Texas A&M Transportation Institute
Proving Ground

Test Report No. 440822-01

EVALUATION OF ATTACHMENTS TO CONCRETE BARRIER SYSTEMS TO DETER PEDESTRIANS

COOPERATIVE RESEARCH PROGRAM

Texas Department of Transportation
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16. Abstract

The purpose of the tests reported herein was to assess the performance of prioritized attachments to concrete barrier systems according to the safety-performance evaluation guidelines included in the American Association of State Highway and Transportation Officials *Manual for Assessing Safety Hardware* (*MASH*), Second Edition. The crash tests for the attachments on the single-slope concrete median barrier were performed in accordance with *MASH* Test Level 4 (TL-4), and the crash tests for the attachments on the F-shape concrete median barrier were performed in accordance with *MASH* Test Level 3 (TL-3).

This report provides details on the prioritized attachments to concrete barrier systems, the crash tests and results, and the performance assessment of the investigated systems for *MASH* TL-3 and TL-4 longitudinal barrier evaluation criteria.

The investigated systems met the performance criteria for *MASH* TL-3 (F-shape) and TL-4 (single-slope) longitudinal barriers.

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DISCLAIMER

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The results of the crash testing reported herein apply only to the article tested.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

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

APPROXIMATE CONVERSIONS FROM SI UNITS

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

*SI is the symbol for the International System of Units

Chapter 1. INTRODUCTION

The purpose of the tests reported herein was to assess the performance of prioritized attachments to concrete barrier systems according to the safety-performance evaluation guidelines included in the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (*MASH*), Second Edition (*1*). The crash tests for the attachments on single-slope concrete median barrier were performed in accordance with *MASH* Test Level 4 (TL-4), and the crash tests for the attachments on F-shape concrete median barrier were performed in accordance with *MASH* Test Level 3 (TL-3). The intended use of the attachments is to deter pedestrian crossings across highways.

Chapter 2. SYSTEM DETAILS

2.1. TEST ARTICLE AND INSTALLATION DETAILS

Detailed descriptions of each installation are presented in each system's respective chapter.

Figure 2.1 through Figure 2.5 present the overall information on the attachments to concrete barrier systems, and Figure 2.6 through Figure 2.15 provide photographs of the installations. Appendix A through Appendix E provide further details on the attachments to concrete barrier systems. Drawings were provided by the Texas A&M Transportation Institute (TTI) Proving Ground and the manufacturers of the attachments, and construction was performed by MBC Construction and TTI Proving Ground personnel.

2.2. DESIGN MODIFICATIONS DURING TESTS

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

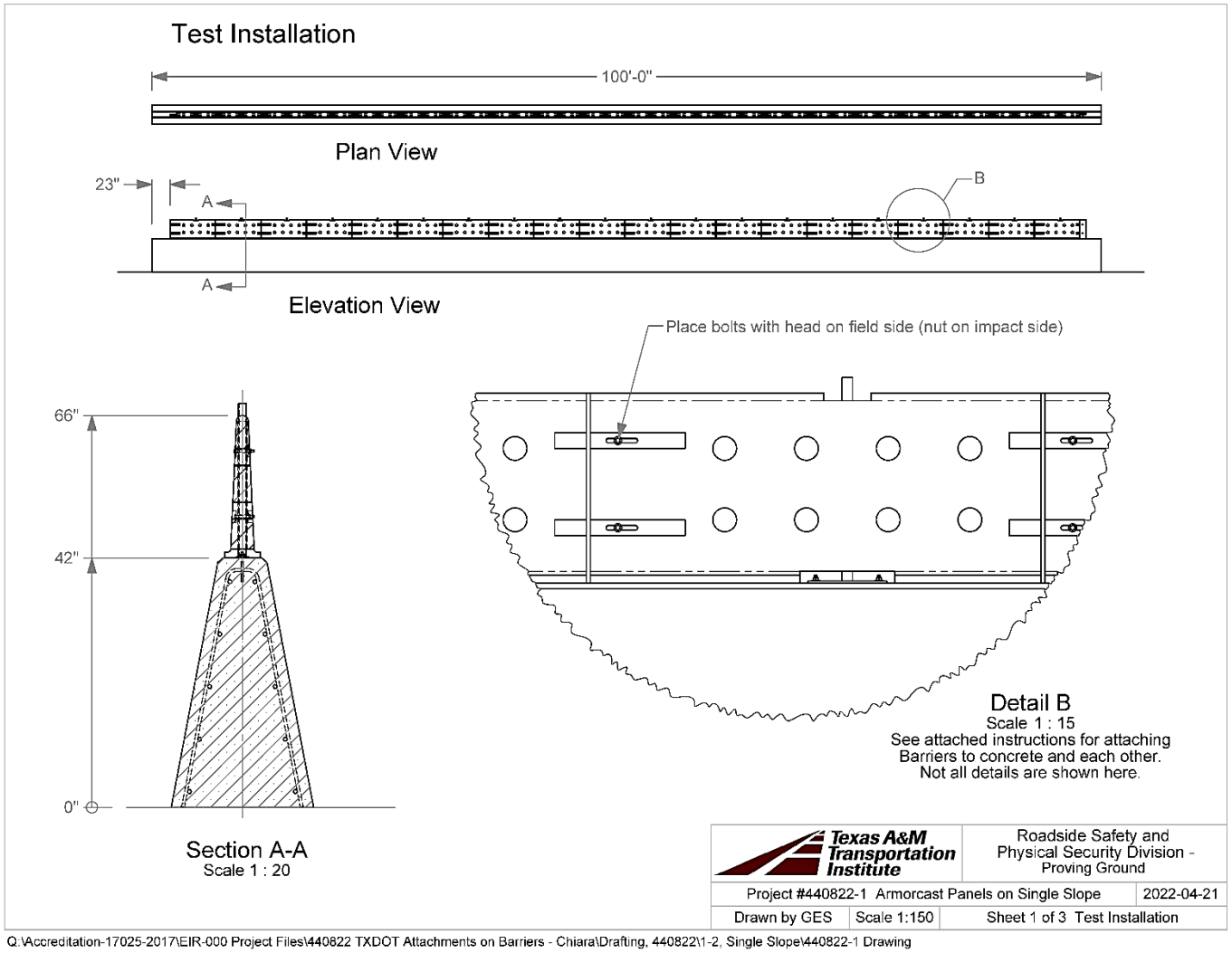

Figure 2.1. Details of Armorcast® Gawk Screen on Single-Slope Barrier.

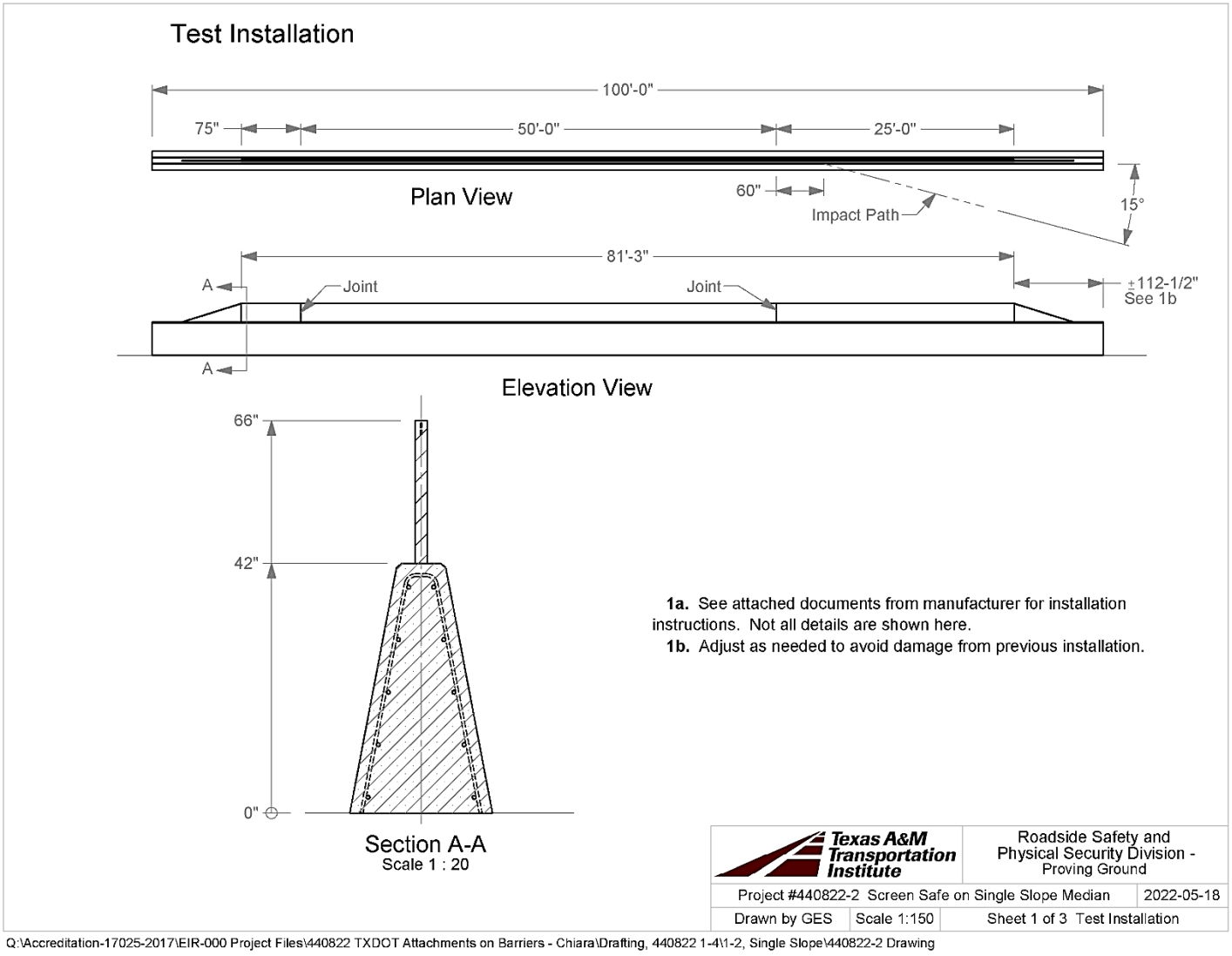

Figure 2.2. Details of Screen-Safe® Glare Screen on Single-Slope Barrier.

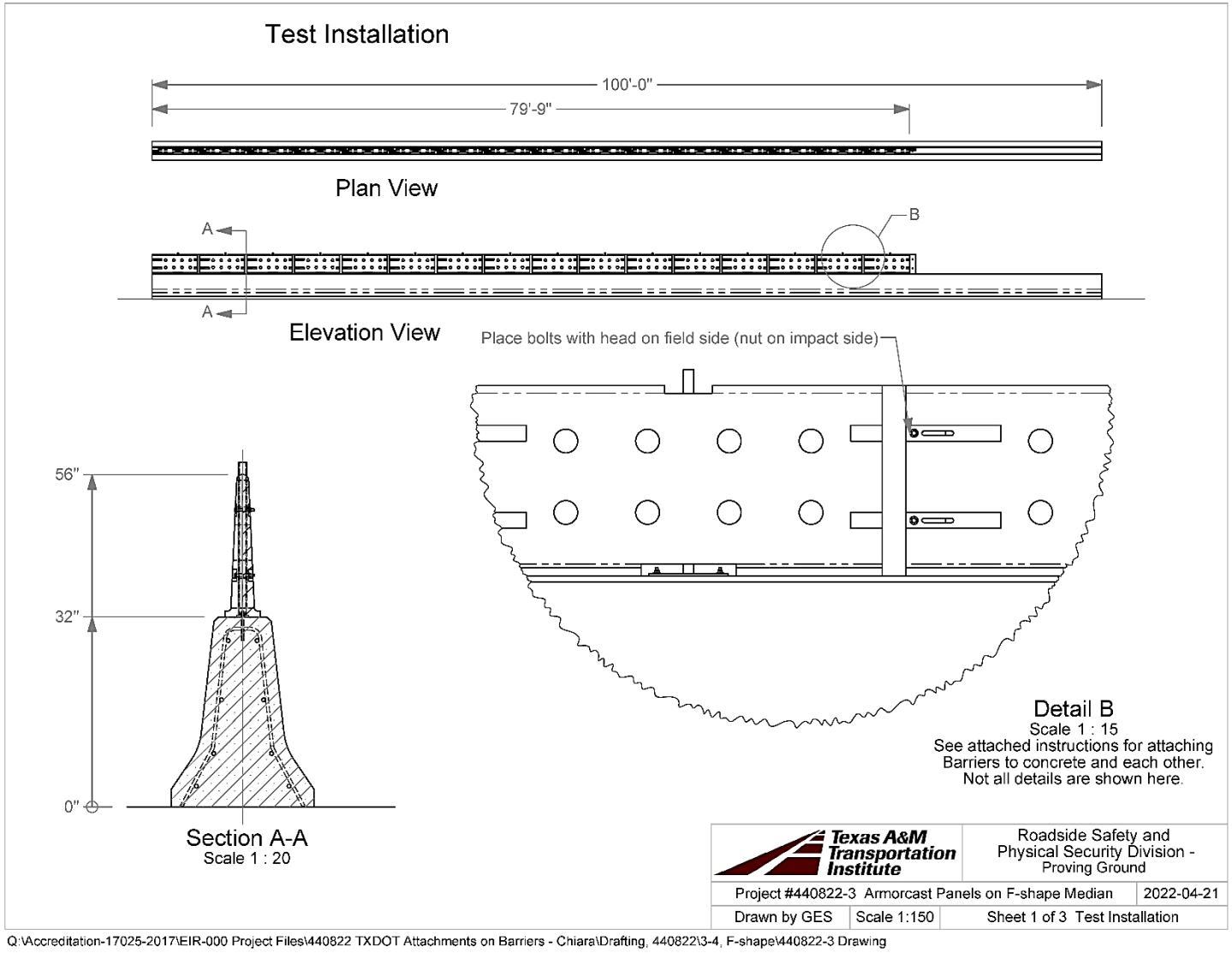

Figure 2.3. Details of Armorcast® Gawk Screen on F-Shape Barrier.

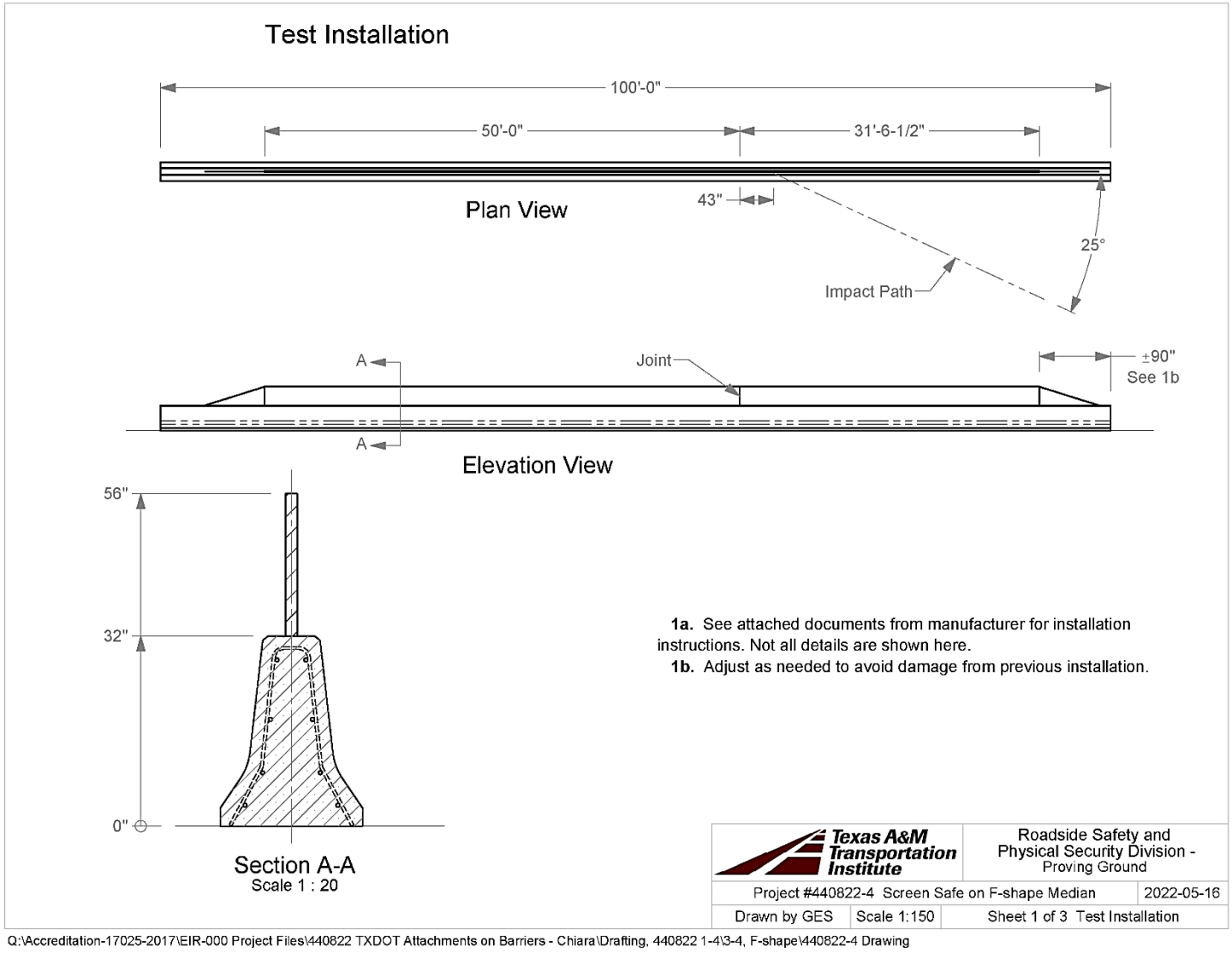

Figure 2.4. Details of Screen-Safe® Glare Screen on F-Shape Barrier.

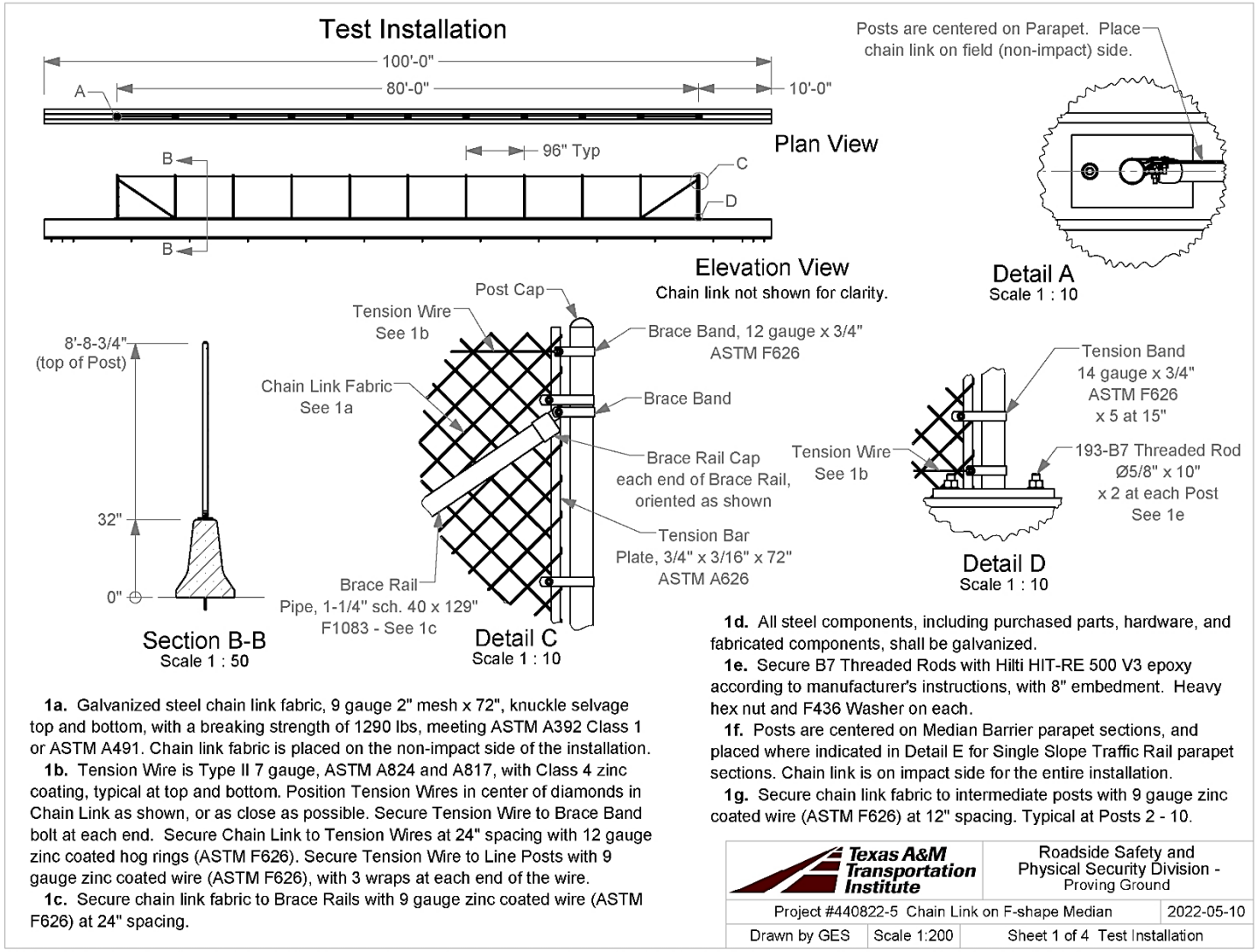

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Figure 2.6. Impact Side of Armorcast® Gawk Screen on Single-Slope Barrier prior to Testing.

Figure 2.7. Field Side of Armorcast® Gawk Screen on Single-Slope Barrier prior to Testing.

Figure 2.8. Impact Side of Screen-Safe® Glare Screen on Single-Slope Barrier prior to Testing.

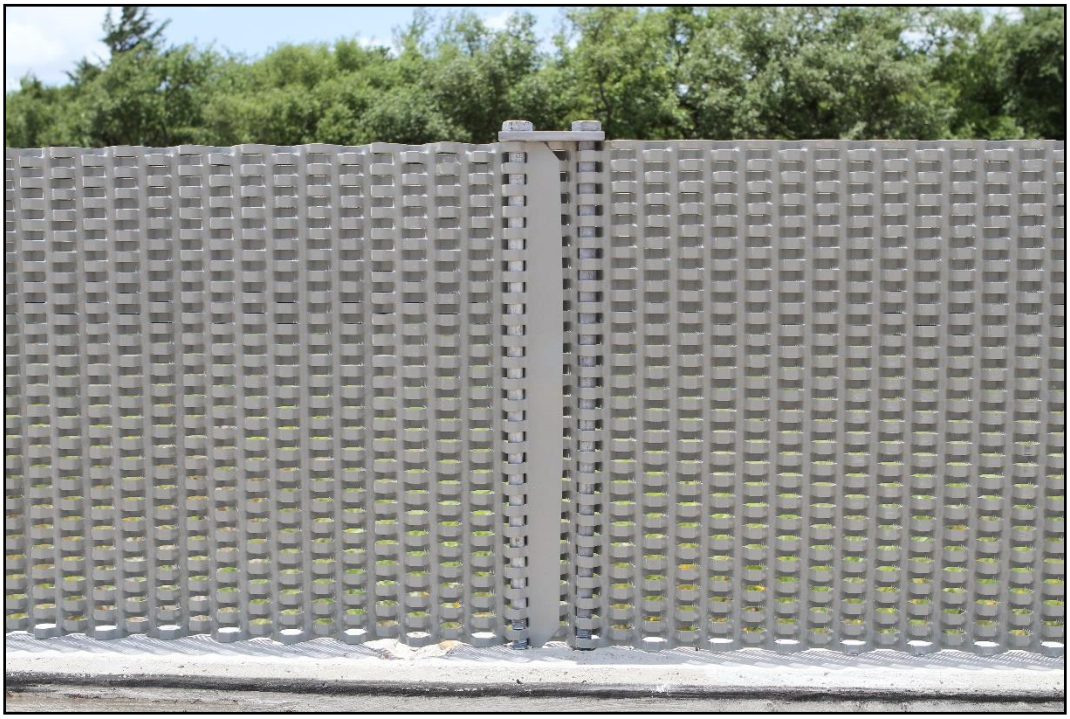


Figure 2.9. Screen-Safe® Glare Screen on Single-Slope Barrier prior to Testing.

Figure 2.10. The Armorcast® Gawk Screen on F-Shape Barrier prior to Testing.

Figure 2.11. Impact Side of Armorcast® Gawk Screen on F-Shape Barrier prior to Testing.

Figure 2.12. Impact Side of Screen-Safe® Glare Screen on F-Shape Barrier prior to Testing.

Figure 2.13. Screen-Safe® Glare Screen on F-Shape Barrier prior to Testing.

Figure 2.14. Chain-Link Fence on F-Shape Barrier prior to Testing.

Figure 2.15. Impact Side of Chain-Link Fence on F-Shape Barrier prior to Testing.

2.3. MATERIAL SPECIFICATIONS

Appendix F provides material certification documents for the materials used to install/construct the F-shape and single-slope barriers. Table 2.1 shows the average compressive strengths of the concrete on the days of the first tests: April 19, 2022, for the F-shape barriers, and April 29, 2022, for the single-slope barriers.

Table 2.1. Concrete Strength.

Location	Design Strength (psi)	Avg. Strength (psi)	Age (days)	Detailed Location	Casting Date
F-Shape	3600	5370	36	South ⅔ of Barrier	March 14, 2022
F-Shape	3600	5140	36	North ⅓ of Barrier	March 14, 2022
Single-Slope	3600	5280	36	South ⅔ of Barrier	March 24, 2022
Single-Slope	3600	4873	36	North ⅓ of Barrier	March 24, 2022

Chapter 3. TEST REQUIREMENTS AND EVALUATION CRITERIA

3.1. CRASH TEST PERFORMED/MATRIX

Table 3.1 shows the test conditions and evaluation criteria for *MASH* Test 4-12 (Tests 440822-01-1 and 440822-01-2) and *MASH* Test 3-11 (Tests 440822-01-3, 440822-01-4, 440822-01-5) for longitudinal barriers. The target critical impact points (CIPs) for each test were determined using the information provided in *MASH* Section 2.2.1 and Section 2.3.2. The target CIPs for *MASH* Tests 3-11 and 4-12 are shown in their respective chapters.

Table 3.1. Test Conditions and Evaluation Criteria Specified for Longitudinal Barriers.

Test Designation	Test Vehicle	Impact Speed	Impact Angle	*MASH* Evaluation Criteria
3-11	2270P	62 mi/h	25º	A, D, F, H, I
4-12	10000S	56 mi/h	15º	A, D, G

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

3.2. EVALUATION CRITERIA

The appropriate safety evaluation criteria from Tables 2.2 and 5.1 of *MASH* were used to evaluate the crash tests reported herein. Table 3.2 provides detailed information on the evaluation criteria.

Table 3.2. Evaluation Criteria Required for *MASH* Testing.

Evaluation Factors	Evaluation Criteria	*MASH* Test
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.	11, 12
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*.	11, 12
F.	The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	11
G.	It is preferable, although not essential, that the vehicle remain upright during and after the collision.	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. Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 10 ft/s, or maximum allowable value of 16 ft/s.	11
I.	The occupant ridedown accelerations should satisfy the following: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.	11

Chapter 4. TEST CONDITIONS

4.1. TEST FACILITY

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

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

4.2. VEHICLE TOW AND GUIDANCE SYSTEM

For the testing utilizing the 2270P and 10000S vehicles, each was towed into the test installation using a steel cable guidance and reverse tow system. A steel cable for guiding the test vehicle was tensioned along the path, anchored at each end, and threaded through an attachment to the front wheel of the test vehicle. An additional steel cable was connected to the test vehicle, passed around a pulley near the impact point and through a pulley on the tow vehicle, and then anchored to the ground such that the tow vehicle moved away from the test site. A 2:1 speed ratio between the test and tow vehicle existed with this system. Just prior to impact with the installation, the test vehicle was released and ran unrestrained. The vehicle remained freewheeling (i.e., no steering or braking inputs) until it cleared the immediate area of the test site.

4.3. DATA ACQUISITION SYSTEMS

4.3.1. Vehicle Instrumentation and Data Processing

Each test vehicle was instrumented with a self-contained onboard data acquisition system. The signal conditioning and acquisition system is a multi-channel data acquisition system (DAS) produced by Diversified Technical Systems Inc. The accelerometers, which measure the x, y, and z axis of vehicle acceleration, are strain gauge type with linear millivolt output proportional to acceleration. Angular rate sensors, measuring vehicle roll, pitch, and yaw rates, are ultra-small, solid-state units designed for crash test service. The data acquisition hardware and software conform to the latest SAE J211, Instrumentation for Impact Test. Each of

the channels is capable of providing precision amplification, scaling, and filtering based on transducer specifications and calibrations. During the test, data are recorded from each channel at a rate of 10,000 samples per second with a resolution of one part in 65,536. Once data are recorded, internal batteries back these up inside the unit in case the primary battery cable is severed. Initial contact of the pressure switch on the vehicle bumper provides a time zero mark and initiates the recording process. After each test, the data are downloaded from the DAS unit into a laptop computer at the test site. The Test Risk Assessment Program (TRAP) software then processes the raw data to produce detailed reports of the test results.

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

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

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

4.3.2. Anthropomorphic Dummy Instrumentation

An Alderson Research Laboratories Hybrid II, 50th percentile male anthropomorphic dummy, restrained with lap and shoulder belts, was placed in the front seat on the impact side/opposite side of impact of each of the 2270P vehicles. The dummy was not instrumented.

According to *MASH*, use of a dummy in the 2270P vehicle is optional. However, *MASH* recommends that a dummy be used when testing “any longitudinal barrier with a height greater than or equal to 33 inches.” More specifically, use of the dummy in the 2270P vehicle is recommended for tall rails to evaluate the “potential for an occupant to extend out of the vehicle and come into direct contact with the test article.” Although this information is reported, it is not part of the impact performance evaluation. Since the height of the barriers with attachments

ranged from 56 inches to 104¾ inches, a dummy was placed in the front seat of each 2270P vehicle on the impact side and restrained with lap and shoulder belts.

MASH does not recommend or require use of a dummy in the 10000S vehicle, and no dummy was placed in the vehicle.

4.3.3. Photographic Instrumentation Data Processing

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

- One located overhead with a field of view perpendicular to the ground and directly over the impact point.
- One placed upstream from the installation at an angle to have a field of view of the interaction of the rear of the vehicle with the installation.
- A third placed with 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 concrete barriers. The flashbulb was visible from each camera. The video files from these digital high-speed cameras were analyzed to observe phenomena occurring during the collision and to obtain time-event, displacement, and angular data. A digital camera recorded and documented conditions of each test vehicle and the installation before and after the test.

Chapter 5. *MASH* TEST 4-12 OF ARMORCAST GAWK SCREENS ON SINGLE SLOPE CONCRETE BARRIER (CRASH TEST NO. 440822-01-1)

5.1. TEST ARTICLE DETAILS AND CRITICAL IMPACT POINT

The installation consisted of a 100-ft long section of a cast-in-place single-slope concrete median barrier, with 20 sections of Armorcast® gawk screen panels mounted on top starting 23 inches from the upstream end of the concrete. The single-slope barrier was 42 inches tall, 24 inches wide at its base, and sloped symmetrically upward on both sides for a final width of 8 inches at the top of the barrier. The gawk screen panels were 63 inches long with a 6-inch overlap; thus, each individual panel spanned 57 inches. The panels were 24 inches tall and had a 6-inch wide, 1-inch tall base that sloped up on both sides for a final width of 2 inches at the top of the screen. The screens had two 9⁄16-inch slots spaced vertically on one end and two 9⁄16-inch holes spaced vertically on the opposite end in order to bolt the screens end to end on top of the single-slope barrier. Each screen was fixed to the barrier by being placed over a 26-inch tall post that was anchored to the top of the concrete barrier. The posts were centered on their respective screens, and a hitch pin attached to a chain welded to the inside of the post was inserted into a ¼-inch through hole in order to keep the screens from being easily removed from the posts.

Figure 5.1 shows the impact conditions for *MASH* Test 4-12 (Crash Test 440822-01-1).

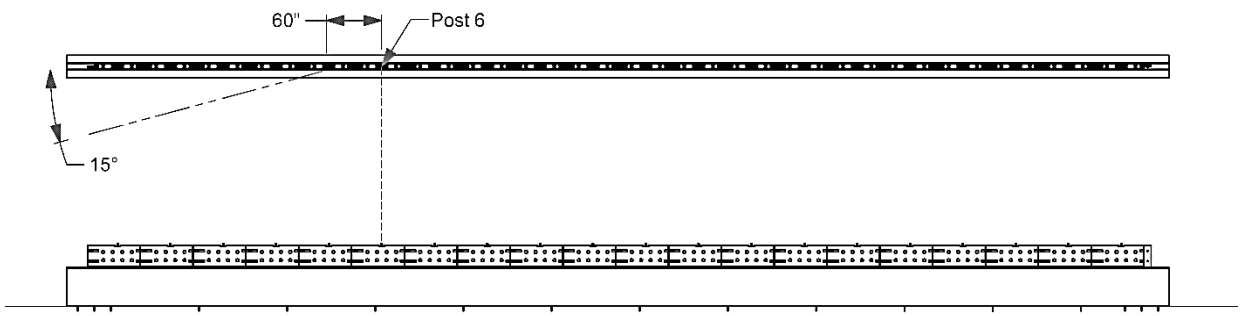


Figure 5.1. Critical Impact Point for Test 440822-01-1.

5.2. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 5.1 for the *MASH* impact conditions and Table 5.2 for the exit parameters for Test 440822-01-1. Figure 5.2 and Figure 5.3 depict the target impact setup.

Table 5.1. Impact Conditions for *MASH* Test 4-12, Crash Test 440822-01-1.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	56	±2.5	56.7
Impact Angle (deg)	15	±1.5	15
Vehicle Inertial Weight (lb)	22,000	±660	22,430
Impact Severity (kip-ft)	142	≥142	161.5

Test Parameter	Specification	Tolerance	Measured
Impact Location	60 inches upstream from the center of post 6	±12 inches	70.4 inches upstream from the center of post 6

Table 5.2. Exit Parameters for *MASH* Test 4-12, Crash Test 440822-01-1.

Exit Parameter	Measured
Speed (mi/h)	Not Measureable
Trajectory (deg)	Along barrier
Heading (deg)	Along barrier
Brakes applied post impact (s)	2.9
Vehicle at rest position	242 ft downstream of impact point 5 ft to the field side 0° downstream
Comments:	Vehicle remained upright and stable.

Figure 5.2. Armorcast® Gawk Screen on Single-Slope Barrier/Test Vehicle Geometrics for Test 440822-01-1.

Figure 5.3. Armorcast® Gawk Screen on Single-Slope Barrier/Test Vehicle Impact Location for Test 440822-01-1.

5.3. WEATHER CONDITIONS

Table 5.3 provides the weather conditions for Test 440822-01-1.

Table 5.3. Weather Conditions for Test 440822-01-1.

Date of Test	April 29, 2022 AM
Temperature (°F)	79
Relative Humidity (%)	78
Wind Direction (deg)	178
Vehicle Traveling (deg)	335
Wind Speed (mi/h)	14

5.4. TEST VEHICLE

Figure 5.4 and Figure 5.5 show the 2008 Sterling used for the crash test. Table 5.4 shows the vehicle measurements. Figure A.1 in Appendix A.2 gives additional dimensions and information on the vehicle.

Figure 5.4. Impact Side of Test Vehicle before Test 440822-01-1.

Figure 5.5. Opposite Impact Side of Test Vehicle before Test 440822-01-1.

Table 5.4. Vehicle Measurements for Test 440822-01-1.

Test Parameter	*MASH*	Allowed Tolerance	Measured
Curb Weight (lb)	13,200	±2200	14,690
Wheelbase (inches)	240	≤240	207.5
Overall Length (inches)	394	≤394	339
Cargo Bed Height (inches)[a]	49	±2	50
Center of Gravity (CG) of Ballast above Ground[b] (inches)	63	±2	61.8

[a] Without ballast.
[b] See Section 4.2.1.2 in *MASH* 2016 for recommended ballasting procedures.

5.5. TEST DESCRIPTION

Table 5.5 lists events that occurred during Test No. 440822-01-1. Figures A.4 through A.6 in Appendix A.3 present sequential photographs during the test.

Table 5.5. Events during Test 440822-01-1.

Time (s)	Events
0.0000	Vehicle impacted the installation
0.0400	Screen began to deform
0.0440	Vehicle began to redirect
0.0660	Post 6 began to deflect toward the field side
0.1070	Front passenger side tire lifted off pavement
0.2700	Rear driver side lower corner of box impacted top of barrier
0.2990	Vehicle was parallel with the installation
1.1260	Panels fully released from the concrete barrier
1.2890	Front passenger side tire contacted pavement

5.6. DAMAGE TO TEST INSTALLATION

There was some scuffing and gouging at impact on the concrete barrier. Panels 6–20 were removed from the parapet. Panels 6 and 7 landed behind the parapet, and the others landed from 195 to 240 ft downstream. The pipe-to-plate connection failed at panels 7, 11, 15, and 16. The anchor bolts failed on the others.

Table 5.6 describes the damage to the Armorcast® gawk screen on the single-slope barrier. Figure 5.6 and Figure 5.7 show the damage to the Armorcast® gawk screen on the single-slope barrier.

Table 5.6. Damage to Armorcast® Gawk Screen on Single-Slope Barrier, Test 440822-01-1.

Test Parameter	Measured
Permanent Deflection/Location	0 inches at the concrete barrier
Dynamic Deflection	0 inches at the concrete barrier (screen released from barrier)
Working Width[a] and Height	Dislodged Screen panels at 129.9 inches, at a height of 27.7 inches

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

Figure 5.6. Armorcast® Gawk Screen on Single-Slope Barrier after Test at Impact Location, Test 440822-01-1.

Figure 5.7. Rear View of the Armorcast® Gawk Screen on Single-Slope Barrier Post Impact, Test 440822-01-1.

Figure 5.8. Armorcast® Gawk Screen on Single-Slope Barrier after Test at Base Plate with Missing Post, Test 440822-01-1.

5.7. DAMAGE TO TEST VEHICLE

Figure 5.9 and Figure 5.10 show the damage sustained by the vehicle. Figure 5.11 and Figure 5.12 show the interior of the test vehicle. Table 5.7 and Table 5.8 provide details on the occupant compartment deformation and exterior vehicle damage.

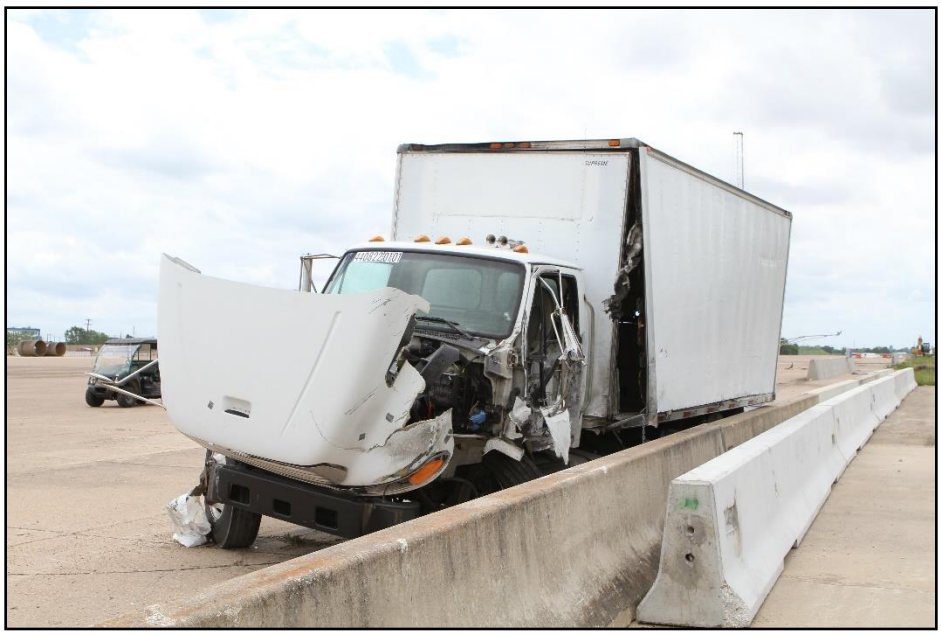


Figure 5.9. Impact Side of Test Vehicle after Test 440822-01-1.

Figure 5.10. Rear Impact Side of Test Vehicle after Test 440822-01-1.

Figure 5.11. Overall Interior of Test Vehicle after Test 440822-01-1.

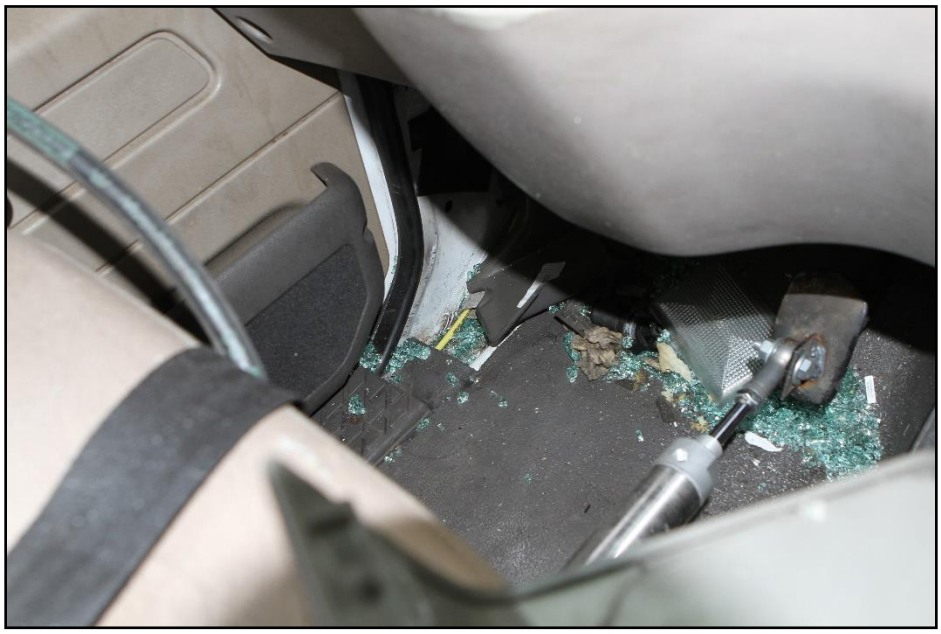


Figure 5.12. Interior of Test Vehicle on Impact Side after Test 440822-01-1.

Table 5.7. Occupant Compartment Deformation for Test 440822-01-1.

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

Table 5.8. Exterior Vehicle Damage for Test 440822-01-1.

Side Windows	Side windows shattered due to flexing in the door panel.
Maximum Exterior Deformation	15 inches in the front plane at the left front corner at bumper height.
VDS	11LFQ5
CDC	11FLEW6
Fuel Tank Damage	Yes, but there was no rupture of the tank.
Description of Damage to Vehicle:	The front bumper and hood, left headlight, left front U-bolts and spring assembly, left front tire and rim, outer fiberglass skin of left front door, left door glass and window track, left mirror, left cab corner, left fuel tank, left battery box, and left rear inner tire and rim were all damaged. The windshield had a 3½-inch diameter break, but there was no damage to the laminate.

5.8. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 5.9. Figure A.7 in Appendix A.4 shows the vehicle angular displacements, and Figures A.8 through A.10 in Appendix A.5 show acceleration versus time traces.

Table 5.9. Occupant Risk Factors for Test 440822-01-1.

Test Parameter	*MASH*	Measured	Time
OIV, Longitudinal (ft/s)	≤40.0	7.5	0.2048 s on left side of interior
OIV, Lateral (ft/s)	≤40.0	11.2	0.2048 s on left side of interior
Ridedown, Longitudinal (g)	≤20.49	4.8	0.2913–0.3013 s
Ridedown, Lateral (g)	≤20.49	6.1	0.2437–0.2537 s
Theoretical Head Impact Velocity (THIV) (m/s)	N/A	4.1	0.1961 s on left side of interior
Acceleration Severity Index (ASI)	N/A	0.4	0.2502–0.3002 s
50-ms Moving Avg. Accelerations (MA) Longitudinal (g)	N/A	−2.2	0.0462–0.0962 s
50-ms MA Lateral (g)	N/A	2.9	0.0651–0.1151 s
50-ms MA Vertical (g)	N/A	3.0	0.2617–0.3117 s
Roll (deg)	≤75	24	0.7004 s
Pitch (deg)	≤75	6	0.8283 s
Yaw (deg)	N/A	19	0.6689 s

5.9. TEST SUMMARY

Figure 5.13, Table 5.10, and Table 5.11 summarize the results of *MASH* Test 440862-03-3. Figure 5.14 shows the sequential photographs from the crash test. Figure 5.15 shows the summary drawing for the crash test.

0.000 s

0.100 s

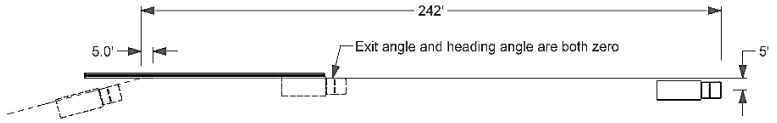
0.200 s

0.300 s

Test Agency	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.	*MASH* 2016, Test 4-12
TTI Project No.	440822-01-1
Test Date	2022-04-29
TEST ARTICLE	
Type	Longitudinal Barrier
Name	Armorcast® Gawk Screen on Single-Slope Barrier
Length	100 ft
Key Materials	42-inch tall single-slope barrier, 24-inch × 120-inch gawk screens, 26-inch tall 1-inch schedule 40 pipe posts
Soil Type and Condition	Concrete, damp
TEST VEHICLE	
Type/Designation	10000S
Year, Make and Model	2008 Sterling
Curb Weight (lb)	14,690
Inertial Weight (lb)	22,430
Dummy (lb)	N/A
Gross Static (lb)	22,430
IMPACT CONDITIONS	
Impact Speed (mi/h)	56.7
Impact Angle (deg)	15
Impact Location	70.4 inches upstream from the center of post 6
Impact Severity (kip-ft)	161.5
EXIT CONDITIONS	
Exit Speed (mi/h)	N/A
Trajectory/Heading Angle (deg)	Along barrier
Exit Box Criteria	N/A
Stopping Distance	242 ft downstream of impact point 5 ft to the field side
TEST ARTICLE DEFLECTIONS	
Dynamic (inches)	Concrete Barrier at 0 inches
Permanent (inches)	Concrete Barrier at 0 inches
Working Width/Height (inches)	129.9/27.7
VEHICLE DAMAGE	
VDS	11LFQ5
CDC	11FLEW6
Max Ext. Deformation	15 inches
Max. Occupant Compartment Deformation	No Occupant Compartment Deformation

OCCUPANT RISK VALUES

Long. OIV (ft/s)	7.5	Long. Ridedown (g)	4.8	Max. 50-ms Long. (g)	−2.2	Max. Roll (deg)	24
Lat. OIV (ft/s)	11.2	Lat. Ridedown (g)	6.1	Max. 50-ms Lat. (g)	2.9	Max. Pitch (deg)	6
THIV (m/s)	4.1	ASI	0.4	Max. 50-ms Vert. (g)	3.0	Max. Yaw (deg)	19



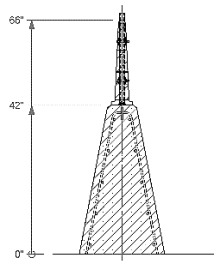


Figure 5.13. Summary of Results for *MASH* Test 4-12 on Armorcast® Gawk Screen on Single-Slope Barrier.

Table 5.10. Summary of Results for Test 440822-01-1, General Information, Impact and Exit Conditions.

General Information	Test Agency	Texas A&M Transportation Institute (TTI)
	Test Standard Test No.	*MASH* 2016, Test 4-12
	TTI Test No.	440822-01-1
	Test Date	2022-04-29
Test Article	Type	Longitudinal Barrier
	Name	Armorcast® Gawk Screen on Single-Slope Barrier
	Installation Length	100 ft
	Material or Key Elements	42-inch tall single-slope barrier, 24-inch × 120-inch gawk screens, 26-inch tall 1-inch schedule 40 pipe posts
	Foundation Type/Condition	Concrete, damp
Test Vehicle	Type/Designation	10000S
	Make and Model	2008 Sterling
	Curb	14,690 lb
	Test Inertial	22,430 lb
	Dummy	N/A
	Gross Static	22,430 lb
Impact Conditions	Speed	56.7 mi/h
	Angle	15 degrees
	Location	70.4 inches upstream from the center of post 6
	Impact Severity	161.5 kip-ft
Exit Conditions	Speed	N/A
	Exit Trajectory/ Heading	Along barrier

Table 5.11. Summary of Results for Test 440822-01-1, Occupant Risk, Vehicle and Test Article Damage.

Occupant Risk Values	Longitudinal OIV	7.5 ft/s
	Lateral OIV	11.2 ft/s
	Longitudinal RDA	4.8 g
	Lateral RDA	6.1 g
	THIV	4.1 m/s
	ASI	0.4
Max. 0.050-s Average	Longitudinal	−2.2 g
	Lateral	2.9 g
	Vertical	3.0 g
Post-Impact Trajectory	Stopping Distance	242 ft downstream of impact 5 ft to the field side
Vehicle Stability	Maximum Roll Angle	24 degrees
	Maximum Pitch Angle	6 degrees
	Maximum Yaw Angle	19 degrees
	Vehicle Snagging	No
	Vehicle Pocketing	No
Test Article Deflections	Dynamic	Concrete Barrier at 0 inches
	Permanent	Concrete Barrier at 0 inches
	Working Width	129.9 inches (barrier attachment)
	Height of Working Width	27.7 inches
Vehicle Damage	VDS	11LFQ5
	CDC	11FLEW6
	Max. Exterior Deformation	15 inches
	Max. Occupant Compartment Deformation	No Occupant Compartment Deformation

(a) 0.000 s

(b) 0.100 s

Figure 5.14. Summary of Results for Test 440822-01-1, Sequential Test Pictures.

(c) 0.200 s

(d) 0.300 s

Figure 5.13. Summary of Results for Test 440822-01-1, Sequential Test Pictures (Continued).

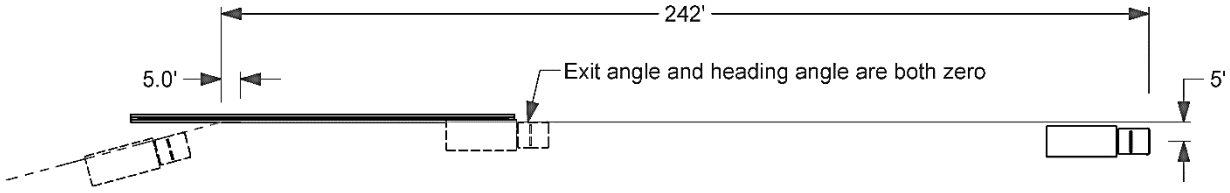


Figure 5.15. Summary of Results for Test 440822-01-1, Summary Drawing.

Chapter 6. *MASH* TEST 4-12 OF CREEN-SAFE® GLARE SCREEN ON SINGLE-SLOPE BARRIER (CRASH TEST NO. 440822-01-2)

6.1. TEST ARTICLE DETAILS AND CRITICAL IMPACT POINT

The installation consisted of a 100-ft long section of a cast-in-place single-slope concrete median barrier, with an 81-ft 3-inch section of Screen-Safe® glare screen and work-zone safety shield mounted on top, starting approximately 112 inches from the upstream end of the single-slope barrier. The single-slope barrier was 42 inches tall, 24 inches wide at its base, and sloped symmetrically upward on both sides for a final width of 8 inches at the top of the barrier. The Screen-Safe® glare screen was split into two sections. The upstream section was 25 ft long, and the downstream section was 50 ft long. Each end of the screen was anchored with a 6-ft 7-inch long anchor cable attached from the top of the end posts to an eyebolt anchored to the top of the single-slope barrier. The glare screen was a double-reverse corrugated steel screen fabric that stood 24 inches above the top of the single-slope barrier and was affixed to the barrier by threaded 26-inch long post bolts that were screwed into wedge anchors installed in the top of the concrete barriers.

Figure 6.1 shows the impact conditions for *MASH* Test 4-12 (Crash Test 440822-01-2).

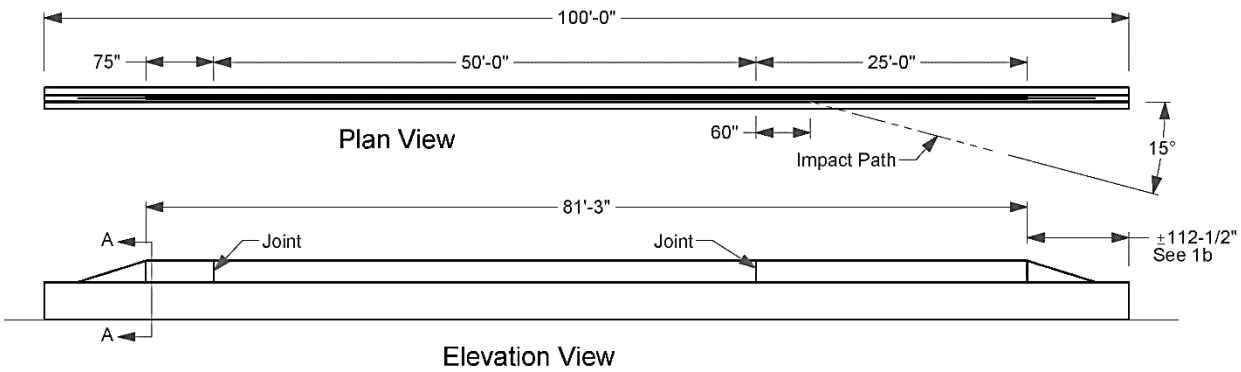


Figure 6.1. Critical Impact Point for Test 440822-01-2.

6.2. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 6.1 for the *MASH* impact conditions and Table 6.2 for the exit parameters for Test 440822-01-2. Figure 6.2 and Figure 6.3 depict the target impact setup.

Table 6.1. Impact Conditions for *MASH* Test 4-12, Crash Test 440822-01-2.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	56	±2.5	56.7
Impact Angle (deg)	15	±1.5	15.2
Vehicle Inertial Weight (lb)	22,000	±660	22,210
Impact Severity (kip-ft)	142	≥142	164.1
Impact Location	60 inches upstream from the centerline of	±12 inches	64.6 inches upstream from the centerline of

Test Parameter	Specification	Tolerance	Measured
	joint between posts 5 and 6		joint between posts 5 and 6

Table 6.2. Exit Parameters for *MASH* Test 4-12, Crash Test 440822-01-2.

Exit Parameter	Measured
Speed (mi/h)	N/A
Trajectory (deg)	Along barrier
Heading (deg)	Along barrier
Brakes applied post impact (s)	3.0
Vehicle at rest position	333 ft downstream of impact point 21 ft to the field side 180 degrees
Comments:	Vehicle remained upright and stable

Figure 6.2. Screen-Safe® Glare Screen on Single-Slope Barrier/Test Vehicle Geometrics for Test 440822-01-2.

Figure 6.3. Screen-Safe® Glare Screen on Single-Slope Barrier/Test Vehicle Impact Location for Test 440822-01-2.

6.3. WEATHER CONDITIONS

Table 6.3 provides the weather conditions for Test 440822-01-2.

Table 6.3. Weather Conditions for Test 440822-01-2.

Date of Test	June 1, 2022 PM
Temperature (°F)	80
Relative Humidity (%)	91
Wind Direction (deg)	270
Vehicle Traveling (deg)	185
Wind Speed (mi/h)	8

6.4. TEST VEHICLE

Figure 6.4 and Figure 6.5 show the 2011 Freightliner M2 used for the crash test. Table 6.4 shows the vehicle measurements. Figure B.1 in Appendix B.2 gives additional dimensions and information on the vehicle.

Figure 6.4. Impact Side of Test Vehicle before Test 440822-01-2.

Figure 6.5. Opposite Impact Side of Test Vehicle before Test 440822-01-2.

Table 6.4. Vehicle Measurements for Test 440822-01-2.

Test Parameter	*MASH*	Allowed Tolerance	Measured
Curb Weight (lb)	13,200	±2200	13,110
Wheelbase (inches)	240	≤240	205
Overall Length (inches)	394	≤394	330.5
Cargo Bed Height (inches)[a]	49	±2	51
CG of Ballast above Ground[b] (inches)	63	±2	63.5

[a] Without ballast.
[b] See Section 4.2.1.2 in *MASH* 2016 for recommended ballasting procedures.

6.5. TEST DESCRIPTION

Table 6.5 lists events that occurred during Test No. 440822-01-2. Figures B.4 through B.6 in Appendix B.3 present sequential photographs during the test.

Table 6.5. Events during Test 440822-01-2.

Time (s)	Events
0.0000	Vehicle impacted the installation
0.0420	Vehicle began to redirect
0.0440	Screen began to deform
0.0640	Posts 5 and 6 began to deflect toward the field side
0.1710	Front driver side tire lifted off pavement
0.2300	Rear driver side tire lifted off pavement
0.2660	Rear passenger side lower corner of box impacted top of barrier
0.2670	Vehicle was parallel to the installation
0.7560	Front driver side tire contacted pavement

6.6. DAMAGE TO TEST INSTALLATION

There was some scuffing and gouging at the impact location and along the barrier for the duration of contact. The screen remained intact, but it was bunched up and severely deformed at post 8. There was some slight damage to the screen at posts 4 and 9. Post 14 and its anchor insert pulled loose from the barrier. Several post bolts were bent toward the field side. Posts 5 and 6 had a 26-degree lean, post 7 had a 46-degree lean, post 8 had an 83-degree lean, post 9 had a 45-degree lean, post 10 had a 38-degree lean, post 11 had a 37-degree lean, post 12 had a 43-degree lean, post 13 had a 39-degree lean, and post 15 had a 36-degree lean, all from vertical. Posts 1 through 3 and 16 were all undamaged.

Table 6.6 describes the damage to the Screen-Safe® glare screen on the single-slope barrier. Figure 6.6 and Figure 6.7 show the damage to the Screen-Safe® glare screen on the single-slope barrier.

Table 6.6. Damage to Screen-Safe® Glare Screen on Single-Slope Barrier, Test 440822-01-2.

Test Parameter	Measured
Permanent Deflection/Location	The fence at 20.5 inches toward field side, 20 inches downstream of post 9
Dynamic Deflection	Not measurable (view obscured by box truck)
Working Width[a] and Height	The box truck at 69 inches, at a height of 136.6 inches

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

Figure 6.6. Screen-Safe® Glare Screen on Single-Slope Barrier after Test at Impact Location, Test 440822-01-2.

Figure 6.7. Screen-Safe® Glare Screen on Single-Slope Barrier after Test at Post 8, Test 440822-01-2.

6.7. DAMAGE TO TEST VEHICLE

Figure 6.8 and Figure 6.9 show the damage sustained by the vehicle. Figure 6.10 and Figure 6.11 show the interior of the test vehicle. Table 6.7 and Table 6.8 provide details on the occupant compartment deformation and exterior vehicle damage.

Figure 6.8. Impact Side of Test Vehicle after Test 440822-01-2.

Figure 6.9. Rear Impact Side of Test Vehicle after Test 440822-01-2.

Figure 6.10. Overall Interior of Test Vehicle after Test 440822-01-2.

Figure 6.11. Interior of Test Vehicle on Impact Side after Test 440822-01-2.

Table 6.7. Occupant Compartment Deformation for Test 440822-01-2.

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

Table 6.8. Exterior Vehicle Damage for Test 440822-01-2.

Side Windows	Side windows remained intact.
Maximum Exterior Deformation	12 inches in the front plane at the right front corner at bumper height.
VDS	01RFQ2
CDC	01FREN3
Fuel Tank Damage	Yes, there was some scuffing and denting, but no punctures were noted.
Description of Damage to Vehicle:	The front axle of the box truck was knocked out. The right front bumper, right front tire and wheel, right front headlight and wheel, right side steps, right side diesel tank, right side mirror, and left front axle and bottom fender were all damaged. The right front corner of the box had a 1.5-inch × 12-inch tear, and there was a 1.5-inch × 1.5-inch hole in the right front corner 46 inches up.

6.8. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 6.9. Figure B.7 in Appendix B.4 shows the vehicle angular displacements, and Figures B.8 through B.10 in Appendix B.5 show acceleration versus time traces.

Table 6.9. Occupant Risk Factors for Test 440822-01-2.

Test Parameter	*MASH*	Measured	Time
OIV, Longitudinal (ft/s)	≤40.0	6.3	0.2067 s on right side of interior
OIV, Lateral (ft/s)	≤40.0	10.4	0.2067 s on right side of interior
Ridedown, Longitudinal (g)	≤20.49	4.2	0.2499–0.2599 s
Ridedown, Lateral (g)	≤20.49	10.7	0.2413–0.2513 s
THIV (m/s)	N/A	3.8	0.1979 s on right side of interior
ASI	N/A	0.6	0.2482–0.2982 s
50-ms MA Longitudinal (g)	N/A	−2.1	0.0542–0.1042 s
50-ms MA Lateral (g)	N/A	−5.0	0.2190–0.2690 s
50-ms MA Vertical (g)	N/A	−3.1	0.2507–0.3007 s
Roll (deg)	≤75	23	0.7006 s
Pitch (deg)	≤75	25	5.0000 s
Yaw (deg)	N/A	53	5.0000 s

6.9. TEST SUMMARY

Figure 6.12, Table 6.10, and Table 6.11 summarize the results of *MASH* Test 440862-03-3. Figure 6.13 shows the sequential photographs from the crash test. Figure 6.14 shows the summary drawing for the crash test.

0.000 s

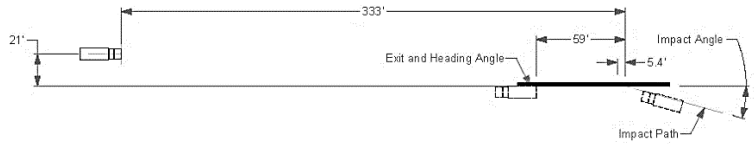
0.100 s

0.200 s

0.300 s

Test Agency	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.	*MASH* 2016, Test 4-12
TTI Project No.	440822-01-2
Test Date	2022-06-01
TEST ARTICLE	
Type	Longitudinal Barrier
Name	Screen-Safe® Glare Screen on Single-Slope Barrier
Length	100 ft
Key Materials	42-inch tall single-slope concrete barrier, 24-inch tall double-reverse corrugated steel, and 26-inch long ¾-inch post bolts
Soil Type and Condition	Concrete, damp
TEST VEHICLE	
Type/Designation	10000S
Year, Make and Model	2011 Freightliner M2
Curb Weight (lb)	13,110
Inertial Weight (lb)	22,210
Dummy (lb)	N/A
Gross Static (lb)	22,210
IMPACT CONDITIONS	
Impact Speed (mi/h)	56.7
Impact Angle (deg)	15.2
Impact Location	64.6 inches upstream from the centerline of joint between posts 5 and 6
Impact Severity (kip-ft)	164.1
EXIT CONDITIONS	
Exit Speed (mi/h)	Not measurable
Trajectory/Heading Angle (deg)	Along barrier
Exit Box Criteria	N/A
Stopping Distance	333 ft downstream of impact point 21 ft to the field side
TEST ARTICLE DEFLECTIONS	
Dynamic (inches)	Not measurable
Permanent (inches)	20.5
Working Width/Height (inches)	69/136.6
VEHICLE DAMAGE	
VDS	01RFQ2
CDC	01FREN3
Max. Ext. Deformation	12 inches
Max. Occupant Compartment Deformation	3.5 inches in the right front floor pan

OCCUPANT RISK VALUES							
Long. OIV (ft/s)	6.3	Long. Ridedown (g)	4.2	Max. 50-ms Long. (g)	−2.1	Max. Roll (deg)	23
Lat. OIV (ft/s)	10.4	Lat. Ridedown (g)	10.7	Max. 50-ms Lat. (g)	−5.0	Max. Pitch (deg)	25
THIV (m/s)	3.8	ASI	0.6	Max. 50-ms Vert. (g)	−3.1	Max. Yaw (deg)	53



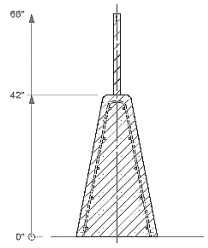


Figure 6.12. Summary of Results for *MASH* Test 4-12 on Screen-Safe® Glare Screen on Single-Slope Barrier.

Table 6.10. Summary of Results for Test 440822-01-2, General Information, Impact and Exit Conditions.

General Information	Test Agency	Texas A&M Transportation Institute
	Test Standard Test No.	*MASH* 2016, Test 4-12
	TTI Test No.	440822-01-2
	Test Date	2022-06-01
Test Article	Type	Longitudinal Barrier
	Name	Screen-Safe® Glare Screen on Single-Slope Barrier
	Installation Length	100 ft
	Material or Key Elements	42-inch tall single-slope concrete barrier, 24-inch tall double-reverse corrugated steel, and 26-inch long ¾-inch post bolts
	Foundation Type/Condition	Concrete, damp
Test Vehicle	Type/Designation	10000S
	Make and Model	2011 Freightliner M2
	Curb	13,110 lb
	Test Inertial	22,210 lb
	Dummy	N/A
	Gross Static	22,210
Impact Conditions	Speed	56.7 mi/h
	Angle	15.2 degrees
	Location	64.6 inches upstream from the centerline of joint between posts 5 and 6
	Impact Severity	164.1 kip-ft
Exit Conditions	Speed	Not measurable
	Exit Trajectory/ Heading	Along barrier

Table 6.11. Summary of Results for Test 440822-01-2, Occupant Risk, Vehicle and Test Article Damage.

Occupant Risk Values	Longitudinal OIV	6.3 ft/s
	Lateral OIV	10.4 ft/s
	Longitudinal RDA	4.2 g
	Lateral RDA	10.7 g
	THIV	3.8 m/s
	ASI	0.6
Max. 0.050-s Average	Longitudinal	−2.1 g
	Lateral	−5.0 g
	Vertical	−3.1 g
Post-Impact Trajectory	Stopping Distance	333 ft downstream of impact point 21 ft to the field side
Vehicle Stability	Maximum Roll Angle	23 degrees
	Maximum Pitch Angle	25 degrees
	Maximum Yaw Angle	53 degrees
	Vehicle Snagging	No
	Vehicle Pocketing	No
Test Article Deflections	Dynamic	Not measurable
	Permanent	20.5 inches
	Working Width	69 inches (truck)
	Height of Working Width	136.6 inches
Vehicle Damage	VDS	01RFQ2
	CDC	01FREN3
	Max. Exterior Deformation	12 inches
	Max. Occupant Compartment Deformation	3.5 inches in the right front floor pan

(a) 0.000 s

(b) 0.100 s

Figure 6.13. Summary of Results for Test 440822-01-2, Sequential Test Pictures.

(c) 0.200 s

(d) 0.300 s

Figure 6.13. Summary of Results for Test 440822-01-2, Sequential Test Pictures (Continued).

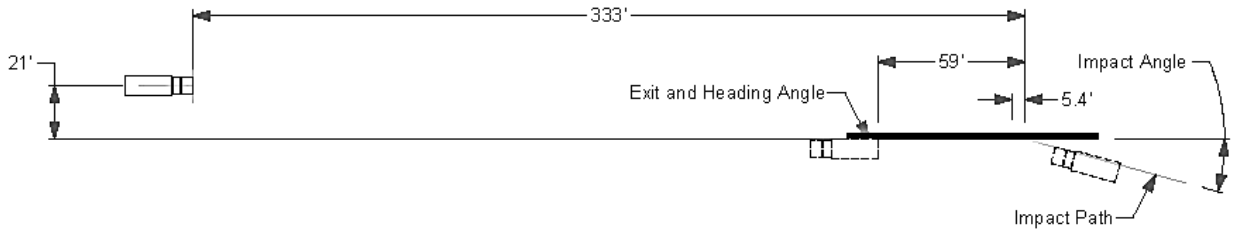


Figure 6.14. Summary of Results for Test 440822-01-2, Summary Drawing.

Chapter 7. *MASH* TEST 3-11 OF ARMORCAST® GAWK SCREEN ON F-SHAPE BARRIER (CRASH TEST NO. 440822-01-3)

7.1. TEST ARTICLE DETAILS AND CRITICAL IMPACT POINT

The installation consisted of a 100-ft long section of a cast-in-place F-shape concrete median barrier, with a 79-ft 9-inch section of Armorcast® gawk screen panels mounted on top starting from the upstream end of the F-shape barrier. The F-shape barrier was 32 inches tall, 24 inches wide at its base, and sloped upward on both sides for a final width of 9½ inches at the top of the barrier. The gawk screens were 63 inches long, with a 6-inch overlap, so each individual barrier spanned 57 inches. The screens were 24 inches tall, and had a 6-inch wide 1-inch tall base that sloped up on both sides for a final width of 2 inches at the top of the screen. The screens had two 9⁄16-inch wide slots vertically spaced on one end and two 9⁄16-inch holes vertically spaced on the opposite end in order to bolt the screens end to end on top of the F-shape barrier. Each screen was fixed to the barrier by being placed over a 26-inch tall post that was anchored to the top of the concrete barrier. The posts were centered on their respective screens, and a hitch pin attached to a chain welded to the inside of the post was inserted into a ¼-inch through hole in order to keep the screens from being easily removed from the posts.

Figure 7.1 shows the impact conditions for *MASH* Test 3-11 (Crash Test 440822-01-3).

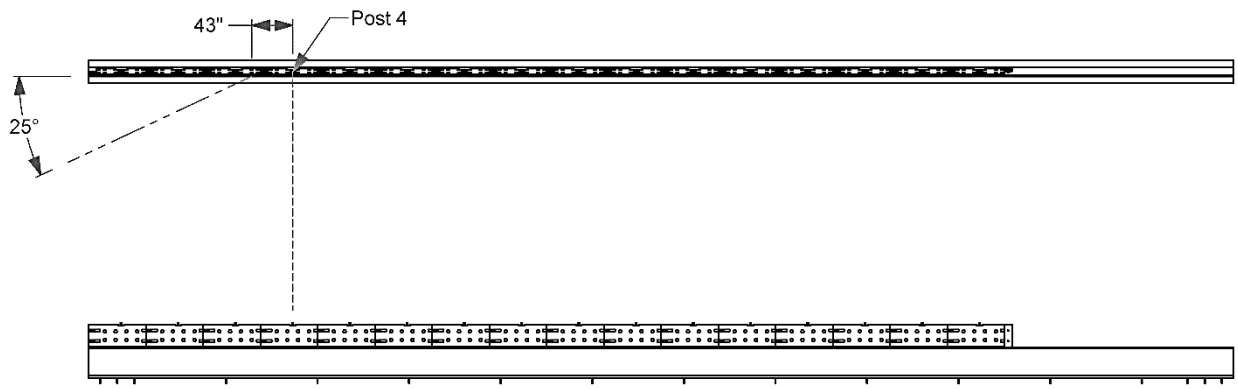


Figure 7.1. Critical Impact Point for Test 440822-01-3.

7.2. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 7.1 for the *MASH* impact conditions and Table 7.2 for the exit parameters for Test 440822-01-3. Figure 7.2 and Figure 7.3 depict the target impact setup.

Table 7.1. Impact Conditions for *MASH* Test 3-11, Crash Test 440822-01-3.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	62	±2.5 mi/h	62.8
Impact Angle (deg)	25	±1.5°	24.6
Impact Severity (kip-ft)	106	≥106 kip-ft	114.8
Impact Location	43 inches upstream from the centerline of post 4	±12 inches	45.2 inches upstream from the centerline of post 4

Table 7.2. Exit Parameters for *MASH* Test 3-11, Crash Test 440822-01-3.

Exit Parameter	Measured
Speed (mi/h)	52.7
Trajectory (deg)	1
Heading (deg)	8
Brakes applied post impact (s)	Brakes not applied
Vehicle at rest position	184 ft downstream of impact point 32 ft to the traffic side 100° right
Comments:	Vehicle remained upright and stable. Vehicle crossed exit box[a] 76 ft downstream from loss of contact.

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

Figure 7.2. Armorcast® Gawk Screen on F-Shape Barrier/Test Vehicle Geometrics for Test 440822-01-3.

Figure 7.3. Armorcast® Gawk Screen on F-Shape Barrier/Test Vehicle Impact Location, Test 440822-01-3.

7.3. WEATHER CONDITIONS

Table 7.3 provides the weather conditions for Test 440822-01-3.

Table 7.3. Weather Conditions for Test 440822-01-3.

Date of Test	April 19, 2022 AM
Temperature (°F)	69
Relative Humidity (%)	50
Wind Direction (deg)	270
Vehicle Traveling (deg)	325
Wind Speed (mi/h)	10

7.4. TEST VEHICLE

Figure 7.4 and Figure 7.5 show the 2017 RAM 1500 used for the crash test. Table 7.4 shows the vehicle measurements. Figure C.1 in Appendix C.2 gives additional dimensions and information on the vehicle.

Figure 7.4. Impact Side of Test Vehicle before Test 440822-01-3.

Figure 7.5. Opposite Impact Side of Test Vehicle before Test 440822-01-3.

Table 7.4. Vehicle Measurements for Test 440822-01-3.

Test Parameter	*MASH*	Allowed Tolerance	Measured
Dummy (if applicable)[a] (lb)	165	N/A	165
Inertial Weight (lb)	5000	±110	5025
Gross Static[a] (lb)	5165	±110	5190
Wheelbase (inches)	148	±12	140.5
Front Overhang (inches)	39	±3	40
Overall Length (inches)	237	±13	227.5
Overall Width (inches)	78	±2	78.5
Hood Height (inches)	43	±4	46
Track Width[b] (inches)	67	±1.5	68.3
CG aft of Front Axle[c] (inches)	63	±4	61.4
CG above Ground[c,d] (inches)	28	≥28	28.3

[a] If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.
[b] Average of front and rear axles.
[c] For test inertial mass.
[d] 2270P vehicle must meet minimum CG height requirement.

7.5. TEST DESCRIPTION

Table 7.5 lists events that occurred during Test No. 440822-01-3. Figures C.4 through C.6 in Appendix C.3 present sequential photographs during the test.

Table 7.5. Events during Test 440822-01-3.

Time (s)	Events
0.0000	Vehicle impacted the installation
0.0175	Front driver side fender contacted screen attachment
0.0240	Screen began to deform
0.0390	Vehicle began to redirect
0.0430	Post 6 began to deflect toward the field side
0.0780	Front passenger side tire lifted off pavement
0.1340	Rear passenger side tire lifted off pavement
0.1960	Vehicle was parallel with the installation
0.2000	Rear driver side bumper contacted F-shape barrier
0.3960	Vehicle lost contact with the rail and exited the test article traveling 52.7 mi/h at a trajectory of 1.2 degrees and a vehicle heading of 8.3 degrees

7.6. DAMAGE TO TEST INSTALLATION

There was some scuffing and gouging at impact on the concrete barrier. Screen 4 was damaged and had a vertical tear at its post. The posts and baseplates of screens 3, 4, and 5 were all bent.

Table 7.6 describes the damage to the Armorcast® gawk screen on the F-shape barrier. Figure 7.6 and Figure 7.7 show the damage to the Armorcast® gawk screen on the F-shape barrier.

Table 7.6. Damage to Armorcast® Gawk Screen on F-Shape Barrier, Test 440822-01-3.

Test Parameter	Measured
Permanent Deflection/Location	The screen at 8.5 inches toward field side, 5 inches upstream of post 4
Dynamic Deflection	The screen at 16.5 inches toward field side
Working Width[a] and Height	29.5 inches, at a height of 56 inches (barrier attachment)

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

Figure 7.6. Armorcast® Gawk Screen on F-Shape Barrier after Test at Impact Location, Test 440822-01-3.

Figure 7.7. Armorcast® Gawk Screen on F-Shape Barrier after Test at Post 4, Test 440822-01-3.

7.7. DAMAGE TO TEST VEHICLE

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

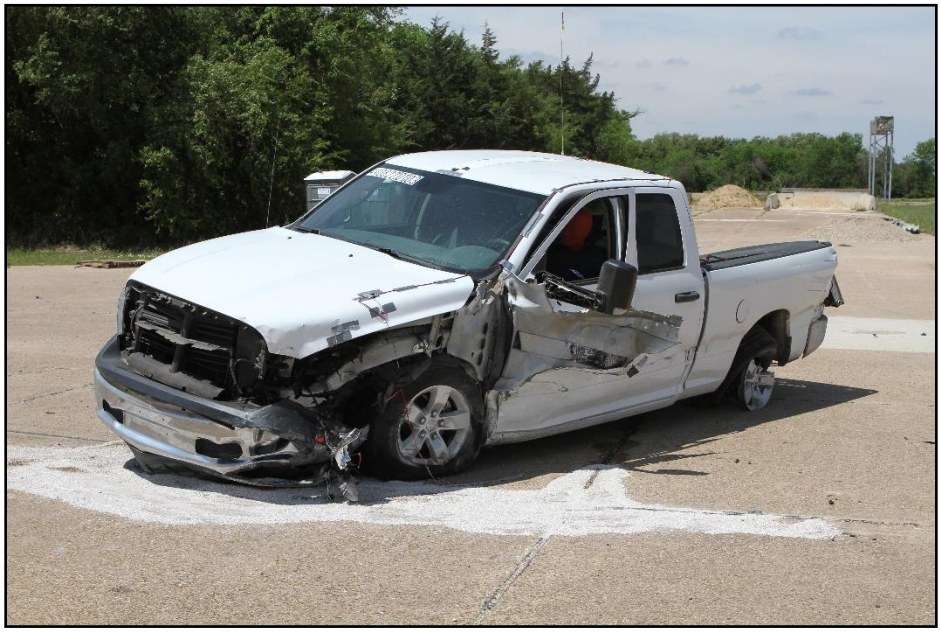


Figure 7.8. Impact Side of Test Vehicle after Test 440822-01-3.

Figure 7.9. Rear Impact Side of Test Vehicle after Test 440822-01-3.

Figure 7.10. Overall Interior of Test Vehicle after Test 440822-01-3.

Figure 7.11. Interior of Test Vehicle on Impact Side after Test 440822-01-3.

Table 7.7. Occupant Compartment Deformation for Test 440822-01-3.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	0 inches
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	−2 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	−1 inch
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 7.8. Exterior Vehicle Damage for Test 440822-01-3.

Side Windows	The side window shattered due to the flex of the door and was not caused by the test article impacting or penetrating the vehicle.
Maximum Exterior Deformation	12 inches in the front plane at the left front corner at bumper height.
VDS	11LFQ4
CDC	11FLEW4
Fuel Tank Damage	None
Description of Damage to Vehicle:	The front bumper, hood and grill, radiator and support, left headlight, left front quarter fender, left front tire and rim, left rear door, left cab corner, left rear tire and rim, left taillight, and rear bumper were damaged. The windshield had a lateral crack on the left side as a result of the deformation of the vehicle, and the left front door had a 6-inch gap at the top.

7.8. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 7.9. Figure C.7 in Appendix C.4 shows the vehicle angular displacements, and Figures C.8 through C.10 in Appendix C.5 show acceleration versus time traces.

Table 7.9. Occupant Risk Factors for Test 440822-01-3.

Test Parameter	*MASH*	Measured	Time
OIV, Longitudinal (ft/s)	≤40.0	20.1	0.0886 s on left side of interior
OIV, Lateral (ft/s)	≤40.0	30.4	0.0886 s on left side of interior
Ridedown, Longitudinal (g)	≤20.49	3.1	0.1085–0.1185 s
Ridedown, Lateral (g)	≤20.49	13.5	0.2347–0.2447 s
THIV (m/s)	N/A	11.3	0.0869 s on left side of interior
ASI	N/A	2.2	0.0581–0.1081 s
50-ms MA Longitudinal (g)	N/A	−9.7	0.0333–0.0833 s
50-ms MA Lateral (g)	N/A	16.6	0.0370–0.0870 s
50-ms MA Vertical (g)	N/A	3.6	0.0858–0.1358 s
Roll (deg)	≤75	27	0.5651 s
Pitch (deg)	≤75	17	4.9784 s
Yaw (deg)	N/A	145	4.9045 s

7.9. TEST SUMMARY

Figure 7.12, Table 7.10, and Table 7.11 summarize the results of *MASH* Test 440862-03-3. Figure 7.13 shows the sequential photographs from the crash test. Figure 7.14 shows the summary drawing for the crash test.

0.000 s

0.100 s

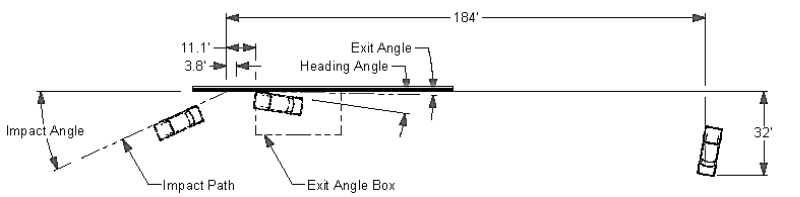
0.200 s

0.300 s

Test Agency	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.	*MASH* 2016, Test 3-11
TTI Project No.	440822-01-3
Test Date	2022-04-19
TEST ARTICLE	
Type	Longitudinal Barrier
Name	Armorcast® Gawk Screen on F-Shape Barrier
Length	100 ft
Key Materials	32-inch tall F-shape barrier, 24-inch × 120-inch gawk screens, 26-inch tall 1-inch schedule 40 pipe posts
Soil Type and Condition	Concrete, damp
TEST VEHICLE	
Type/Designation	2270P
Year, Make and Model	2017 RAM 1500
Curb Weight (lb)	5040
Inertial Weight (lb)	5025
Dummy (lb)	165
Gross Static (lb)	5190
IMPACT CONDITIONS	
Impact Speed (mi/h)	62.8
Impact Angle (deg)	24.6
Impact Location	45.2 inches upstream from the centerline of post 4
Impact Severity (kip-ft)	114.8
EXIT CONDITIONS	
Exit Speed (mi/h)	52.7
Trajectory/Heading Angle (deg)	1/8
Exit Box Criteria	Crossed 76 ft downstream from loss of contact
Stopping Distance	184 ft downstream of impact point 32 ft to the traffic side
TEST ARTICLE DEFLECTIONS	
Dynamic (inches)	16.5
Permanent (inches)	8.5
Working Width/Height (inches)	29.5/56.0
VEHICLE DAMAGE	
VDS	01LFQ6
CDC	01FLEW4
Max. Ext. Deformation	12 inches
Max. Occupant Compartment Deformation	2 inches in the toe pan

OCCUPANT RISK VALUES

Long. OIV (ft/s)	20.1	Long. Ridedown (g)	3.1	Max. 50-ms Long. (g)	−9.7	Max. Roll (deg)	27
Lat. OIV (ft/s)	30.4	Lat. Ridedown (g)	13.5	Max. 50-ms Lat. (g)	16.6	Max. Pitch (deg)	17
THIV (m/s)	11.3	ASI	2.2	Max. 50-ms Vert. (g)	3.6	Max Yaw (deg)	145



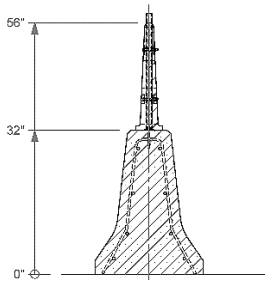


Figure 7.12. Summary of Results for *MASH* Test 3-11 on Armorcast® Gawk Screen on F-Shape Barrier.

Table 7.10. Summary of Results for Test 440822-01-3, General Information, Impact and Exit Conditions.

General Information	Test Agency	Texas A&M Transportation Institute (TTI)
	Test Standard Test No.	*MASH* 2016, Test 3-11
	TTI Test No.	440822-01-3
	Test Date	2022-04-19
Test Article	Type	Longitudinal Barrier
	Name	Armorcast® Gawk Screen on F-Shape Barrier
	Installation Length	100 ft
	Material or Key Elements	32-inch tall F-shape barrier, 24-inch × 120-inch gawk screens, 26-inch tall 1-inch schedule 40 pipe posts
	Foundation Type/Condition	Concrete, damp
Test Vehicle	Type/Designation	2270P
	Make and Model	2017 RAM 1500
	Curb	5040 lb
	Test Inertial	5025 lb
	Dummy	165 lb
	Gross Static	5190 lb
Impact Conditions	Speed	62.8 mi/h
	Angle	24.6 degrees
	Location	45.2 inches upstream from the centerline of post 4
	Impact Severity	114.8 kip-fit
Exit Conditions	Speed	52.7 mi/h
	Exit Trajectory/ Heading	1 degree/8 degrees

Table 7.11. Summary of Results for Test 440822-01-3, Occupant Risk, Vehicle and Test Article Damage.

Occupant Risk Values	Longitudinal OIV	20.1 ft/s
	Lateral OIV	30.4 ft/s
	Longitudinal RDA	3.1 g
	Lateral RDA	13.5 g
	THIV	11.3 m/s
	ASI	2.2
Max. 0.050-s Average	Longitudinal	−9.7 g
	Lateral	16.6 g
	Vertical	3.6 g
Post-Impact Trajectory	Stopping Distance	184 ft downstream of impact point 32 ft to the traffic side
Vehicle Stability	Maximum Roll Angle	27 degrees
	Maximum Pitch Angle	17 degrees
	Maximum Yaw Angle	145 degrees
	Vehicle Snagging	No
	Vehicle Pocketing	No
Test Article Deflections	Dynamic	16.5 inches
	Permanent	8.5 inches
	Working Width	29.5 inches (barrier attachment)
	Height of Working Width	56.0 inches
Vehicle Damage	VDS	01LFQ6
	CDC	01FLEW4
	Max. Exterior Deformation	12 inches
	Max. Occupant Compartment Deformation	2 inches in the toe pan

(a) 0.000 s

(b) 0.100 s

Figure 7.13. Summary of Results for Test 440822-01-3, Sequential Test Pictures.

(c) 0.200 s

(d) 0.300 s

Figure 7.13. Summary of Results for Test 440822-01-3, Sequential Test Pictures (Continued).

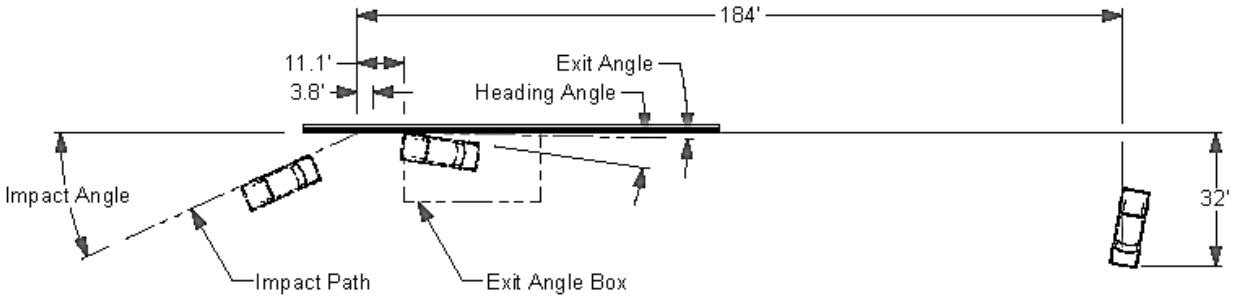


Figure 7.14. Summary of Results for Test 440822-01-3, Summary Drawing.

Chapter 8. *MASH* TEST 3-11 OF SCREEN-SAFE® GLARE SCREEN ON F-SHAPE BARRIER (CRASH TEST NO. 440822-01-4)

8.1. TEST ARTICLE DETAILS AND CRITICAL IMPACT POINT

The installation consisted of a 100-ft long section of a cast-in-place F-shape concrete barrier, with an 81-ft 6½-inch section of Screen-Safe® glare screen and work-zone safety shield mounted on top starting approximately 90 inches from the upstream end of the F-shape barrier. The F-shape barrier was 32 inches tall, 24 inches wide at its base, and sloped upward on both sides for a final width of 9½ inches at the top of the barrier. The Screen-Safe® glare screen was split into two sections. The upstream section was 31 ft 6½ inches long, and the downstream section was 50 ft long. Each end of the screen was anchored with a 6-ft 7-inch long anchor cable attached from the top of the end posts to an eyebolt anchored to the top of the F-shape barrier. The glare screen was a double-reverse corrugated steel screen fabric that stood 24 inches above the top of the F-shape barrier and was affixed to the barrier by threaded 26-inch long, ¾-inch diameter post bolts that were screwed into wedge anchors installed in the top of the concrete barriers.

Figure 8.1 shows the impact conditions for *MASH* Test 3-11 (Crash Test 440822-01-4).

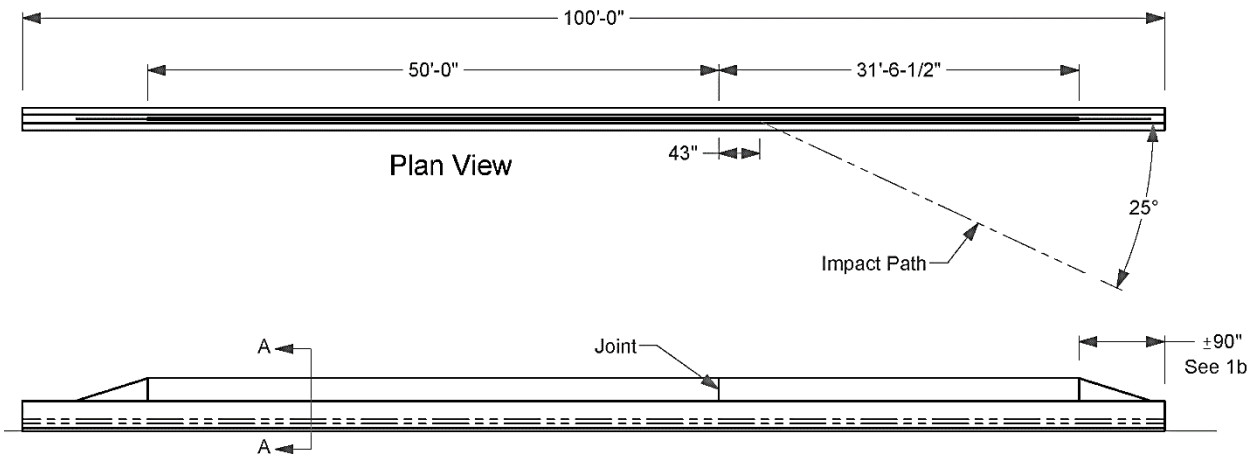


Figure 8.1. Critical Impact Point for Test 440822-01-4.

8.2. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 8.1 for the *MASH* impact conditions and Table 8.2 for the exit parameters for Test 440822-01-4. Figure 8.2 and Figure 8.3 depict the target impact setup.

Table 8.1. Impact Conditions for *MASH* Test 3-11, Crash Test 440822-01-4.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	62	±2.5 mi/h	62.3
Impact Angle (deg)	25	±1.5°	24.5
Impact Severity (kip-ft)	106	≥106 kip-ft	112.9
Impact Location	43 inches upstream from the centerline of the screen joint (between posts 6 and 7)	±12 inches	41.4 inches upstream from the centerline of the screen joint (between posts 6 and 7)

Table 8.2. Exit Parameters for *MASH* Test 3-11, Crash Test 440822-01-4.

Exit Parameter	Measured
Speed (mi/h)	47.8
Trajectory (deg)	2
Heading (deg)	9
Brakes applied post impact (s)	2.5
Vehicle at rest position	195 ft downstream of impact point 8 ft to the traffic side 45° right
Comments:	Vehicle remained upright and stable. Vehicle crossed exit box[a] 79 ft downstream from loss of contact.

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

Figure 8.2. Screen-Safe® Glare Screen on F-Shape Barrier/Test Vehicle Geometrics for Test 440822-01-4.

Figure 8.3. Screen-Safe® Glare Screen on F-Shape Barrier/Test Vehicle Impact Location, Test 440822-01-4.

8.3. WEATHER CONDITIONS

Table 8.3 provides the weather conditions for Test 440822-01-4.

Table 8.3. Weather Conditions for Test 440822-01-4.

Date of Test	May 17, 2022 PM
Temperature (°F)	89
Relative Humidity (%)	63
Wind Direction (deg)	177
Vehicle Traveling (deg)	195
Wind Speed (mi/h)	11

8.4. TEST VEHICLE

Figure 8.4 and Figure 8.5 show the 2017 RAM 1500 used for the crash test. Table 8.4 shows the vehicle measurements. Figure D.1 in Appendix D.2 gives additional dimensions and information on the vehicle.

Figure 8.4. Impact Side of Test Vehicle before Test 440822-01-4.

Figure 8.5. Opposite Impact Side of Test Vehicle before Test 440822-01-4.

Table 8.4. Vehicle Measurements for Test 440822-01-4.

Test Parameter	*MASH*	Allowed Tolerance	Measured
Dummy (if applicable)a (lb)	165	N/A	165
Inertial Weight (lb)	5000	±110	5060
Gross Static[a] (lb)	5165	±110	5225
Wheelbase (inches)	148	±12	140.5
Front Overhang (inches)	39	±3	40
Overall Length (inches)	237	±13	227.5
Overall Width (inches)	78	±2	78.5
Hood Height (inches)	43	±4	46
Track Width[b] (inches)	67	±1.5	68.3
CG aft of Front Axle[c] (inches)	63	±4	61
CG above Ground[c,d] (inches)	28	≥28	28.8

[a] If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.
[b] Average of front and rear axles.
[c] For test inertial mass.
[d] 2270P vehicle must meet minimum CG height requirement.

8.5. TEST DESCRIPTION

Table 8.5 lists events that occurred during Test No. 440822-01-4. Figures D.4 through D.6 in Appendix D.3 present sequential photographs during the test.

Table 8.5. Events during Test 440822-01-4.

Time (s)	Events
0.0000	Vehicle impacted the installation
0.0420	Vehicle began to redirect
0.0650	Windshield began to crack due to truck body twisting from impact
0.0900	Front driver side tire lifted off pavement
0.1280	Rear driver side tire lifted off pavement
0.1960	Vehicle was parallel with the installation
0.1980	Rear passenger side corner contacted F-shape barrier
0.3930	Vehicle lost contact with the rail and exited the test article traveling 47.8 mi/h at a trajectory of 1.7 degrees and a vehicle heading of 8.9 degrees

8.6. DAMAGE TO TEST INSTALLATION

There was some scuffing and gouging at impact on the concrete barrier. The glare screen was deformed, and several post bolts were bent toward the field side. Post 5 had a 10-degree lean from vertical, posts 6 and 7 had a 63-degree lean, post 8 had a 45-degree lean, and post 9 had an 11-degree lean.

Table 8.6 describes the damage to the Screen-Safe® glare screen on the F-shape barrier. Figure 8.6 and Figure 8.7 show the damage to the Screen-Safe® glare screen on the F-shape barrier.

Table 8.6. Damage to Screen-Safe® Glare Screen on F-Shape Barrier, Test 440822-01-4.

Test Parameter	Measured
Permanent Deflection/Location	The screen at 21 inches toward field side at the joint of posts 6 and 7
Dynamic Deflection	The screen at 24 inches toward field side
Working Width[a] and Height	36 inches, at a height of 56 inches (barrier attachment)

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

Figure 8.6. Screen-Safe® Glare Screen on F-Shape Barrier after Test at Impact Location, Test 440822-01-4.

Figure 8.7. Screen-Safe® Glare Screen on F-Shape Barrier after Test at the Joint of Posts 6 and 7, Test 440822-01-4.

8.7. DAMAGE TO TEST VEHICLE

Figure 8.8 and Figure 8.9 show the damage sustained by the vehicle. Figure 8.10 and Figure 8.11 show the interior of the test vehicle. Table 8.7 and Table 8.8 provide details on the occupant compartment deformation and exterior vehicle damage. Figures D.2 and D.3 in Appendix D.2 provide exterior crush and occupant compartment measurements.

Figure 8.8. Impact Side of Test Vehicle after Test 440822-01-4.

Figure 8.9. Rear Impact Side of Test Vehicle after Test 440822-01-4.

Figure 8.10. Overall Interior of Test Vehicle after Test 440822-01-4.

Figure 8.11. Interior of Test Vehicle on Impact Side after Test 440822-01-4.

Table 8.7. Occupant Compartment Deformation for Test 440822-01-4.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	0 inches
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	−7 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	−5 inches
Front Door (above Seat)	≤9.0 inches	−2.3 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 8.8. Exterior Vehicle Damage for Test 440822-01-4.

Side Windows	The right passenger's side window shattered due to the deformation of the door and was not caused by penetration of the test article.
Maximum Exterior Deformation	14 inches in the front plane at the right front corner above the bumper.
VDS	01RFQ4
CDC	01FREW3
Fuel Tank Damage	None
Description of Damage to Vehicle:	The front bumper, hood, grill, radiator and support, right frame rail, right front tire and rim, right front quarter fender, right front door, right rear door, right cab corner, right rear quarter fender, right rear rim, and rear bumper were damaged. The windshield had some separation in the laminate due to the deformation of the vehicle. The right front door had a 6.75-inch gap at the top.

8.8. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 8.9. Figure D.7 in Appendix D.4 shows the vehicle angular displacements, and Figures D.8 through D.10 in Appendix D.5 show acceleration versus time traces.

Table 8.9. Occupant Risk Factors for Test 440822-01-4.

Test Parameter	*MASH*	Measured	Time
OIV, Longitudinal (ft/s)	≤40.0	21.6	0.0991 s on right side of interior
OIV, Lateral (ft/s)	≤40.0	25.4	0.0991 s on right side of interior
Ridedown, Longitudinal (g)	≤20.49	3.3	0.2041–0.2141 s
Ridedown, Lateral (g)	≤20.49	7.2	0.2048–0.2148 s
THIV (m/s)	N/A	10.3	0.0960 s on right side of interior
ASI	N/A	1.9	0.0627–0.1127 s
50-ms MA Longitudinal (g)	N/A	−10.5	0.0374–0.0874 s
50-ms MA Lateral (g)	N/A	−14.0	0.0379–0.0879 s
50-ms MA Vertical (g)	N/A	4.0	0.1007–0.1507 s
Roll (deg)	≤75	39	0.6754 s
Pitch (deg)	≤75	12	0.6032 s
Yaw (deg)	N/A	48	1.0782 s

8.9. TEST SUMMARY

Figure 8.12, Table 8.10, and Table 8.11 summarize the results of *MASH* Test 440862-03-3. Figure 8.13 shows the sequential photographs from the crash test. Figure 8.14 shows the summary drawing for the crash test.

0.000 s

0.100 s

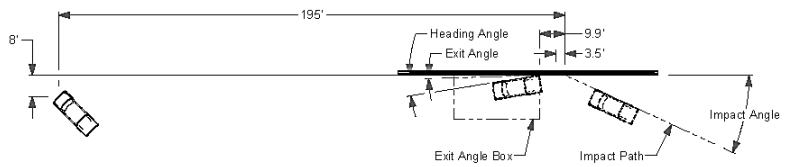
0.200 s

0.300 s

Test Agency	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.	*MASH* 2016, Test 3-11
TTI Project No.	440822-01-4
Test Date	2022-05-17
TEST ARTICLE	
Type	Longitudinal Barrier
Name	Screen-Safe® Glare Screen on F-Shape Barrier
Length	100 ft
Key Materials	32-inch tall F-shape barrier, 24-inch × 120-inch glare screens, 26-inch tall 1-inch schedule 40 pipe posts
Soil Type and Condition	Concrete, damp
TEST VEHICLE	
Type/Designation	2270P
Year, Make and Model	2017 RAM 1500
Curb Weight (lb)	5080
Inertial Weight (lb)	5060
Dummy (lb)	165
Gross Static (lb)	5225
IMPACT CONDITIONS	
Impact Speed (mi/h)	62.3
Impact Angle (deg)	24.5
Impact Location	41.4 inches upstream from the centerline of the screen joint (between posts 6 and 7)
Impact Severity (kip-ft)	112.9
EXIT CONDITIONS	
Exit Speed (mi/h)	47.8
Trajectory/Heading Angle (deg)	2/9
Exit Box Criteria	Crossed 79 ft downstream from loss of contact
Stopping Distance	195 ft downstream of impact point 8 ft to the traffic side
TEST ARTICLE DEFLECTIONS	
Dynamic (inches)	24
Permanent (inches)	21
Working Width/Height (inches)	36/56
VEHICLE DAMAGE	
VDS	01RFQ4
CDC	01FREW3
Max. Ext. Deformation	14 inches
Max. Occupant Compartment Deformation	7 inches in the toe pan

OCCUPANT RISK VALUES

Long. OIV (ft/s)	21.6	Long. Ridedown (g)	3.3	Max. 50-ms Long. (g)	−10.5	Max. Roll (deg)	39
Lat. OIV (ft/s)	25.4	Lat. Ridedown (g)	7.2	Max. 50-ms Lat. (g)	−14.0	Max. Pitch (deg)	12
THIV (m/s)	10.3	ASI	1.9	Max. 50-ms Vert. (g)	4.0	Max. Yaw (deg)	48



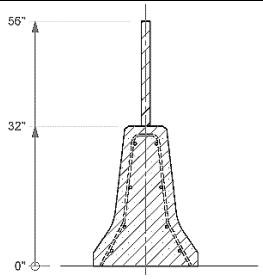


Figure 8.12. Summary of Results for *MASH* Test 3-11 on Screen-Safe® Glare Screen on F-Shape Barrier.

Table 8.10. Summary of Results for Test 440822-01-4, General Information, Impact and Exit Conditions.

General Information	Test Agency	Texas A&M Transportation Institute
	Test Standard Test No.	*MASH* 2016, Test 3-11
	TTI Test No.	440822-01-4
	Test Date	2022-05-17
Test Article	Type	Longitudinal Barrier
	Name	Screen-Safe® Glare Screen on F-Shape Barrier
	Installation Length	100 ft
	Material or Key Elements	32-inch tall F-shape barrier, 24-inch × 120-inch glare screens, 26-inch tall 1-inch schedule 40 pipe posts
	Foundation Type/Condition	Concrete, damp
Test Vehicle	Type/Designation	2270P
	Make and Model	2017 RAM 1500
	Curb	5080 lb
	Test Inertial	5060 lb
	Dummy	165 lb
	Gross Static	5225 lb
Impact Conditions	Speed	62.3 mi/h
	Angle	24.5 degrees
	Location	41.4 inches upstream from the centerline of the screen joint (between posts 6 and 7)
	Impact Severity	112.9 kip-ft
Exit Conditions	Speed	47.8 mi/h
	Exit Trajectory/ Heading	2 degrees/9 degrees

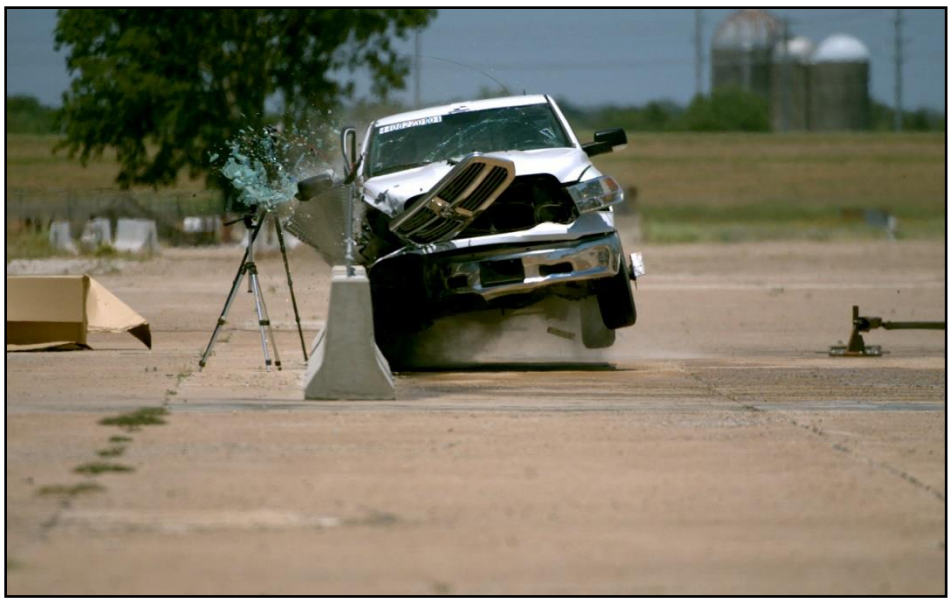
Table 8.11. Summary of Results for Test 440822-01-4, Occupant Risk, Vehicle and Test Article Damage.

Occupant Risk Values	Longitudinal OIV	21.6 ft/s
	Lateral OIV	25.4 ft/s
	Longitudinal RDA	3.3 g
	Lateral RDA	7.2 g
	THIV	10.3 m/s
	ASI	1.9
Max. 0.050-s Average	Longitudinal	−10.5 g
	Lateral	−14.0 g
	Vertical	4.0 g
Post-Impact Trajectory	Stopping Distance	195 ft downstream of impact point 8 ft to the traffic side
Vehicle Stability	Maximum Roll Angle	39 degrees
	Maximum Pitch Angle	12 degrees
	Maximum Yaw Angle	48 degrees
	Vehicle Snagging	No
	Vehicle Pocketing	No
Test Article Deflections	Dynamic	24 inches
	Permanent	21 inches
	Working Width	36 inches (barrier attachment)
	Height of Working Width	56 inches
Vehicle Damage	VDS	01RFQ4
	CDC	01FREW3
	Max. Exterior Deformation	14 inches
	Max. Occupant Compartment Deformation	7 inches in the toe pan

(a) 0.000 s

(b) 0.100 s

Figure 8.13. Summary of Results for Test 440822-01-4, Sequential Test Pictures.



(c) 0.200 s

(d) 0.300 s

Figure 8.13. Summary of Results for Test 440822-01-4, Sequential Test Pictures (Continued).

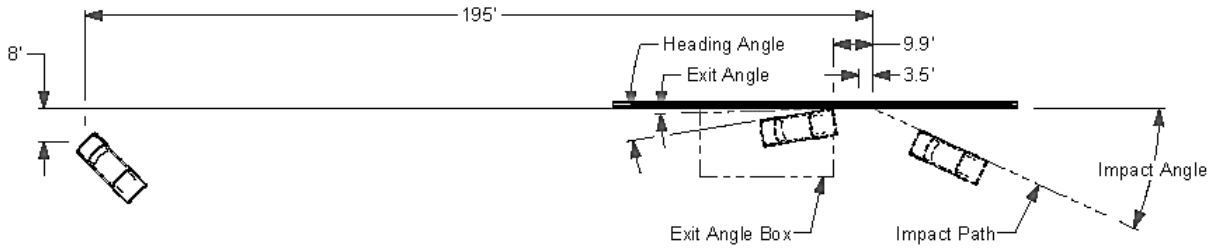


Figure 8.14. Summary of Results for Test 440822-01-4, Summary Drawing.

Chapter 9. *MASH* TEST 3-11 OF CHAIN-LINK FENCE ON F-SHAPE BARRIER (CRASH TEST NO. 440822-01-5)

9.1. TEST ARTICLE DETAILS AND CRITICAL IMPACT POINT

The installation consisted of a 100-ft long section of a cast-in-place F-shape concrete barrier, with an 80-ft long section of chain-link fence mounted on top and approximately centered on the F-shape barrier. The F-shape barrier was 32 inches tall, 24 inches wide at its base, and sloped upward on both sides for a final width of 9½ inches at the top of the barrier. The chain-link fence was 72 inches tall and was secured to the posts, which were spaced at 96 inches. The posts were affixed to the barrier by threaded ⅝-inch diameter rods secured in the concrete with epoxy.

Figure 9.1 shows the impact conditions for *MASH* Test 3-11 (Crash Test 440822-01-5).

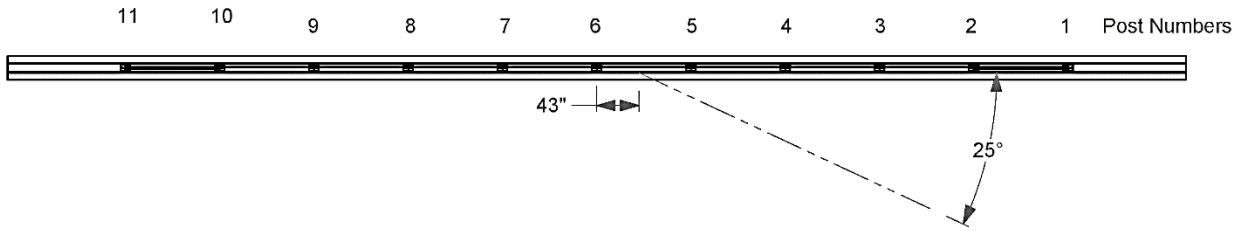


Figure 9.1. Critical Impact Point for Test 440822-01-5.

9.2. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 9.1 for the *MASH* impact conditions and Table 9.2 for the exit parameters for Test 440822-01-5. Figure 9.2 and Figure 9.3 depict the target impact setup.

Table 9.1. Impact Conditions for *MASH* Test 3-11, Crash Test 440822-01-5.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	62	±2.5 mi/h	61
Impact Angle (deg)	25	±1.5°	25
Impact Severity (kip-ft)	106	≥106 kip-ft	112.5
Impact Location	43 inches upstream from the centerline of post 6	±12 inches	42 inches upstream from the centerline of post 6

Table 9.2. Exit Parameters for *MASH* Test 3-11, Crash Test 440822-01-5.

Exit Parameter	Measured
Speed (mi/h)	48.3
Trajectory (deg)	3
Heading (deg)	10
Brakes applied post impact (s)	2.1
Vehicle at rest position	210 ft downstream of impact point 2 ft to the traffic side 5° right
Comments:	Vehicle remained upright and stable. Vehicle crossed exit box[a] 75 ft downstream from loss of contact.

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

Figure 9.2. Chain-Link Fence on F-Shape Barrier/Test Vehicle Geometrics for Test 440822-01-5.

Figure 9.3. Chain-Link Fence on F-Shape Barrier/Test Vehicle Impact Location, Test 440822-01-5.

9.3. WEATHER CONDITIONS

Table 9.3 provides the weather conditions for Test 440822-01-5.

Table 9.3. Weather Conditions for Test 440822-01-5.

Date of Test	August 4, 2022 AM
Temperature (°F)	90
Relative Humidity (%)	68
Wind Direction (deg)	174
Vehicle Traveling (deg)	195
Wind Speed (mi/h)	11

9.4. TEST VEHICLE

Figure 9.4 and Figure 9.5 show the 2016 RAM 1500 used for the crash test. Table 9.4 shows the vehicle measurements. Figure E.1 in Appendix E.2 gives additional dimensions and information on the vehicle.

Figure 9.4. Impact Side of Test Vehicle before Test 440822-01-5.

Figure 9.5. Opposite Impact Side of Test Vehicle before Test 440822-01-5.

Table 9.4. Vehicle Measurements for Test 440822-01-5.

Test Parameter	*MASH*	Allowed Tolerance	Measured
Dummy (if applicable)[a] (lb)	165	N/A	165
Inertial Weight (lb)	5000	±110	5065
Gross Static[a] (lb)	5165	±110	5230
Wheelbase (inches)	148	±12	140.5
Front Overhang (inches)	39	±3	40
Overall Length (inches)	237	±13	227.5
Overall Width (inches)	78	±2	78.5
Hood Height (inches)	43	±4	46
Track Width[b] (inches)	67	±1.5	68.3
CG aft of Front Axle[c] (inches)	63	±4	61.2
CG above Ground[c,d] (inches)	28	≥28	28.5

[a] If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.
[b] Average of front and rear axles.
[c] For test inertial mass.
[d] 2270P vehicle must meet minimum CG height requirement.

9.5. TEST DESCRIPTION

Table 9.5 lists events that occurred during Test No. 440822-01-5. Figures E.4 through E.6 in Appendix E.3 present sequential photographs during the test.

Table 9.5. Events during Test 440822-01-5.

Time (s)	Events
0.0000	Vehicle impacted the installation
0.0370	Passenger side front of vehicle impacted post 6
0.0390	Vehicle began to redirect
0.0810	Windshield on passenger side began to crack due to flexing of the vehicle body
0.2070	Passenger side rear bumper impacted barrier
0.2080	Vehicle was parallel with installation
0.4410	Vehicle exited installation at 48.3 mi/h and at a trajectory of 3.5 degrees and heading of 9.6 degrees

9.6. DAMAGE TO TEST INSTALLATION

There was some scuffing and gouging at the impact location on the concrete barrier. The chain link was pulled loose from the bottom wire from post 5 to post 7. The chain link was pushed up 10 inches and back 12 inches just upstream of post 6. Post 6 was bent at 20 inches from the bottom, and the weld securing the pipe to the base plate failed ¾ of the way around the pipe.

Table 9.6 describes the damage to the chain-link fence on the F-shape barrier. Figure 9.6 and Figure 9.7 show the damage to the chain-link fence on the F-shape barrier.

Table 9.6. Damage to Chain-Link Fence on F-Shape Barrier, Test 440822-01-5.

Test Parameter	Measured
Permanent Deflection/Location	The fence at 7.3 inches toward field side, at post 6
Dynamic Deflection	The fence at 28.6 inches toward field side
Working Width[a] and Height	The fence at 41.4 inches, at a height of 103.8 inches

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

Figure 9.6. Chain-Link Fence on F-Shape Barrier after Test at Impact Location, Test 440822-01-5.

Figure 9.7. Chain-Link Fence on F-Shape Barrier after Test at the Base of Post 6, Test 440822-01-5.

9.7. DAMAGE TO TEST VEHICLE

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

Figure 9.8. Impact Side of Test Vehicle after Test 440822-01-5.

Figure 9.9. Rear Impact Side of Test Vehicle after Test 440822-01-5.

Figure 9.10. Overall Interior of Test Vehicle after Test 440822-01-5.

Figure 9.11. Interior of Test Vehicle on Impact Side after Test 440822-01-5.

Table 9.7. Occupant Compartment Deformation for Test 440822-01-5.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	0 inches
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	−5 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	−4 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	−3 inches

Table 9.8. Exterior Vehicle Damage for Test 440822-01-5.

Side Windows	The right passenger's side window shattered due to the deformation of the door and was not caused by penetration of the test article.
Maximum Exterior Deformation	10.5 inches in the front plane at the right front corner at bumper height.
VDS	01RFQ4
CDC	01FREW3
Fuel Tank Damage	None
Description of Damage to Vehicle:	The front bumper, hood, grill, radiator and support, right front tire and rim, right front quarter fender, windshield, right front door and glass, right rear door, right rear quarter fender, right taillight, and rear bumper were all damaged. The right front door had a 9-inch gap at the top of the door.

9.8. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 9.9. Figure E.7 in Appendix E.4 shows the vehicle angular displacements, and Figures E.8 through E.10 in Appendix E.5 show acceleration versus time traces.

Table 9.9. Occupant Risk Factors for Test 440822-01-5.

Test Parameter	*MASH*	Measured	Time
OIV, Longitudinal (ft/s)	≤40.0	23.1	0.0982 s on right side of interior
OIV, Lateral (ft/s)	≤40.0	25.8	0.0982 s on right side of interior
Ridedown, Longitudinal (g)	≤20.49	4.2	0.2236–0.2336 s
Ridedown, Lateral (g)	≤20.49	5.7	0.2195–0.2295 s
THIV (m/s)	N/A	10.7	0.0953 s on right side of interior
ASI	N/A	1.8	0.0613–0.1113 s
50-ms MA Longitudinal (g)	N/A	−11.2	0.0339–0.0839 s
50-ms MA Lateral (g)	N/A	−14.3	0.0381–0.0881 s
50-ms MA Vertical (g)	N/A	3.4	0.0994–0.1494 s
Roll (deg)	≤75	23	0.5730 s
Pitch (deg)	≤75	8	0.5848 s
Yaw (deg)	N/A	41	0.9163 s

9.9. TEST SUMMARY

Figure 9.12, Table 9.10, and Table 9.11 summarize the results of *MASH* Test 440862-03-3. Figure 9.13 shows the sequential photographs from the crash test. Figure 9.14 shows the summary drawing for the crash test.

0.000 s

0.100 s

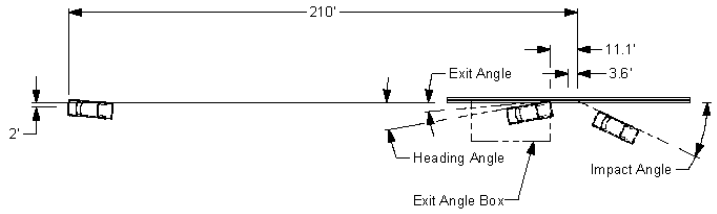
0.200 s

0.300 s

Test Agency	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.	*MASH* 2016, Test 3-11
TTI Project No.	440822-01-5
Test Date	2022-08-04
TEST ARTICLE	
Type	Longitudinal Barrier
Name	Chain-Link Fence on F-Shape Barrier
Length	100 ft
Key Materials	32-inch tall F-shape barrier, 72-inch tall chain-link fence
Soil Type and Condition	Concrete, damp
TEST VEHICLE	
Type/Designation	2270 P
Year, Make and Model	2016 RAM 1500
Curb Weight (lb)	5066
Inertial Weight (lb)	5065
Dummy (lb)	165
Gross Static (lb)	5230
IMPACT CONDITIONS	
Impact Speed (mi/h)	61.0
Impact Angle (deg)	25.0
Impact Location	42 inches upstream from the centerline of post 6
Impact Severity (kip-ft)	112.5
EXIT CONDITIONS	
Exit Speed (mi/h)	48.3
Trajectory/Heading Angle (deg)	3/10
Exit Box Criteria	Crossed 75 ft downstream from loss of contact
Stopping Distance	210 ft downstream of impact point 2 ft to the traffic side
TEST ARTICLE DEFLECTIONS	
Dynamic (inches)	28.6
Permanent (inches)	7.3
Working Width/Height (inches)	41.4/103.8
VEHICLE DAMAGE	
VDS	01RFQ4
CDC	01FREW3
Max. Ext. Deformation	10.5 inches
Max. Occupant Compartment Deformation	5 inches in the right foot well

OCCUPANT RISK VALUES

Long. OIV (ft/s)	23.1	Long. Ridedown (g)	4.2	Max. 50-ms Long. (g)	−11.2	Max. Roll (deg)	23
Lat. OIV (ft/s)	25.8	Lat. Ridedown (g)	5.7	Max. 50-ms Lat. (g)	−14.3	Max. Pitch (deg)	8
THIV (m/s)	10.7	ASI	1.8	Max. 50-ms Vert. (g)	3.4	Max. Yaw (deg)	41



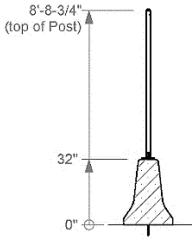


Figure 9.12. Summary of Results for *MASH* Test 3-11 on Chain-Link Fence on F-Shape Barrier.

Table 9.10. Summary of Results for Test 440822-01-5, General Information, Impact and Exit Conditions.

General Information	Test Agency	Texas A&M Transportation Institute
	Test Standard Test No.	*MASH* 2016, Test 3-11
	TTI Test No.	440822-01-5
	Test Date	2022-08-04
Test Article	Type	Longitudinal Barrier
	Name	Chain-Link Fence on F-Shape Barrier
	Installation Length	100 ft
	Material or Key Elements	32-inch tall F-shape barrier, 72-inch tall chain-link fence
	Foundation Type/Condition	Concrete, damp
Test Vehicle	Type/Designation	2270 P
	Make and Model	2016 RAM 1500
	Curb	5066 lb
	Test Inertial	5065 lb
	Dummy	165 lb
	Gross Static	5230 lb
Impact Conditions	Speed	61 mi/h
	Angle	25 degrees
	Location	42 inches upstream from the centerline of post 6
	Impact Severity	112.5 kip-ft
Exit Conditions	Speed	48.3 mi/h
	Exit Trajectory/Heading	3 degrees/10 degrees

Table 9.11. Summary of Results for Test 440822-01-5, Occupant Risk, Vehicle and Test Article Damage.

Occupant Risk Values	Longitudinal OIV	23.1 ft/s
	Lateral OIV	25.8 ft/s
	Longitudinal RDA	4.2 g
	Lateral RDA	5.7 g
	THIV	10.7 m/s
	ASI	1.8
Max. 0.050-s Average	Longitudinal	−11.2 g
	Lateral	−14.3 g
	Vertical	3.4 g
Post-Impact Trajectory	Stopping Distance	210 ft downstream of impact point 2 ft to the traffic side
Vehicle Stability	Maximum Roll Angle	23 degrees
	Maximum Pitch Angle	8 degrees
	Maximum Yaw Angle	41 degrees
	Vehicle Snagging	No
	Vehicle Pocketing	No
Test Article Deflections	Dynamic	28.6 inches
	Permanent	7.3 inches
	Working Width	41.4 inches (fence)
	Height of Working Width	103.8 inches
Vehicle Damage	VDS	01RFQ4
	CDC	01FREW3
	Max. Exterior Deformation	10.5 inches
	Max. Occupant Compartment Deformation	5 inches

(a) 0.000 s

(b) 0.100 s

Figure 9.13. Summary of Results for Test 440822-01-5, Sequential Test Pictures.

(c) 0.200 s

(d) 0.300 s

Figure 9.13. Summary of Results for Test 440822-01-5, Sequential Test Pictures (Continued).

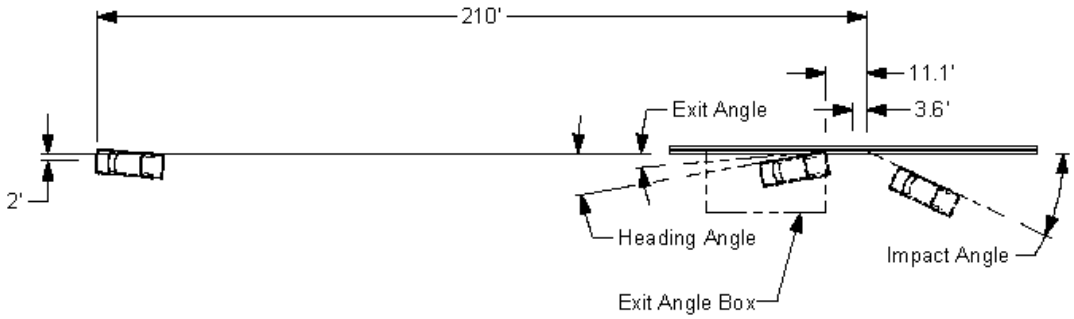


Figure 9.14. Summary of Results for Test 440822-01-5, Summary Drawing.

Chapter 10. SUMMARY AND CONCLUSIONS

10.1. ASSESSMENT OF TEST RESULTS

The crash tests for the attachments on the single-slope concrete median barrier were performed in accordance with *MASH* TL-4, and the crash tests for the attachments on the F-shape concrete median barrier were performed in accordance with *MASH* TL-3. The tables in this chapter provide an assessment of each test based on the applicable safety evaluation criteria for *MASH* longitudinal barriers.

10.2. CONCLUSIONS

Table 10.1 through Table 10.6 show that the attachments on concrete barriers met the performance criteria for *MASH* longitudinal barriers for their respective test levels.

Table 10.1. Performance Evaluation Summary for *MASH* Test 4-12 on Armorcast® Gawk Screen on Single-Slope Barrier, Test 440822-01-1, April 29, 2022.

Evaluation Criteria	*MASH* Description	Assessment
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.	Pass
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. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of *MASH*.	Pass
G.	It is preferable, although not essential, that the vehicle remain upright during and after collision.	Pass

Table 10.2. Performance Evaluation Summary for *MASH* Test 4-12 on Screen-Safe® Glare Screen on Single-Slope Barrier, Test 440822-01-2, June 1, 2022.

Evaluation Criteria	*MASH* Description	Assessment
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.	Pass
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. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of *MASH*.	Pass
G.	It is preferable, although not essential, that the vehicle remain upright during and after collision.	Pass

Table 10.3. Performance Evaluation Summary for *MASH* Test 3-11 on Armorcast® Gawk Screen on F-Shape Barrier, Test 440822-01-3, April 19, 2022.

Evaluation Criteria	*MASH* Description	Assessment
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.	Pass
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. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of *MASH*.	Pass
F.	The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	Pass
H.	Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 30 ft/s (10 ft/s for supports), or maximum allowable value of 40 ft/s (16 ft/s for supports).	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.	Pass

Table 10.4. Performance Evaluation Summary for *MASH* Test 3-11 on Screen-Safe® Glare Screen on F-Shape Barrier, Test 440822-01-4, May 17, 2022.

Evaluation Criteria	*MASH* Description	Assessment
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.	Pass
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. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of *MASH*.	Pass
F.	The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	Pass
H.	Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 30 ft/s (10 ft/s for supports), or maximum allowable value of 40 ft/s (16 ft/s for supports).	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.	Pass

Table 10.5. Performance Evaluation Summary for *MASH* Test 3-11 on Chain-Link Fence on F-Shape Barrier, Test 440822-01-5, August 4, 2022.

Evaluation Criteria	*MASH* Description	Assessment
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.	Pass
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. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of *MASH*.	Pass
F.	The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	Pass
H.	Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 30 ft/s (10 ft/s for supports), or maximum allowable value of 40 ft/s (16 ft/s for supports).	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.	Pass

Table 10.6. Assessment Summary for *MASH* TL-3 Tests on Armorcast® Gawk Screen, Screen-Safe® Glare Screen, and Chain-Link Fence on F-Shape Barrier; and *MASH* TL-4 Tests on Armorcast® Gawk Screen and Screen-Safe® Glare Screen on Single-Slope Barrier.

Evaluation Criteria	Test No. 440822-01-1 *MASH* 4-12	Test No. 440822-01-2 *MASH* 4-12	Test No. 440822-01-3 *MASH* 3-11	Test No. 440822-01-4 *MASH* 3-11	Test No. 440822-01-5 *MASH* 3-11
A	S	S	S	S	S
D	S	S	S	S	S
F	N/A	N/A	S	S	S
G	S	S	N/A	N/A	N/A
H	N/A	N/A	S	S	S
I	N/A	N/A	S	S	S
Overall	Pass	Pass	Pass	Pass	Pass

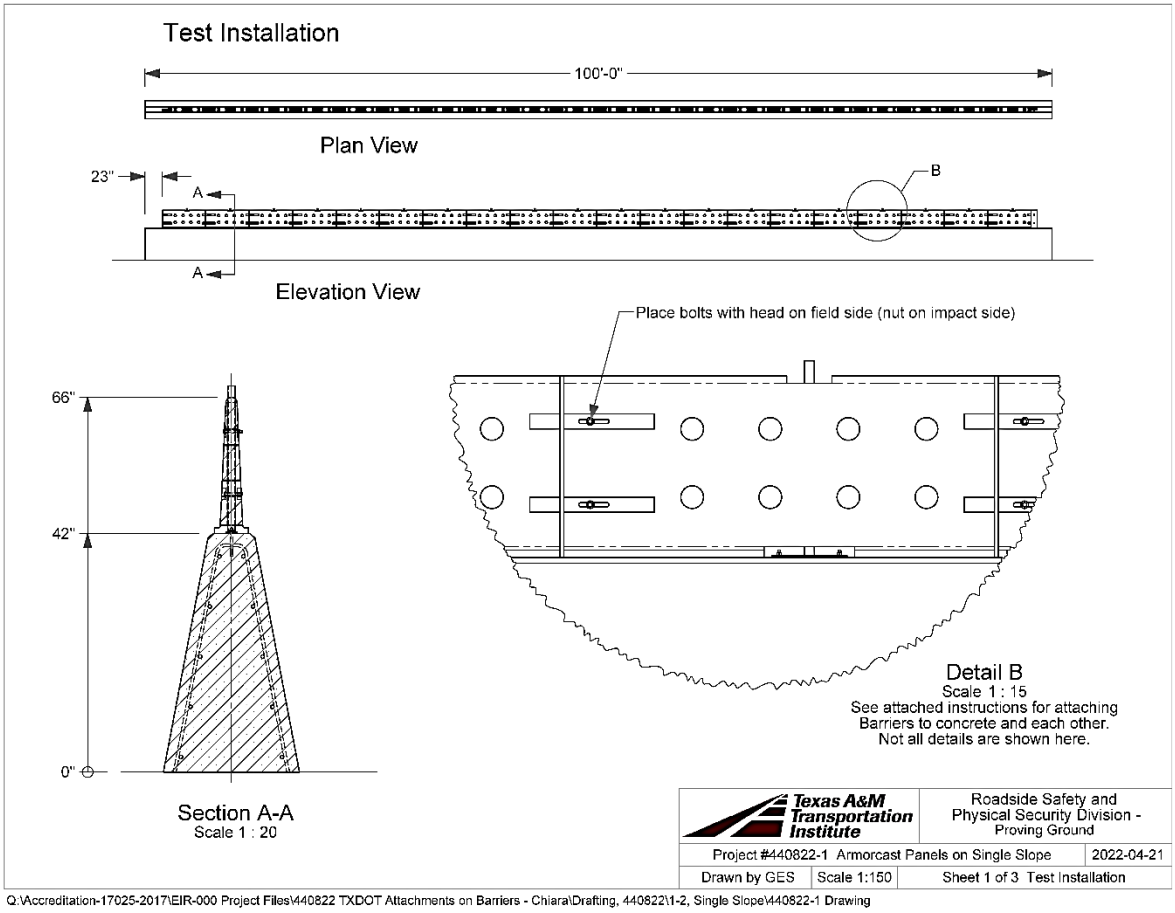
Note: S = Satisfactory; N/A = Not Applicable.

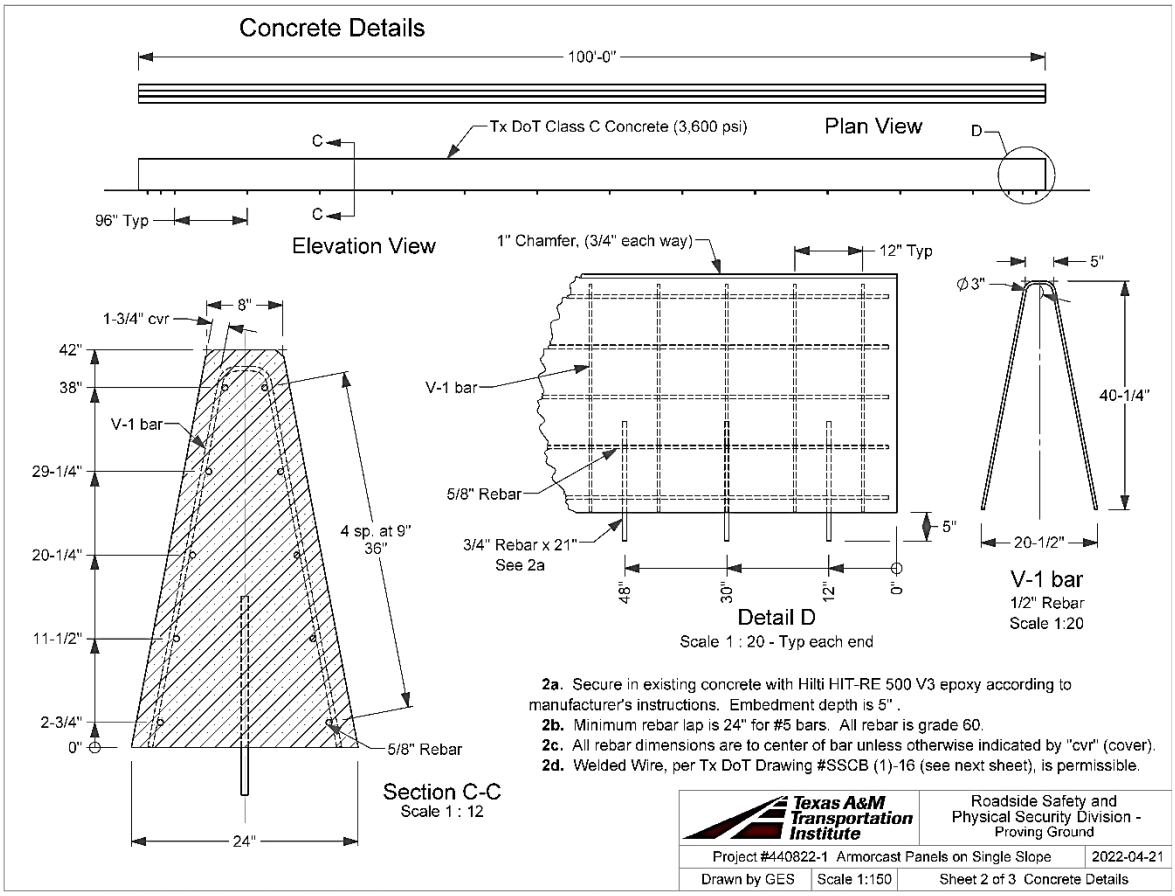
REFERENCES

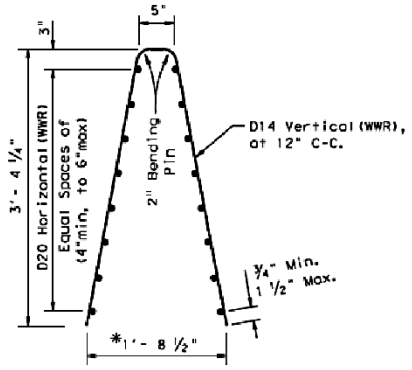
1. AASHTO. *Manual for Assessing Roadside Safety Hardware*, Second Edition. American Association of State Highway and Transportation Officials, Washington, DC, 2016.

APPENDIX A. CRASH TEST 440822-01-1

A.1. DETAILS OF TEST ARTICLE




Concrete Details
100'-0"
Tx DoT Class C Concrete (3,600 psi)
Plan View
C
C
D
96" Typ
Elevation View
1" Chamfer, (3/4" each way)
12" Typ
5"
Ø3"
8"
1-3/4" cvr
42"
38"
V-1 bar
29-1/4"
20-1/4"
11-1/2"
2-3/4"
0"
4 sp. at 9"
36"
5/8" Rebar
24"
Section C-C
Scale 1 : 12
V-1 bar
5/8" Rebar
3/4" Rebar x 21"
See 2a
5"
48"
30"
12"
0"
Detail D
Scale 1 : 20 - Typ each end
40-1/4"
20-1/2"
V-1 bar
1/2" Rebar
Scale 1:20
2a. Secure in existing concrete with Hilti HIT-RE 500 V3 epoxy according to manufacturer's instructions. Embedment depth is 5".
2b. Minimum rebar lap is 24" for #5 bars. All rebar is grade 60.
2c. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).
2d. Welded Wire, per Tx DoT Drawing #SSCB (1)-16 (see next sheet), is permissible.
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #440822-1 Armorcast Panels on Single Slope
2022-04-21
Drawn by GES
Scale 1:150
Sheet 2 of 3 Concrete Details
Q:\Accreditation-17025-2017\EIR-000 Project Files\440822 TXDOT Attachments on Barriers - Chiara\Drafting, 440822\1-2, Single Slope\440822-1 Drawing



Welded Wire Reinforcement (WWR) Option for Bars V1 and H1

(WWR) General Notes

1. Deformed Welded Wire Reinforcement (WWR) shall conform to ASTM A497.

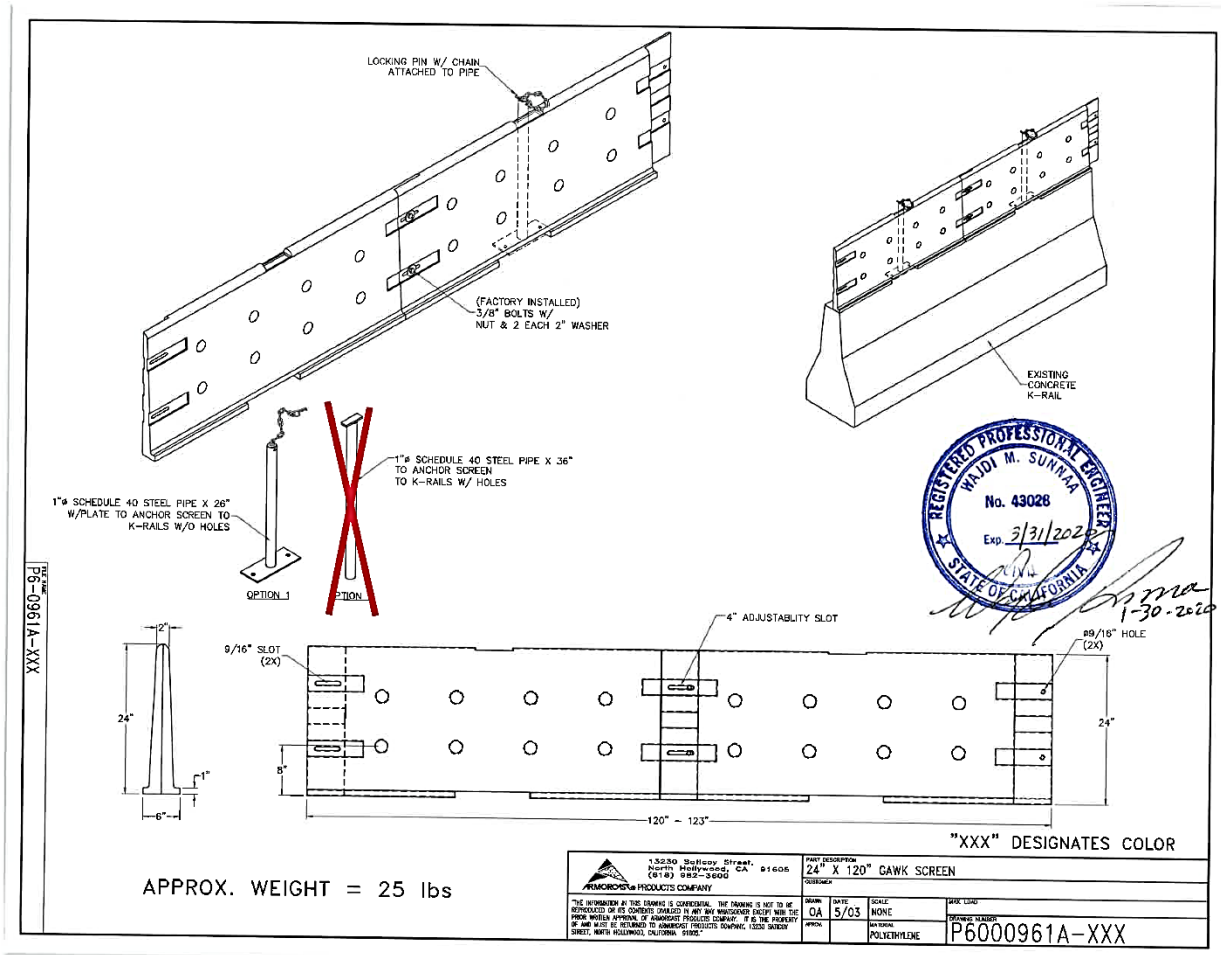
2. ~~Welded wire sags may be cut and bent to accommodate the drainage slots, as directed by the Engineer.~~

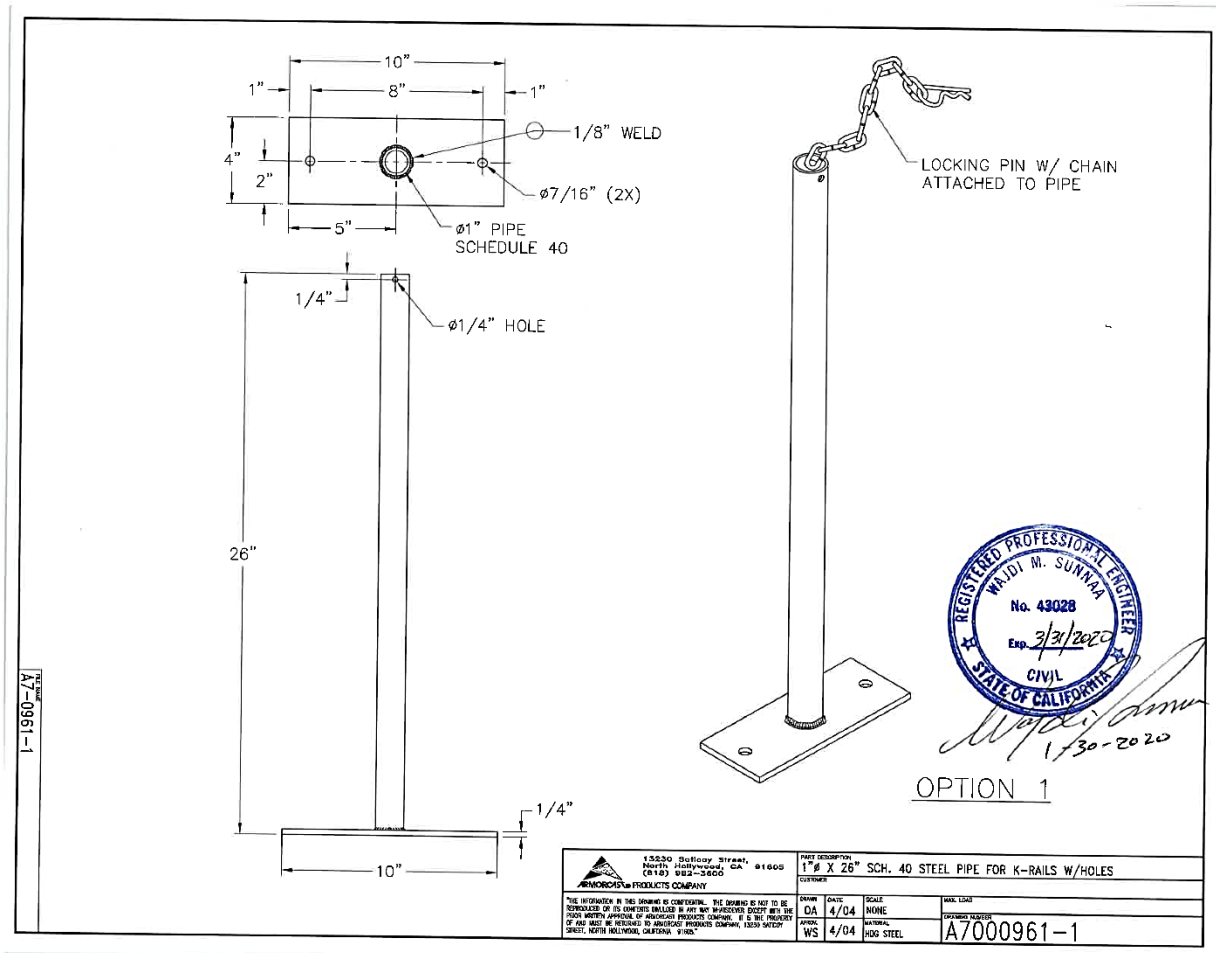
3. Welded wire splice locations shall have a "minimum" splice lap length of 12".

4. ~~Combinations of reinforcing steel and WWR will be permitted, as directed by the Engineer.~~ The dimension from the end of the barrier section to the first wire shall not exceed 3".

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground
Project #440822-1 Armorcast Panels on Single Slope		2022-04-21
Drawn by GES	Scale 1:150	Sheet 3 of 3 Welded Wire

Q:\Accreditation-17025-2017\EIR-000 Project Files\440822 TXDOT Attachments on Barriers - Chiara\Drafting, 440822\1-2, Single Slope\440822-1 Drawing


LOCKING PIN W/ CHAIN ATTACHED TO PIPE
(FACTORY INSTALLED) 3/8" BOLTS W/ NUT & 2 EACH 2" WASHER
EXISTING CONCRETE K-RAIL
1"ø SCHEDULE 40 STEEL PIPE X 36" TO ANCHOR SCREEN TO K-RAILS W/ HOLES
1"ø SCHEDULE 40 STEEL PIPE X 26" W/PLATE TO ANCHOR SCREEN TO K-RAILS W/O HOLES
OPTION 1
OPTION
REGISTERED PROFESSIONAL ENGINEER
WAJDI M. SUNNAA
No. 43028
Exp. 3/31/2020
STATE OF CALIFORNIA
1-30-2020
4" ADJUSTABILITY SLOT
9/16" SLOT (2X)
ø9/16" HOLE (2X)
2"
24"
1"
6"
8"
24"
120" ~ 123"
"XXX" DESIGNATES COLOR
APPROX. WEIGHT = 25 lbs
13230 Sutlloy Street, North Hollywood, CA 91605 (818) 982-3600
ARMORCAST PRODUCTS COMPANY
PART DESCRIPTION 24" X 120" GAWK SCREEN
DESIGNER
DRAWN OA
DATE 5/03
SCALE NONE
MATERIAL POLYETHYLENE
DRAWING NUMBER P6000961A-XXX
P6000961A-XXX


10"
1"
8"
1"
1/8" WELD
4"
2"
ø7/16" (2X)
5"
ø1" PIPE
SCHEDULE 40
1/4"
ø1/4" HOLE
26"
1/4"
10"
LOCKING PIN W/ CHAIN
ATTACHED TO PIPE
REGISTERED PROFESSIONAL ENGINEER
WAJDI M. SUNNAA
No. 43028
Exp. 3/31/2020
CIVIL
STATE OF CALIFORNIA
1-30-2020
OPTION 1
A7-0961-1
13230 Sutcoy Street,
North Hollywood, CA 91605
(818) 982-3600
ARMORCAST PRODUCTS COMPANY
1"ø X 26" SCH. 40 STEEL PIPE FOR K-RAILS W/HOLES
DA 4/04
WS 4/04
NONE
HDG STEEL
A7000961-1

Armorcast Products Company
9140 Lurline Ave
Chatsworth, Ca 91311
Tel: (818) 982-3600
Fax: (818) 982-7742

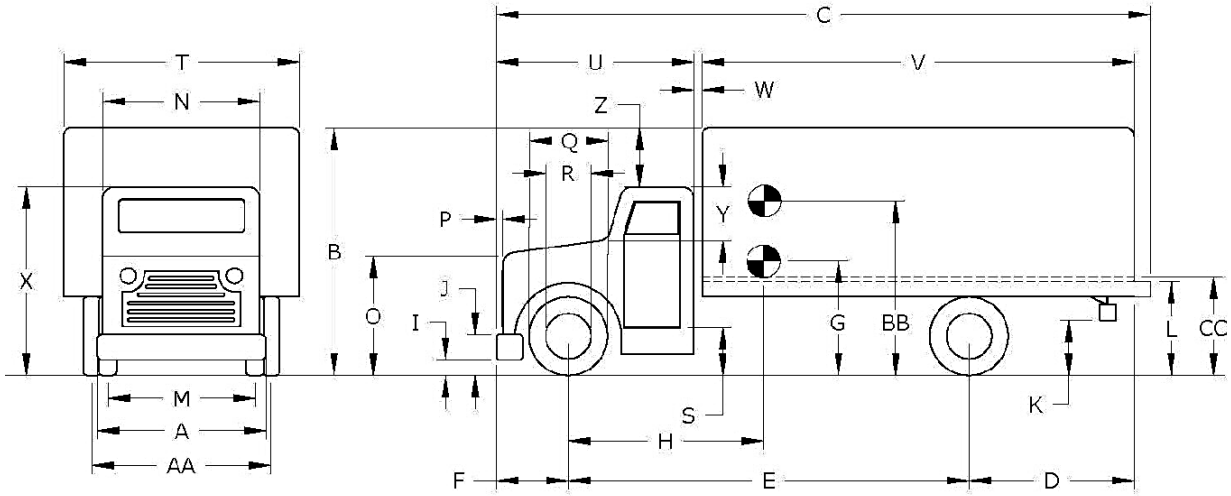
Gawk Screen

Recommended Installation Instructions

1. **Place the first 10 foot long Gawk Screen on the concrete K- Rail and mark the centers of the bottom opening. Two openings per 10 foot sections at approximately 60" apart. Remove the gawk screen.**
2. **Center the provided 1" diameter steel pipes with plate over the marked location and top of the K-Rail.**
3. **Mark the holes through the steel plate onto the top of the K-Rail for each side.**
4. **Use 3/8" diameter wedge anchors, also known as Red Heads.**
5. **Drill a minimum of 1 ½" deep hole into concrete with a carbide tipped masonry drill. Follow wedge anchor manufacturer recommendations for embedment length and installation instructions.**
6. **Clean hole, place the wedge anchor through the hole directly into the concrete and hammer it in to the drilled hole until the threads are below the concrete surface.**
7. **Remove the nuts and place the steel pipes with plate assembly over the threaded anchors and into the holes in the plate.**
8. **Replace the nuts and turn by hand until the unit is hand tightened. Tighten each nut with a wrench, approximately three or four full turns, to complete the fastening.**
9. **Place the first gawk screen over the steel pipe and place the locking pin into the ¼" hole on the steel pipe.**
10. **Repeat the above steps for each 10 foot section. Place another plastic extension on the adjacent concrete K-Rail and slide toward the installed plastic extension to interlock the two extensions.**
11. **Continue the above procedure until all gawk screens are placed.**

A.2. VEHICLE PROPERTIES AND INFORMATION

Date:	2022-3-29	Test No.:	440822-01-01	VIN No.:	2FZACGBSX8AZ54986
Year:	2008	Make:	STERLING	Model:	
Odometer:	248044	Tire Size Front:	275/80R22.5	Tire Size Rear:	11R22.5



Vehicle Geometry: ☑ inches or ☐ mm

A	Front Bumper Width:	94.00	K	Rear Bumper Bottom:		U	Cab Length: 106.00
B	Overall Height:	136.50	L	Rear Frame Top:	34.50	V	Trailer/Box Length: 220.00
C	Overall Length:	339.00	M	Front Track Width:	82.50	W	Gap Width: 3.00
D	Rear Overhang:	92.50	N	Roof Width:	71.00	X	Overall Front Height: 97.75
E	Wheel Base:	207.50	O	Hood Height:	59.00	Y	Roof-Hood Distance: 26.00
F	Front Overhang:	39.00	P	Bumper Extension:	1.00	Z	Roof-Box Height Difference: 38.75
G	C.G. Height:		Q	Front Tire Width:	40.50	AA	Rear Track Width: 73.00
H	C.G. Horizontal Dist. w/Ballast:	131.54	R	Front Wheel Width:	23.25	BB	Ballast Center of Mass: 61.75
I	Front Bumper Bottom:	19.00	S	Bottom Door Height:	36.00	CC	Cargo Bed Height: 50.00
J	Front Bumper Top:	30.50	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	19.50	Wheel Well Clearance (Front)	7.25	Bottom Frame Height (Front)	26.00
Wheel Center Height Rear	19.50	Wheel Well Clearance (Rear)	4.25	Bottom Frame Height (Rear)	24.75

Figure A.1. Vehicle Properties for Test No. 440822-01-1.

Date: 2022-3-29 Test No.: 440822-01-01 VIN No.: 2FZACGBSX8AZ54986

Year: 2008 Make: STERLING Model:

WEIGHTS (☑ lb or ☐ kg)	CURB	TEST INERTIAL
$W_{front\ axle}$	7080	8210
$W_{rear\ axle}$	7610	14220
W_{TOTAL}	14690	22430

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

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

Mass Distribution
(☐ lb or ☐ kg): **LF:** 4210 **RF:** 4000 **LR:** 7920 **RR:** 6300

Engine Type: _____

Engine Size: _____

Transmission Type:

☑ Auto or ☐ Manual

☐ FWD ☑ RWD ☐ 4WD

Accelerometer Locations (☐ inches or ☐ mm)

	x[1]	y	z[2]
Front:			
Center:	131.50	0.00	50.00
Rear:	231.50	0.00	50.00

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 H 30 W 60 L 30

CENTERED IN MIDDLE OF BED

TIED DOWN WITH FOUR 3/8 CABLES PER BLOCK

Figure A.1. Vehicle Properties for Test No. 440822-01-1 (Continued).

A.3. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure A.4. Sequential Photographs for Test No. 440822-01-1 (Overhead Views).

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure A.5. Sequential Photographs for Test No. 440822-01-1 (Frontal Views).

(a) 0.000 s

(b) 0.100 s

(c) 0.200 s

(d) 0.300 s

(e) 0.400 s

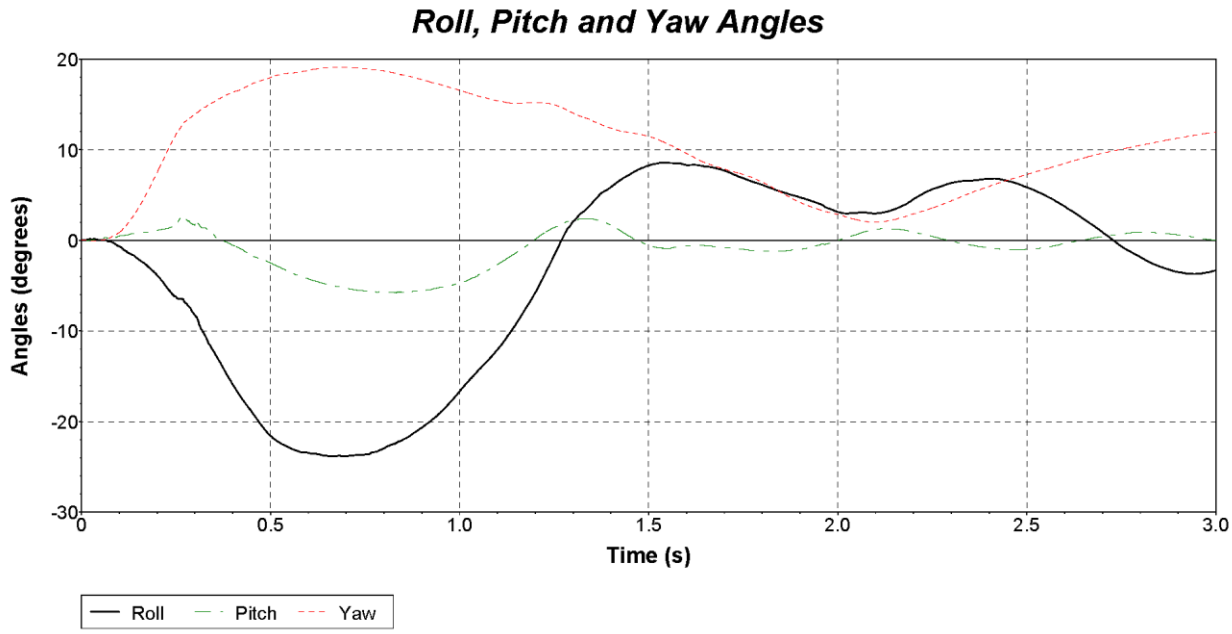
(f) 0.500 s

(g) 0.600 s

(h) 0.700 s

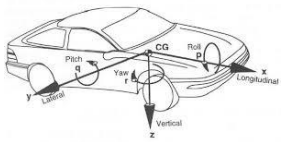
Figure A.6. Sequential Photographs for Test No. 440822-01-1 (Rear Views).

A.4. VEHICLE ANGULAR DISPLACEMENT



Axes are vehicle-fixed.
Sequence for determining orientation:

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



Test Number: 440822-01-1
Test Standard Test Number: *MASH* Test 4-12
Test Article: Armorcast® Gawk Screen on Single-Slope Barrier
Test Vehicle: 2008 Sterling
Inertial Mass: 22,430 lb
Curb Mass: 14,690 lb
Impact Speed: 56.7 mi/h
Impact Angle: 15°

Figure A.7. Vehicle Angular Displacements for Test No. 440822-01-1.

A.5. VEHICLE ACCELERATIONS

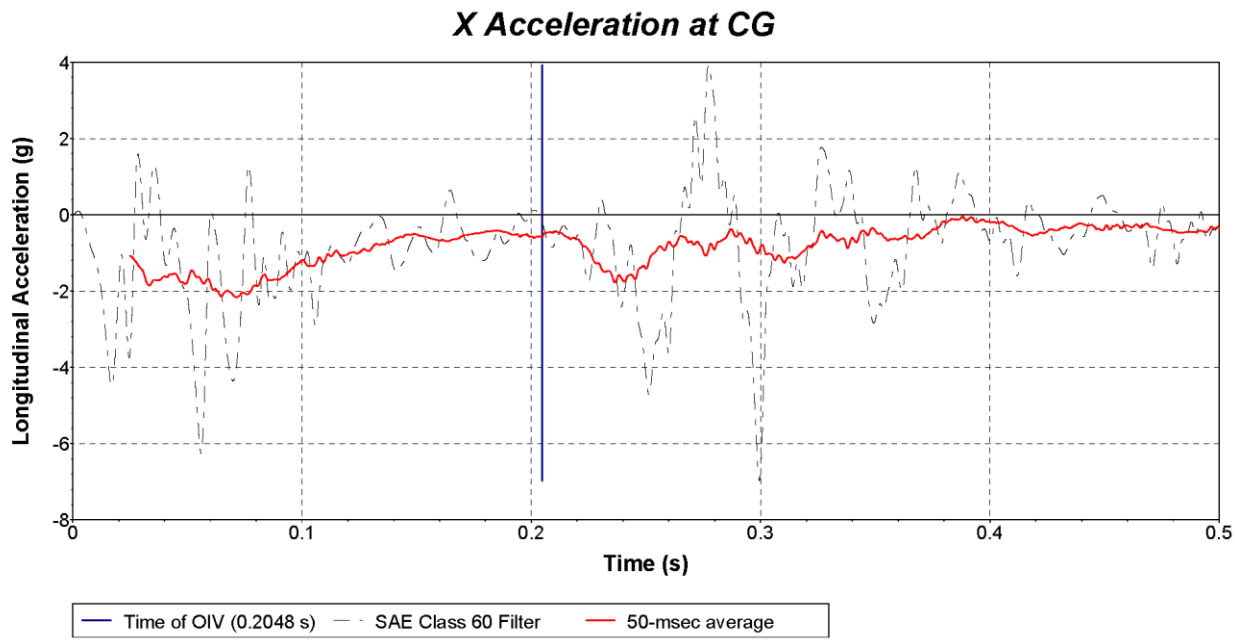


Figure A.8. Vehicle Longitudinal Accelerometer Trace for Test No. 440822-01-1 (Accelerometer Located at Center of Gravity).

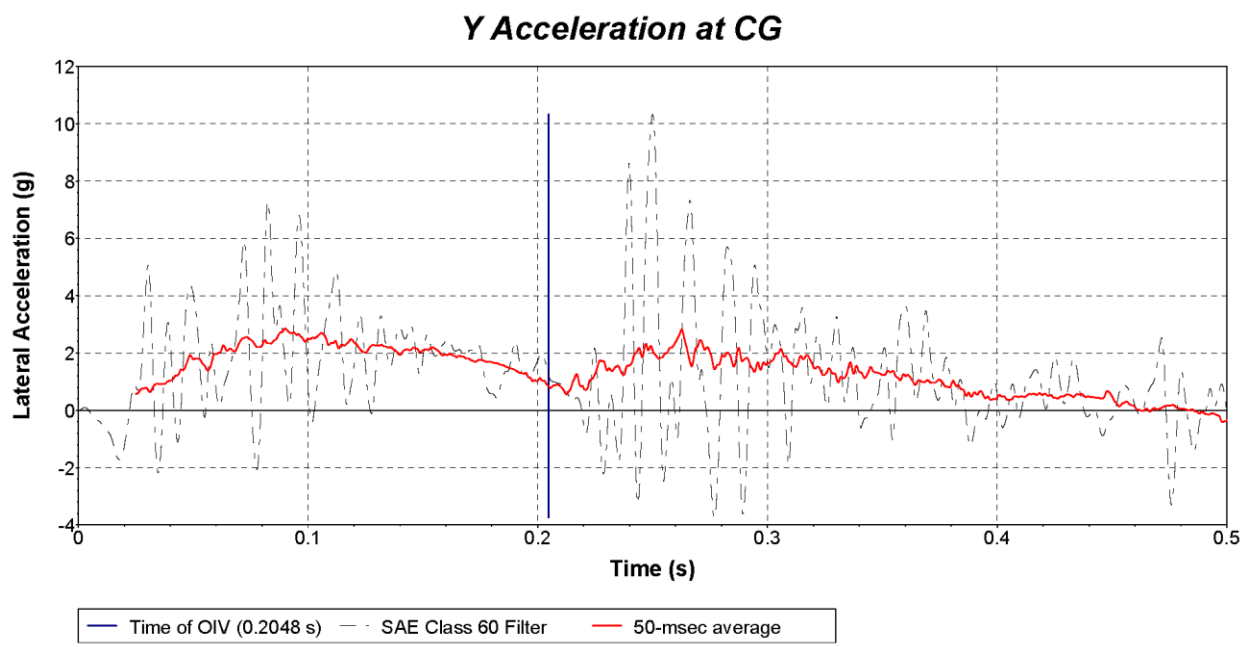


Figure A.9. Vehicle Lateral Accelerometer Trace for Test No. 440822-01-1 (Accelerometer Located at Center of Gravity).

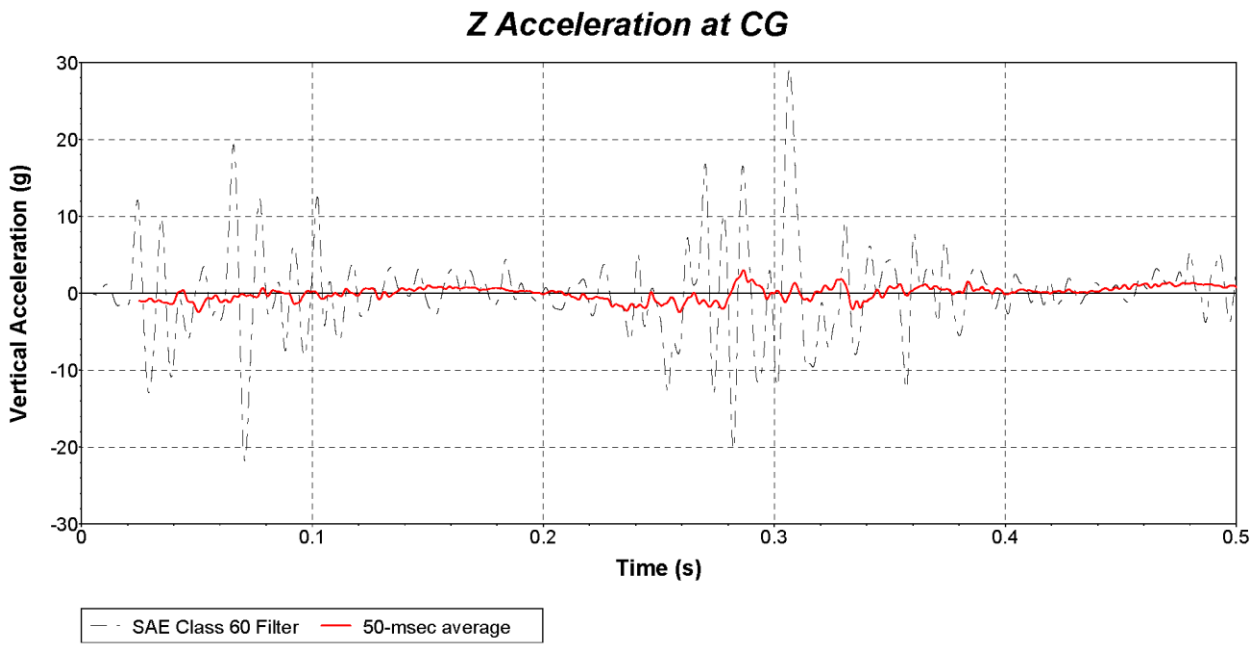
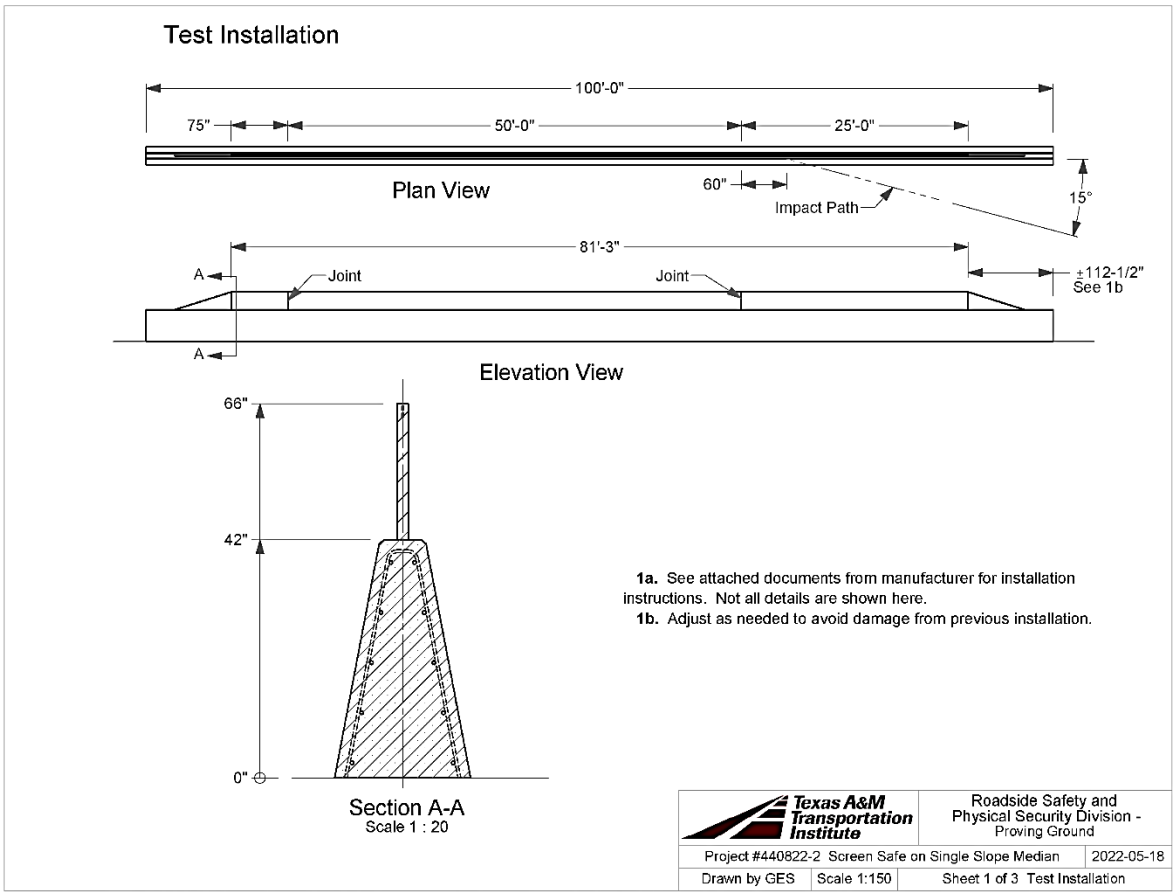
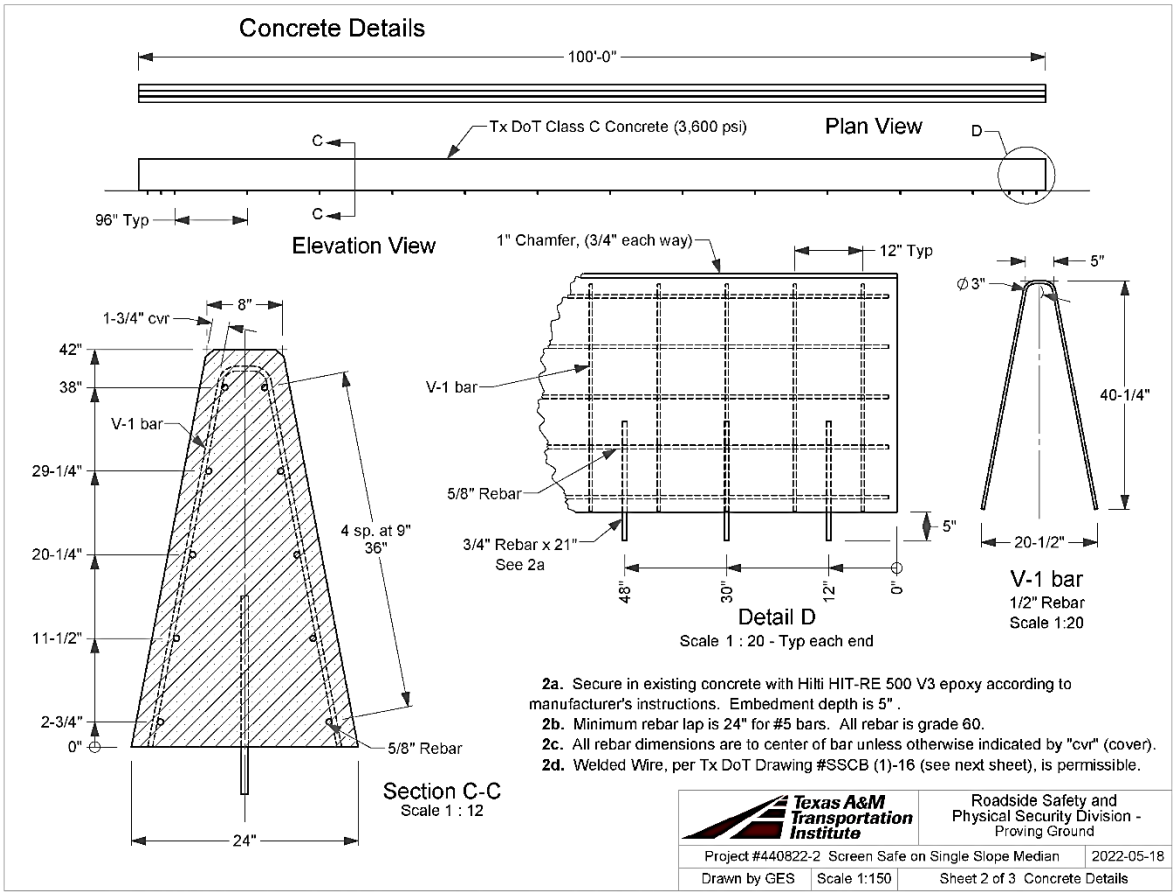


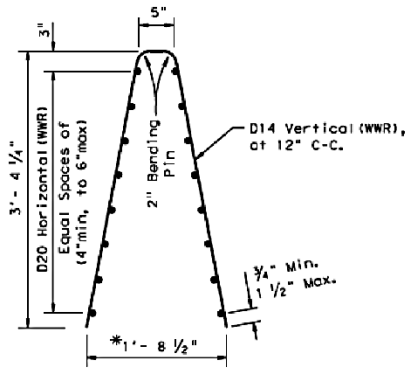
Figure A.10. Vehicle Vertical Accelerometer Trace for Test No. 440822-01-1 (Accelerometer Located at Center of Gravity).

APPENDIX B. CRASH TEST 440822-01-2

B.1. DETAILS OF TEST ARTICLE




Concrete Details
100'-0"
Tx DoT Class C Concrete (3,600 psi)
Plan View
C
C
D
96" Typ
Elevation View
1" Chamfer, (3/4" each way)
12" Typ
5"
∅3"
8"
1-3/4" cvr
42"
38"
V-1 bar
29-1/4"
20-1/4"
11-1/2"
2-3/4"
0"
4 sp. at 9"
36"
5/8" Rebar
24"
Section C-C
Scale 1 : 12
V-1 bar
5/8" Rebar
3/4" Rebar x 21"
See 2a
5"
48"
30"
12"
0"
Detail D
Scale 1 : 20 - Typ each end
40-1/4"
20-1/2"
V-1 bar
1/2" Rebar
Scale 1:20
2a. Secure in existing concrete with Hilti HIT-RE 500 V3 epoxy according to manufacturer's instructions. Embedment depth is 5" .
2b. Minimum rebar lap is 24" for #5 bars. All rebar is grade 60.
2c. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).
2d. Welded Wire, per Tx DoT Drawing #SSCB (1)-16 (see next sheet), is permissible.
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #440822-2 Screen Safe on Single Slope Median
2022-05-18
Drawn by GES
Scale 1:150
Sheet 2 of 3 Concrete Details
Q:\Accreditation-17025-2017\EIR-000 Project Files\440822 TXDOT Attachments on Barriers - Chiara\Drafting, 440822 1-4\1-2, Single Slope\440822-2 Drawing



Welded Wire Reinforcement (WWR) Option for Bars V1 and H1

(WWR) General Notes

1. Deformed Welded Wire Reinforcement (WWR) shall conform to ASTM A497.

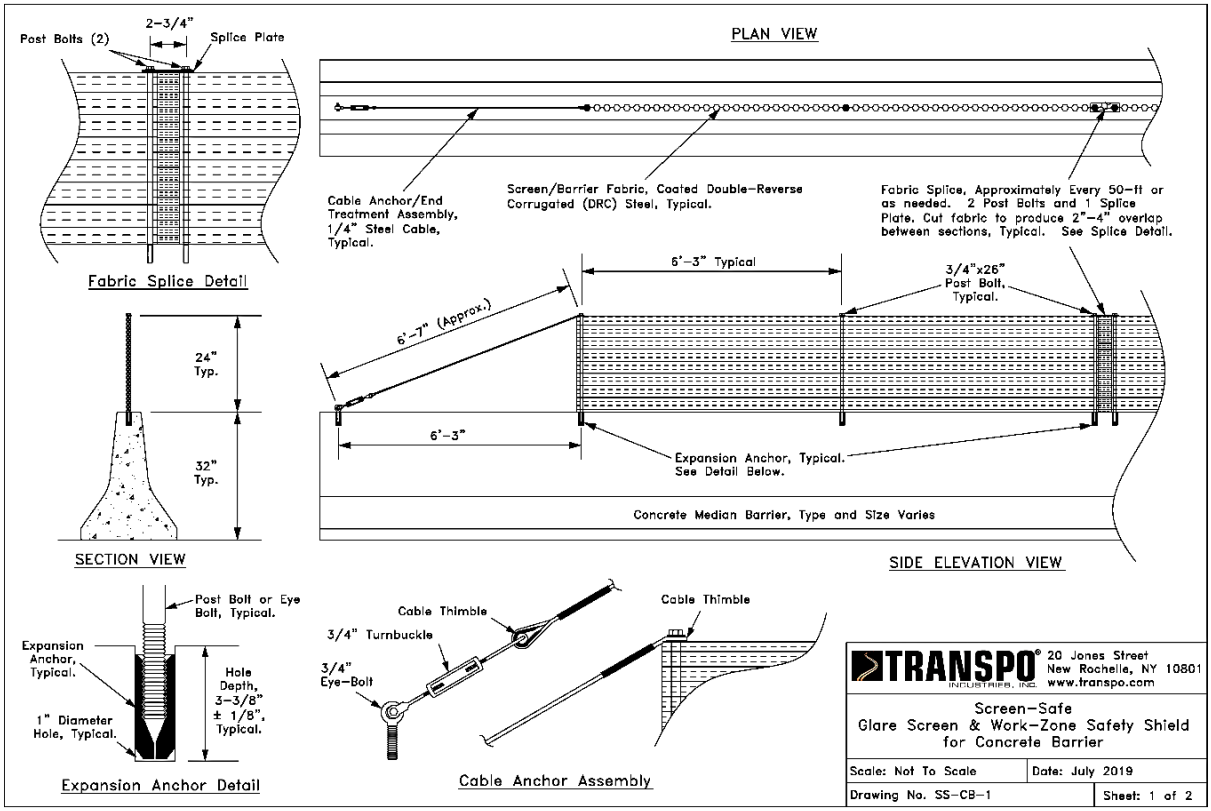
2. ~~Welded wire ends may be cut and bent to accommodate the drainage ditch, as directed by the Engineer.~~

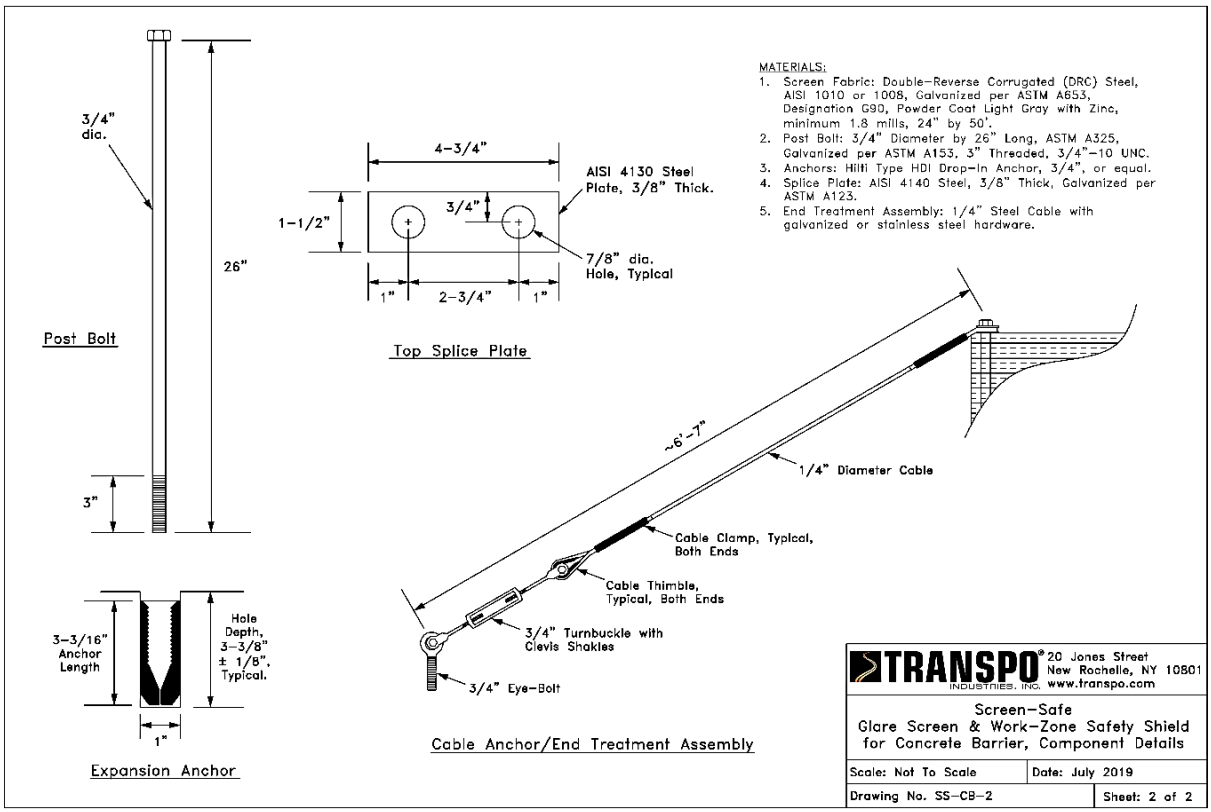
3. Welded wire splice locations shall have a "minimum" splice lap length of 12".

4. ~~Combinations of reinforcing steel and "WWR" will be permitted, as directed by the Engineer.~~ The dimension from the end of the barrier section to the first wire shall not exceed 3".

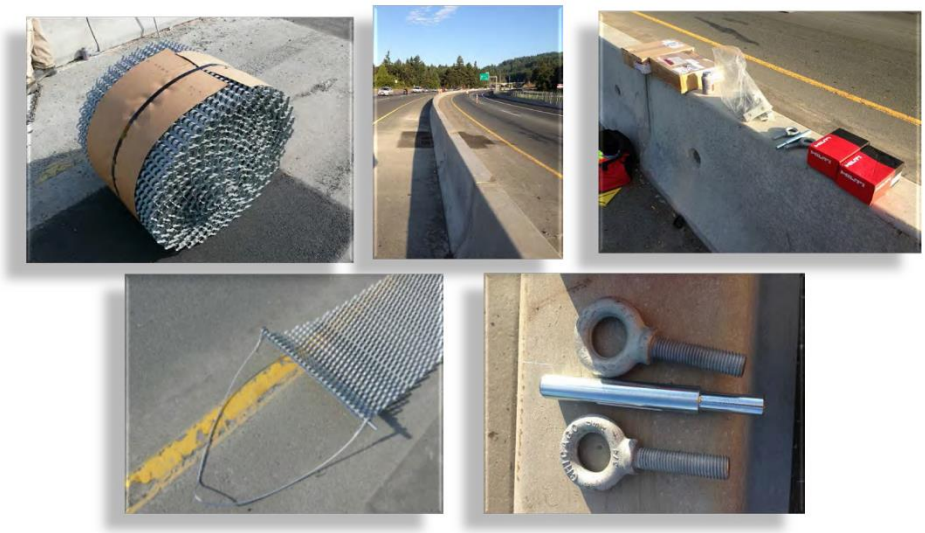
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #440822-2 Screen Safe on Single Slope Median		2022-05-18
Drawn by GES	Scale 1:150	Sheet 3 of 3 Welded Wire

Q:\Accreditation-17025-2017\EIR-000 Project Files\440822 TXDOT Attachments on Barriers - Chiara\Drafting, 440822 1-4\1-2, Single Slope\440822-2 Drawing

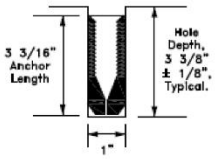

Post Bolts (2)
2–3/4"
Splice Plate
Fabric Splice Detail
PLAN VIEW
Cable Anchor/End Treatment Assembly, 1/4" Steel Cable, Typical.
Screen/Barrier Fabric, Coated Double–Reverse Corrugated (DRC) Steel, Typical.
Fabric Splice, Approximately Every 50–ft or as needed. 2 Post Bolts and 1 Splice Plate. Cut fabric to produce 2"–4" overlap between sections, Typical. See Splice Detail.
6'–3" Typical
3/4"x26" Post Bolt, Typical.
6'–7" (Approx.)
24" Typ.
32" Typ.
6'–3"
Expansion Anchor, Typical. See Detail Below.
Concrete Median Barrier, Type and Size Varies
SECTION VIEW
SIDE ELEVATION VIEW
Post Bolt or Eye Bolt, Typical.
Expansion Anchor, Typical.
Hole Depth, 3–3/8" ± 1/8", Typical.
1" Diameter Hole, Typical.
Expansion Anchor Detail
Cable Thimble
3/4" Turnbuckle
3/4" Eye–Bolt
Cable Thimble
Cable Anchor Assembly
TRANSPO INDUSTRIES, INC.
20 Jones Street
New Rochelle, NY 10801
www.transpo.com
Screen–Safe
Glare Screen & Work–Zone Safety Shield for Concrete Barrier
Scale: Not To Scale
Date: July 2019
Drawing No. SS–CB–1
Sheet: 1 of 2

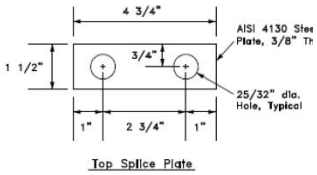

3/4" dia.
26"
3"
Post Bolt
4–3/4"
AISI 4130 Steel Plate, 3/8" Thick.
3/4"
1–1/2"
7/8" dia. Hole, Typical
1"
2–3/4"
1"
Top Splice Plate
MATERIALS:
1. Screen Fabric: Double–Reverse Corrugated (DRC) Steel, AISI 1010 or 1008, Galvanized per ASTM A653, Designation G90, Powder Coat Light Gray with Zinc, minimum 1.8 mills, 24" by 50'.
2. Post Bolt: 3/4" Diameter by 26" Long, ASTM A325, Galvanized per ASTM A153, 3" Threaded, 3/4"–10 UNC.
3. Anchors: Hilti Type HDI Drop–In Anchor, 3/4", or equal.
4. Splice Plate: AISI 4140 Steel, 3/8" Thick, Galvanized per ASTM A123.
5. End Treatment Assembly: 1/4" Steel Cable with galvanized or stainless steel hardware.
~6'–7"
1/4" Diameter Cable
Cable Clamp, Typical, Both Ends
Cable Thimble, Typical, Both Ends
3/4" Turnbuckle with Clevis Shakles
3/4" Eye–Bolt
Cable Anchor/End Treatment Assembly
3–3/16" Anchor Length
Hole Depth, 3–3/8" ± 1/8", Typical.
1"
Expansion Anchor
TRANSPO INDUSTRIES, INC.
20 Jones Street
New Rochelle, NY 10801
www.transpo.com
Screen–Safe
Glare Screen & Work–Zone Safety Shield for Concrete Barrier, Component Details
Scale: Not To Scale
Date: July 2019
Drawing No. SS–CB–2
Sheet: 2 of 2

Concrete Barrier Installation:



- Using 1” Masonry Bit, Drill anchor holes beginning at location where the Screen Safe is to start
- Drill 1” diameter holes with depth of 3-3/8” (+/- 1/8”) to accommodate Hilti-Anchor
  - Clean drilled holes with air blower
- Use anchor tool provided to set anchor flush, and seat into concrete
- Remove plastic insert inside anchor





- Unroll DRC next to predrilled holes
- Attach supplied Com-A-Long attachment to far end of DRC from starting point
- It is best to have a post bolt at each anchor location

- Lift entire section of Screen Safe DRC onto barrier
- Insert first post bolt with end treatment cable attached through first row of DRC past end tab. Secure into anchor.
- Attach turnbuckle end to eye bolt, tighten turnbuckle by hand keeping first post bolt vertical.
- At other end of 50' section attach a Come-A-Long Ratchet to the attachment, and secure Come-A-Long to a fixed object in line with barrier.
- Ratchet Come-A-Long tightening DRC taking slack out of the section. Pay attention to first post bolt and that it is not bending; use turnbuckle to keep vertical.
- Section should be mostly free standing at this point with minimal support.

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Screen Safe DRC should be under tension. The roll will stretch, and proper tension is the key to performance.

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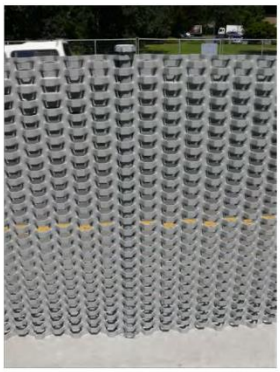
- After first post bolt and end treatment are secured and plumb with DRC under tension, thread next post bolt at anchor location as close as possible.
- Use the come-a-long to ratchet the DRC into place where the anchor bolt lines up with the anchor hole.
- Completely thread the post bolt until the head is flush with the top of the DRC. Be careful not to over tighten and compress the DRC.
- DO NOT insert the next bolt until the previous is fully seated.
- Continue this process, one by one, tightening as you go, seating each bolt completely
- Anti-Seize is not required, but recommended on post bolt threads. Use of pneumatic wrenches and or power tools is acceptable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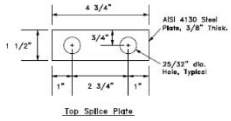
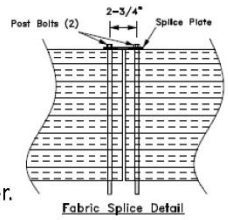
- When you reach the end of a section of DRC you can either end it with another end treatment, or continue it using a splice plate.
- When Splicing the DRC, insert the final post bolt in the section through the splice plate BEFORE threading into DRC and anchor.
- With final bolt secure, and splice plate in place, cut remaining DRC leaving one row of DRC beyond last ¾" post bolt. *(Note: release DRC tension and attachments prior to cutting)*
- Spray Galvanize all cut sections of DRC
- Lift the next section in place and thread the post bolt through the splice plate and DRC, and secure in the anchor.
- Attach come-a-long to far end and pull DRC under tension. Note: Splice will require tension to keep plumb and vertical.







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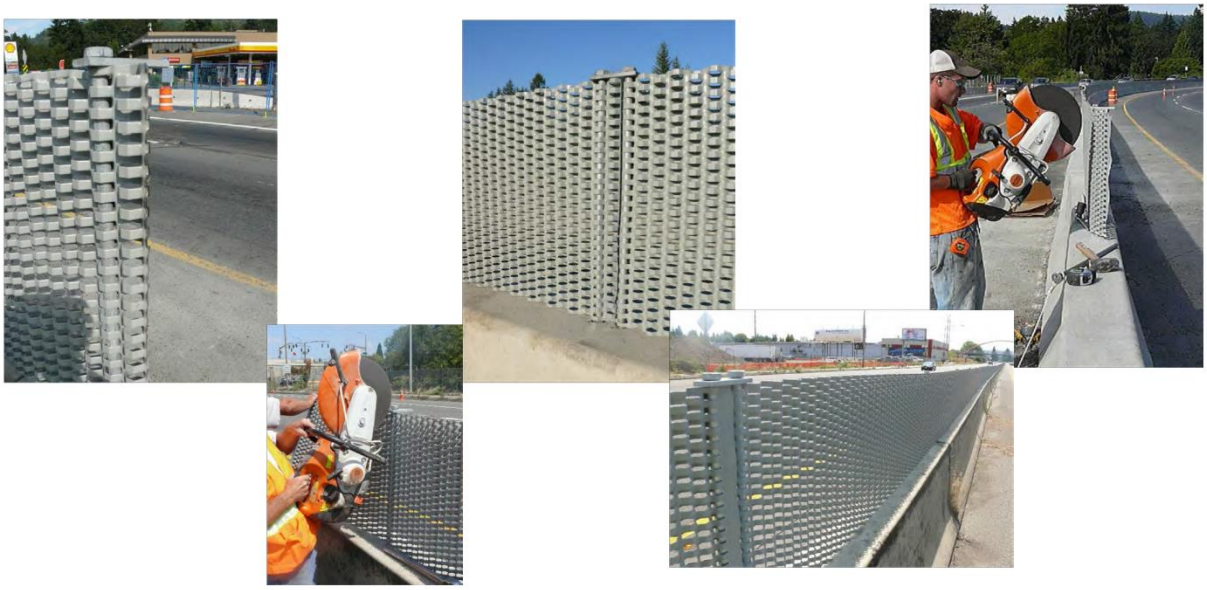

- When you reach the end of the run that is to be protected, insert the final post bolt with the end cable attachment threaded trough the post bolt before threading into the DRC.
- Secure final post bolt, and trim remaining DRC off leaving at least one row of fabric between the final post bolt and the cut.
- With final bolt secure, and end treatment in place and free of saw path, cut remaining DRC leaving one row of DRC beyond last ¾" post bolt. *(again, release DRC tension and attachments prior to cutting)*
- Spray all cut ends of DRC with Cold Spray Galvanizing.
- Secure end treatment to eye bolt anchored in approx. 6'-3" from final post bolt.
- Use turnbuckle to apply tension to keep final post bolt plumb and vertical.

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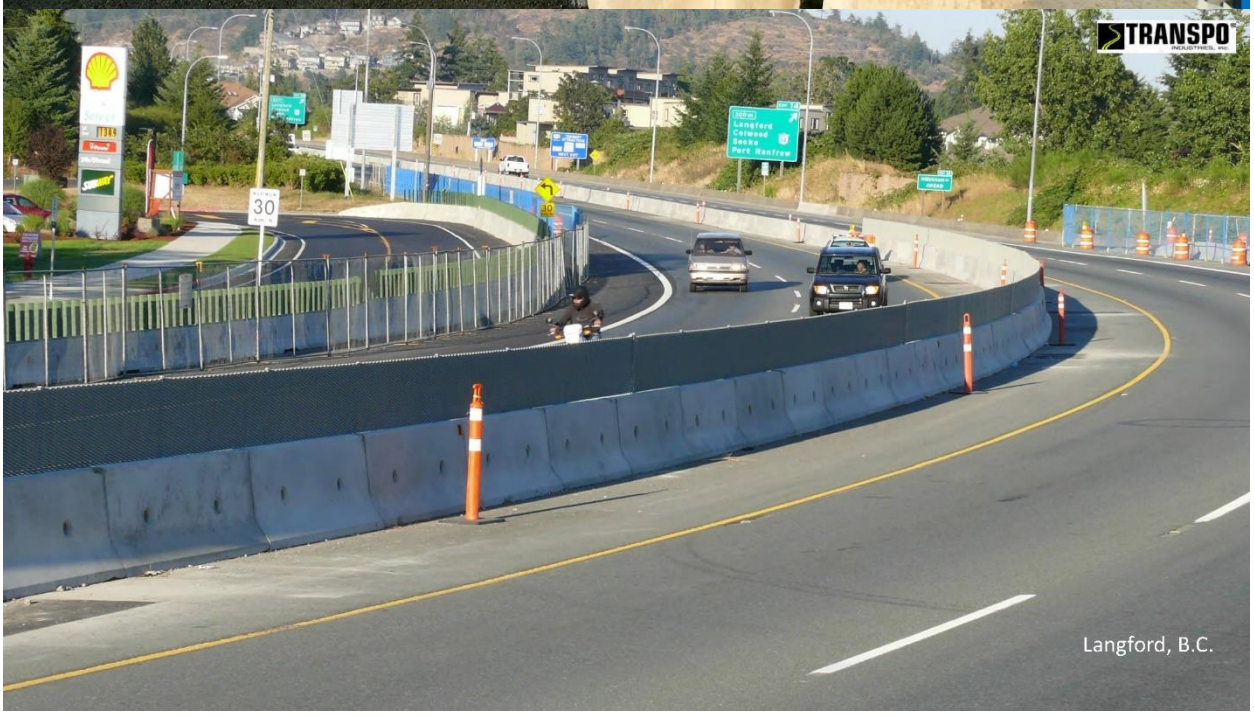
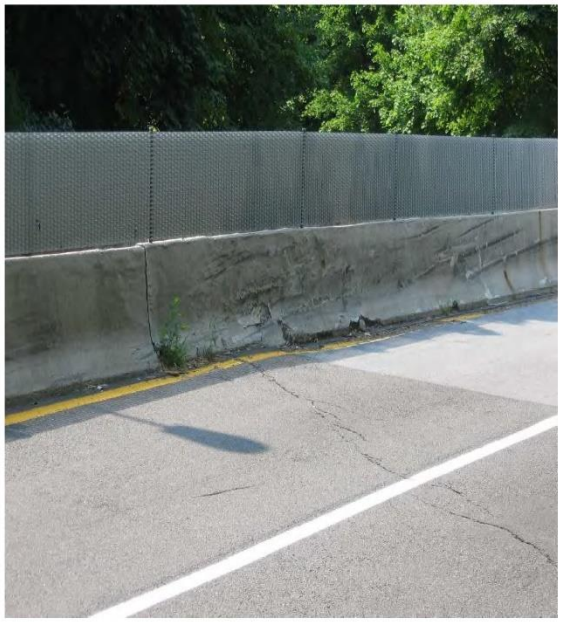
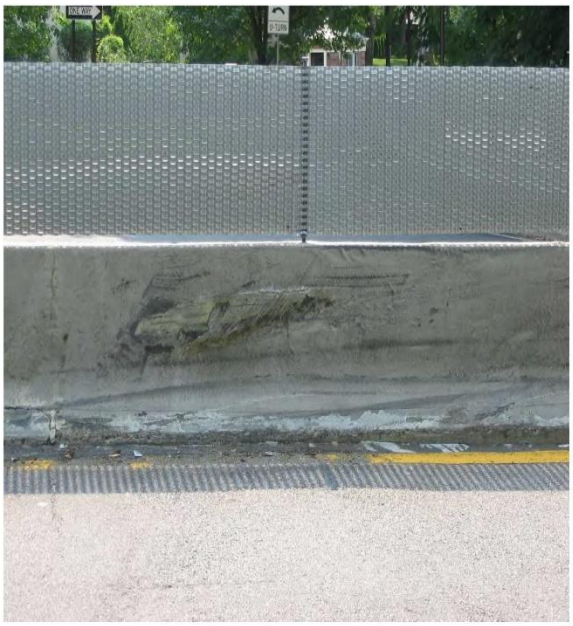
Nanaimo, B.C.


TRANSPO
Coeur D' Alene, ID


TRANSPO
30
Langford, B.C.





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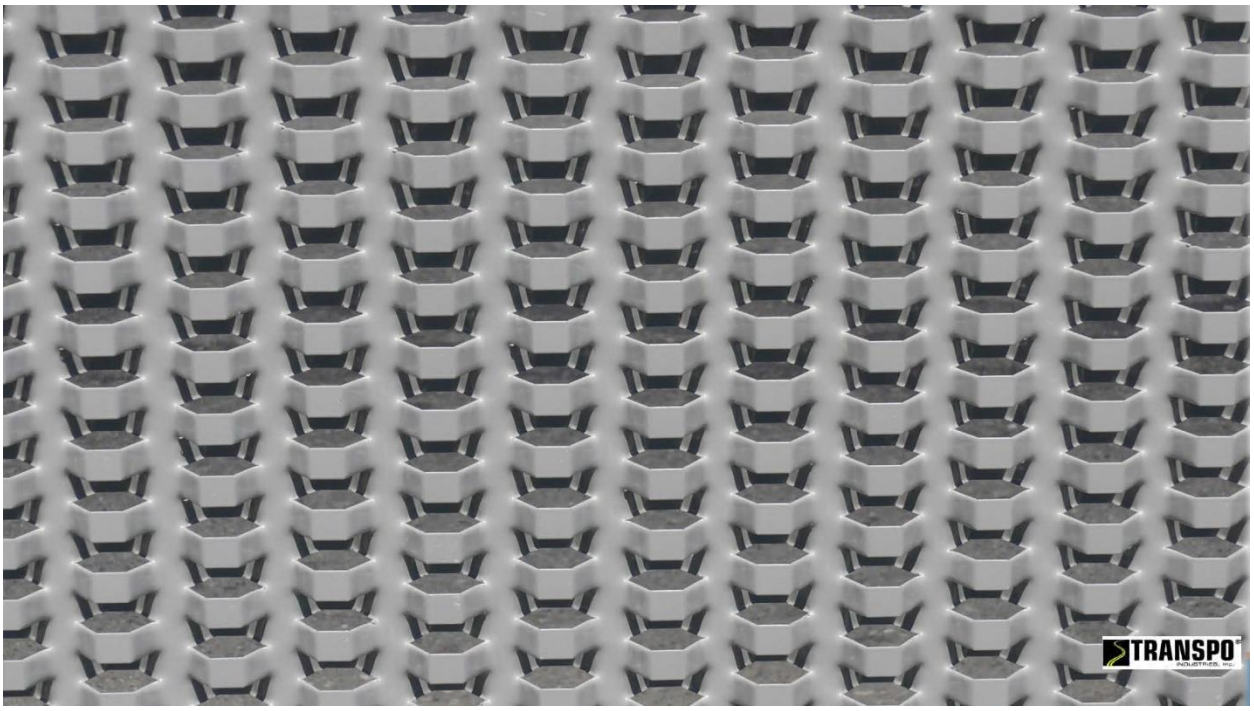
TRANSPO INDUSTRIES, INC.

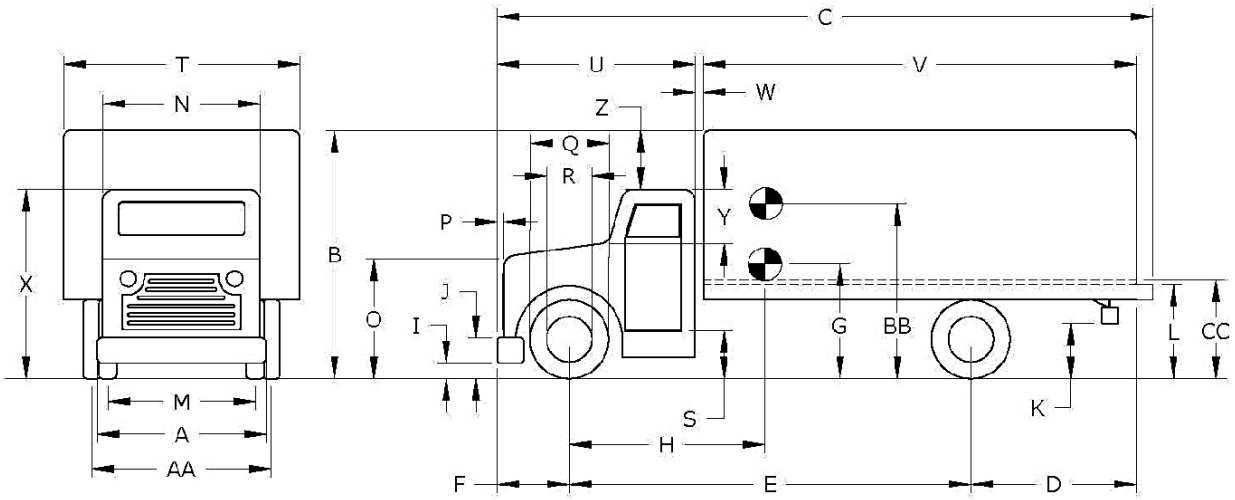
Hwy 285, Morrison, CO

5/6/2021 Safer Transportation Through Innovation 20


TRANSPO

B.2. VEHICLE PROPERTIES AND INFORMATION

Date:	2022-06-01	Test No.:	440822-01-2	VIN No.:	1FVACWBSXBHAZ5837
Year:	2011	Make:	FREIGHTLINER	Model:	M2
Odometer:	495460	Tire Size Front:	275/80R22.5	Tire Size Rear:	275/80R22.5



Vehicle Geometry: ☐ inches or ☐ mm

A	Front Bumper Width:	90.00	K	Rear Bumper Bottom:	0.00	U	Cab Length:	105.50
B	Overall Height:	134.00	L	Rear Frame Top:	39.25	V	Trailer/Box Length:	223.50
C	Overall Length:	330.50	M	Front Track Width:	82.50	W	Gap Width:	4.00
D	Rear Overhang:	85.00	N	Roof Width:	70.50	X	Overall Front Height:	101.50
E	Wheel Base:	205.00	O	Hood Height:	58.75	Y	Roof-Hood Distance:	35.00
F	Front Overhang:	40.50	P	Bumper Extension:	2.00	Z	Roof-Box Height Difference:	32.50
G	C.G. Height:	-	Q	Front Tire Width:	39.00	AA	Rear Track Width:	74.00
H	C.G. Horizontal Dist. w/Ballast:	146.30	R	Front Wheel Width:	23.50	BB	Ballast Center of Mass:	63.50
I	Front Bumper Bottom:	14.50	S	Bottom Door Height:	37.00	CC	Cargo Bed Height:	51.00
J	Front Bumper Top:	28.50	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)	12.00	Bottom Frame Height (Front)	24.00
Wheel Center Height Rear	19.00	Wheel Well Clearance (Rear)	4.50	Bottom Frame Height (Rear)	29.50

Figure B.1. Vehicle Properties for Test No. 440822-01-2.

Date:	2022-06-01	Test No.:	440822-01-2	VIN No.:	1FVACWBSXBHAZ5837
Year:	2011	Make:	FREIGHTLINER	Model:	M2

WEIGHTS (☑ lb or ☐ kg)	CURB	TEST INERTIAL
$W_{front\ axle}$	6990	6360
$W_{rear\ axle}$	6120	15850
W_{TOTAL}	13110	22210

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

Ballast: 9100 (☑ lb or ☐ kg) **(as-needed)**
(See *MASH* Section 4.2.1.2 for recommended ballasting)

Mass Distribution (☑ lb or ☐ kg): **LF:** 3130 **RF:** 3230 **LR:** 7930 **RR:** 7920

Engine Type: CUMMINS

Engine Size: 8.3L

Transmission Type:

☑ Auto or ☐ Manual

☐ FWD ☑ RWD ☐ 4WD

Accelerometer Locations (☑ inches or ☐ mm)

	x[1]	y	z[2]
Front:	0.00	0.00	0.00
Center:	146.30	0.00	50.00
Rear:	244.30	0.00	50.00

Describe any damage to the vehicle prior to test: -

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

TWO BLOCKS H 30 W 60 L 30

CENTERED IN MIDDLE OF BED

TIED DOWN WITH FOUR 3/8 CABLES PER BLOCK

63.5 INCHES FROM GROUND TO CENTER OF BLOCK

Figure B.1. Vehicle Properties for Test No. 440822-01-2 (Continued).

B.3. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure B.4. Sequential Photographs for Test No. 440822-01-2 (Overhead Views).

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure B.5. Sequential Photographs for Test No. 440822-01-2 (Frontal Views).

(a) 0.000 s (b) 0.100 s

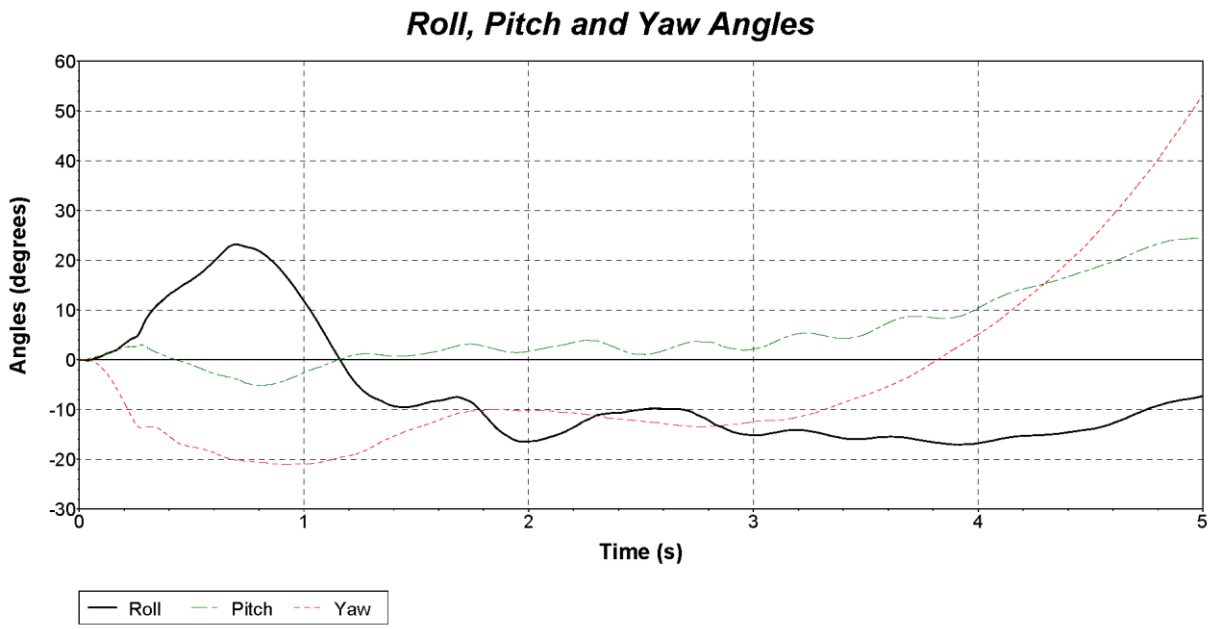
(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

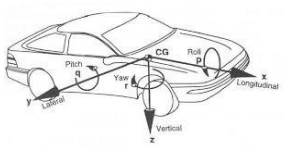
Figure B.6. Sequential Photographs for Test No. 440822-01-2 (Rear Views).

B.4. VEHICLE ANGULAR DISPLACEMENT



Axes are vehicle-fixed.
Sequence for determining orientation:

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



Test Number: 440822-01-2
Test Standard Test Number: *MASH* Test 4-12
Test Article: Screen-Safe® Glare Screen on Single-Slope Barrier
Test Vehicle: 2011 Freightliner M2
Inertial Mass: 22,210 lb
Curb Mass: 13,110 lb
Impact Speed: 56.7 mi/h
Impact Angle: 15.2°

Figure B.7. Vehicle Angular Displacements for Test No. 440822-01-2.

B.5. VEHICLE ACCELERATIONS

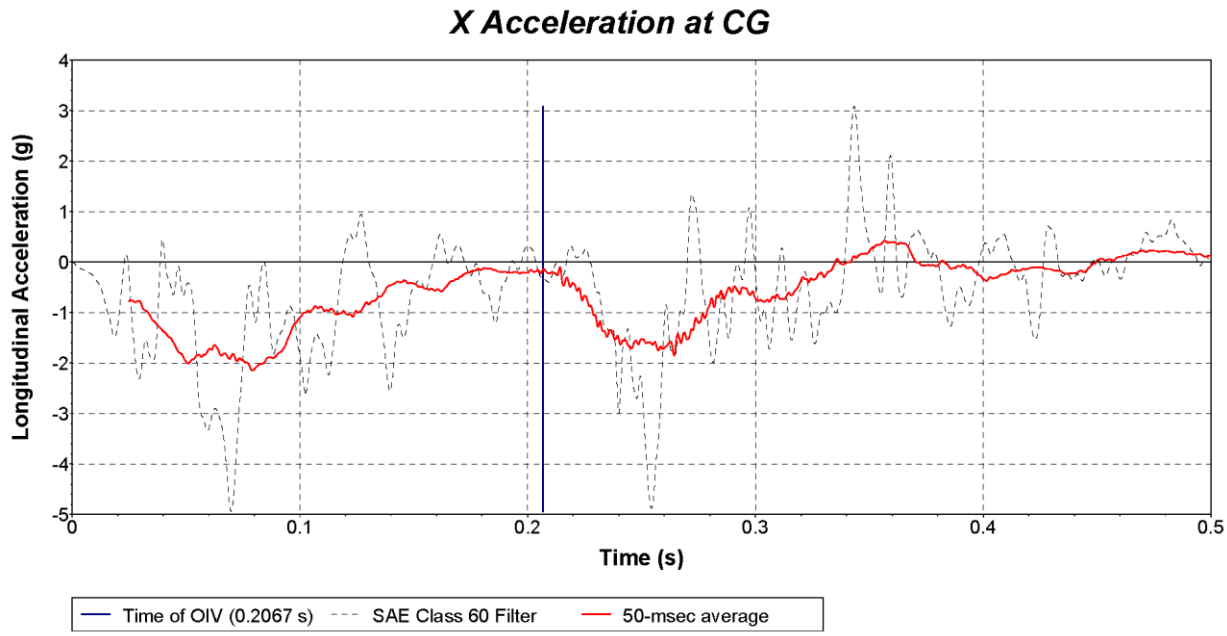


Figure B.8. Vehicle Longitudinal Accelerometer Trace for Test No. 440822-01-2 (Accelerometer Located at Center of Gravity).

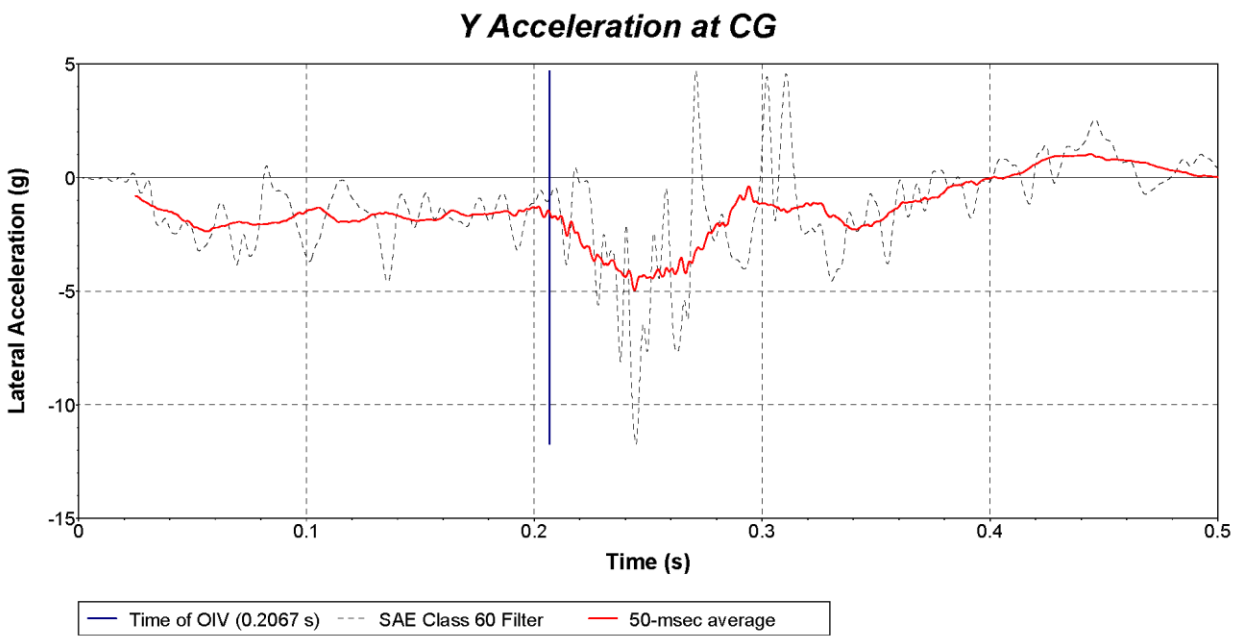


Figure B.9. Vehicle Lateral Accelerometer Trace for Test No. 440822-01-2 (Accelerometer Located at Center of Gravity).

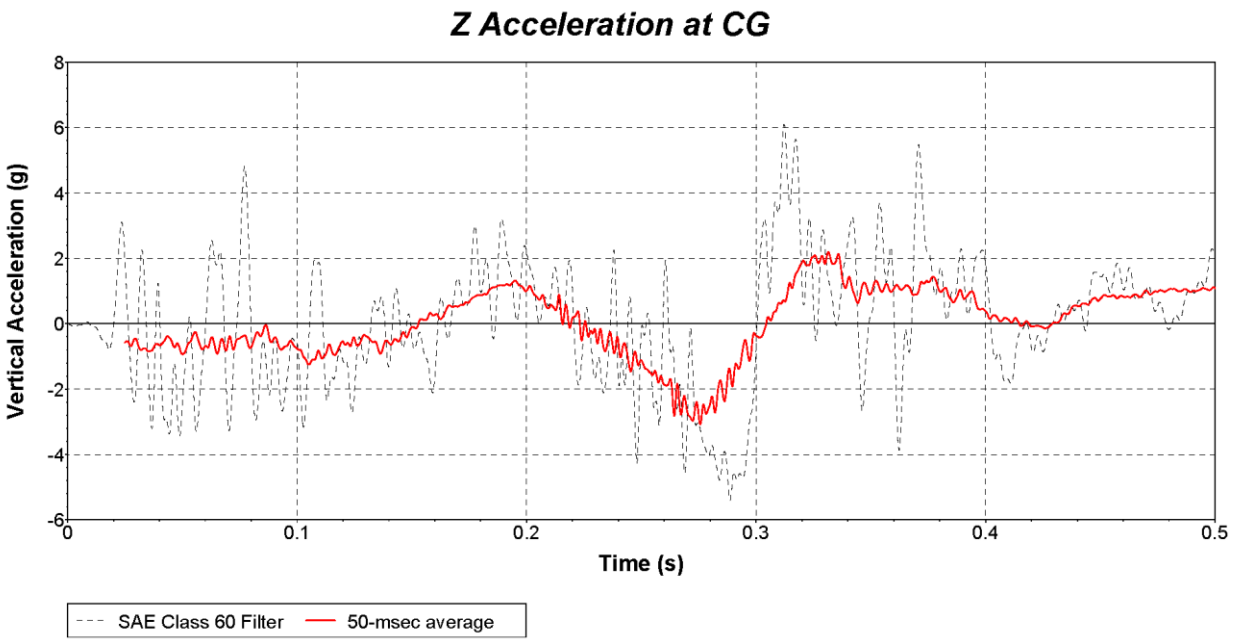
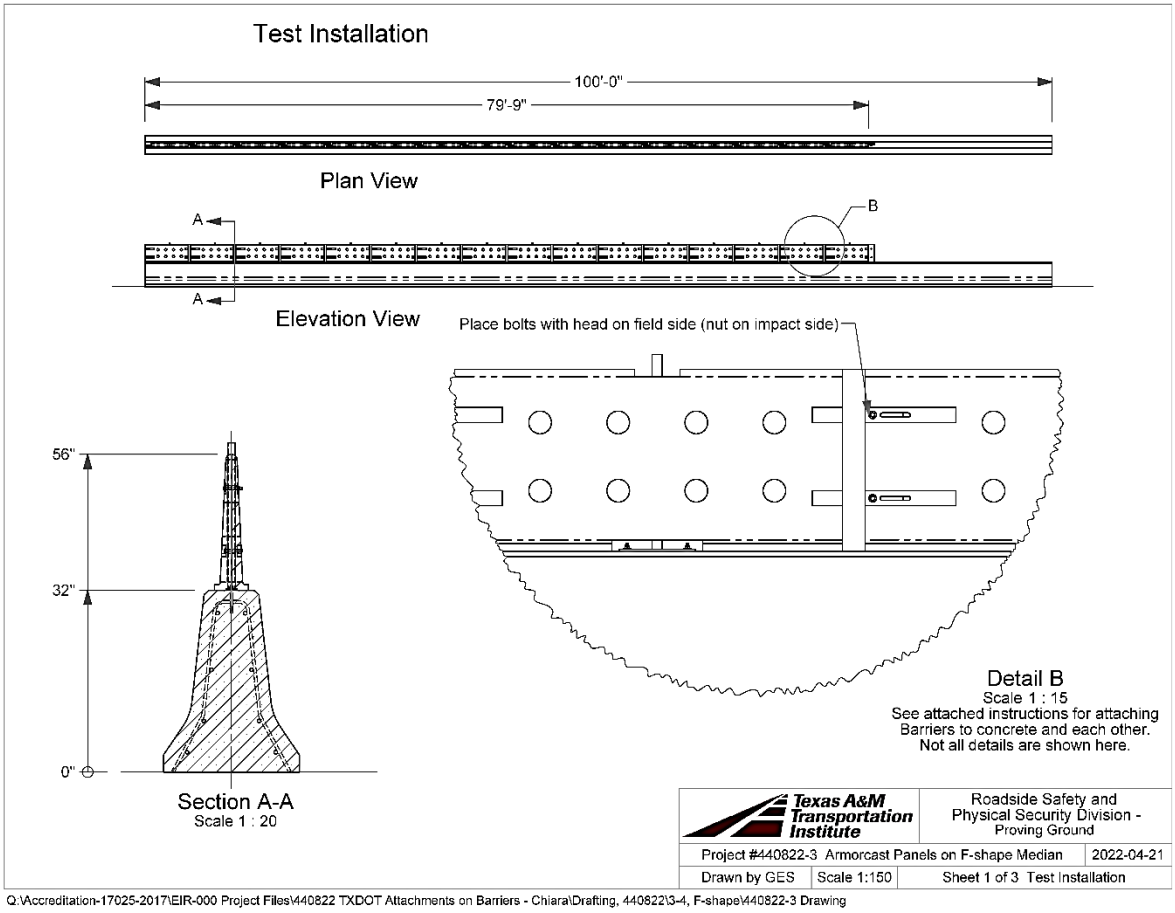
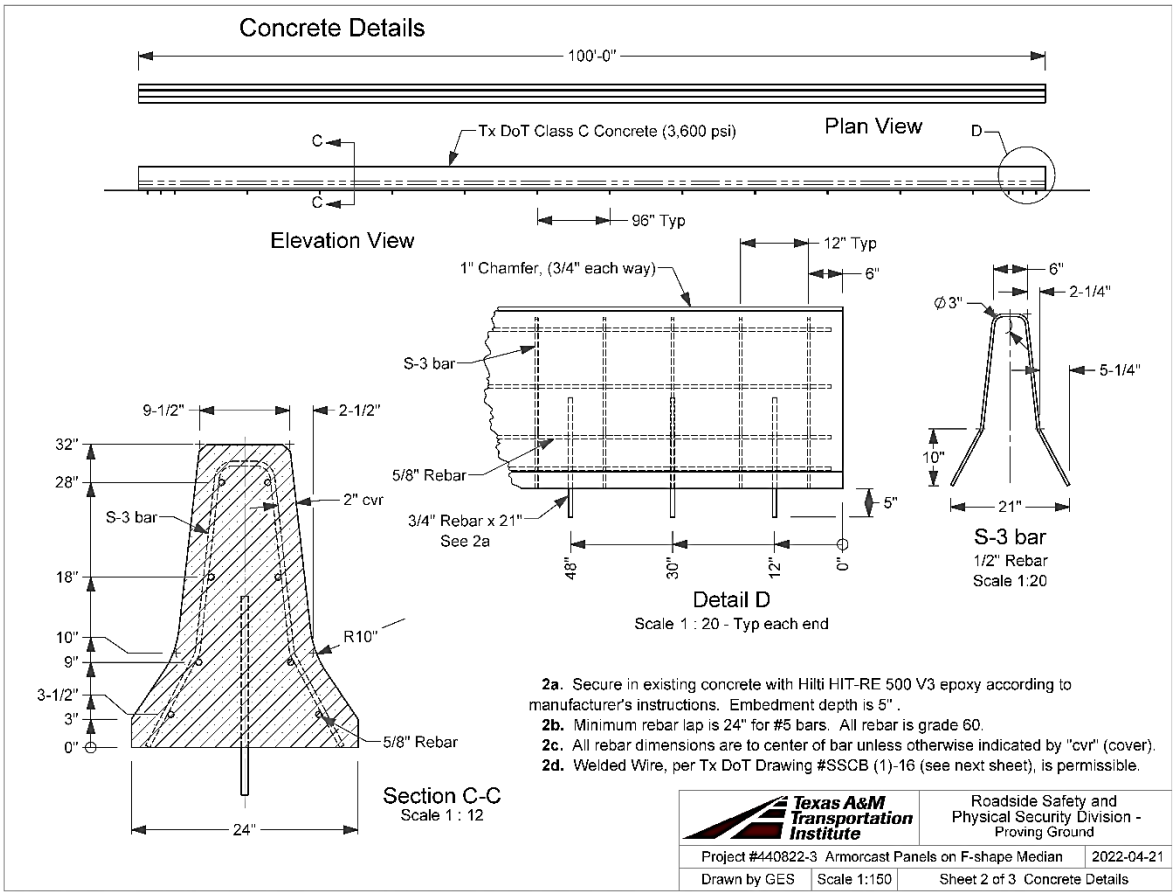


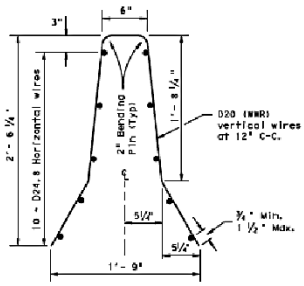
Figure B.10. Vehicle Vertical Accelerometer Trace for Test No. 440822-01-2 (Accelerometer Located at Center of Gravity).

APPENDIX C. CRASH TEST 440822-01-3

C.1. DETAILS OF TEST ARTICLE




Concrete Details
100'-0"
Tx DoT Class C Concrete (3,600 psi)
Plan View
C
C
D
96" Typ
Elevation View
12" Typ
1" Chamfer, (3/4" each way)
6"
S-3 bar
5/8" Rebar
3/4" Rebar x 21"
See 2a
5"
48"
30"
12"
0"
Detail D
Scale 1 : 20 - Typ each end
6"
2-1/4"
Ø3"
5-1/4"
10"
21"
S-3 bar
1/2" Rebar
Scale 1:20
9-1/2"
2-1/2"
32"
28"
2" cvr
S-3 bar
18"
10"
9"
3-1/2"
3"
0"
R10"
5/8" Rebar
24"
Section C-C
Scale 1 : 12
2a. Secure in existing concrete with Hilti HIT-RE 500 V3 epoxy according to manufacturer's instructions. Embedment depth is 5".
2b. Minimum rebar lap is 24" for #5 bars. All rebar is grade 60.
2c. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).
2d. Welded Wire, per Tx DoT Drawing #SSCB (1)-16 (see next sheet), is permissible.
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #440822-3 Armorcast Panels on F-shape Median
2022-04-21
Drawn by GES
Scale 1:150
Sheet 2 of 3 Concrete Details
Q:\Accreditation-17025-2017\EIR-000 Project Files\440822 TXDOT Attachments on Barriers - Chiara\Drafting, 440822\3-4, F-shape\440822-3 Drawing



WELDED WIRE REINFORCEMENT (WWR) OPTION FOR BARS S AND R

(WWR) General Notes

1. Deformed Welded Wire Reinforcement (WWR) shall conform to ASTM A497.

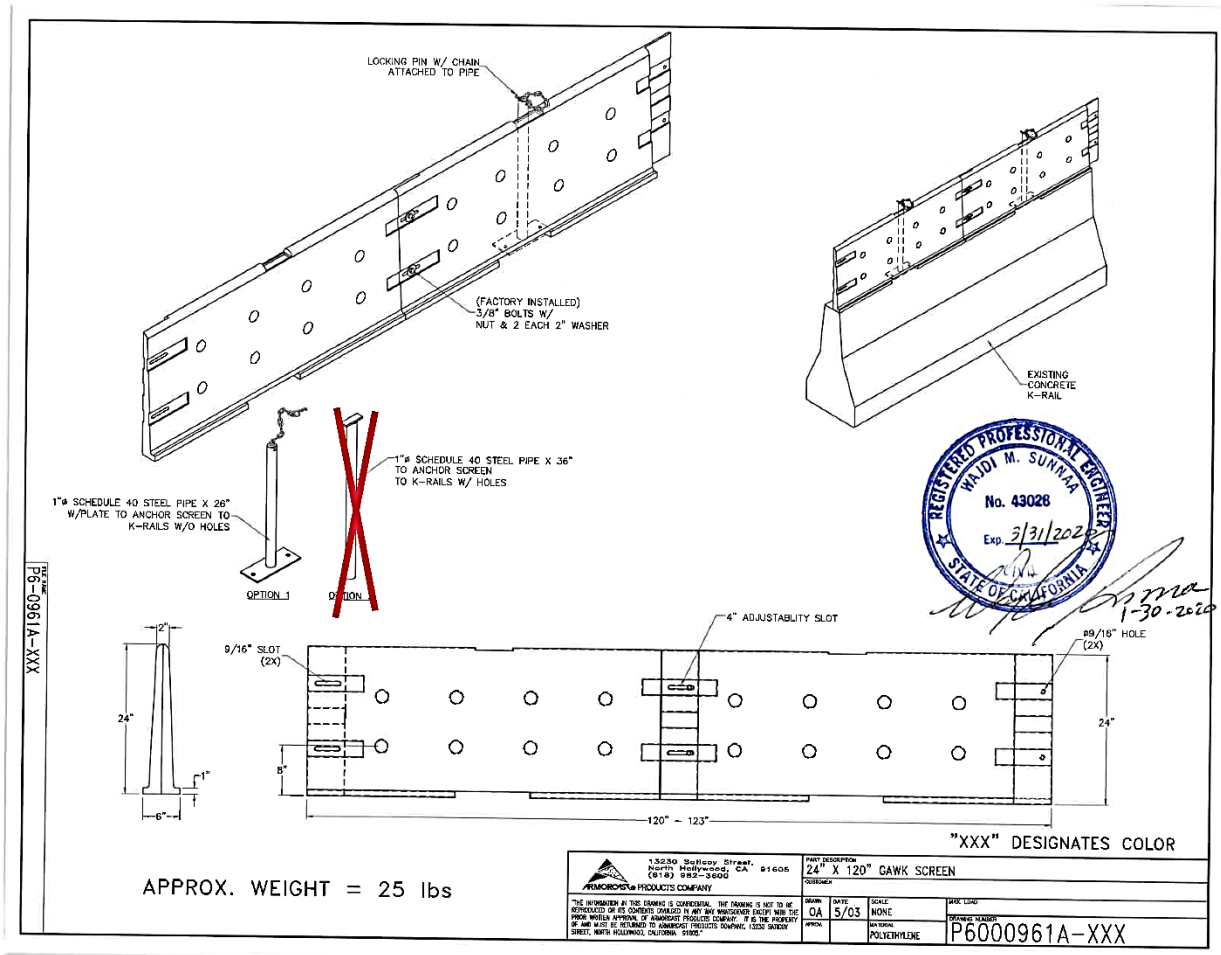
[redacted]

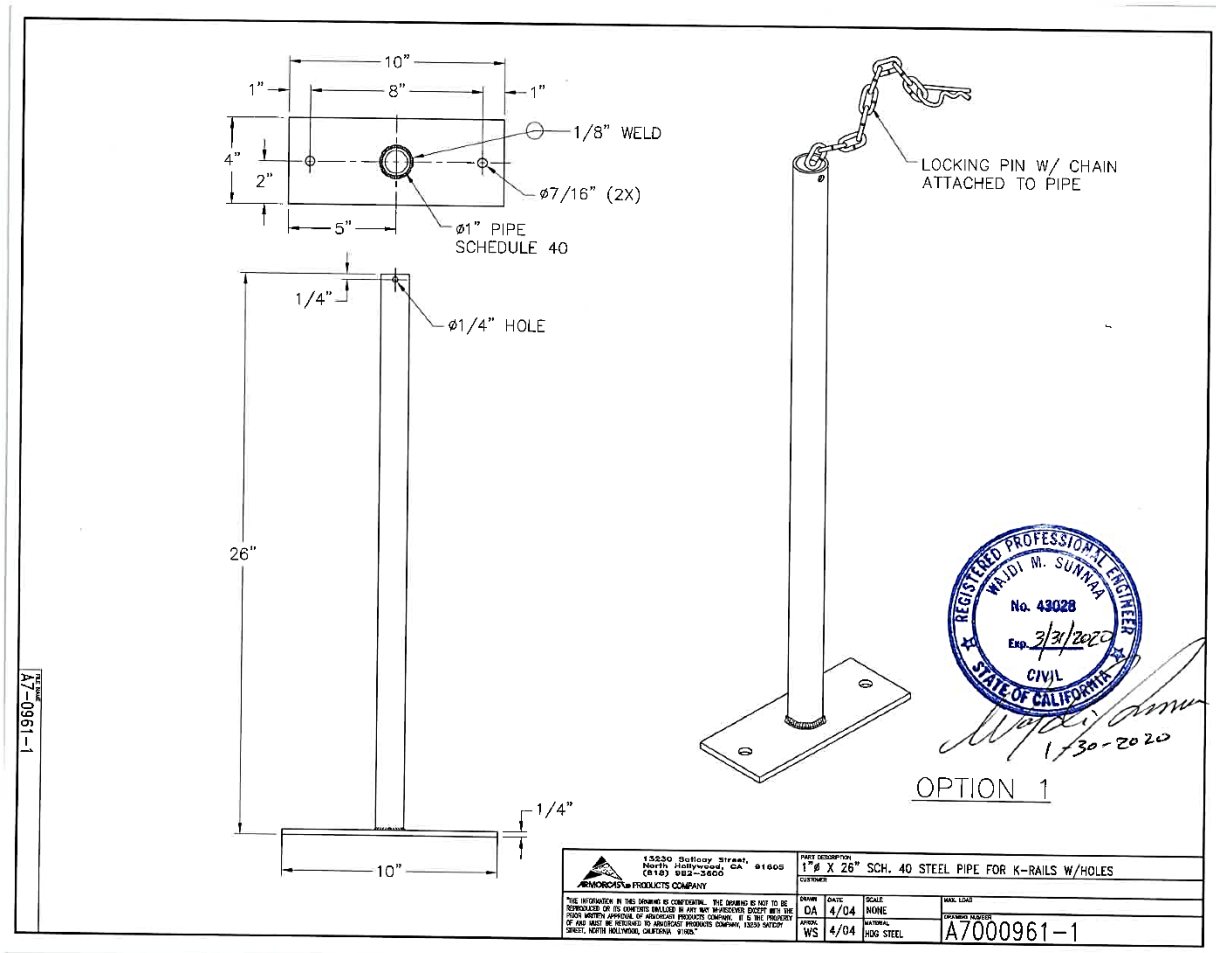
3. The welded wire splice locations shall have a "minimum" splice lap length of 12".

4. [redacted] The dimension from the end of the barrier section to the first wire shall not exceed 3".

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #440822-3 Armorcast Panels on F-shape Median		2022-04-21
Drawn by GES	Scale 1:150	Sheet 3 of 3 Welded Wire

Q:\Accreditation-17025-2017\EIR-000 Project Files\440822 TXDOT Attachments on Barriers - Chiara\Drafting, 440822\3-4, F-shape\440822-3 Drawing


LOCKING PIN W/ CHAIN ATTACHED TO PIPE
(FACTORY INSTALLED) 3/8" BOLTS W/ NUT & 2 EACH 2" WASHER
EXISTING CONCRETE K-RAIL
1"ø SCHEDULE 40 STEEL PIPE X 36" TO ANCHOR SCREEN TO K-RAILS W/ HOLES
1"ø SCHEDULE 40 STEEL PIPE X 26" W/PLATE TO ANCHOR SCREEN TO K-RAILS W/O HOLES
OPTION 1
OPTION
REGISTERED PROFESSIONAL ENGINEER
WAJDI M. SUNNAA
No. 43028
Exp. 3/31/2020
STATE OF CALIFORNIA
1-30-2020
P6000961A-XXX
2"
24"
1"
6"
9/16" SLOT (2X)
4" ADJUSTABILITY SLOT
ø9/16" HOLE (2X)
8"
24"
120" ~ 123"
"XXX" DESIGNATES COLOR
APPROX. WEIGHT = 25 lbs
13230 Sutloy Street, North Hollywood, CA 91605 (818) 982-3600
ARMORGARD PRODUCTS COMPANY
PART DESCRIPTION 24" X 120" GAWK SCREEN
DRAWN OA
DATE 5/03
SCALE NONE
MATERIAL POLYETHYLENE
DRAWING NUMBER P6000961A-XXX


10"
1"
8"
1"
1/8" WELD
4"
2"
ø7/16" (2X)
5"
ø1" PIPE
SCHEDULE 40
1/4"
ø1/4" HOLE
26"
1/4"
10"
LOCKING PIN W/ CHAIN
ATTACHED TO PIPE
OPTION 1
REGISTERED PROFESSIONAL ENGINEER
WAJDI M. SUNNAA
No. 43028
Exp. 3/31/2020
CIVIL
STATE OF CALIFORNIA
1-30-2020
A7-0961-1
13230 Sutcoy Street,
North Hollywood, CA 91605
(818) 982-3600
ARMORCAST PRODUCTS COMPANY
PART DESCRIPTION
1"ø X 26" SCH. 40 STEEL PIPE FOR K-RAILS W/HOLES
CUSTOMER
"THE INFORMATION IN THIS DRAWING IS CONFIDENTIAL. THE DRAWING IS NOT TO BE REPRODUCED OR ITS CONTENTS DISCLOSED IN ANY WAY WHATSOEVER EXCEPT WITH THE PRIOR WRITTEN APPROVAL OF ARMORCAST PRODUCTS COMPANY. IT IS THE PROPERTY OF AND MUST BE RETURNED TO ARMORCAST PRODUCTS COMPANY, 13230 SUTCOY STREET, NORTH HOLLYWOOD, CALIFORNIA 91605."
DRAWN DA 4/04
APPRV WS 4/04
DATE
SCALE NONE
MATERIAL HDG STEEL
MAX. LOAD
DRAWING NUMBER A7000961-1

Armorcast Products Company
9140 Lurline Ave
Chatsworth, Ca 91311
Tel: (818) 982-3600
Fax: (818) 982-7742

Gawk Screen

Recommended Installation Instructions

1. **Place the first 10 foot long Gawk Screen on the concrete K- Rail and mark the centers of the bottom opening. Two openings per 10 foot sections at approximately 60" apart. Remove the gawk screen.**
2. **Center the provided 1" diameter steel pipes with plate over the marked location and top of the K-Rail.**
3. **Mark the holes through the steel plate onto the top of the K-Rail for each side.**
4. **Use 3/8" diameter wedge anchors, also known as Red Heads.**
5. **Drill a minimum of 1 ½" deep hole into concrete with a carbide tipped masonry drill. Follow wedge anchor manufacturer recommendations for embedment length and installation instructions.**
6. **Clean hole, place the wedge anchor through the hole directly into the concrete and hammer it in to the drilled hole until the threads are below the concrete surface.**
7. **Remove the nuts and place the steel pipes with plate assembly over the threaded anchors and into the holes in the plate.**
8. **Replace the nuts and turn by hand until the unit is hand tightened. Tighten each nut with a wrench, approximately three or four full turns, to complete the fastening.**
9. **Place the first gawk screen over the steel pipe and place the locking pin into the ¼" hole on the steel pipe.**
10. **Repeat the above steps for each 10 foot section. Place another plastic extension on the adjacent concrete K-Rail and slide toward the installed plastic extension to interlock the two extensions.**
11. **Continue the above procedure until all gawk screens are placed.**

C.2. VEHICLE PROPERTIES AND INFORMATION

Date: 0220-03-19 Test No.: 440822-01-03 VIN No.: 1C6RR6FT8HS55155

Year: 2017 Make: RAM Model: 1500

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

Tread Type: Highway Odometer: 185370

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

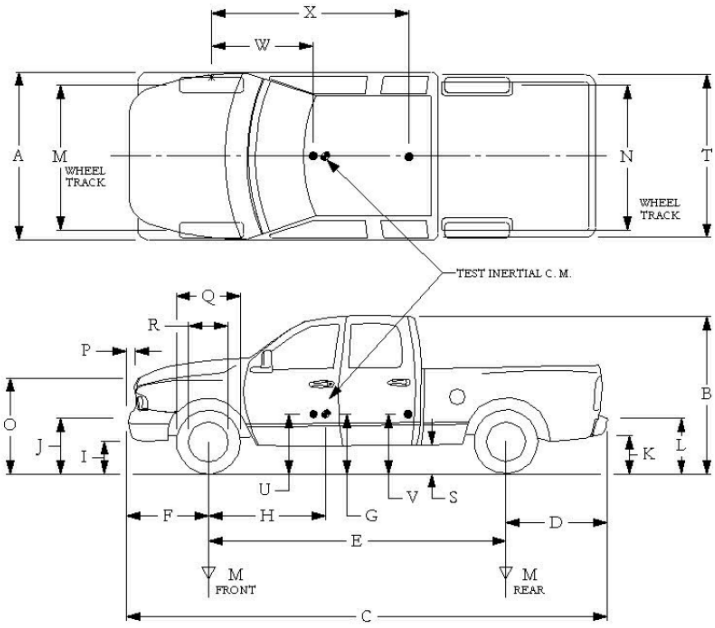
NOTES: None

Engine Type: V-8
Engine CID: 5.7 liter

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

Optional Equipment:
None

Dummy Data:
Type: 50th Percentile male
Mass: 165
Seat Position: IMPACT SIDE



Geometry: inches

A	78.50	F	40.00	K	20.00	P	3.00	U	26.75
B	74.00	G	28.25	L	30.00	Q	30.50	V	30.25
C	227.50	H	61.40	M	68.50	R	18.00	W	61.40
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}	2962	2829	
Back	3900	M_{rear}	2078	2196	
Total	6700	M_{Total}	5040	5025	5190

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

Mass Distribution:
lb LF: 1419 RF: 1410 LR: 1120 RR: 1076

Figure C.1. Vehicle Properties for Test No. 440822-01-3.

Date:	0220-03-19	Test No.:	440822-01-03	VIN No.:	1C6RR6FT8HS55155
Year:	2017	Make:	RAM	Model:	1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

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

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

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max**** Crush								
1	AT FT BUMPER	14	12	32							-11
2	ABOVE FT BUMPER	14	6	50							76
	Measurements recorded										
	☑ **inches or** ☐ **mm**										

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

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

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

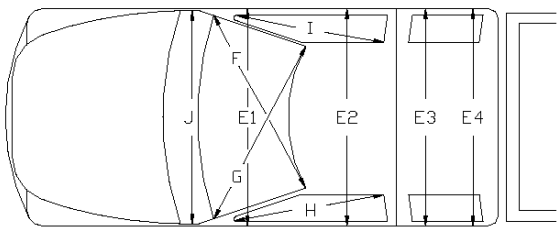
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

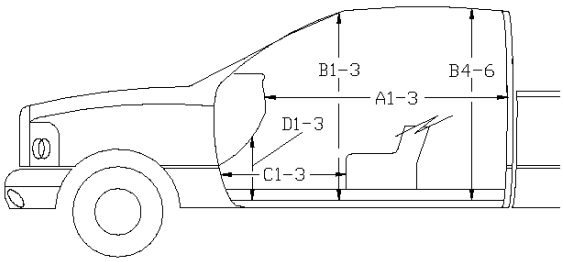
***Measure and document on the vehicle diagram the location of the maximum crush.

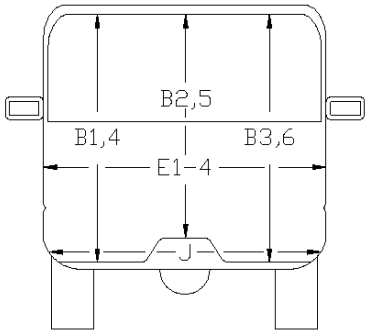
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure C.2. Exterior Crush Measurements for Test No. 440822-01-3.

Date:	0220-03-19	Test No.:	440822-01-03	VIN No.:	1C6RR6FT8HS55155
Year:	2017	Make:	RAM	Model:	1500







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

OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	65.00	65.00	0.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	45.00	0.00
B2	38.00	38.00	0.00
B3	45.00	45.00	0.00
B4	39.50	39.50	0.00
B5	43.00	43.00	0.00
B6	39.50	39.50	0.00
C1	26.00	24.00	-2.00
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	24.00	-1.00

Figure C.3. Occupant Compartment Measurements for Test No. 440822-01-3.

C.3. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure C.4. Sequential Photographs for Test No. 440822-01-3 (Overhead Views).

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure C.5. Sequential Photographs for Test No. 440822-01-3 (Frontal Views).

(a) 0.000 s

(b) 0.100 s

(c) 0.200 s

(d) 0.300 s

(e) 0.400 s

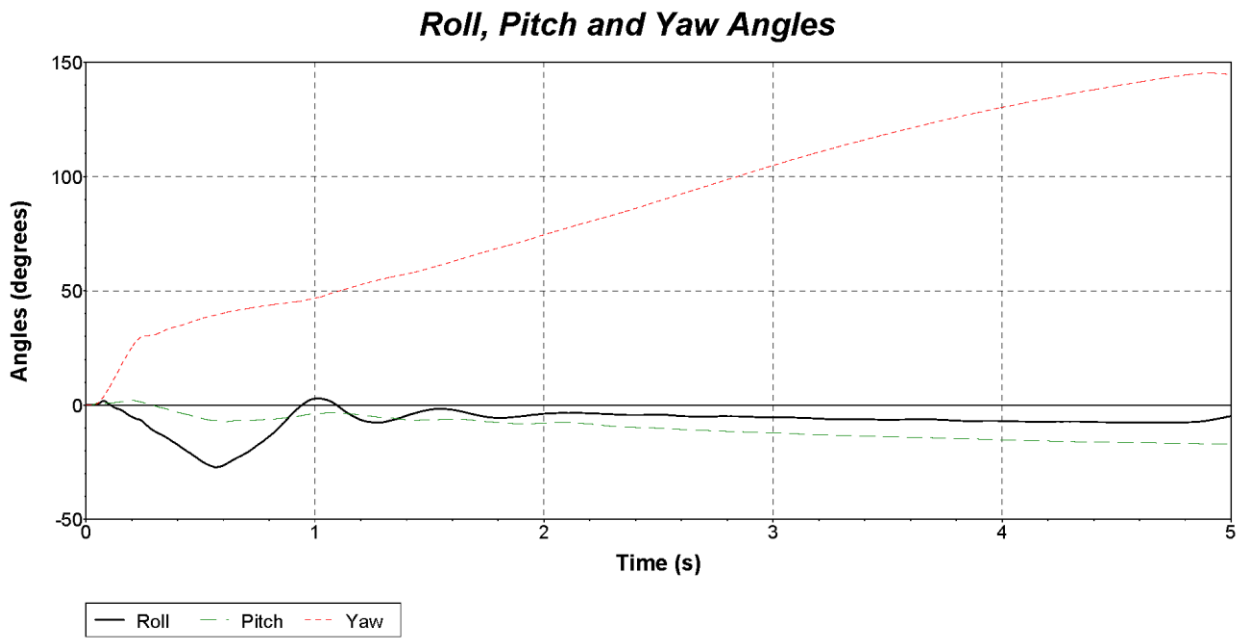
(f) 0.500 s

(g) 0.600 s

(h) 0.700 s

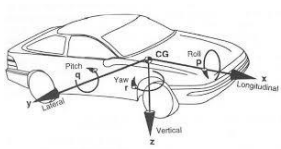
Figure C.6. Sequential Photographs for Test No. 440822-01-3 (Rear Views).

C.4. VEHICLE ANGULAR DISPLACEMENT



Axes are vehicle-fixed.
Sequence for determining orientation:

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



Test Number: 440822-01-3
Test Standard Test Number: *MASH* Test 3-11
Test Article: Armorcast® Gawk Screen on F-Shape Barrier
Test Vehicle: 2017 RAM 1500
Inertial Mass: 5025 lb
Gross Mass: 5190 lb
Impact Speed: 62.8 mi/h
Impact Angle: 24.6°

Figure C.7. Vehicle Angular Displacements for Test No. 440822-01-3.

C.5. VEHICLE ACCELERATIONS

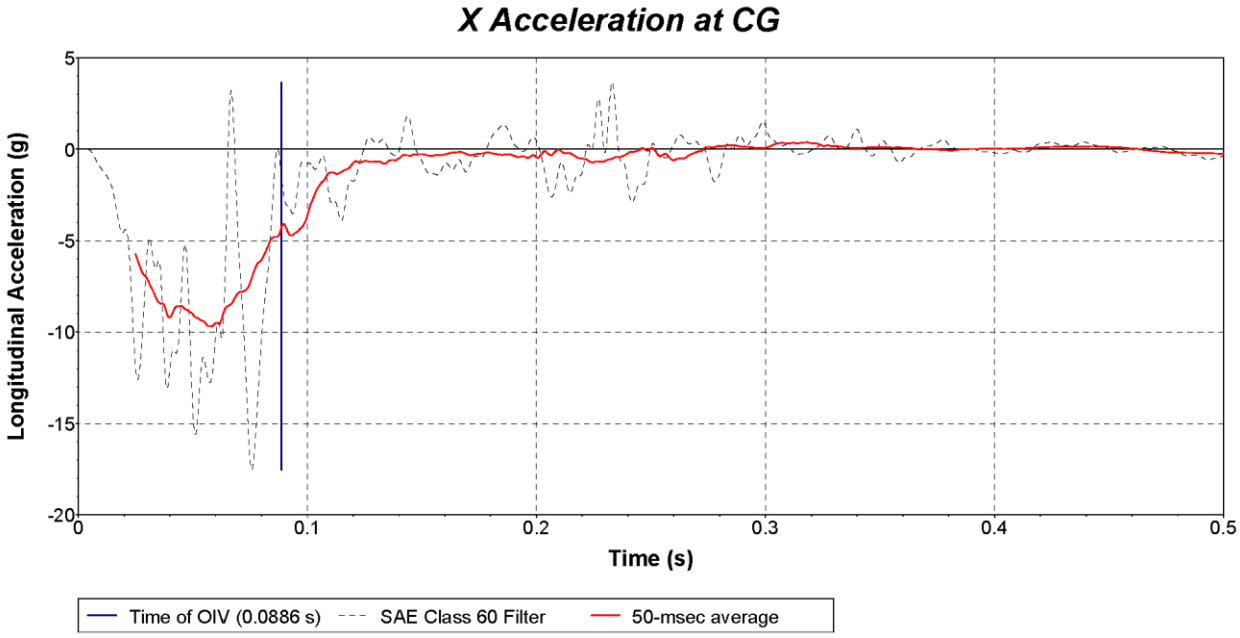


Figure C.8. Vehicle Longitudinal Accelerometer Trace for Test No. 440822-01-3 (Accelerometer Located at Center of Gravity).

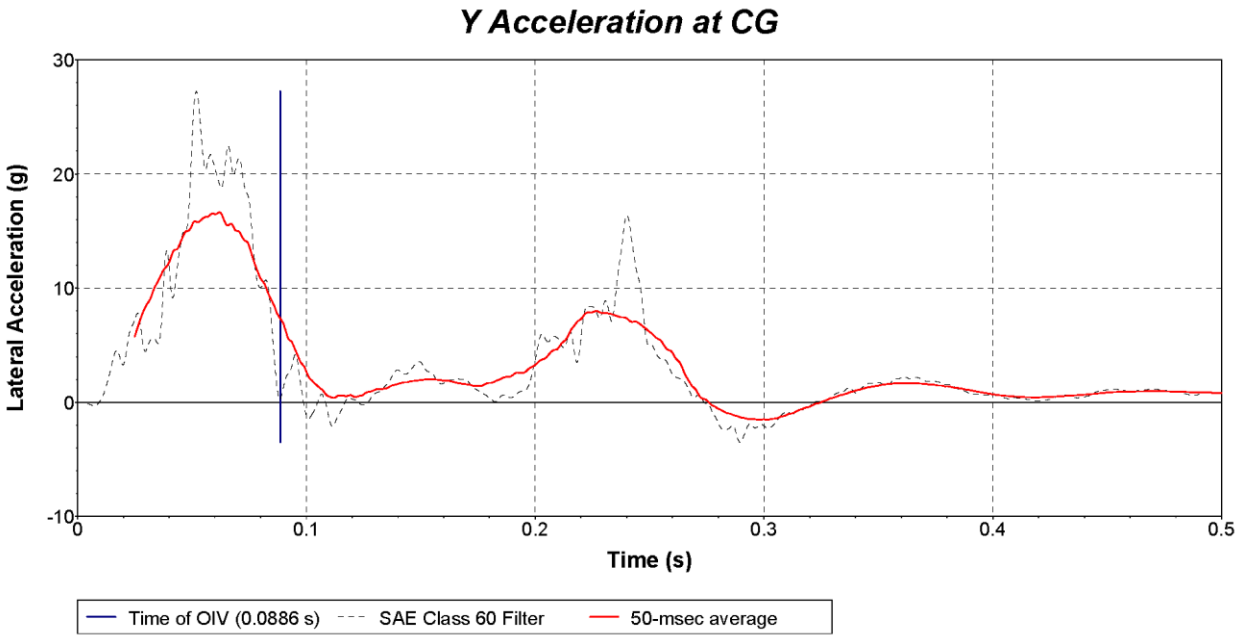


Figure C.9. Vehicle Lateral Accelerometer Trace for Test No. 440822-01-3 (Accelerometer Located at Center of Gravity).

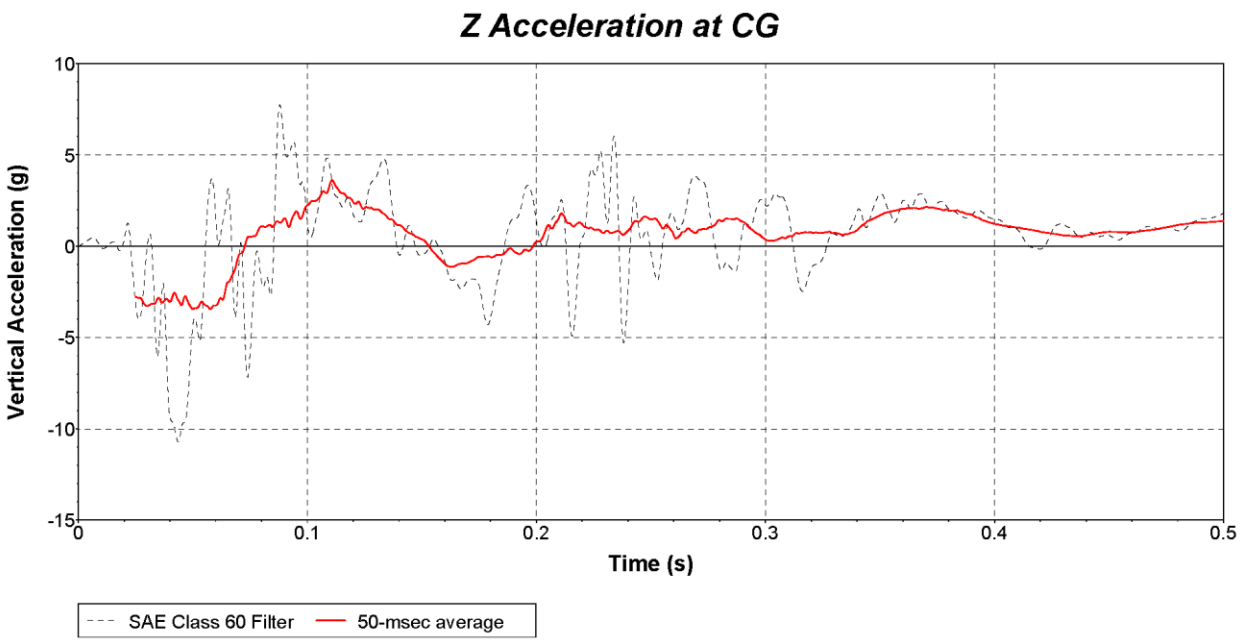
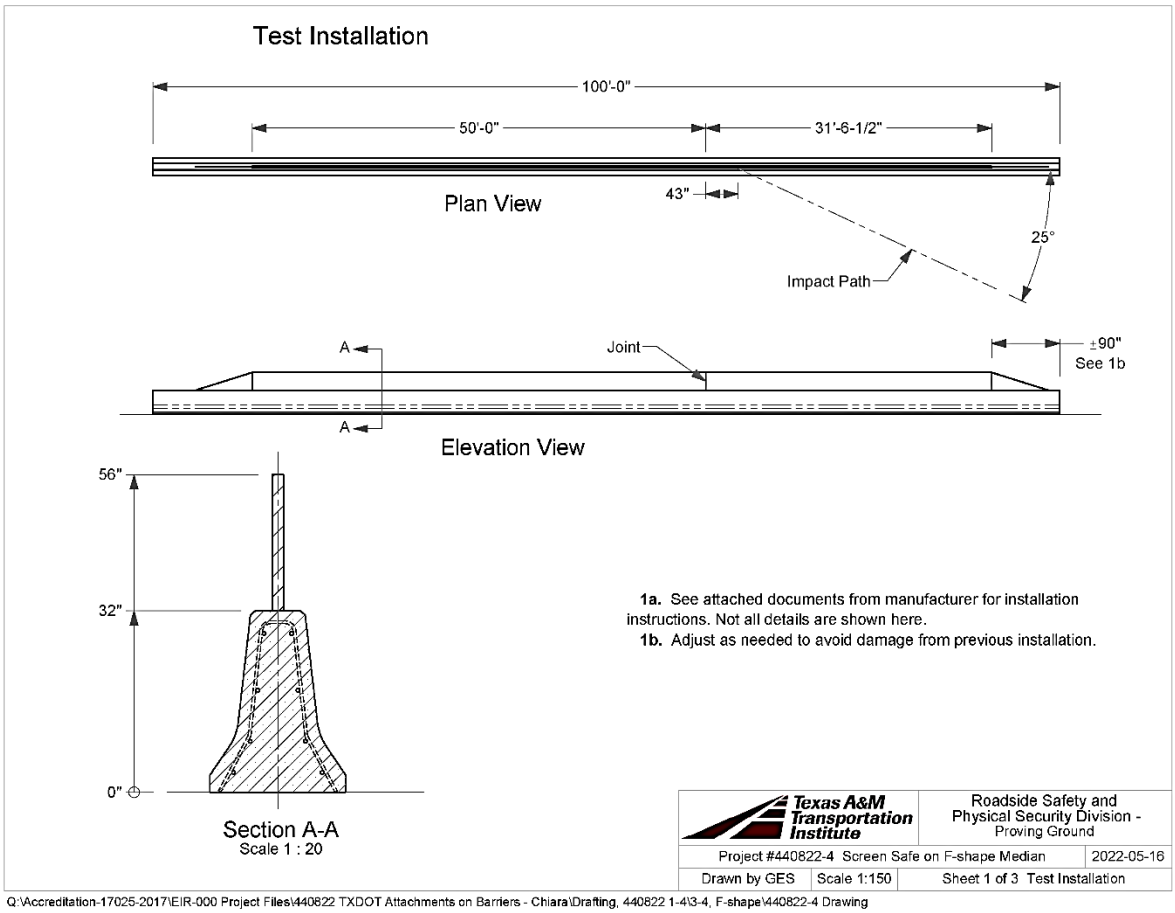
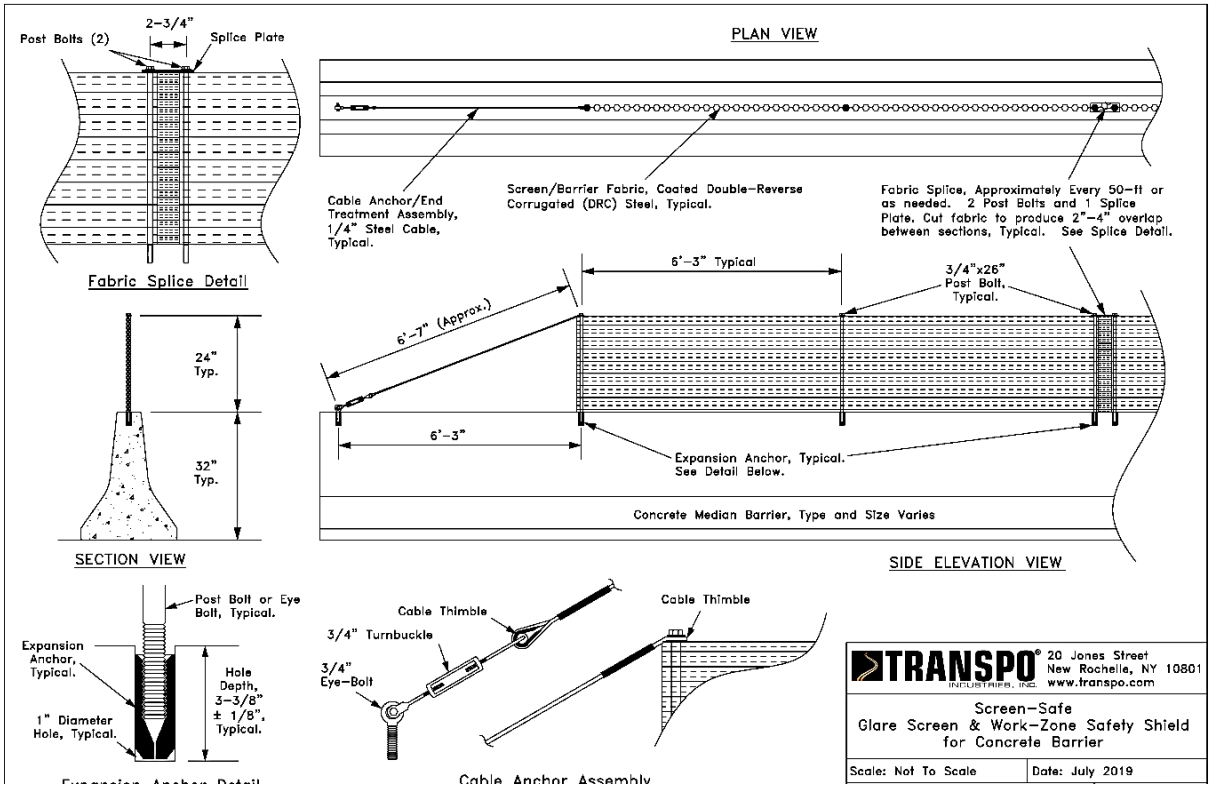


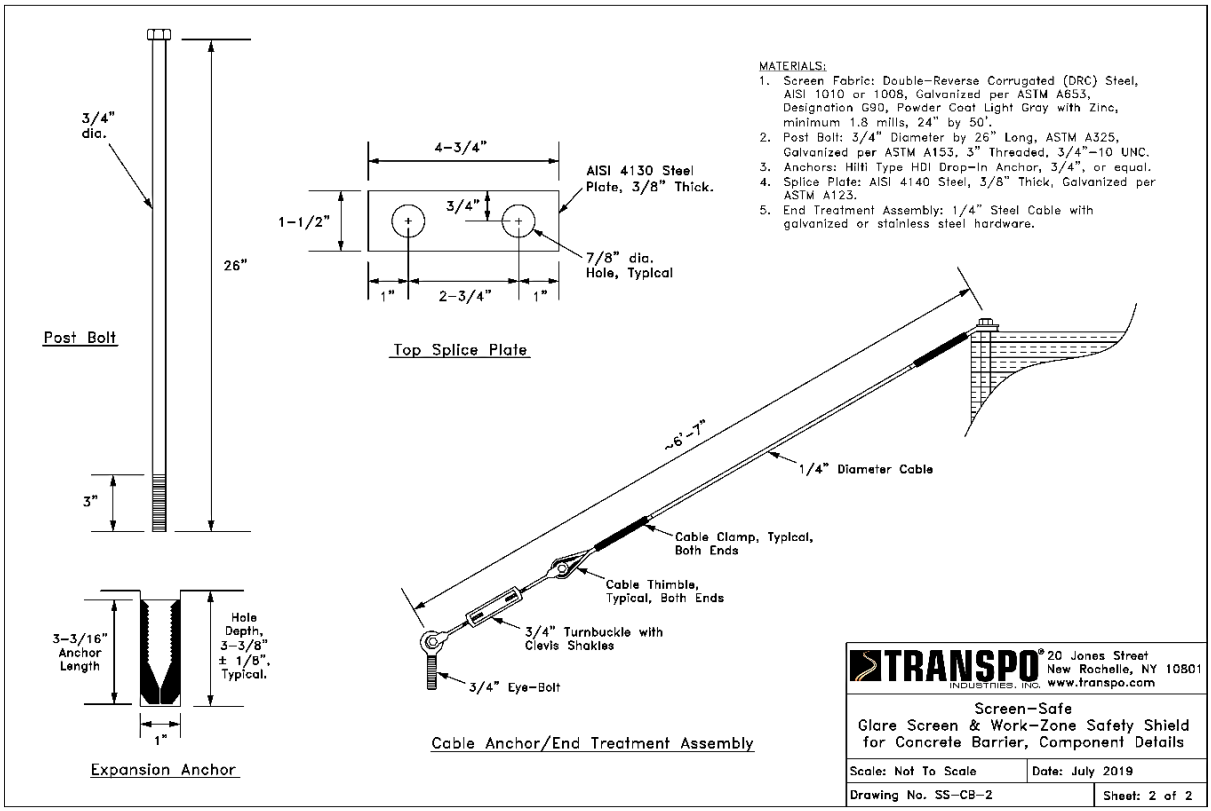
Figure C.10. Vehicle Vertical Accelerometer Trace for Test No. 440822-01-3 (Accelerometer Located at Center of Gravity).

APPENDIX D. CRASH TEST 440822-01-4

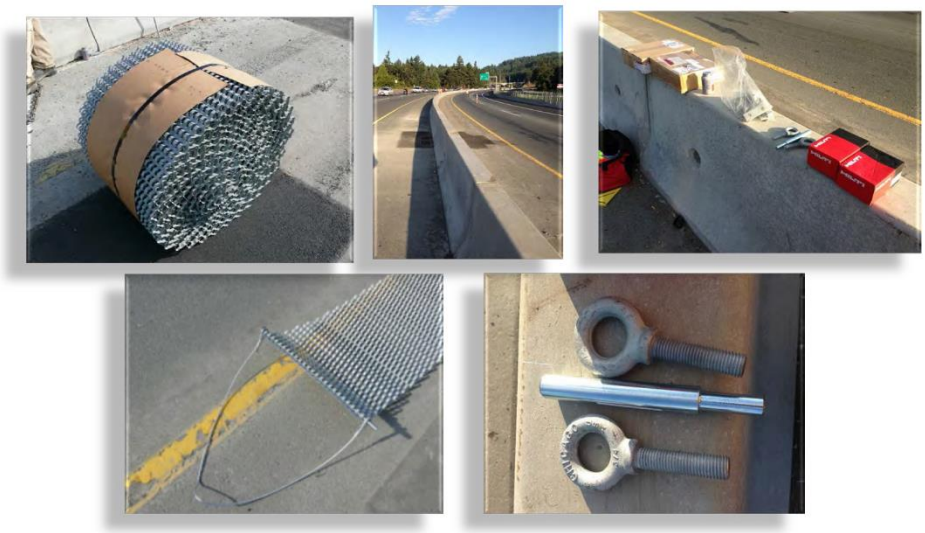
D.1. DETAILS OF TEST ARTICLE



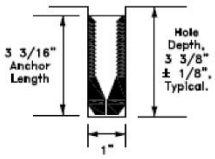

Post Bolts (2)
2–3/4"
Splice Plate
Fabric Splice Detail
PLAN VIEW
Cable Anchor/End Treatment Assembly, 1/4" Steel Cable, Typical.
Screen/Barrier Fabric, Coated Double–Reverse Corrugated (DRC) Steel, Typical.
Fabric Splice, Approximately Every 50–ft or as needed. 2 Post Bolts and 1 Splice Plate. Cut fabric to produce 2"–4" overlap between sections, Typical. See Splice Detail.
6'–3" Typical
3/4"x26" Post Bolt, Typical.
6'–7" (Approx.)
24" Typ.
32" Typ.
6'–3"
Expansion Anchor, Typical. See Detail Below.
Concrete Median Barrier, Type and Size Varies
SECTION VIEW
SIDE ELEVATION VIEW
Post Bolt or Eye Bolt, Typical.
Expansion Anchor, Typical.
1" Diameter Hole, Typical.
Hole Depth, 3–3/8" ± 1/8", Typical.
Cable Thimble
3/4" Turnbuckle
3/4" Eye–Bolt
Cable Thimble
Cable Anchor Assembly
TRANSPO INDUSTRIES, INC.
20 Jones Street
New Rochelle, NY 10801
www.transpo.com
Screen–Safe
Glare Screen & Work–Zone Safety Shield for Concrete Barrier
Scale: Not To Scale
Date: July 2019

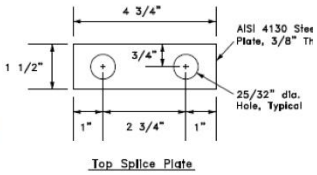

3/4" dia.
26"
3"
Post Bolt
4–3/4"
AISI 4130 Steel Plate, 3/8" Thick.
3/4"
1–1/2"
7/8" dia. Hole, Typical
1"
2–3/4"
1"
Top Splice Plate
MATERIALS:
1. Screen Fabric: Double–Reverse Corrugated (DRC) Steel, AISI 1010 or 1008, Galvanized per ASTM A653, Designation G90, Powder Coat Light Gray with Zinc, minimum 1.8 mills, 24" by 50'.
2. Post Bolt: 3/4" Diameter by 26" Long, ASTM A325, Galvanized per ASTM A153, 3" Threaded, 3/4"–10 UNC.
3. Anchors: Hilti Type HDI Drop–In Anchor, 3/4", or equal.
4. Splice Plate: AISI 4140 Steel, 3/8" Thick, Galvanized per ASTM A123.
5. End Treatment Assembly: 1/4" Steel Cable with galvanized or stainless steel hardware.
~6'–7"
1/4" Diameter Cable
Cable Clamp, Typical, Both Ends
Cable Thimble, Typical, Both Ends
3/4" Turnbuckle with Clevis Shakles
3/4" Eye–Bolt
Cable Anchor/End Treatment Assembly
3–3/16" Anchor Length
Hole Depth, 3–3/8" ± 1/8", Typical.
1"
Expansion Anchor
TRANSPO INDUSTRIES, INC.
20 Jones Street
New Rochelle, NY 10801
www.transpo.com
Screen–Safe
Glare Screen & Work–Zone Safety Shield for Concrete Barrier, Component Details
Scale: Not To Scale
Date: July 2019
Drawing No. SS–CB–2
Sheet: 2 of 2

Concrete Barrier Installation:



- Using 1” Masonry Bit, Drill anchor holes beginning at location where the Screen Safe is to start
- Drill 1” diameter holes with depth of 3-3/8” (+/- 1/8”) to accommodate Hilti-Anchor
  - Clean drilled holes with air blower
- Use anchor tool provided to set anchor flush, and seat into concrete
- Remove plastic insert inside anchor





- Unroll DRC next to predrilled holes
- Attach supplied Com-A-Long attachment to far end of DRC from starting point
- It is best to have a post bolt at each anchor location

- Lift entire section of Screen Safe DRC onto barrier
- Insert first post bolt with end treatment cable attached through first row of DRC past end tab. Secure into anchor.
- Attach turnbuckle end to eye bolt, tighten turnbuckle by hand keeping first post bolt vertical.
- At other end of 50' section attach a Come-A-Long Ratchet to the attachment, and secure Come-A-Long to a fixed object in line with barrier.
- Ratchet Come-A-Long tightening DRC taking slack out of the section. Pay attention to first post bolt and that it is not bending; use turnbuckle to keep vertical.
- Section should be mostly free standing at this point with minimal support.

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Screen Safe DRC should be under tension. The roll will stretch, and proper tension is the key to performance.

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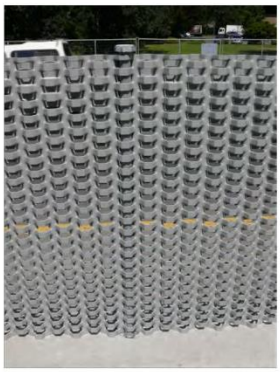
- After first post bolt and end treatment are secured and plumb with DRC under tension, thread next post bolt at anchor location as close as possible.
- Use the come-a-long to ratchet the DRC into place where the anchor bolt lines up with the anchor hole.
- Completely thread the post bolt until the head is flush with the top of the DRC. Be careful not to over tighten and compress the DRC.
- DO NOT insert the next bolt until the previous is fully seated.
- Continue this process, one by one, tightening as you go, seating each bolt completely
- Anti-Seize is not required, but recommended on post bolt threads. Use of pneumatic wrenches and or power tools is acceptable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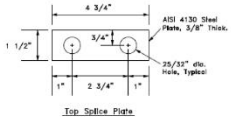
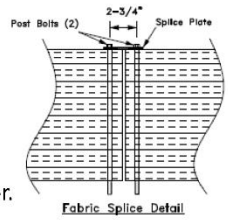
- When you reach the end of a section of DRC you can either end it with another end treatment, or continue it using a splice plate.
- When Splicing the DRC, insert the final post bolt in the section through the splice plate BEFORE threading into DRC and anchor.
- With final bolt secure, and splice plate in place, cut remaining DRC leaving one row of DRC beyond last ¾" post bolt. *(Note: release DRC tension and attachments prior to cutting)*
- Spray Galvanize all cut sections of DRC
- Lift the next section in place and thread the post bolt through the splice plate and DRC, and secure in the anchor.
- Attach come-a-long to far end and pull DRC under tension. Note: Splice will require tension to keep plumb and vertical.







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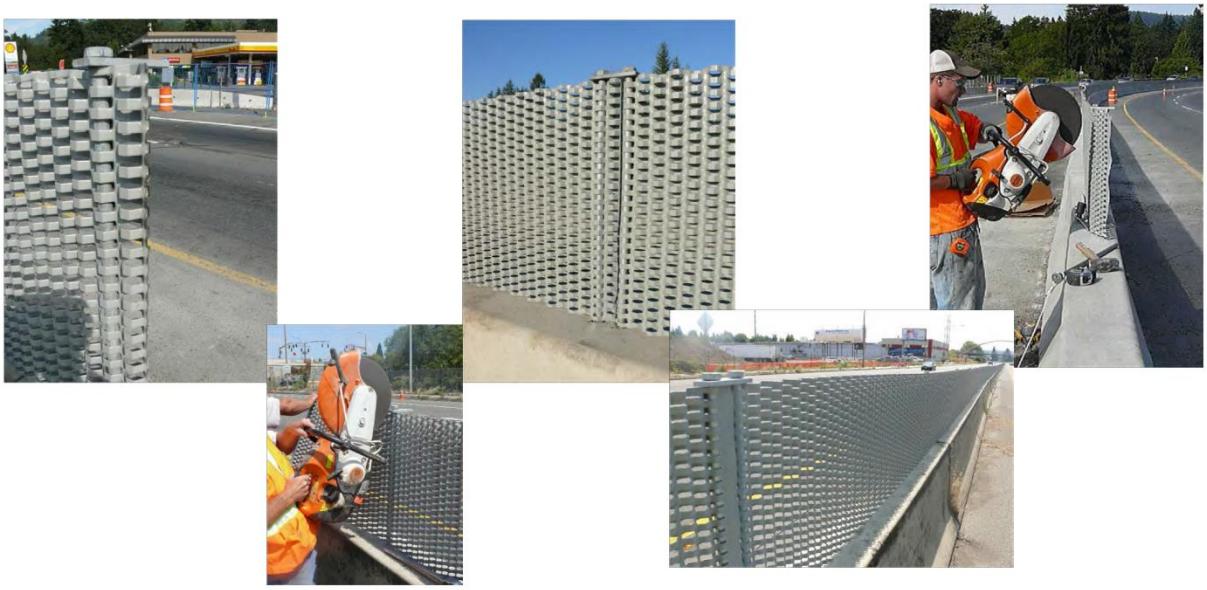

- When you reach the end of the run that is to be protected, insert the final post bolt with the end cable attachment threaded trough the post bolt before threading into the DRC.
- Secure final post bolt, and trim remaining DRC off leaving at least one row of fabric between the final post bolt and the cut.
- With final bolt secure, and end treatment in place and free of saw path, cut remaining DRC leaving one row of DRC beyond last ¾" post bolt. *(again, release DRC tension and attachments prior to cutting)*
- Spray all cut ends of DRC with Cold Spray Galvanizing.
- Secure end treatment to eye bolt anchored in approx. 6'-3" from final post bolt.
- Use turnbuckle to apply tension to keep final post bolt plumb and vertical.

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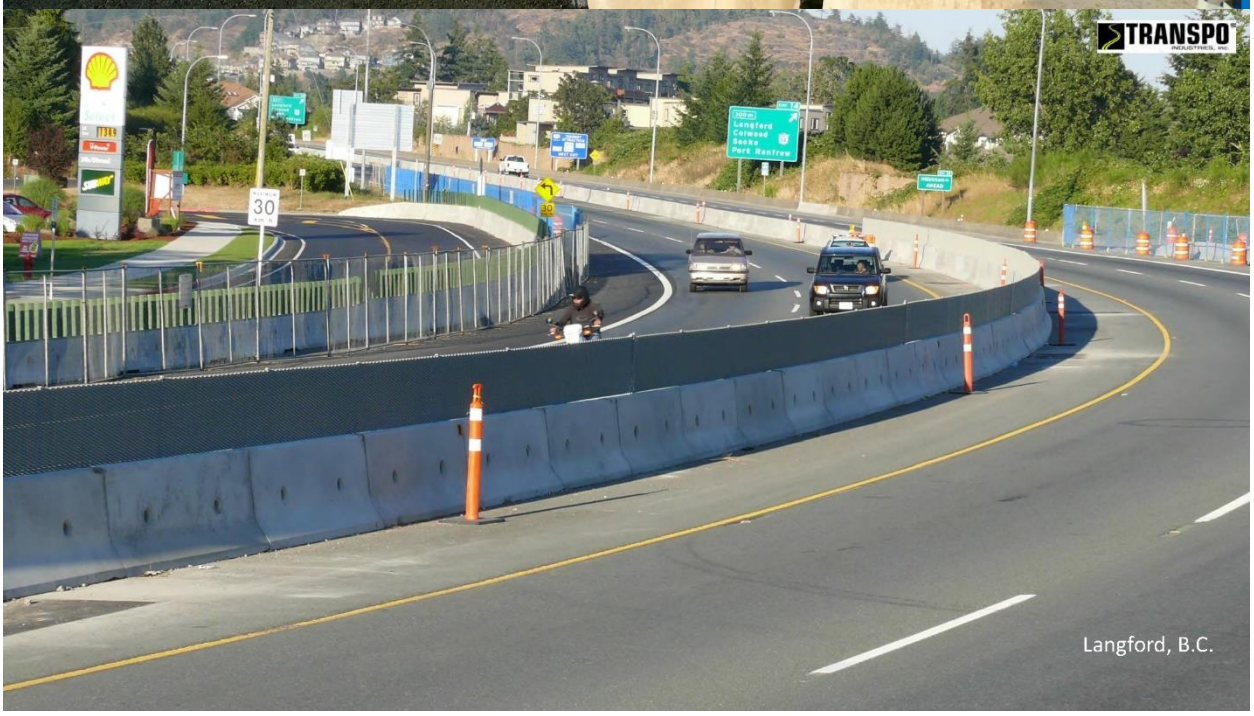
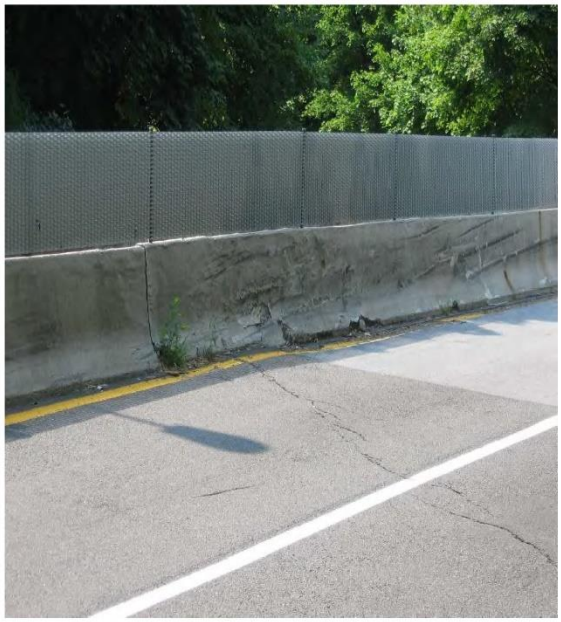
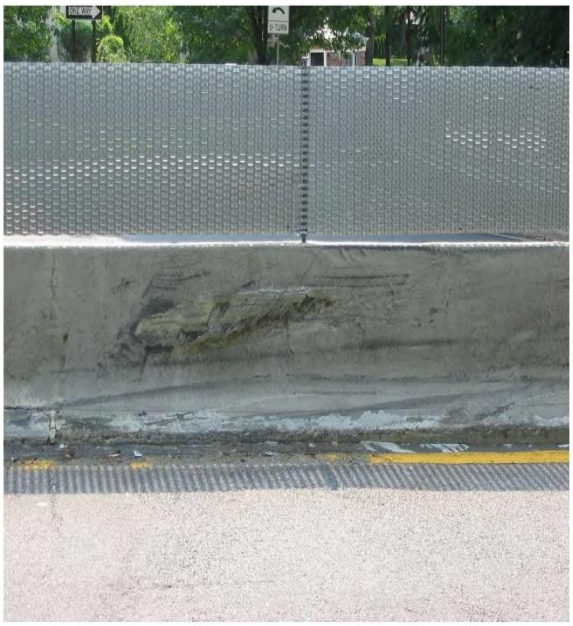

TRANSPO
30
Langford, B.C.





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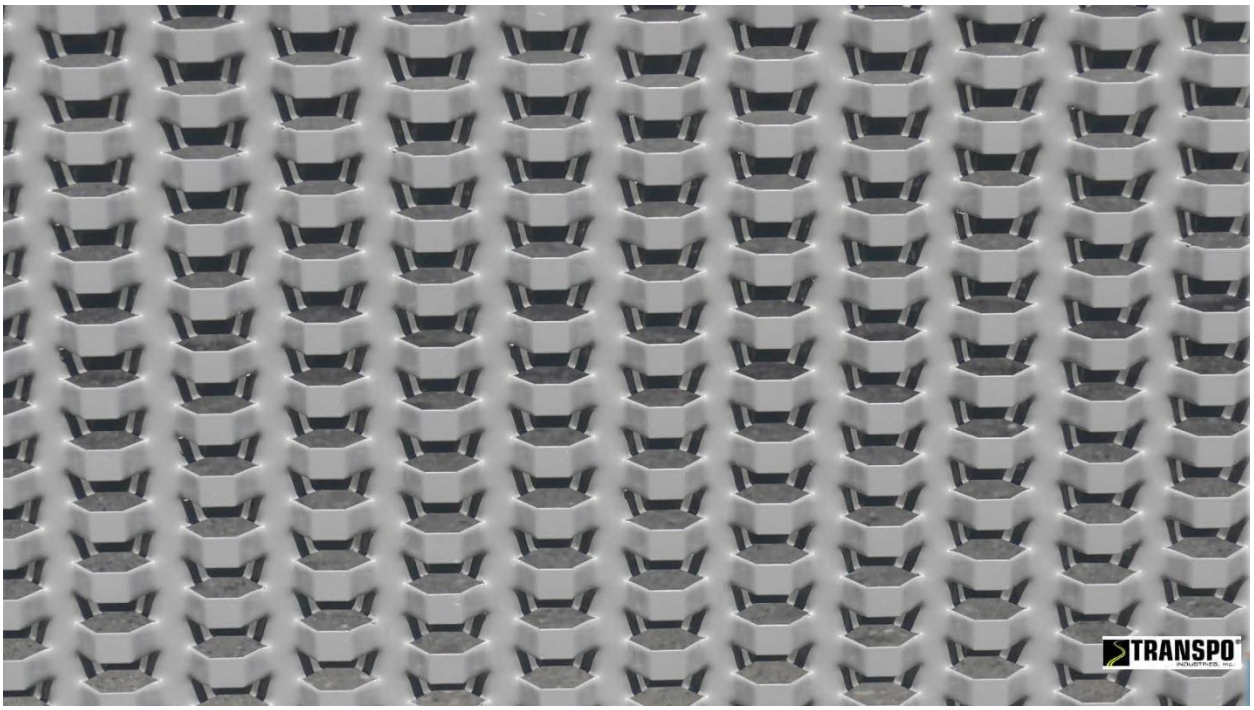
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INDUSTRIES, INC.

D.2. VEHICLE PROPERTIES AND INFORMATION

Date: 2022-05-17 Test No.: 440822-01-04 VIN No.: 1C6RR6GT2HS576423

Year: 2017 Make: RAM Model: 1500

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

Tread Type: Highway Odometer: 125200

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

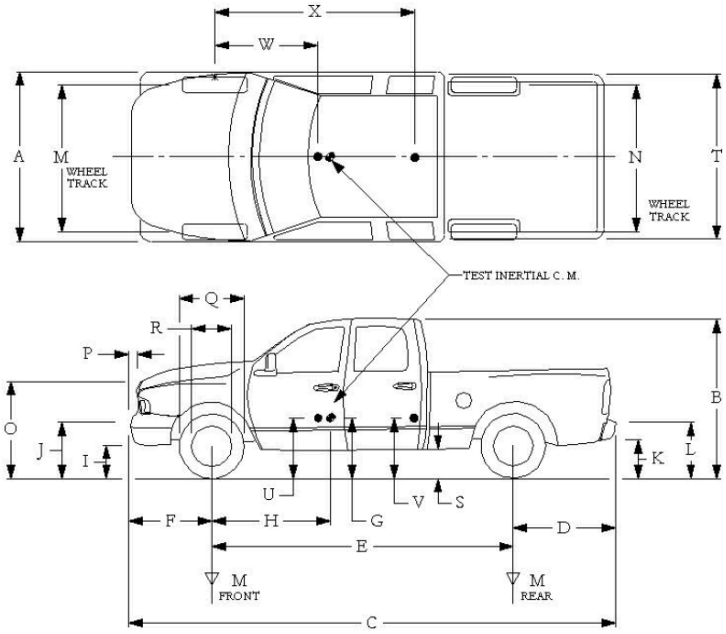
NOTES: None

Engine Type: V-8
Engine CID: 5.7 liter

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

Optional Equipment:
None

Dummy Data:
Type: 50th Percentile Male
Mass: 165 lb
Seat Position: Impact Side



Geometry: inches

A	78.50	F	40.00	K	20.00	P	3.00	U	25.75
B	74.00	G	28.80	L	30.00	Q	30.50	V	30.25
C	227.50	H	61.03	M	68.50	R	18.00	W	61.00
D	44.00	I	11.75	N	68.00	S	13.00	X	79.00
E	140.50	J	27.00	O	46.00	T	77.00		

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

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

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	3700	M_{front}	2881	2862	2947
Back	3900	M_{rear}	2199	2198	2278
Total	6700	M_{Total}	5080	5060	5225

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

Mass Distribution:
lb LF: 1435 RF: 1427 LR: 1132 RR: 1066

Figure D.1. Vehicle Properties for Test No. 440822-01-4.

Date:	2022-05-17	Test No.:	440822-01-04	VIN No.:	1C6RR6GT2HS576423
Year:	2017	Make:	RAM	Model:	1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

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

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

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width*** (CDC)	Max**** Crush								
1	AT FT BUMPER	16	9	34	-	-	-	-	-	-	+12
2	ABOVE FT BUMPER	16	14	54	-	-	-	-	-	-	+64
	Measurements recorded										
	☑ **inches or** ☐ **mm**										

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

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

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

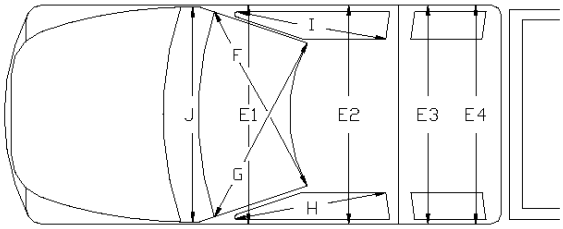
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

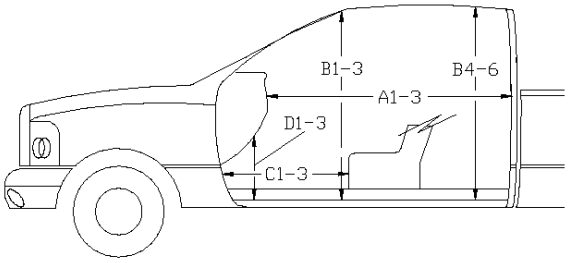
***Measure and document on the vehicle diagram the location of the maximum crush.

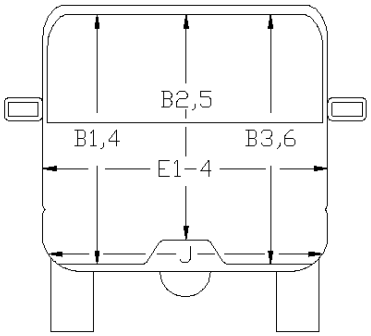
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure D.2. Exterior Crush Measurements for Test No. 440822-01-4.

Date:	2022-05-17	Test No.:	440822-01-04	VIN No.:	1C6RR6GT2HS576423
Year:	2017	Make:	RAM	Model:	1500







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

OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

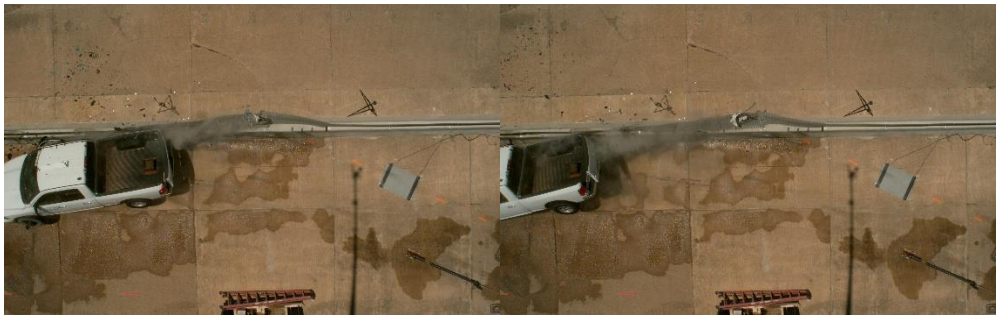
	Before	After (inches)	Differ.
A1	65.00	65.00	0.00
A2	63.00	63.00	0.00
A3	65.50	65.50	0.00
B1	45.00	45.00	0.00
B2	38.00	38.00	0.00
B3	45.00	45.00	0.00
B4	39.50	39.50	0.00
B5	43.00	43.00	0.00
B6	39.50	39.50	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	19.00	-7.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	13.25	1.75
E1	60.00	57.75	-2.25
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*	24.00	19.00	-5.00

Figure D.3. Occupant Compartment Measurements for Test No. 440822-01-4.

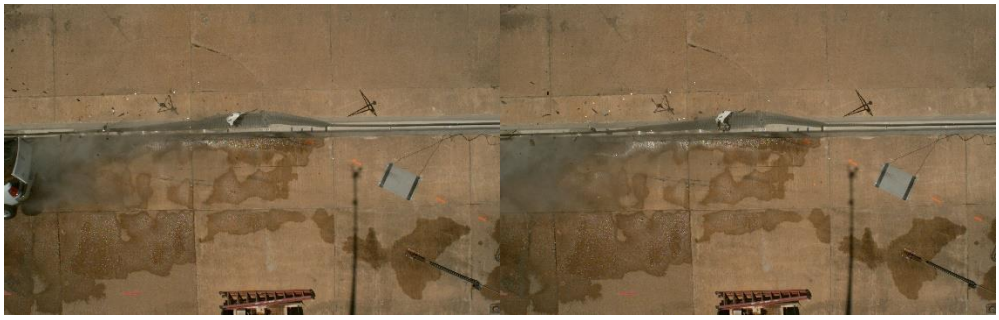
D.3. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s



(e) 0.400 s (f) 0.500 s



(g) 0.600 s (h) 0.700 s

Figure D.4. Sequential Photographs for Test No. 440822-01-4 (Overhead Views).

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure D.5. Sequential Photographs for Test No. 440822-01-4 (Frontal Views).

(a) 0.000 s (b) 0.100 s

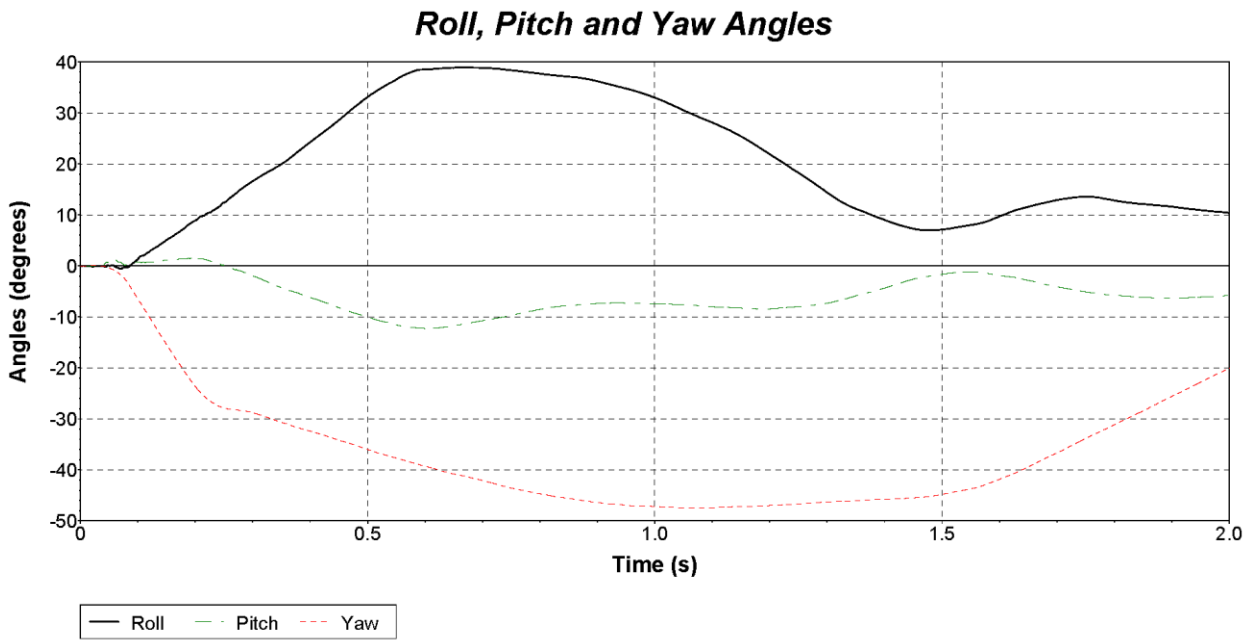
(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

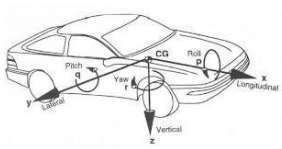
Figure D.6. Sequential Photographs for Test No. 440822-01-4 (Rear Views).

D.4. VEHICLE ANGULAR DISPLACEMENT



Axes are vehicle-fixed.
Sequence for determining orientation:

10. Yaw.
11. Pitch.
12. Roll.



Test Number: 440822-01-4
Test Standard Test Number: *MASH* Test 3-11
Test Article: Screen-Safe® Glare Screen on F-Shape Barrier
Test Vehicle: 2017 RAM 1500
Inertial Mass: 5060 lb
Gross Mass: 5225 lb
Impact Speed: 62.3 mi/h
Impact Angle: 24.5°

Figure D.7. Vehicle Angular Displacements for Test No. 440822-01-4.

D.5. VEHICLE ACCELERATIONS

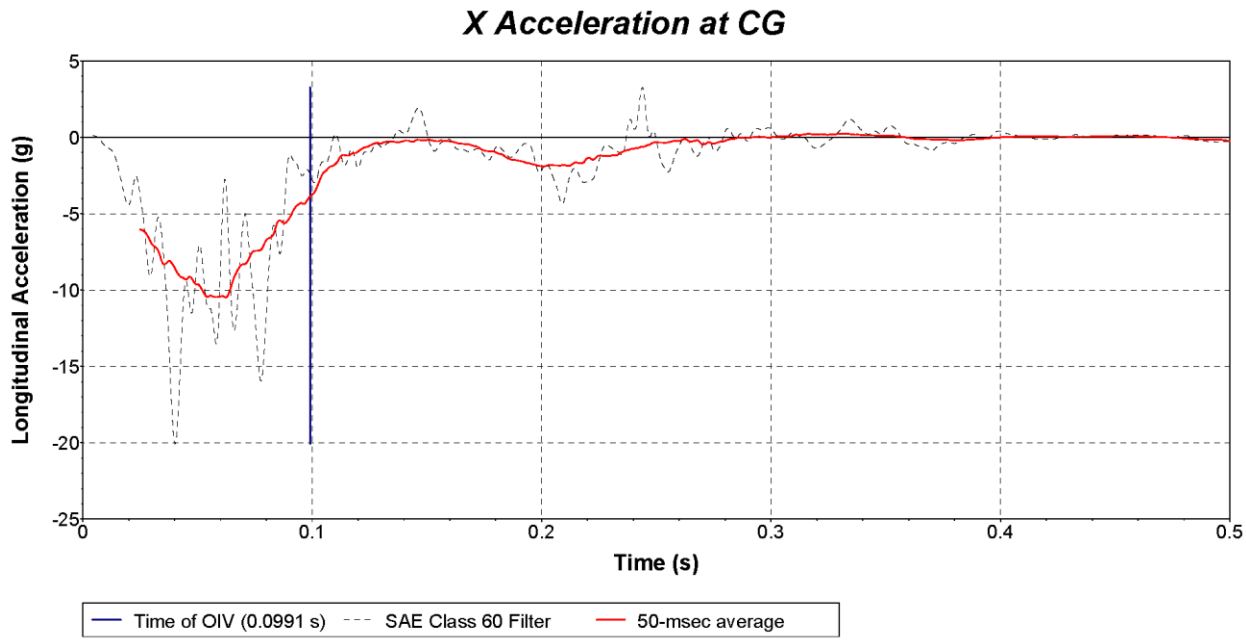


Figure D.8. Vehicle Longitudinal Accelerometer Trace for Test No. 440822-01-4 (Accelerometer Located at Center of Gravity).

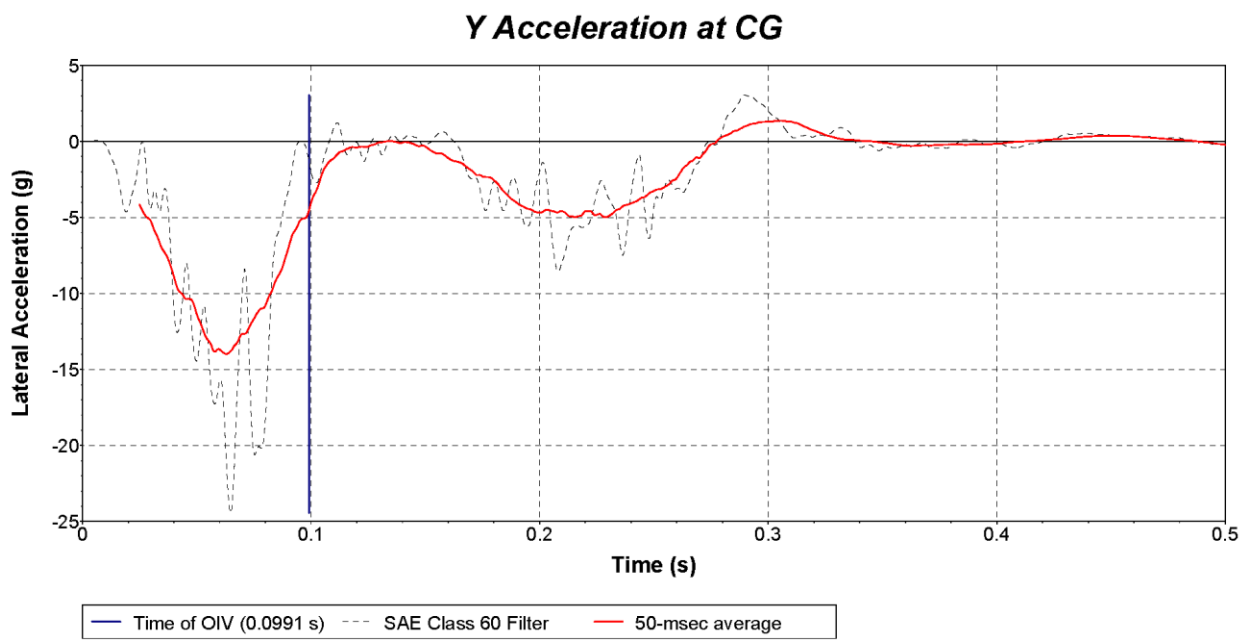


Figure D.9. Vehicle Lateral Accelerometer Trace for Test No. 440822-01-4 (Accelerometer Located at Center of Gravity).

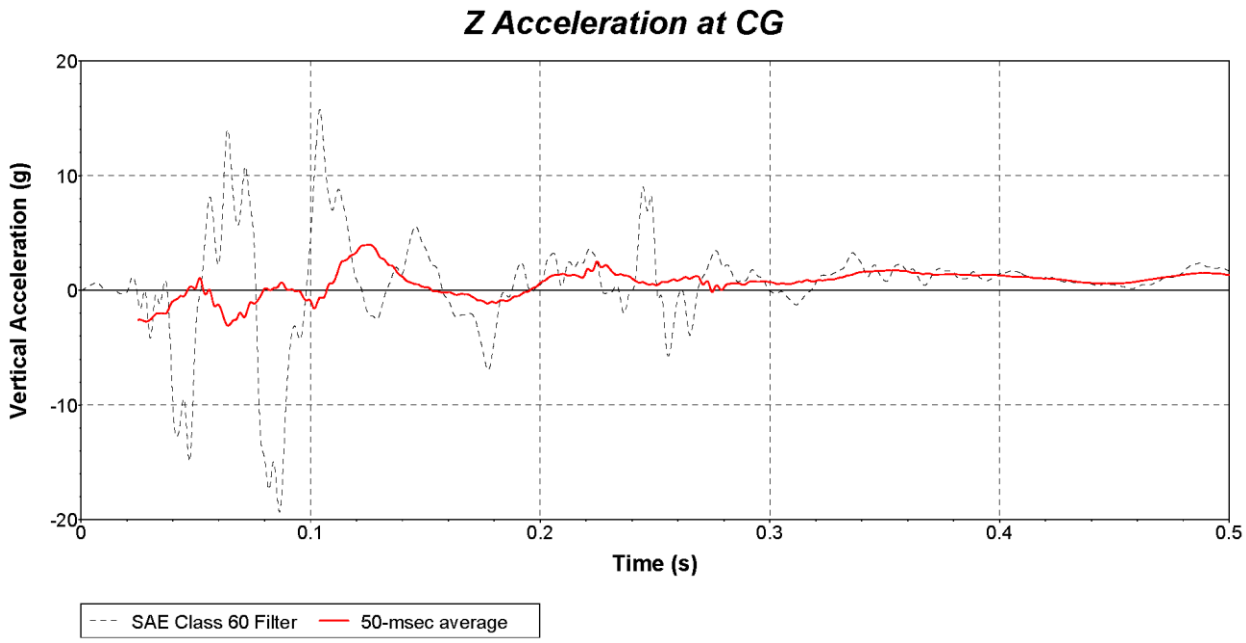
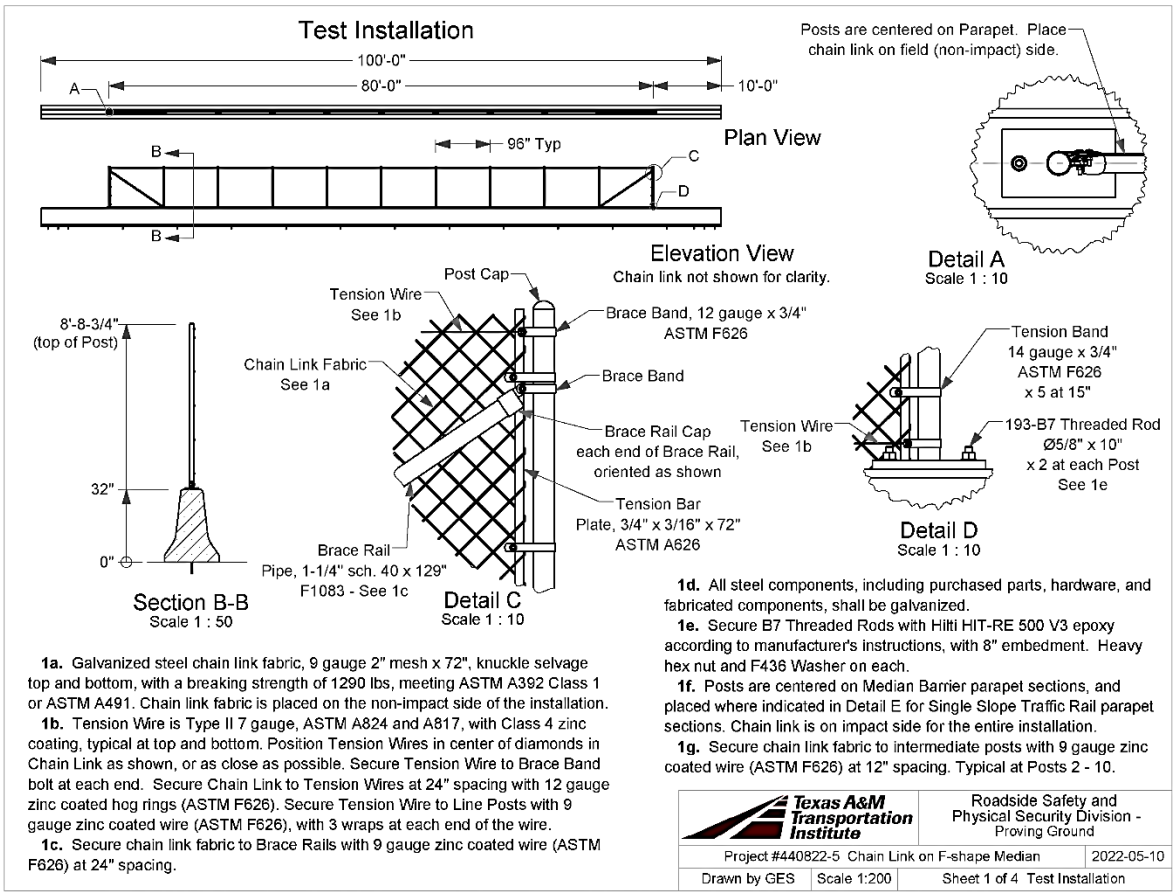
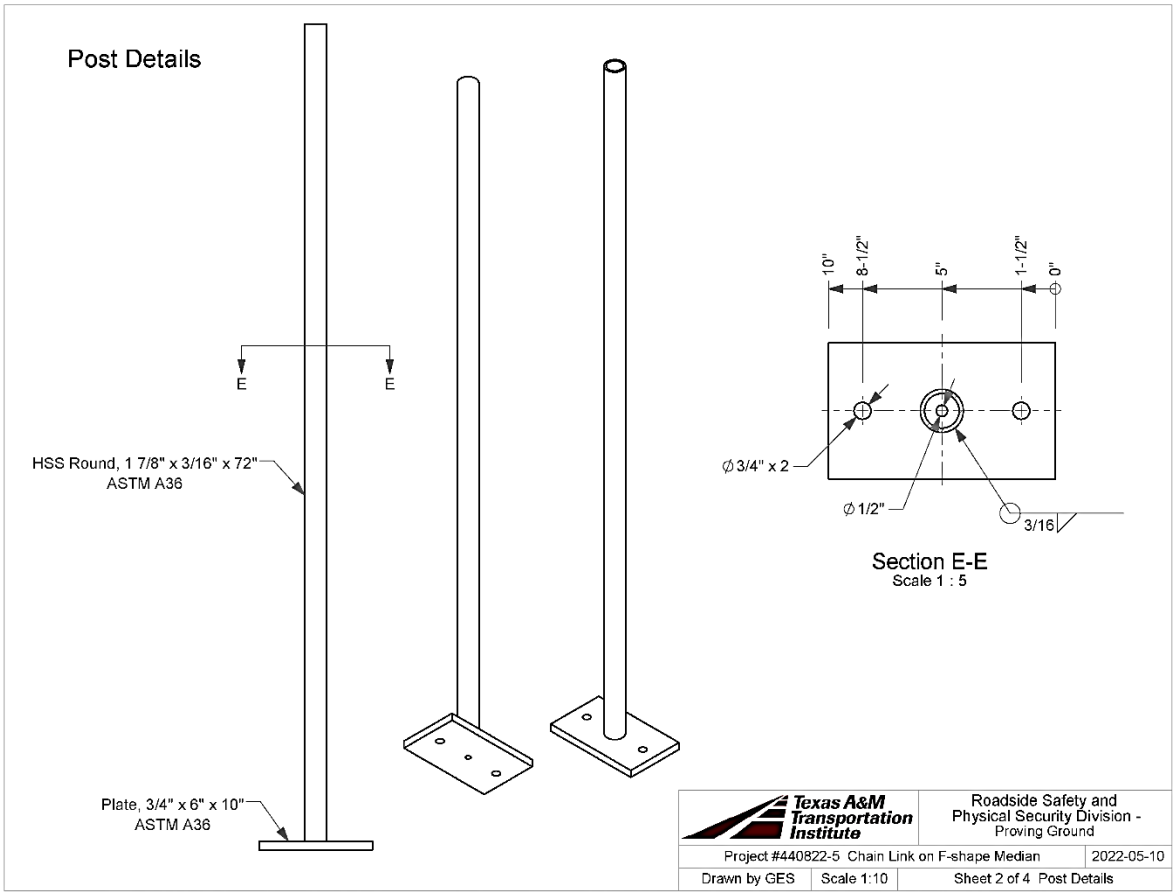


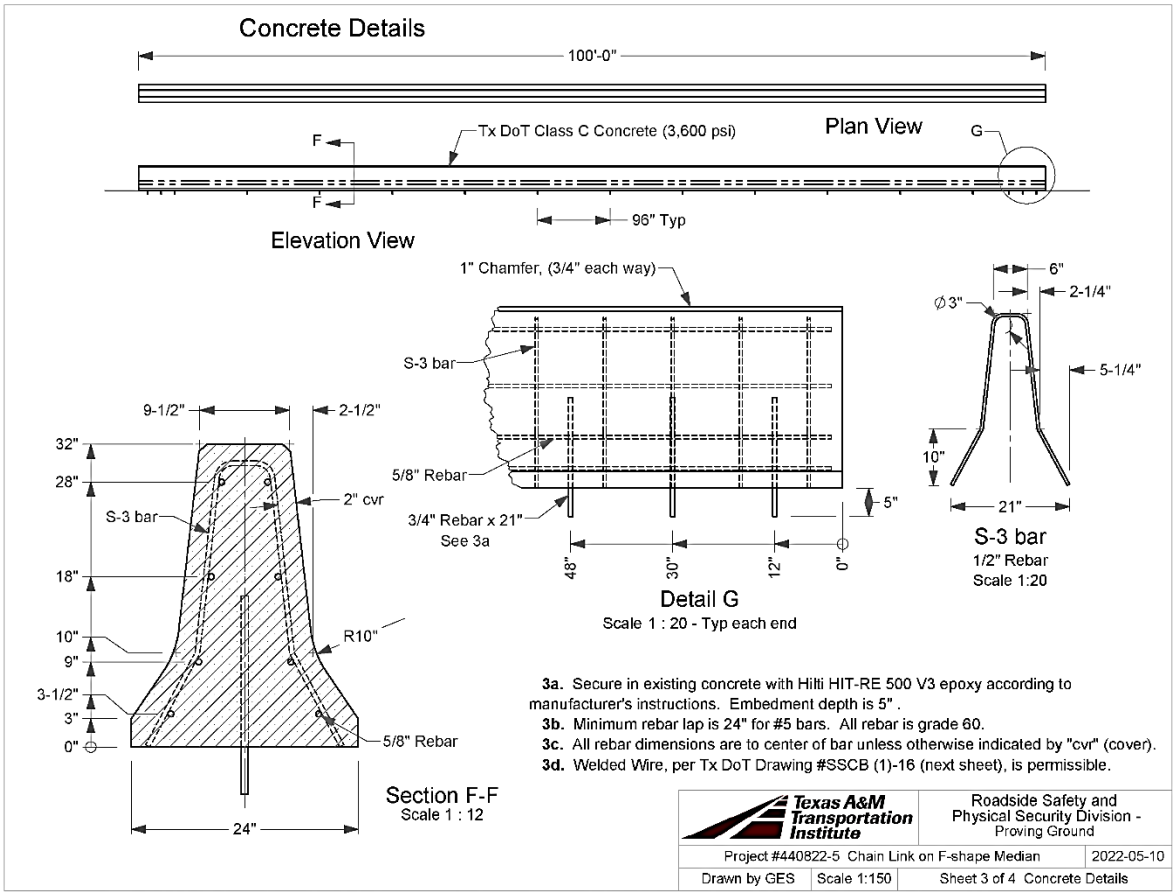
Figure D.10. Vehicle Vertical Accelerometer Trace for Test No. 440822-01-4 (Accelerometer Located at Center of Gravity).

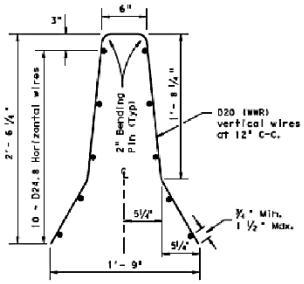
APPENDIX E. CRASH TEST 440822-01-5

E.1. DETAILS OF TEST ARTICLE




Post Details
E
E
HSS Round, 1 7/8" x 3/16" x 72"
ASTM A36
Plate, 3/4" x 6" x 10"
ASTM A36
10"
8-1/2"
5"
1-1/2"
0"
∅3/4" x 2
∅1/2"
3/16
Section E-E
Scale 1 : 5
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #440822-5 Chain Link on F-shape Median
2022-05-10
Drawn by GES
Scale 1:10
Sheet 2 of 4 Post Details
Q:\Accreditation-17025-2017\EIR-000 Project Files\440822 TXDOT Attachments on Barriers - Chiara\440822-01-5 Chain Link Fence on F-Shape\Drafting, 440822-5\440822-5 Drawing


Concrete Details
100'-0"
Tx DoT Class C Concrete (3,600 psi)
Plan View
F
F
G
96" Typ
Elevation View
1" Chamfer, (3/4" each way)
S-3 bar
5/8" Rebar
3/4" Rebar x 21"
See 3a
5"
48"
30"
12"
0"
Detail G
Scale 1 : 20 - Typ each end
6"
2-1/4"
∅3"
5-1/4"
10"
21"
S-3 bar
1/2" Rebar
Scale 1:20
9-1/2"
2-1/2"
32"
28"
2" cvr
S-3 bar
18"
10"
9"
3-1/2"
3"
0"
R10"
5/8" Rebar
24"
Section F-F
Scale 1 : 12
3a. Secure in existing concrete with Hilti HIT-RE 500 V3 epoxy according to manufacturer's instructions. Embedment depth is 5" .
3b. Minimum rebar lap is 24" for #5 bars. All rebar is grade 60.
3c. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).
3d. Welded Wire, per Tx DoT Drawing #SSCB (1)-16 (next sheet), is permissible.
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #440822-5 Chain Link on F-shape Median
2022-05-10
Drawn by GES
Scale 1:150
Sheet 3 of 4 Concrete Details
Q:\Accreditation-17025-2017\EIR-000 Project Files\440822 TXDOT Attachments on Barriers - Chiara\440822-01-5 Chain Link Fence on F-Shape\Drafting, 440822-5\440822-5 Drawing



WELDED WIRE REINFORCEMENT (WWR) OPTION FOR BARS S AND R

(WWR) General Notes

1. Deformed Welded Wire Reinforcement (WWR) shall conform to ASTM A497.

[redacted]

3. The welded wire splice locations shall have a "minimum" splice lap length of 12".

4. [redacted] The dimension from the end of the barrier section to the first wire shall not exceed 3".

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #440822-5 Chain Link on F-shape Median		2022-05-10
Drawn by GES	Scale 1:150	Sheet 4 of 4 Welded Wire

Q:\Accreditation-17025-2017\EIR-000 Project Files\440822 TXDOT Attachments on Barriers - Chiara\440822-01-5 Chain Link Fence on F-Shape\Drafting, 440822-5\440822-5 Drawing

E.2. VEHICLE PROPERTIES AND INFORMATION

Date: 2022-08-04 Test No.: 440822-01-5 VIN No.: 1C6RRGT5GS326771

Year: 2016 Make: RAM Model: 1500

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

Tread Type: Highway Odometer: 184470

Note any damage to the vehicle prior to test: None

● Denotes accelerometer location.

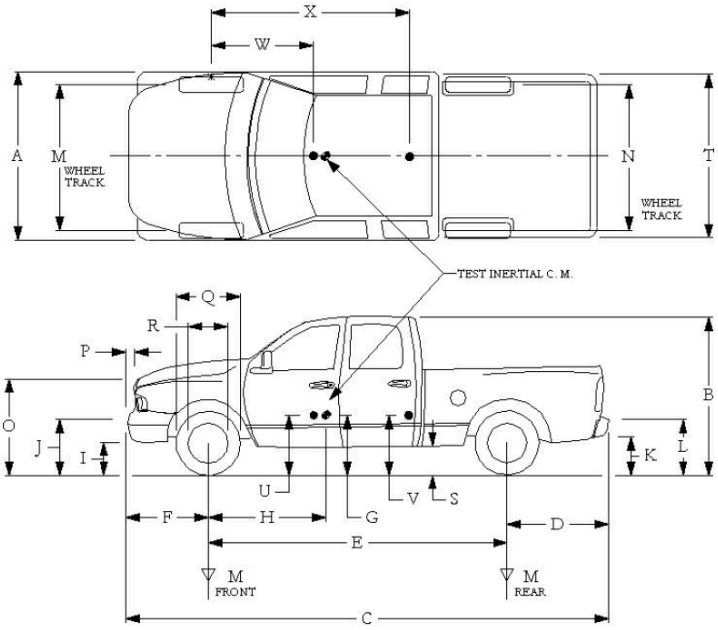
NOTES: None

Engine Type: V-8
Engine CID: 5.7 liter

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

Optional Equipment:
None

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



Geometry: inches

A	78.50	F	40.00	K	20.00	P	3.00	U	26.75
B	74.00	G	28.50	L	30.00	Q	30.50	V	30.25
C	227.50	H	61.19	M	68.50	R	18.00	W	61.20
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}	2962	2859	2944
Back	3900	M_{rear}	2104	2206	2286
Total	6700	M_{Total}	5066	5065	5230

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

Mass Distribution:
lb LF: 1448 RF: 1411 LR: 1111 RR: 1095

Figure E.1. Vehicle Properties for Test No. 440822-01-5.

Date:	2022-08-04	Test No.:	440822-01-5	VIN No.:	1C6RRGT5GS326771
Year:	2016	Make:	RAM	Model:	1500

VEHICLE CRUSH MEASUREMENT SHEET[1]

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

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

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max*** Crush								
1	AT FT BUMPER	16	9	36							18
2	SAME	16	10.5	59							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.

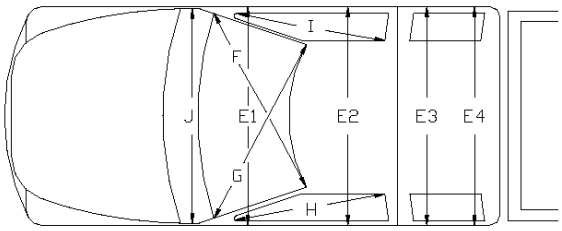
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

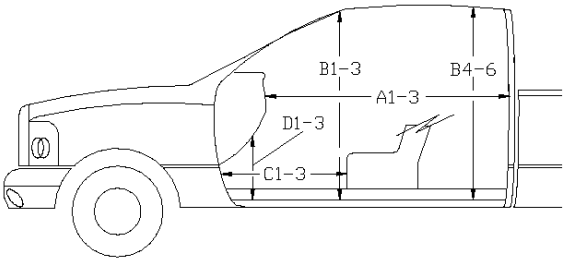
***Measure and document on the vehicle diagram the location of the maximum crush.

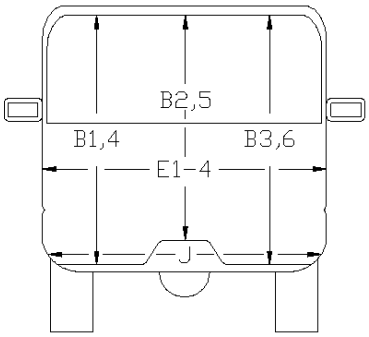
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure E.2. Exterior Crush Measurements for Test No. 440822-01-5.

Date:	2022-08-04	Test No.:	440822-01-5	VIN No.:	1C6RRGT5GS326771
Year:	2016	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	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	21.00	-5.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	11.50	0.00
E1	58.50	61.00	2.50
E2	63.50	60.50	-3.00
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	21.00	-4.00

Figure E.3. Occupant Compartment Measurements for Test No. 440822-01-5.

E.3. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure E.4. Sequential Photographs for Test No. 440822-01-5 (Overhead Views).

(a) 0.000 s (b) 0.100 s

(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

Figure E.5. Sequential Photographs for Test No. 440822-01-5 (Frontal Views).

(a) 0.000 s (b) 0.100 s

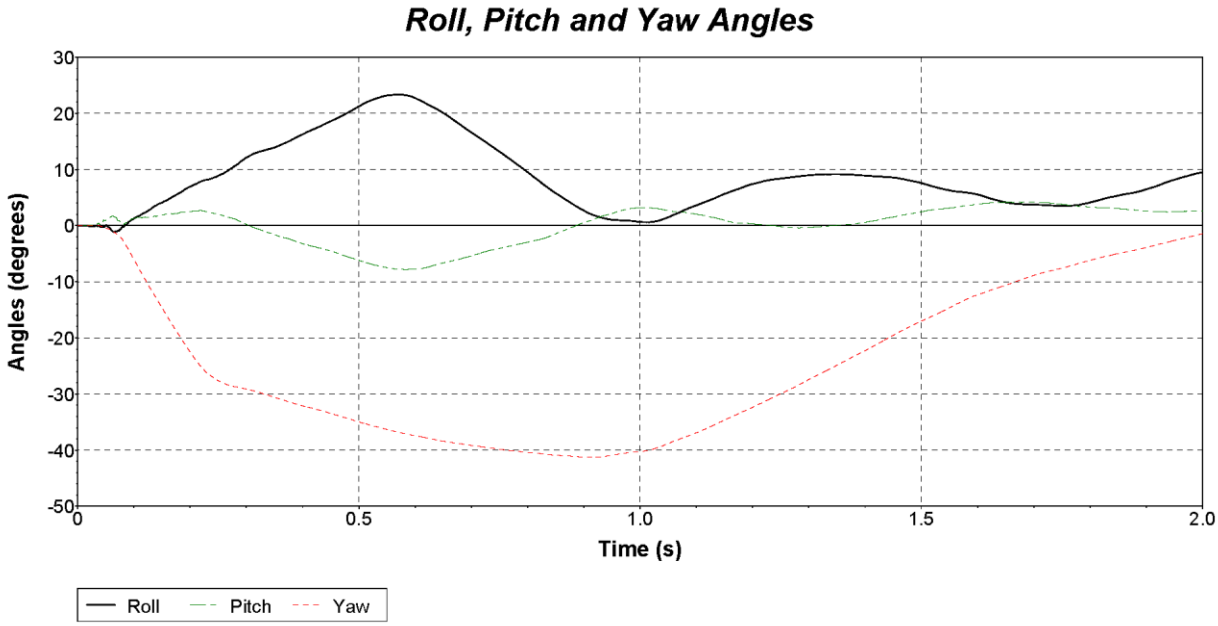
(c) 0.200 s (d) 0.300 s

(e) 0.400 s (f) 0.500 s

(g) 0.600 s (h) 0.700 s

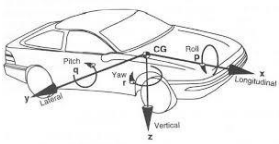
Figure E.6. Sequential Photographs for Test No. 440822-01-5 (Rear Views).

E.4. VEHICLE ANGULAR DISPLACEMENT



Axes are vehicle-fixed.
Sequence for determining orientation:

13. Yaw.
14. Pitch.
15. Roll.



Test Number: 440822-01-5
Test Standard Test Number: *MASH* Test 3-11
Test Article: Chain-Link Fence on F-Shape Barrier
Test Vehicle: 2016 RAM 1500
Inertial Mass: 5065 lb
Gross Mass: 5230 lb
Impact Speed: 61 mi/h
Impact Angle: 25°

Figure E.7. Vehicle Angular Displacements for Test No. 440822-01-5.

E.5. VEHICLE ACCELERATIONS

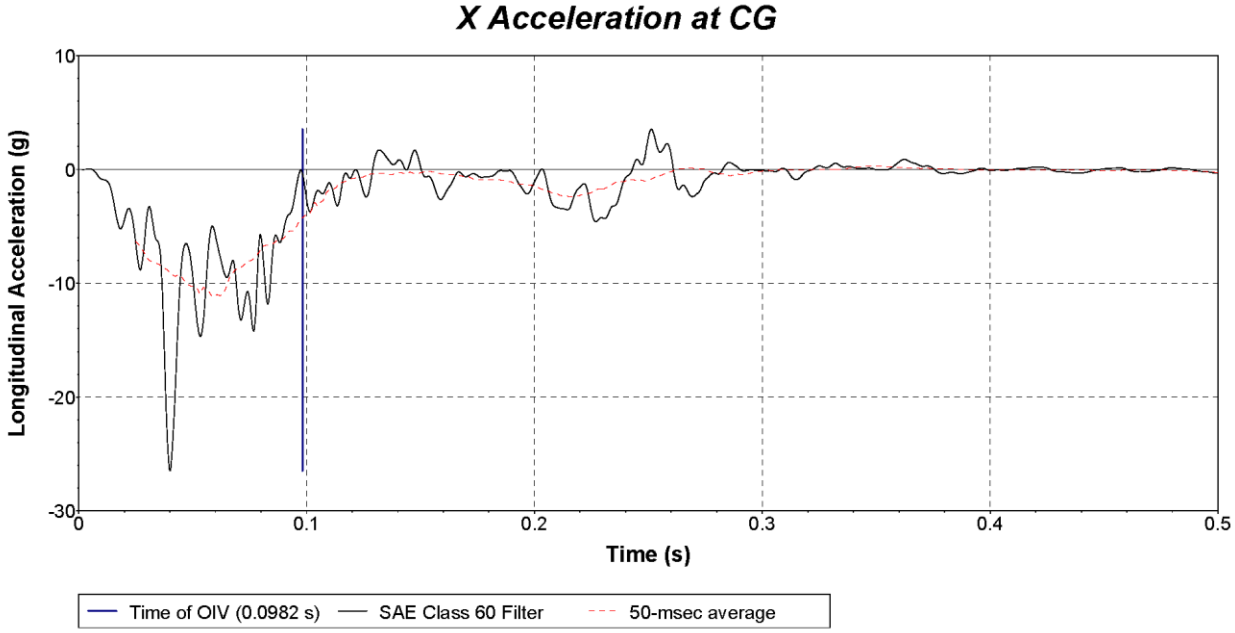


Figure E.8. Vehicle Longitudinal Accelerometer Trace for Test No. 440822-01-5 (Accelerometer Located at Center of Gravity).

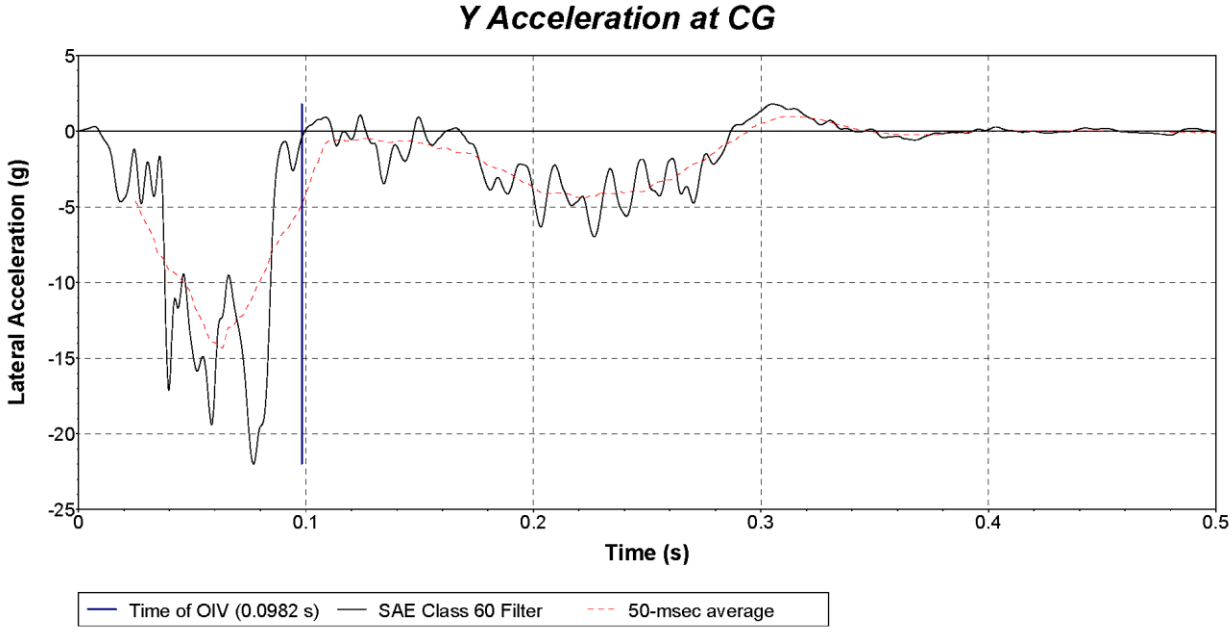


Figure E.9. Vehicle Lateral Accelerometer Trace for Test No. 440822-01-5 (Accelerometer Located at Center of Gravity).

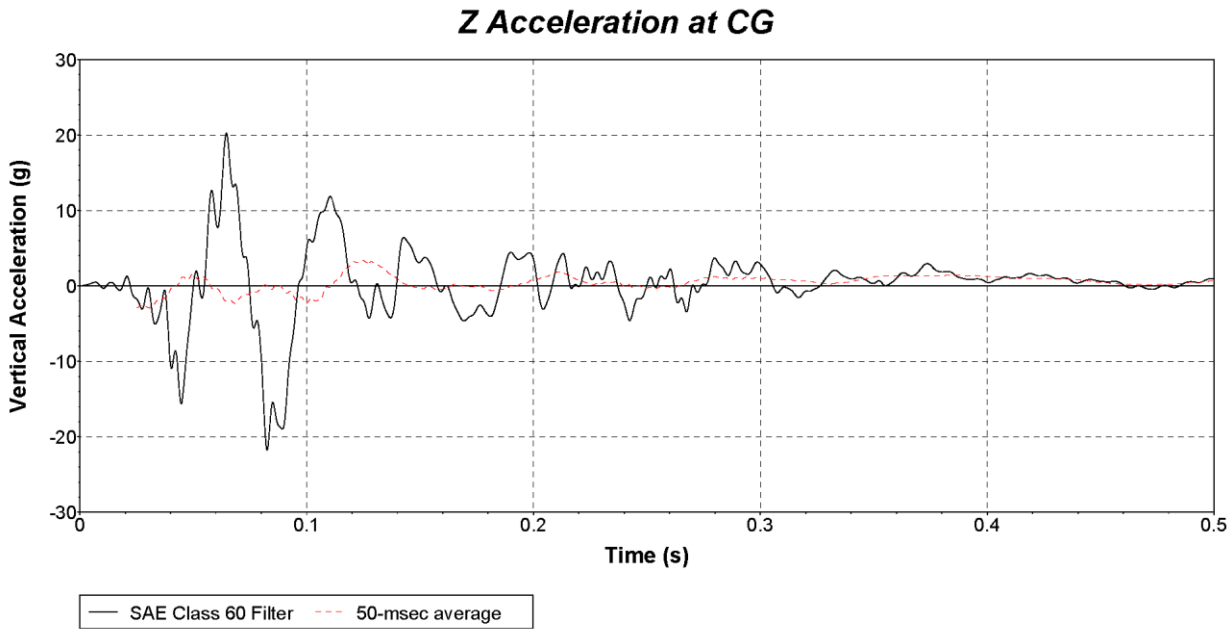


Figure E.10. Vehicle Vertical Accelerometer Trace for Test No. 440822-01-5 (Accelerometer Located at Center of Gravity).

APPENDIX F. MATERIAL PROPERTIES

F.1. CONCRETE INFORMATION FOR THE SINGLE-SLOPE CONCRETE BARRIER

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

Project No: 440822 **Casting Date:** 3/24/2022 **Mix Design (psi):** 3600

Name of Technician Taking Sample: Terracon

Name of Technician Breaking Sample: Terracon

Signature of Technician Taking Sample: Terracon

Signature of Technician Breaking Sample: Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	RickLeroy121	111716	Single Slope South 2/3 of Barrier
T2	ChrisBurns130	111718	Single Slope North 1/3 of Barrier

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

TEXCRETE
Redi-mix Concrete Company

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

TEXCRETE

5222 Sandy Point RD.
Bryan, Tx 77807

17534 SH 6 South
College Station, TX 77845

111716

DISPATCH - 979-316-2906
OFFICE - 979-985-3636
ESPANOL - 512-658-7809

MBC MANAGEMENT
RELLIS CAMPUS, BRYAN TX

RT 2818, RT HWY 21, LT SILVER HILL GO TO "T"RT HWY 47, LT INTO RELLIS CAMPUS, STRAIGHT THRU THE CIRCLE TO THE SECURITY GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
8:28	DCLLC3600	10.00	20.00	PO#	RICK LEROY 121		58970

DATE	PROJECT	LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
3/24/22	TTIARMO	10.00	10.00			5.00 in	57138

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
10.00 yd	TDCLLC3600	CLASS C 3600		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

8:40 8:55

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

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

TESTED	AIR	CYLINDERS
☐ YES ☐ NO		

Tax
Prev. AMT
Ticket Total

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

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

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

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

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

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

X_____

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

_____GAL X_____

WEIGHMASTER

Surcharge for credit cards

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

LOAD RECEIVED BY

X_____

111716

TEXCRETE
Redi-mix Concrete Company

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

TEXCRETE

5222 Sandy Point RD.
Bryan, Tx 77807

17534 SH 6 South
College Station, TX 77845

111718

DISPATCH - 979-316-2906
OFFICE - 979-985-3636
ESPANOL - 512-658-7809

MBC MANAGEMENT
RELLIS CAMPUS, BRYAN TX

RT 2818, RT HWY 21, LT SILVER HILL, GO TO "T"RT HWY 47, LT INTO RELLIS CAMPUS, STRAIGHT THRU THE CIRCLE TO THE SECURITY GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
9:14	DCLC3600	10.00	20.00	PO#	CHRIS	BURNS130	58972

DATE		LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
3/24/22	TTIARMO	10.00	30.00			5.00 in	57140

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
10.00 yd	TDCLC3600	CLASS C 3600		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
924	947	949			

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

TESTED	AIR	CYLINDERS
☐ YES ☐ NO		

Tax
Prev. AMT
Ticket Total

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

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

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

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

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

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

X_____

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

_____GAL X_____

WEIGHMASTER

Surcharge for credit cards

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

LOAD RECEIVED BY

X_____

111718

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0222
Service Date: 03/24/22
Report Date: 05/03/22 Revision 1 - cylinder break
Task: PO# 440822

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: 3,600 psi @ 28 days

Mix ID: Class C
Supplier: Texcrete
Batch Time: 0828 **Plant:** 2
Truck No.: 121 **Ticket No.:** 57138

Sample Information

Sample Date: 03/24/22 **Sample Time:** 0925
Sampled By: Brian Maass
Weather Conditions: Clear light wind
Accumulative Yards: 10/10 **Batch Size (cy):** 10
Placement Method: Direct Discharge
Water Added Before (gal): 5
Water Added After (gal): 0
Sample Location: Center of left barricade
Placement Location: Barricade 1

Field Test Data

Test	Result	Specification
Slump (in):	6	
Air Content (%):	2.0	
Concrete Temp. (F):	67	
Ambient Temp. (F):	52	
Plastic Unit Wt. (pcf):	146.4	
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	6.01	28.37		04/29/22	36 F	150,350	5,300	4	SLS
1	B	Good	6.01	28.37		04/29/22	36 F	150,600	5,310	4	SLS
1	C	Good	6.01	28.37		04/29/22	36 F	148,300	5,230	1	JTE
1	D						Hold				

Initial Cure: Outside Plastic Lids **Final Cure:** Field Cured **Sample Description:** 6-inch diameter cylinders

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

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).
Terracon Rep.: Brian Maass **Start/Stop:** 0800-1100
Reported To:
Contractor: MDC
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Alex Dunigan, P.E.
(1) Texas Transportation Institute, Bill Griffith

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

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0222
Service Date: 03/24/22
Report Date: 05/03/22 Revision 1 - cylinder break
Task: PO# 440822

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: 3,600 psi @ 28 days

Mix ID: Class C
Supplier: Texcrete
Batch Time: 0914 **Plant:** 2
Truck No.: 130 **Ticket No.:** 57140

Sample Information

Sample Date: 03/24/22 **Sample Time:** 1010
Sampled By: Brian Maass
Weather Conditions: Clear light wind
Accumulative Yards: 20/20 **Batch Size (cy):** 10
Placement Method: Direct Discharge
Water Added Before (gal): 5
Water Added After (gal): 0
Sample Location: Center of right barricade
Placement Location: Barricade 2

Field Test Data

Test	Result	Specification
Slump (in):	7 1/2	
Air Content (%):	1.8	
Concrete Temp. (F):	66	
Ambient Temp. (F):	58	
Plastic Unit Wt. (pcf):	147.0	
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
2	A	Good	6.01	28.37		04/29/22	36 F	136,520	4,810	4	SLS
2	B	Good	6.01	28.37		04/29/22	36 F	138,620	4,890	2	SLS
2	C	Good	6.01	28.37		04/29/22	36 F	139,680	4,920	1	JTE
2	D						Hold				

Initial Cure: Outside Plastic Lids **Final Cure:** Field Cured **Sample Description:** 6-inch diameter cylinders

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

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).
Terracon Rep.: Brian Maass **Start/Stop:** 0800-1100
Reported To:
Contractor: MDC
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Alex Dunigan, P.E.
(1) Texas Transportation Institute, Bill Griffith

Reviewed By: Alexander Dunigan
Project Manager

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

F.2. CONCRETE INFORMATION FOR THE F-SHAPE CONCRETE BARRIER

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

Project No: 440822 **Casting Date:** 3/14/2022 **Mix Design (psi):** 3600

Name of Technician Taking Sample: Terracon

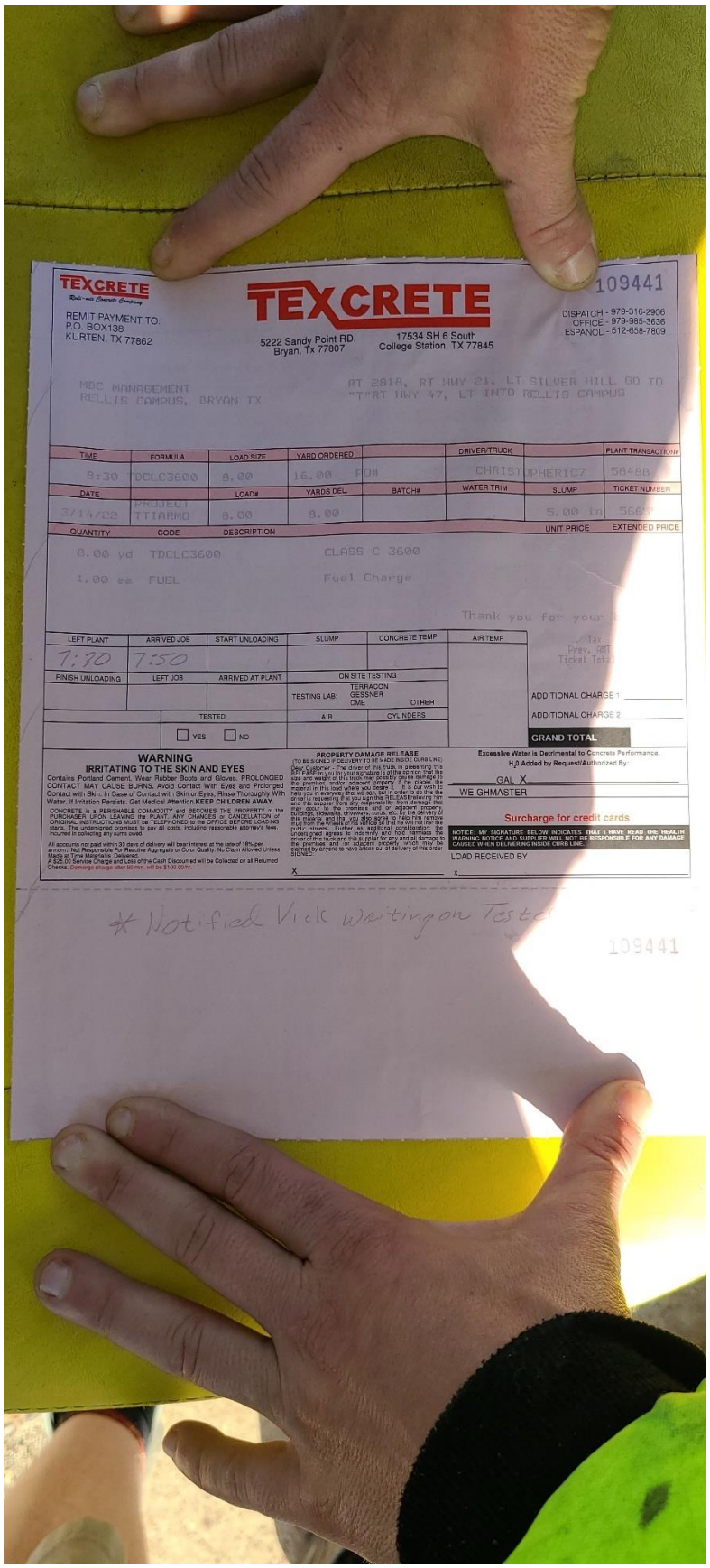
Name of Technician Breaking Sample: Terracon

Signature of Technician Taking Sample: Terracon

Signature of Technician Breaking Sample: Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)	
T1	Christopher1C7	109441	F-Shape	South 2/3 of Barrier
T2	JamesJ131	109443	F-Shape	North 1/3 of Barrier

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



TEXCRETE
Ready-mix Concrete Company

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

TEXCRETE

5222 Sandy Point RD.
Bryan, Tx 77807

17534 SH 6 South
College Station, TX 77845

109441

DISPATCH - 979-316-2906
OFFICE - 979-985-3636
ESPANOL - 512-658-7809

MBC MANAGEMENT
RELLIS CAMPUS, BRYAN TX

RT 2818, RT HWY 21, LT SILVER HILL GO TO
"T"RT HWY 47, LT INTO RELLIS CAMPUS

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
8:30	TDCLC3600	8.00	16.00	POH	CHRISTOPHERIC7		58488
DATE		LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
3/14/22	PROJECT TTIARMO	8.00	8.00			5.00 in	5660[illegible]

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
8.00 yd	TDCLC3600	CLASS C 3600		
1.00 ea	FUEL	Fuel Charge		

Thank you for your b

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP.
7:30	7:50				
FINISH UNLOADING	LEFT JOB	ARRIVED AT PLANT	ON SITE TESTING		
			TESTING LAB: TERRACON GESSNER CME OTHER		
TESTED			AIR	CYLINDERS	
	☐ YES ☐ NO				

Tax
Prev. AMT
Ticket Total

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

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

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

All accounts not paid within 30 days of delivery will bear interest at the rate of 18% per annum. Not Responsible For Reactive Aggregate or Color Quality. No Claim Allowed Unless Made at Time Material is Delivered.
A $25.00 Service Charge and Loss of the Cash Discounted will be Collected on all Returned Checks. Demurge charge after 60 min. will be $100.00/hr.

PROPERTY DAMAGE RELEASE
(TO BE SIGNED IF DELIVERY TO BE MADE INSIDE CURB LINE)
Dear Customer: The driver of this truck is presenting this Release to you for your signature in order that we may use the size and weight of this truck now greatly cause damage to the premises and/or adjacent property if he placed the material in this load where you desire it. It is our wish to help you in everyway that we can, but in order to do this the driver must have your signature on this Release and this supplier from any responsibility from damage that may occur to the premises and or adjacent property, buildings, sidewalks, driveways, curbs, etc. by the delivery of this material and that you also agree to help him remove the material from the truck if it should get stuck in your or public streets. Further as additional consideration, the undersigned agrees to indemnify and hold harmless the driver of this truck and his supplier for any and all damage to the premises and/or adjacent property which may be injured by anyone to have arisen out of delivery of this order SIGNED:

X_____

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

GAL X_____

WEIGHMASTER

Surcharge for credit cards

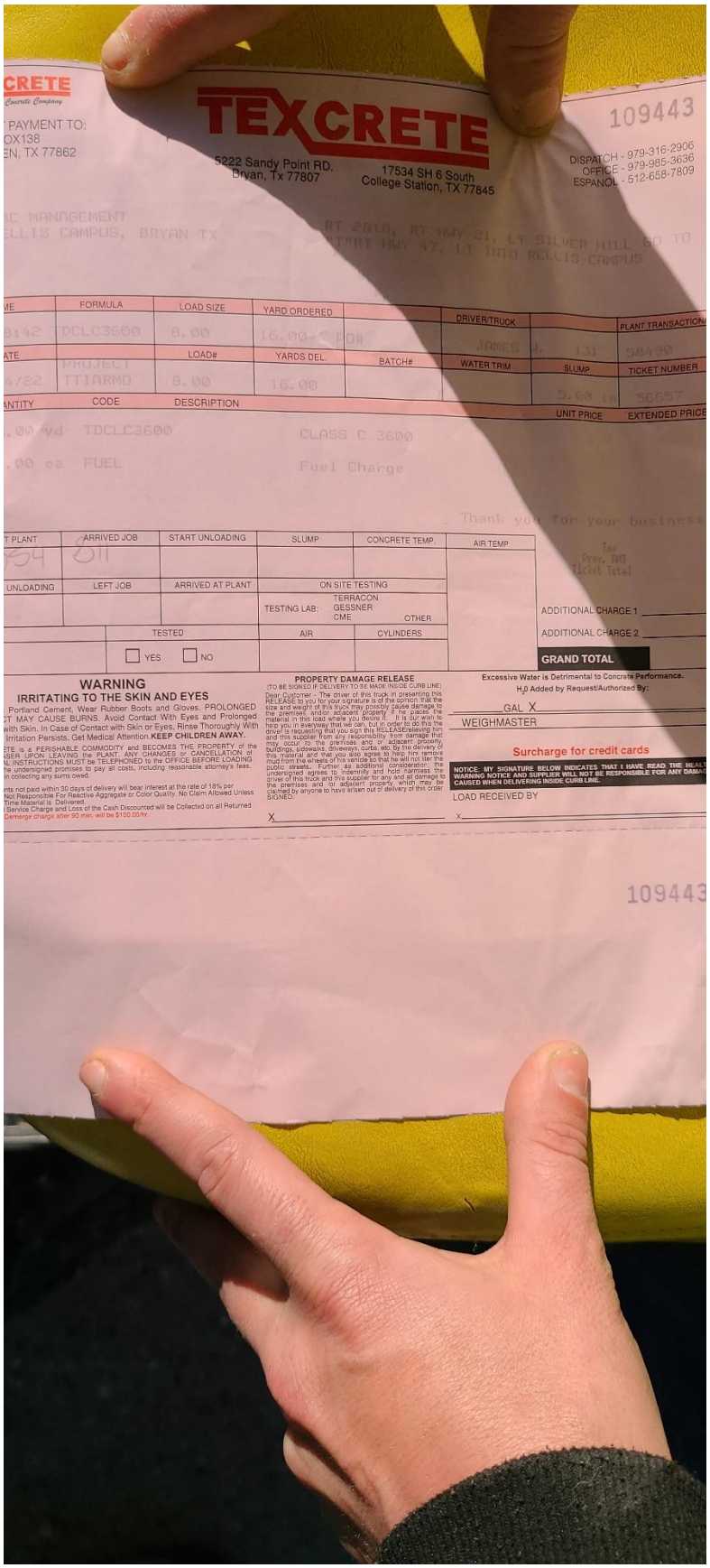
NOTICE: MY SIGNATURE BELOW INDICATES **THAT I HAVE READ THE HEALTH WARNING NOTICE AND SUPPLIER WILL NOT BE RESPONSIBLE FOR ANY DAMAGE CAUSED WHEN DELIVERING INSIDE CURB LINE.**

LOAD RECEIVED BY

X_____

* Notified Vick Waitington Tested

109441



TEXCRETE

5222 Sandy Point RD.
Bryan, Tx 77807

17534 SH 6 South
College Station, TX 77845

109443

DISPATCH - 979-316-2906
OFFICE - 979-985-3636
ESPANOL - 512-658-7809

FORMULA	LOAD SIZE	YARD ORDERED	DRIVER/TRUCK	PLANT TRANSACTION
TDCLC3600	8.00	16.00	JAMES H. 131	58430

LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
TTIARMO	8.00	16.00		5.00 in	56657

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
8.00 yd	TDCLC3600	CLASS C 3600		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
011				

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

TESTED	AIR	CYLINDERS
☐ YES ☐ NO		

Tax
Prev. PMT
Ticket Total

ADDITIONAL CHARGE 1
ADDITIONAL CHARGE 2
GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES
Portland Cement, Wear Rubber Boots and Gloves. PROLONGED CT MAY CAUSE BURNS. Avoid Contact With Eyes and Prolonged with Skin. In Case of Contact with Skin or Eyes, Rinse Thoroughly With Irritation Persists, Get Medical Attention. **KEEP CHILDREN AWAY.**
ETE is a PERISHABLE COMMODITY and BECOMES THE PROPERTY of the SER UPON LEAVING the PLANT. ANY CHANGES or CANCELLATION of AL INSTRUCTIONS MUST be TELEPHONED to the OFFICE BEFORE LOADING he undersigned promises to pay all costs, including reasonable attorney's fees, n collecting any sums owed.
nts not paid within 30 days of delivery will bear interest at the rate of 18% per Not Responsible For Reactive Aggregate or Color Quality. No Claim Allowed Unless Time Material is Delivered.
Service Charge and Loss of the Cash Discounted will be Collected on all Returned Demerge charge after 90 min. will be $100.00/hr.

PROPERTY DAMAGE RELEASE
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Dear Customer - The driver of this truck, in presenting this RELEASE to you for your signature is of the opinion that the size and weight of this truck may possibly cause damage to the premises and/or adjacent property if he places the material in this load where you desire it. It is our wish to help you in everyway that we can, but in order to do this the driver is requesting that you sign this RELEASE/relieving him and this supplier from any responsibility from damage that may occur to the premises and or adjacent property buildings, sidewalks, driveways, curbs, etc. by the mere presence this material and that you also agree to help to remove mud from the wheels of his vehicle if it should fall off the public streets. For the additional consideration: The undersigned agrees to indemnify and hold harmless the driver of this truck and this supplier for any and all damage to the premises and /or adjacent property which may be claimed by anyone to have arisen out of delivery of this order SIGNED:
X

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

Surcharge for credit cards

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

LOAD RECEIVED BY
X

109443

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0221
Service Date: 03/14/22
Report Date: 05/02/22
Task: PO# 440822

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: 3,600 psi @ 46 days

Mix ID: TDCLC3600
Supplier: Texcrete
Batch Time: 2030 **Plant:** Bryan
Truck No.: 1C7 **Ticket No.:** 56655

Sample Information

Sample Date: 03/14/22 **Sample Time:** 2145
Sampled By: Randy Rippstein
Weather Conditions: Cloudy, Heavy Wind
Accumulative Yards: 8 **Batch Size (cy):** 8
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: See GPS Location
Placement Location: Project # 440822-3 Amorcast panels on F-Shape median

Field Test Data

Test	Result	Specification
Slump (in):	6	
Air Content (%):	1.3	
Concrete Temp. (F):	70	
Ambient Temp. (F):	60	
Plastic Unit Wt. (pcf):	149.2	
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	6.01	28.37		04/19/22	36 F	153,410	5,410	4	SLS
1	B	Good	6.01	28.37		04/19/22	36 F	152,050	5,360		SLS
1	C	Good	6.01	28.37		04/19/22	36 F	151,420	5,340		SLS
1	D						Hold				

Initial Cure: Outside Plastic Lids **Final Cure:** Field Cured **Sample Description:** 6-inch diameter cylinders

Comments: **F = Field Cured**
Note: Reported air content does not include Aggregate Correction Factor (ACF).
"To be Utilized" Break 3 cylinders on April 29 & Hold 1.

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.: Randy Rippstein **Start/Stop:** 0900-1300
Reported To: Bill with TTI
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Alex Dunigan, P.E.
(1) Texas Transportation Institute, Bill Griffith

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

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0221
Service Date: 03/14/22
Report Date: 05/02/22
Task: PO# 440822

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: 3,600 psi @ 46 days

Mix ID: TDCLC3600
Supplier: Texcrete
Batch Time: 0842 **Plant:** Bryan
Truck No.: 131 **Ticket No.:** 56657

Sample Information

Sample Date: 03/14/22 **Sample Time:** 1010
Sampled By: Randy Rippstein
Weather Conditions: Cloudy, Heavy Wind
Accumulative Yards: 16 **Batch Size (cy):** 8
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: See GPS Location
Placement Location: Project # 440822-3 Amorcast Panels on F-Shape Median

Field Test Data

Test	Result	Specification
Slump (in):	6 1/2	
Air Content (%):	1.5	
Concrete Temp. (F):	71	
Ambient Temp. (F):	73	
Plastic Unit Wt. (pcf):	148.6	
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
2	A	Good	6.01	28.37		04/19/22	36 F	147,980	5,220	3	SLS
2	B	Good	6.01	28.37		04/19/22	36 F	147,510	5,200		SLS
2	C	Good	6.01	28.37		04/19/22	36 F	141,830	5,000		SLS
2	D						Hold				

Initial Cure: Outside Plastic Lids **Final Cure:** Field Cured **Sample Description:** 6-inch diameter cylinders

Comments: **F = Field Cured**
Note: Reported air content does not include Aggregate Correction Factor (ACF).
"To be Utilized" Break 3 cylinders on April 29 & Hold 1.

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.: Randy Rippstein **Start/Stop:** 0900-1300
Reported To: Bill with TTI
Contractor:
Report Distribution:
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Test Methods: ASTM C 31, ASTM C143, ASTM C231, ASTM C1064