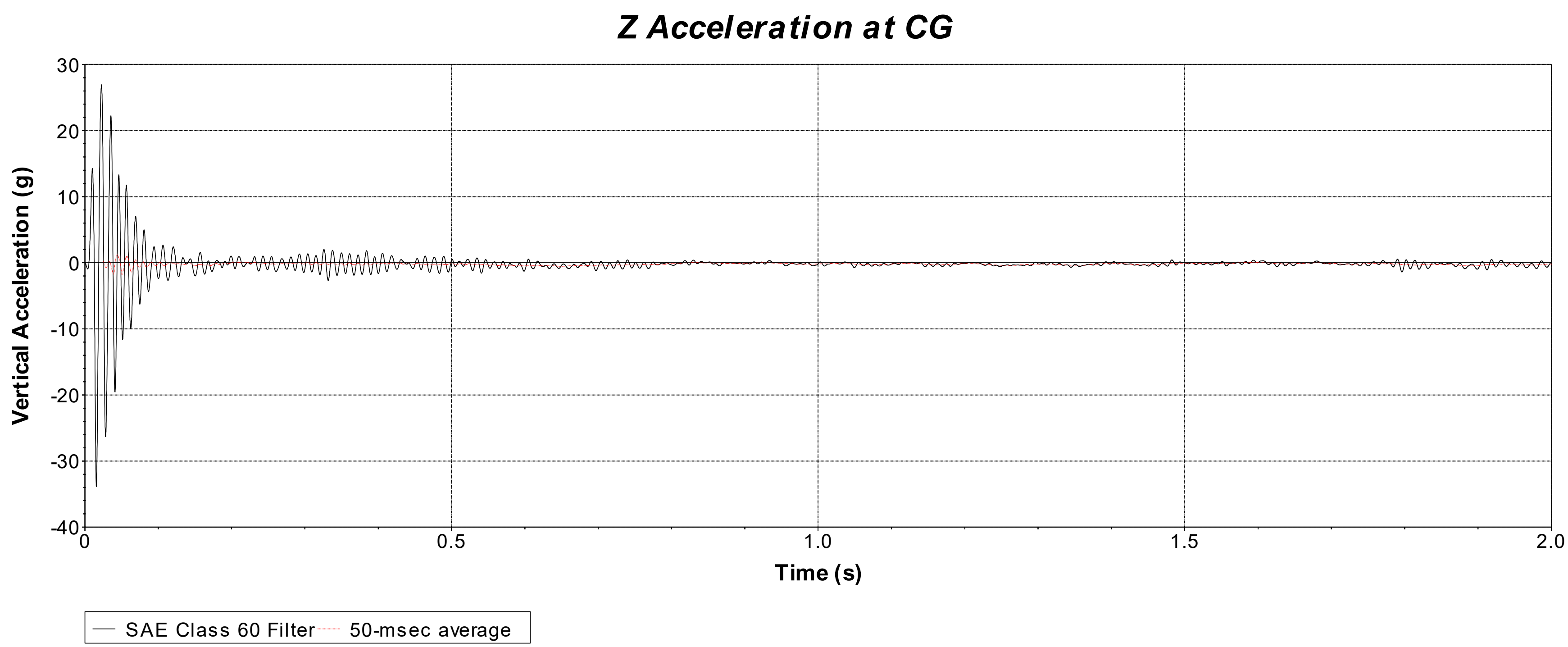


Figure B.9. Vehicle Vertical Accelerometer Trace for Test 621201-01-1 (Accelerometer Located at Center of Gravity).

APPENDIX C.

MASH TEST 3-62 (CRASH TEST 621201-01-2)

C.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2026-03-09 Test No.: 621201-01-2 VIN No.: 1C6RR6FT9MS517798

Year: 2021 Make: RAM Model: 1500

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

Tread Type: Highway Odometer: 87,432

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

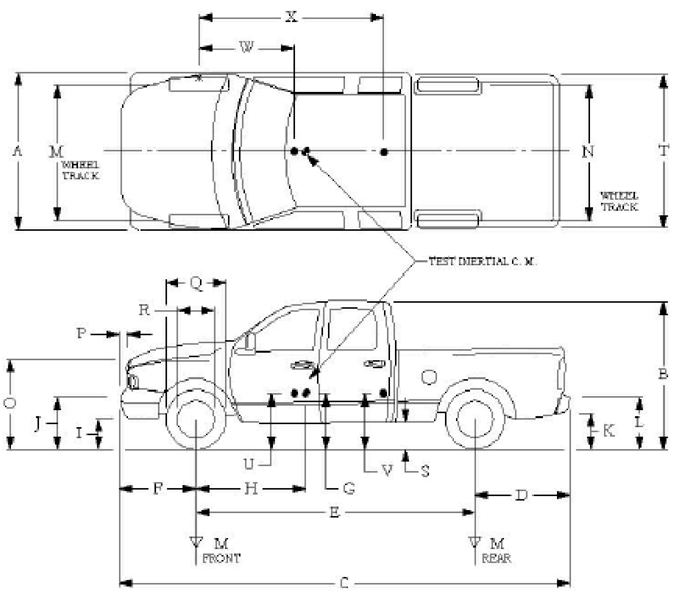
NOTES: None

Engine Type: V-8
Engine CID: 5.7 liter

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

Optional Equipment:
None

Dummy Data:
Type: 50th Percentile Male
Mass: 165 lb
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	61.60	M	68.50	R	18.00	W	0.00
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=81 ±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=68 ±1.5 inches

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	3700	M_{front}	2923	2836	
Back	3900	M_{rear}	2051	2217	
Total	6700	M_{Total}	4974	5053	5218

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

Mass Distribution:
lb LF: 1419 RF: 1417 LR: 1132 RR: 1085

Figure C.1. Vehicle Properties for Test 621201-01-2.

Date:	2026-03-09	Test No.:	621201-01-2	VIN No.:	1C6RR6FT9MS517798
Year:	2021	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 ________	
$\geq$ 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	AFB	-44	-7.5	78.75							-12.75
2	ABOVE BUMPER	-19	-3.25								-12.75
	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.

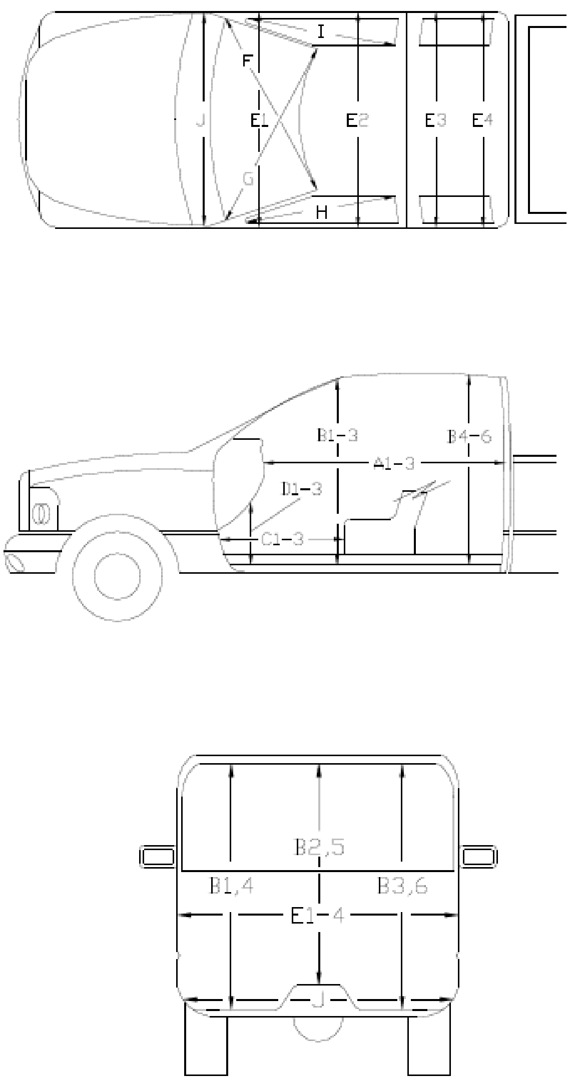
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

***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 621201-01-2.

Date:	2026-03-09	Test No.:	621201-01-2	VIN No.:	1C6RR6FT9MS517798
Year:	2021	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	37.00	-2.50
B5	43.00	39.75	-3.25
B6	39.50	38.50	-1.00
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 C.3. Occupant Compartment Measurements for Test 621201-01-2.

C.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.0500 s

(c) 0.1000 s (d) 0.1500 s

(e) 0.2000 s (f) 0.2500 s

(g) 0.3000 s (h) 0.3500 s

Figure C.4. Sequential Photographs for Test 621201-01-2 (Right Angle Views).


(a) 0.000 s (b) 0.0500 s

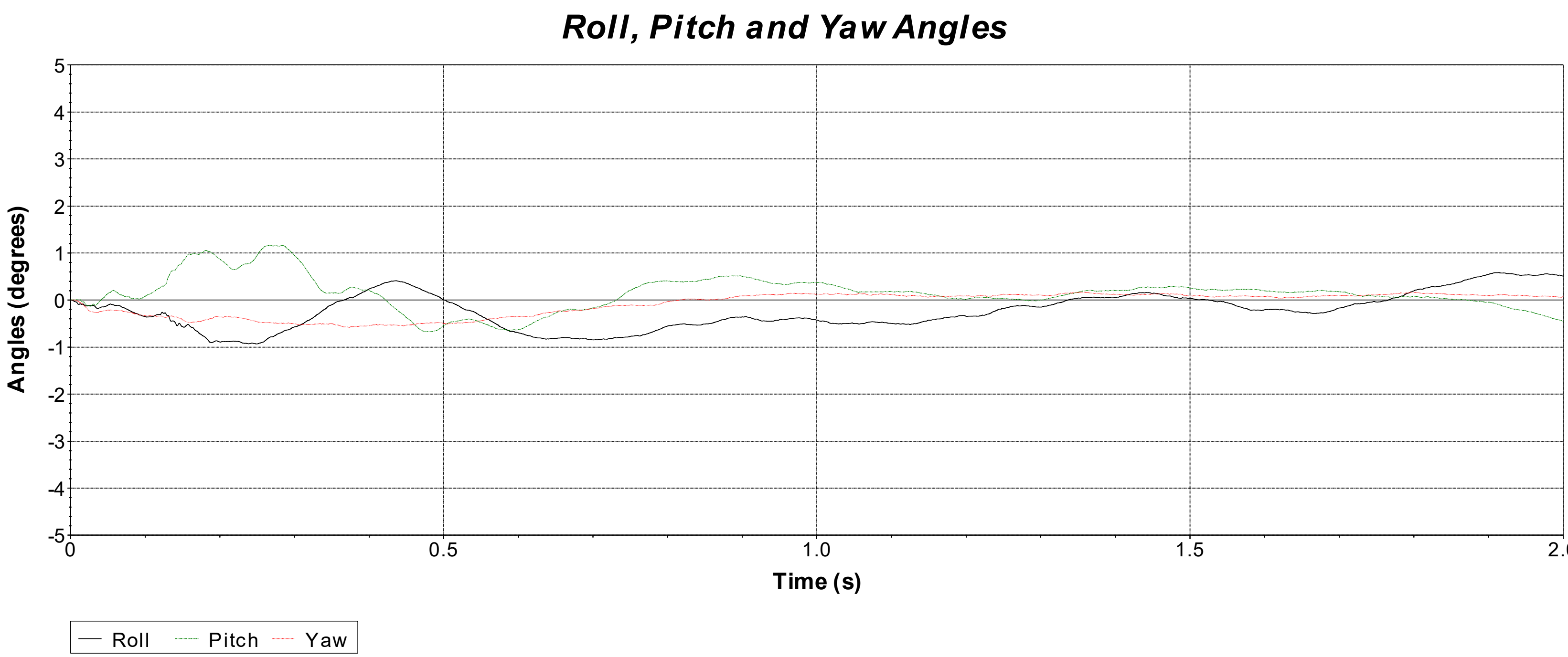

(c) 0.1000 s (d) 0.1500 s


(e) 0.2000 s (f) 0.2500 s


(g) 0.3000 s (h) 0.3500 s

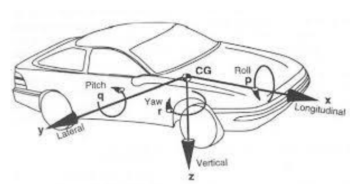
Figure C.5. Sequential Photographs for Test 621201-01-2 (Downstream Oblique Views).

C.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

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



Test Number: 621201-01-2
Test Standard Test Number: *MASH* Test 3-62
Test Article: 3 × 3 Square Tube Slip Base Sign Support System
Test Vehicle: 2021 RAM 1500
Inertial Mass: 5053 lbs
Gross Mass: 5053 lbs
Impact Speed: 61.72 mi/h
Impact Angle: 0.0°

Figure C.6. Vehicle Angular Displacements for Test 621201-01-2.

C.4. VEHICLE ACCELERATIONS

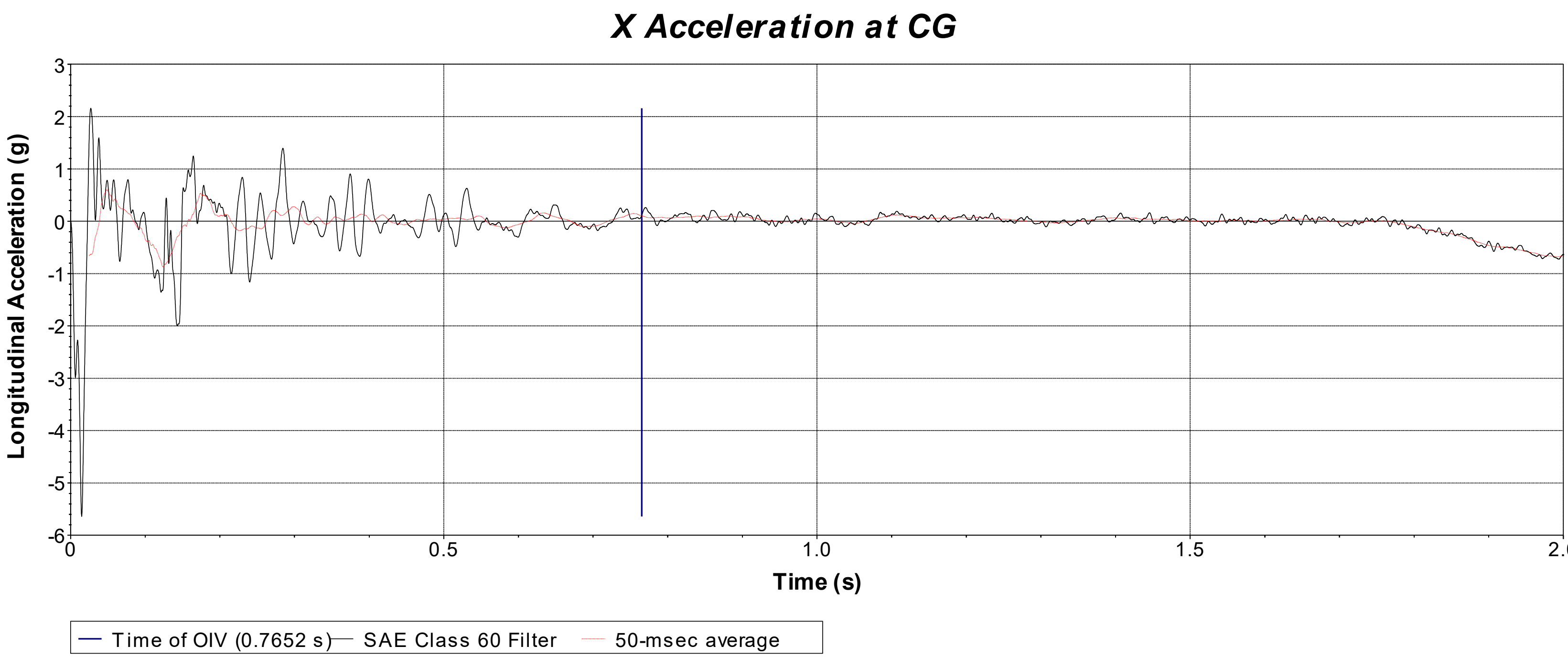


Figure C.7. Vehicle Longitudinal Accelerometer Trace for Test 621201-01-2 (Accelerometer Located at Center of Gravity).

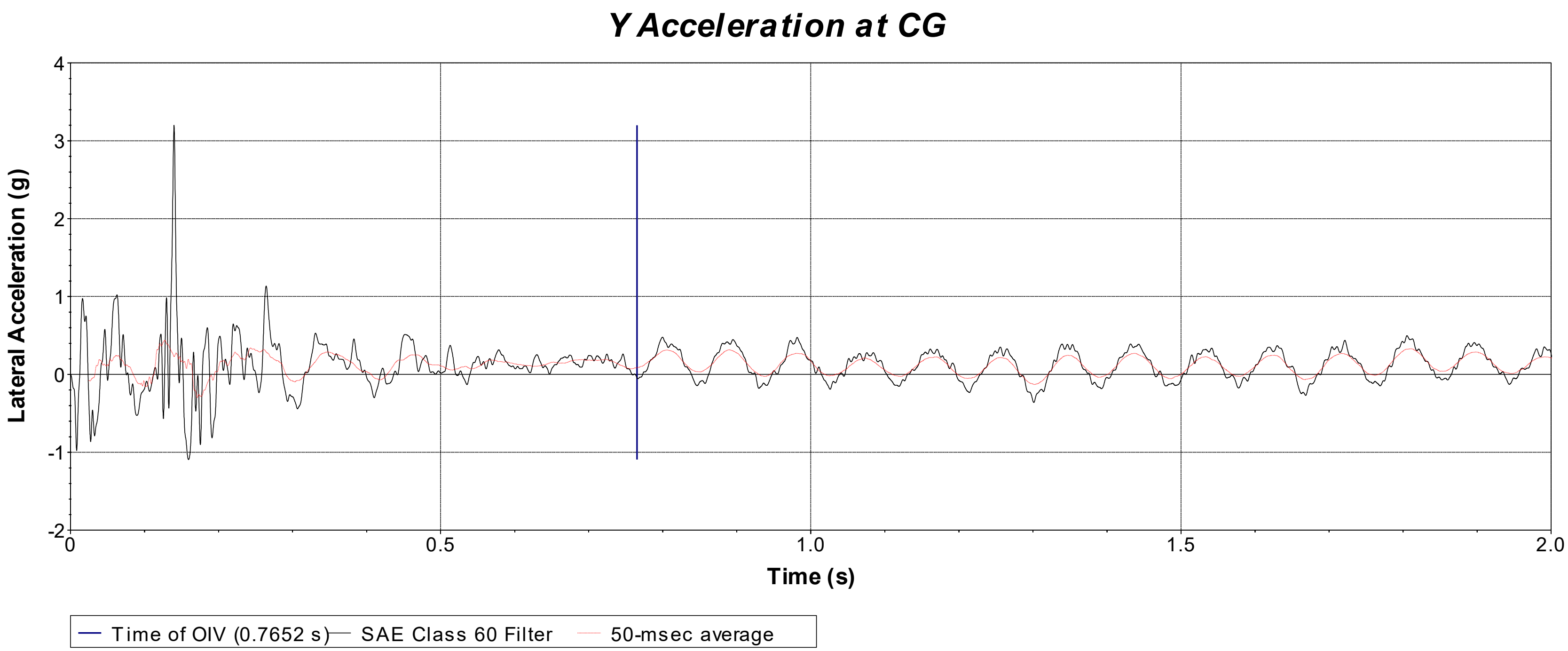


Figure C.8. Vehicle Lateral Accelerometer Trace for Test 621201-01-2 (Accelerometer Located at Center of Gravity).

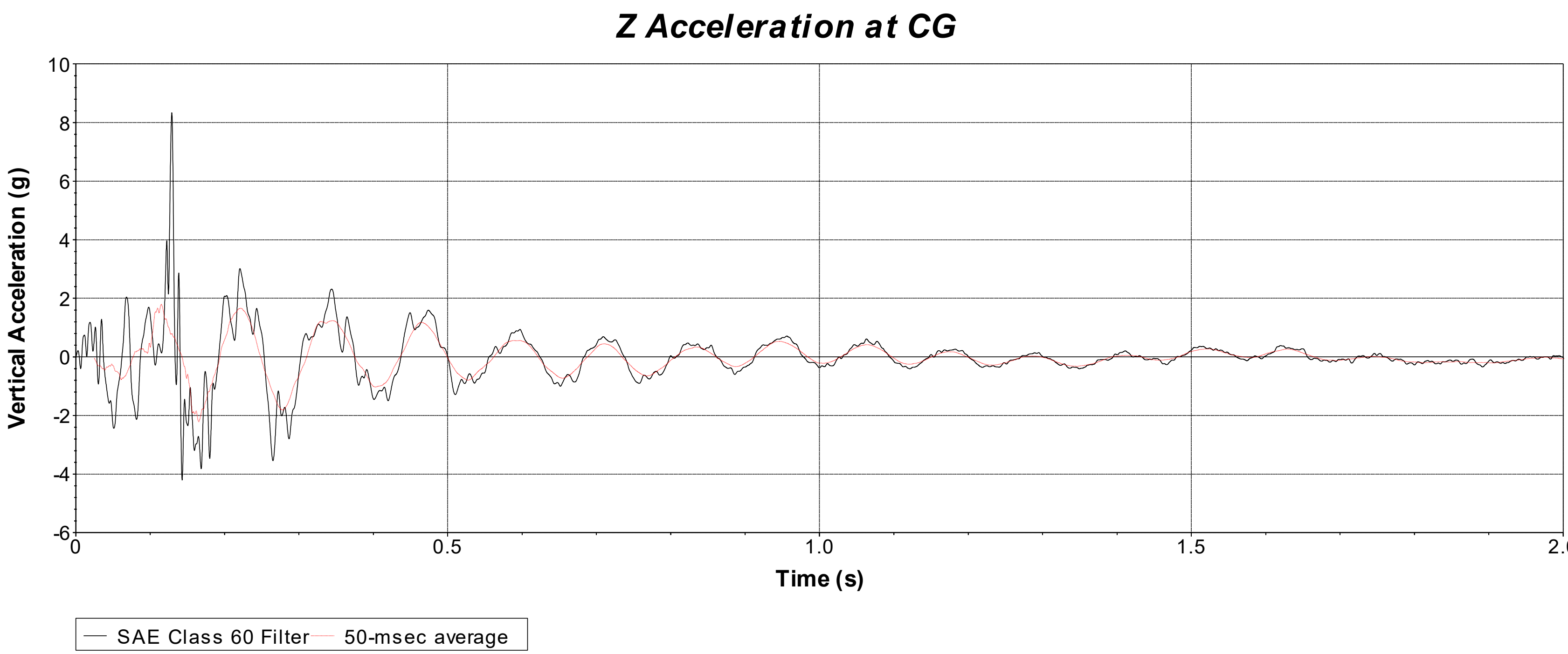
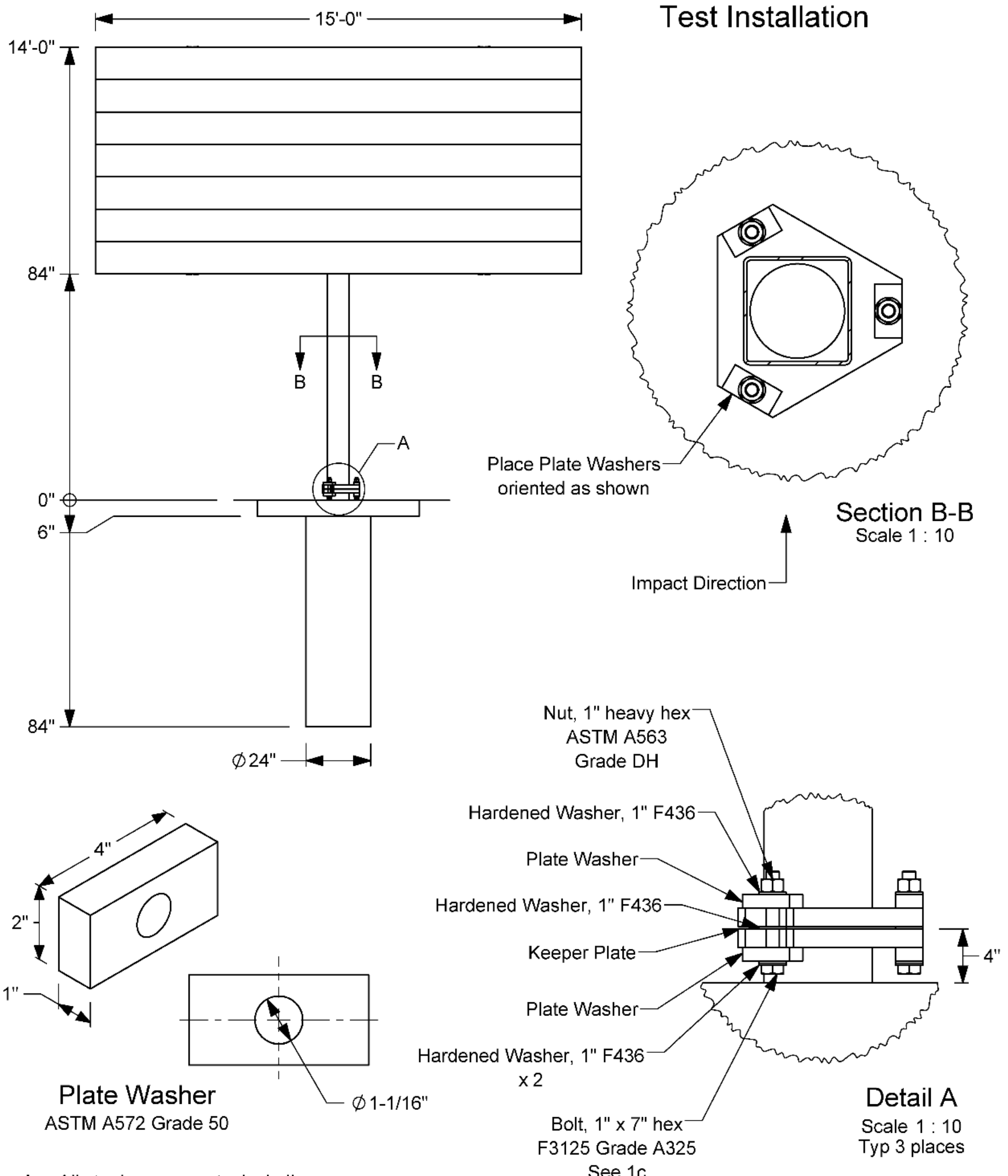


Figure C.9. Vehicle Vertical Accelerometer Trace for Test 621201-01-2 (Accelerometer Located at Center of Gravity).

APPENDIX D.

DETAILS OF THE 8 × 8 SQUARE TUBE SLIP BASE SIGN SUPPORT SYSTEM

Test Installation



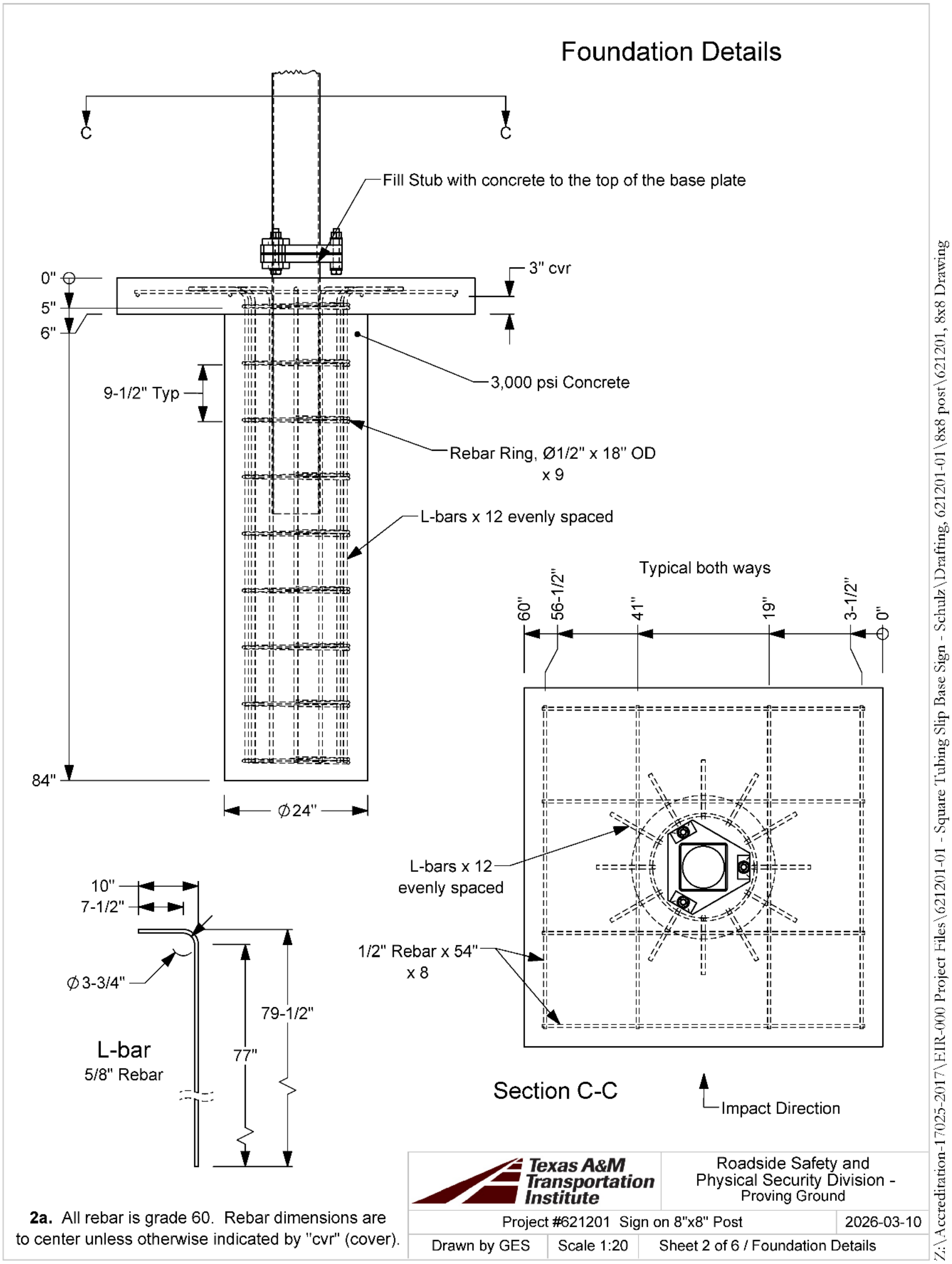
1a. All steel components, including fasteners, shall be hot-dipped galvanized after fabrication unless otherwise indicated.

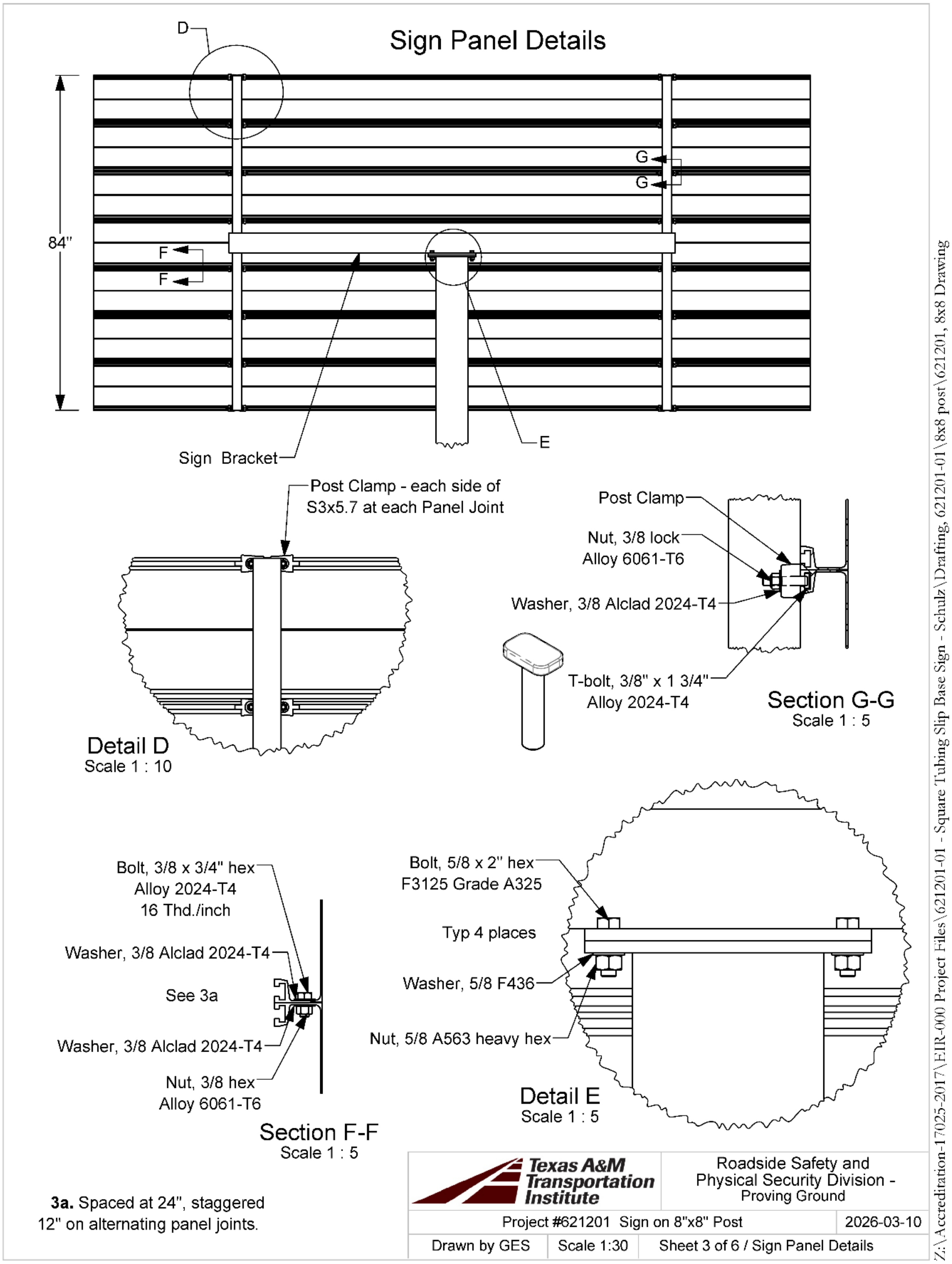
1b. Components not detailed here are detailed on following sheets.

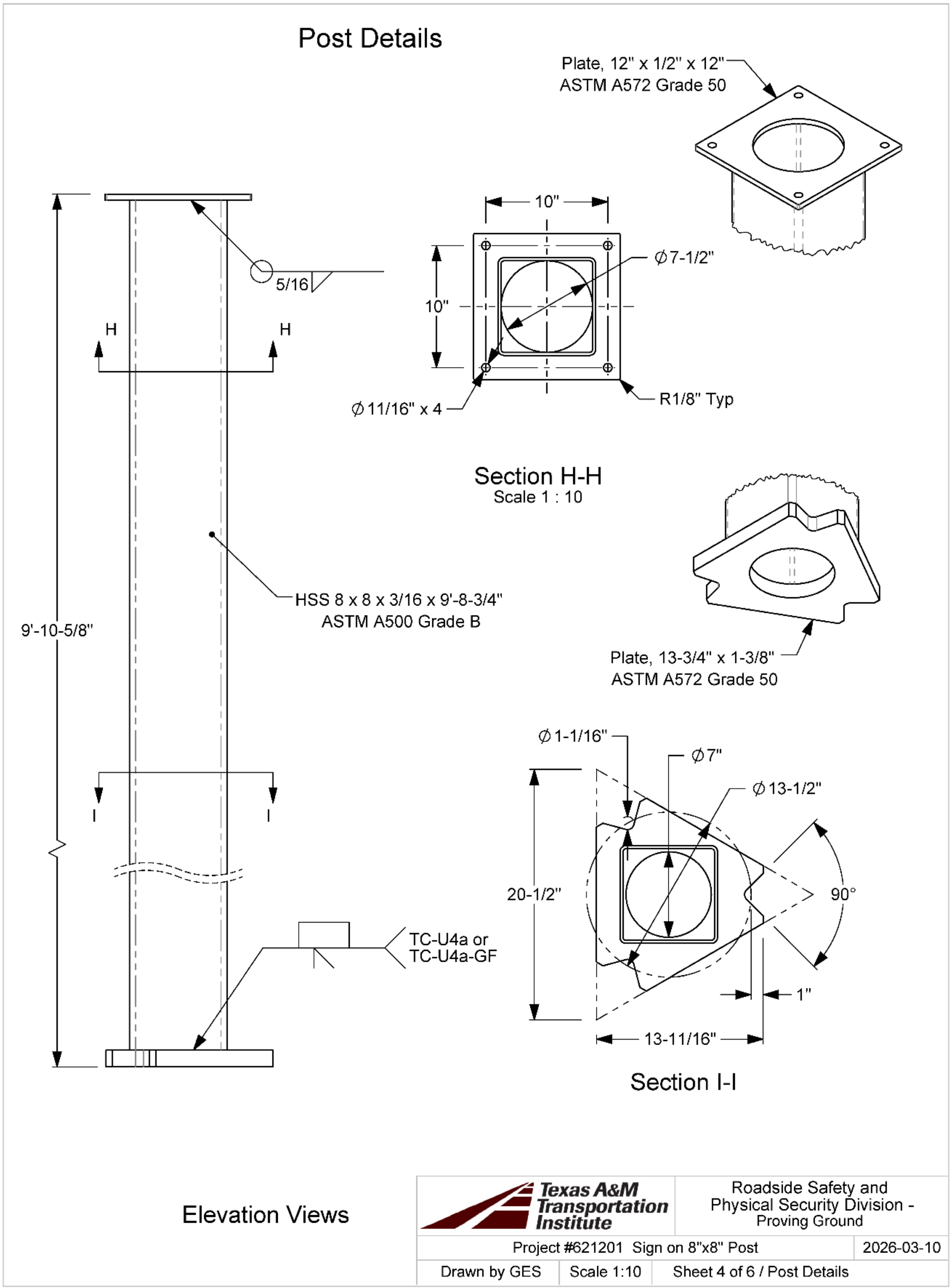
1c. Tighten bolts in a systematic order to 550 ft/lbs. Loosen and re-tighten bolts to 75 ft/lbs using the same order as the initial tightening.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #621201 Sign on 8"x8" Post		2026-03-10
Drawn by GES	Scale 1:50	Sheet 1 of 6 / Test Installation

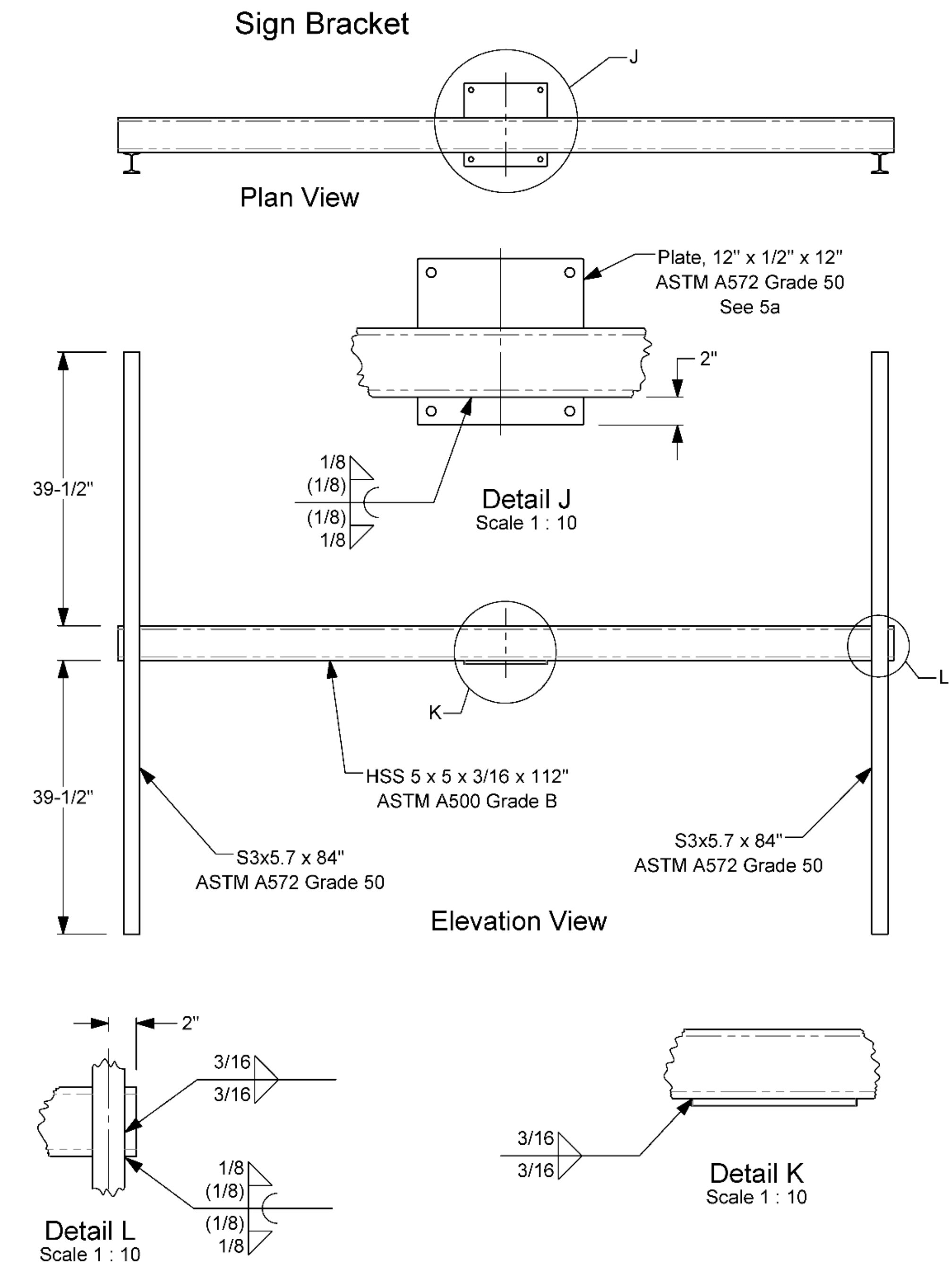
Z:\Accreditation-17025-2017\EIR-000 Project Files\621201-01 - Square Tubing Slip Base Sign - Schulz\Drafting, 621201-01\8x8 post\621201, 8x8 Drawing


Foundation Details
C
C
Fill Stub with concrete to the top of the base plate
0"
5"
6"
3" cvr
9-1/2" Typ
3,000 psi Concrete
Rebar Ring, Ø1/2" x 18" OD
x 9
L-bars x 12 evenly spaced
84"
Ø24"
Typical both ways
60"
56-1/2"
41"
19"
3-1/2"
0"
L-bars x 12
evenly spaced
1/2" Rebar x 54"
x 8
10"
7-1/2"
Ø3-3/4"
79-1/2"
77"
L-bar
5/8" Rebar
Section C-C
Impact Direction
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #621201 Sign on 8"x8" Post
2026-03-10
Drawn by GES
Scale 1:20
Sheet 2 of 6 / Foundation Details
2a. All rebar is grade 60. Rebar dimensions are to center unless otherwise indicated by "cvr" (cover).
Z:\Accreditation-17025-2017\EIR-000 Project Files\621201-01 - Square Tubing Slip Base Sign - Schulz\Drafting, 621201, 8x8 post\621201, 8x8 Drawing


Sign Panel Details
D
84"
G
G
F
F
Sign Bracket
E
Post Clamp - each side of
S3x5.7 at each Panel Joint
Detail D
Scale 1 : 10
Post Clamp
Nut, 3/8 lock
Alloy 6061-T6
Washer, 3/8 Alclad 2024-T4
T-bolt, 3/8" x 1 3/4"
Alloy 2024-T4
Section G-G
Scale 1 : 5
Bolt, 3/8 x 3/4" hex
Alloy 2024-T4
16 Thd./inch
Washer, 3/8 Alclad 2024-T4
See 3a
Washer, 3/8 Alclad 2024-T4
Nut, 3/8 hex
Alloy 6061-T6
Section F-F
Scale 1 : 5
Bolt, 5/8 x 2" hex
F3125 Grade A325
Typ 4 places
Washer, 5/8 F436
Nut, 5/8 A563 heavy hex
Detail E
Scale 1 : 5
3a. Spaced at 24", staggered
12" on alternating panel joints.
Texas A&M Transportation Institute
Roadside Safety and
Physical Security Division -
Proving Ground
Project #621201 Sign on 8"x8" Post
2026-03-10
Drawn by GES
Scale 1:30
Sheet 3 of 6 / Sign Panel Details
Z:\Accreditation-17025-2017\EIR-000 Project Files\621201-01 - Square Tubing Slip Base Sign - Schulz\Drafting, 621201, 8x8 Drawing



Z:\Accreditation-17025-2017\EIR-000 Project Files\621201-01 - Square Tubing Slip Base Sign - Schulz\Drafting, 621201-01\8x8 post\621201, 8x8 Drawing

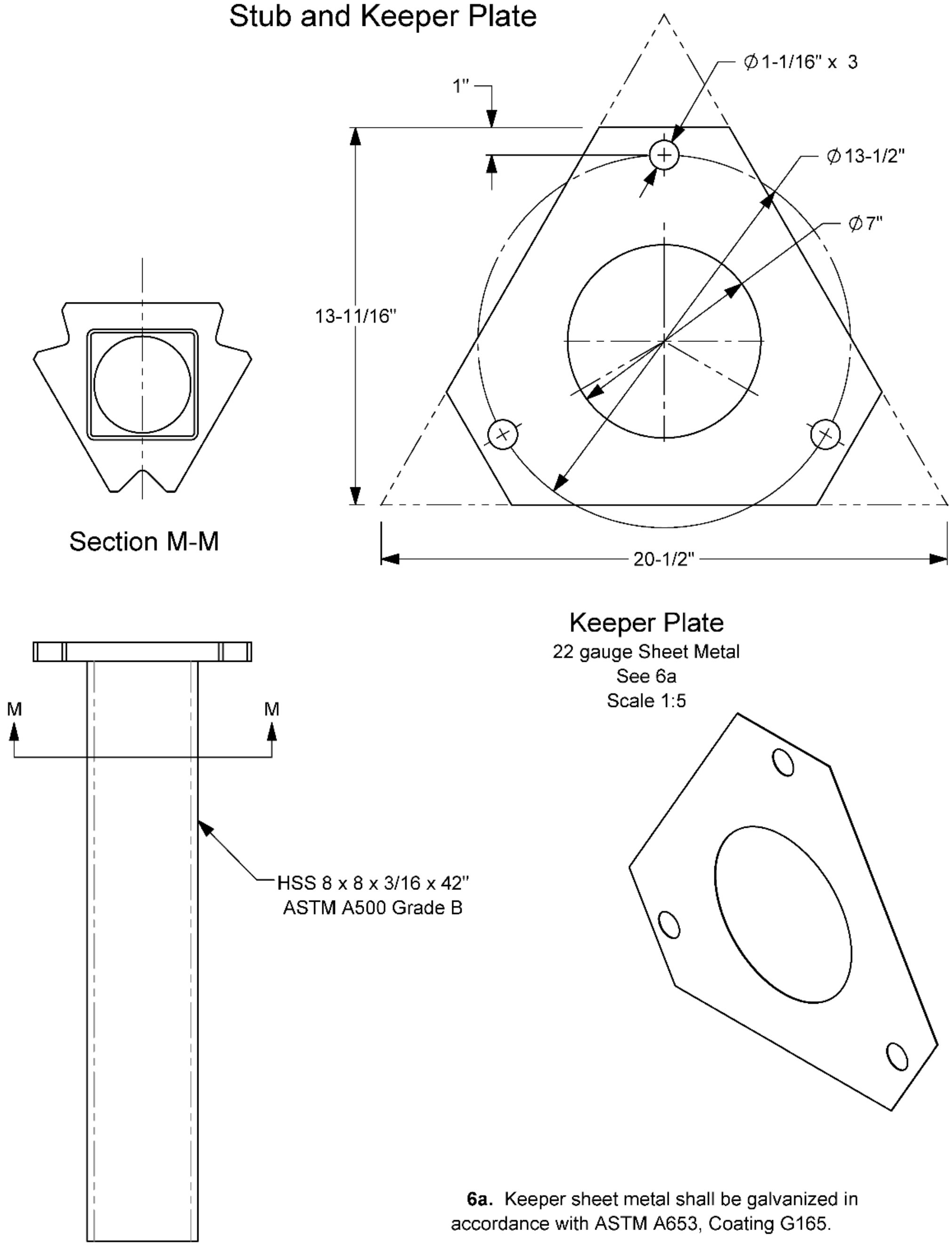


5a. Plate is identical to top Post plate on previous sheet, except no center hole.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #621201 Sign on 8"x8" Post		2026-03-10
Drawn by GES	Scale 1:20	Sheet 5 of 6 / Sign Bracket

Z:\Accreditation-17025-2017\EIR-000 Project Files\621201-01 - Square Tubing Slip Base Sign - Schulz\Drafting, 621201-01\8x8 post\621201, 8x8 Drawing

Stub and Keeper Plate



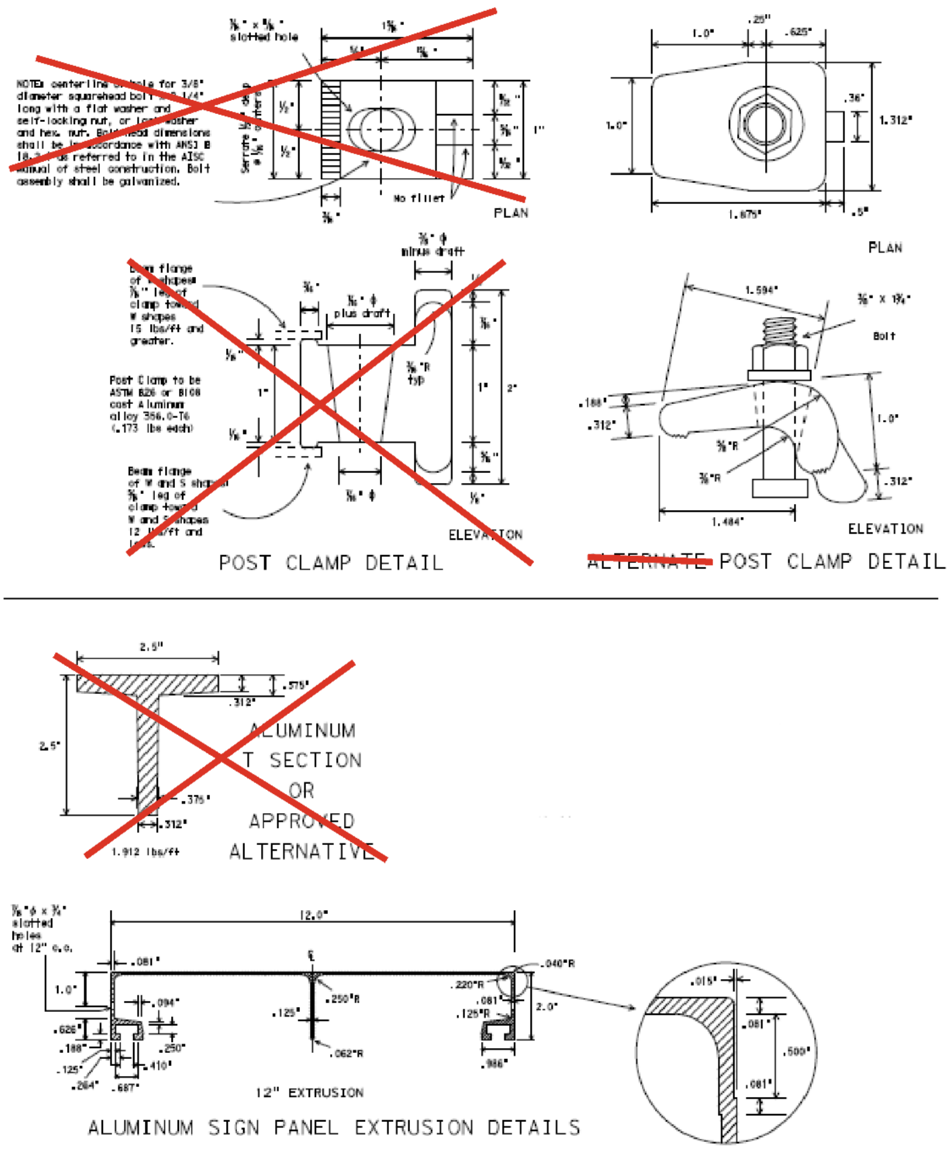
Keeper Plate
22 gauge Sheet Metal
See 6a
Scale 1:5

Stub
See Post Details on previous sheet for details not shown here

6a. Keeper sheet metal shall be galvanized in accordance with ASTM A653, Coating G165.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #621201 Sign on 8"x8" Post		2026-03-10
Drawn by GES	Scale 1:10	Sheet 6 of 6 / Stub and Keeper Plate

Z:\Accreditation-17025-2017\EIR-000 Project Files\621201-01 - Square Tubing Slip Base Sign - Schulz\Drafting, 621201, 8x8 post\621201, 8x8 Drawing



*From TxDoT Drawing SMD(2-1) -08

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #12" Sign Panel and Post Clamp		2025-08-25
Drawn by GES	Scale 1:20	Sheet 1 of 1 / Details

S:\Accreditation-17025-2017\Drafting Department\Solidworks\Standard Parts\Sign Parts\Sign Parts Drawings\12in Sign Panel and Clamp

APPENDIX E.

MASH TEST 3-60 (CRASH TEST 621201-01-3)

E.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2026-09-03 Test No.: 621201-01-3 VIN No.: 3N1CN8DV1LL872006

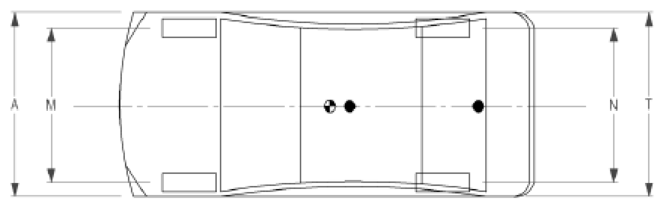
Year: 2020 Make: Nissan Model: Versa

Tire Inflation Pressure: 36 PSI Odometer: 97,333 Tire Size: P185/65R15

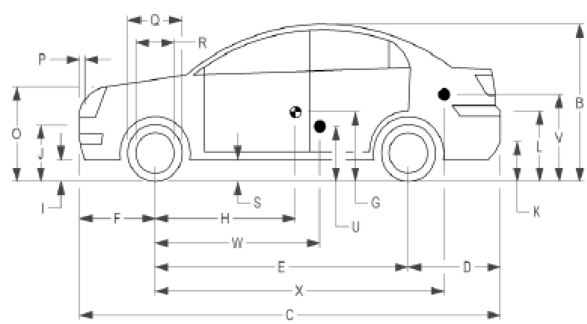
Describe any damage to the vehicle prior to test: None

● 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:

Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G		L	26.00	Q	24.00	V	21.25
C	175.40	H	38.40	M	58.30	R	16.25	W	
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 -38.40

RANGE LIMIT: A = 67 ±3 inches; C = 171 ±8 inches; E = 100 ±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}	1578	1575	
Back	1687	M_{rear}	995	934	
Total	3389	M_{Total}	2573	2509	0

Allowable TIM = 2420 lb -55 lb / +120 lb | Allowable GSM = 2585 lb -55 lb / +120 lb

Mass Distribution:
lb LF: 830 RF: 745 LR: 501 RR: 433

Figure E.1. Vehicle Properties for Test 621201-01-3.

Date:	2026-09-03	Test No.:	621201-01-3	VIN No.:	3N1CN8DV1LL872006
Year:	2020	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	AFB	-10	-.25								-14.5
2	ABOVE BUMPER	-6	=.5								-14
	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.

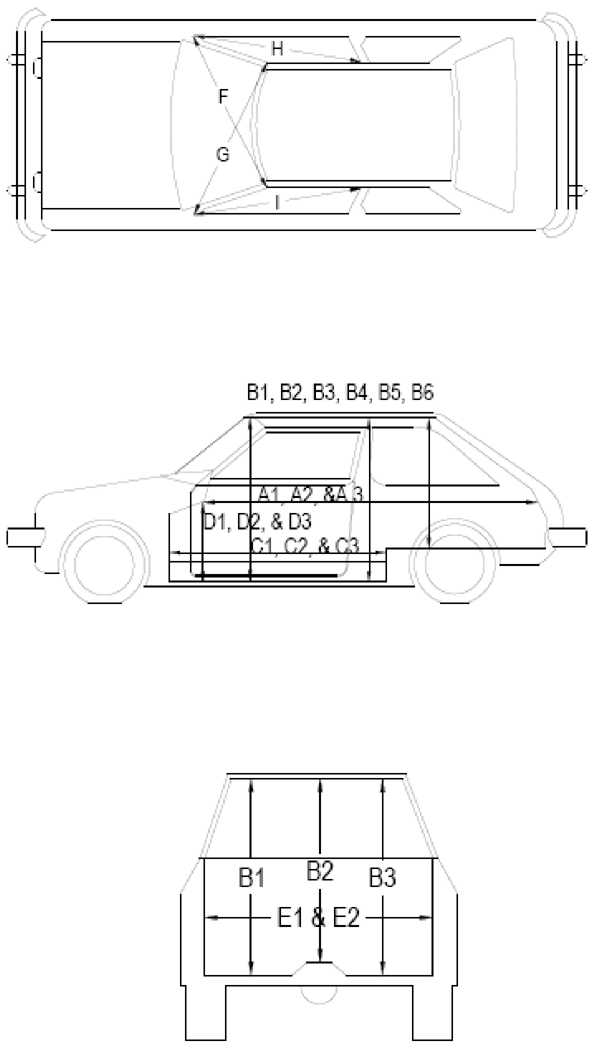
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

***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 621201-01-3.

Date:	2026-09-03	Test No.:	621201-01-3	VIN No.:	3N1CN8DV1LL872006
Year:	2020	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	35.00	-1.25
B5	36.00	34.25	-1.75
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 E.3. Occupant Compartment Measurements for Test 621201-01-3.

E.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.1000 s

(c) 0.2000 s (d) 0.3000 s

(e) 0.4000 s (f) 0.5000 s

(g) 0.6000 s (h) 0.7000 s

Figure E.4. Sequential Photographs for Test 621201-01-3 (Right Angle Views).

(a) 0.000 s

(b) 0.1000 s

(c) 0.2000 s

(d) 0.3000 s

(e) 0.4000 s

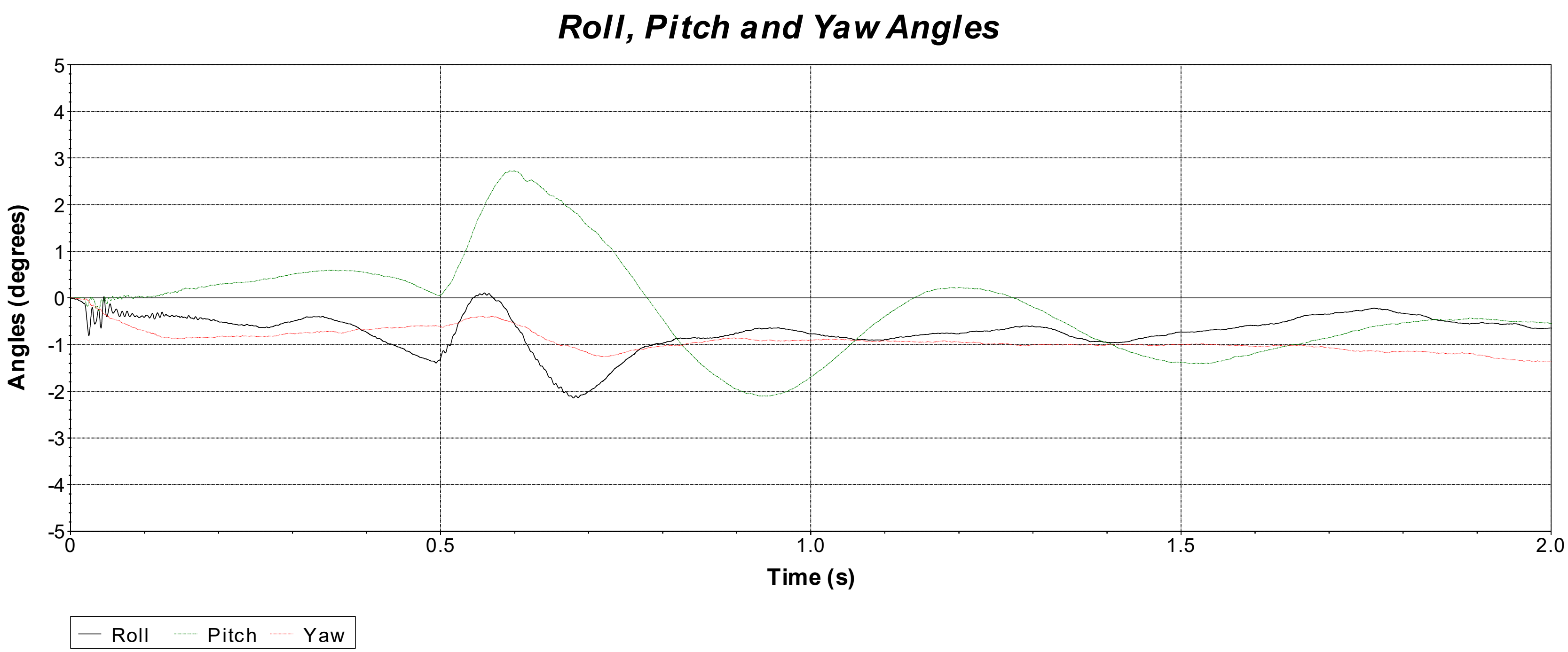
(f) 0.5000 s

(g) 0.6000 s

(h) 0.7000 s

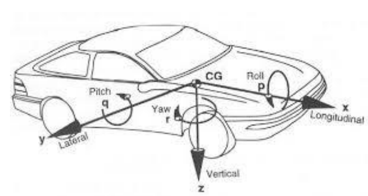
Figure E.5. Sequential Photographs for Test 621201-01-3 (Views).

E.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

7. Yaw.
8. Pitch.
9. Roll.



Test Number: 621201-01-3
Test Standard Test Number: *MASH* Test 3-60
Test Article: 8 × 8 Square Tube Slip Base Sign Support System
Test Vehicle: 2020 Nissan Versa
Inertial Mass: 2509 lbs
Gross Mass: 2674 lbs
Impact Speed: 19.04 mi/h
Impact Angle: 0.0°

Figure E.6. Vehicle Angular Displacements for Test 621201-01-3.

E.4. VEHICLE ACCELERATIONS

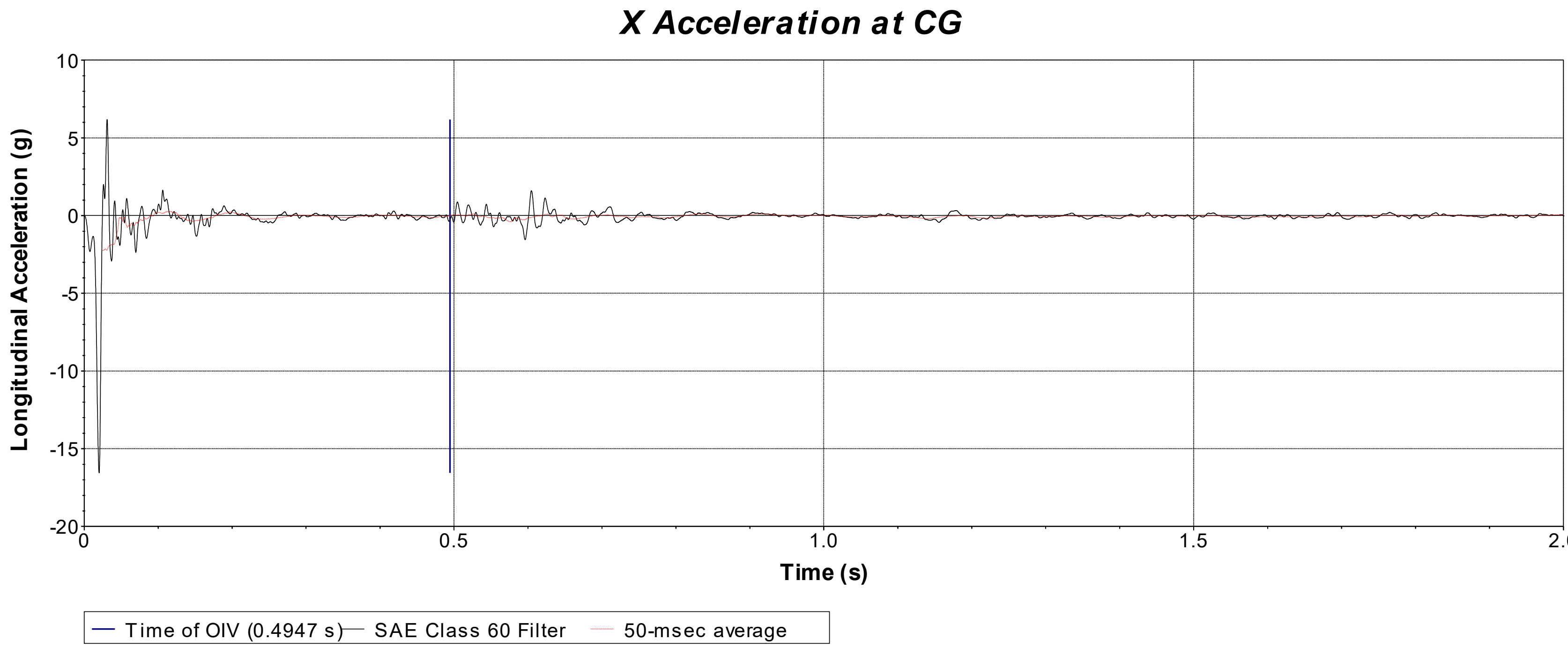


Figure E.7. Vehicle Longitudinal Accelerometer Trace for Test 621201-01-3 (Accelerometer Located at Center of Gravity).

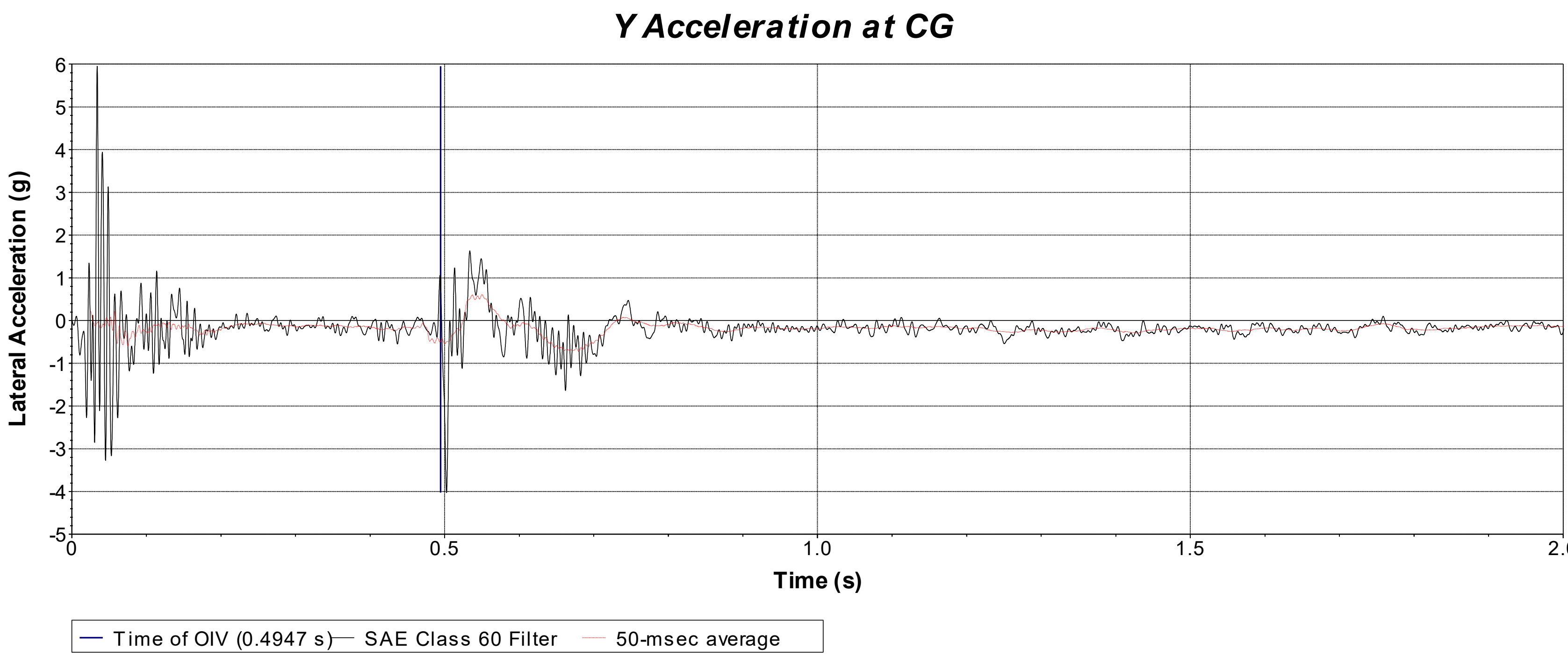


Figure E.8. Vehicle Lateral Accelerometer Trace for Test 621201-01-3 (Accelerometer Located at Center of Gravity).

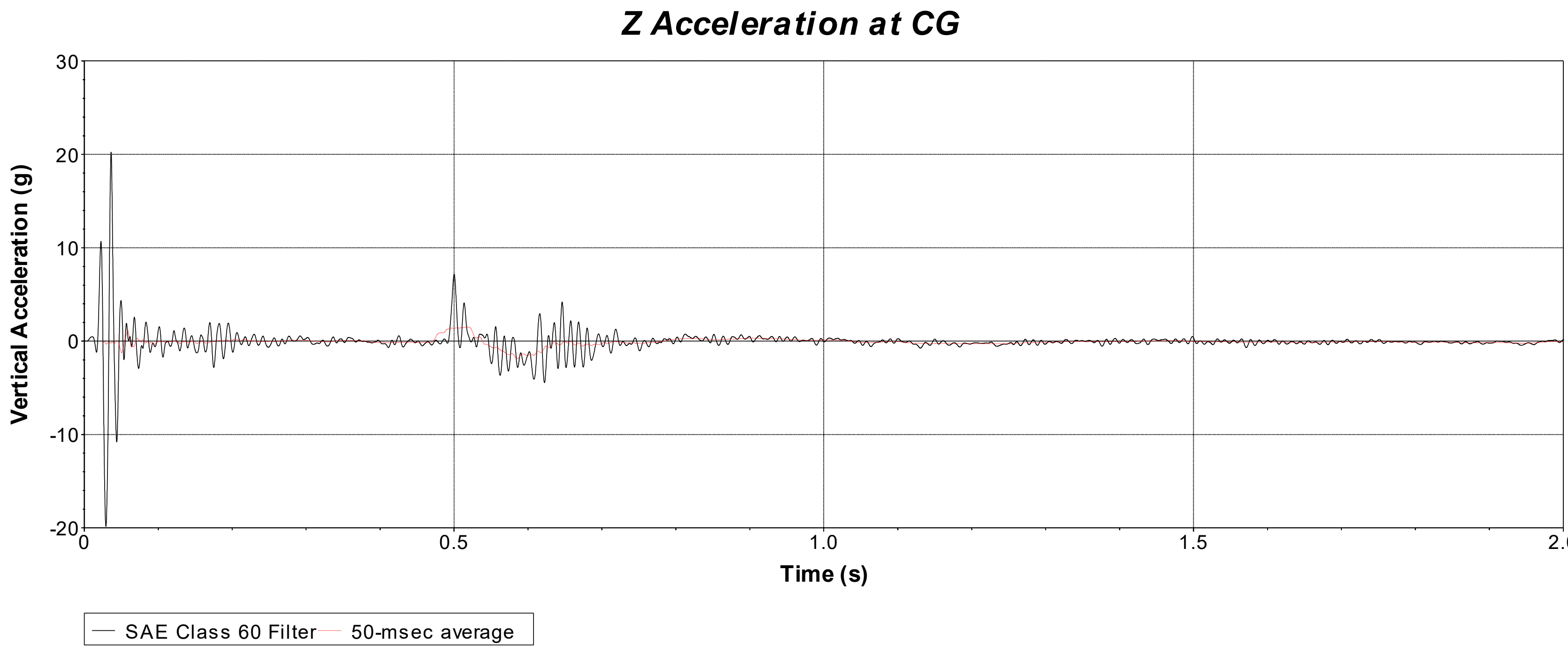


Figure E.9. Vehicle Vertical Accelerometer Trace for Test 621201-01-3 (Accelerometer Located at Center of Gravity).

APPENDIX F.

SUPPORTING CERTIFICATION DOCUMENTS

Customer Name	Customer PO#	Shipper No	Heat Number
CUSTOM FABRICATORS & REPAII	10148	594808	2410055

NUCOR STEEL - BERKELEY
1455 Hagan Avenue
Huger, SC 29450
Phone: (843) 336-6000

CERTIFIED MILL TEST REPORT

11/15/24 16:46:36

100% EAF MELTED AND MANUFACTURED IN THE USA
Structural Sections produced by Nucor-Berkeley are cast
and hot rolled to a fully killed and fine grain practice.
Mercury not intentionally added at any point during manufacturing.

Sold To: DELTA STEEL INC
7355 ROUNDHOUSE LN

HOUSTON, TX 77078

Ship To: DELTA STEEL
7355 ROUNDHOUSE LANE
IS372 YARD #15 TRACK 733
HOUSTON, TX 77008

Customer #.: 643 - 63
Customer PO: HOU-104256
B.O.L. #...: 1795506
MOS: T

SPECIFICATIONS: Tested in accordance with ASTM specification A6/A6M-22 and A370-22. Tested in accordance with EN10204-2004-3.1.
Quality Manual Rev #19 (11-30-22).
AASHTO : M270-50-23
ASTM : A992-22:A36-19/A529-19-50/A5725021T1/A7095021
CSA : G40.2150WM

Description Part #	Heat# Grade(s) Test/Heat JW	Yield/ Tensile Ratio	Yield (PSI) (MPa)	Tensile (PSI) (MPa)	Elong %	C Cr ******	Mn Mo Ti	P Sn ******	S B ******	Si V N	Cu Nb ******	Ni ****** CI	CE1 CE2 Pcm
S3X5.7	2410055	.84	61600	72900	26.00	.07	.85	.010	.020	.18	.14	.05	.24
040' 00.00"	A992-22		425	503		.05	.01	.0065	.0002	.002	.015		.2690
S75X8.5		.84	62000	73600	27.00		.001			.0083		3.58	.1292
012.1920m			427	507	35 Pc(s) 7,980 lbs Customer PO: HOU-104256 BoL#: 1795506								
S3X5.7	2315217	.84	55600	66400	28.00	.07	.85	.008	.019	.20	.13	.04	.23
050' 00.00"	A992-22		383	458		.06	.01	.0048	.0003	.002	.017		.2709
S75X8.5		.84	55600	66200	28.00		.001			.0059		3.42	.1288
015.2400m			383	456	35 Pc(s) 9,975 lbs Customer PO: HOU-104256 BoL#: 1795506								
S4X7.7	2414445	.85	61300	72000	25.00	.07	.85	.019	.008	.26	.17	.13	.26
020' 00.00"	A992-22		423	496		.14	.04	.0101	.0002	.002	.029		.3132
S100X11.5		.85	60700	71700	28.00		.001			.0062		4.70	.1391
006.0960m			419	494	20 Pc(s) 3,080 lbs Customer PO: HOU-104256 BoL#: 1795506								

Elongation based on 8" (20.32cm) gauge length. 'No Weld Repair' was performed.
CI = 26.01Cu+3.88Ni+1.20Cr+1.49Si+17.28P-(7.29Cu*Ni)-(9.10Ni*P)-33.39(Cu*Cu)
Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)+(V/10)+5B
CE1= C+(Mn/6)+((Cr+Mo+V)/5)+((Ni+Cu)/15)

'All mechanical testing is performed by the Quality testing lab, which is independent of the production departments'
CE2 = C+((Mn+Si)/6)+((Cr+Mo+V+Cb)/5)+((Ni+Cu)/15)

Nucor certifies that the contents of this report are accurate and correct. All test results and operations performed by the material manufacturer are in compliance with material specifications, and when designated by the Purchaser, meet applicable specifications.

Emma Summers
Metallurgist/
Quality Control

Emma K Summers

Customer Name	Customer PO#	Shipper No	Heat Number
CUSTOM FABRICATORS & REPAII	10148	594881	246191-03

NUCOR®

NUCOR STEEL TUSCALOOSA, INC.

MILL TEST CERTIFICATE

Nucor Steel Tuscaloosa, Inc.
1700 HOLT RD N.E.
Tuscaloosa, AL 35404-1000 USA
800 800-8204
customerservice@nucortusk.com

Page:1 of 1

Load Number	Tally	Mill Order Number	PO NO | Line NO	Part Number	Certificate Number	Prepared
R359755	00000001216734	N-213408-032	HOU-104354 32		S21673401-1	12/29/2024 19:36

Grade

Order Description:
Hot Roll Plate
A572 50, 1.3750 IN x 96.000 IN x 240.000 IN

Quality Plan Description:
A57250 .750-1.5: ASTM A572-50-21/ASME SA572-50-21/A709-50/M270-50

Customer:

Sold TO:
DELTA STEEL HOUSTON TX

Ship TO:
DELTA STEEL, INC. Englewood TX

Sent TO:

Shipped Item	Heat/Slab Number	Certified By	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Cb	V	Al	Ti	N2	B	Ca	Sn	CEV	ACI
4K2482CA	246191-03 ***	246191	0.20	1.16	0.011	0.005	0.19	0.19	0.05	0.07	0.021	0.002	0.071	0.027	0.002	0.009	0.0004	0.0023		0.44	
4K2482AA	246191-03 ***	246191	0.20	1.16	0.011	0.005	0.19	0.19	0.05	0.07	0.021	0.002	0.071	0.027	0.002	0.009	0.0004	0.0023		0.44	

Shipped Item	Certified By	Heat/Slab Number	Yield ksi	Tensile ksi	Y/T %	ELONGATION % 2"	ELONGATION % 8"	Bend OK?	Hard HB	Charpy Impacts (ft-lbs) Size mm	1	2	3	Avg	Shear % 1	2	3	Avg	Test Temp
4K2482CA	S4K2485FTT	246191-03 ***	60.3	83.0	72.6		25.8												
4K2482CA	S4K2488FTT	246191-03 ***	55.2	82.6	66.9	39.6													
4K2482AA	S4K2485FTT	246191-03 ***	60.3	83.0	72.6		25.8												
4K2482AA	S4K2488FTT	246191-03 ***	55.2	82.6	66.9	39.6													

Items: 2 PCS: 2 Weight: 17968.8 LBS

Mercury has not come in contact with this product during the manufacturing process nor has any mercury been used by the manufacturing process. Certified in accordance with EN 10204 3.1. No weld repair has been performed on this material. Yield strength is determined by the 0.2% offset method unless otherwise noted. Fully killed fine grain practice. Manufactured to a fully killed fine grain practice.
ISO 9001:2015 Registered, PED Certified

"***" indicates Heats melted and Manufactured in the U.S.A.

We hereby certify that the product described above passed all of the tests required by the specifications.

Jon Walton

Jon Walton - Metallurgist

Autora
2pcs

Start Time: ____________
End Time: ____________

HOUSTON

7355 ROUNDHOUSE LANE
HOUSTON, TX 77078

December 19, 2025
08:28:24 AM
Page 1 of 1

REPRINT HT#246191-03 **Work Order No.** 594881

Bill To CUSTOM FABRICATORS & REPAIRS, INC
1379 N. HARVEY MITCHELL PKWY
BRYAN, TX 77803
PO 10148

Ship To CUSTOM FABRICATORS & REPAIRS
416 INDUSTRIAL BLVD
BRYAN, TX 77803

OPERATOR
PLATE CHECK
REG CHECK
PRO-CHECK

Attn: CUSTOM FABRICATORS & REPAIRS- TAX EXEMPT

Terms: 1/2 % 10, Net 30 Due Date: 12/23/2025

Customer P.O. #: 10148 F.O.B.: ORIGIN Ship Via: Our Truck

Sales 1: Jeff Rocha Sales 2: Jeff Rocha Sales Order No: 594881

Ln#	Ship Qty	UM	Description	Width	Length	Weight
1	2	P	PLATE 1-3/8	13 11/16"	20 1/2"	218.87
DRL			ASTM - A572 GR 50	LOC:		PcsOnHand 0
LOC:			PcsOnHand 2	W: 13 11/16"	L: 20 1/2"	
			BURN PER DRAWING 57250)1-3/8X30X86 Tag-2850520			
			BURN PLATE:			
	2			Totals		218.87

1st CARLOS
5th
10th
20th

12-13-2022 05:42 Load - 4200840 BL - 3926777 blr466

Custom Fabricators Heat - NM5523

Cust. PO - 03178 Order - 22008252

NUCOR TUBULAR PRODUCTS

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

https://www.nucortubular.com
https://www.ntpportal.com
Certificate Number: BHM 867865

3926777

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

Purchase Order No: 7784262
Sales Order No: BHM 593056 - 18
Bill of Lading No: BHM 50862 - 6
Invoice No:

Shipped: 11/9/2022
Invoiced:

Sold To:
145 - KLOECKNER METALS - SOUTH
500 COLONIAL PARKWAY
SUITE 500
ROSWELL, GA 30076

Ship To:
900 - KLOECKNER-SUWANEE 4Q 2022 SB
3775 NAMASCO DRIVE
SUWANEE CREEK INDUSTRIAL PARK
770-271-9948
SUWANEE, GA 30024

CERTIFICATE of ANALYSIS and TESTS

Customer Part No:

TUBING A500 GRADE B(C)
5" SQ X 3/16" X 48'

Certificate No: BHM 867865
Test Date: 10/18/2022

Total Pieces	Total Weight Lbs
9	5,171

12.13.22

Bundle Tag	Mill	Heat	Specs	Y/T Ratio	Pieces	Weight Lbs
199338	40N	NM5523	YLD=63200/TEN=76500/ELG=26.5/RWB=85	0.8261	9	5,171

Mill #: 40N Heat #: NM5523 Carbon Eq: 0.2885 Heat Src Origin: MELTED AND MANUFACTURED IN THE USA

C	Mn	P	S	Si	Al	Cu	Cr	Mo	V	Ni	Nb	Sn
0.2000	0.4100	0.0070	0.0010	0.0280	0.0380	0.1100	0.0400	0.0100	0.0010	0.0400	0.0060	0.0030

N	B	Ti	Ca
0.0063	0.0001	0.0010	0.0016

T/R FAX

Certification:

I certify that the above results are a true and correct copy of records prepared and maintained by NUCOR TUBULAR PRODUCTS INC. Sworn this day, 10/18/2022.

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

Nora Oukajji

Nora Oukajji
Metallurgist/Quality Supervisor

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

Kloeckner

12-23-2025 03:08 Load - 4892018 BL - 3976923 blr466

CUSTOM FABRICATORS & REPAIRS, INC Heat - SQ3781

Cust. PO - 10149 Order - 25051667

NUCOR TUBULAR PRODUCTS

MILL CERTIFICATION

Page 1 of 1

Ship From:
Nucor Tubular Products Inc.
2000 Independence Ave NW
Decatur, AL 35601
USA

Sold To: C009244
KLOECKNER METALS - BUDA
500 COLONIAL PARKWAY SUITE 500
Roswell, GA 30076
USA

Ship To: C009328
KLOECKNER METALS CORP - BUDA, TX
2560 SOUTH LOOP 4
Buda, TX 78610
USA

Nucor item number:	102131
PO No:	8049310/1
Part No:	T8316SQA5000600
Nucor SO No/ Line No:	SN1138158/1
Order Class:	PRIME
BOL No:	BL1065560
Nucor Load No:	LD1096717
Heat No:	SQ3781
Mill #:	40N
Heat Source Origin:	EAF Melted and Manufactured in the USA
Quantity Shipped:	(2) PC
Bundles:	1
Description:	8" X 8" X 3/16" A500 50' (600")
Inventory status:	

MTR No: TC1332727
Ship date: 6/23/2025
Validated: 6/16/2025

Chemical:

C = 0.2	Mn = 0.42	P = 0.01
S = 0.003	Si = 0.028	Al = 0.028
Cu = 0.13	Cr = 0.04	Mo = 0.01
V = 0.003	Ni = 0.03	Nb = 0.006
Sn = 0.003	N = 0.0077	B = 0.0001
Ti = 0	Ca = 0.0020	CARBON EQ. = 0.2913
O = 0	Sb = 0	Zr = 0.0000

Mechanical:

YIELD = 53500	TENSILE = 76100	ELONGATION % = 33.5

Tag numbers :	Bundle weight
DCM125061410001 (2)	1963 lbs

MTR Notes:

THIS MATERIAL MEETS A500 B/C GRADE

Certification:

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

CURRENT STANDARDS:
A252-19
A500/A500M-23
A513/A513M-24A
ASTM A53/A53M-24| ASME SA-53/SA-53M-21
A847/A847M-21
A1085/A1085M-22
IN COMPLIANCE WITH EN 10204 SECTION 4.1
INSPECTION CERTIFICATE TYPE 3.1

I certify that the above results are a true and correct copy of records prepared and maintained by NUCOR TUBULAR PRODUCTS INC. Sworn this day 6/23/2025

Nora Oukajji

Quality Supervisor
Nora Oukajji

Steel Dynamics® Flat Roll Group

Steel Dynamics Southwest, LLC
8534 Hwy 89
Sinton, TX 78387 United States
Telephone (361) 424-6200

Metallurgical Certification

Cert # 383084 - Cert Date : 08/11/2025 01:52

Ship To	Kloeckner, Houston, TX-R 7400 Mesa Dr Houston, TX 77028 United States	**Contact**
Sold To	Kloeckner Metals - Houston, TX 7400 Mesa Drive Houston, TX 77028 United States	**Contact**

Length	1,232ft	**Width**	60.0000in	**Chem Treat**	No
Weight (A)	46,280lb | 20,992.2798 kg	**Gauge**	0.1775in | Min	**Oiled**	No

Coil #	25B335966	**Coil Alias**	
Order #	132474	**Heat #**	A2538240
Line Item #	5	**PO #**	HTX-8057334 - 5
Part #			
Alt Part #			
Material Spec.	ASTM A36 conversion to - 19		
Product Desc.	Prime Hot Rolled Band		
Cert Comment	Suitable for conv to ASTM A36, A709 Gr36, ASME SA36. Meets chemistry, additional testing required. Al-killed Fine GP - Elong 2 gge		
Surface Treatment			

Ladle Chemical Analysis (%)

C	Mn	P	S	Si	Al	Cu	Ni	Cr	Mo	Sn	N	V	Nb	Ti	B	Ca	Pb
0.20	0.44	0.001	0.001	0.01	0.030	0.11	0.05	0.07	0.01	0.005	0.008	0.002	0.000	0.001	0.0002	0.002	0.000

Mechanical Properties (if applicable)

Sample 1	English	Metric
Sample Location	Tail	
Tensile Direction	Transverse	
Testing Standard	ASTME	
Cert Mode	Heat	
Yield Strength	55.8 KSI	384.7 MPa
Tensile Strength	77.6 KSI	535.0 MPa
Total Elongation	25 %	

Dmitry Tsvetkov
Dmitry Tsvetkov
Metallurgist

Shipped From Sinton, TX, United States

Melted, poured, thin slab cast and rolled by proud Americans in Sinton, TX, United States

SDI does not weld or repair Prime Hot Rolled Band Products.

All tests were performed according to applicable standards and are correct as contained in the records of the company.

Retrieved on: 8/15/2025 6:07:52 PM *Steel Dynamics, Inc. Rev. Level 1.49 [1560]* Page 1 of 1

Texas A&M Transportation Institute PROVING GROUND	QF 7.3-01 Concrete Sampling	Doc. No. QF 7.3-01	Revision Date: 2025-06-20
Quality Form	Revised by: W. Schroeder Approved by: B. Griffith	Revision: 8	Page: 1 of 1

Project No: 621201-01 Casting Date: 2026-02-20 Mix Design (psi): 3000

Collecting Samples: Terracon Breaking Samples: Terracon

Batch No.	Ticket No.	Location (from concrete map)
1	14001510	100% of footers

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

PO#: 621201-01

KNIFE RIVER

www.kniferiver.com

Safety First!

BRYAN NORTH
Dispatch: (979) 361-2931
Mailing: PO Box 674, Bryan, TX., 77806

DATE: 02/20/26
REQUESTED DELIVERY TIME: 12:00
ORDER NUMBER: 2050
TICKET NUMBER: 14001510

TRUCK ID	DRIVER	PLANT ID	LEAVE PLANT	ARRIVE JOB	START POUR	END POUR	LEAVE JOB	AT PLANT
39034279	JEREMY GONZALEZ	14						

CUSTOMER ACCT ID	CUSTOMER P.O. / PROJECT NO.	PROJECT NAME	LOT & BLOCK	PREVIOUS TRUCK
434995	/TTIRELLI	TTI RELLIS CAMPUS		

SOLD TO:
TEXAS A & M TRANSPORTATION INSTI
ATTN: THERESA BORISKI
COLLEGE STATION

DELIVERY ADDRESS/LOCATION: **ADDRESS VERIFIED?** ☐ Check
TTI RELLIS CAMPUS (GATE 5) OFF

ADDITIONAL DELIVERY INSTRUCTIONS: **RT 2818 RT 21 MAKE UTURN RT GU S GRISSOM LFT RELLIS PARKWAY LF T GUS GRISSOM RD**

DRUM REVOLUTIONS		
BEGINNING	ENDING	TOTAL

Qty this Load	Qty Ordered	Qty Dlvd	Product Code	Product Description	UOM	Unit Price	EXT Amount
4.00	4.00	4.00	39352010GRNA	3500 PSIA 1"GR NO AIR	yd		
1.00	1.00	1.00	39LOADCHG	SMALL LOAD CHARGE	EA		
1.00	0.00		39FUELSU	FUEL SURCHARGE	EA		

KRC provided washout container was used: YES   Customer Signature

WATER ADDED / ESTIMATED SLUMP			
Full Load:	GAL		SLUMP
2/3 Load:	GAL		SLUMP
1/3 Load:	GAL		SLUMP

STANDBY AND UNLOADING TIME
Excess truck time will be assessed by dispatch at the current rate per minute for orders exceeding five (5) minutes per cubic yard PLUS an additional fifteen (15) minutes per load.

OVERTIME MINUTES

ADDITIONAL TIME FEE

SUB TOTAL
SALES TAX
TICKET TOTAL
GRAND TOTAL

DESIGN SLUMP	REQUESTED SLUMP
5.00	5.00

ACKNOWLEDGEMENT OF RECEIPT, WATER ADDED, & TERMS AND CONDITIONS ON WEB SITE

Signature:____________________ Printed Name:____________________

USE OF CONCRETE, AS PLACED:

RELEASE: Contractor or Owners agree to indemnify and save harmless Knife River Corporation from liability imposed as a result of any damage caused to the property of others as a result of such delivery. FOR ADDITIONAL RELEASE INFORMATION: SEE WWW.KNIFERIVER.COM/CTX

TESTED BY	AIR/SLUMP/TEMP/CYL'S

Signature:____________________ Printed Name:____________________

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat	Trim
CEMENT	376.0 lb	1504.0 lb	1530.0lb	1.73%			
FLYASH	94.0 lb	376.0 lb	390.0lb	3.72%			
GRAVEL1"	1314 lb	5335 lb	5340lb	0.10%	1.50% M	9 gl	
WATER	28.20 gl	46.14 gl	46.26gl	0.25%		46.26 gl	-2.00 gl
POLY900	14.00 oz	56.00 oz	56.00oz	0.00%			100.00 %
POZZ80	19.00 oz	76.00 oz	76.00oz	0.00%			100.00 %
SAND	1380 lb	5824 lb	5860lb	0.63%	5.50% M	37 gl	
GRAVEL3/8"	591 lb	2388 lb	2360lb	-1.16%	1.00% M	3 gl	

Actual Num Batches: 1
Load 15874 lb Design W/C: 0.501 Water/Cement: 0.490 T Design 112.8 gl Actual 95.1 gl To Add: 7.7 gl
Slump: 5.00 in Water in Truck: 10.0 gl Adjust Water: 0.0 gl / Load Trim Water: -2.0 gl / CYD
Wat Cem Contact: 11:19:57

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0376
Service Date: 02/20/26
Report Date: 03/12/26
Task: 621021

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: 3,200 psi @ 28 days

Mix ID: 39352010GRNA
Supplier: Knife River
Batch Time: **Plant:**
Truck No.: 39034279 **Ticket No.:** 14001510

Field Test Data

Test	Result	Specification
Slump (in):	4	
Air Content (%):	2.75	
Concrete Temp. (F):	75	
Ambient Temp. (F):	67	
Plastic Unit Wt. (pcf):		
Yield (Cu. Yds.):		

Sample Information
Sample Date: 02/20/26 **Sample Time:** 1200
Sampled By: Brayden Bill
Weather Conditions: Cloudy, Light Wind
Accumulative Yards: 4/4 **Batch Size (cy):** 4
Placement Method: Direct Discharge
Water Added Before (gal): 5
Water Added After (gal): 0
Sample Location: Bottom of East Footing
Placement Location: 621021 - 151
Sample Description: 6-inch diameter cylinders

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	02/23/26	03/11/26	17	98,008	3,470	3	
1	B	Good	6.00	28.27	02/23/26	03/11/26	17	94,640	3,350	3	
1	C	Good	6.00	28.27	02/23/26	03/11/26	17	96,153	3,400	3	
							Average (17 days)		**3,400**		
1	D	Good			02/23/26		Hold				
1	E	Good			02/23/26		Hold				

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

Comments: **Not tested for plastic unit weight.**
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.: Brayden Bill **Start/Stop:** 1130-1230
Reported To: Adam w/ TTI
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Bill Griffith
(1) Texas Transportation Institute, Adam Mayer
(1) Texas Transportation Institute, William Schroeder

Reviewed By:
Justin Maass
Project Manager

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

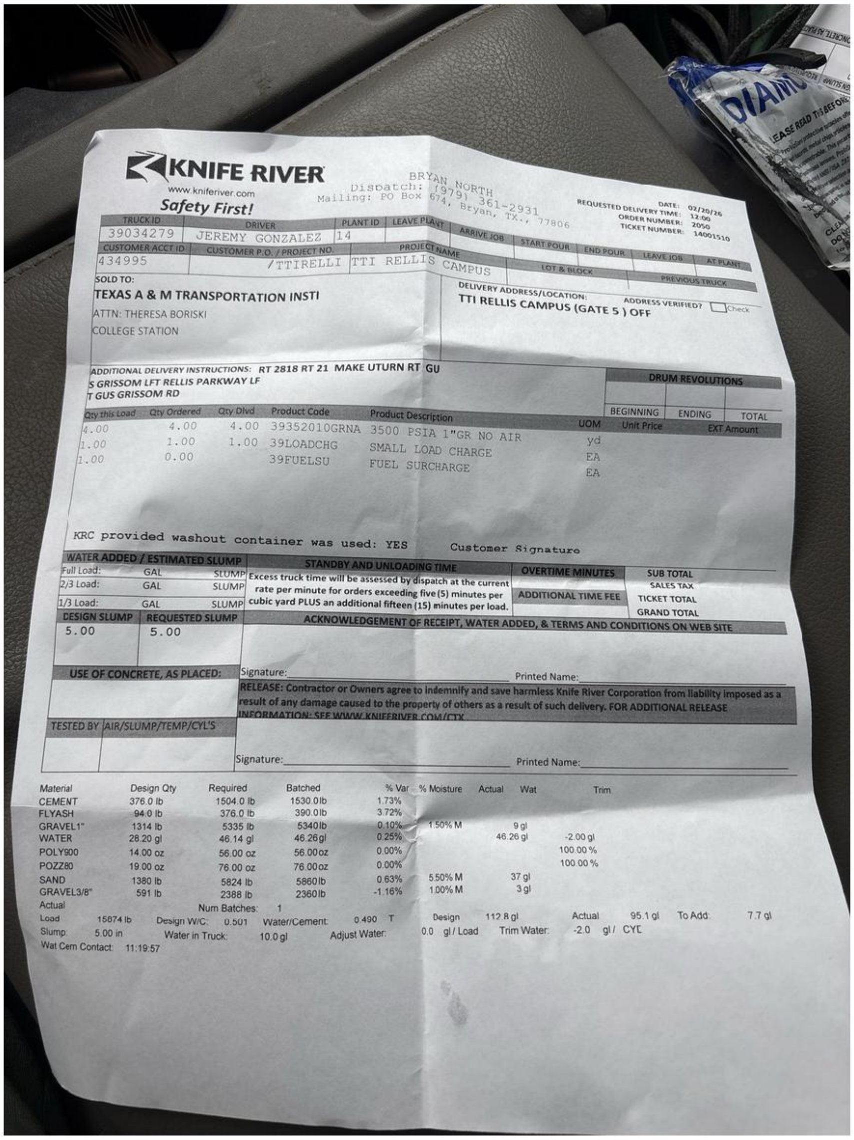
CR0001, 3-31-22, Rev.7

Photo Log

Report Number:	A1171057.0376
Service Date:	02/20/26
Report Date:	03/12/26
Task:	621021

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

(P1) Placement Location



KNIFE RIVER
www.kniferiver.com
Safety First!

BRYAN NORTH
Dispatch: (979) 361-2931
Mailing: PO Box 674, Bryan, TX., 77806

DATE: 02/20/26
REQUESTED DELIVERY TIME: 12:00
ORDER NUMBER: 2050
TICKET NUMBER: 14001510

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434995	/TTIRELLI	TTI RELLIS CAMPUS		

SOLD TO:
TEXAS A & M TRANSPORTATION INSTI
ATTN: THERESA BORISKI
COLLEGE STATION

DELIVERY ADDRESS/LOCATION: ADDRESS VERIFIED? Check
TTI RELLIS CAMPUS (GATE 5) OFF

ADDITIONAL DELIVERY INSTRUCTIONS: RT 2818 RT 21 MAKE UTURN RT GU
S GRISSOM LFT RELLIS PARKWAY LF
T GUS GRISSOM RD

DRUM REVOLUTIONS

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ADDITIONAL TIME FEE

SUB TOTAL
SALES TAX
TICKET TOTAL
GRAND TOTAL

DESIGN SLUMP	REQUESTED SLUMP
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Signature:________ Printed Name:________

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TESTED BY | AIR/SLUMP/TEMP/CYL'S

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Slump: 5.00 in Water in Truck: 10.0 gl Adjust Water: 0.0 gl / Load Trim Water: -2.0 gl / CYD
Wat Cem Contact: 11:19:57

(P2) Batch Ticket