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MASH EVALUATION OF F-SHAPE AND SINGLE-SLOPE CONCRETE BARRIERS WITH DRAINAGE SCUPPERS

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16. Abstract

Washington State Department of Transportation (WSDOT) desired to evaluate F-shape and single slope concrete barriers with 6-inch tall drainage scuppers for compliance with American Association of State Highway and Transportation Official's (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*) evaluation criteria. The F-shape was a temporary concrete barrier with pin-and-loop connection. It was evaluated as a free-standing and a pinned-down barrier system on asphalt pavement. The single slope concrete barrier was comprised of 12.5-ft precast barrier segments that were connected using the grouted rebar grid connections. The single slope barrier system was embedded 4 inches in asphalt.

The free-standing and pinned F-shape barrier systems were evaluated for *MASH* Test Level 3 (TL-3) criteria by performing *MASH* Test 3-11. The single slope barrier was evaluated for *MASH* Test Level 4 (TL-4) criteria by performing *MASH* Test 4-12.

The pinned-down and the free-standing F-shape barriers with drainage scuppers passed the criteria for *MASH* Test 3-11 for longitudinal barriers. The embedded single-slope barrier with drainage scuppers also performed acceptably for *MASH* Test 4-12 for longitudinal barriers.

17. Key Words	18. Distribution Statement
Portable concrete barrier, PCB, temporary concrete barrier, TCB, pinned down, anchored, free standing, embedded, drainage scuppers, F-shape, MASH, crash testing, roadside safety	

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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

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

TABLE OF FIGURES (CONTINUED)

LIST OF TABLES

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Chapter 1. INTRODUCTION

1.1 PROBLEM STATEMENT

Washington State Department of Transportation (WSDOT) wanted to analyze and test three concrete barrier systems with drainage scuppers. These systems included a pinned F-shape barrier, a freestanding F-shape barrier, and an embedded single-slope barrier. All three barriers have 6-inch tall drainage scuppers when installed. The F-shape barrier systems needed to be compliant to Test Level 3 (TL-3) criteria of American Association of State Highway and Transportation Official's (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*) (*1*). The single-slope barrier system needed to be compliant to Test Level 4 (TL-4) criteria of *MASH*. For each of the three barrier systems, only essential tests were to be performed.

1.2 OBJECTIVE AND SCOPE

The objective of this project was to evaluate the crash performance of two F-shape concrete barrier systems under *MASH* TL-3 criteria by performing *MASH* Test 3-11 for each system. Additionally, a single-slope barrier system was evaluated under *MASH* TL-4 criteria by performing *MASH* Test 4-12. More specifically, the following three systems were tested.

1. 32-inch tall F-shape barrier with drainage scuppers and pin-and-loop connections, restrained to underlying asphalt pavement with anchoring pins. The barrier was installed adjacent to 1V:1.5H slope with a 1-ft offset on the field side. This system was evaluated by performing *MASH* Test 3-11.
2. The above-mentioned system while unpinned and free-standing on concrete. This system was also evaluated by performing *MASH* Test 3-11.
3. 42-inch tall single slope barrier with grouted rebar-grid connections and drainage scuppers, embedded 4 inches in asphalt for an above-grade height of 38 inches. This barrier system was evaluated by performing *MASH* Test 4-12.

Prior to crash testing, TTI researchers evaluated the reinforcement details, barrier connections, barrier anchoring, barrier embedment, and scupper height of the barrier systems provided by WSDOT. New reinforcement details that incorporated the drainage scuppers were developed by the researchers. The design details of the barriers are presented in this report. Also presented are detailed documentation of the crash tests and results, and an assessment of the performance of each barrier per the *MASH* evaluation criteria.

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Chapter 2. TEST REQUIREMENTS AND EVALUATION CRITERIA

2.1 CRASH TEST PERFORMED / MATRIX

Table 2.1 shows the test conditions and evaluation criteria for *MASH* TL-3 and TL-4 longitudinal barriers.

Table 2.1. Test Conditions and Evaluation Criteria Specified for *MASH* TL-3 and TL-4 Longitudinal Barriers.

Test Article	Test Designation	Test Vehicle	Impact Conditions		Evaluation Criteria
			Speed	Angle	
Longitudinal Barrier	3-10 4-10	1100C	62 mi/h	25°	A, D, F, H, I
	3-11 4-11	2270P	62 mi/h	25°	A, D, F, H, I
	4-12	10000S	56 mi/h	15°	A, D, G

It should be noted that *MASH* TL-3 criteria also requires testing with the small passenger car (1100C vehicle). This test, however, is not critical for all three systems due to the successfully performed Test 3-10 for similar systems in the past (*2,3,4*). Furthermore, the lighter small car will not impart a greater load into the barrier systems and their restraint mechanisms in comparison to the heavier pickup truck of Test 3-11 (for the F-shape barriers) or the single unit truck of Test 4-12 (for the single slope barrier).

Similarly, Test 4-11 with the pickup truck is not critical for the single slope barrier due to the successfully performed past testing of a similar single slope barrier (*5*). It is also not expected to impart greater lateral load in the barrier compared to Test 4-12 with the single unit truck.

Thus, only Test 3-11 will be performed for the F-shape barriers and Test 4-12 for the single slope barrier. The crash tests and data analysis procedures were in accordance with guidelines presented in *MASH*. Chapter 3 presents brief descriptions of these procedures.

2.2 EVALUATION CRITERIA

The appropriate safety evaluation criteria from Tables 2-2 and 5-1 of *MASH* were used to evaluate the crash tests reported herein. The test conditions and evaluation criteria required for *MASH* TL-3 and TL-4 are listed in Table 2.1, and the substance of the evaluation criteria in Table 2.2. An evaluation of the crash test results is presented in detail under the section Assessment of Test Results.

Table 2.2. Evaluation Criteria Required for *MASH* TL-3 and TL-4 Longitudinal Barriers.

Evaluation Factors	Evaluation Criteria		*MASH* Test
Structural Adequacy	*A.*	*Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.*	3-10, 4-10, 3-11, 4-11, 4-12
Occupant Risk	*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.*	3-10, 4-10, 3-11, 4-11, 4-12
	F.	*The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.*	3-10, 4-10, 3-11, 4-11
	G.	*It is preferable, although not essential, that the vehicle remain upright during and after the collision.*	4-12
	H.	*Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 30 ft/s, or maximum allowable value of 40 ft/s.*	3-10, 4-10, 3-11, 4-11
	I.	*The occupant ridedown accelerations should satisfy the following: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.*	3-10, 4-10, 3-11, 4-11

Chapter 3. TEST CONDITIONS

3.1 TEST FACILITY

The full-scale crash tests reported herein were performed at Texas A&M Transportation Institute (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, and according to the *MASH* guidelines and standards.

The test facilities of the TTI Proving Ground are located on the Texas A&M University System RELLIS Campus, which consists of a 2000-acre complex of research and training facilities situated 10 miles 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, durability and efficacy of highway pavements, and evaluation of roadside safety hardware and perimeter protective devices. The site selected for construction and testing of the barriers was along the edge of an out-of-service apron. The apron 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.

3.2 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, 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, after which the brakes were activated, if needed, to bring the test vehicle to a safe and controlled stop.

3.3 DATA ACQUISITION SYSTEMS

3.3.1 Vehicle Instrumentation and Data Processing

Each test vehicle was instrumented with a self-contained, on-board data acquisition system. The signal conditioning and acquisition system is a 16-channel, Tiny Data Acquisition System (TDAS) Pro 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 TDAS Pro hardware

and software conform to the latest SAE J211, Instrumentation for Impact Test. Each of the 16 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 should the primary battery cable be 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 TDAS Pro 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 of the TDAS Pro units is returned to the factory annually for complete recalibration and all instrumentation used in the vehicle conforms to all specifications outlined by SAE J211. All accelerometers are calibrated annually by means of an ENDEVCO® 2901, precision primary vibration standard. This standard and its support instruments are checked annually and receive a National Institute of Standards Technology (NIST) traceable calibration. The rate transducers used in the data acquisition system receive a calibration via a Genisco Rate-of-Turn table. The subsystems of each data channel are also evaluated annually, using instruments with current NIST traceability, and the results are factored into the accuracy of the total data channel, per SAE J211. Calibrations and evaluations are also made any time data are suspect. Acceleration data are measured with an expanded uncertainty of ±1.7 percent at a confidence factor of 95 percent (k=2).

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

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

3.3.2 Anthropomorphic Dummy Instrumentation

According to *MASH*, use of a dummy in the 2270P vehicle is optional, and no dummy was used in the tests. *MASH* does not recommend or require use of a dummy in the 10000S vehicle, and thus no dummy was used.

3.3.3 Photographic Instrumentation Data Processing

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

- One overhead with a field of view perpendicular to the ground and directly over the impact point;
- One placed behind the installation at an angle; and
- A third placed to have a field of view parallel to and aligned with the installation at the downstream end.

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

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Chapter 4. *MASH* TEST 3-11 ON PINNED F-SHAPE BARRIER WITH DRAINAGE SCUPPERS

4.1 TEST ARTICLE AND INSTALLATION DETAILS

The installation consisted of eight reinforced F-shape concrete barriers, each 12.5 ft long, with an approximately 1-inch wide gap between barriers, for a total installation length of approximately 100 ft-7 inches. The barriers were placed on a 4-inch thick layer of TxDOT Type D Asphalt, which was in turn placed on a 12-inch layer of compacted crushed limestone base. The barrier system was installed adjacent to 1V:1.5H slope with a 1-ft offset from the top edge of the slope to the field-side toe of the barrier.

Adjacent barrier segments were connected with a 1-inch diameter pin that extended through three loops cast into each end of each barrier. Each barrier segment had two 6-inch tall drainage scuppers at the bottom, and three inclined slots on each side to receive anchor pins. The barrier segments were anchored to the underlying pavement by installing a 48-inch long, 1½-inch diameter anchor pin in each of the three inclined slots from the impact (traffic) side of the barrier segments. Plate washers welded to the top of the anchoring pins were installed flush to the toe of the barrier segments.

Figure 4.1 presents overall information on the pinned F-shape barrier with drainage scuppers, and Figure 4.2 provides photographs of the installation. Appendix A1 provides further details of the pinned F-shape barrier with drainage scuppers.

4.2 DESIGN MODIFICATIONS DURING TESTS

No modification was made to the installation during the testing phase.

4.3 MATERIAL SPECIFICATIONS

The specified minimum compressive strength of the concrete used in the barrier was 5000 psi. A total of eight barriers were constructed for this test. On the day of the test, barriers 1 through 4 had an average compressive strength of 5957 psi, and barriers 5 through 8 had an average compressive strength of 6555 psi. Soil compaction of the base was 100%.

Appendix B provides material certification documents for the materials used to install/construct the pinned F-shape barrier with drainage scuppers.

4.4 TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

MASH Test 3-11 involves a 2270P vehicle weighing 5000 lb ±110 lb impacting the target critical impact point (CIP) of the barrier at an impact speed of 62 mi/h ±2.5 mi/h and an angle of 25° ±1.5°. The CIP for *MASH* Test 3-11 on the pinned F-shape barrier was 4.3 ft ±1 ft upstream of the center of the joint between segments 3 and 4. Figure 4.3 depicts the target impact setup.

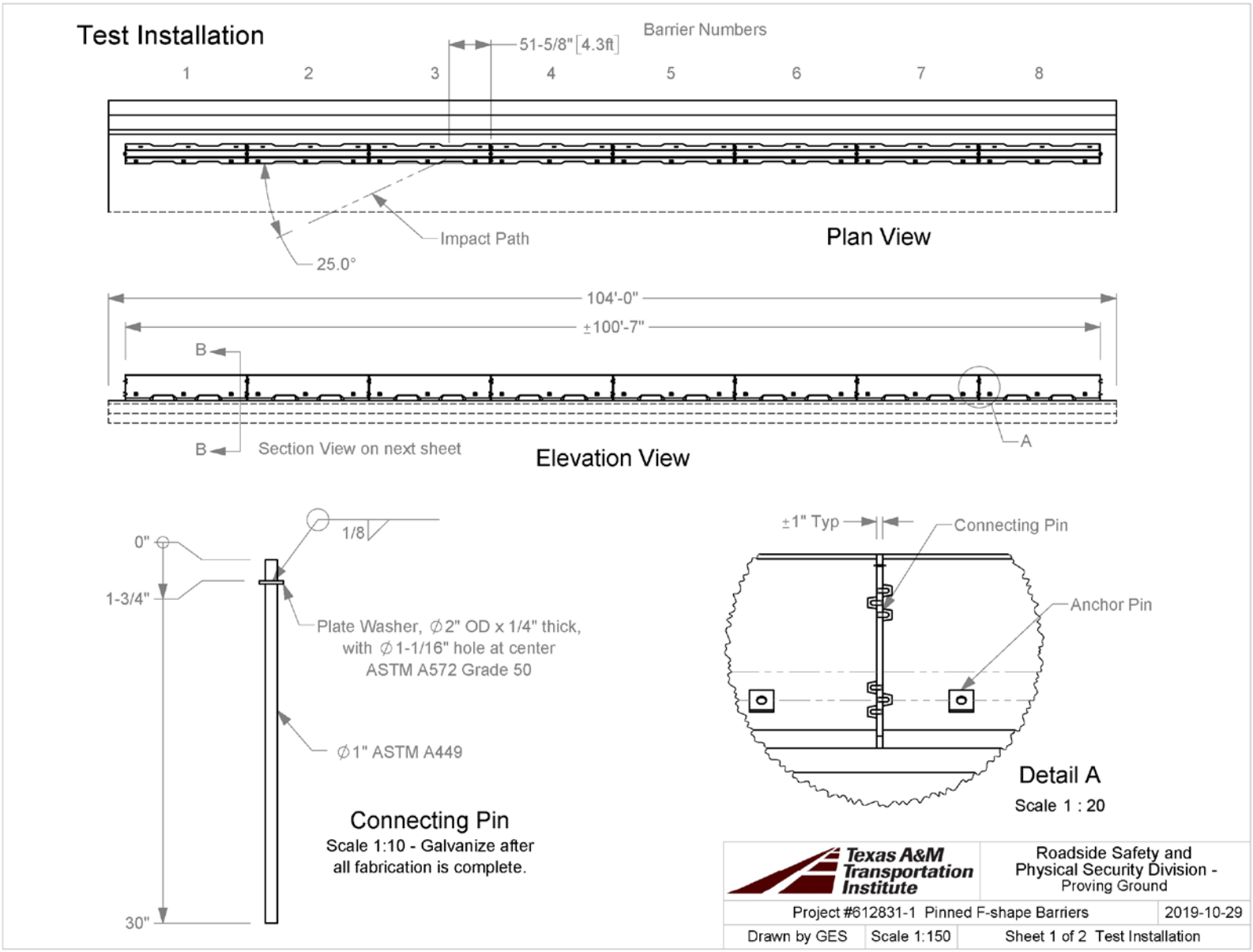


Figure 4.1. Details of Pinned F-Shape Barrier with Drainage Scuppers.

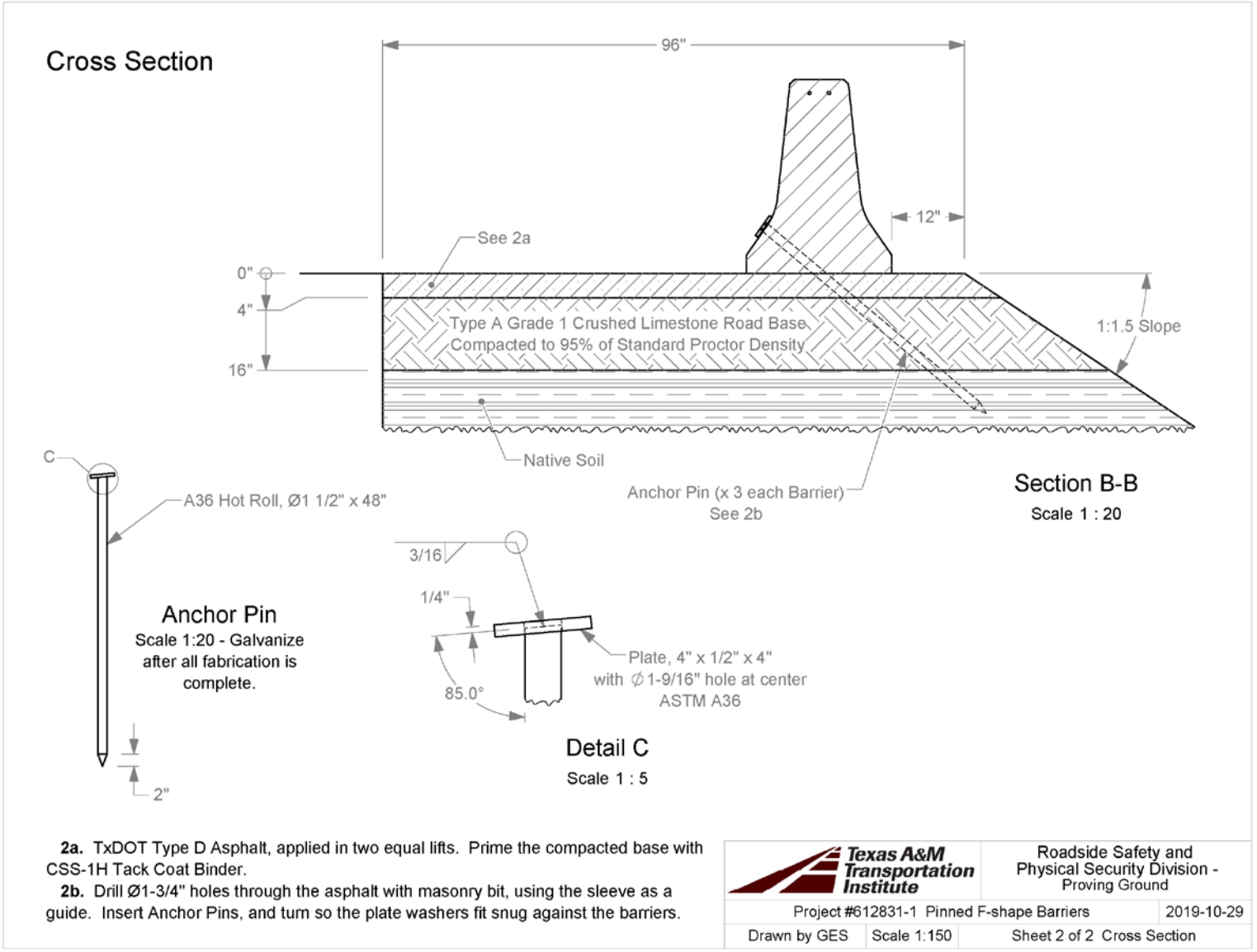


Figure 4.1. Details of Pinned F-Shape Barrier with Drainage Scuppers (Continued).

Figure 4.2. Pinned F-Shape Barrier with Drainage Scuppers prior to Testing.

Figure 4.3. Barrier/Test Vehicle Geometrics for Test No. 612831-01-1.

The 2014 RAM 1500 pickup truck used in the test weighed 5000 lb, and the actual impact speed and angle were 63.2 mi/h and 25.5°. The actual impact point was 4.4 ft upstream of the center of the joint between segments 3 and 4. Minimum target impact severity (IS) was 106 kip-ft, and actual IS was 124 kip-ft.

4.5 WEATHER CONDITIONS

The test was performed on the morning of January 7, 2020. Weather conditions at the time of testing were as follows: wind speed: 5 mi/h; wind direction: 49° (vehicle was traveling at magnetic heading of 335°); temperature: 58°F; relative humidity: 42 percent.

4.6 TEST VEHICLE

Figure 4.4 shows the 2014 RAM 1500 pickup truck used for the crash test. The vehicle's test inertia weight was 5000 lb, and its gross static weight was 5000 lb. The height to the lower edge of the vehicle bumper was 11.75 inches, and height to the upper edge of the bumper was 27.00 inches. The height to the vehicle's center of gravity was 28.5 inches. Tables C.1 and C.2 in Appendix C1 give additional dimensions and information on the vehicle. The vehicle was directed into the installation using a cable reverse tow and guidance system. It was released to be freewheeling and unrestrained just prior to impact.

4.7 TEST DESCRIPTION

Table 4.1 lists events that occurred during Test No. 612831-01-1. Figures C.1 and C.2 in Appendix C2 present sequential photographs during the test.

For longitudinal barriers, it is desirable that the vehicle redirects and exits the barrier within the exit box criteria (not less than 32.8 ft downstream from loss of contact for cars and pickups). The test vehicle exited within the exit box criteria defined in *MASH*. Brakes on the vehicle were applied at 2.4 s after impact, and the vehicle came to rest 170 ft downstream of the impact and 32 ft toward traffic lanes.

Figure 4.4. Test Vehicle before Test No. 612831-01-1.

Table 4.1. Events during Test No. 612831-01-1.

TIME (s)	EVENTS
0.000	Vehicle contacts barrier while traveling at 63.2 mi/h and 25.5°
0.015	Left front tire lifts off pavement, climbs barrier
0.029	Barrier segments 3 and 4 begin to slide toward protected side
0.043	Vehicle begins to redirect
0.089	Right front tire lifts off pavement
0.118	Right rear tire lifts off pavement
0.216	Vehicle traveling parallel with barrier
0.230	Left rear bumper and quarter panel impact barrier 3
0.467	Vehicle loses contact with barrier while traveling at 50.6 mi/h, trajectory of 3.0° and heading of 9.7°.
0.535	Front left tire contacts pavement

4.8 DAMAGE TO TEST INSTALLATION

Figure 4.5 shows the damage to the barrier. Table 4.2 shows transverse barrier movement at the joints, and Table 4.3 shows how much the anchoring pins protruded after the test. Barriers 1 through 3 each moved downstream 1½-inches. No movement was noted at barriers 6 through 8. There was some spalling at the downstream scupper of barrier 3, and there was some damage to the toes of barriers 3 and 4 on the traffic side. There was a crack running approximately vertical radiating from the corner of the upstream scupper on barrier 4, and the upper field side upstream corner of barrier 5 was broken off approximately 4 inches down from the top of barrier and 4 inches downstream barrier.

Working width* was 39.6 inches, and height of working width was 32.0 inches. Maximum dynamic deflection during the test was 21.7 inches, and maximum permanent deformation was 10.0 inches.

Figure 4.5. Barrier after Test No. 612831-01-1.

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

Table 4.2. Barrier Segment Movement for Test No. 612831-01-1.

Joint	Movement	Direction
1-2	½ inch	Field side
2-3	1½ inches	Traffic side
3-4	10 inches	Field side
4-5	3 inches	Field side

Table 4.3. Barrier Segment Pin Lift for Test No. 612831-01-1.

Barrier	Pin Lift
2	1½ inches
3	2 inches – 3 inches
4	2 inches – 7 inches (head pulled off one pin and bent over 90°)
5	1 inch – 3-½ inches

4.9 DAMAGE TO TEST VEHICLE

Figure 4.6 shows the damage sustained by the vehicle. The front bumper, hood, radiator and support, grill, left front fender, left front tire and rim, left frame rail, left front control arm, sway bar, tie rod, left front floor pan, left front door, left rear tire and rim, and rear bumper were damaged. Maximum exterior crush to the vehicle was 14.0 inches in the side plane at the left front corner at bumper height. Maximum occupant compartment deformation was 3.0 inches in the left front firewall. Figure 4.7 shows the interior of the vehicle. Tables C.3 and C.4 in Appendix C1 provide exterior crush and occupant compartment measurements.

Figure 4.6. Test Vehicle after Test No. 612831-01-1.

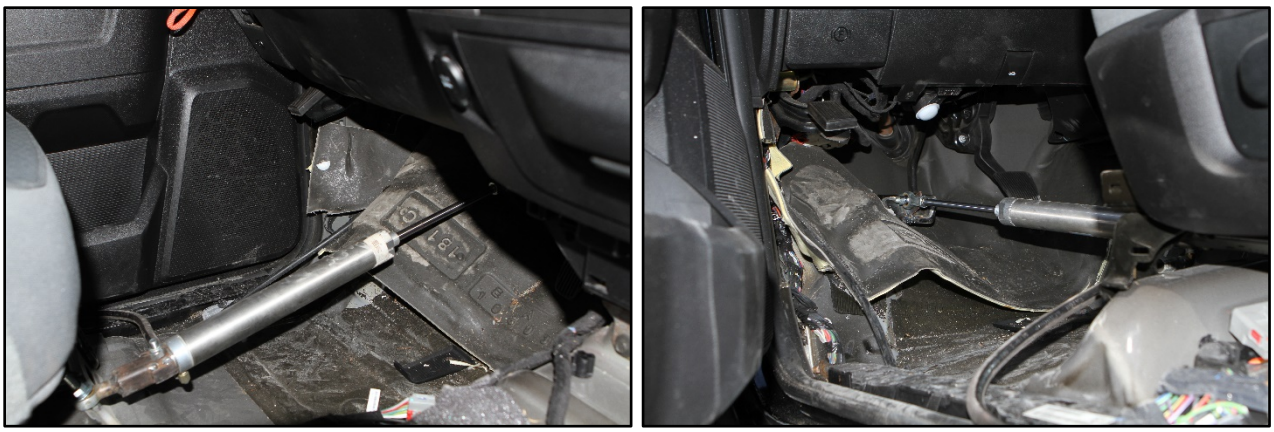


Figure 4.7. Interior of Test Vehicle after Test No. 612831-01-1.

4.10 OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 4.4. Figure C.3 in Appendix C3 shows the vehicle angular displacements, and Figures C.4 through C.6 in Appendix C4 show acceleration versus time traces. Figure 4.8 summarizes pertinent information from the test.

Table 4.4. Occupant Risk Factors for Test No. 612831-01-1.

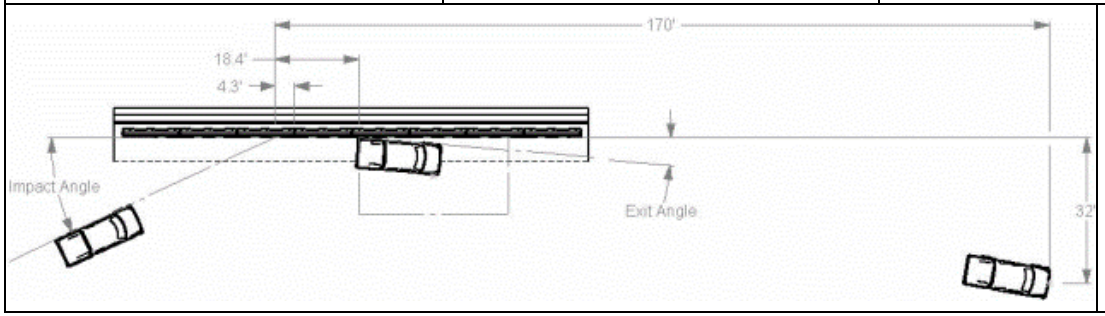
Occupant Risk Factor	Value	Time
Occupant Impact Velocity (OIV)		
Longitudinal	18.4 ft/s	at 0.1053 s on left side of interior
Lateral	21.0 ft/s	
Occupant Ridedown Accelerations		
Longitudinal	7.8 g	0.2186 – 0.2286 s
Lateral	9.7 g	0.2390 – 0.2490 s
Theoretical Head Impact Velocity (THIV)	8.4 m/s	at 0.1018 s on left side of interior
Acceleration Severity Index (ASI)	1.44	0.0575 – 0.1075 s
Maximum 50-ms Moving Average		
Longitudinal	-8.7 g	0.0332 – 0.0832 s
Lateral	11.1 g	0.0336 – 0.0836 s
Vertical	-5.2 g	1.2633 – 1.3133 s
Maximum Roll, Pitch, and Yaw Angles		
Roll	27°	0.6717 s
Pitch	17°	0.7280 s
Yaw	43°	1.5000 s

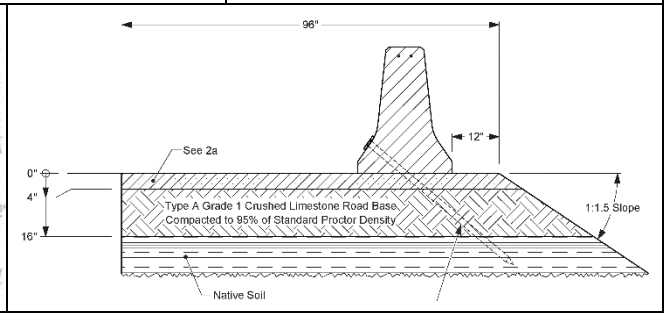
0.000 s

0.200 s

0.400 s

0.600 s





General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-11
- TTI Test No. 612831-01-1
- Test Date 2020-01-07

Test Article
- Type ..... Longitudinal Barrier – Pinned PCB
- Name ..... Pinned F-Shape Barrier with Drainage Scuppers
- Installation Length ..... 100 ft-7 inches
- Material or Key Elements .... 9½ inches wide at top x 24 inches wide at bottom x 12.5 ft long with two 6-inch tall scuppers at bottom, and three slots on each side to receive anchor pins
- **Soil Type and Condition** ..... Pinned to 4-inch thick layer of TxDOT Type D asphalt atop crushed limestone

Test Vehicle
- Type/Designation..... 2270P
- Make and Model ..... 2014 RAM 1500 pickup truck
- Curb ..... 4967 lb
- Test Inertial ..... 5000 lb
- Dummy..... No dummy
- Gross Static ..... 5000 lb

Impact Conditions
- Speed ..... 63.2 mi/h
- Angle..... 25.5°
- Location/Orientation ..... 4.4 ft upstream of joint 3-4

Impact Severity ..... 124 kip-ft

Exit Conditions
- Speed ..... 50.6 mi/h
- Trajectory/Heading Angle ... 3.0° / 9.7°

Occupant Risk Values
- Longitudinal OIV..... 18.4 ft/s
- Lateral OIV ..... 21.0 ft/s
- Longitudinal Ridedown..... 7.8 g
- Lateral Ridedown ..... 9.7 g
- THIV..... 8.4 m/s
- ASI 1.44

Max. 0.050-s Average
- Longitudinal..... -8.7 g
- Lateral ..... 11.1 g
- Vertical ..... -5.2 g

Post-Impact Trajectory
- Stopping Distance ..... 170 ft downstream 32 ft twd traffic

Vehicle Stability
- Maximum Yaw Angle..... 43°
- Maximum Pitch Angle..... 17°
- Maximum Roll Angle ..... 27°
- Vehicle Snagging..... No
- Vehicle Pocketing..... No

Test Article Deflections
- Dynamic ..... 21.7 inches
- Permanent ..... 10.0 inches
- Working Width ..... 39.6 inches
- Height of Working Width ..... 32.0 inches

Vehicle Damage
- VDS..... 11LFQ 6
- CDC 11FLEW5
- Max. Exterior Deformation ..... 14.0 inches
- OCDI LF0010000
- Max. Occupant Compartment Deformation..... 3.0 inches

Figure 4.8. Summary of Results for *MASH* Test 3-11 on Pinned F-Shape Barrier with Drainage Scuppers.

Chapter 5. *MASH* TEST 3-11 ON FREE-STANDING F-SHAPE BARRIER WITH DRAINAGE SCUPPERS

5.1 TEST ARTICLE AND INSTALLATION DETAILS

The installation consisted of sixteen reinforced F-shape concrete barrier segments, each 12.5 ft long, with an approximately 1-inch wide gap between the segments, for a total installation length of approximately 201 ft-3 inches. Adjacent barrier segments were connected with a 1-inch diameter pin that extended through three loops cast into each end of the segments. The barrier segments were 9½ inches wide at the top and 24 inches wide at the bottom. Each segment had two 6-inch tall drainage scuppers at the bottom and three inclined slots on each side to receive anchor pins. No anchor pins were used for this test and the barrier was installed unrestrained on concrete pavement.

Figure 5.1 presents overall information on the free-standing F-shape barrier with drainage scuppers, and Figure 5.2 provides photographs of the installation. Appendix A2 provides further details of the free-standing F-shape barrier with drainage scuppers.

5.2 DESIGN MODIFICATIONS DURING TESTS

No modification was made to the installation during the testing phase.

5.3 MATERIAL SPECIFICATIONS

The specified minimum compressive strength of the concrete used in the barrier was 5000 psi. A total of sixteen barriers were constructed. On the day of the test, barriers 5 through 8 had an average compressive strength of 5813 psi, barriers 1-4, 15 and 16 had an average compressive strength of 5957 psi, and barriers 9 through 14 had an average compressive strength of 6555.

Appendix B provides material certification documents for the materials used to install or construct the free-standing F-shape barrier.

5.4 TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

MASH Test 3-11 involves a 2270P vehicle weighing 5000 lb ±110 lb impacting the target CIP of the barrier at an impact speed of 62 mi/h ±2.5 mi/h and an angle of 25° ±1.5°. The CIP for *MASH* Test 3-11 on the free-standing F-shape barrier with drainage scuppers was 4.3 ft ±1 ft upstream of the center of the joint between segments 6 and 7. Figure 5.3 depicts the target impact setup.

The 2014 RAM 1500 pickup truck used in the test weighed 5054 lb, and the actual impact speed and angle were 61.5 mi/h and 24.8°. The actual impact point was 4.3 ft upstream of the center of the joint between segments 6 and 7. Minimum target IS was 106 kip-ft, and actual IS was 112 kip-ft.

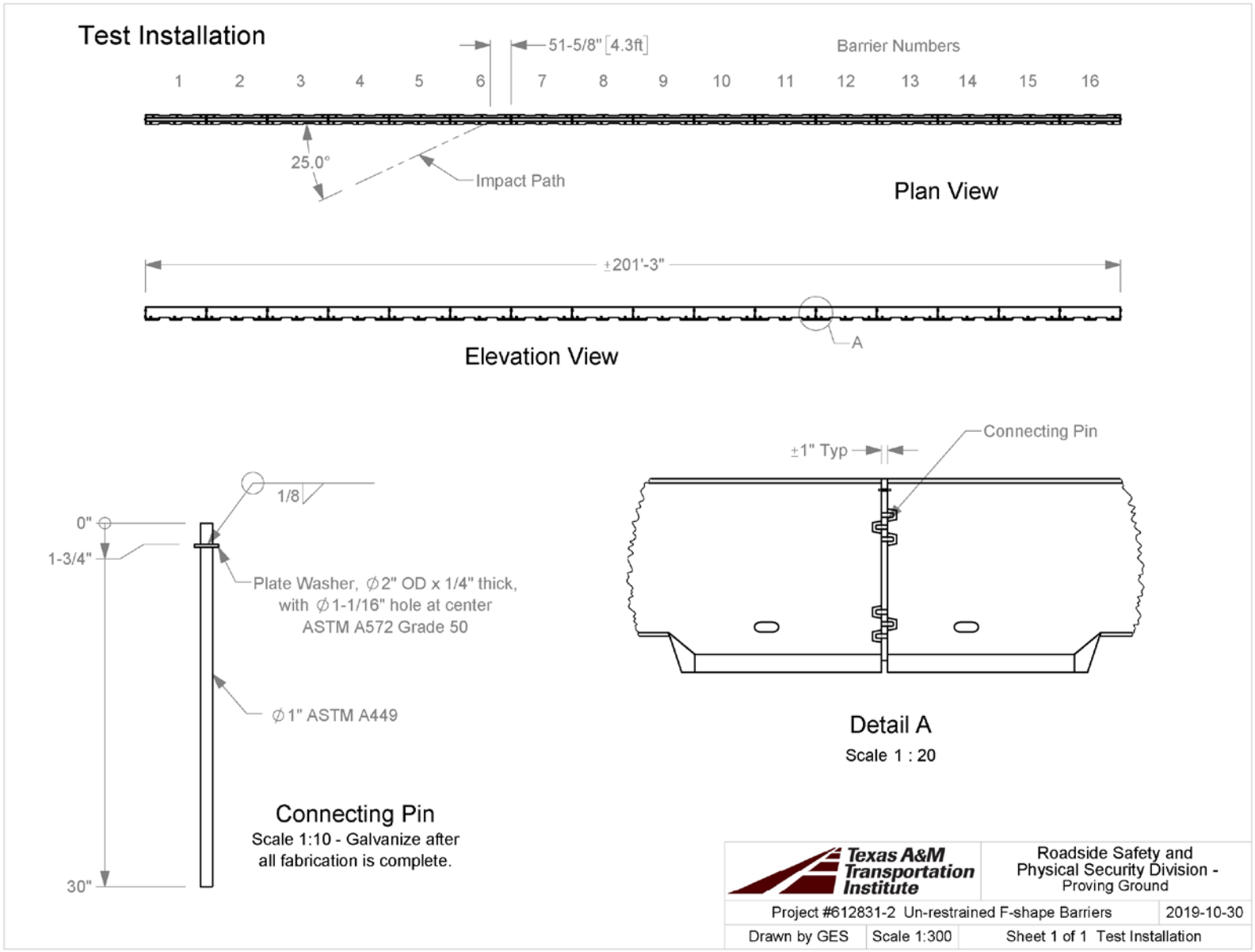


Figure 5.1. Details of Free-Standing F-Shape Barrier with Drainage Scuppers.

Figure 5.2. Free-Standing F-Shape Barrier with Drainage Scuppers Prior to Testing.

(photos taken after a rain event prior to the test)

Figure 5.3. Barrier/Test Vehicle Geometrics for Test No. 612831-01-2.

5.5 WEATHER CONDITIONS

The test was performed on the afternoon of January 9, 2020. Weather conditions at the time of testing were as follows: wind speed: 9 mi/h; wind direction: 170° (vehicle was traveling at magnetic heading of 0°); temperature: 70°F; relative humidity: 99 percent.

5.6 TEST VEHICLE

Figure 5.4 shows the 2014 RAM 1500 pickup truck used for the crash test. The vehicle's test inertia weight was 5054 lb, and its gross static weight was 5054 lb. The height to the lower edge of the vehicle bumper was 11.75 inches, and height to the upper edge of the bumper was 27.00 inches. The height to the vehicle's center of gravity was 28.75 inches. Tables D.1 and D.2 in Appendix D1 give additional dimensions and information on the vehicle. The vehicle was directed into the installation using a cable reverse tow and guidance system. The vehicle was released to be freewheeling and unrestrained just prior to impact.

Figure 5.4. Test Vehicle before Test No. 612831-01-2.

5.7 TEST DESCRIPTION

Table 5.1 lists events that occurred during Test No. 612831-01-2. Figures D.1 and D.2 in Appendix D2 present sequential photographs during the test.

Table 5.1. Events during Test No. 612831-01-2.

TIME (s)	EVENTS
0.000	Vehicle contacts barrier while traveling at 61.5 mi/h and 24.8°
0.012	Left front tire lifts off pavement
0.020	Barrier 6 begins to deflect toward field side
0.036	Barrier 7 begins to deflect toward field side
0.053	Vehicle begins to redirect
0.096	Right front tire lifts off pavement
0.128	Right rear tire lifts off pavement
0.218	Vehicle traveling parallel with barrier
0.273	Left rear quarter panel contacts barrier 7
0.404	Left front tire contacts pavement
0.492	Vehicle loses contact with barrier while traveling at 49.6 mi/h, trajectory of 6.0°, and heading of 21.6°.
0.966	Right front tire contacts pavement
1.104	Right rear tire contacts pavement

For longitudinal barriers, it is desirable that the vehicle redirects and exits the barrier within the exit box criteria (not less than 32.8 ft downstream from loss of contact for cars and pickups). The test vehicle exited within the exit box criteria defined in *MASH*. Brakes on the vehicle were applied after the vehicle exited the test site, and the vehicle came to rest 200 ft downstream of the impact and 28 ft toward field side.

5.8 DAMAGE TO TEST INSTALLATION

Figures 5.5 and 5.6 show the damage to the barrier. Barriers 1 and 2 moved downstream 7 inches, and barrier 3 moved downstream 7½ inches. Barrier 4 moved downstream 8 inches, and its upstream end moved 2 inches toward the field side. Barriers 10 and 11 moved upstream 2 inches, barrier 12 moved upstream 1½ inches, barrier 13 moved upstream 1 inch, and barriers 14 and 15 moved upstream ½ inch. Barrier 16 did not move. Table 5.2 shows transverse movement at the joints.

There were multiple cracks in barrier 7, but it remained intact. There was minor damage to the lower corners of both barriers on the field side at joint 4-5. There was significant damage to both corners of both barriers on the traffic side at joint 6-7, and joint 7-8. There was also significant damage to the field side corners of both barriers at joints, 5-6, 7-8, 8-9 and 9-10. Barriers 1-3 and 11-16 were not damaged during this test (barriers 15 and 16 had minor damage from use in a previous test).

Working width* was 86.9 inches, and height of working width was 3 inches. Maximum dynamic deflection during the test was 63.0 inches, and maximum permanent deformation was 63.0 inches.

Figure 5.5. Barrier after Test No. 612831-01-2.

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

Figure 5.6. Field Side of Barrier after Test No. 612831-01-2.

Table 5.2. Barrier Segment Movement for Test No. 612831-01-2.

Joint	Movement	Direction
4-5	3 inches	Field side
5-6	30 inches	Field side
6-7	63 inches	Field side
7-8	60 inches	Field side
8-9	30½ inches	Field side
9-10	4 inches	Traffic side
10-11	5 inches	Traffic side

5.9 DAMAGE TO TEST VEHICLE

Figure 5.7 shows the damage sustained by the vehicle. The front bumper, hood, grill, left front fender, left front tire and rim, left upper and lower control arms, left frame rail, left front floor pan, left front and rear doors, left rear cab corner, left rear exterior bed, and rear bumper were damaged. Maximum exterior crush to the vehicle was 15.0 inches in the side plane at the left front corner at bumper height. Maximum occupant compartment deformation was 1.5 inches

in the left front fire wall. Figure 5.8 shows the interior of the vehicle. Tables D.3 and D.4 in Appendix D1 provide exterior crush and occupant compartment measurements.

Figure 5.7. Test Vehicle after Test No. 612831-01-2.

Figure 5.8. Interior of Test Vehicle after Test No. 612831-01-2.

5.10 OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 5.3. Figure D.3 in Appendix D3 shows the vehicle angular displacements, and Figures D.4 through D.9 in Appendix D4 show acceleration versus time traces. Figure 5.8 summarizes pertinent information from the test.

Table 5.3. Occupant Risk Factors for Test No. 612831-01-2.

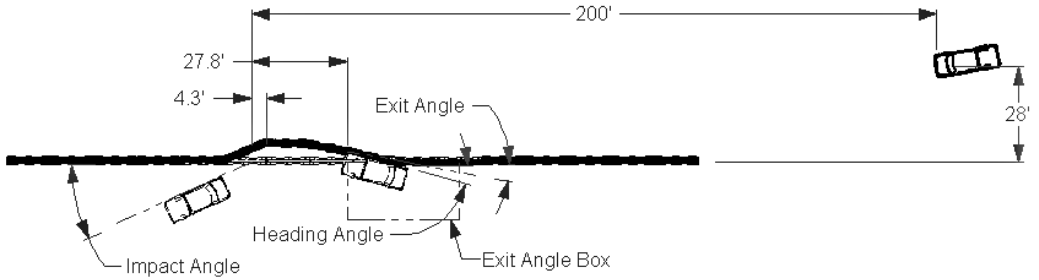
Occupant Risk Factor	Value	Time
Occupant Impact Velocity (OIV)		
Longitudinal	1.3 ft/s	at 0.1745 s on left side of interior
Lateral	8.5 ft/s	
Occupant Ridedown Accelerations		
Longitudinal	2.0 g	0.2488 – 0.2588 s
Lateral	2.6 g	0.2538 – 0.2638 s
Theoretical Head Impact Velocity (THIV)	2.6 m/s	at 0.1744 s on left side of interior
Acceleration Severity Index (ASI)	0.97	0.0020 – 0.0520 s
Maximum 50-ms Moving Average		
Longitudinal	-1.4 g	0.2327 – 0.2827 s
Lateral	4.7 g	0.0000 – 0.0500 s
Vertical	2.5 g	0.1258 – 0.1758 s
Maximum Roll, Pitch, and Yaw Angles		
Roll	20°	0.2919 s
Pitch	14°	0.4154 s
Yaw	19°	1.1800 s

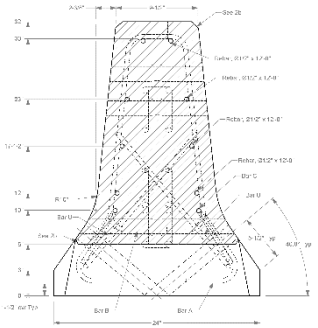
0.000 s

0.200 s

0.400 s

0.600 s





General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-11
- TTI Test No. 612831-01-2
- Test Date 2020-01-09

Test Article
- Type ..... Longitudinal Barrier – Free-Standing PCB
- Name ..... Free-Standing F-Shape PCB
- Installation Length ..... 201 ft-3 inches
- Material or Key Elements .... 9½ inches wide at top x 24 inches wide at bottom x 12.5 ft long with two 6 inch tall scuppers at bottom

Soil Type and Condition ..... Set on concrete pavement, damp

Test Vehicle
- Type/Designation..... 2270P
- Make and Model ..... 2014 RAM 1500 pickup truck
- Curb ..... 5036 lb
- Test Inertial ..... 5054 lb
- Dummy..... No dummy
- Gross Static ..... 5054 lb

Impact Conditions
- Speed 61.5
- Angle..... 24.8°
- Location/Orientation ..... 4.3 ft upstream of joint 6-7

Impact Severity ..... 112 kip-ft

Exit Conditions
- Speed ..... 49.6 mi/h
- Trajectory/Heading Angle ... 6.0° / 21.6°

Occupant Risk Values
- Longitudinal OIV..... 1.3 ft/s
- Lateral OIV ..... 8.5 ft/s
- Longitudinal Ridedown..... 2.0 g
- Lateral Ridedown ..... 2.6 g
- THIV..... 2.6 m/s
- ASI 0.97

Max. 0.050-s Average
- Longitudinal..... -1.4 g
- Lateral ..... 4.7 g
- Vertical ..... 2.5 g

Post-Impact Trajectory
- Stopping Distance ..... 200 ft downstream
  28 ft twd field side

Vehicle Stability
- Maximum Yaw Angle..... 19°
- Maximum Pitch Angle..... 14°
- Maximum Roll Angle ..... 20°
- Vehicle Snagging..... No
- Vehicle Pocketing..... No

Test Article Deflections
- Dynamic ..... 63.0 inches
- Permanent ..... 63.0 inches
- Working Width ..... 86.9 inches
- Height of Working Width ..... Toe of barrier

Vehicle Damage
- VDS..... 11LFQ3
- CDC 11FLEW3
- Max. Exterior Deformation ..... 15.0 inches
- OCDI LF0010000
- Max. Occupant Compartment Deformation..... 1.5 inches

Figure 5.9. Summary of Results for *MASH* Test 3-11 on Free-Standing F-Shape Barrier with Drainage Scuppers.

Chapter 6. *MASH* TEST 4-12 ON EMBEDDED SINGLE-SLOPE BARRIER WITH DRAINAGE SCUPPERS

6.1 TEST ARTICLE AND INSTALLATION DETAILS

The installation consisted of twelve reinforced concrete single-slope barrier segments, each 12.5 ft long, with the ends butted together, for a total installation length of 150 ft. The barrier segments were 8 inches wide at the top and 24 inches wide at the base, with an equal constant slope on both the traffic and field sides. Each segment had three 10-inch tall drainage scuppers at the bottom. The barrier segments were 42 inches tall and were placed on 12 inches of compacted limestone base, set 4 inches below grade. Asphalt was then placed on the base in two 2-inch thick lifts. Due to the 4-inch embedment, the above grade barrier height was 38 inches and the above grade drainage scupper height was 6 inches.

The barrier segments contained vertical slots cast into each end to receive rebar-grids used to reinforce the joints. These slots were filled with grout after installation of the grids.

Figure 6.1 presents overall information on the embedded single-slope barrier with drainage scuppers, and Figure 6.2 provides photographs of the installation. Appendix A.3 provides further details of the embedded single-slope barrier with drainage scuppers.

6.2 DESIGN MODIFICATIONS DURING TESTS

No modification was made to the installation during the testing phase.

6.3 MATERIAL SPECIFICATIONS

The specified minimum compressive strength of the concrete used in the barrier was 4000 psi. Twelve barriers were constructed. Barriers 1 through 6 had an average compressive strength of 4367 psi, and barriers 7 through 12 had an average compressive strength of 5710 psi. Non-shrink grout was used between the joints of the barriers and its average compressive strength on the day of testing was 7620 psi. Soil compaction of the base was 100%.

Appendix B provides material certification documents for the materials used to install or construct the embedded single-slope barrier with drainage scuppers.

6.4 TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

MASH Test 4-12 involves a 10000S vehicle weighing 22,000 lb ±660 lb impacting the CIP of the barrier at an impact speed of 56 mi/h ±2.5 mi/h and an angle of 15° ±1.5°. The CIP for this test was 5 ft ±1 ft upstream of the center of the joint between barrier segments 3 and 4. Figure 6.3 depicts the target impact setup.

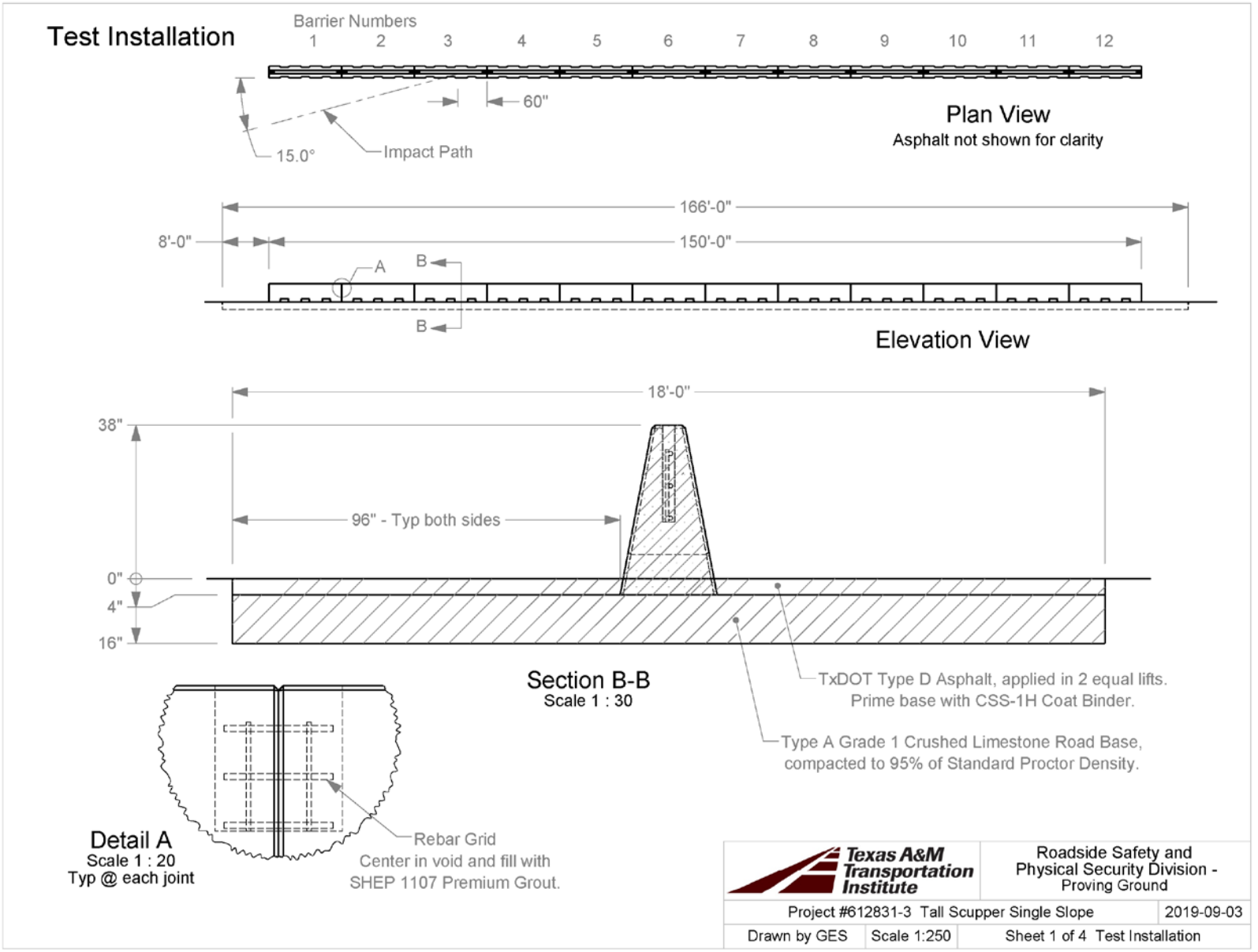


Figure 6.1. Details of Embedded Single-Slope Barrier with Drainage Scuppers.

Figure 6.2. Embedded Single-Slope Barrier with Drainage Scuppers Prior to Testing.

Figure 6.3. Embedded Single-Slope Barrier with Drainage Scuppers/Test Vehicle Geometrics for Test No. 612831-01-3.

The 2012 International 4300 single-unit truck used in the test weighed 22,370 lb, and the actual impact speed and angle were 57.7 mi/h and 16.7°. The actual impact point was 6.5 ft upstream of the center of the joint between barriers 3 and 4. Minimum target IS was 142 kip-ft, and actual IS was 206 kip-ft.

The point of impact in the test was 0.5 ft outside the target impact tolerance, and the impact angle was 0.2° greater than the tolerance specified in *MASH*. Both these tolerance exceedances, however, did not adversely affect the evaluation of the barrier for Test 4-12 compliance. The target impact point was selected to be 5-ft upstream of a barrier joint for consistency with past testing practice. The offset from the joint itself was not considered to be critical for evaluating the barrier system. The 0.2° exceedance in impact angle also did not adversely affect the evaluation of the barrier since it imparted greater impact energy to the barrier. Successful performance of the barrier with slightly higher impact angle implies that the barrier is able to perform acceptably for impact within the *MASH* impact angle tolerances.

6.5 WEATHER CONDITIONS

The test was performed on the morning of December 17, 2019. Weather conditions at the time of testing were as follows: wind speed: 14 mi/h; wind direction: 337° (vehicle was traveling at magnetic heading of 345°); temperature: 44°F; relative humidity: 71 percent.

6.6 TEST VEHICLE

Figure 6.4 shows the 2012 International 4300 single-unit truck used for the crash test. The vehicle's test inertia weight was 22,370 lb and its gross static weight was 22,370 lb. The height to the lower edge of the vehicle bumper was 18.25 inches, and height to the upper edge of the bumper was 33.25 inches. The height to the vehicle's ballast center of gravity was 62.0 inches. Table E.1 in Appendix E1 gives additional dimensions and information on the vehicle. The vehicle was directed into the installation using a cable reverse tow and guidance system and was released to be freewheeling and unrestrained just prior to impact.

Figure 6.4. Test Vehicle before Test No. 612831-01-3.

6.7 TEST DESCRIPTION

Table 6.1 lists events that occurred during Test No. 612831-01-3. Figures E.1 and E.2 in Appendix E2 present sequential photographs during the test.

Table 6.1. Events during Test No. 612831-01-3.

TIME (s)	EVENTS
0.000	Vehicle contacts barrier while traveling at 57.7 mi/h and 16.7°
0.023	Vehicle begins to redirect
0.108	Right front tire leaves the pavement
0.221	Right rear tire leaves the pavement
0.251	Rear left corner of vehicle contacts barrier
0.252	Vehicle traveling parallel with test article
0.312	Left rear tire leaves the pavement
0.898	Right front tire lands on the pavement
1.701	Right rear tire lands on the pavement

For longitudinal barriers, it is desirable that the vehicle redirects and exits the barrier within the exit box criteria (not less than 65.6 ft downstream from loss of contact for heavy vehicles). The test vehicle exited within the exit box criteria defined in *MASH*. Brakes on the vehicle were applied at 2.4 s after impact. After loss of contact with the barrier, the vehicle came to rest 218 ft downstream of the impact and 32 ft toward the field side.

6.8 DAMAGE TO TEST INSTALLATION

Figure 6.5 shows the damage to the barrier. Barrier segment 3 had a crack on the traffic side at top near each end, and there were scrapes and gouges up to one inch deep on barrier segments 3 and 4. There was no visible movement in the asphalt, and no measurable static deflection.

Working width* was 70.8 inches, and height of working width was 153.0 inches. Maximum dynamic deflection during the test was 1.8 inches, and no permanent deformation was observed. Maximum lateral intrusion of the passenger cab, measured from the pre-impact traffic-side face of the barrier was 26.3 inches at a height of 87.8 inches.

Figure 6.5. Embedded Single-Slope Barrier with Scuppers after Test No. 612831-01-3.

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

6.9 DAMAGE TO TEST VEHICLE

Figure 6.6 shows the damage sustained by the vehicle. The front bumper, hood, left front tire and rim, left door, left side steps, left front springs left floor pan, left front corner of box, left rear outer tire, and left rear lower corner of box were damaged. Maximum exterior crush to the vehicle was 12.0 inches in the side plane at the left front corner at bumper height. Maximum occupant compartment deformation was 5.0 inches in the left center floor pan. Figure 6.7 shows the interior of the vehicle.

Figure 6.6. Test Vehicle after Test No. 612831-01-3.

Figure 6.7. Interior of Test Vehicle after Test No. 612831-01-3.

6.10 VEHICLE INSTRUMENTATION)

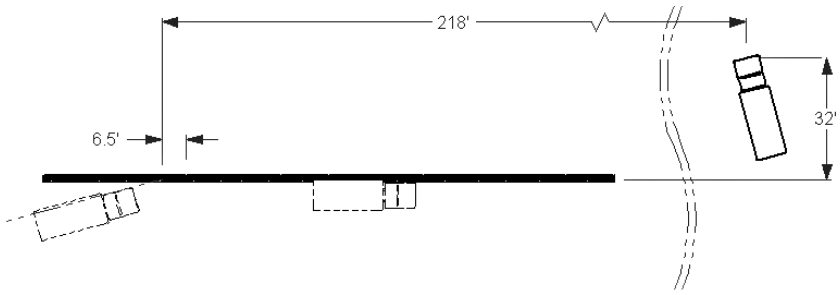
Data from the accelerometers were digitized for informational purposes only. Figure E.3 in Appendix E3 shows the vehicle angular displacements, and Figures E.4 through E.6 in Appendix E4 show acceleration versus time traces. Figure 6.8 summarizes pertinent information from the test.

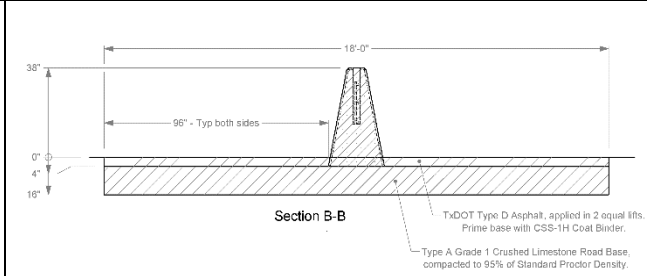
0.000 s

0.200 s

0.400 s

0.700 s





General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 4-12
- TTI Test No. 612831-01-3
- Test Date 2019-12-17

Test Article
- Type ..... Longitudinal Barrier – Concrete Barrier
- Name ..... Embedded Single-Slope Barrier with Drainage Scuppers
- Installation Length ..... 150 ft
- Material or Key Elements .... 42-inch tall and 12.5-ft long single slope barrier segments with 10-inch tall scuppers, embedded 4 inches in asphalt and connected with rebar grid connection
- **Soil Type and Condition** ..... Embedded 4 inches in asphalt pavement on top crushed limestone base, damp

Test Vehicle
- Type/Designation..... 10000S
- Make and Model ..... 2012 International 4300 SUT
- Curb ..... 13,940 lb
- Test Inertial ..... 22,370 lb
- Dummy..... No dummy
- Gross Static ..... 22,370 lb

Impact Conditions
- Speed ..... 57.7 mi/h
- Angle..... 16.7°
- Location/Orientation ..... 6.5 ft upstream of joint 3-4

Impact Severity ..... 206 kip-ft

Exit Conditions
- Speed ..... Not obtainable
- Trajectory/Heading Angle ... 0° / 0°

Occupant Risk Values
- Longitudinal OIV..... 6.6 ft/s
- Lateral OIV ..... 13.8 ft/s
- Longitudinal Ridedown..... 29.1 g
- Lateral Ridedown ..... 14.5 g
- THIV..... 4.7 m/s
- ASI 0.82

Max. 0.050-s Average
- Longitudinal..... -7.3 g
- Lateral ..... 4.3 g
- Vertical ..... -3.0 g

Post-Impact Trajectory
- Stopping Distance ..... 218 ft downstream
  32 ft twd field side

Vehicle Stability
- Maximum Yaw Angle..... 18°
- Maximum Pitch Angle..... 11°
- Maximum Roll Angle ..... 27°
- Vehicle Snagging..... No
- Vehicle Pocketing..... No

Test Article Deflections
- Dynamic ..... 1.8 inches
- Permanent ..... None observed
- Working Width ..... 70.8 inches
- Height of Working Width ..... 153.0 inches

Vehicle Damage
- VDS..... NA
- CDC 11FLEW3
- Max. Exterior Deformation ..... 12.0 inches
- OCDI ..... NA
- Max. Occupant Compartment Deformation..... 5.0 inches

Figure 6.8. Summary of Results for *MASH* Test 4-12 on Embedded Single-Slope Barrier with Drainage Scuppers.

Chapter 7. SUMMARY AND CONCLUSIONS

7.1 ASSESSMENT OF TEST RESULTS

An assessment of each test based on the applicable safety evaluation criteria for *MASH* longitudinal barriers is provided below and in Tables 7.1 through 7.3.

7.1.1 *MASH* Test 3-11 on Pinned F-Shape Barrier with Drainage Scuppers

The barrier contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 21.7 inches. Permanent deformation of the barrier was 10.0 inches. No detached elements, fragments, or other debris were present to penetrate or show potential for penetrating the occupant compartment, or to present hazard to others in the area. Maximum occupant compartment deformation was 3.0 inches in the left front firewall. The 2270P vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 27° and 17°. Occupant risk factors were within the preferred limits of *MASH*.

7.1.2 *MASH* Test 3-11 on Free-Standing F-Shape Barrier with Drainage Scuppers

The barrier contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 63.0 inches. Permanent deformation of the barrier was also 63.0 inches. A few small pieces of debris were present; however, this debris did not penetrate or show potential for penetrating the occupant compartment, or to present hazard to others in the area. Maximum occupant compartment deformation was 1.5 inches in the left front fire wall. The 2270P vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 20° and 14°. Occupant risk factors were within the preferred limits of *MASH*.

7.1.3 *MASH* Test 4-12 on the Embedded Single-Slope Barrier with Drainage Scuppers

The barrier contained and redirected the 10000S vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 1.8 inches. No permanent deformation of the barrier could be observed. No detached elements, fragments, or other debris was present to penetrate or show potential for penetrating the occupant compartment, or present undue hazard to others in the area. Maximum occupant compartment deformation was 5.0 inches in the left center floor pan. The 10000S vehicle remained upright during and after the collision event.

Table 7.1. Performance Evaluation Summary for *MASH* Test 3-11 on Pinned F-Shape Barrier with Drainage Scuppers.

Test Agency: Texas A&M Transportation Institute Test No.: 612831-01-1 Test Date: 2020-01-07

***MASH* Test 3-11 Evaluation Criteria**	**Test Results**	**Assessment**
Structural Adequacy		
A. Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.	The barrier contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 21.7 inches. Permanent barrier deformation was 10.0 inches.	Pass
Occupant Risk		
D. Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone.	No detached elements, fragments, or other debris were present to penetrate or show potential for penetrating the occupant compartment, or to present hazard to others in the area.	Pass
Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH.	Maximum occupant compartment deformation was 3.0 inches in the left front firewall.	
F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	The 2270P vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 27° and 17°.	Pass
H. Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 30 ft/s, or maximum allowable value of 40 ft/s.	Longitudinal OIV was 18.4 ft/s, and lateral OIV was 21.0 ft/s.	Pass
I. The occupant ridedown accelerations should satisfy the following limits: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.	Longitudinal occupant ridedown acceleration was 7.8 g, and lateral occupant ridedown acceleration was 9.7 g.	Pass

Table 7.2. Performance Evaluation Summary for *MASH* Test 3-11 on Free-Standing F-Shape Barrier with Drainage Scuppers.

Test Agency: Texas A&M Transportation Institute Test No.: 612831-01-2 Test Date: 2020-01-09

MASH Test 3-11 Evaluation Criteria	Test Results	Assessment
Structural Adequacy		
A. Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.	The barrier contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 63.0 inches. Permanent barrier deformation was 63.0 inches.	Pass
Occupant Risk		
D. Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone.	A few small pieces of debris were present; however, this debris did not penetrate or show potential for penetrating the occupant compartment, or to present hazard to others in the area.	Pass
Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH.	Maximum occupant compartment deformation was 1.5 inches in the left front fire wall.	
F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	The 2270P vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 20° and 14°.	Pass
H. Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 30 ft/s, or maximum allowable value of 40 ft/s.	Longitudinal OIV was 1.3 ft/s, and lateral OIV was 8.5 ft/s.	Pass
I. The occupant ridedown accelerations should satisfy the following limits: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.	Longitudinal occupant ridedown acceleration was 2.0 g, and lateral occupant ridedown acceleration was 2.6 g.	Pass

Table 7.3. Performance Evaluation Summary for *MASH* Test 4-12 on Embedded Single-Slope Barrier with Drainage Scuppers.

Test Agency: Texas A&M Transportation Institute Test No.: 612831-01-3 Test Date: 2019-12-17

***MASH* Test 4-12 Evaluation Criteria**	**Test Results**	**Assessment**
Structural Adequacy		
A. Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.	The barrier contained and redirected the 10000S vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 1.8 inches. There was no permanent barrier deformation.	Pass
Occupant Risk		
D. Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone.	No detached elements, fragments, or other debris was present to penetrate or show potential for penetrating the occupant compartment, or present undue hazard to others in the area.	Pass
Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH.	Maximum occupant compartment deformation was 5.0 inches in the left center floor pan.	
G. It is preferable, although not essential, that the vehicle remain upright during and after collision.	The 10000S vehicle remained upright during and after the collision event.	Pass

7.2 CONCLUSIONS

7.2.1 *MASH* Test 3-11 on Pinned F-Shape Barrier with Drainage Scuppers

The F-shape barrier with drainage scuppers, pinned on 4 inches of asphalt, passed the performance criteria for *MASH* Test 3-11 for longitudinal barriers.

7.2.2 *MASH* Test 3-11 on Free-Standing F-Shape Barrier with Drainage Scuppers

The free-standing F-shape barrier with drainage scuppers passed the performance criteria for *MASH* Test 3-11 for longitudinal barriers.

7.2.3 *MASH* Test 4-12 on the Embedded Single-Slope Barrier with Drainage Scuppers

The embedded single-slope barrier with drainage scuppers passed the performance criteria for *MASH* Test 4-12 for longitudinal barriers.

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Chapter 8. IMPLEMENTATION*

Based on the results of the tests performed in this project, it can be concluded that the free-standing and pinned-down F-shape barrier systems with 6-inch drainage scuppers are *MASH* TL-3 compliant. Similarly, it can be concluded that the embedded single slope barrier with drainage scuppers and 12.5-ft long segments is *MASH* TL-4 compliant. Both F-shape barrier systems passed *MASH* Test 3-11, and the single slope barrier system passed *MASH* Test 4-12.

While the *MASH* small car Test 3-10 was not performed for all three systems, successful past testing of similar systems shows that these tests are not critical (*2,3,4*). Furthermore, the lighter small car will not impart greater load into the barrier systems and their restraint mechanisms in comparison to the heavier pickup truck of Test 3-11 (for the F-shape barriers) or the single unit truck of Test 4-12 (for the single slope barrier). Based on past testing of similar systems, Test 4-11 with the pickup truck is also not critical for the single slope barrier system (*5*). Thus, only Test 3-11 was performed for the F-shape barriers and Test 4-12 for the single slope barrier.

The free-standing F-shape barrier was tested with a segment length of 12.5 ft. Longer segment lengths may also be used for this system since increasing segment length reduces the number of connections per unit length of the system, leading to reduced relative rotation of the barrier segments at joints – resulting in reduction in barrier deflection. It also increases the segment mass that must be moved by the vehicle to deflect the barrier.

The pinned-down F-shape barrier was also tested with a segment length of 12.5 ft. In this case, however, increase in segment length may need to accompany an increase in the number of anchor pins installed per segment to adequately restrain the barrier. Segment lengths up to 15 ft may be restrained with three anchor pins per segment. Segments lengths greater than 15 ft and up to 20 ft may be restrained with four anchor pins per segment.

The test installation of pinned-down F-shape barrier was comprised of a 12-inch thick Type-A Grade-1 crushed limestone road base, over which a 4-inch thick asphalt pavement was constructed. This road base was primarily used to meet *MASH* requirements for the type of soil that should be used for testing, and to be able to compact the 4-inch thick asphalt pavement on top. In a field installation, it may not always be feasible to have a 12-inch thick road base. Furthermore, native soil conditions may vary from one site to another. It should be noted that the primary resistance to the deflection of the barrier comes from the asphalt pavement. While differences in soil properties underneath the asphalt layer can have some influence on the lateral deflection of the barrier, their effect is expected to be minimal as long as the sub-base is stable enough to roll and compact the asphalt pavement on top of it. Thus, smaller thickness of road base may also be used in combination with native soil if the sub-base can be stabilized to achieve proper compaction of the 4-inch thick asphalt pavement on top.

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

The embedded single slope barrier was tested with 4-inch embedment and a segment length of 12.5 ft. This barrier may be used with longer segment lengths since increasing segment length increases its mass, which makes the barrier more difficult to move by the impacting vehicle. The barrier segments tested in this project were 42 inches tall, and with 4-inch embedment, the effective above grade barrier height was 38 inches. Past testing has shown that barrier height of 36 inches performs acceptably for *MASH* Test 4-12 (*6*). Thus the 42-inch tall barrier segments may be embedded up to 6 inches in asphalt for a minimum above grade height of 36 inches. Furthermore, a taller barrier segment that is embedded 4 inches or greater in asphalt may also be used.

In the test installation of the embedded single slope barrier, asphalt backfill was used under the drainage scuppers. This backfill material does not have a meaningful interaction with the barrier during vehicle impact, and therefore, its material properties do not influence the lateral restraint of the barrier. In a field installation, a different backfill material may be used under the scuppers if desired.

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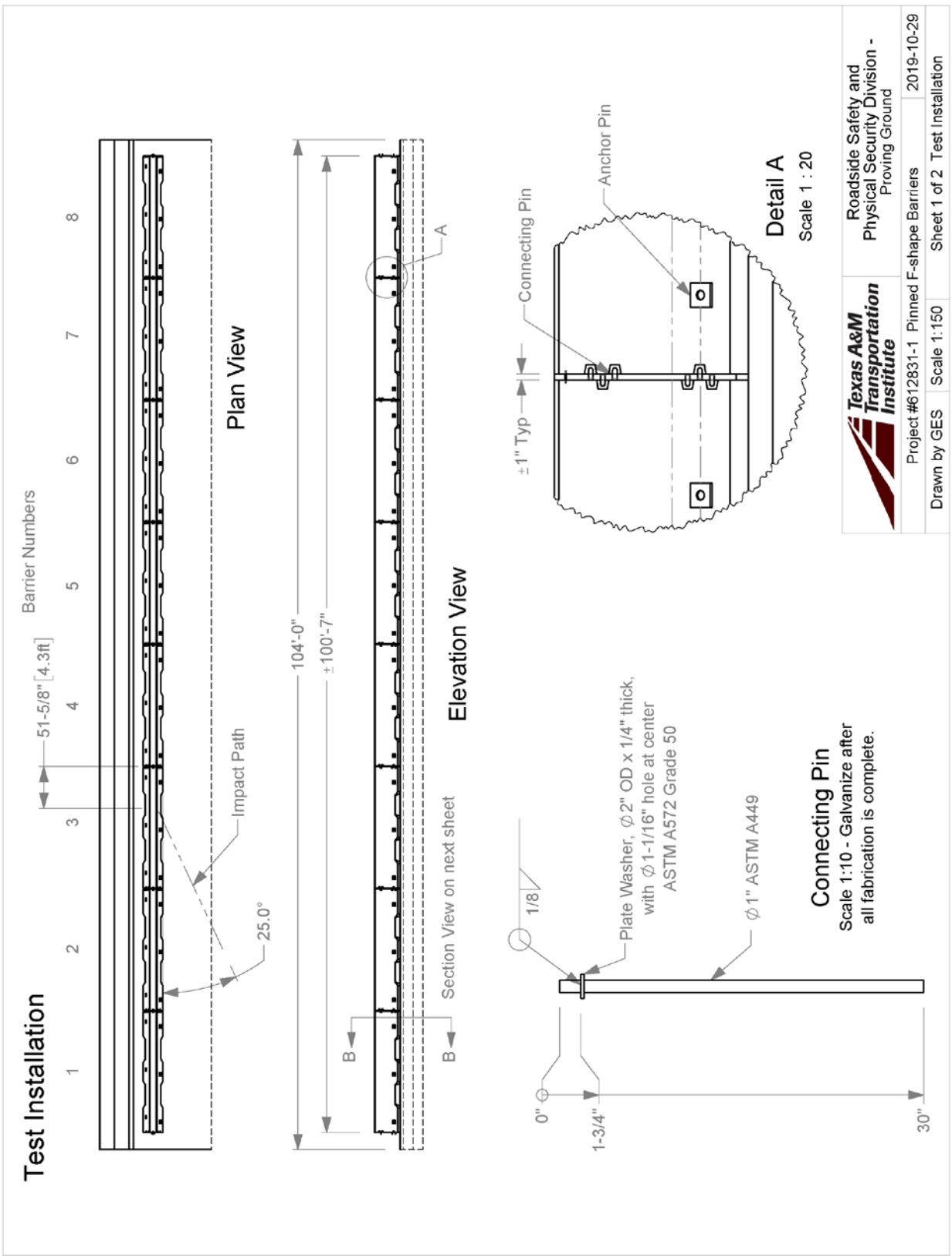
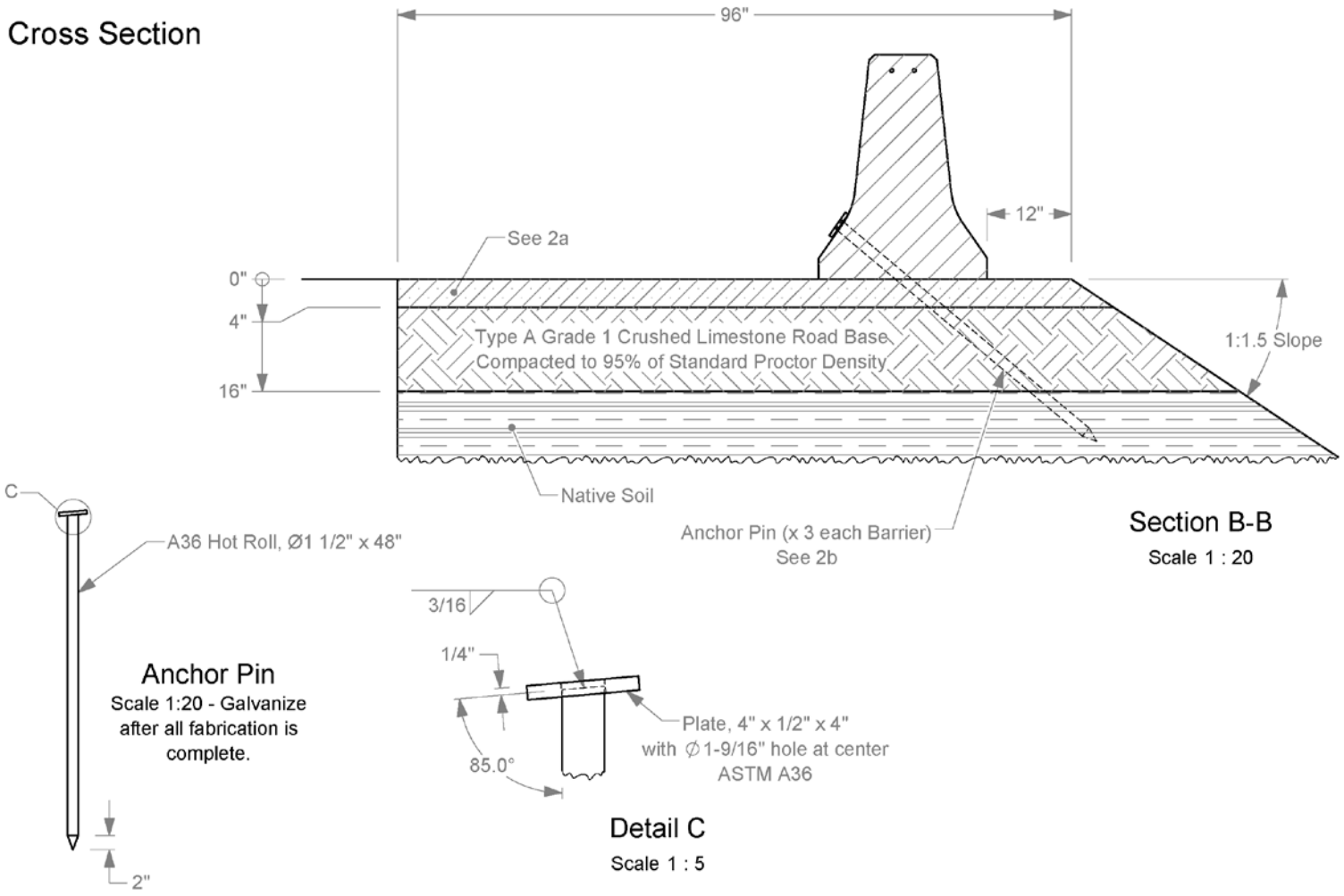
APPENDIX A. DETAILS OF THE TEST ARTICLES

A1. PINNED F-SHAPE BARRIER WITH DRAINAGE SCUPPERS



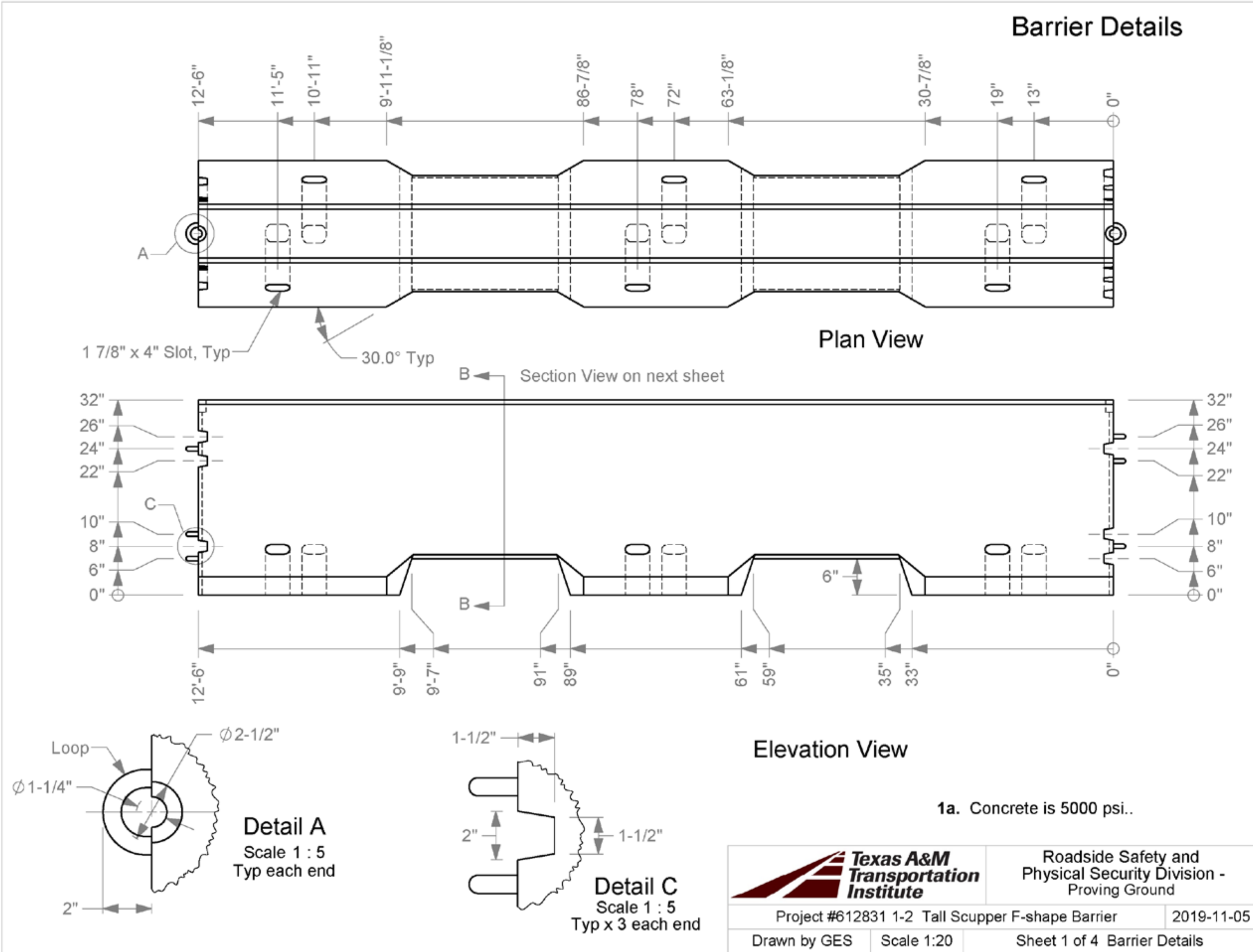


2a. TxDOT Type D Asphalt, applied in two equal lifts. Prime the compacted base with CSS-1H Tack Coat Binder.

2b. Drill Ø1-3/4" holes through the asphalt with masonry bit, using the sleeve as a guide. Insert Anchor Pins, and turn so the plate washers fit snug against the barriers.

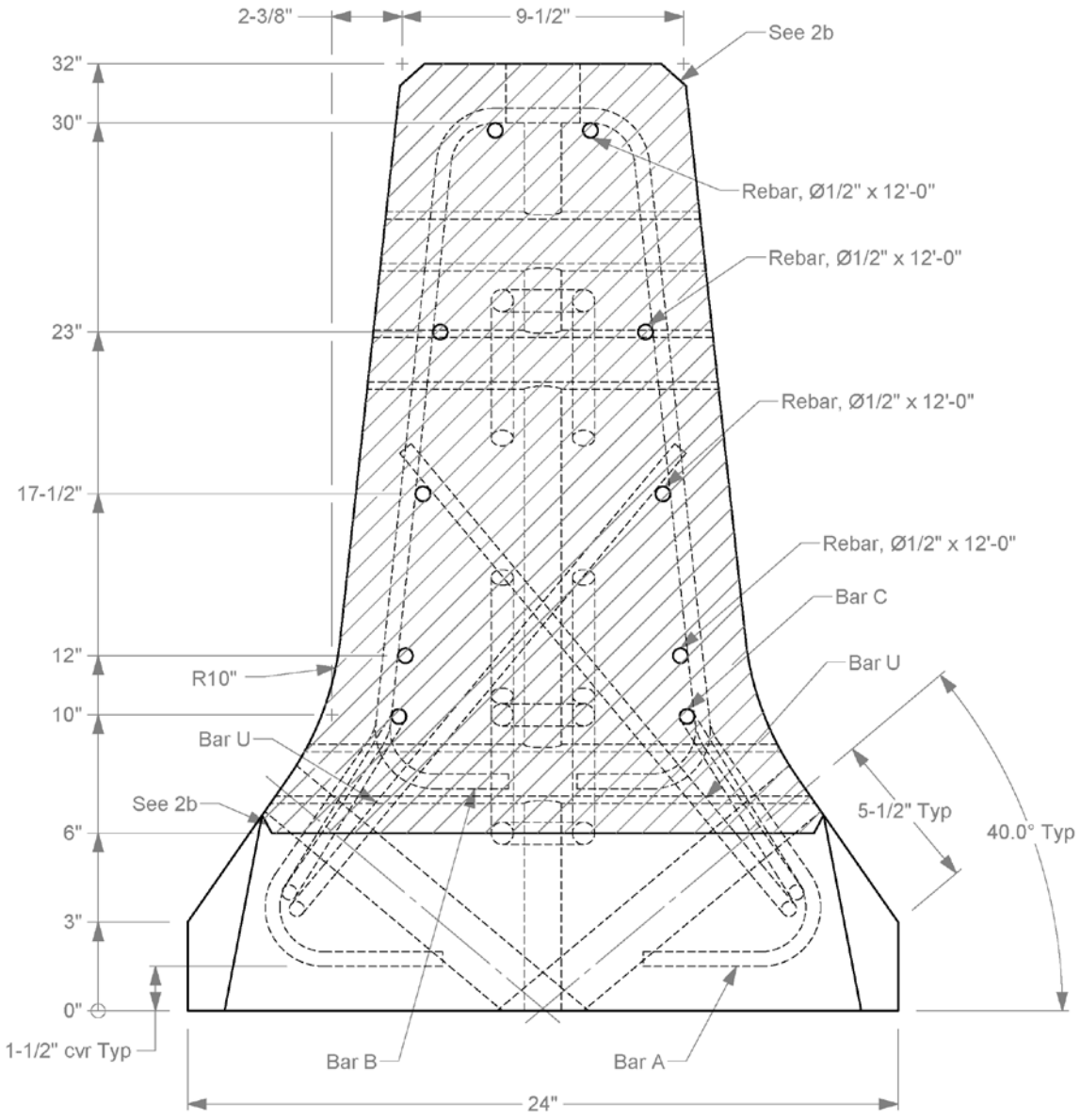
Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground	
Project #612831-1 Pinned F-shape Barriers			2019-10-29
Drawn by GES	Scale 1:150	Sheet 2 of 2 Cross Section	

Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\01-1 F-shape Pinned 3-11\Drafting, 612831-1\612831-1 Drawing



Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\01-2 F-shape Unrestrained 3-11\Drafting, 612831-2\612831 1-2 Barrier

Section B-B



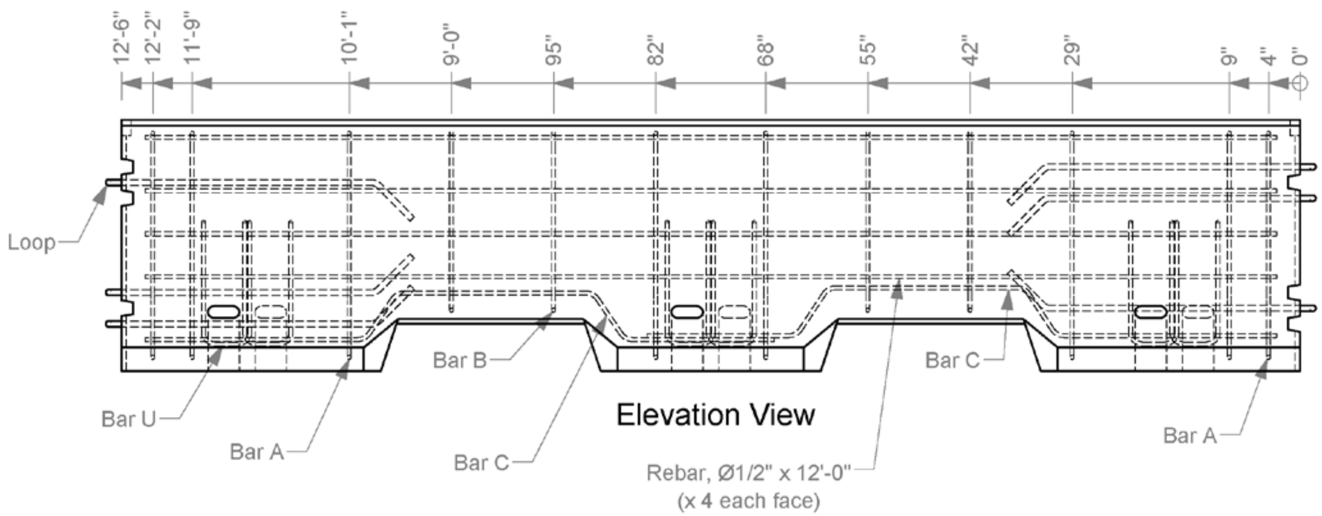
2a. All rebar is grade 60. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).

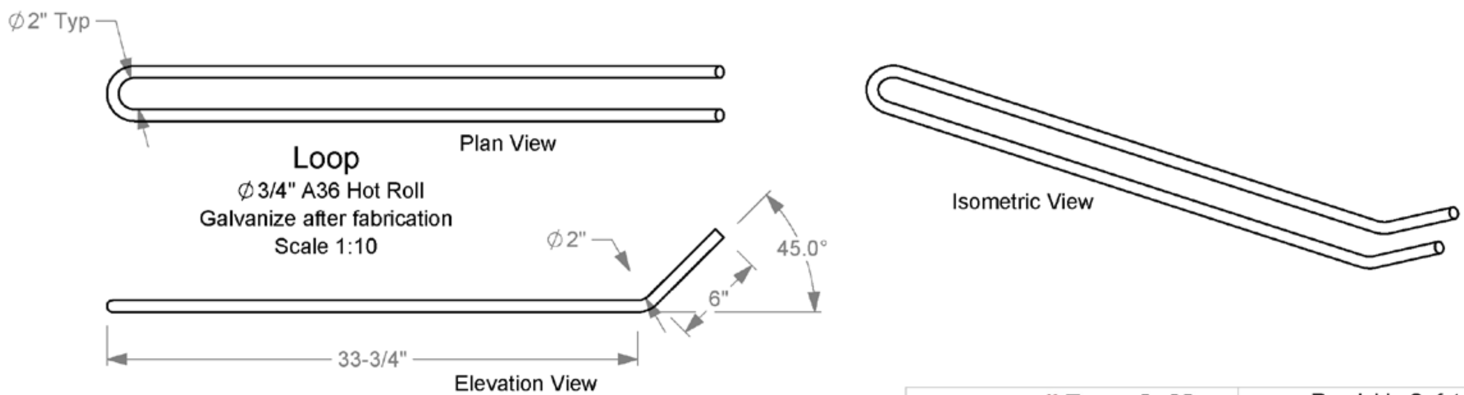
2b. 1" chamfer (3/4" each way) top edges of parapet and scuppers.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612831 1-2 Tall Scupper F-shape Barrier		2019-11-05
Drawn by GES	Scale 1:5	Sheet 2 of 4 / Section View

Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\01-2 F-shape Unrestrained 3-11\Drafting, 612831-2\612831 1-2 Barrier

Rebar, etc





3a. All rebar is grade 60. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).

Texas A&M Transportation Institute

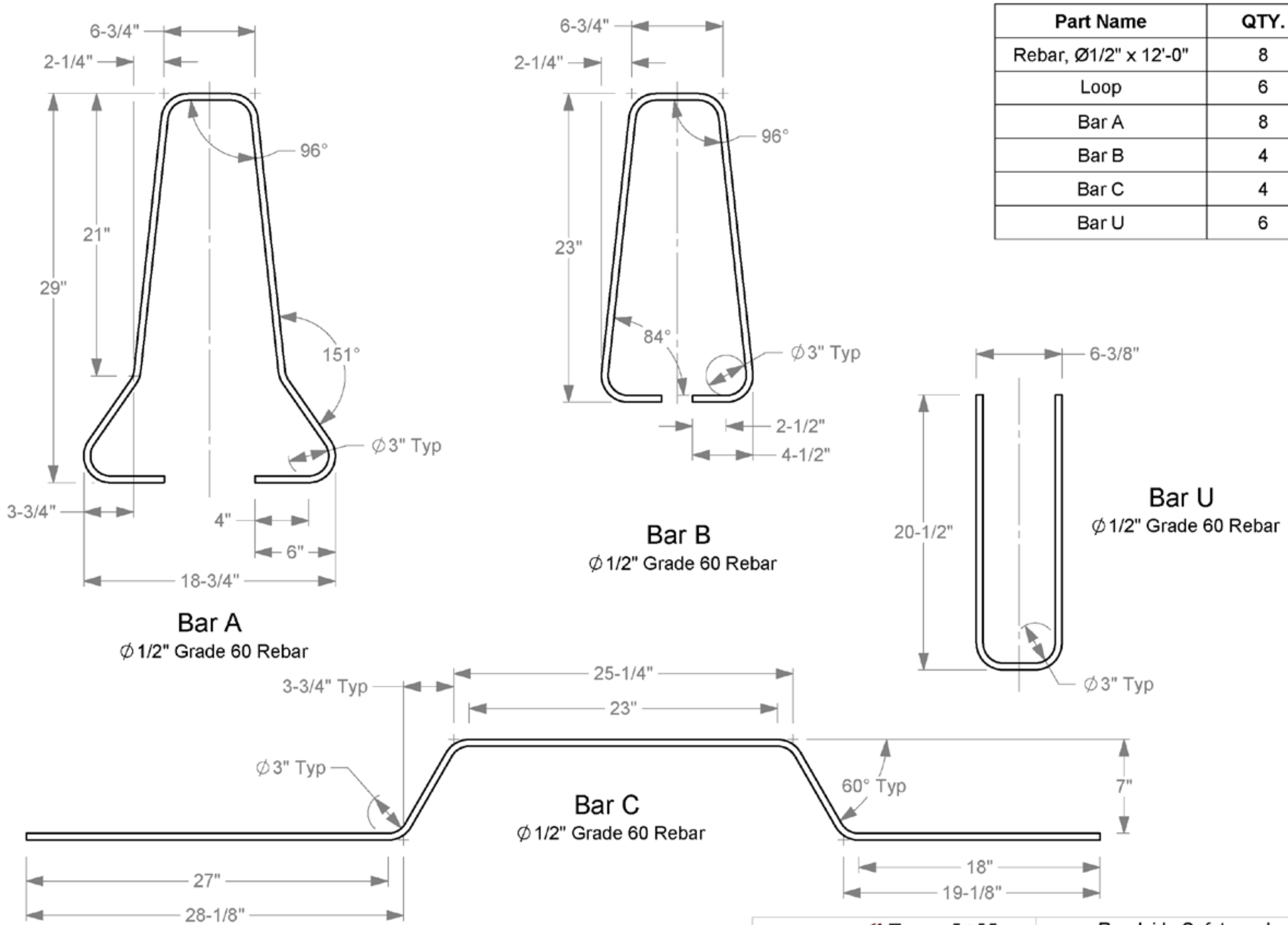
Roadside Safety and Physical Security Division - Proving Ground

Project #612831 1-2 Tall Scupper F-shape Barrier | 2019-11-05

Drawn by GES | Scale 1:20 | Sheet 3 of 4 Rebar, etc

Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\01-2 F-shape Unrestrained 3-11\Drafting, 612831-2\612831 1-2 Barrier

Part Name	QTY.
Rebar, Ø1/2" x 12'-0"	8
Loop	6
Bar A	8
Bar B	4
Bar C	4
Bar U	6



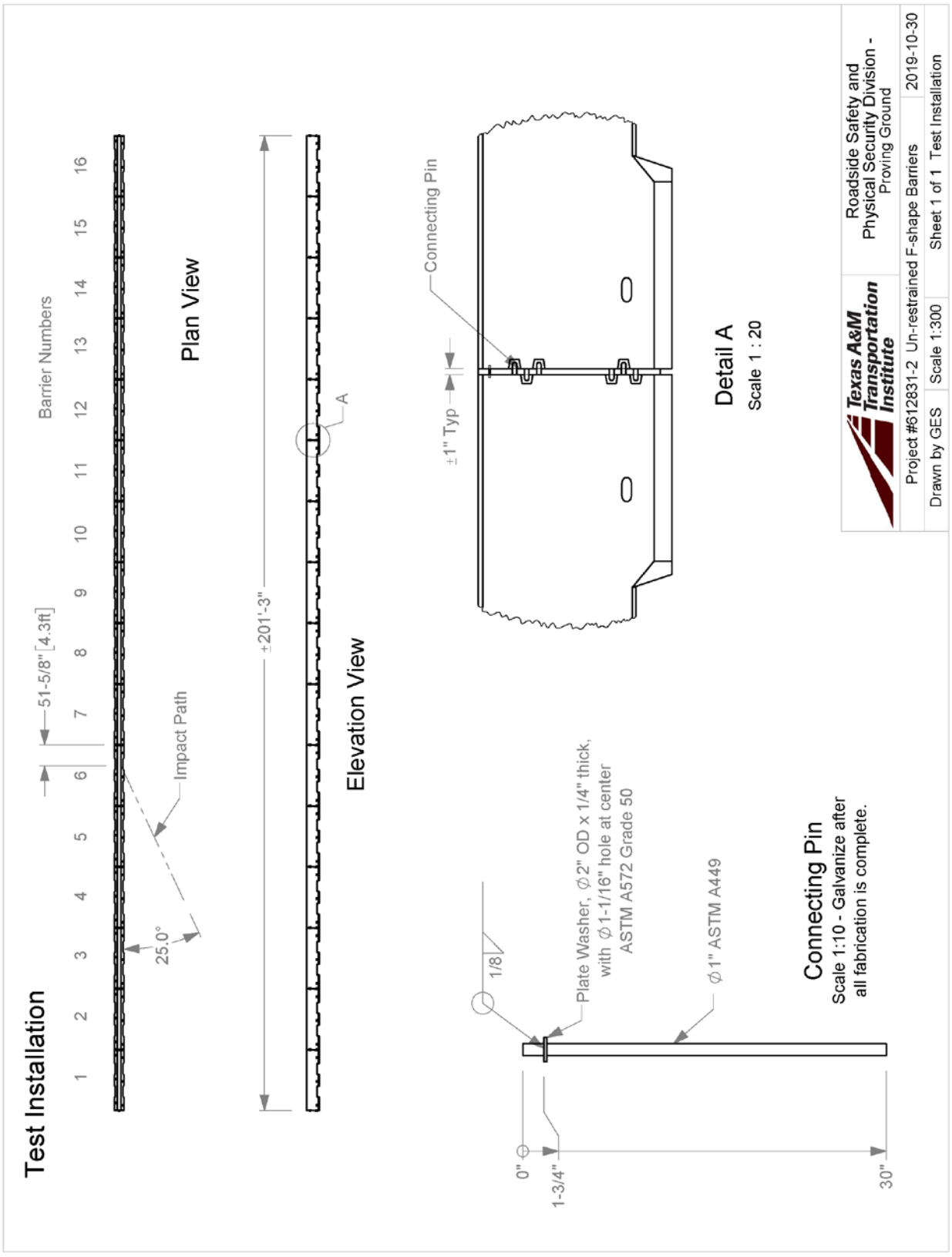
Texas A&M Transportation Institute | Roadside Safety and Physical Security Division - Proving Ground

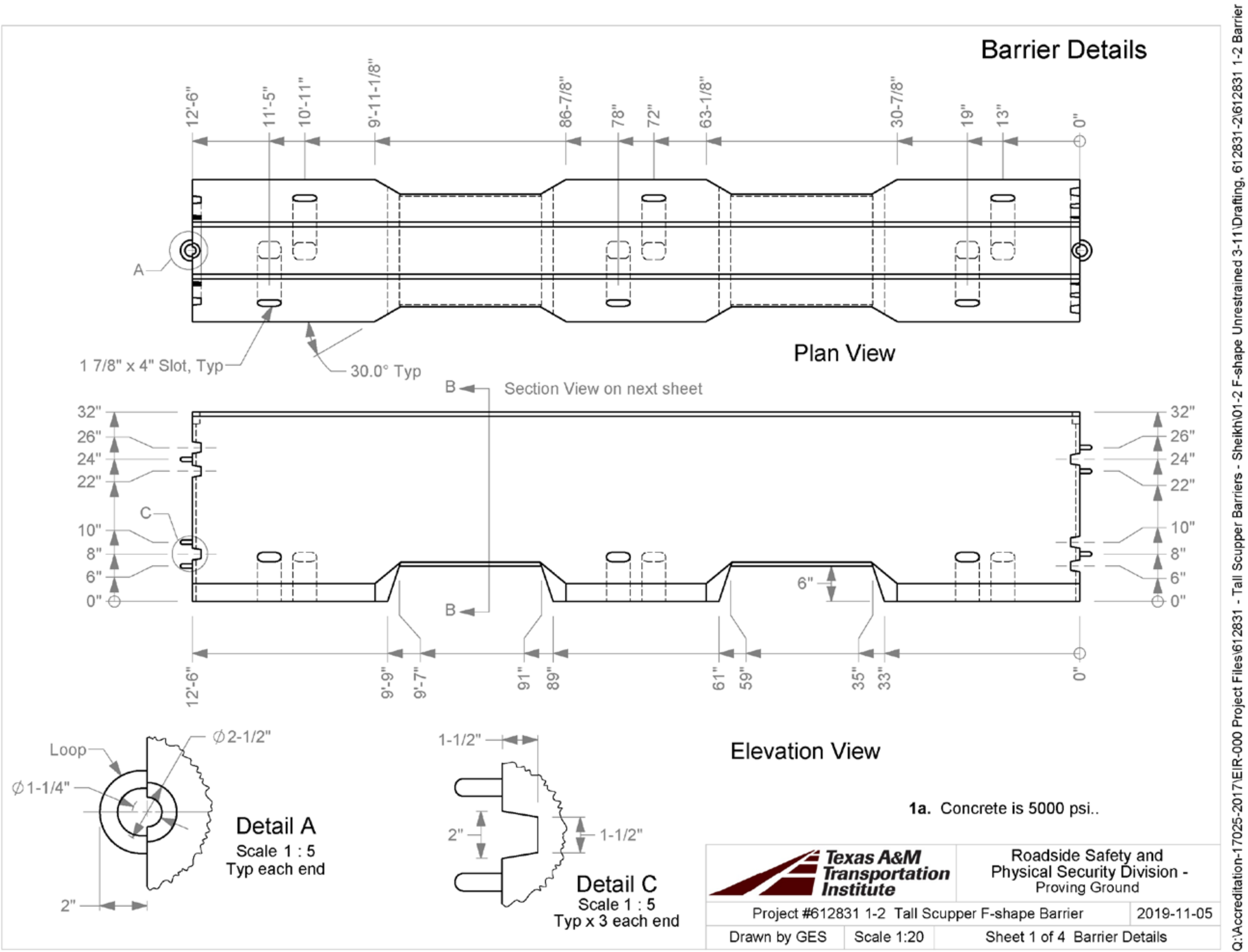
Project #612831 1-2 Tall Scupper F-shape Barrier | 2019-11-05

Drawn by GES | Scale 1:10 | Sheet 4 of 4 Rebar Bends

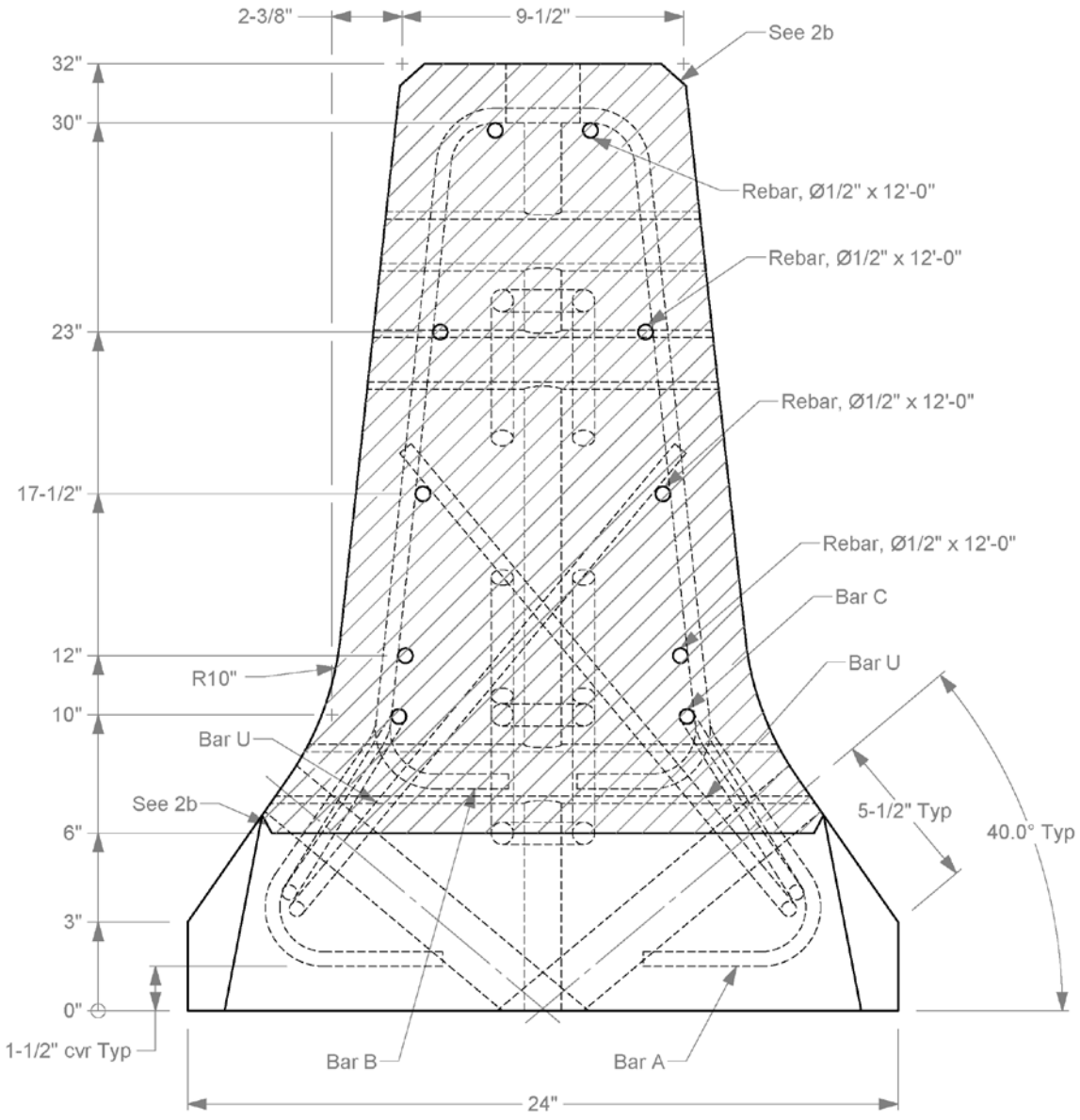
Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\01-2 F-shape Unrestrained 3-11\Drafting, 612831-2\612831 1-2 Barrier

A2. FREE-STANDING F-SHAPE BARRIER WITH DRAINAGE SCUPPERS




Barrier Details
Plan View
1 7/8" x 4" Slot, Typ
30.0° Typ
Section View on next sheet
Elevation View
Detail A
Scale 1 : 5
Typ each end
Loop
Ø2-1/2"
Ø1-1/4"
Detail C
Scale 1 : 5
Typ x 3 each end
1a. Concrete is 5000 psi..
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #612831 1-2 Tall Scupper F-shape Barrier
2019-11-05
Drawn by GES
Scale 1:20
Sheet 1 of 4 Barrier Details
Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\01-2 F-shape Unrestrained 3-11\Drafting, 612831-2\612831 1-2 Barrier

Section B-B



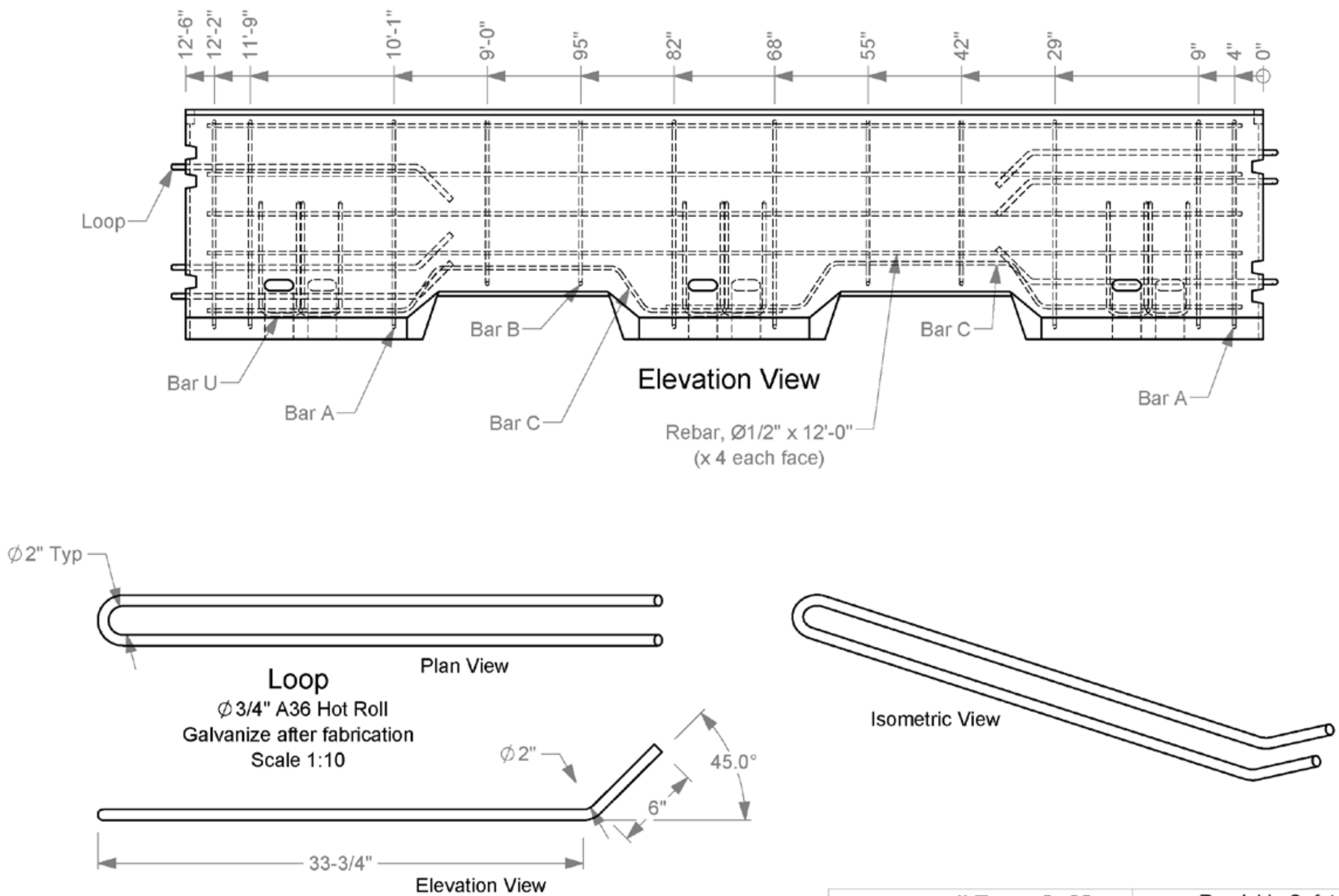
2a. All rebar is grade 60. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).

2b. 1" chamfer (3/4" each way) top edges of parapet and scuppers.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612831 1-2 Tall Scupper F-shape Barrier		2019-11-05
Drawn by GES	Scale 1:5	Sheet 2 of 4 / Section View

Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\01-2 F-shape Unrestrained 3-11\Drafting, 612831-2\612831 1-2 Barrier

Rebar, etc

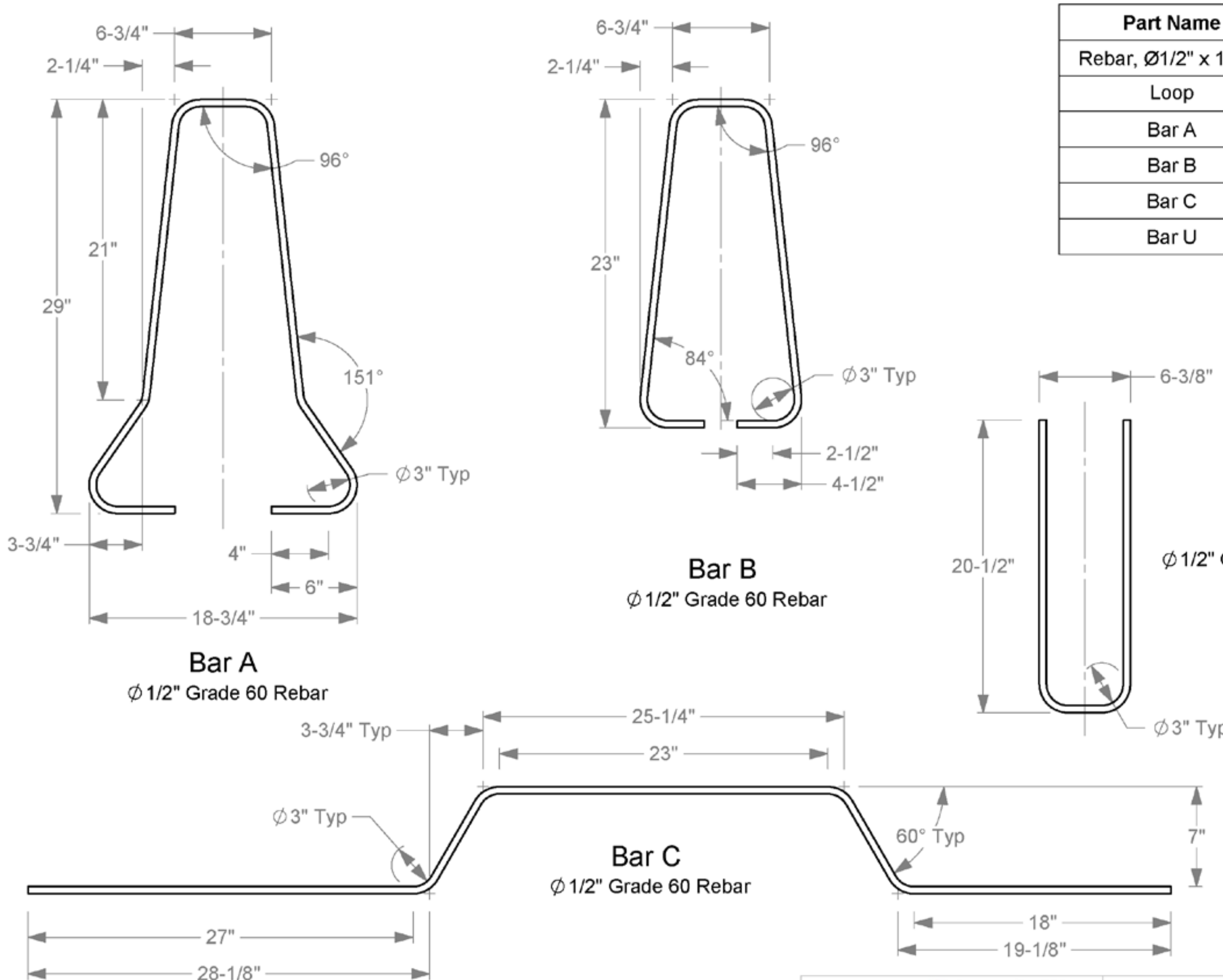


Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground
Project #612831 1-2 Tall Scupper F-shape Barrier	2019-11-05
Drawn by GES / Scale 1:20	Sheet 3 of 4 Rebar, etc

3a. All rebar is grade 60. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).

Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\01-2 F-shape Unrestrained 3-11\Drafting, 612831-2\612831 1-2 Barrier

Part Name	QTY.
Rebar, Ø1/2" x 12'-0"	8
Loop	6
Bar A	8
Bar B	4
Bar C	4
Bar U	6



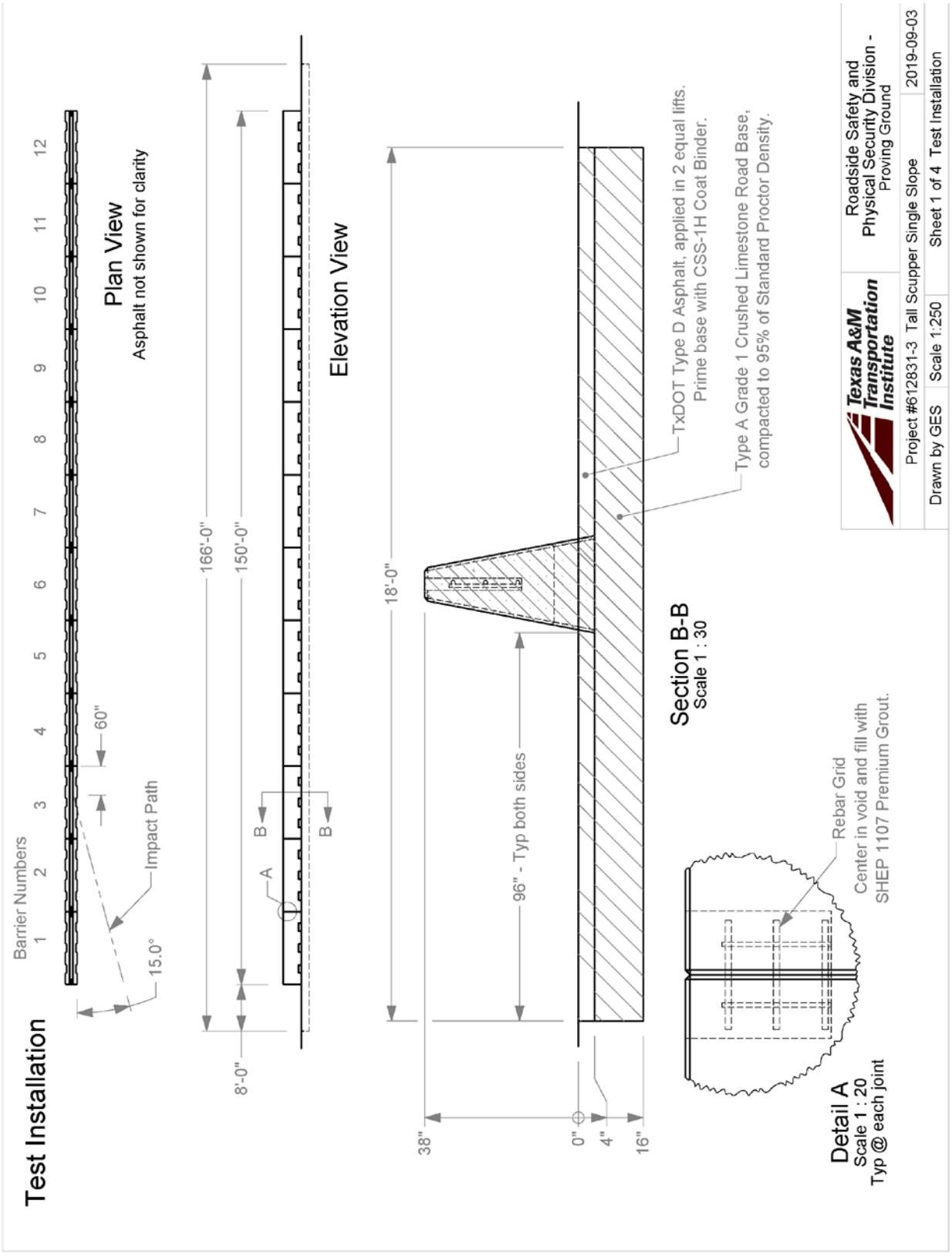
Texas A&M Transportation Institute

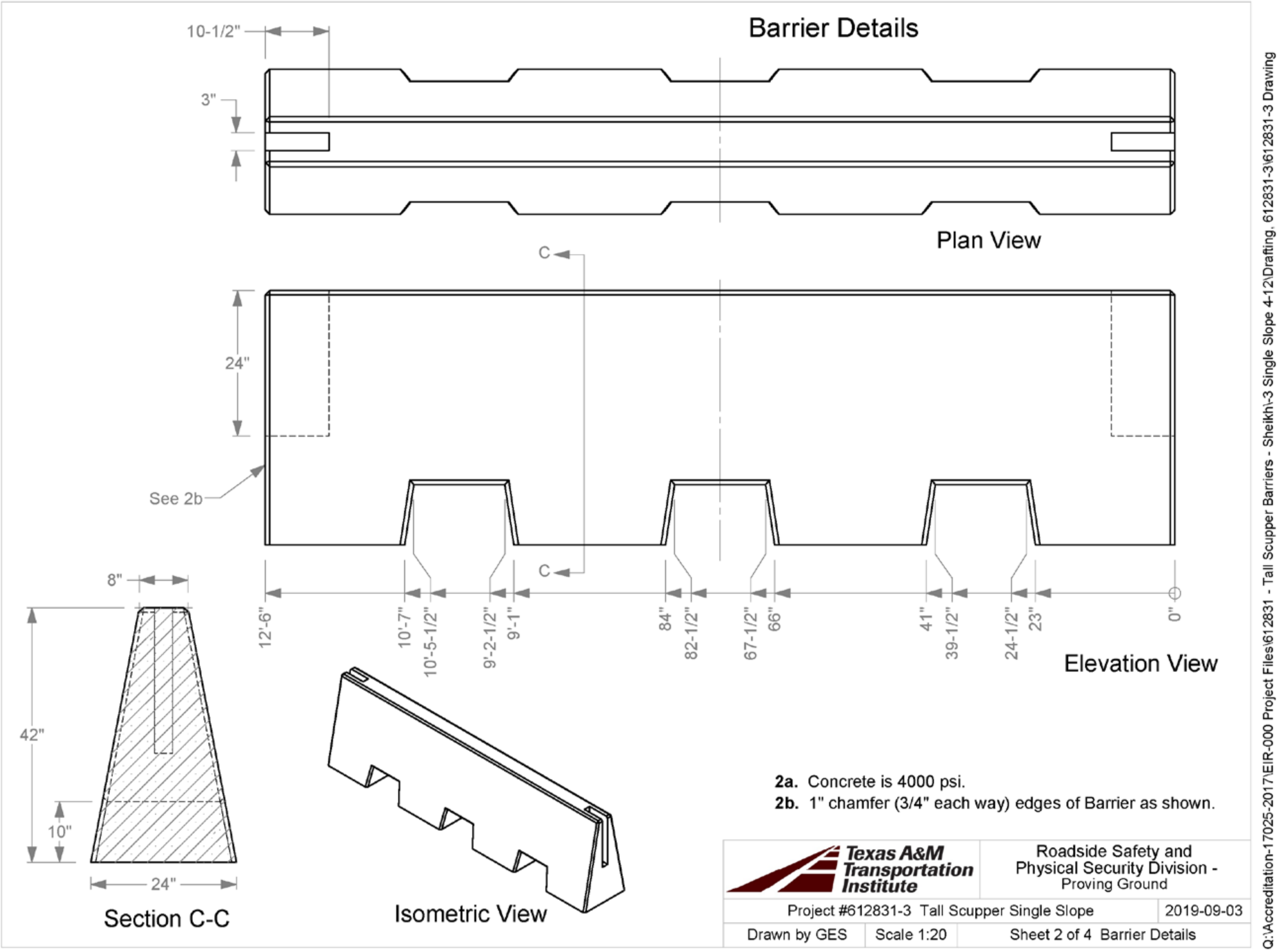
Roadside Safety and Physical Security Division - Proving Ground

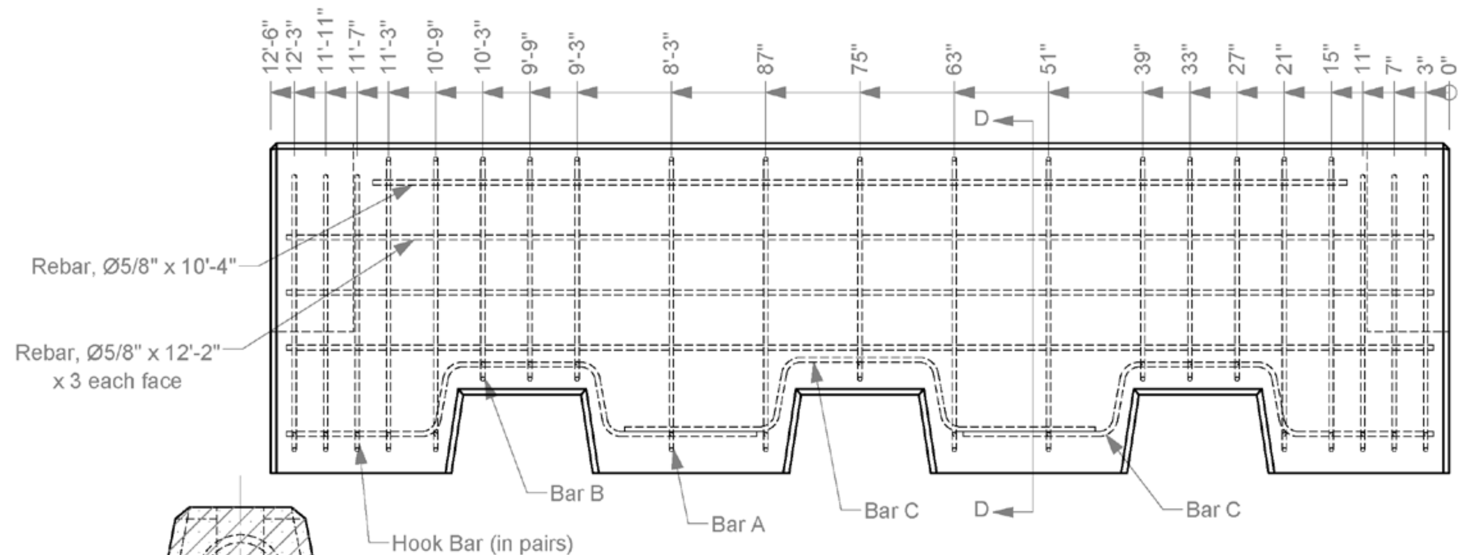
Project #612831 1-2 Tall Scupper F-shape Barrier		2019-11-05
Drawn by GES	Scale 1:10	Sheet 4 of 4 Rebar Bends

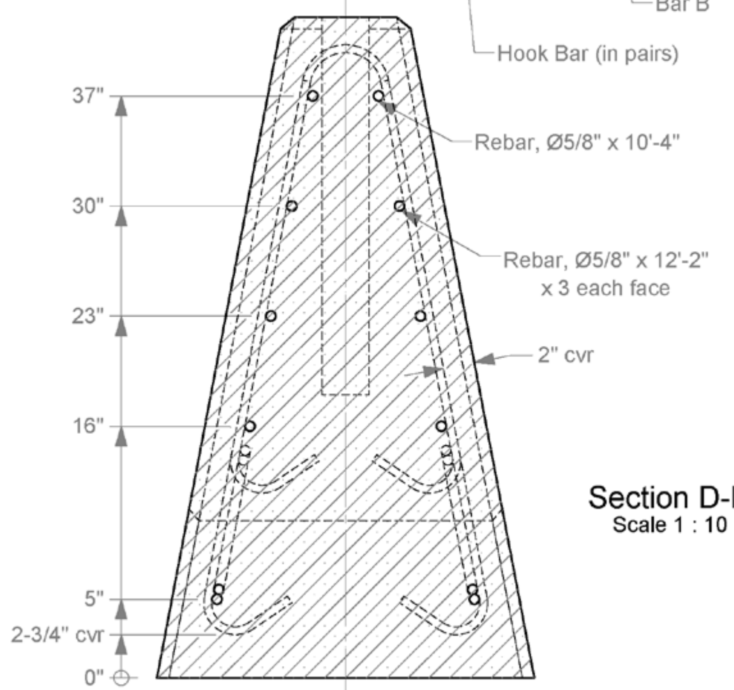
Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\01-2 F-shape Unrestrained 3-11\Drafting, 612831-2\612831 1-2 Barrier

A3 EMBEDDED SINGLE-SLOPE BARRIER WITH DRAINAGE SCUPPERS




Barrier Details
10-1/2"
3"
Plan View
C
24"
See 2b
C
12'-6"
10'-7"
10'-5-1/2"
9'-2-1/2"
9'-1"
84"
82-1/2"
67-1/2"
66"
41"
39-1/2"
24-1/2"
23"
0"
Elevation View
8"
42"
10"
24"
Section C-C
Isometric View
2a. Concrete is 4000 psi.
2b. 1" chamfer (3/4" each way) edges of Barrier as shown.
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #612831-3 Tall Scupper Single Slope
2019-09-03
Drawn by GES
Scale 1:20
Sheet 2 of 4 Barrier Details
Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\-3 Single Slope 4-12\Drafting, 612831-3\612831-3 Drawing





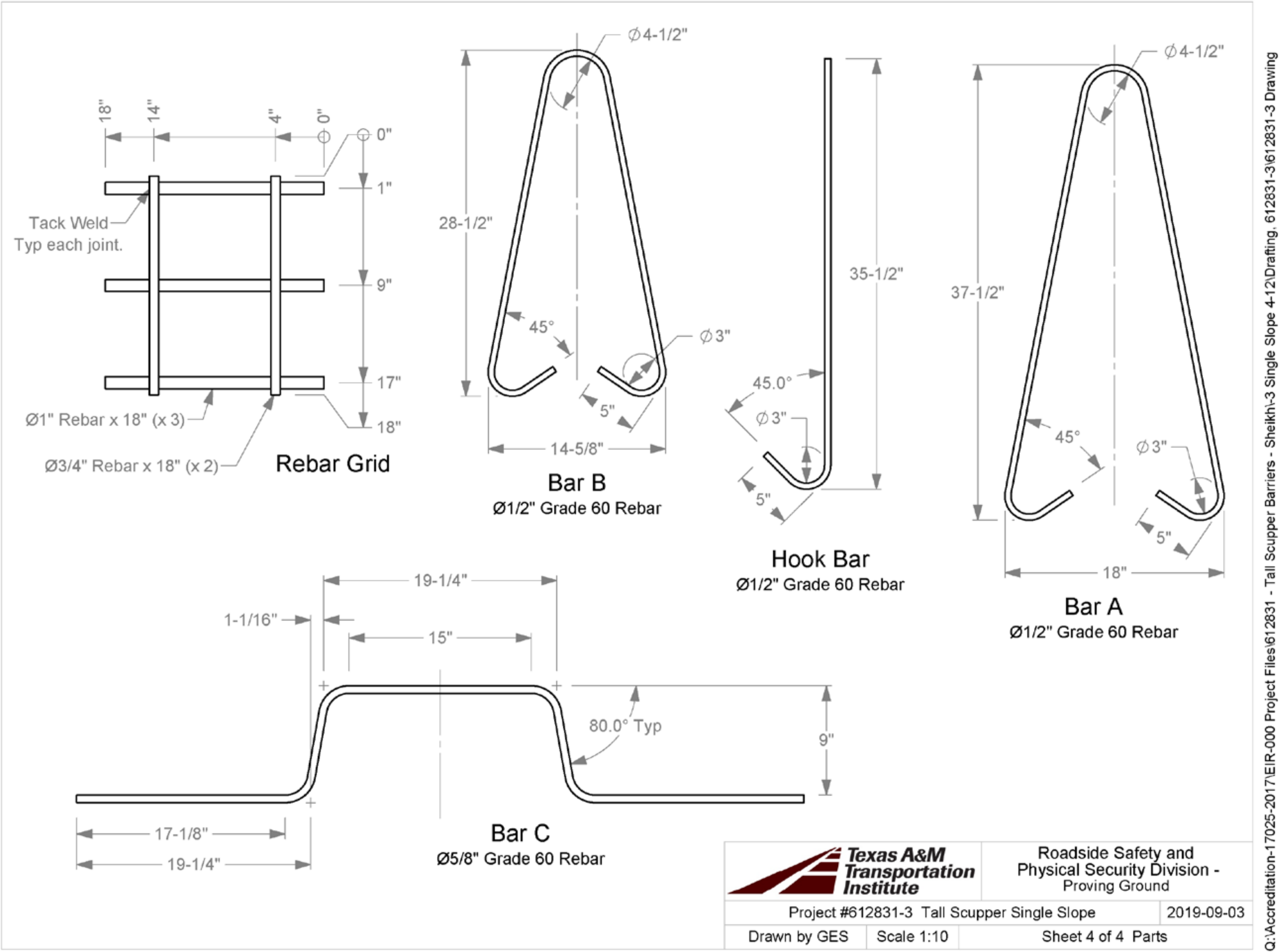
Section D-D
Scale 1 : 10

Part Name	QTY.
Hook Bar	12
Bar A	8
Bar B	7
Bar C	6
Rebar, Ø5/8" x 10'-4"	2
Rebar, Ø5/8" x 12'-2"	6

3a. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).
3b. All rebar is grade 60.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #612831-3 Tall Scupper Single Slope		2019-09-03
Drawn by GES	Scale 1:20	Sheet 3 of 4 Rebar Details

Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\-3 Single Slope 4-12\Drafting, 612831-3\612831-3 Drawing


Rebar Grid
18"
14"
4"
0"
0"
1"
9"
17"
18"
Tack Weld
Typ each joint.
Ø1" Rebar x 18" (x 3)
Ø3/4" Rebar x 18" (x 2)
Bar B
Ø1/2" Grade 60 Rebar
Ø4-1/2"
28-1/2"
45°
Ø3"
5"
14-5/8"
Hook Bar
Ø1/2" Grade 60 Rebar
35-1/2"
45.0°
Ø3"
5"
Bar A
Ø1/2" Grade 60 Rebar
Ø4-1/2"
37-1/2"
45°
Ø3"
5"
18"
Bar C
Ø5/8" Grade 60 Rebar
19-1/4"
1-1/16"
15"
80.0° Typ
9"
17-1/8"
19-1/4"
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #612831-3 Tall Scupper Single Slope
2019-09-03
Drawn by GES
Scale 1:10
Sheet 4 of 4 Parts
Q:\Accreditation-17025-2017\EIR-000 Project Files\612831 - Tall Scupper Barriers - Sheikh\-3 Single Slope 4-12\Drafting, 612831-3\612831-3 Drawing

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

CERTIFIED MILL TEST REPORT
For additional copies call
830-372-8771

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

Rolando A Davila
Quality Assurance Manager

HEAT NO.:3089816 SECTION: REBAR 13MM (#4) 20'0" 420/60 GRADE: ASTM A615-18e1 Gr 420/60 ROLL DATE: 07/16/2019 MELT DATE: 07/16/2019 Cert. No.: 82794205 / 089816A130	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 82794205 BOL#: 73120574 CUST PO#: 823592 CUST P/N: DLVRY LBS / HEAT: 2191.000 LB DLVRY PCS / HEAT: 164 EA

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.44%	Bend Test Diameter	1.750IN		
Mn	0.79%				
P	0.013%				
S	0.031%				
Si	0.18%				
Cu	0.33%				
Cr	0.11%				
Ni	0.20%				
Mo	0.074%				
V	0.000%				
Cb	0.001%				
Sn	0.014%				
Al	0.000%				
Yield Strength test 1	65.8ksi				
Tensile Strength test 1	105.1ksi				
Elongation test 1	15%				
Elongation Gage Lgth test 1	8IN				
Tensile to Yield ratio test1	1.60				
Bend Test 1	Passed				

612831-1, 2, 3

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

REMARKS :

Page 1 OF 1 08/06/2019 09:53:38

TR No. 612831-01

3/4" A36 round bar

DEACERO
EXCELENCIA EN CALIDAD

Acería Ramos Arizpe
CARRETERA MONCLOVA KM 4 NUMERO 2125
TRAMO SANTA CRUZ OJO CALIENTE
C.P./ZIP RAMOS ARIZPE, COAHUILA
Tel/Phone (+52) 01 818 368 1111
MX 01 800 021 3322, USA 1800 332 2376

/ CERTIFICATE OF TEST AN ANALYSIS

No. Certificado / Certificate No:	147830 - 21973241
Fecha / Date:	27/06/2019

P.O 184275 B/L UK4085

Hecho en México / Made in Mexico

DATOS DEL CLIENTE / SOLD TO	CLIENTE CONSIGNADO / SHIP TO	DATOS DEL EMBARQUE / SHIPPING INFORMATION
Cliente / Customer: DEACERO USA INC (HOUSTON DISTRIBUTION CENTER)	Cliente / Customer: DEACERO USA INC (HOUSTON DISTRIBUTION CENTER)	Núm. Viaje / Travel No: 147830
Dirección / Address: 8411 IRVINGTON BLVD	Dirección / Address: 1755 FEDERAL RD	Núm. Factura / Invoice No: FQ85739
Ciudad / City: HOUSTON Estado / State: , TX	Ciudad / City: HOUSTON Estado / State: , TX	Pedido / Customer Order No: 21973241
Teléfono / Phone: 332 2376 País / Country: U.S.A. C.P./ZIP 77022-3		Núm. Plan / Shipping Plan: 158261
Correo Electrónico / eMail:		Fecha Embarque / Date: 26/06/2019
		Orden de Compra / Purchase Order:

COMPOSICIÓN QUÍMICA / CHEMICAL COMPOSITION (% PESO / WEIGHT)

Colada / Heat	Secuencia / Sequence	Clave / Code	Producto / Description of Goods	% C	% Mn	% Si	% P	% S	% Cu	% Cr	% Ni	% Mo	% Sn	% Ti	% V	% Nb	% N	CE
				AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG
26135	9541	13158	ROUND BAR 3/4" A-36 P 20' 1.5T	0.14	0.67	0.18	0.007	0.003	0.24	0.0665	0.0835	0.0205	0.0110	0.0015	0.0043	0.0036	0.0091	0.2705
36240	42241	13158	ROUND BAR 3/4" A-36 P 20' 1.5T	0.21	0.78	0.18	0.010	0.008	0.30	0.1195	0.1145	0.0255	0.0115	0.0014	0.0040	0.0006	0.0088	0.3682
36243	42228	13158	ROUND BAR 3/4" A-36 P 20' 1.5T	0.21	0.73	0.19	0.008	0.003	0.25	0.1170	0.1005	0.0225	0.0120	0.0014	0.0053	0.0003	0.0086	0.3579
36246	42224	13158	ROUND BAR 3/4" A-36 P 20' 1.5T	0.21	0.72	0.20	0.009	0.014	0.26	0.0955	0.1180	0.0270	0.0145	0.0016	0.0055	0.0003	0.0094	0.3530

PROPIEDADES MECÁNICAS / MECHANICAL PROPERTIES

Colada / Heat	Secuencia / Sequence	Clave / Code	Producto / Description of Goods	Calibre / Diameter	Cantidad / Bundle	RT kg/mm²	TS PSI	% Elong / Elong	LF kg/mm²	YS PSI	P. Doblez / Bend Test
						AVG	AVG	AVG	AVG	AVG	
26135	9541	13158	ROUND BAR 3/4" A-36 P 20' 1.5T	3/4"	2	53.39	75973.97	24.70	39.34	55980.82	Cumple / Successfully
36240	42241	13158	ROUND BAR 3/4" A-36 P 20' 1.5T	3/4"	2	50.45	71790.35	31.79	35.14	50004.22	Cumple / Successfully
36243	42228	13158	ROUND BAR 3/4" A-36 P 20' 1.5T	3/4"	3	45.71	65045.33	32.91	35.01	49819.23	Cumple / Successfully
36246	42224	13158	ROUND BAR 3/4" A-36 P 20' 1.5T	3/4"	6	48.26	68673.98	33.05	29.19	41537.37	Cumple / Successfully

CE=[C]+([Cu]/40)+([Mn]/6)+([Ni]/20)+([Cr]/10)-([Mo]/50)-([V]/10)

DEACERO +VERDE

Certificamos que este material ha sido producido, inspeccionado y probado de acuerdo a las normas de fabricación del acero aplicables a la ASTM A36-2008, A529-2005 (re aprobada el 2009), A572-2012 y A992-2011 y a las normas dimensionales NMX B252, ASTM A6/A6M-2012. / We certify that this material has been produced hot-rolled carbon, inspected and tested according to standards applicable steelmaking to ASTM A36-2008, A529-2005 (Reapproved 2009), A572-2012 y A992-2011, and the dimensional standards NMX B252, ASTM A5/A6M-2012.

JUAN ALEJANDRO GALVAN GARCIA
Gerente de Aseguramiento de Calidad / Quality Assurance Manager

64

2020-05-07

BL HOU-762501-1 3/29/2019
Order HOU-131906-1 Page: 1 of 2

DEACERO
EXCELENCIA EN CALIDAD

Acería Ramos Arizpe
CARRETERA MONCLOVA KM 4 NUMERO 2125
TRAMO SANTA CRUZ OJO CALIENTE
C.P./ZIP RAMOS ARIZPE, COAHUILA
Tel/Phone (+52) 01 818 368 1111
MX 01 800 021 3322, USA 1800 332 2376

/ CERTIFICATE OF TEST AN ANALYSIS

No. Certificado / Certificate No:	135714 - 21847733
Fecha / Date:	22/01/2019

Hecho en México / Made in Mexico

DATOS DEL CLIENTE / SOLD TO	CLIENTE CONSIGNADO / SHIP TO	DATOS DEL EMBARQUE / SHIPPING INFORMATION
Cliente / Customer: DEACERO USA INC (HOUSTON DISTRIBUTION CENTER)	Clienta / Customer: DEACERO USA INC (HOUSTON DISTRIBUTION CENTER)	Núm. Viaje / Travel No: 135714
Dirección / Address: 8411 IRVINGTON BLVD	Dirección / Address: 1755 FEDERAL RD	Núm. Factura / Invoice No: FQ77449
Ciudad / City: HOUSTON Estado / State: , TX	Ciudad / City: HOUSTON Estado / State: , TX	Pedido / Customer Order No: 21847733
Teléfono / Phone: 332 2376 País / Country: U.S.A. C.P./ZIP 77022-3		Núm. Plan / Shipping Plan: 144949
Correo Electrónico / eMail:		Fecha Embarque / Date: 21/01/2019
		Orden de Compra / Purchase Order:

PO/REL HOU-STOCK/
HEAT: 33530

COMPOSICIÓN QUÍMICA / CHEMICAL COMPOSITION (% PESO / WEIGHT)

Colada / Heat	Secuencia / Sequence	Clave / Code	Producto / Description of Goods	% C	% Mn	% Si	% P	% S	% Cu	% Cr	% Ni	% Mo	% Sn	% Ti	% V	% Nb	% N	CE
				AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG
33530	39468	60683	ROUND BAR 1 1/2" A-36 P 20' 2.0T	0.22	0.75	0.20	0.009	0.009	0.24	0.0740	0.0745	0.0170	0.0140	0.0010	0.0043	0.0024	0.0102	0.3682
33507	743	60584	FLAT BAR 1 1/2" x 3/16" A-36 P 20' 2.0T	0.21	0.73	0.21	0.012	0.004	0.24	0.0650	0.0840	0.0195	0.0120	0.0011	0.0044	0.0015	0.0092	0.3523
33509	740	60584	FLAT BAR 1 1/2" x 3/16" A-36 P 20' 2.0T	0.21	0.77	0.24	0.010	0.005	0.21	0.0740	0.0790	0.0185	0.0120	0.0014	0.0048	0.0017	0.0084	0.3648
33510	736	60584	FLAT BAR 1 1/2" x 3/16" A-36 P 20' 2.0T	0.21	0.76	0.23	0.011	0.010	0.24	0.0760	0.0880	0.0250	0.0120	0.0011	0.0040	0.0016	0.0086	0.3623
33512	739	60584	FLAT BAR 1 1/2" x 3/16" A-36 P 20' 2.0T	0.20	0.76	0.23	0.014	0.011	0.21	0.0810	0.0625	0.0170	0.0090	0.0011	0.0044	0.0012	0.0085	0.3500
33514	734	60584	FLAT BAR 1 1/2" x 3/16" A-36 P 20' 2.0T	0.21	0.76	0.22	0.014	0.005	0.27	0.1040	0.0795	0.0160	0.0140	0.0012	0.0042	0.0014	0.0088	0.3592
105080	39839	60611	ANGLE 1 1/2" x 1 1/2" x 1/8" A36/529-50 20' 2.0T	0.20	0.72	0.20	0.007	0.020	0.16	0.0925	0.0634	0.0223	0.0100	0.0014	0.0052	0.0023	0.0000	0.3451

PROPIEDADES MECÁNICAS / MECHANICAL PROPERTIES

Colada / Heat	Secuencia / Sequence	Clave / Code	Producto / Description of Goods	Calibre / Diameter	Cantidad / Bundle	RT kg/mm²	TS PSI	% Elong / Elong	LF kg/mm²	YS PSI	P. Doblez / Bend Test
						AVG	AVG	AVG	AVG	AVG	
33530	39468	60683	ROUND BAR 1 1/2" A-36 P 20' 2.0T	1 1/2"	5	52.42	74593.66	32.58	32.24	45877.52	Cumple / Successfully
33507	743	60584	FLAT BAR 1 1/2" x 3/16" A-36 P 20' 2.0T	1 1/2" x 3/16"	4	43.72	62213.56	30.57	30.44	43316.12	Cumple / Successfully
33509	740	60584	FLAT BAR 1 1/2" x 3/16" A-36 P 20' 2.0T	1 1/2" x 3/16"	2	50.85	72359.55	31.06	36.79	52352.17	Cumple / Successfully
33510	736	60584	FLAT BAR 1 1/2" x 3/16" A-36 P 20' 2.0T	1 1/2" x 3/16"	1	52.77	75091.71	33.54	37.22	52964.06	Cumple / Successfully
33512	739	60584	FLAT BAR 1 1/2" x 3/16" A-36 P 20' 2.0T	1 1/2" x 3/16"	1	52.11	74152.53	31.57	36.20	51512.60	Cumple / Successfully
33514	734	60584	FLAT BAR 1 1/2" x 3/16" A-36 P 20' 2.0T	1 1/2" x 3/16"	2	42.26	60135.98	32.38	36.97	52608.31	Cumple / Successfully

ROUND BAR A-36/A 529 GR50
1-1/2 X 20'

DEACERO +VERDE

Certificamos que este material ha sido producido, inspeccionado y probado de acuerdo a las normas de fabricación del acero aplicables a la ASTM A36-2008, A529-2005 (re aprobada el 2009), A572-2012 y A992-2011 y a las normas dimensionales NMX B252, ASTM A6/A6M-2012. / We certify that this material has been produced hot-rolled carbon, inspected and tested according to standards applicable steelmaking to ASTM A36-2008, A529-2005 (Reapproved 2009), A572-2012 y A992-2011, and the dimensional standards NMX B252, ASTM A6/A6M-2012.

GUSTAVO GABRIEL MANCILLA GARZA
Gerente de Aseguramiento de Calidad / Quality Assurance Manager

TR No. 612831-01

BL HOU-762501-1 3/29/2019
Order HOU-131906-1 Page:2 of 2

DEACERO
EXCELENCIA EN CALIDAD

Acería Ramos Arizpe
CARRETERA MONCLOVA KM 4 NUMERO 2125
TRAMO SANTA CRUZ OJO CALIENTE
C.P./ZIP RAMOS ARIZPE, COAHUILA
Tel/Phone (+52) 01 818 368 1111
MX 01 800 021 3322, USA 1800 332 2376

/ CERTIFICATE OF TEST AN ANALYSIS

No. Certificado / Certificate No:	135714 - 21847733
Fecha / Date:	22/01/2019

Hecho en México / Made in Mexico

PROPIEDADES MECÁNICAS / MECHANICAL PROPERTIES

Colada / Heat	Secuencia / Sequence	Clave / Code	Producto / Description of Goods	Calibre / Diameter	Cantidad / Bundle	RT kg/mm²	TS PSI	% Elong / Elong	LF kg/mm²	YS PSI	P. Doblez / Bend Test
						AVG	AVG	AVG	AVG	AVG	
105080	39839	60611	ANGLE 1 1/2" x 1 1/2" x 1/8" A36/529-50 20' 2.0T	1 1/2" x 1 1/2" x 1/8"	4	53.17	75660.91	34.29	37.24	52992.52	Cumple / Successfully

PO/REL HOU-STOCK/
HEAT: 33530

99

DEACERO +VERDE

Certificamos que este material ha sido producido, inspeccionado y probado de acuerdo a las normas de fabricación del acero aplicables a la ASTM A36-2008, A529-2005 (re aprobada el 2009), A572-2012 y A992-2011 y a las normas dimensionales NMX B252, ASTM A6/A6M-2012. / We certify that this material has been produced hot-rolled carbon, inspected and tested according to standards applicable steelmaking to ASTM A36-2008, A529-2005 (Reapproved 2009), A572-2012 y A992-2011, and the dimensional standards NMX B252, ASTM A6/A6M-2012.

ROUND BAR A-36/A 529 GR50
1-1/2 X 20'

GUSTAVO GABRIEL MANCILLA GARZA
Gerente de Aseguramiento de Calidad / Quality Assurance Manager

2020-05-07

09-23-2019 23:53 Load - 3420331 BL - 3870965 blr466

Custom Fabricators Heat - 2910110

Cust. PO - CF19-24152 Order - 17857122

½" A36 plate pg 1 of 2

Kloeckner metals

Kloeckner Metals Corporation

Kloeckner Metals Corp - HTX
7400 Mesa Drive
Houston,TX 77028, United States
(713) 633-7400

Material Certifications for Shipment August 13, 2019

Bl Num: 8.0e5e83

Customer
Kloeckner Metals Corp - HOU
11333 Almeda Road
Houston,TX 770513510

Ship To
Kloeckner Metals Corp-HOU
14200 Almeda 88
Houston,TX 77053-2513

Orders

Order No	SA Ord	Width	Length	Description/Part Number	Grade
17705462-1		48.000	96.000	Strip Mill Plate 1/2	A5TM A36

Cust PO: 7415486

Heat: 2910110 Mill ID:2910110-4 Vendor: NUCOR STEEL - BERKELEY

Certification # 4724465 Issue Date: 26-JUL-19

Carbon Equivalent: .29

Chemical Properties

C	Mn	P	S	Si	Al	B	Ca	Cr	Cu
.19L	.490	.012	.031	.040	.025	.000	.001	.050	.080

Mo	N	Nb	Ni	Sn	Ti	V
.010	.006	.000	.030	.006	.001	.001

Physical Properties

Property	YIELD	TENSILE	ELONG
Mill Test	45.5 KSI	65 KSI	37.0
Internal Test Head			
Internal Test Middle			
Internal Test Tail			

	NVALUE	ROCKWELL
	.2	60

Charpy Properties

Property	CHARPY SAMPLE	IMPACT FT-LBS1	IMPACT FT-LBS2	IMPACT FT-LBS3	AVG FT-LBS
Value					
Internal Test Head					
Internal Test Middle					
Internal Test Tail					

EDI#63_1424141

We certify that the listed information is correct as contained in the records of the company and that all results meet the requirements of the specification cited above. All ASME Section II Part A specifications are 2017 Edition. All Charpy tests are at -20 F unless otherwise indicated.

Page 3

09-23-2019 23:53 Load - 3420331 BL - 3870965 blr466
Custom Fabricators Heat - 2910110
Cust. PO - CF19-24152 Order - 17857122

1/2" A36 plate pg 2 of 2

08-13-2019 16:25 Load - 3386911 BL - 81069683 blr466
Kloeckner Metals Corp - HOU Heat - 2910110
Cust. PO - 7418486 Order - 17709462

METALLURGICAL TEST REPORT
Nucor Steel Berkeley
a division of NUCOR corporation

1455 Hagan Avenue
Huger, SC 29450

Phone: 843-336-6000
Sales Fax: 843-336-6150

Issuance Date 7/26/19 MTR# 1597077 MTR DER INQUIRIES@NUCOR.COM

Sold To:	Ship To:	
KLOECKNER METALS CORPORATION	COASTAL CARGO	Ship Date 7/26/19
500 COLONIAL CTR PKWY	16800 PENINSULA BLVD	Bill of Lading # 1424141
STE 500	CPT CARE TERMINALS	Vehicle # SOMERSET
ROSWELL, GA 30076	HOUSTON, TX 77067	Rls # BLUE
		P/O # 7403049
		Mill Order # 465927-11
		Part # .49X48 A635 HTX

Gauge x Width .4900 MIN X 48.0000 MIN HR HOT ROLL COIL
ASTM A1018 / SS GR36 TYPE 2 / REV: 2018

SUITABLE FOR CONVERSION TO ASTM A36

Heat	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	V	Nb	N	Ti	B	Ca
2910110	.19	.49	.012	.001	.04	.08	.03	.05	.01	.006	.025	.003	.000	.006	.001	.000	.001

Heat/Coils	YIELD STRENGTH (ksi) long.	YIELD STRENGTH (ksi) trans.	TENSILE STRENGTH (ksi) long.	TENSILE STRENGTH (ksi) trans.	ELONGATION (% IN 2") long.	ELONGATION (% IN 2") trans.	HARDNESS (Rockwell B)	N Value long.	N Value trans.
2910110-1		45.2		66.6		31	72		.17
2910110-7		43.5		65.0		37	60		.20

Coil (tag) 2910110-4 (47080.00 LB) 2910110-5 (47160.00 LB) 2910110-6 (47160.00 LB)

Mill Test Reports according to EN10204 3.1

All material is sold subject to the description, specifications and terms and conditions set forth on the face and reverse side of Nucor Steel - Berkeley's sales order acknowledgment.

Tensile Testing, when applicable, is performed in accordance with ASTM A-370 specifications. Specimen is machined to standard rectangular test configuration (Figure 3 of ASTM A-370) with a 2" gage length. Yield Strength is determined at 0.2% offset.

This material has been produced in compliance with the chemistry and established rolling practices of the ordered specification. If material is ordered to a chemical composition only and if physical testing is not a requirement of the customer's order, testing is not performed by the producer.

We hereby certify the above information is correct as contained in the records of the corporation.

Kevin Skero, Hot Mill Metallurgist
Robert Moses, Chief Metallurgist

** 100% MELTED AND MANUFACTURED IN THE USA **

Material Test Report

aaris™ LLC

7953 Washington Woods Dr.,
Dayton, OH 45459
Phone: (937)573-4675 Fax: (702)926-4128

3.125 x .095

Date 5/05/2019 MTR No. 0000065775
Ref No 108380

TEST CERTIFICATE ACC TO DIN 50049 : 3.1 B/EN: 10204: 3.1

Customer:

Part Number:2233-N

PO Number:146313

Description: ASTM A513T5-14, SRA-(BKS); DOM; Grade=1020; Category=CARBON WELDED; Round; OD=3.125"; ID=2.935"; (WT=0.095"); Deburred; Length=240" to 288"

Product: TUBE

Ends: Deburred

Heat No: 18C6983

Steel Grade: 1020

DIMENSIONS	MM	IN	TOLERANCE -VE	+VE	UOM
OD	79.375	3.125	0.0000	0.0090	IN
ID	74.549	2.935	0.0090	0.0000	IN
WT	2.413	0.095	0.0000	0.0000	IN

QUANTITY	NUMBER	METER / FT		WEIGHT TON
	5	804.672	2,640.000	4.058
	6,096.000	7,315.200 MM	240.000 - 288.000 IN	

CHEMICAL ANALYSIS

ELEMENTS	UOM	MIN	MAX	MILL	PRODUCT
Carbon (C)	%	0.1800	0.2300	0.2010	
Manganese (Mn)	%	0.3000	0.6000	0.4510	
Silicon (Si)	%			0.0270	
Aluminum (AL)	%			0.0370	
Phosphorus (P)	%		0.0350	0.0150	
Sulfur (S)	%		0.0350	0.0060	
Chromium (Cr)	%				
Nickel (Ni)	%				
Molybdenum (Mo)	%				
Vanadium (V)	%				
Copper (Cu)	%				
Columbium (CB)	%				
Calcium (Ca)	%				
Titanium (Ti)	%				
Nitrogen (N)	%				
Boron (B)	%				
Zirconium (Zr)	%				
Antimony (Sb)	%				
Tin (Sn)	%				

MECHANICAL PROPERTIES

	Y.S Psi	U.T.S Psi	% E	HARDNESS HRB
MIN	55.000	65.000	10.00	75.00
MAX				
MILL PROD	72.020	81.490	12.00	85.00

Sample Orientation
Tensile Spec Type:
Gauge Width (MM):

Remarks:

MTR# 138474

PO/Line# 146313-8

Heat# 18C6983

100% EDDY CURRENT TESTING- E309	PASSED (AS PER S8 OF ASTM A513)
FLATTENING TEST	1/3% OF OD PASSED
FLARING TEST	15 % of ID PASSED
STRAIGHTNESS	(1/1000 MM MAX) PASSED

Remarks:

Melted In: INDIA Produced In: INDIA

Product is free of weld repair and has not come in contact with Mercury or any of its components.

We hereby Certify that the material described above conforms to Specification and Purchase Order.

Bill Johnston
Quality Co-ordinator

Any questions, Please email: TestReports@aaris-llc.com

TR No. 612831-01

70

2020-05-07

¼" A572-50 plate

ALTOS HORNOS DE MEXICO

MILL TEST CERTIFICATE AHMSA:QUALITY WITH THE STRENGTH OF STEEL

PROLONGACION JUAREZ SIN NUMERO COLONIA LA LOMA MONCLOVA COAHUILA 25770

B024046B

CUSTOMER	DATE OF ISSUED	PAGE
AHMSA INT/ TRIPLE-S HOUSTON	12.07.2017	1

ADDRESS: 5150 N LOOP1604 W SAN ANTONIO, TX.

PRODUCT: WIDE PLATE..

WE HEREBY THAT CHEMICAL AND / OR TEST SHOW IN THIS REPORT ARE CORRECT AS CONTAINED THE RECORDS OF THE COMPANY.

ING. RAMIRO CISNEROS MENCHACA

MECHANICAL TESTING AND CERTIFICATION

CHEMICAL COMPOSITION

HEAT	SPECIFICATION	C	Mn	P	S	Si	Cu	Cr	Ni	Mo	Alt	V	Cb	Ti
173583	ASTM A572-50/A709-50	0.170	0.850	0.022	0.003	0.120	0.019	0.028	0.027	0.006	0.034	0.004	0.007	0.002
173584	ASTM A572-50/A709-50	0.160	0.840	0.023	0.003	0.120	0.014	0.023	0.022	0.005	0.034	0.005	0.007	0.002
173585	ASTM A572-50/A709-50	0.170	0.850	0.024	0.003	0.120	0.034	0.023	0.022	0.005	0.031	0.004	0.007	0.002

TEST OF THE PRODUCT

HEAT	SLAB	PLATE NO.	THICKNESS(Inch)	Y.STRENGTH	T.STRENGTH	%ELON.	T.ELONG.
173583	3170	11144791	0.2500	64.776(KSI)	80.464(KSI)	32(%)	2
173583	3220	11145011	0.2500	64.857(KSI)	80.160(KSI)	33(%)	2
173584	3080	11145051	0.2500	64.577(KSI)	79.498(KSI)	33(%)	2
173584	3110	11145041	0.2500	64.785(KSI)	80.550(KSI)	34(%)	2
173585	3030	11145071	0.2500	64.799(KSI)	80.938(KSI)	34(%)	2
173585	4070	11145251	0.2500	63.488(KSI)	80.527(KSI)	38(%)	2

SHIPPED PRODUCT

HEAT	PLANCHON	PLATE NO.	THICKNESS(Inch)	WIDTH(Inch)	LARGE(Inch)	ORDER	ITEM	DELIVERY
173583	3140	11145081	0.2500	96.0000	240.0000	0000201489	000010	1002477499
173583	3190	11145033	0.2500	96.0000	240.0000	0000201489	000010	1002477499
173583	3220	11145011	0.2500	96.0000	240.0000	0000201489	000010	1002477499
173583	3220	11145012	0.2500	96.0000	240.0000	0000201489	000010	1002477499
173584	4120	11145061	0.2500	96.0000	240.0000	0000201489	000010	1002477499
173584	4120	11145062	0.2500	96.0000	240.0000	0000201489	000010	1002477499
173584	4120	11145063	0.2500	96.0000	240.0000	0000201489	000010	1002477499
173585	3030	11145071	0.2500	96.0000	240.0000	0000201489	000010	1002477499
173585	3030	11145072	0.2500	96.0000	240.0000	0000201489	000010	1002477499
173585	3030	11145073	0.2500	96.0000	240.0000	0000201489	000010	1002477499

HEAT	PLANCHON	PLATE NO.	CUSTOMER ORD.	STANDARD
173583	3140	11145081	AHI4820(WLY-20161)/M	A-6
173583	3190	11145033	AHI4820(WLY-20161)/M	A-6
173583	3220	11145011	AHI4820(WLY-20161)/M	A-6
173583	3220	11145012	AHI4820(WLY-20161)/M	A-6
173584	4120	11145061	AHI4820(WLY-20161)/M	A-6
173584	4120	11145062	AHI4820(WLY-20161)/M	A-6
173584	4120	11145063	AHI4820(WLY-20161)/M	A-6
173585	3030	11145071	AHI4820(WLY-20161)/M	A-6

AHMSA'S COMPROMISE IS ONLY WITH THE CUSTOMER MENTIONED IN THISCERTIFICATE, AHMSA WILL ONLY ACCEPT THE ORIGINAL DOCUMENT.

ISSUED : C01AI10

CC-03-F-01-A

ALTOS HORNOS DE MEXICO

MILL TEST CERTIFICATE **AHMSA:QUALITY WITH THE STRENGTH OF STEEL**

PROLONGACION JUAREZ SIN NUMERO COLONIA LA LOMA MONCLOVA COAHUILA 25770

B024046B

CUSTOMER	DATE OF ISSUED	PAGE	WE HEREBY THAT CHEMICAL AND / OR TEST SHOW IN THIS REPORT ARE CORRECT AS CONTAINED THE RECORDS OF THE COMPANY
AHMSA INT/ TRIPLE-S HOUSTON	12.07.2017	2	
ADDRESS: 5150 N LOOP1604 W SAN ANTONIO, TX.			ING. RAMIRO CISNEROS MENCHACA
PRODUCT: WIDE PLATE..			MECHANICAL TESTS AND CERTIFICATION

SHIPPED PRODUCT

HEAT	PLANCHON	PLATE NO.	CUSTOMER ORD.	STANDARD
173585	3030	11145072	AHI4820(WLY-20161)/M	A-6
173585	3030	11145073	AHI4820(WLY-20161)/M	A-6

ALL HEATS AND SIZES ARE FULLY ALUMINUM KILLED WITH FINE GRAIN PRACTICE.
DIN EN10204 3.1 COMPLIANT
COUNTRY OF ORIGIN: MÉXICO

END OF DATA

AHMSA'S COMPROMISE IS ONLY WITH THE CUSTOMER MENTIONED IN THISCERTIFICATE, AHMSA WILL ONLY ACCEPT THE ORIGINAL DOCUMENT.

ISSUED : C01AI10

CC-03-F-01-A

TR No. 612831-01

72

2020-05-07

ALTOS HORNOS DE MEXICO

MILL TEST CERTIFICATE AHMSA:QUALITY WITH THE STRENGTH OF STEEL

PROLONGACION JUAREZ SIN NUMERO COLONIA LA LOMA MONCLOVA COAHUILA 25770

B024047B

CUSTOMER	DATE OF ISSUED	PAGE
AHMSA INT/ TRIPLE-S HOUSTON	12.07.2017	1

ADDRESS: 5150 N LOOP1604 W SAN ANTONIO, TX.

PRODUCT: WIDE PLATE..

WE HEREBY THAT CHEMICAL AND / OR TEST SHOWN IN THIS REPORT ARE CORRECT AS CONTAINED THE RECORDS OF THE COMPANY

ING. RAMIRO CISNEROS BENCHACA

MECHANICAL TESTS AND CERTIFICATION

CHEMICAL COMPOSITION

HEAT	SPECIFICATION	C	Mn	P	S	Si	Cu	Cr	Ni	Mo	Alt	V	Cb	Ti
173583	ASTM A572-50/A709-50	0.170	0.850	0.022	0.003	0.120	0.019	0.028	0.027	0.006	0.034	0.004	0.007	0.002
173584	ASTM A572-50/A709-50	0.160	0.840	0.023	0.003	0.120	0.014	0.023	0.022	0.005	0.034	0.005	0.007	0.002

TEST OF THE PRODUCT

HEAT	SLAB	PLATE NO.	THICKNESS(Inch)	Y.STRENGTH	T.STRENGTH	%ELON.	T.ELONG.
173583	3170	11144791	0.2500	64.776(KSI)	80.464(KSI)	32(%)	2
173583	3220	11145011	0.2500	64.857(KSI)	80.160(KSI)	33(%)	2
173584	3080	11145051	0.2500	64.577(KSI)	79.498(KSI)	33(%)	2
173584	3110	11145041	0.2500	64.785(KSI)	80.550(KSI)	34(%)	2

SHIPPED PRODUCT

HEAT	PLANCHON	PLATE NO.	THICKNESS(Inch)	WIDTH(Inch)	LARGE(Inch)	ORDER	ITEM	DELIVERY
173583	3180	11145021	0.2500	96.0000	240.0000	0000201489	000010	1002477497
173583	3180	11145022	0.2500	96.0000	240.0000	0000201489	000010	1002477497
173583	3180	11145023	0.2500	96.0000	240.0000	0000201489	000010	1002477497
173583	3220	11145013	0.2500	96.0000	240.0000	0000201489	000010	1002477497
173584	3080	11145051	0.2500	96.0000	240.0000	0000201489	000010	1002477497
173584	3080	11145052	0.2500	96.0000	240.0000	0000201489	000010	1002477497
173584	3080	11145053	0.2500	96.0000	240.0000	0000201489	000010	1002477497
173584	3110	11145041	0.2500	96.0000	240.0000	0000201489	000010	1002477497
173584	3110	11145042	0.2500	96.0000	240.0000	0000201489	000010	1002477497
173584	3110	11145043	0.2500	96.0000	240.0000	0000201489	000010	1002477497

HEAT	PLANCHON	PLATE NO.	CUSTOMER ORD.	STANDARD
173583	3180	11145021	AHI4820(WLY-20161)/M	A-6
173583	3180	11145022	AHI4820(WLY-20161)/M	A-6
173583	3180	11145023	AHI4820(WLY-20161)/M	A-6
173583	3220	11145013	AHI4820(WLY-20161)/M	A-6
173584	3080	11145051	AHI4820(WLY-20161)/M	A-6
173584	3080	11145052	AHI4820(WLY-20161)/M	A-6
173584	3080	11145053	AHI4820(WLY-20161)/M	A-6
173584	3110	11145041	AHI4820(WLY-20161)/M	A-6
173584	3110	11145042	AHI4820(WLY-20161)/M	A-6
173584	3110	11145043	AHI4820(WLY-20161)/M	A-6

ALL HEATS AND SIZES ARE FULLY ALUMINUM KILLED WITH FINE GRAIN PRACTICE.

AHMSA'S COMPROMISE IS ONLY WITH THE CUSTOMER MENTIONED IN THISCERTIFICATE, AHMSA WILL ONLY ACCEPT THE ORIGINAL DOCUMENT.

ISSUED : C01AI10

CC-03-F-01-A

ALTOS HORNOS DE MEXICO

MILL TEST CERTIFICATE **AHMSA:QUALITY WITH THE STRENGTH OF STEEL**

PROLONGACION JUAREZ SIN NUMERO COLONIA LA LOMA MONCLOVA COAHUILA 25770

B024047B

CUSTOMER	DATE OF ISSUED	PAGE	WE HEREBY THAT CHEMICAL AND / OR TEST SHOW IN THIS REPORT ARE CORRECT AS CONTAINED THE RECORDS OF THE COMPANY
AHMSA INT/ TRIPLE-S HOUSTON	12.07.2017	2	
ADDRESS: 5150 N LOOP1604 W SAN ANTONIO, TX.			ING. RAMIRO CISNEROS MENCHACA
PRODUCT: WIDE PLATE..			MECHANICAL TESTS AND CERTIFICATION

DIN EN10204 3.1 COMPLIANT
COUNTRY OF ORIGIN: MÉXICO

END OF DATA

AHMSA'S COMPROMISE IS ONLY WITH THE CUSTOMER MENTIONED IN THISCERTIFICATE, AHMSA WILL ONLY ACCEPT THE ORIGINAL DOCUMENT.

ISSUED : C01AI10

CC-03-F-01-A

Texas A&M Transportation Institute Proving Ground 3100 SH 47, Bldg 7091 Bryan, TX 77807 Texas A&M University College Station, TX 77843 Phone 979-845-6375	QF 7.3-01 Concrete Sampling	Doc. No. QF 7.3-01	Issue Date: 2018-06-18
Quality Form	Prepared by: Wanda L. Menges Approved by: Darrell L. Kuhn	Revision: 6	Page: 1 of 1

Project No: 612831 **Casting Date:** 11/26/2019 **Mix Design (psi):** 5000

Technician Taking Sample: TERRACON

Technician Breaking Sample: TERRACON

Signature of Technician Taking Sample: TERRACON

Signature of Technician Breaking Sample: TERRACON

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	7131	5793157	6 of the F-shape Barriers

Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average
T1- SEE ATTACHED SHEETS FROM TERRACON					

CUSTOMER'S COPY

TICKET NO. 5793157

Martin Marietta

1503 LBJ Freeway
Suite 400
Dallas, Tx 75234

LOAD TIME	TO JOB	ARRIVE JOB SITE	BEGIN POUR	FINISH POUR	LEAVE JOB SITE	ARRIVE PLANT
9:28	9:41	10:04	10:10	:	:	:

WATER ADDED ON JOB AT CUSTOMER'S REQUEST 260 GAL.
ALLOWABLE WATER (withheld from batch) 153 GAL.
TEST CYLINDER TAKEN ❑ YES ❑ NO BY TECHNICIAN
CYLINDER TAKEN ❑ BEFORE ❑ AFTER WATER

ADDITIONAL WATER ADDED TO THIS CONCRETE WILL REDUCE ITS STRENGTH. ANY WATER ADDED IN EXCESS OF SPECIFIED SLUMP IS AT CUSTOMER'S RISK.

CUSTOMER SIGNATURE
X

DELIVERY OF THESE MATERIALS IS SUBJECT TO THE TERMS ANI CONDITIONS ON THE REVERSE SIDE HEREOF AS ACCEPTED B' SIGNATURE ABOVE .

CUSTOMER NAME AND DELIVERY ADDRESS
TEXAS A & M UNIVERSI
TTI-Riverside Campus

PLANT	TRUCK	ORDER NO.	SLUMP	P.O. #/JOB/LOT	GRID
617	7131	2012	5.0	612831	

DRIVER NAME: Steven Albrecht
DATE: 11/25/19

CUSTOMER NUMBER	PROJECT	CUM. QTY	ORDERED QTY
783659	79546	9.00	9.00

LOAD QUANTITY	PRODUCT CODE	DESCRIPTION	UNIT PRICE	AMOUNT
9.00	CYDS	R9Z50547 COM, RR, Z, 5000, RE		
1.00	ea	12987 FREIGHT CHARGE		

SPECIAL DELIVERY INSTRUCTIONS
SOUTH 2818, RIGHT ON LEONARD RR, RIGHT ON HWY-47 LEFT INTO RELLIS CAMPUS THEY WILL MEET YOU AT THE GATE

SALES TAX

TOTAL

DANGER! MAY CAUSE ALKALI BURNS.
SEE WARNINGS ON REVERSE SIDE.

FOR OFFICE USE ONLY **FORM:**

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
7131	934547	user	5793157	80621	9:28	11/25/19

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
9.00	CYDS R9Z50547				D	81674

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
1"RG	1300 lb	11747 lb	11720 lb	-0.23%	0.40% M	6 gl
3/8"PG	525 lb	4742 lb	4720 lb	-0.46%	0.35% M	2 gl
SAND-1	1302 lb	12387 lb	12400 lb	0.11%	5.40% M	80 gl
CMT-I/II	528 lb	4752 lb	4750 lb	-0.04%		
FLYASH-C	127 lb	1143 lb	1140 lb	-0.26%		
H20	256 lb	1444 lb	1443 lb	-0.05%		173 gl
ZY-610	21 oz	190 oz	190 oz	-0.04%		
Actual	Num Batches: 1					

Load Total: 36185 lb Design 0.391 Water/Cement 0.391 T Design 276.1 gl Actual 260.8 gl To Add: 15.3 gl
Slump: 5.00 in # Water in Truck: 0.0 gl Adjust Water: 0.0 gl / Load Trim Water: -1.7 gl/ CYD

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0071
Service Date: 11/25/19
Report Date: 01/07/20 Revision 2 - 43-day results
Task: PO #612831-01

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

Client

Texas Transportation Institute
Attn: Gary Gerke
TTI Business Office
3135 TAMU
College Station, TX 77843-3135

Project

Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength: 5,000 psi @ 28 days

Mix ID: R9Z50547
Supplier: Martin Marietta
Batch Time: 0928 **Plant:** 617
Truck No.: 7131 **Ticket No.:** 5793157

Sample Information

Sample Date: 11/25/19 **Sample Time:** 1020
Sampled By: David Thompson
Weather Conditions: Clear, no wind
Accumulative Yards: 9/9 **Batch Size (cy):** 9
Placement Method: Direct Discharge
Water Added Before (gal): 15
Water Added After (gal):
Sample Location: Traffic barricade
Placement Location: Traffic barricade (PO #612831-01)

Field Test Data

Test	Result	Specification
Slump (in):	4 3/4	Not Specified
Air Content (%):	1.0	Not Speciified
Concrete Temp. (F):	72	40 - 95
Ambient Temp. (F):	69	40 - 95
Plastic Unit Wt. (pcf):	148.2	Not Specified
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Specimen ID	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Maximum Load (lbs)	Compressive Strength (psi)	Fracture Type	Tested By
1	A	4.00	12.57	11/26/19	12/02/19	7 F	62,170	4,950		JCM
1	B	4.00	12.57	11/26/19	01/07/20	43 F	81,920	6,520	1	BJA
1	C	4.00	12.57	11/26/19	01/07/20	43 F	83,210	6,620	1	BJA
1	D	4.00	12.57	11/26/19	01/07/20	43 F	87,260	6,940	1	BJA
1	F	4.00	12.57	11/26/19	01/07/20	43 F	77,210	6,140	1	BJA
1	E			11/26/19		Hold				

Initial Cure: Cure Blanket **Final Cure:** Field Cured
Comments: **F = Field Cured**

**Time and mileage shown on Report No. A1171057.0070.

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.: David Thompson **Start/Stop:** **
Reported To:
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Andrea Allen

Reviewed By:
Andrea Allen
Project Manager

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

Texas A&M Transportation Institute Proving Ground 3100 SH 47, Bldg 7091 Bryan, TX 77807	QF 7.3-01 Concrete Sampling	Doc. No. QF 7.3-01	Issue Date: 2018-06-18
Quality Form	Prepared by: Wanda L. Menges Approved by: Darrell L. Kuhn	Revision: 6	Page: 1 of 1

Project No: 612831 **Casting Date:** 12/9/2019 **Mix Design (psi):** 5000

Technician Taking Sample: TERRACON

Technician Breaking Sample: TERRACON

Signature of Technician Taking Sample: TERRACON

Signature of Technician Breaking Sample: TERRACON

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	7165	5817467	6 of the F-shape Barriers

Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average
T1- SEE ATTACHED SHEETS FROM TERRACON					

CUSTOMER'S COPY

TICKET NO. 5817467

Martin Marietta

1503 LBJ Freeway
Suite 400
Dallas, Tx 75234

LOAD TIME	TO JOB	ARRIVE JOB SITE	BEGIN POUR	FINISH POUR	LEAVE JOB SITE	ARRIVE PLANT
7:23	7:45	8:00	:	:	:	:

WATER ADDED ON JOB AT CUSTOMER'S REQUEST 15 GAL.
ALLOWABLE WATER (withheld from batch) 15.0 GAL.
TEST CYLINDER TAKEN ❑ YES ❑ NO BY
CYLINDER TAKEN ❑ BEFORE ❑ AFTER WATER

ADDITIONAL WATER ADDED TO THIS CONCRETE WILL REDUCE ITS STRENGTH. ANY WATER ADDED IN EXCESS OF SPECIFIED SLUMP IS AT CUSTOMER'S RISK.

CUSTOMER SIGNATURE
X

DELIVERY OF THESE MATERIALS IS SUBJECT TO THE TERMS AN CONDITIONS ON THE REVERSE SIDE HEREOF AS ACCEPTED B SIGNATURE ABOVE .

CUSTOMER NAME AND DELIVERY ADDRESS
TEXAS A & M UNIVERSI
TTI-Riverside Campus

PLANT	TRUCK	ORDER NO.	SLUMP	P.O. #/JOB/LOT	GRID
617	7165	2016	5.0	690900-ER	

DRIVER NAME: DemariUs Williams
DATE: 12/9/19

CUSTOMER NUMBER	PROJECT	CUM. QTY	ORDERED QTY
783659	79546	9.00	9.00

LOAD QUANTITY	PRODUCT CODE	DESCRIPTION	UNIT PRICE	AMOUNT
9.00	CYDS	R9Z50547 COM,RG,Z,5000,RE		
1.00	ea	12987 FREIGHT CHARGE		

SPECIAL DELIVERY INSTRUCTIONS
2816-RT ON LEONARD RT ON HWY-47-LFT INTO RIVERSIDE CAMPUS WILL MEET AT GATE

SALES TAX

TOTAL

DANGER! MAY CAUSE ALKALI BURNS.
SEE WARNINGS ON REVERSE SIDE.

FOR OFFICE USE ONLY **FORM:**

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
7165	951956	user	5817467	80848	7:23	12/9/19

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
9.00	CYDS R9Z50547				D	81902

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
1"RG	1300 lb	11729 lb	11720 lb	-0.08%	0.25% M	4 gl
3/8"PG	525 lb	4737 lb	4720 lb	-0.36%	0.25% M	1 gl
SAND-1	1302 lb	12206 lb	12240 lb	0.28%	4.00% M	59 gl
CMT-I/II	528 lb	4752 lb	4750 lb	0.00%		
FLYASH-C	127 lb	1143 lb	1140 lb	* -0.26%		
H20	256 lb	1580 lb	1581 lb	0.05%		189 gl
ZY-610	21 oz	190 oz	190 oz	-0.04%		

Actual Num Batches: 1
Load Total: 36203 lb Design 0.391 Water/Cement 0.389 T Design 276.1 gl Actual 253.1 gl To Add: 15.0 gl
Slump: 5.00 in # Water in Truck: 8.0 gl Adjust Water: 0.0 gl / Load Trim Water: -1.7 gl/ CYD

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0078
Service Date: 12/09/19
Report Date: 01/07/20 Revision 1 - 29-day results
Task: PO #612831

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

Client

Texas Transportation Institute
Attn: Gary Gerke
TTI Business Office
3135 TAMU
College Station, TX 77843-3135

Project

Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength: 5,000 psi @ 28 days

Mix ID: R9Z50547
Supplier: Martin Marietta
Batch Time: 0723 **Plant:** 617
Truck No.: 7615 **Ticket No.:** 5817467

Sample Information

Sample Date: 12/09/19 **Sample Time:** 0825
Sampled By: Alexander Dunigan
Weather Conditions: Cloudy, no wind
Accumulative Yards: 9/9 **Batch Size (cy):** 9
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: South end of 3rd barrier from the south
Placement Location: Concrete barriers

Field Test Data

Test	Result	Specification
Slump (in):	6 1/2	Not Specified
Air Content (%):		Not Specified
Concrete Temp. (F):	75	40 - 95
Ambient Temp. (F):	70	40 - 95
Plastic Unit Wt. (pcf):	147.4	Not Specified
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Specimen ID	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Maximum Load (lbs)	Compressive Strength (psi)	Fracture Type	Tested By
1	A	4.00	12.57	12/10/19	01/07/20	29 F	75,380	6,000	3	BJA
1	B	4.00	12.57	12/10/19	01/07/20	29 F	73,690	5,860	3	BJA
1	C	4.00	12.57	12/10/19	01/07/20	29 F	75,470	6,010	3	BJA
1	D			12/10/19		Hold				

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

Comments: F = Field Cured

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).
Terracon Rep.: Alexander Dunigan **Start/Stop:** 0715-0930
Reported To:
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Andrea Allen

Reviewed By:
Andrea Allen
Project Manager

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

Texas A&M Transportation Institute Proving Ground 3100 SH 47, Bldg 7091 Bryan, TX 77807	QF 7.3-01 Concrete Sampling	Doc. No. QF 7.3-01	Issue Date: 2018-06-18
Quality Form	Prepared by: Wanda L. Menges Approved by: Darrell L. Kuhn	Revision: 6	Page: 1 of 1

Project No: 612831 **Casting Date:** 12/18/2019 **Mix Design (psi):** 5000

Name of Technician Taking Sample: TERRACON

Name of Technician Breaking Sample: TERRACON

Signature of Technician Taking Sample: TERRACON

Signature of Technician Breaking Sample: TERRACON

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	8130	5836268	Remaining F-shape Barriers

Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average
T1 - SEE ATTACHED SHEETS FROM TERRACON					

CUSTOMER'S COPY

TICKET NO. 5836268

Martin Marietta

1503 LBJ Freeway
Suite 400
Dallas, Tx 75234

LOAD TIME	TO JOB	ARRIVE JOB SITE	BEGIN POUR	FINISH POUR	LEAVE JOB SITE	ARRIVE PLANT
11:54	12:04	12:30	12:37	:	:	:

WATER ADDED ON JOB AT CUSTOMER'S REQUEST 105 GAL.
ALLOWABLE WATER (withheld from batch) _____ GAL.
TEST CYLINDER TAKEN ❑ YES ❑ NO BY _____
CYLINDER TAKEN ❑ BEFORE ❑ AFTER WATER

ADDITIONAL WATER ADDED TO THIS CONCRETE WILL REDUCE ITS STRENGTH. ANY WATER ADDED IN EXCESS OF SPECIFIED SLUMP IS AT CUSTOMER'S RISK.

CUSTOMER SIGNATURE
X

DELIVERY OF THESE MATERIALS IS SUBJECT TO THE TERMS ANI CONDITIONS ON THE REVERSE SIDE HEREOF AS ACCEPTED B SIGNATURE ABOVE .

CUSTOMER NAME AND DELIVERY ADDRESS
TEXAS A & M UNIVERSI
TTI-RELLIS CAMPUS

PLANT	TRUCK	ORDER NO.	SLUMP	P.O. #/JOB/LOT	GRID
617	8130	2017	5.0	690900-ER	

DRIVER NAME: Ray Williams — DATE: 12/18/19

CUSTOMER NUMBER	PROJECT	CUM. QTY	ORDERED QTY
783659	79346	7.00	7.00

LOAD QUANTITY	PRODUCT CODE	DESCRIPTION	UNIT PRICE	AMOUNT
7.00	CYDS	R9750547 COM,RG,2,5000,RE		
1.00	ea	12987 FREIGHT CHARGE		

612831

Ryan Kegley

SPECIAL DELIVERY INSTRUCTIONS
2818-RT ON LEONARD RT ON HWY-47-LFT INTO RIVERSIDE CAMPUS WILL MEET AT GATE

SALES TAX

TOTAL

DANGER! MAY CAUSE ALKALI BURNS.
SEE WARNINGS ON REVERSE SIDE.

FOR OFFICE USE ONLY **FORM:**

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
8130	726612	user	5836268	78698	11:54	12/18/19

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
7.00	CYDS R9750547				D	79347

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
1"RG	1300 lb	9118 lb	9100 lb	-0.20%	0.20% M	2 gl
3/8"PG	525 lb	3682 lb	3680 lb	-0.06%	0.20% M	1 gl
SAND-1	1302 lb	9494 lb	9500 lb	0.07%	4.00% M	46 gl
CMT-I/II	528 lb	3696 lb	3690 lb	-0.16%		
FLYASH-C	127 lb	889 lb	880 lb	-1.01%		
H20	256 lb	1228 lb	1220 lb	-0.66%		146 gl
ZY-610	21 oz	74 oz	73 oz	-1.24%		

Actual Num Batches: 1
Load Total: 28075 lb Design 0.391 Water/Cement 0.392 T Design 214.7 gl Actual 194.8 gl To Add: 14.9 gl
Slump: 5.00 in # Water in Truck: 5.0 gl Adjust Water: 0.0 gl / Load Trim Water: -2.0 gl CYD

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0081
Service Date: 12/18/19
Report Date: 01/07/20 Revision 1 - 20-day results
Task: PO #612831

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

Client

Texas Transportation Institute
Attn: Gary Gerke
TTI Business Office
3135 TAMU
College Station, TX 77843-3135

Project

Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength: 4,000 psi @ 28 days

Mix ID: R9Z50547
Supplier: Martin Marietta
Batch Time: 1154 **Plant:** 617
Truck No.: 8130 **Ticket No.:** 5836268

Sample Information

Sample Date: 12/18/19 **Sample Time:** 1243
Sampled By: Cullen Turney
Weather Conditions: Clear, moderate wind
Accumulative Yards: 7/7 **Batch Size (cy):** 7
Placement Method: Direct Discharge
Water Added Before (gal): 10
Water Added After (gal): 0
Sample Location: Third F beam
Placement Location: Apron 4 (PO #612831)

Field Test Data

Test	Result	Specification
		Not Specified
Air Content (%):		Not Specified
Concrete Temp. (F):		40 - 95
Ambient Temp. (F):	55	40 - 95
Plastic Unit Wt. (pcf):		Not Specified
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Specimen ID	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Maximum Load (lbs)	Compressive Strength (psi)	Fracture Type	Tested By
1	A	6.00	28.27	12/19/19	01/07/20	20 F	162,820	5,760	1	BJA
1	B	6.00	28.27	12/19/19	01/07/20	20 F	166,840	5,900	1	BJA
1	C	6.00	28.27	12/19/19	01/07/20	20 F	163,510	5,780	1	BJA
1	D			12/19/19		Hold				

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

Comments: **Not tested for plastic unit weight. F = Field Cured**

**Time and mileage shown on Report No. A1171057.0080.

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.: Cullen Turney **Start/Stop:** **
Reported To:
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Andrea Allen

Reviewed By:
Andrea Allen
Project Manager

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

TR No. 612831-01

83

2020-05-07

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

CERTIFIED MILL TEST REPORT

For additional copies call
830-372-8771

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

Rolando A Davila
Quality Assurance Manager

HEAT NO.:3090295 SECTION: REBAR 16MM (#5) 20'0" 420/60 GRADE: ASTM A615-18e1 Gr 420/60 ROLL DATE: 08/13/2019 MELT DATE: 08/04/2019 Cert. No.: 82812501 / 090295A371	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 82812501 BOL#: 73150643 CUST PO#: 825407 CUST P/N: DLVRY LBS / HEAT: 24090.000 LB DLVRY PCS / HEAT: 1155 EA

Characteristic	Value
C	0.42%
Mn	0.90%
P	0.010%
S	0.039%
Si	0.23%
Cu	0.32%
Cr	0.13%
Ni	0.19%
Mo	0.054%
V	0.000%
Cb	0.001%
Sn	0.011%
Al	0.000%
Yield Strength test 1	67.7ksi
Tensile Strength test 1	105.1ksi
Elongation test 1	16%
Elongation Gage Lgth test 1	8IN
Tensile to Yield ratio test1	1.55
Bend Test 1	Passed

Characteristic	Value
Bend Test Diameter	2.188IN

612831 - 3

Characteristic	Value

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

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

REMARKS :

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

CERTIFIED MILL TEST REPORT

For additional copies call
830-372-8771

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

Rolando A Davila
Quality Assurance Manager

HEAT NO.:3090116 SECTION: REBAR 25MM (#8) 20'0" 420/60 GRADE: ASTM A615-18e1 Gr 420/60 ROLL DATE: 08/03/2019 MELT DATE: 07/27/2019 Cert. No.: 82799443 / 090116A041	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 82799443 BOL#: 73129113 CUST PO#: 824142 CUST P/N: DLVRY LBS / HEAT: 12816.000 LB DLVRY PCS / HEAT: 240 EA

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.42%	Bend Test Diameter	5.000IN		
Mn	1.25%				
P	0.013%				
S	0.043%				
Si	0.22%				
Cu	0.31%				
Cr	0.07%				
Ni	0.08%				
Mo	0.027%				
V	0.000%				
Cb	0.001%				
Sn	0.010%				
Al	0.000%				
Yield Strength test 1	64.6ksi				
Tensile Strength test 1	107.1ksi				
Elongation test 1	15%				
Elongation Gage Lgth test 1	8IN				
Tensile to Yield ratio test1	1.66				
Bend Test 1	Passed				

612831-3

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

REMARKS :

TR No. 612831-01

85

2020-05-07

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

CERTIFIED MILL TEST REPORT
For additional copies call
830-372-8771

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

Rolando A Davila
Quality Assurance Manager

HEAT NO.:3088704 SECTION: REBAR 19MM (#6) 20'0" 420/60 GRADE: ASTM A615-18e1 Gr 420/60 ROLL DATE: 05/31/2019 MELT DATE: 05/21/2019 Cert. No.: 82794206 / 088704A619	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 82794206 BOL#: 73120575 CUST PO#: 823593 CUST P/N: DLVRY LBS / HEAT: 12978.000 LB DLVRY PCS / HEAT: 432 EA

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.44%				
Mn	0.88%				
P	0.010%				
S	0.036%				
Si	0.17%				
Cu	0.29%				
Cr	0.10%				
Ni	0.25%				
Mo	0.092%				
V	0.000%				
Cb	0.001%				
Sn	0.011%				
Al	0.000%				
Yield Strength test 1	69.4ksi				
Tensile Strength test 1	109.8ksi				
Elongation test 1	15%				
Elongation Gage Lgth test 1	8IN				
Bend Test 1	Passed				
Bend Test Diameter	3.750IN				

612831-3

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

REMARKS :

TR No. 612831-01

86

2020-05-07

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

CERTIFIED MILL TEST REPORT

For additional copies call
830-372-8771

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

Rolando A Davila
Quality Assurance Manager

HEAT NO.:3089816 SECTION: REBAR 13MM (#4) 20'0" 420/60 GRADE: ASTM A615-18e1 Gr 420/60 ROLL DATE: 07/16/2019 MELT DATE: 07/16/2019 Cert. No.: 82794205 / 089816A130	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 82794205 BOL#: 73120574 CUST PO#: 823592 CUST P/N: DLVRY LBS / HEAT: 2191.000 LB DLVRY PCS / HEAT: 164 EA

Characteristic	Value
C	0.44%
Mn	0.79%
P	0.013%
S	0.031%
Si	0.18%
Cu	0.33%
Cr	0.11%
Ni	0.20%
Mo	0.074%
V	0.000%
Cb	0.001%
Sn	0.014%
Al	0.000%
Yield Strength test 1	65.8ksi
Tensile Strength test 1	105.1ksi
Elongation test 1	15%
Elongation Gage Lgth test 1	8IN
Tensile to Yield ratio test1	1.60
Bend Test 1	Passed

Characteristic	Value
Bend Test Diameter	1.750IN

612831-1, 2, 3

Characteristic	Value

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

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

REMARKS :

TR No. 612831-01

87

2020-05-07

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

CERTIFIED MILL TEST REPORT

For additional copies call
830-372-8771

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

Rolando A Davila
Quality Assurance Manager

HEAT NO.:3090295 SECTION: REBAR 16MM (#5) 20'0" 420/60 GRADE: ASTM A615-18e1 Gr 420/60 ROLL DATE: 08/13/2019 MELT DATE: 08/04/2019 Cert. No.: 82812501 / 090295A371	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 82812501 BOL#: 73150643 CUST PO#: 825407 CUST P/N: DLVRY LBS / HEAT: 24090.000 LB DLVRY PCS / HEAT: 1155 EA

Characteristic	Value
C	0.42%
Mn	0.90%
P	0.010%
S	0.039%
Si	0.23%
Cu	0.32%
Cr	0.13%
Ni	0.19%
Mo	0.054%
V	0.000%
Cb	0.001%
Sn	0.011%
Al	0.000%
Yield Strength test 1	67.7ksi
Tensile Strength test 1	105.1ksi
Elongation test 1	16%
Elongation Gage Lgth test 1	8IN
Tensile to Yield ratio test1	1.55
Bend Test 1	Passed

Characteristic	Value
Bend Test Diameter	2.188IN

612831-3

Characteristic	Value

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

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

REMARKS :

Project No: 612831 **Casting Date:** 10/3/2019 **Mix Design (psi):** 4000

Name of Technician Taking Sample: TERRACON

Name of Technician Breaking Sample: TERRACON

Signature of Technician Taking Sample: TERRACON

Signature of Technician Breaking Sample: TERRACON

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	7211	5695733	Lower 3 ft of all Barrier, remaining for 3 barrier from south end
T2	8162	5695885	half of the top of the 4th barrier, top of remaining 2 barriers on north side

Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average
T1 - SEE ATTACHED SHEETS FROM TERRACON					
T2 - SEE ATTACHED SHEETS FROM TERRACON					

CUSTOMER'S COPY

TICKET NO. 5695885

Martin Marietta

1503 LBJ Freeway
Suite 400
Dallas, Tx 75234

LOAD TIME	TO JOB	ARRIVE JOB SITE	BEGIN POUR	FINISH POUR	LEAVE JOB SITE	ARRIVE PLANT
10:17	10:29	10:39	:	:	:	:

WATER ADDED ON JOB AT CUSTOMER'S REQUEST 15 GAL.
ALLOWABLE WATER (withheld from batch) _____ GAL.
TEST CYLINDER TAKEN ❑ YES ❑ NO BY _____
CYLINDER TAKEN ❑ BEFORE ❑ AFTER WATER

ADDITIONAL WATER ADDED TO THIS CONCRETE WILL REDUCE ITS STRENGTH. ANY WATER ADDED IN EXCESS OF SPECIFIED SLUMP IS AT CUSTOMER'S RISK.

CUSTOMER SIGNATURE
X

DELIVERY OF THESE MATERIALS IS SUBJECT TO THE TERMS AN CONDITIONS ON THE REVERSE SIDE HEREOF AS ACCEPTED B SIGNATURE ABOVE .

CUSTOMER NAME AND DELIVERY ADDRESS
TEXAS A & M UNIVERSITY
TTI-RIVERSIDE/RELLIS

PLANT	TRUCK	ORDER NO.	SLUMP	P.O. #/JOB/LOT	GRID
617	0162	20361	5.0	612831-3	

DRIVER NAME: ANDRA DARNELL
DATE: 10/3/19

CUSTOMER NUMBER	PROJECT	CUM. QTY	ORDERED QTY
783659	79546	15.00	15.00

LOAD QUANTITY	PRODUCT CODE	DESCRIPTION	UNIT PRICE	AMOUNT
5.00	CYDS	R9Z40528 CONC,F'C,4000,RE		
1.00	ea	12987 FREIGHT CHARGE		

SPECIAL DELIVERY INSTRUCTIONS
SOUTH 281A, RIGHT ON LEONARD RD, RIGHT ON HWY 47 LEFT INTO RELLIS CAMPUS WILL MEET AT THE TURN AROUND

SALES TAX

TOTAL

DANGER! MAY CAUSE ALKALI BURNS.
SEE WARNINGS ON REVERSE SIDE.

FOR OFFICE USE ONLY **FORM:** 2573205

Truck	Driver	User	Disp Ticket Num	Picked ID	Time	Date
0162	746154	user	5695885	79387	10:17	10/3/19

Load Size	Mix Code	(Returned)	Qty	Mix Age	Seq	Load ID
5.00	CYDS R9Z40528				0	80431

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
1"RG	1305 lb	655# lb	6640 lb	1.28%	0.40% M	5 gl
3/8"PG	507 lb	254# lb	2520 lb	-0.84%	0.25% M	1 gl
SAND-1	1412 lb	731# lb	7360 lb	0.10%	3.50% M	31 gl
CMT-I/II	552 lb	276# lb	2660 lb	1.00%		
FLYASH-C	108 lb	54# lb	570 lb	1.85%		
H20	250 lb	125# lb	858 lb	0.41%		183 gl
ZY-610	18 oz	11# oz	114 oz	0.08%		
Actual	Num Batches: 5					

Load Total: 20175 lb Design 0.446 Water/Cement 0.448 T Design 149.8 gl Actual 137.6 gl To Add: 8.2 gl
Slump: 5.00 in # Water in Truck: 4.0 gl Adjust Water: 0.0 gl / Load Trim Water: -1.7 gl/ CYD

CUSTOMER'S COPY

TICKET NO. 5695733

Martin Marietta

1503 LBJ Freeway
Suite 400
Dallas, Tx 75234

LOAD TIME	TO JOB	ARRIVE JOB SITE	BEGIN POUR	FINISH POUR	LEAVE JOB SITE	ARRIVE PLANT
9:45	10:02	10:25	10:31	:	:	:

WATER ADDED ON JOB AT CUSTOMER'S REQUEST 20 GAL.
ALLOWABLE WATER (withheld from batch) 16.7 GAL.
TEST CYLINDER TAKEN ❑ YES ❑ NO BY
CYLINDER TAKEN ❑ BEFORE ❑ AFTER WATER

ADDITIONAL WATER ADDED TO THIS CONCRETE WILL REDUCE ITS STRENGTH. ANY WATER ADDED IN EXCESS OF SPECIFIED SLUMP IS AT CUSTOMER'S RISK.

CUSTOMER SIGNATURE
X

DELIVERY OF THESE MATERIALS IS SUBJECT TO THE TERMS AN CONDITIONS ON THE REVERSE SIDE HEREOF AS ACCEPTED B SIGNATURE ABOVE .

CUSTOMER NAME AND DELIVERY ADDRESS
TEXAS A & M UNIVERSI
TTI-RIVERSIDE/RELLIS

PLANT	TRUCK	ORDER NO.	SLUMP	P.O. #/JOB/LOT	GRID
617	7211	2036	5.0	612831-3	

DRIVER NAME: LARRY JANTZEN — DATE: 10/3/19

CUSTOMER NUMBER	PROJECT	CUM. QTY	ORDERED QTY
783659	79546	10.00	15.00

LOAD QUANTITY	PRODUCT CODE	DESCRIPTION	UNIT PRICE	AMOUNT
10.00 CYDS	R9Z40528	CON,RG,7,4000,PE		
1.00 ea	12987	FREIGHT CHARGE		

SPECIAL DELIVERY INSTRUCTIONS
SOUTH 2818, RIGHT ON LEONARD RD, RIGHT ON HWY-47-LEFT INTO RELLIS CAMPUS WILL MEET AT THE TURN AROUND

SALES TAX

TOTAL

DANGER! MAY CAUSE ALKALI BURNS.
SEE WARNINGS ON REVERSE SIDE.

FOR OFFICE USE ONLY **FORM:** 2573203

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
7211	777135	user	5695733	79385	9:45	10/3/19

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
10.00 CYDS	R9Z40528				D	80469

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
1"RG	1306 lb	13112 lb	13120 lb	-0.06%-	0.40% M	6 gl
3/8"PG	507 lb	5063 lb	5040 lb	-0.84%	0.25% M	2 gl
SAND-I	1412 lb	14632 lb	14680 lb	0.33%	3.50% M	62 gl
CMT-I/II	452 lb	4520 lb	4510 lb	-0.22%		
FLYASH-C	108 lb	1080 lb	1070 lb	-0.93%		
WR0	250 lb	1739 lb	1740 lb	0.05%		209 gl
ZY-610	18 oz	226 oz	225 oz	-0.44%		
Actual		Num Batches: 1				

Load Total: 40174 lb Design 0.446 Water/Cement 0.448 T Design 299.6 gl Actual 277.9 gl To Add: 16.7 gl
Slump: 5.00 in # Water in Trucks: 5.0 gl Adjust Water: 0.0 gl / Load Trim Water: -1.7 gl/ CYD

Project No: 612831 **Casting Date:** 10/16/2019 **Mix Design (psi):** 4000

Name of Technician Taking Sample: TERRACON

Name of Technician Breaking Sample: TERRACON

Signature of Technician Taking Sample: TERRACON

Signature of Technician Breaking Sample: TERRACON

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	7124	5719600	Lower 3 ft of all Barriers
T2	8162	5719691	Top half of all barriers

Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average
T1 - SEE ATTACHED SHEETS FROM TERRACON					
T2 - SEE ATTACHED SHEETS FROM TERRACON					

CUSTOMER'S COPY

TICKET NO. 5719600

Martin Marietta

1503 LBJ Freeway
Suite 400
Dallas, Tx 75234

LOAD TIME	TO JOB	ARRIVE JOB SITE	BEGIN POUR	FINISH POUR	LEAVE JOB SITE	ARRIVE PLANT
:55	8:04	8:27	8:31	:	:	:

WATER ADDED ON JOB AT CUSTOMER'S REQUEST 15 GAL.
ALLOWABLE WATER (withheld from batch) 18.7 GAL.
TEST CYLINDER TAKEN ☐ YES ☐ NO BY JEFFAGO
CYLINDER TAKEN ☐ BEFORE ☐ AFTER WATER

ADDITIONAL WATER ADDED TO THIS CONCRETE WILL REDUCE ITS STRENGTH. ANY WATER ADDED IN EXCESS OF SPECIFIED SLUMP IS AT CUSTOMER'S RISK.

CUSTOMER SIGNATURE
X

DELIVERY OF THESE MATERIALS IS SUBJECT TO THE TERMS ANI CONDITIONS ON THE REVERSE SIDE HEREOF AS ACCEPTED B SIGNATURE ABOVE .

CUSTOMER NAME AND DELIVERY ADDRESS
TEXAS A & M UNIVERSI
TTI-RIVERSIDE/RELLIS

PLANT	TRUCK	ORDER NO.	SLUMP	P.O. #/JOB/LOT	GRID
517	7124	2011	4.0	612831-3	

DRIVER NAME: Steven Albrecht
DATE: 10/16/19

CUSTOMER NUMBER	PROJECT	CUM. QTY	ORDERED QTY
783659	79546	10.00	13.50

LOAD QUANTITY	PRODUCT CODE	DESCRIPTION	UNIT PRICE	AMOUNT
10.00 CYDS	R9Z40528	COM, RG, Z, 4000, RE		
1.00 ea	12987	FREIGHT CHARGE		

SPECIAL DELIVERY INSTRUCTIONS
SOUTH 2818, RIGHT ON LEONARD RD, RIGHT ON HWY-47, LEFT INTO RIVERSIDE/RELLIS CAMPUS WILL MEET YOU AT GATE

SALES TAX
TOTAL

DANGER! MAY CAUSE ALKALI BURNS.
SEE WARNINGS ON REVERSE SIDE.

FOR OFFICE USE ONLY **FORM:**

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
7124	934547	user	5719600	79716	7:55	10/16/19

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
10.00 CYDS	R9Z40528				D	80763

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
1"RG	1305 lb	13126 lb	13120 lb	-0.04%	0.50% M	8 gl
3/8"PG	507 lb	5088 lb	5120 lb	0.63%	0.35% M	2 gl
SAND-1	1412 lb	14557 lb	14560 lb	0.02%	3.00% M	52 gl
CMT-I/II	452 lb	4520 lb	4540 lb	0.44%		
FLYASH-C	108 lb	1080 lb	1070 lb	-0.93%		
H20	250 lb	1755 lb	1740 lb	-0.83%		209 gl
ZY-610	18 oz	181 oz	180 oz	-0.44%		

Actual Num Batches: 1
Load Total: 40161 lb Design 0.446 Water/Cement 0.446 T Design 299.6 gl Actual 270.9 gl To Add: 18.7 gl
Slump: 4.00 in Water in Truck: 10.0 gl Adjust Water: 0.0 gl / Load Trim Water: -1.7 gl/ CYD

CUSTOMER'S COPY

TICKET NO. 5719691

Martin Marietta

1503 LBJ Freeway
Suite 400
Dallas, Tx 75234

LOAD TIME	TO JOB	ARRIVE JOB SITE	BEGIN POUR	FINISH POUR	LEAVE JOB SITE	ARRIVE PLANT
8:16	:	:	:	:	:	:

WATER ADDED ON JOB AT CUSTOMER'S REQUEST _____ GAL.
ALLOWABLE WATER (withheld from batch) _____ GAL.
TEST CYLINDER TAKEN ❑ YES ❑ NO BY _____
CYLINDER TAKEN ❑ BEFORE ❑ AFTER WATER

ADDITIONAL WATER ADDED TO THIS CONCRETE WILL REDUCE ITS STRENGTH. ANY WATER ADDED IN EXCESS OF SPECIFIED SLUMP IS AT CUSTOMER'S RISK.

CUSTOMER SIGNATURE
X

DELIVERY OF THESE MATERIALS IS SUBJECT TO THE TERMS AN CONDITIONS ON THE REVERSE SIDE HEREOF AS ACCEPTED I SIGNATURE ABOVE .

CUSTOMER NAME AND DELIVERY ADDRESS
TEXAS A & M UNIVERSI
TTI-RIVERSIDE/RELLIS

PLANT	TRUCK	ORDER NO.	SLUMP	P.O. #/JOB/LOT	GRID
617	8162	2011	4.0	612831-3	

DRIVER NAME: ANDRA DARNELL
DATE: 10/16/19

CUSTOMER NUMBER	PROJECT	CUM. QTY	ORDERED QTY
783659	79546	13.50	13.50

LOAD QUANTITY	PRODUCT CODE	DESCRIPTION	UNIT PRICE	AMOUNT
3.50 CYDS	R9Z40528	COM,RG,Z,4000,RE		
1.00 ea	12987	FREIGHT CHARGE		

SPECIAL DELIVERY INSTRUCTIONS
SOUTH 2818, RIGHT ON LEONARD RD, RIGHT ON HWY-47, LEFT INTO RIVERSIDE/RELLIS CAMPUS WILL MEET YOU AT GATE

SALES TAX
TOTAL

DANGER! MAY CAUSE ALKALI BURNS.
SEE WARNINGS ON REVERSE SIDE.

FOR OFFICE USE ONLY **FORM:**

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
8162	746154	user	5719691	79718	8:16	10/16/19

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
3.50 CYDS	R9Z40528				D	80765

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
1"RG	1306 lb	4594 lb	4640 lb	1.00%	0.50% M	3 gl
3/8"PB	507 lb	1781 lb	1880 lb	5.57%	0.35% M	1 gl
SAND-1	1412 lb	5095 lb	5080 lb	-0.29%	3.00% M	18 gl
CMT-I/II	452 lb	1502 lb	1600 lb	1.14%		
FLYASH-C	108 lb	378 lb	370 lb	-2.12%		
H20	250 lb	577 lb	576 lb	-0.09%		69 gl
ZY-610	18 oz	63 oz	62 oz	-2.02%		

Actual Num Batches: 1
Load Total: 14150 lb Design 0.446 Water/Cement 0.444 T Design 104.9 gl Actual 90.9 gl To Add: 6.0 gl
Slump: 4.00 in Water in Truck: 8.0 gl Adjust Water: 0.0 gl / Load Trim Water: -1.7 gl/ CYD

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APPENDIX C. *MASH* TEST 3-11 (CRASH TEST NO. 612831-01-1)

C1 VEHICLE PROPERTIES AND INFORMATION

Table C.1. Vehicle Properties for Test No. 612831-01-1.

Date: 2020-01-07 Test No.: 612831-01-1 VIN No.: 1C6RR6FT8ES355468

Year: 2014 Make: RAM Model: 1500

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

Tread Type: Highway Odometer: 152623

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

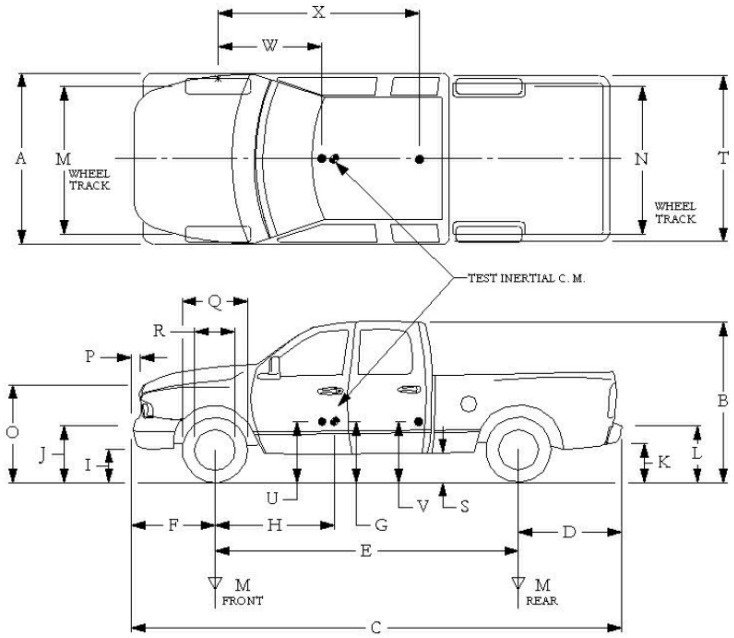
NOTES: None

Engine Type: V-8
Engine CID: 5.7 liter

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

Optional Equipment:
None

Dummy Data:
Type: No dummy used
Mass: 0 lb
Seat Position: NA



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	62.21	M	68.50	R	18.00	W	62.20
D	44.00	I	11.75	N	68.00	S	13.00	X	79.00
E	140.50	J	27.00	O	46.00	T	77.00		

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

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

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	3700	M_{front}	2897	2786	2786
Back	3900	M_{rear}	2070	2214	2214
Total	6700	M_{Total}	4967	5000	5000

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

Mass Distribution:
lb LF: 1372 RF: 1414 LR: 1148 RR: 1066

Table C.2. Measurements of Vehicle Vertical CG for Test No. 612831-01-1.

Date: 2020-01-07 Test No.: 612831-01-1 VIN: 1C6RR6FT8ES355468

Year: 2014 Make: RAM Model: 1500

Body Style: Quad Cab Mileage: 152623

Engine: 5.7 liter V-8 Transmission: Automatic

Fuel Level: Empty Ballast: 160 (440 lb max)

Tire Pressure: Front: 35 psi Rear: 35 psi Size: 265/70 R 17

Measured Vehicle Weights: (lb)

LF:	1372	RF:	1414	Front Axle:	2786
LR:	1148	RR:	1066	Rear Axle:	2214
Left:	2520	Right:	2480	Total:	5000
					5000 ±110 lb allowed

Wheel Base:	140.50	inches	Track: F:	68.50	inches	R: 68.00	inches
148 ±12 inches allowed				Track = (F+R)/2 = 67 ±1.5 inches allowed			

Center of Gravity, SAE J874 Suspension Method

X:	62.21	inches	Rear of Front Axle	(63 ±4 inches allowed)
Y:	-0.27	inches	Left - Right +	of Vehicle Centerline
Z:	28.50	inches	Above Ground	(minumum 28.0 inches allowed)

Hood Height: 46.00 inches (43 ±4 inches allowed)

Front Bumper Height: 27.00 inches

Front Overhang: 40.00 inches (39 ±3 inches allowed)

Rear Bumper Height: 30.00 inches

Overall Length: 227.50 inches (237 ±13 inches allowed)

Table C.3. Exterior Crush Measurements for Test No. 612831-01-1.

Date:	2020-01-07	Test No.:	612831-01-1	VIN No.:	1C6RR6FT8ES355468
Year:	2014	Make:	RAM	Model:	1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

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

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	Front plane at bmpr ht	14	11	28	-	-	-	-	-	-	-20
2	Side plane at bmpr ht	14	14	50	-	-	-	-	-	-	+72
	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.

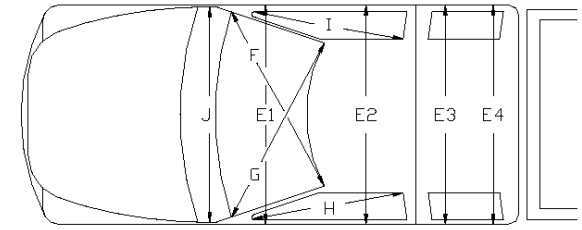
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

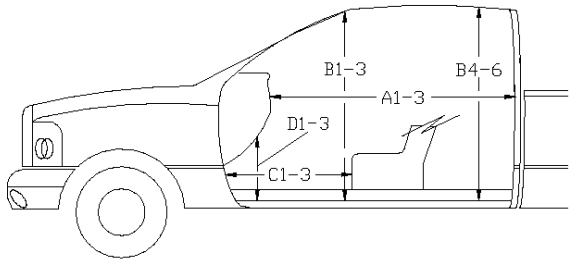
***Measure and document on the vehicle diagram the location of the maximum crush.

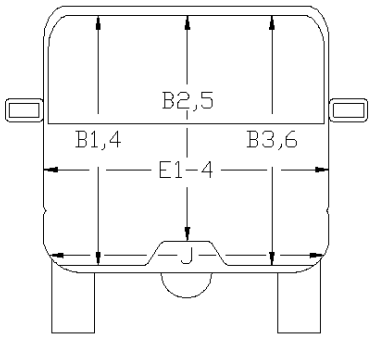
Note: Use as many lines/columns as necessary to describe each damage profile.

Table C.4. Occupant Compartment Measurements for Test No. 612831-01-1.

Date:	2020-01-07	Test No.:	612831-01-1	VIN No.:	1C6RR6FT8ES355468
Year:	2014	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	39.50	0.00
B5	43.00	43.00	0.00
B6	39.50	39.50	0.00
C1	26.00	23.00	-3.00
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

C2 SEQUENTIAL PHOTOGRAPHS

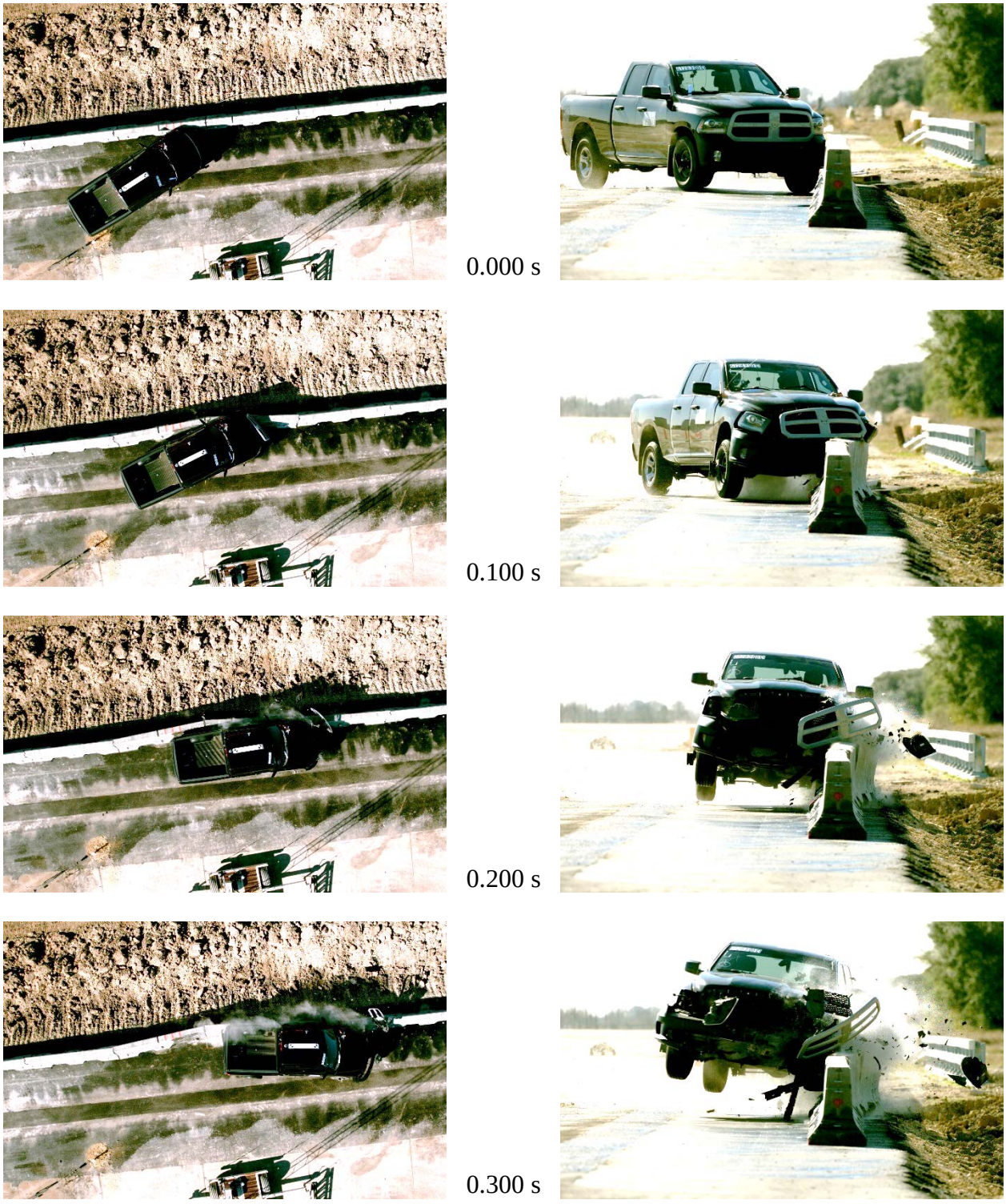
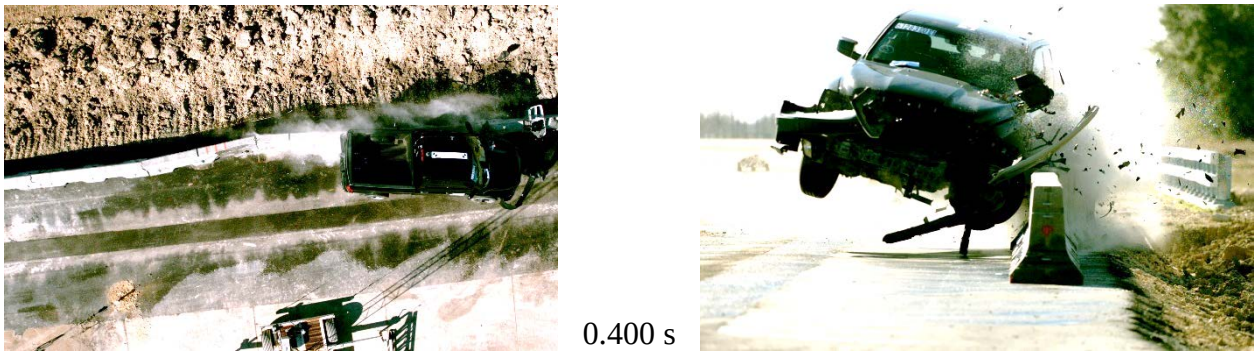


Figure C.1. Sequential Photographs for Test No. 612831-01-1 (Overhead and Frontal Views).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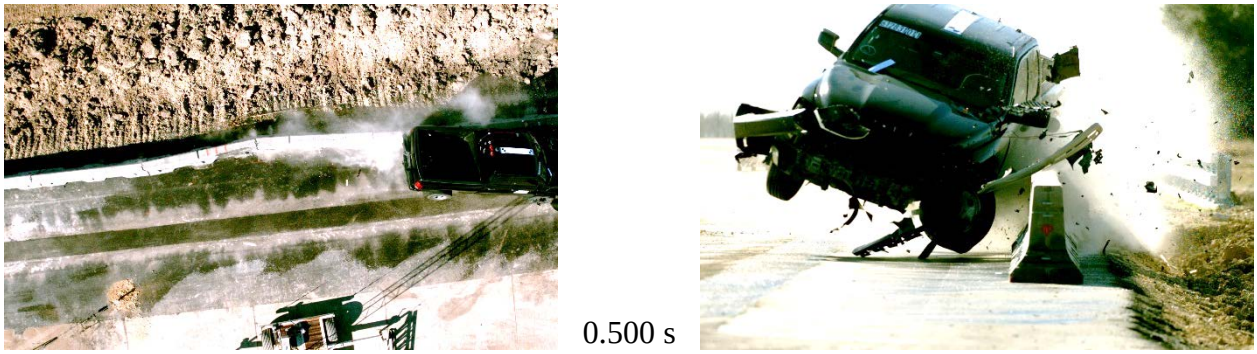
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0.600 s

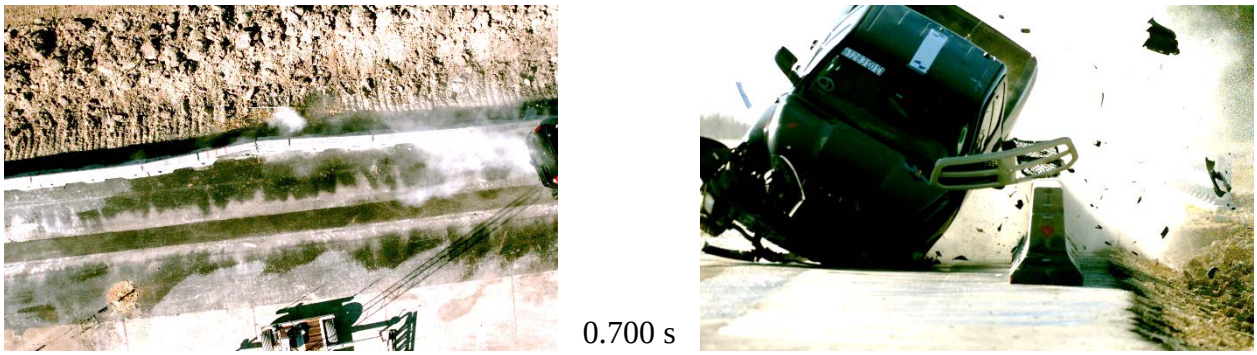
0.700 s

Figure C.1. Sequential Photographs for Test No. 612831-01-1 (Overhead and Frontal Views) (Continued).


0.000 s


0.400 s


0.100 s


0.500 s


0.200 s


0.600 s


0.300 s


0.700 s

Figure C.2. Sequential Photographs for Test No. 612831-01-1 (Rear View).

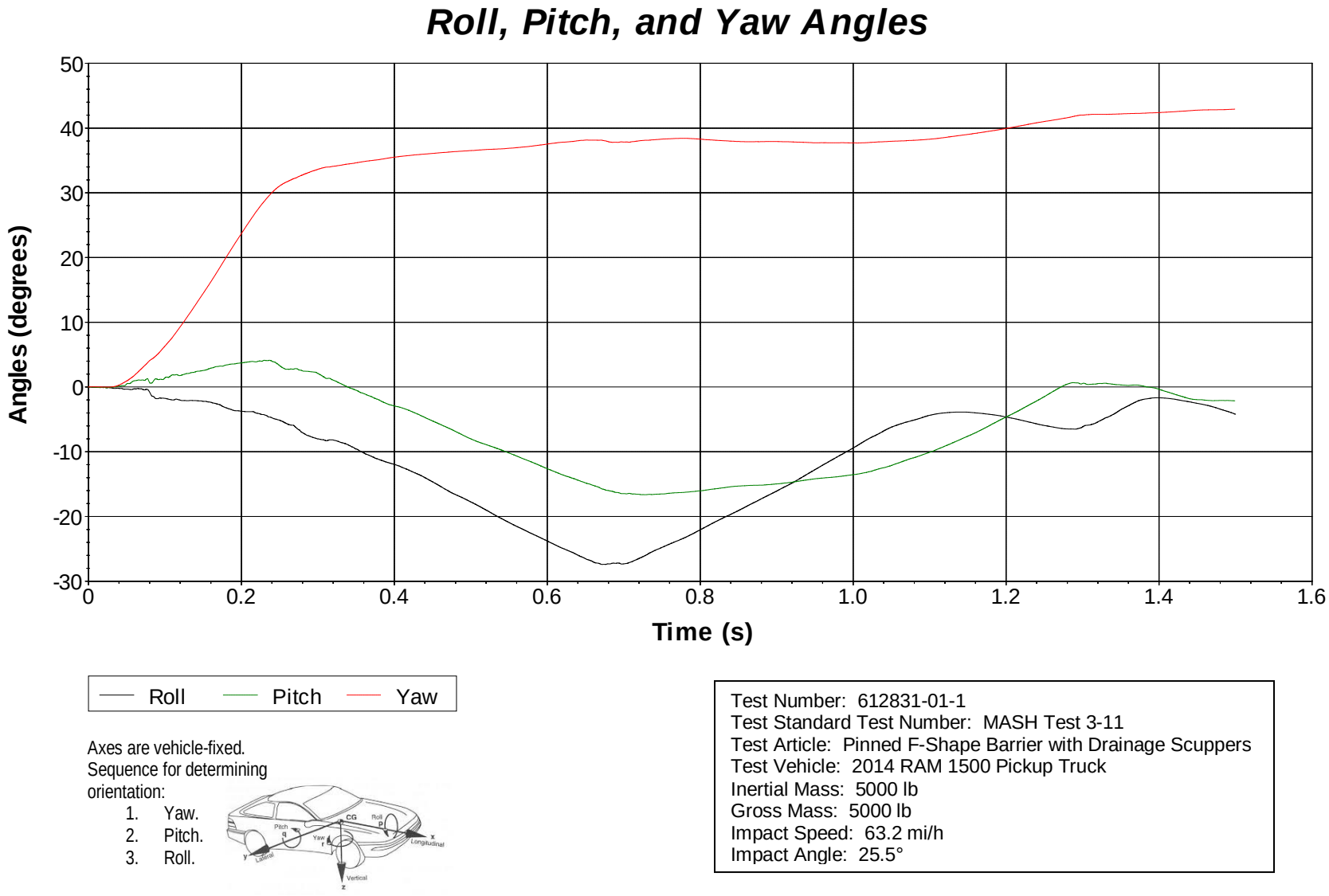

Figure C.3. Vehicle Angular Displacements for Test No. 612831-01-1.

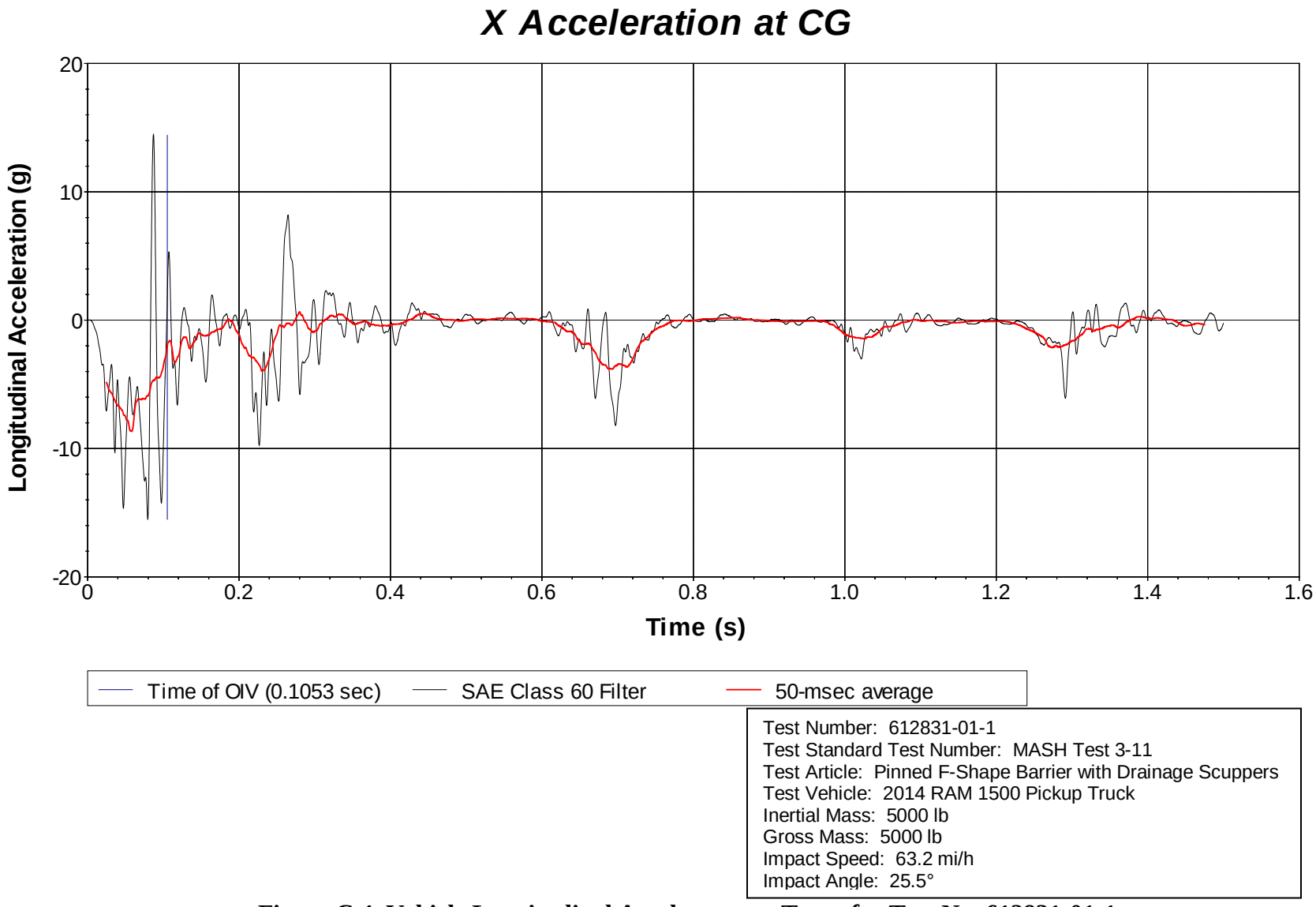

Figure C.4. Vehicle Longitudinal Accelerometer Trace for Test No. 612831-01-1 (Accelerometer Located at Center of Gravity).

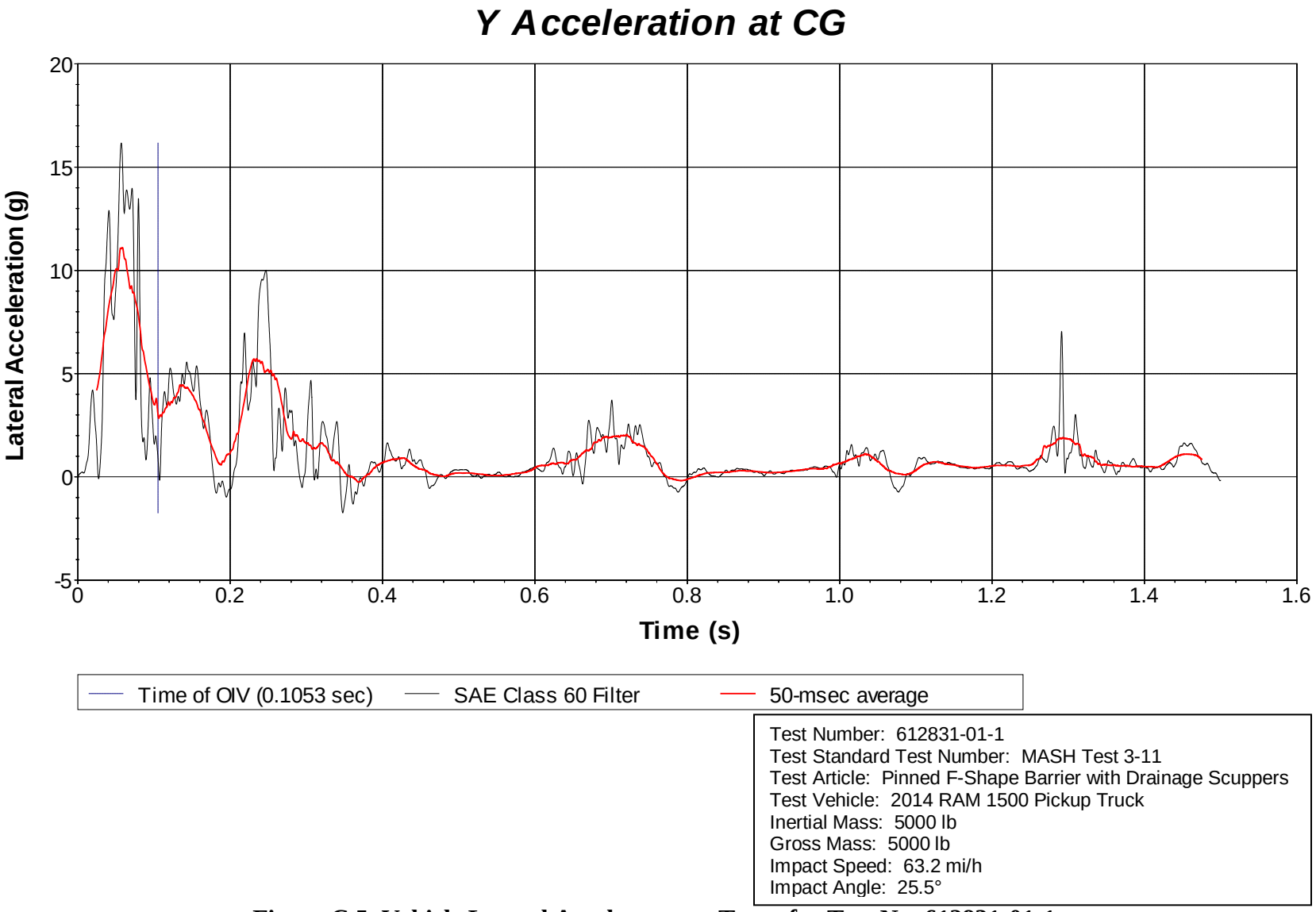

Figure C.5. Vehicle Lateral Accelerometer Trace for Test No. 612831-01-1 (Accelerometer Located at Center of Gravity).

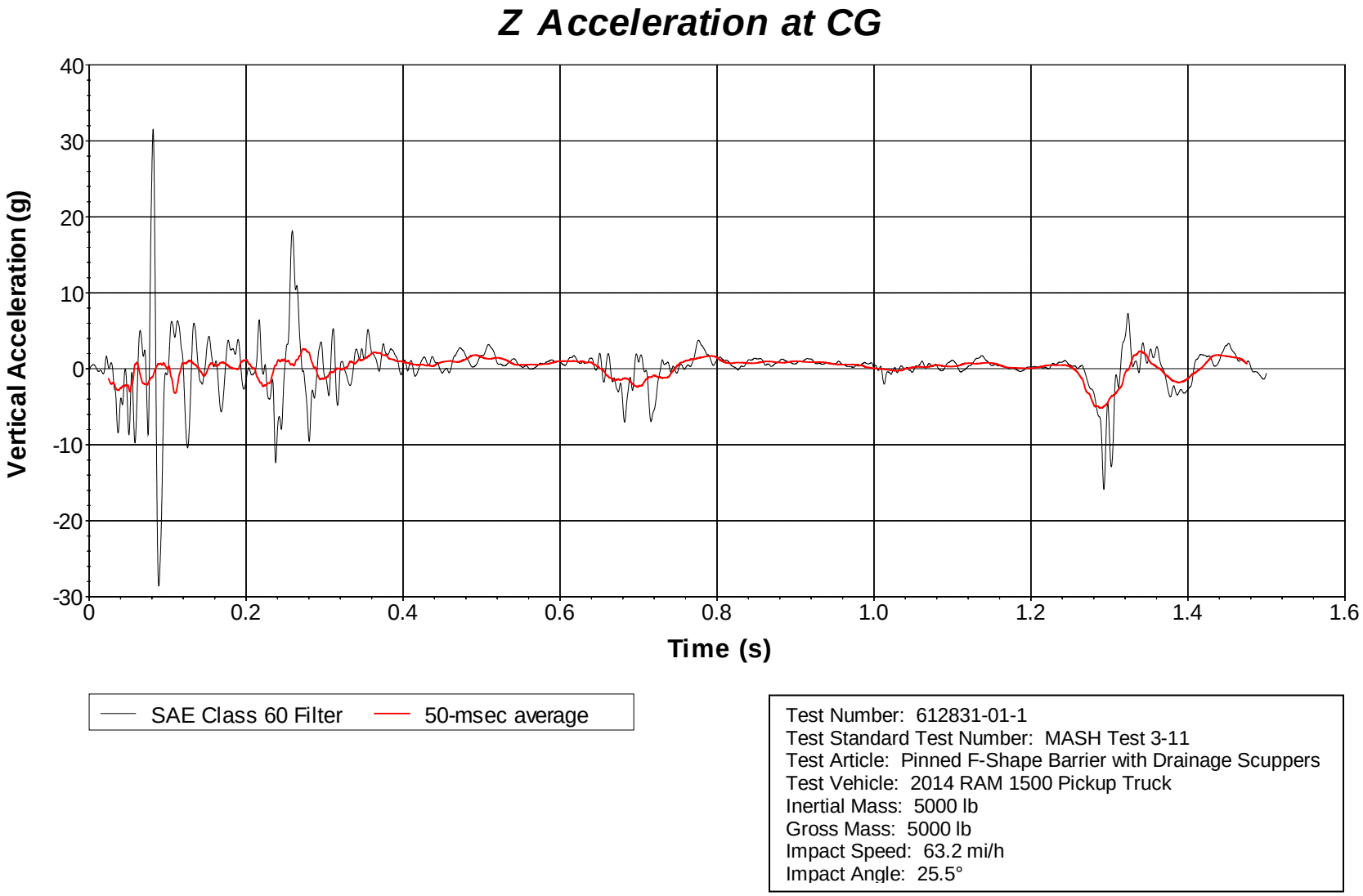

Figure C.6. Vehicle Vertical Accelerometer Trace for Test No. 612831-01-1 (Accelerometer Located at Center of Gravity).

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APPENDIX D. *MASH* TEST 3-11 (CRASH TEST NO. 612831-01-2)

D1 VEHICLE PROPERTIES AND INFORMATION

Table D.1. Vehicle Properties for Test No. 612831-01-2.

Date: 2020-01-09 Test No.: 612831-01-2 VIN No.: 1C6RR6GT2ES477824

Year: 2014 Make: RAM Model: 1500

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

Tread Type: Highway Odometer: 147198

Note any damage to the vehicle prior to test: None

• Denotes accelerometer location.

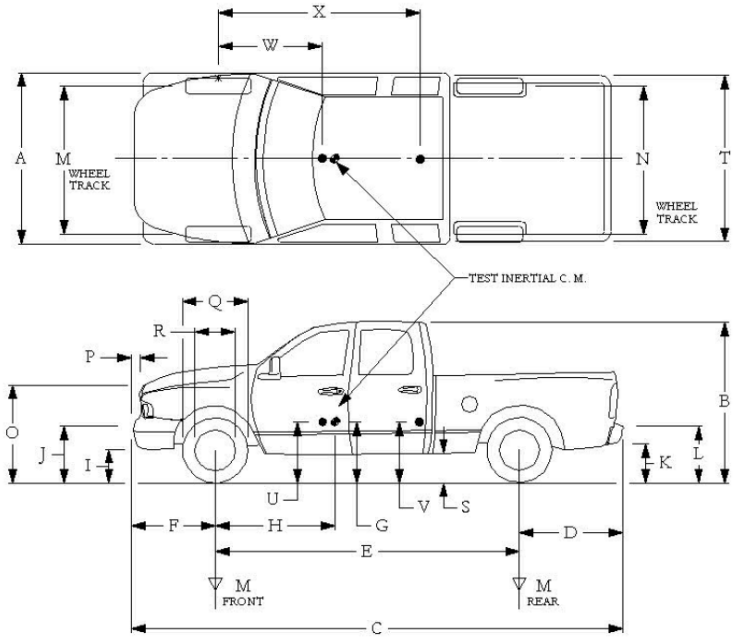
NOTES: None

Engine Type: V-8
Engine CID: 5.7 liter

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

Optional Equipment:
None

Dummy Data:
Type: No dummy
Mass: 0 lb
Seat Position: NA



Geometry: inches

A	78.50	F	40.00	K	20.00	P	3.00	U	26.75
B	74.00	G	28.75	L	30.00	Q	30.50	V	30.25
C	227.50	H	60.43	M	68.50	R	18.00	W	60.40
D	44.00	I	11.75	N	68.00	S	13.00	X	79.00
E	140.50	J	27.00	O	46.00	T	77.00		

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

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

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	3700	M_{front}	2926	2880	2880
Back	3900	M_{rear}	2110	2174	2174
Total	6700	M_{Total}	5036	5054	5054

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

Mass Distribution:
lb LF: 1430 RF: 1450 LR: 1110 RR: 1064

Table D.2. Measurements of Vehicle Vertical CG for Test No. 612831-01-2.

Date: 2020-01-09 Test No.: 612831-01-2 VIN: 1C6RR6GT2ES477824

Year: 2014 Make: RAM Model: 1500

Body Style: Quad Cab Mileage: 147198

Engine: 5.7 liter V-8 Transmission: Automatic

Fuel Level: Empty Ballast: 100 (440 lb max)

Tire Pressure: Front: 35 psi Rear: 35 psi Size: 265/70 R 17

Measured Vehicle Weights: (lb)

LF:	1430	RF:	1450	Front Axle:	2880
LR:	1110	RR:	1064	Rear Axle:	2174
Left:	2540	Right:	2514	Total:	5054
					5000 ±110 lb allowed

Wheel Base: 140.50 inches (148 ±12 inches allowed) Track: F: 68.50 inches R: 68.00 inches

Track = (F+R)/2 = 67 ±1.5 inches allowed

Center of Gravity, SAE J874 Suspension Method

X:	60.44 inches	Rear of Front Axle	(63 ±4 inches allowed)
Y:	-0.18 inches	Left - Right +	of Vehicle Centerline
Z:	28.75 inches	Above Ground	(minumum 28.0 inches allowed)

Hood Height: 46.00 inches (43 ±4 inches allowed) Front Bumper Height: 27.00 inches

Front Overhang: 40.00 inches (39 ±3 inches allowed) Rear Bumper Height: 30.00 inches

Overall Length: 227.50 inches (237 ±13 inches allowed)

Table D.3. Exterior Crush Measurements for Test No. 612831-01-2.

Date:	2020-01-09	Test No.:	612831-01-2	VIN No.:	1C6RR6GT2ES477824
Year:	2014	Make:	RAM	Model:	1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

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

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

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max*** Crush								
1	Front plane at bmpr ht	15	14	36	-	-	-	-	-	-	-18
2	Side plane at bmpr ht	15	15	58	-	-	-	-	-	-	+68
	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.

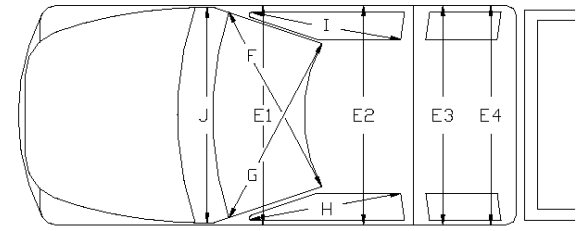
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

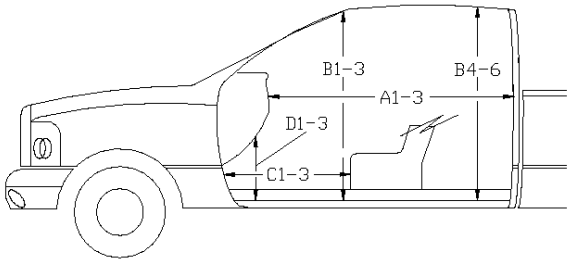
***Measure and document on the vehicle diagram the location of the maximum crush.

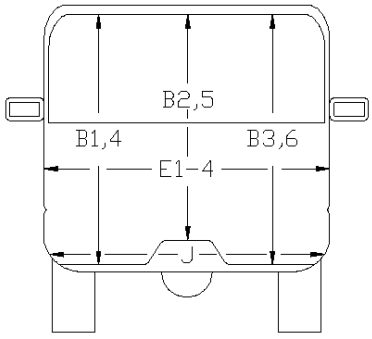
Note: Use as many lines/columns as necessary to describe each damage profile.

Table D.4. Occupant Compartment Measurements for Test No. 612831-01-2.

Date:	2020-01-09	Test No.:	612831-01-2	VIN No.:	1C6RR6GT2ES477824
Year:	2014	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	39.50	0.00
B5	43.00	43.00	0.00
B6	39.50	39.50	0.00
C1	26.00	24.50	-1.50
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

D2 SEQUENTIAL PHOTOGRAPHS

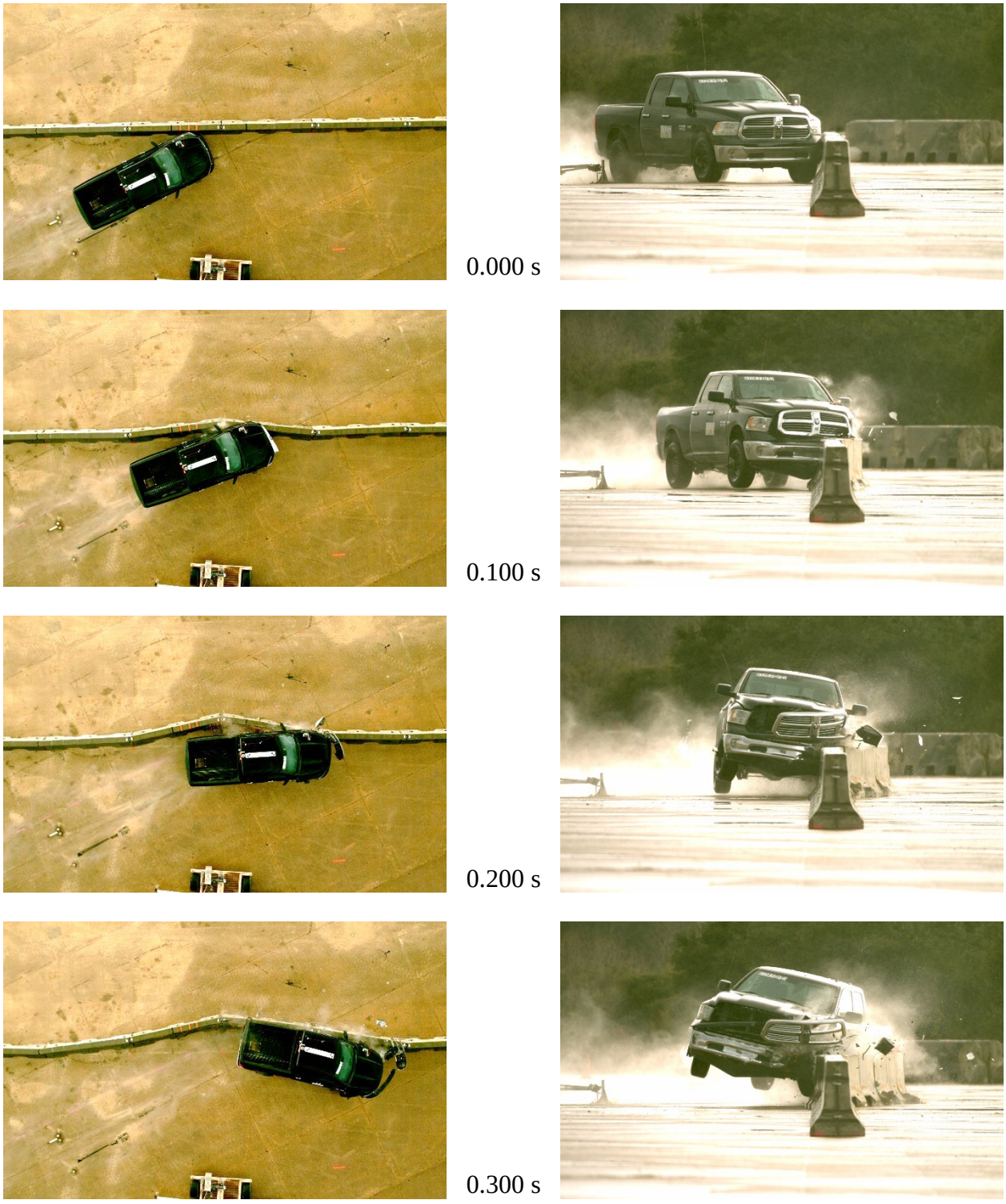
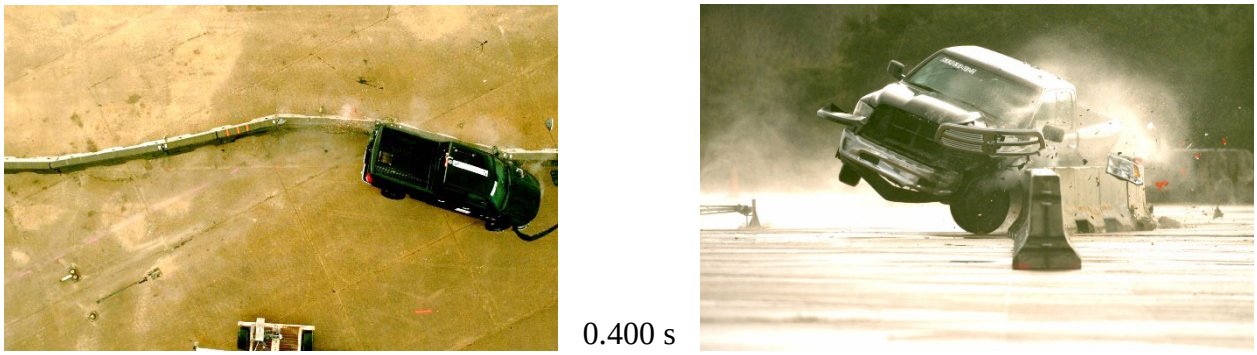
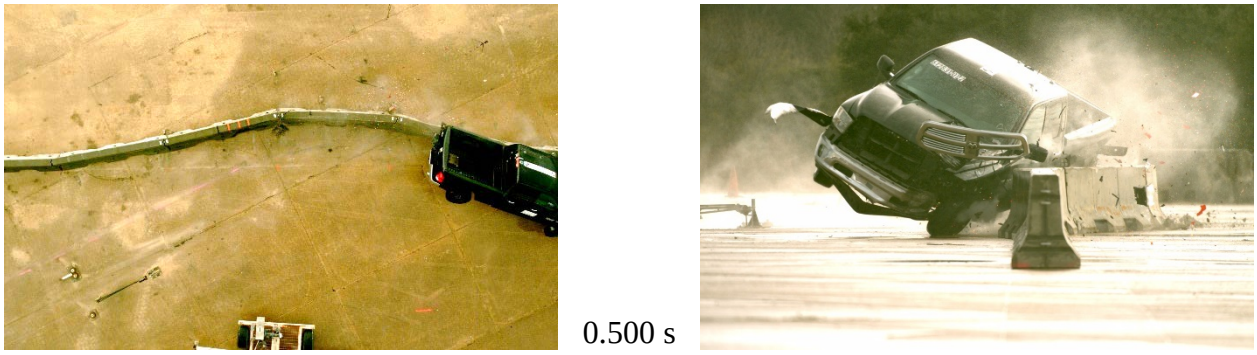
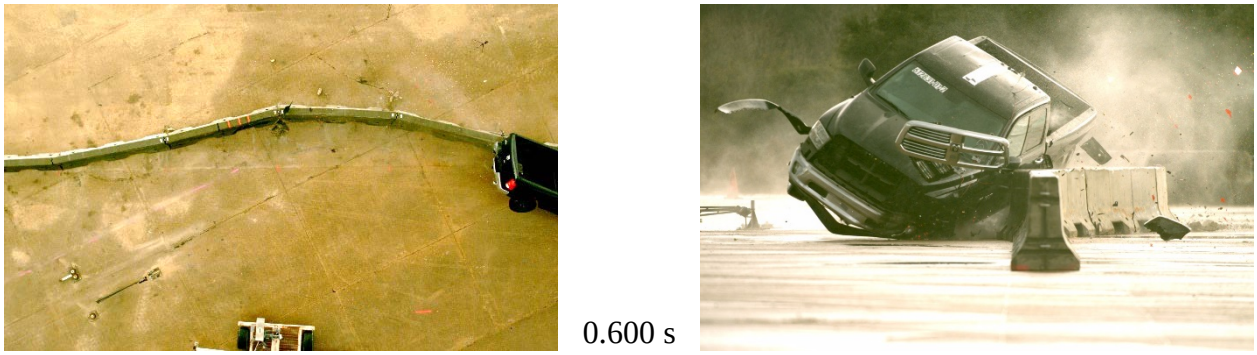


Figure D.1. Sequential Photographs for Test No. 612831-01-2 (Overhead and Frontal Views).







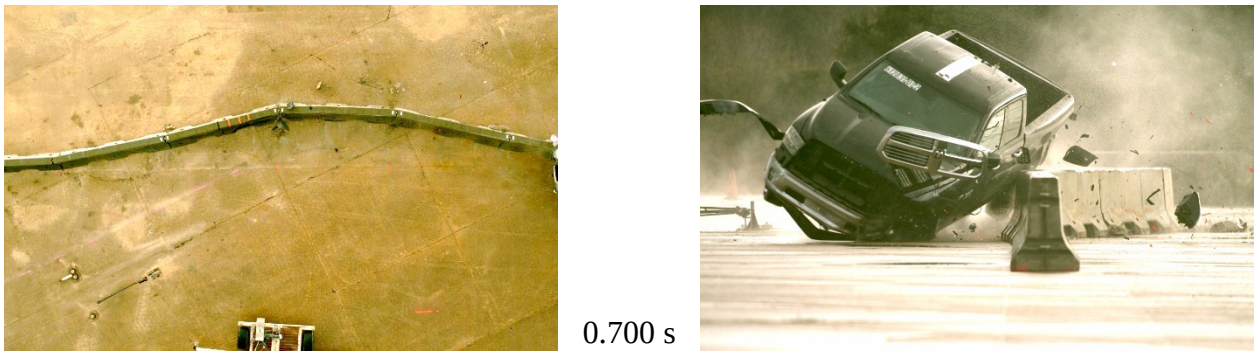


Figure D.1. Sequential Photographs for Test No. 612831-01-2 (Overhead and Frontal Views) (Continued).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0.700 s

Figure D.2. Sequential Photographs for Test No. 612831-01-2 (Rear View).

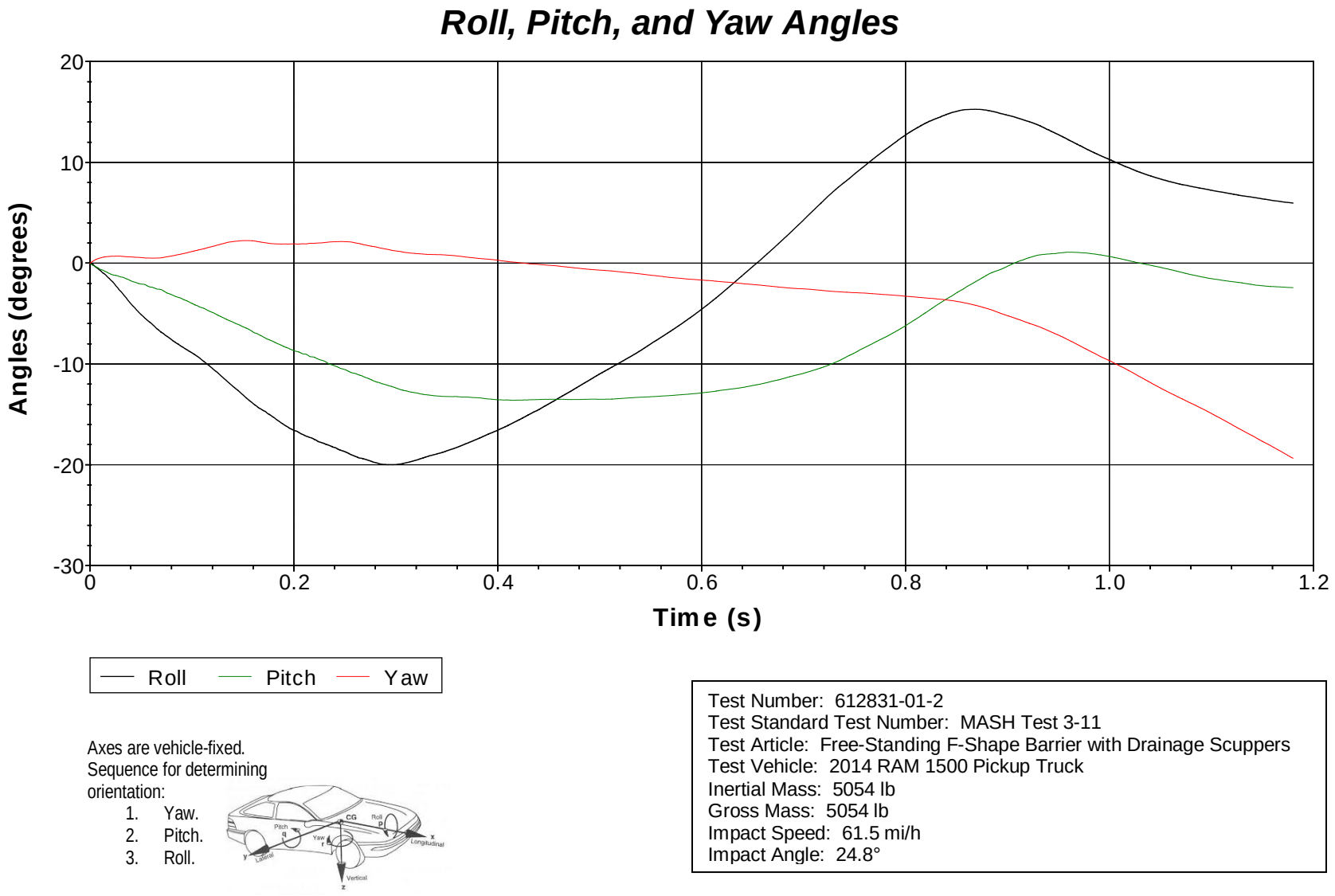

Figure D.3. Vehicle Angular Displacements for Test No. 612831-01-2.

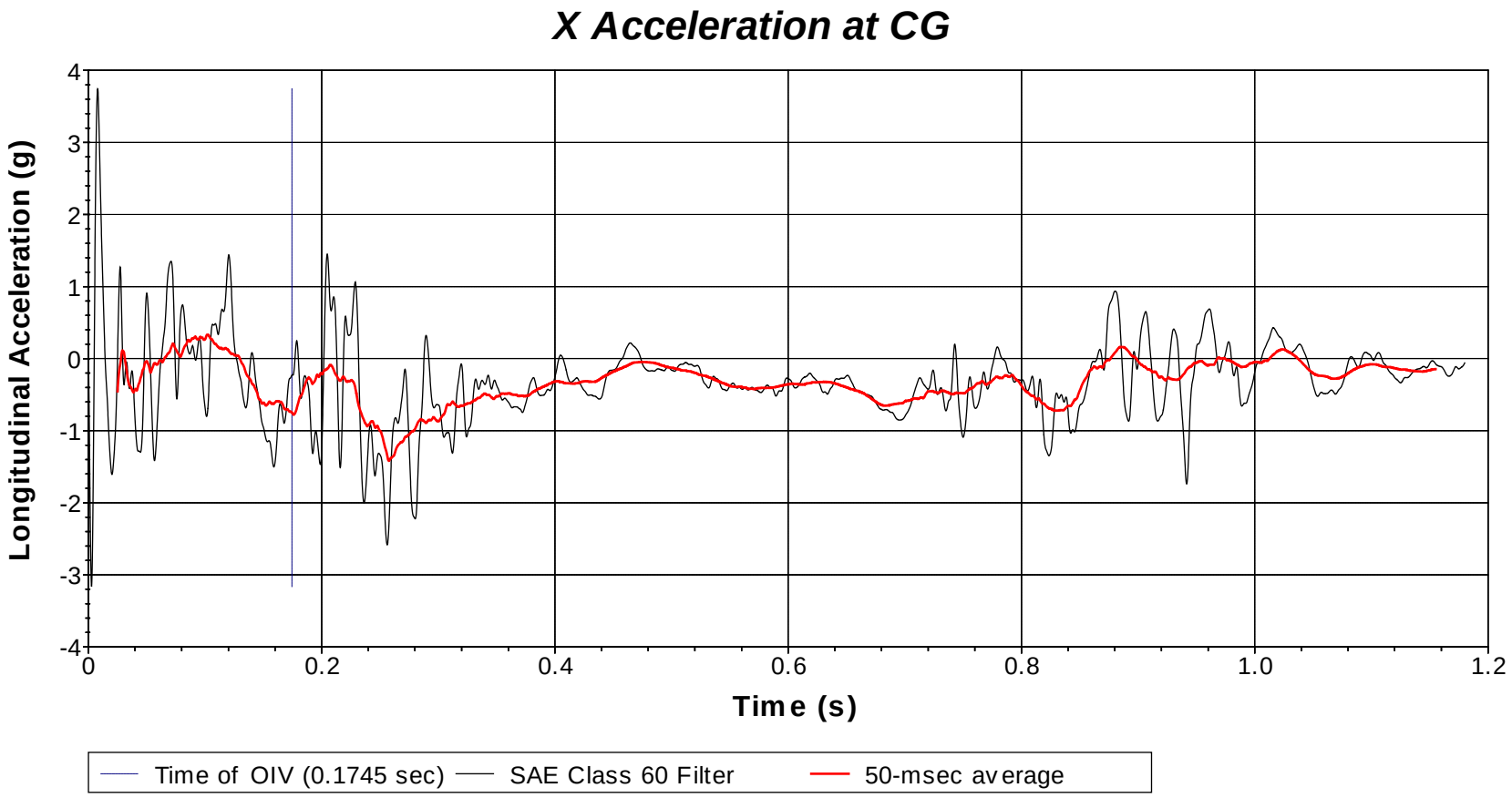

Figure D.4. Vehicle Longitudinal Accelerometer Trace for Test No. 612831-01-2 (Accelerometer Located at Center of Gravity).

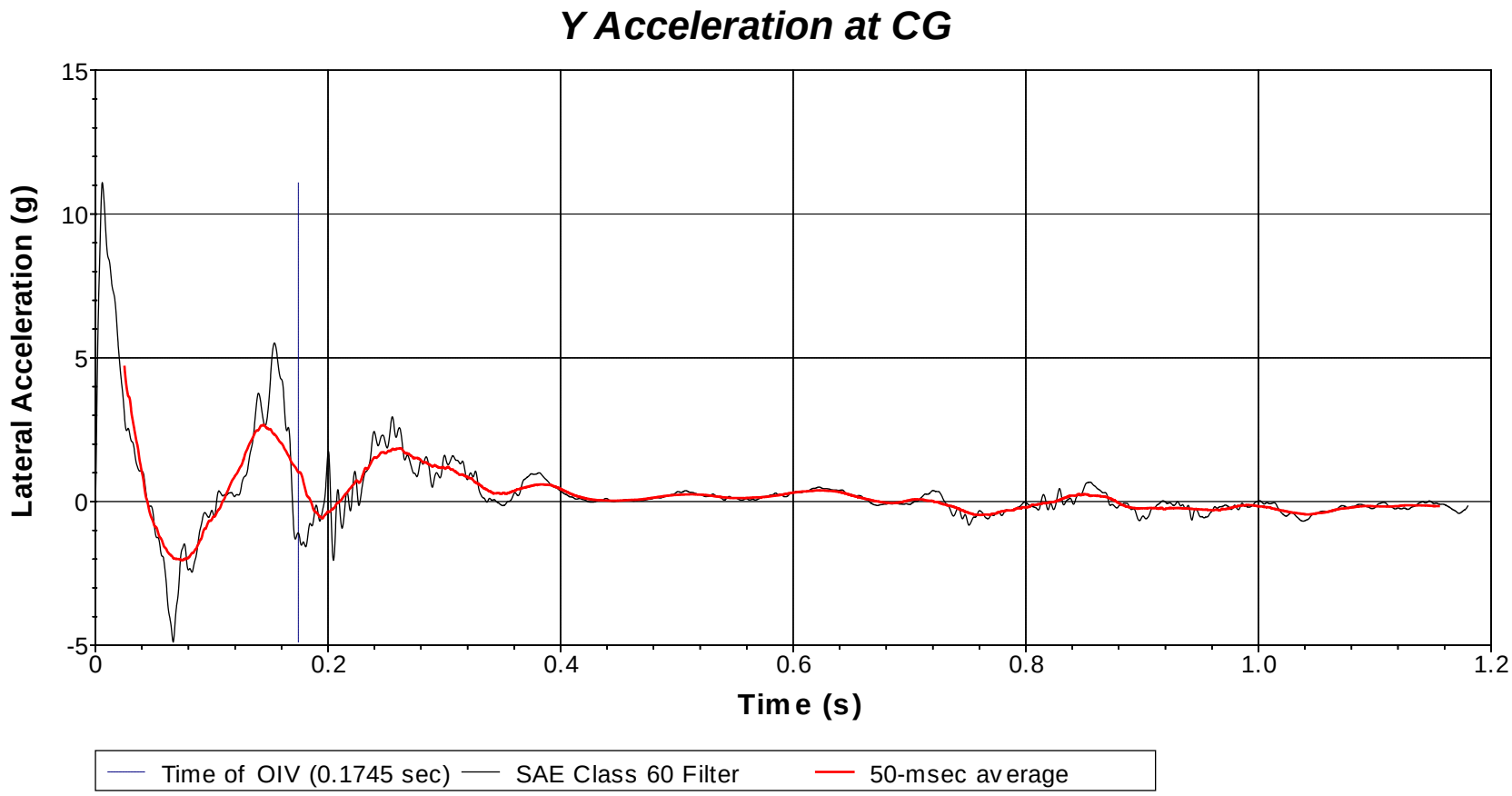

Figure D.5. Vehicle Lateral Accelerometer Trace for Test No. 612831-01-2 (Accelerometer Located at Center of Gravity).

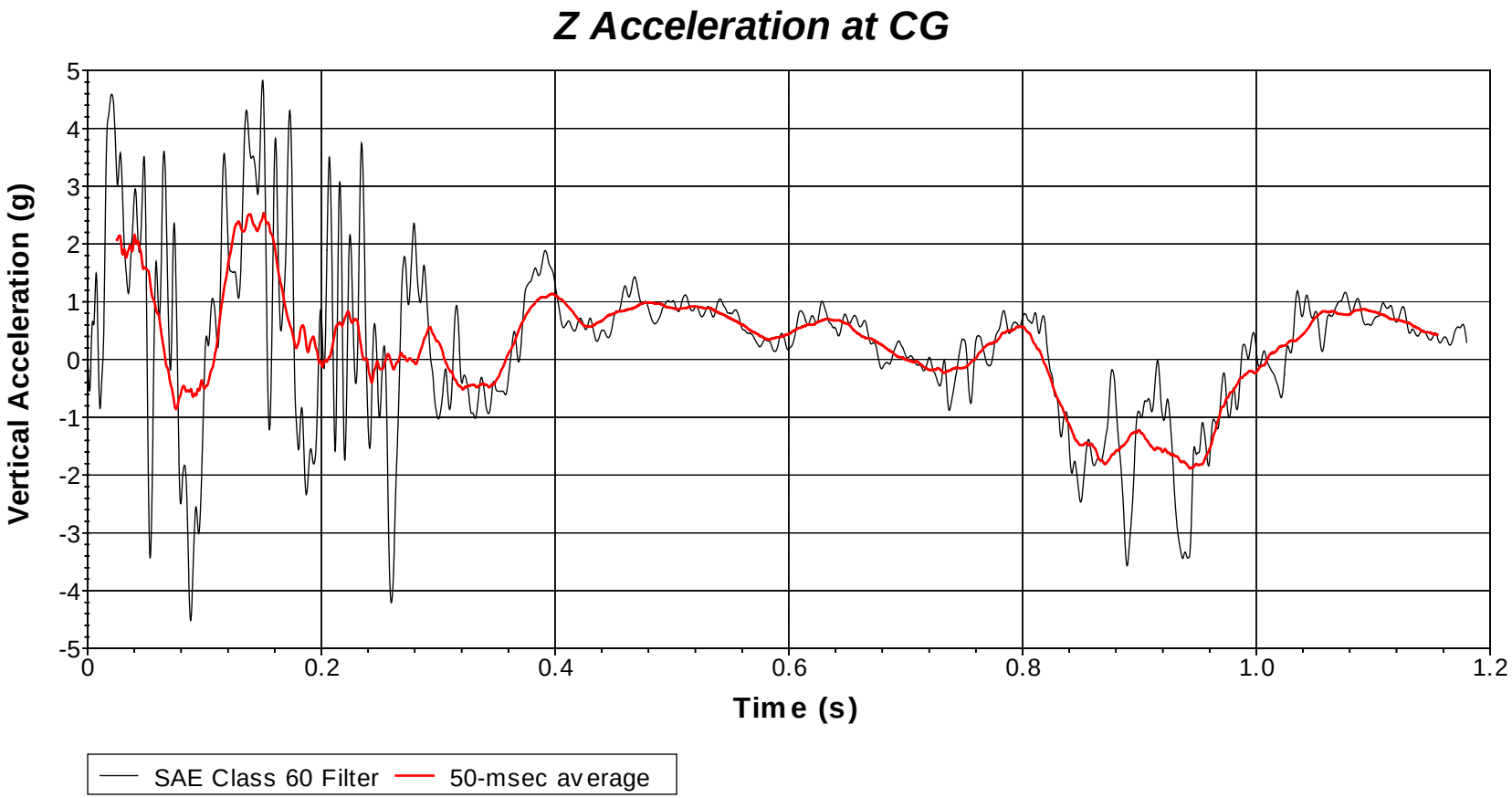

Figure D.6. Vehicle Vertical Accelerometer Trace for Test No. 612831-01-2 (Accelerometer Located at Center of Gravity).

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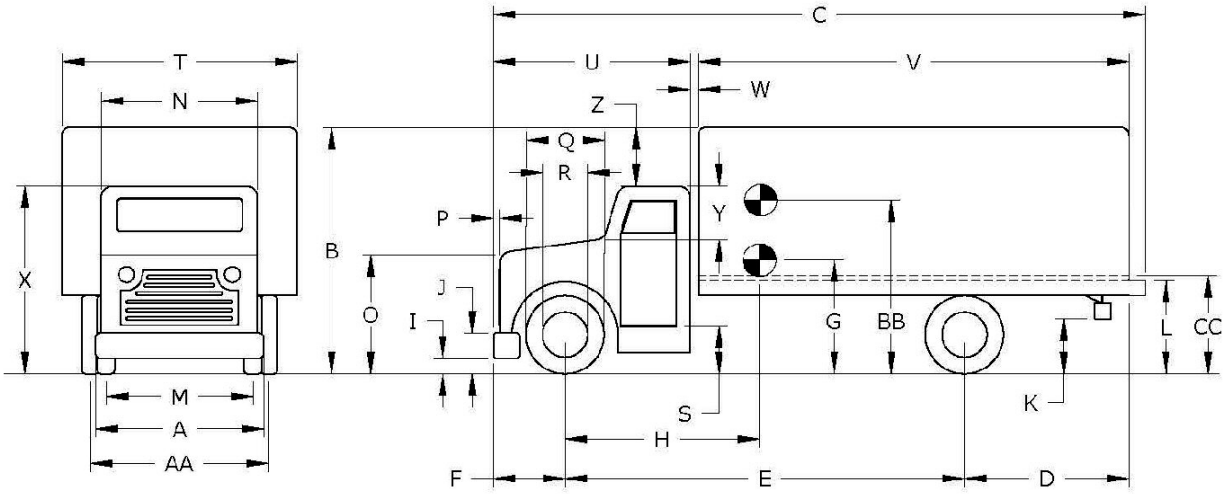
APPENDIX E. *MASH* TEST 4-12 (CRASH TEST NO. 612831-01-3)

E1 VEHICLE PROPERTIES AND INFORMATION

Table E.1. Vehicle Properties for Test No. 612831-01-3.

Date:	2019-12-17	Test No.:	612831-01-3	VIN No.:	3HAMMAAN8CL641700
Year:	2012	Make:	INTERNATIONAL	Model:	4300
Odometer:		Tire Size Front:	275/80R22.5	Tire Size Rear:	275/80R22.5



Vehicle Geometry: ☑ inches or ☐ mm

A	Front Bumper Width:	92.50	K	Rear Bumper Bottom:		U	Cab Length:	106.00
B	Overall Height:	145.50	L	Rear Frame Top:	38.00	V	Trailer/Box Length:	214.00
C	Overall Length:	321.50	M	Front Track Width:	80.00	W	Gap Width:	1.50
D	Rear Overhang:	74.50	N	Roof Width:	71.00	X	Overall Front Height:	98.50
E	Wheel Base:	207.00	O	Hood Height:	58.50	Y	Roof-Hood Distance:	30.00
F	Front Overhang:	40.00	P	Bumper Extension:		Z	Roof-Box Height Difference:	47.00
G	C.G. Height:		Q	Front Tire Width:	39.00	AA	Rear Track Width:	73.00
H	C.G. Horizontal Dist. w/Ballast:	126.77	R	Front Wheel Width:	23.50	BB	Ballast Center of Mass:	62.00
I	Front Bumper Bottom:	18.25	S	Bottom Door Height:	37.00	CC	Cargo Bed Height:	50.00
J	Front Bumper Top:	33.25	T	Overall Width:	96.00			

Allowable Range: C = 394 inches max.; E = 240 inches max.; CC = 49 ±2 inches; BB = 63 ±2 inches above ground;

Wheel Center Height Front	19.00	Wheel Well Clearance (Front)	9.00	Bottom Frame Height (Front)	25.50
Wheel Center Height Rear	19.00	Wheel Well Clearance (Rear)	3.50	Bottom Frame Height (Rear)	27.50

More information needed on next page

Table E.1. Vehicle Properties for Test No. 612831-01-3 (Continued).

Date:	2019-12-17	Test No.:	612831-01-3	VIN No.:	3HAMMAAN8CL641700
Year:	2012	Make:	INTERNATIONAL	Model:	4300

WEIGHTS (☑ lb or ☐ kg)	CURB	TEST INERTIAL
$W_{front\ axle}$	7290	8670
$W_{rear\ axle}$	6650	13700
W_{TOTAL}	13940	22370

Allowable Range for CURB = 13,200 ±2200 lb | Allowable Range for TIM = 22,046 ±660 lb

Ballast: 8430 (☑ lb or ☐ kg) **(as-needed)**
(See *MASH* Section 4.2.1.2 for recommended ballasting)

Mass Distribution (☑ lb or ☐ kg): **LF:** 4380 **RF:** 4290 **LR:** 6880 **RR:** 6820

Engine Type: DT
Engine Size: 466

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

Accelerometer Locations (☑ inches or ☐ mm)

	x[1]	y	z[2]
Front:			
Center:	126.70	0.00	49.50
Rear:	218.70	0.00	49.50

Describe any damage to the vehicle prior to test: none

Other notes to include ballast type, dimensions, mass, location, center of mass, and method of attachment:

Two blocks: Height 30 inches x Width 60 inches x Length 30"
Centered in middle of bed
62 inches from ground to center of block
Each block tied down with four 5/16-inch cables

Performed by: SCD Date: 2019-12-17

[1] Referenced to the front axle
[2] Above ground

E2 SEQUENTIAL PHOTOGRAPHS

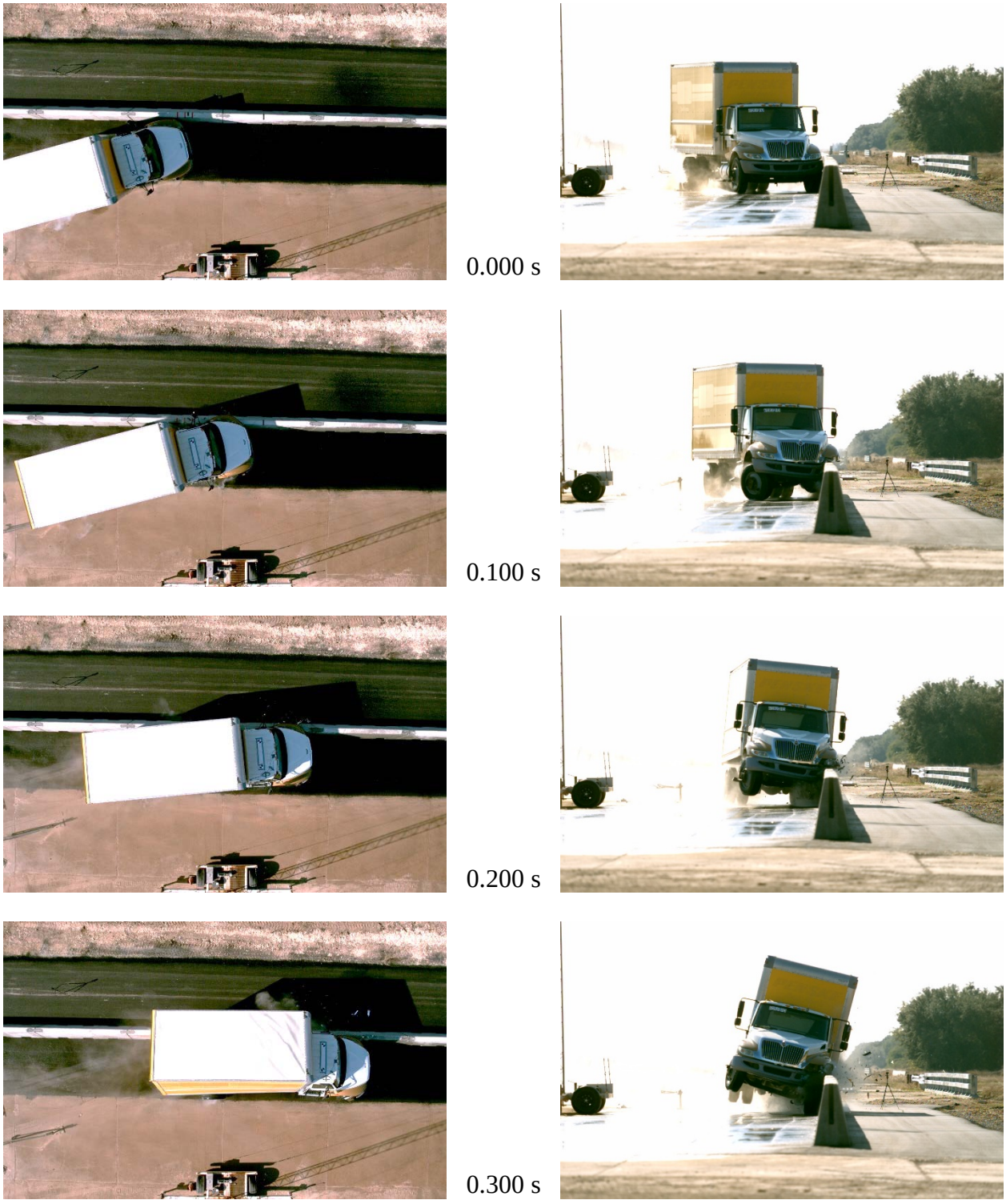
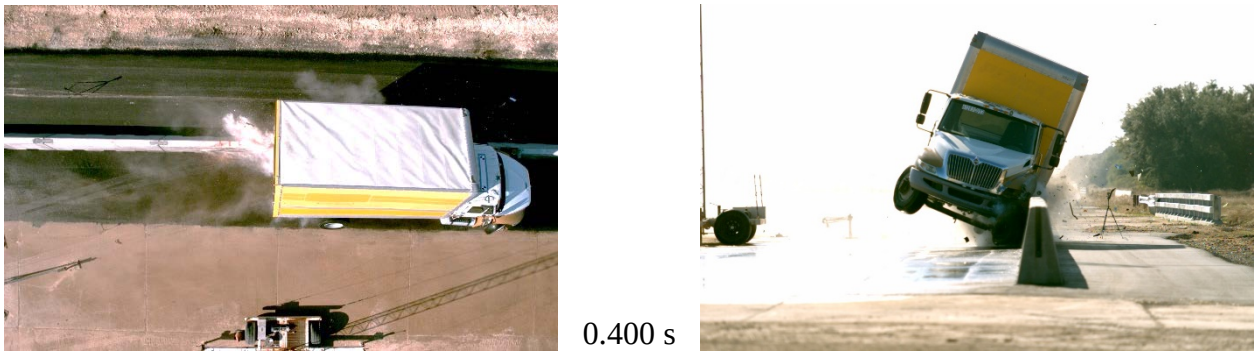


Figure E.1. Sequential Photographs for Test No. 612831-01-3 (Overhead and Frontal Views).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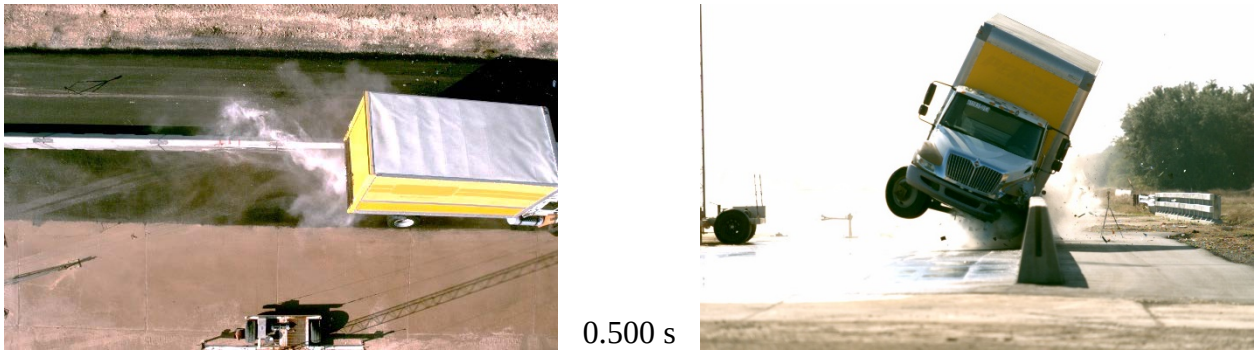
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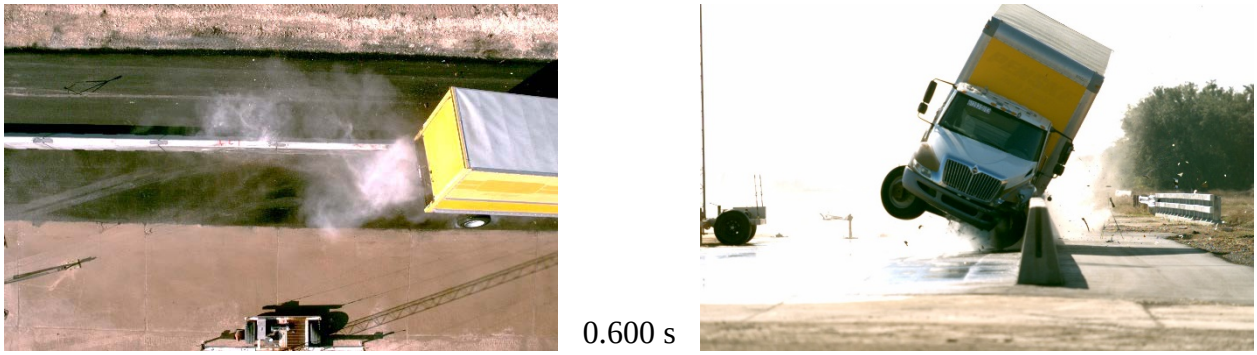
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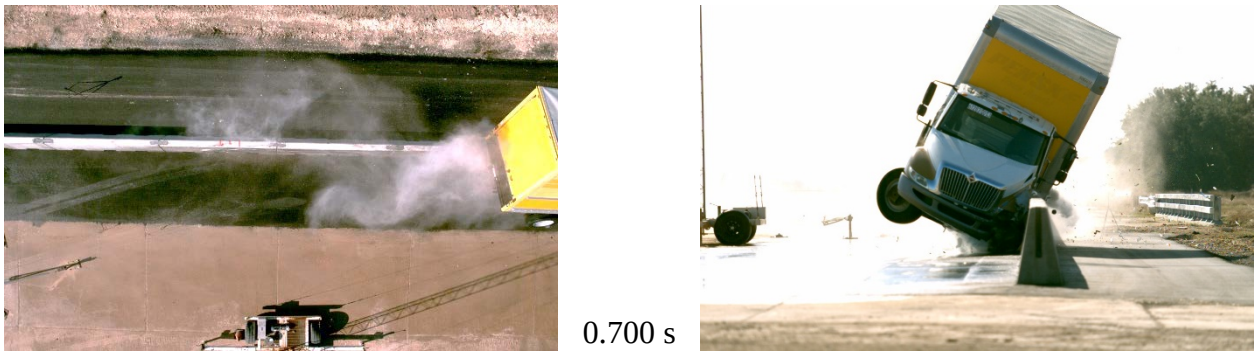
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Figure E.1. Sequential Photographs for Test No. 612831-01-3 (Overhead and Frontal Views) (Continued).


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0.400 s


0.100 s


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0.200 s


0.600 s


0.300 s


0.700 s

Figure E.2. Sequential Photographs for Test No. 612831-01-3 (Rear View).

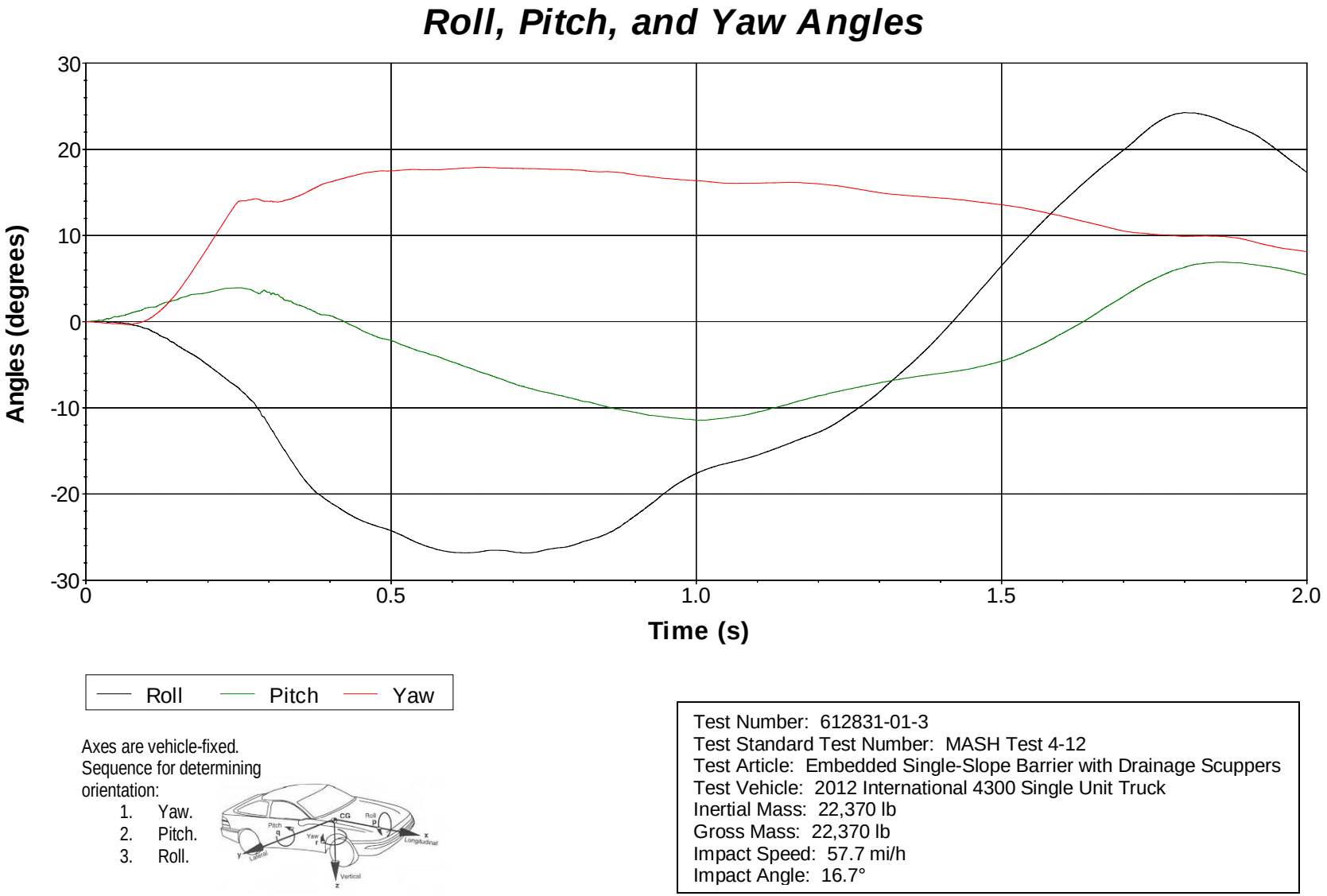

Figure E.3. Vehicle Angular Displacements for Test No. 612831-01-3.

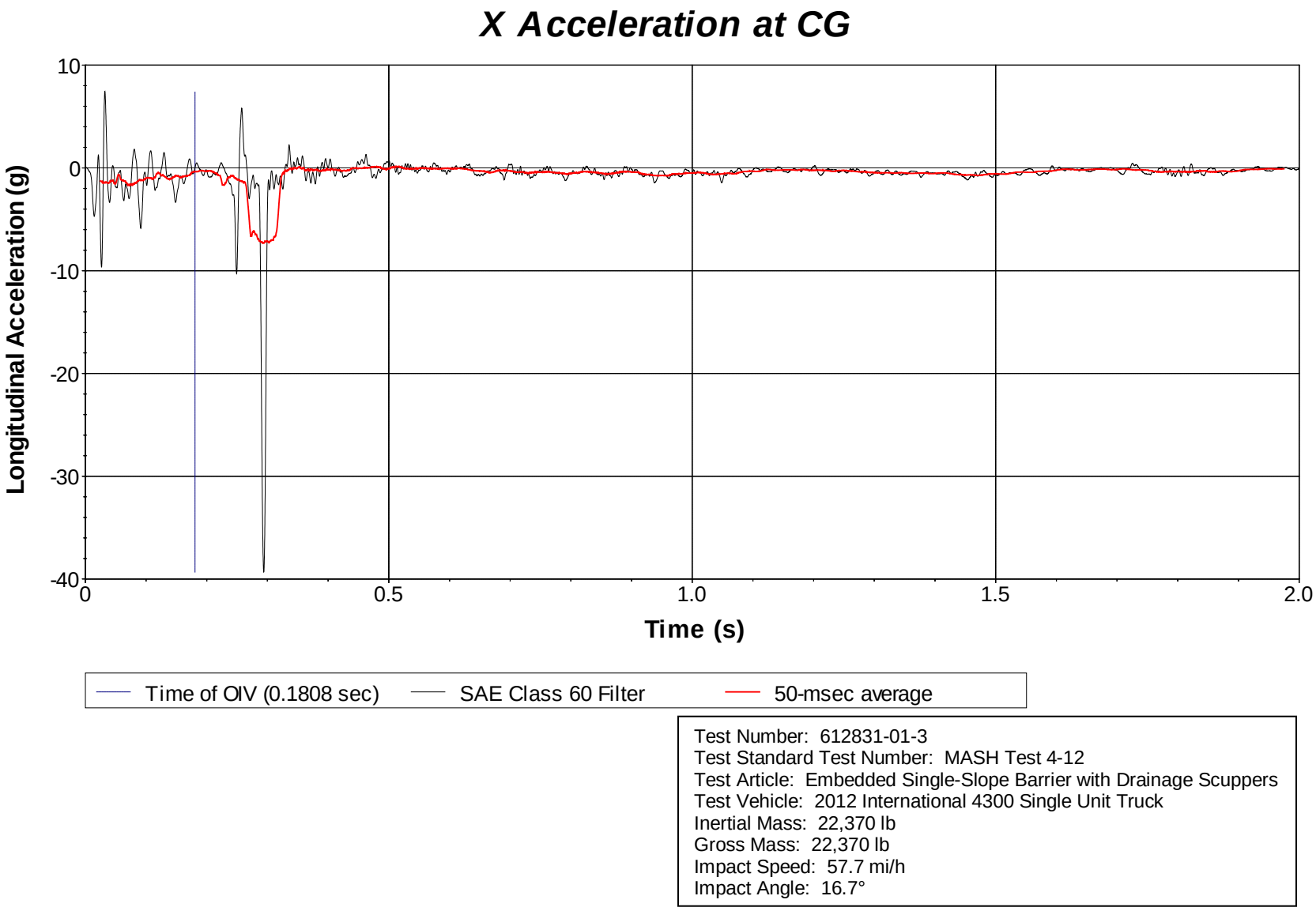

Figure E.4. Vehicle Longitudinal Accelerometer Trace for Test No. 612831-01-3 (Accelerometer Located at Center of Gravity).

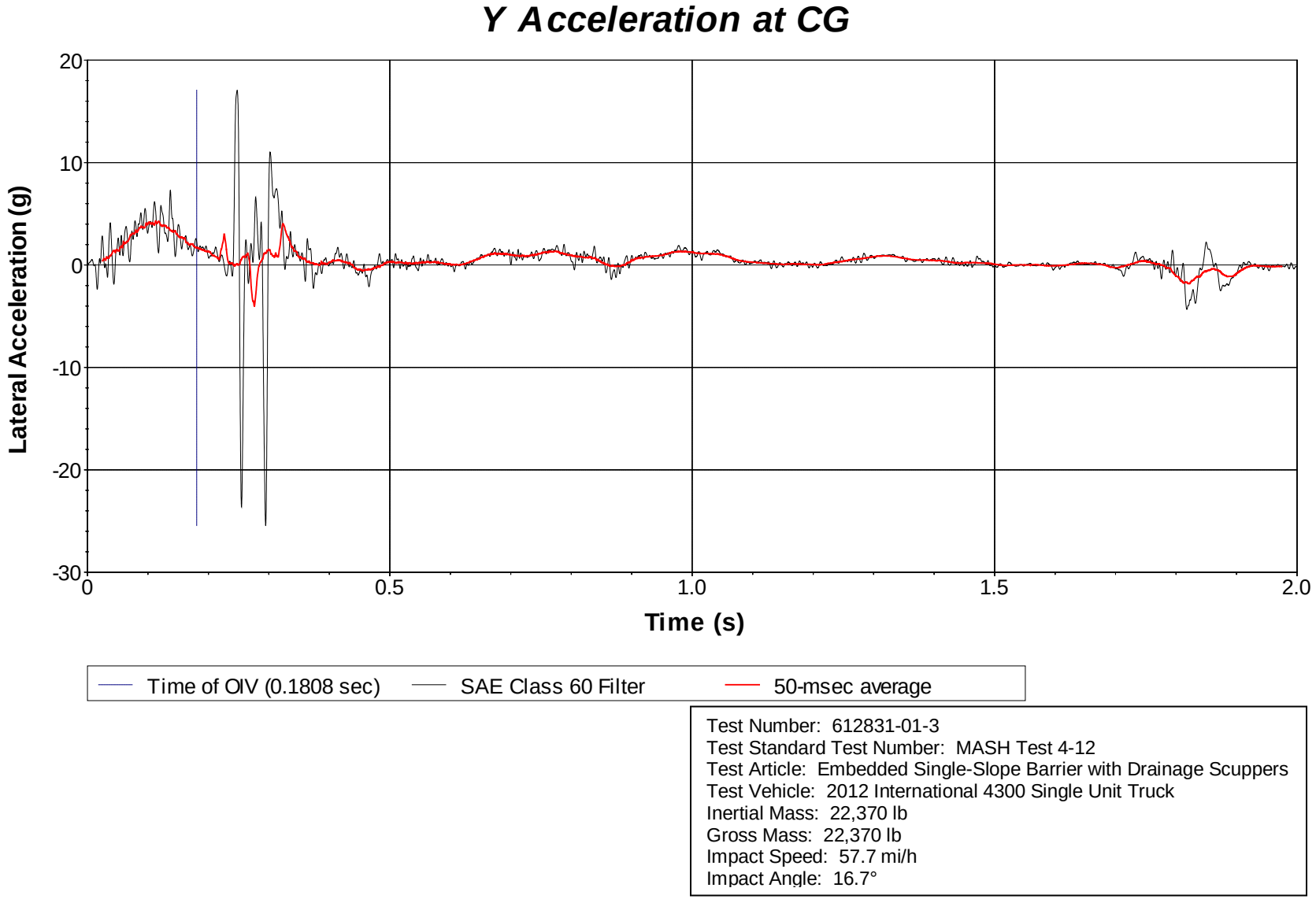

Figure E.5. Vehicle Lateral Accelerometer Trace for Test No. 612831-01-3 (Accelerometer Located at Center of Gravity).

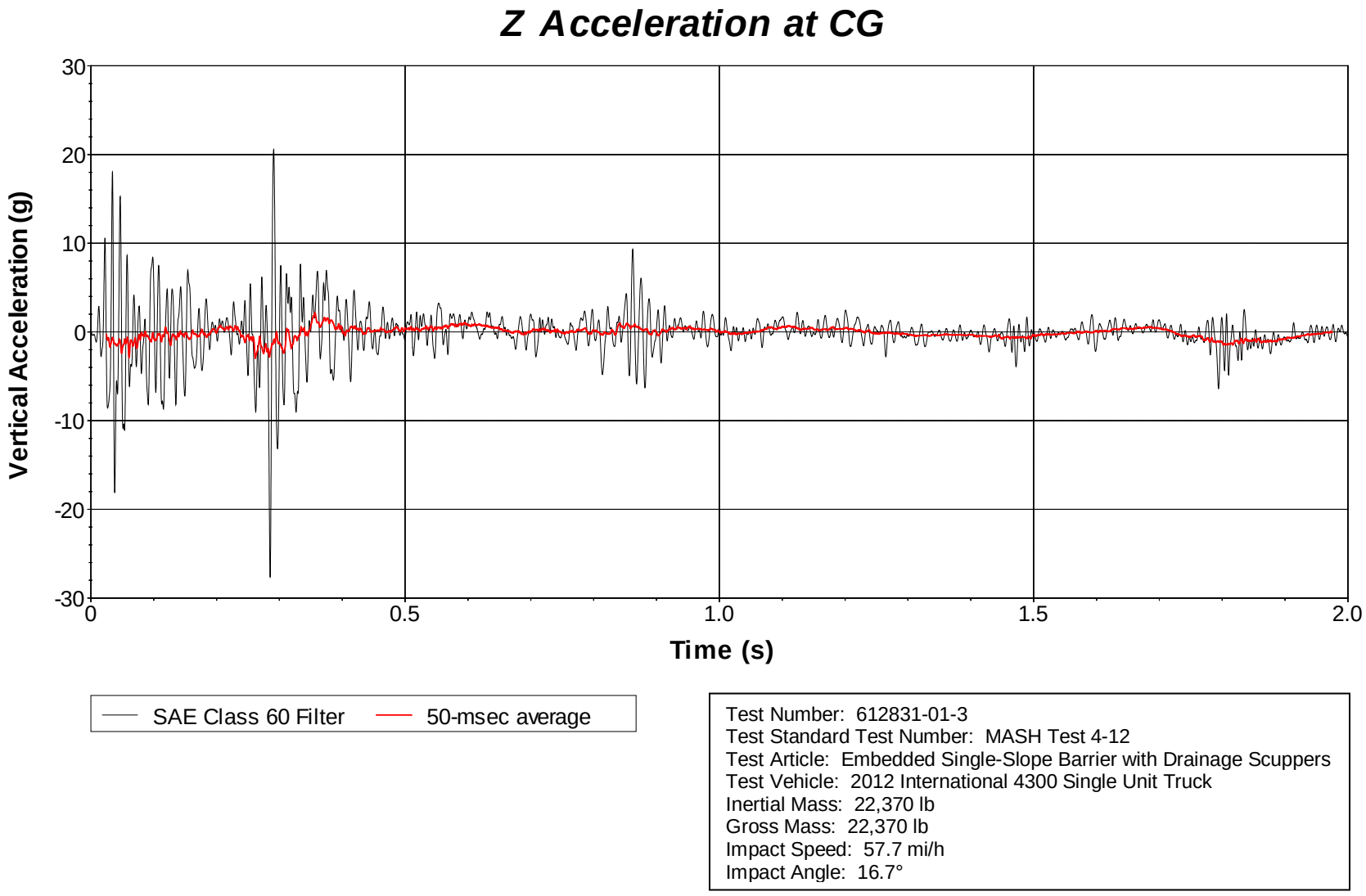

Figure E.6. Vehicle Vertical Accelerometer Trace for Test No. 612831-01-3 (Accelerometer Located at Center of Gravity).