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**Test Report No. 611971-02-1**  
**Test Report Date: June 2020**

**MASH TEST 3-11 EVALUATION OF COMBINATION TRAFFIC-  
PEDESTRIAN-BICYCLE BRIDGE RAILING**

by

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The results reported herein apply only to the article tested. The full-scale crash test was performed according to TTI Proving Ground quality procedures and according to the *MASH* guidelines and standards.

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15. Supplementary Notes <b>Project Title: Analysis and Testing of Florida Department of Transportation Barrier Systems for MASH Compliance Name of Contacting Representative: Derwood C. Sheppard, Jr., P.E.</b>					
16. Abstract  <p>The purpose of this research was to test and evaluation of a 42-inch tall combination traffic-pedestrian-bicycle bridge rail system for use at <i>MASH</i> TL-3 conditions. Design of the new barrier considered utilization of a 36-inch single slope concrete barrier with a 6-inch bullet-profile aluminum rail mounted on top.</p> <p>A full-scale crash test was performed according to <i>MASH</i> Test 3-11 impact conditions, which involves a 5000-lb pickup truck impacting the bridge rail at a nominal impact speed of 62 mi/h and at a nominal impact angle of 25°. This test evaluates the bridge rail's ability to successfully contain and redirect the pickup truck and occupant risk.</p> <p>This report provides details of the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system, detailed documentation of the crash test and results, and an assessment of the performance of the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system for <i>MASH</i> Test 3-11 evaluation criteria.</p> <p>The 42-inch tall combination traffic-pedestrian-bicycle bridge rail system passed the performance criteria for <i>MASH</i> Test 3-11.</p>					
17. Key Words <b>Longitudinal barrier, pedestrian rail, bicycle rail, combination rail, bridge rail, single slope barrier, crash test, roadside safety, MASH</b>			18. Distribution Statement <b>Copyrighted. Not to be copied or reprinted without consent from <a href="#">Roadside Safety Pooled Fund</a>.</b>		
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## SI\* (MODERN METRIC) CONVERSION FACTORS

### APPROXIMATE CONVERSIONS TO SI UNITS

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

### APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
<b>LENGTH</b>				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
<b>AREA</b>				
mm <sup>2</sup>	square millimeters	0.0016	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	10.764	square feet	ft <sup>2</sup>
m <sup>2</sup>	square meters	1.195	square yards	yd <sup>2</sup>
ha	hectares	2.47	acres	ac
km <sup>2</sup>	Square kilometers	0.386	square miles	mi <sup>2</sup>
<b>VOLUME</b>				
mL	milliliters	0.034	fluid ounces	oz
L	liters	0.264	gallons	gal
m <sup>3</sup>	cubic meters	35.314	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.307	cubic yards	yd <sup>3</sup>
<b>MASS</b>				
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
<b>TEMPERATURE (exact degrees)</b>				
°C	Celsius	1.8C+32	Fahrenheit	°F
<b>FORCE and PRESSURE or STRESS</b>				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lb/in <sup>2</sup>

\*SI is the symbol for the International System of Units

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## Chapter 1. INTRODUCTION

As Florida Department of Transportation (FDOT) transitions away from the 32-inch F-shape barrier as the standard shape for permanent concrete barriers to a 36-inch single slope shape, the existing 42-inch combination traffic-pedestrian-bicycle bridge rail system needed to be revised and appropriately modified to be compatible with the new barrier profile and height.

The purpose of this research was to evaluate a 42-inch tall combination traffic-pedestrian-bicycle bridge rail system to American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessment of Safety Hardware (MASH)* Test 3-11 testing and evaluation conditions (I). Design of the barrier considered utilization of a 36-inch single slope concrete barrier with a 6-inch tall bullet-profile aluminum rail mounted on top.

A full-scale crash test was performed according to *MASH* Test 3-11 impact conditions, which involves a 5000-lb pickup truck impacting the bridge rail at a nominal impact speed of 62 mi/h and at a nominal impact angle of 25°. This test evaluates the bridge rail's ability to successfully contain and redirect the pickup truck and occupant risk.

This report provides details of the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system, detailed documentation of the crash test and results, and an assessment of the performance of the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system for *MASH* Test 3-11 evaluation criteria.

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## **Chapter 2. SYSTEM DETAILS**

### **2.1. TEST ARTICLE AND INSTALLATION DETAILS**

The installation consisted of four sections of concrete barrier. The first two sections were single slope roadside concrete barriers, 14½ inches at the bottom, sloping up on the traffic side towards the field side for a width of 9 inches at the top. The field side consisted of two vertical sections offset from each other 1½ inches at 45 degrees. The other two barrier sections were single slope concrete median barrier. All four barriers had a height of 36 inches, and were secured to the concrete apron using Hilti RE 500 V3 epoxy anchor bars embedded to a depth of 6 inches. A single, half-elliptical, aluminum rail supported by short aluminum posts spaced at 96 inches was mounted on these barriers. The total installation length was 120 ft, and the overall rail height was 42 inches.

Figure 2.1 presents overall information on the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system, and Figure 2.2 provides photographs of the installation. Appendix A provides further details of the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system. Drawings were developed by TTI, and construction was performed by Tucker Construction.

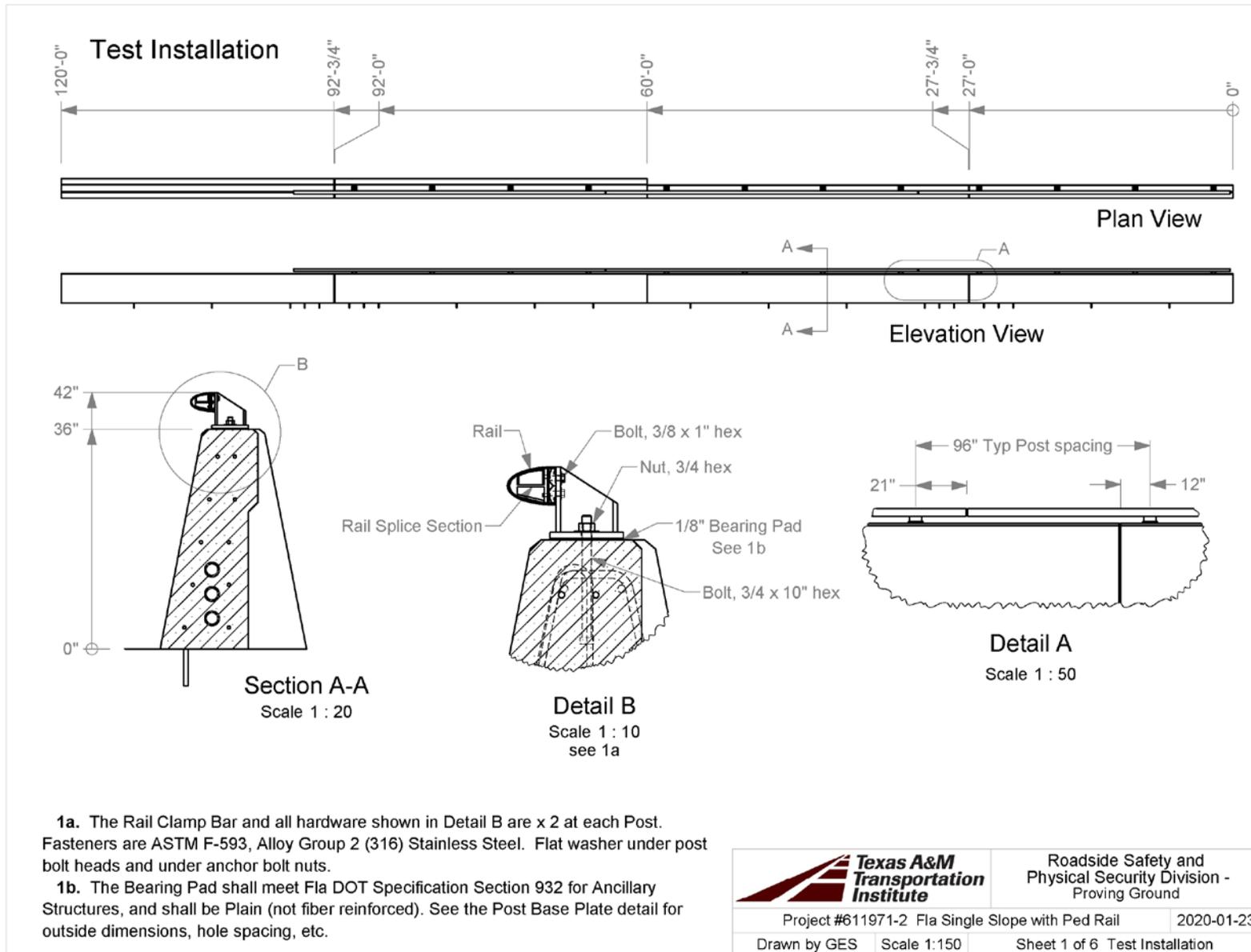
### **2.2. DESIGN MODIFICATIONS DURING TESTS**

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

### **2.3. MATERIAL SPECIFICATIONS**

Concrete compressive strength was specified to be 3400 psi. On the day of the test, barriers 2 and 4 had an average compressive strength of 4507 psi at 32 days of age, and barriers 1 and 3 had an average compressive strength of 5127 psi at 28 days of age.

Appendix B provides certification documents for the materials used to install/ construct the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system.



**Figure 2.1. Details of 42-inch Tall Combination Traffic-Pedestrian-Bicycle Bridge Rail System.**



**Figure 2.2. 42-inch Tall Combination Traffic-Pedestrian-Bicycle Bridge Rail System prior to Testing.**

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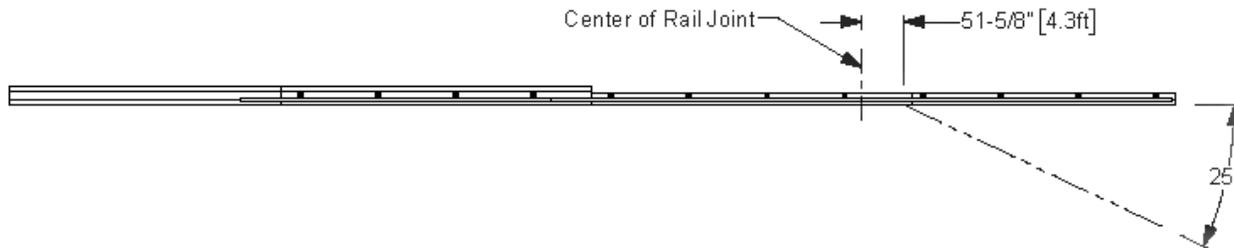
## Chapter 3. TEST REQUIREMENTS AND EVALUATION CRITERIA

### 3.1. CRASH TEST PERFORMED / MATRIX

Table 3.1 shows the test conditions and evaluation criteria for *MASH* TL-3 for longitudinal barriers. *MASH* Test 3-11 involves a 2270P vehicle weighing 5000 lb  $\pm$ 110 lb and impacting the critical impact point (CIP) of the barrier at an impact speed of 62 mi/h  $\pm$ 2.5 mi/h and an angle of 25°  $\pm$ 1.5°. The target CIP was determined using the information provided in *MASH* Section 2.2.1, Section 2.3.2, Figure 2-1, and Table 2-7. Figure 3.1 shows the target CIP for *MASH* Test 3-11 on the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system.

**Table 3.1. Test Conditions and Evaluation Criteria Specified for *MASH* TL-3 Longitudinal Barriers.**

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



**Figure 3.1. Target CIP for *MASH* Test 3-11 on 42-inch Tall Combination Traffic-Pedestrian-Bicycle Bridge Rail System.**

The crash test 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 test reported herein. The test conditions and evaluation criteria required for *MASH* Test 3-11 are listed in Table 3.1, and the substance of the evaluation criteria in Table 3.2. An evaluation of the crash test results is presented in detail under the section Assessment of Test Results.

**Table 3.2. Evaluation Criteria Required for MASH Test 3-11 for Longitudinal Barriers.**

<b>Evaluation Factors</b>	<b>Evaluation Criteria</b>
<b>Structural Adequacy</b>	<p>A. <i>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.</i></p>
<b>Occupant Risk</b>	<p>D. <i>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.</i></p> <p><i>Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH.</i></p>
	<p>F. <i>The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.</i></p>
	<p>H. <i>Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 30 ft/s, or maximum allowable value of 40 ft/s.</i></p>
	<p>I. <i>The occupant ridedown accelerations should satisfy the following: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.</i></p>

## **Chapter 4. TEST CONDITIONS**

### **4.1. TEST FACILITY**

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

The test facilities of the TTI Proving Ground are located on the Texas A&M University System RELLIS Campus, which consists of a 2000-acre complex of research and training facilities situated 10 miles northwest of the flagship campus of Texas A&M University. The site, formerly a United States Army Air Corps base, has large expanses of concrete runways and parking aprons well suited for experimental research and testing in the areas of vehicle performance and handling, vehicle-roadway interaction, durability and efficacy of highway pavements, and evaluation of roadside safety hardware and perimeter protective devices. The site selected for construction and testing of the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system was the surface of an out-of-service apron. The apron consists of an unreinforced jointed-concrete pavement in 12.5-ft × 15-ft blocks nominally 6 inches deep. The aprons were built in 1942, and the joints have some displacement, but are otherwise flat and level.

### **4.2 VEHICLE TOW AND GUIDANCE SYSTEM**

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

### **4.3 DATA ACQUISITION SYSTEMS**

#### **4.3.1 Vehicle Instrumentation and Data Processing**

The test vehicle was instrumented with a self-contained, on-board data acquisition system. The signal conditioning and acquisition system is a 16-channel, Tiny Data Acquisition System (TDAS) Pro produced by Diversified Technical Systems, Inc. The accelerometers, which measure the x, y, and z axis of vehicle acceleration, are strain gauge type with linear millivolt output proportional to acceleration. Angular rate sensors, measuring vehicle roll, pitch, and yaw rates, are ultra-small, solid state units designed for crash test service. The TDAS Pro hardware and

software conform to the latest SAE J211, Instrumentation for Impact Test. Each of the 16 channels is capable of providing precision amplification, scaling, and filtering based on transducer specifications and calibrations. During the test, data are recorded from each channel at a rate of 10,000 samples per second with a resolution of one part in 65,536. Once data are recorded, internal batteries back these up inside the unit should the primary battery cable be severed. Initial contact of the pressure switch on the vehicle bumper provides a time zero mark and initiates the recording process. After each test, the data are downloaded from the TDAS Pro unit into a laptop computer at the test site. The Test Risk Assessment Program (TRAP) software then processes the raw data to produce detailed reports of the test results.

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

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

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

#### **4.3.2 Anthropomorphic Dummy Instrumentation**

According to *MASH*, use of a dummy in the 2270P vehicle is optional. However, it is recommended a dummy be used when testing “any longitudinal barrier with a height greater than or equal to 33 inches.” 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 rail height of the combination traffic-pedestrian-bicycle bridge rail system was 42 inches, a dummy was placed in the front seat of the 2270P vehicle on the impact side and restrained with lap and shoulder belts.

### **4.3.3 Photographic Instrumentation Data Processing**

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

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

A flashbulb on the impacting vehicle was activated by a pressure-sensitive tape switch to indicate the instant of contact with the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system. The flashbulb was visible from each camera. The video files from these digital high-speed cameras were analyzed to observe phenomena occurring during the collision and to obtain time-event, displacement, and angular data. A digital camera recorded and documented conditions of each test vehicle and the installation before and after the test.

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## Chapter 5. MASH TEST 3-11 (CRASH TEST NO. 611971-02-1)

### 5.1 TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

MASH Test 3-11 involves a 2270P vehicle weighing 5000 lb  $\pm$ 110 lb impacting the CIP of the longitudinal barrier at an impact speed of 62 mi/h  $\pm$ 2.5 mi/h and an angle of 25°  $\pm$ 1.5°. The CIP for MASH Test 3-11 on the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system was 4.3  $\pm$ 1 ft upstream of the centerline of the first splice in the metal rail element. Figures 3.1 and 5.1 depict the target impact setup.



Figure 5.1. Bridge Rail/Test Vehicle Geometrics for Test No. 611971-02-1.

The 2270P vehicle used in the test weighed 5029 lb, and the actual impact speed and angle were 61.8 mi/h and 24.5°. The actual impact point was 4.8 ft upstream of the first splice in the metal rail element. Minimum target impact severity (IS) for MASH Test 3-11 is 106 kip-ft, and actual IS was 110 kip-ft.

### 5.2 WEATHER CONDITIONS

The test was performed on the morning of April 3, 2020. Weather conditions at the time of testing were as follows: wind speed: 4 mi/h; wind direction: 142° (vehicle was traveling at a magnetic heading of 330°); temperature: 73°F; relative humidity: 89%.

### 5.3 TEST VEHICLE

Figure 5.2 shows the 2014 RAM 1500 pickup truck used for the crash test. The vehicle's test inertia weight was 5029 lb, and its gross static weight was 5194 lb. The height to the lower edge of the vehicle bumper was 11.75 inches, and height to the upper edge of the bumper was 27.0 inches. The height to the vehicle's center of gravity was 29.0 inches. Tables C.1 and C.2 in Appendix C1 give additional dimensions and information on the vehicle. The vehicle was directed into the installation using a cable reverse tow and guidance system, and was released to be freewheeling and unrestrained just prior to impact.



**Figure 5.2. Test Vehicle before Test No. 611971-02-1.**

#### **5.4 TEST DESCRIPTION**

Table 5.1 lists events that occurred during Test No. 611971-02-1. Figure C.1 in Appendix C2 present sequential photographs during the test.

**Table 5.1. Events during Test No. 611971-02-1.**

<b>TIME (s)</b>	<b>EVENTS</b>
0.000	Vehicle impacts bridge rail
0.033	Vehicle begins to redirect
0.107	Front left tire lifts off pavement
0.217	Rear left tire lifts off pavement
0.181	Vehicle traveling parallel to barrier
0.187	Rear right bumper contacts barrier
0.395	Vehicle loses contact with bridge rail at a trajectory of 6.2° and heading of 7.4°
0.489	Front right tire contacts pavement
0.628	Front left tire contacts pavement

For longitudinal barriers, it is desirable that the vehicle redirects and exits the barrier within the exit box criteria (not less than 32.8 ft downstream from loss of contact for cars and pickups). The test vehicle exited within the exit box criteria defined in *MASH*. Brakes on the vehicle were applied at 2.0 s after impact. After loss of contact with the barrier, the vehicle came to rest 205 ft downstream of the impact point and 7 ft toward traffic lanes.

#### **5.5 DAMAGE TO TEST INSTALLATION**

Figure 5.3 shows the damage to the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system. There were scuff marks on the concrete at the site of contact. A crack was noted on the barrier's traffic side base, beginning at the field joint and extending along the base for 33 ft before stopping at the butt joint. Also, a piece of concrete broke off of the field side at

post 5, exposing the anchors. Working width\* was 23.3 inches, and height of working width was 68.2 inches (vehicle side mirror). Maximum dynamic deflection of the metal rail during the test was 3.1 inches, and maximum permanent deformation was 2.25 inches.



**Figure 5.3. Bridge Rail after Test No. 611971-02-1.**

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\* 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.

## 5.6 DAMAGE TO TEST VEHICLE

Figure 5.4 shows the damage sustained by the vehicle. The front bumper, hood, grill, radiator and support, right front fender, right frame rail, right lower control arm, right front tire and rim, right front floor pan, right front door and window glass, right rear door, right rear cab corner, right rear exterior bed, right rear rim, and rear bumper were damaged. The windshield was cracked along the right A-post. No fuel tank damage was observed. Maximum exterior crush to the vehicle was 14.0 inches in the side plane at the right front corner at bumper height. Maximum occupant compartment deformation was 4.0 inches in the right front floor pan. Figure 5.5 shows the interior of the vehicle. Tables C.3 and C.4 in Appendix C1 provide exterior crush and occupant compartment measurements.



**Figure 5.4. Test Vehicle after Test No. 611971-02-1.**



**Figure 5.5. Interior of Test Vehicle after Test No. 611971-02-1.**

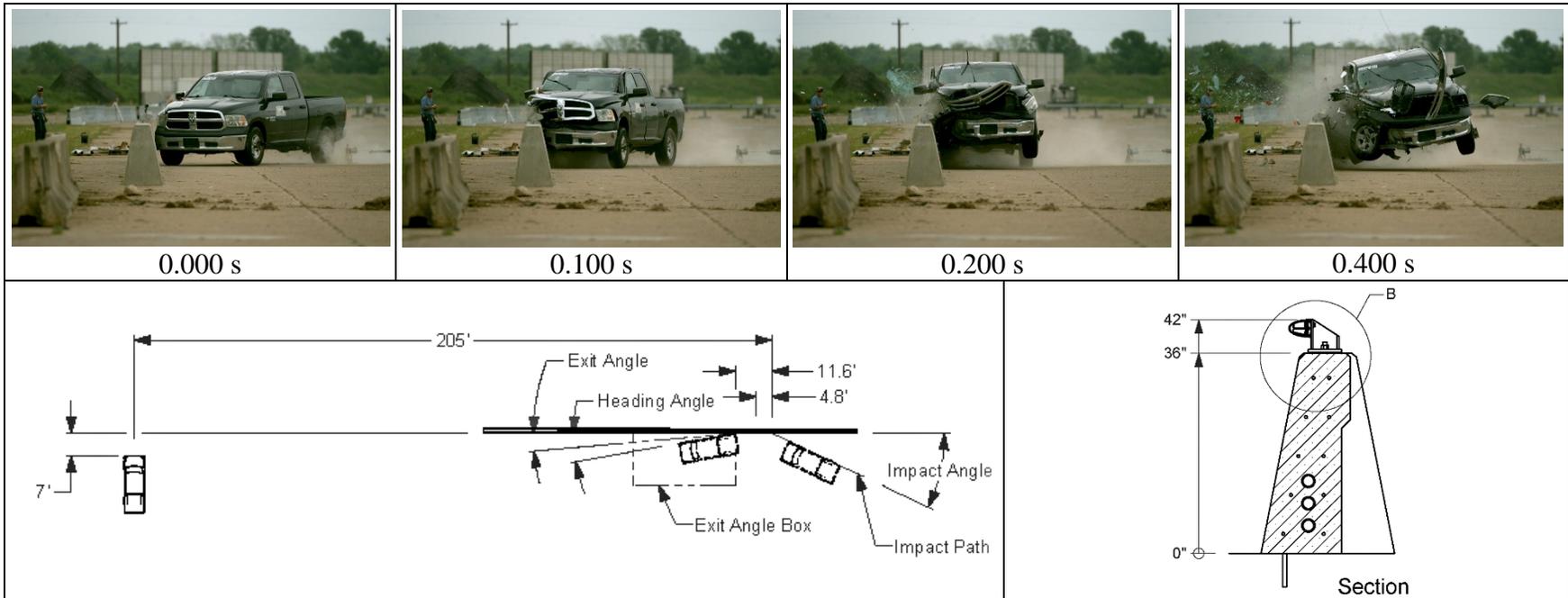
## 5.7 OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 5.2. Figure C.2 in Appendix C3 shows the vehicle angular

displacements, and Figures C.3 through C.5 in Appendix C4 show acceleration versus time traces. Figure 5.6 summarizes pertinent information from the test.

**Table 5.2. Occupant Risk Factors for Test No. 611971-02-1.**

<b>Occupant Risk Factor</b>	<b>Value</b>	<b>Time</b>
<b>Occupant Impact Velocity (OIV)</b> Longitudinal Lateral	15.4 ft/s 24.6 ft/s	at 0.0985 s on right side of interior
<b>Occupant Ridedown Accelerations</b> Longitudinal Lateral	5.4 g 10.4 g	0.0985 – 0.1085 s 0.1885 – 0.1985 s
<b>Theoretical Head Impact Velocity (THIV)</b>	8.8 m/s	at 0.0958 s on right side of interior
<b>Acceleration Severity Index (ASI)</b>	1.6	0.0579 – 0.1079 s
<b>Maximum 50-ms Moving Average</b> Longitudinal Lateral Vertical	-6.8 g -12.2 g -3.9 g	0.0195 – 0.0695 s 0.0372 – 0.0872 s 0.0151 – 0.0651 s
<b>Maximum Roll, Pitch, and Yaw Angles</b> Roll Pitch Yaw	16° 6° 40°	0.5761 s 0.6161 s 0.8948 s



**General Information**

Test Agency ..... Texas A&M Transportation Institute (TTI)  
 Test Standard Test No. .... MASH Test 3-11  
 TTI Test No. .... 611971-02-1  
 Test Date ..... 2020-04-03

**Test Article**

Type ..... Longitudinal Barrier – Bridge Rail  
 Name ..... 42-inch tall combination traffic-pedestrian-bicycle bridge rail system  
 Installation Length ..... 120 ft  
 Material or Key Elements ... 36-inch single slope barrier with aluminum rail atop

**Foundation Type**

..... Anchored to concrete with anchor bars embedded 6 inches in concrete

**Test Vehicle**

Type/Designation ..... 2270P  
 Make and Model ..... 2014 RAM 1500 pickup truck  
 Weight ..... 4952 lb  
 Test Inertial ..... 5029 lb  
 Dummy ..... 165 lb  
 Gross Static ..... 5194 lb

**Impact Conditions**

Speed ..... 61.8 mi/h  
 Angle ..... 24.5°  
 Location/Orientation ..... 4.8 ft upstream of splice

**Impact Severity**

..... 110 kip-ft

**Exit Conditions**

Speed ..... Not obtainable  
 Trajectory/Heading Angle ..... 6.2° / 7.4°

**Occupant Risk Values**

Longitudinal OIV ..... 15.4 ft/s  
 Lateral OIV ..... 24.6 ft/s  
 Longitudinal Ridedown ..... 5.4 g  
 Lateral Ridedown ..... 10.4 g  
 THIV ..... 8.8 m/s  
 ASI ..... 1.6  
 Max. 0.050-s Average  
 Longitudinal ..... -6.8 g  
 Lateral ..... -12.2 g  
 Vertical ..... -3.9 g

**Post-Impact Trajectory**

Stopping Distance ..... 205 ft downstream  
 7 ft twd traffic lanes

**Vehicle Stability**

Yaw Angle ..... 40°  
 Maximum Pitch Angle ..... 6°  
 Maximum Roll Angle ..... 16°  
 Vehicle Snagging ..... No  
 Vehicle Pocketing ..... No

**Test Article Deflections**

Dynamic ..... 3.1 inches  
 Permanent ..... 2.25 inches  
 Working Width ..... 23.3 inches  
 Height of Working Width ..... 68.2 inches

**Vehicle Damage**

VDS ..... 01RFQ5  
 CDC ..... 01FREW4  
 Max. Exterior Deformation ..... 14.0 inches  
 OCDI ..... RF0030000  
 Max. Occupant Compartment Deformation ..... 4.0 inches

**Figure 5.6. Summary of Results for MASH Test 3-11 on 42-inch Tall Combination Traffic-Pedestrian-Bicycle Bridge Rail System.**

## **Chapter 6. SUMMARY AND CONCLUSIONS**

### **6.1. ASSESSMENT OF TEST RESULTS**

The crash test reported herein was performed in accordance with *MASH* Test 3-11, which involves a 2270P vehicle impacting the bridge rail at a target impact speed and impact angle of 62 mi/h and 25°. An assessment of the test based on the applicable safety evaluation criteria for *MASH* Test 3-11 for longitudinal barriers is provided in Table 6.1.

### **6.2 CONCLUSIONS**

Table 6.2 shows the 42-inch tall combination traffic-pedestrian-bicycle bridge rail system passed the performance criteria for *MASH* Test 3-11 for longitudinal barriers.

**Table 6.1. Performance Evaluation Summary for MASH Test 3-11 on 42-inch Tall Combination Traffic-Pedestrian-Bicycle Bridge Rail System.**

Test Agency: Texas A&M Transportation Institute

Test No.: 611971-02-1

Test Date: 2020-04-03

<b>MASH Test 3-11 Evaluation Criteria</b>	<b>Test Results</b>	<b>Assessment</b>
<p><b><u>Structural Adequacy</u></b></p> <p>A. <i>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.</i></p>	<p>The 42-inch tall combination traffic-pedestrian-bicycle bridge rail system contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection of the aluminum rail element during the test was 3.1 inches.</p>	<p>Pass</p>
<p><b><u>Occupant Risk</u></b></p> <p>D. <i>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.</i></p> <p><i>Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH.</i></p>	<p>No detached elements, fragments, or other debris were present to penetrate or show potential for penetrating the occupant compartment, or to present hazard to others in the area.</p> <p>Maximum occupant compartment deformation was 4.0 inches in the right front floor pan.</p>	<p>Pass</p>
<p>F. <i>The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.</i></p>	<p>The 2270P vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 16° and 6°.</p>	<p>Pass</p>
<p>H. <i>Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 30 ft/s, or maximum allowable value of 40 ft/s.</i></p>	<p>Longitudinal OIV was 15.4 ft/s, and lateral OIV was 24.6 ft/s.</p>	<p>Pass</p>
<p>I. <i>The occupant ridedown accelerations should satisfy the following limits: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.</i></p>	<p>Maximum longitudinal ridedown acceleration was 5.4 g, and maximum lateral ridedown acceleration was 10.4 g.</p>	<p>Pass</p>

**Table 6.2. Assessment Summary for *MASH* Test 3-11 on 42-inch Tall Combination Traffic-Pedestrian-Bicycle Bridge Rail System.**

<b>Evaluation Factors</b>	<b>Evaluation Criteria</b>	<b>Test No. 611971-02-1</b>
<b>Structural Adequacy</b>	A	S
<b>Occupant Risk</b>	D	S
	F	S
	H	S
	I	S
<b>Test No.</b>		<b><i>MASH</i> Test 3-11</b>
<b>Pass/Fail</b>		Pass

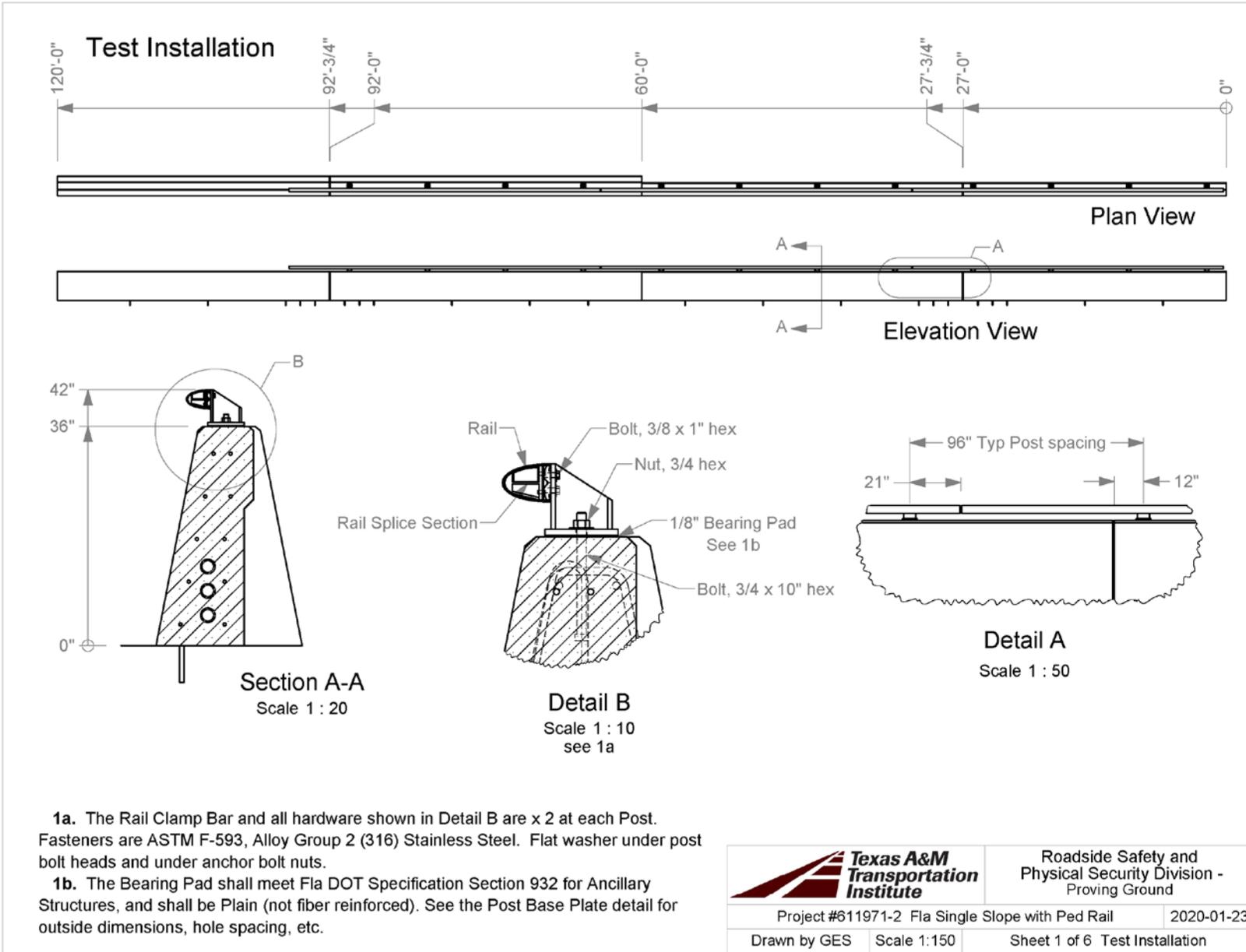
Note: S = Satisfactory

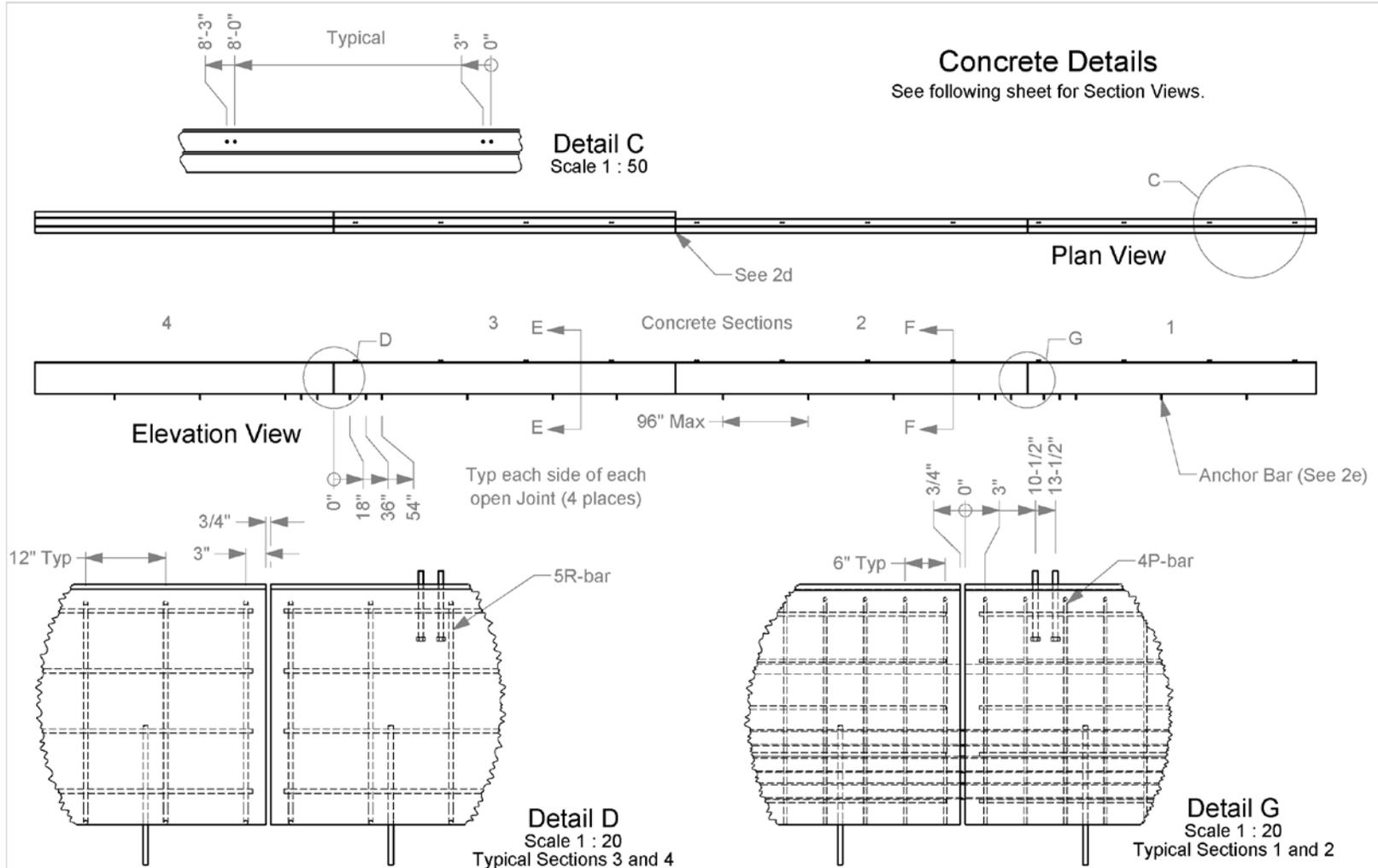
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## REFERENCES

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

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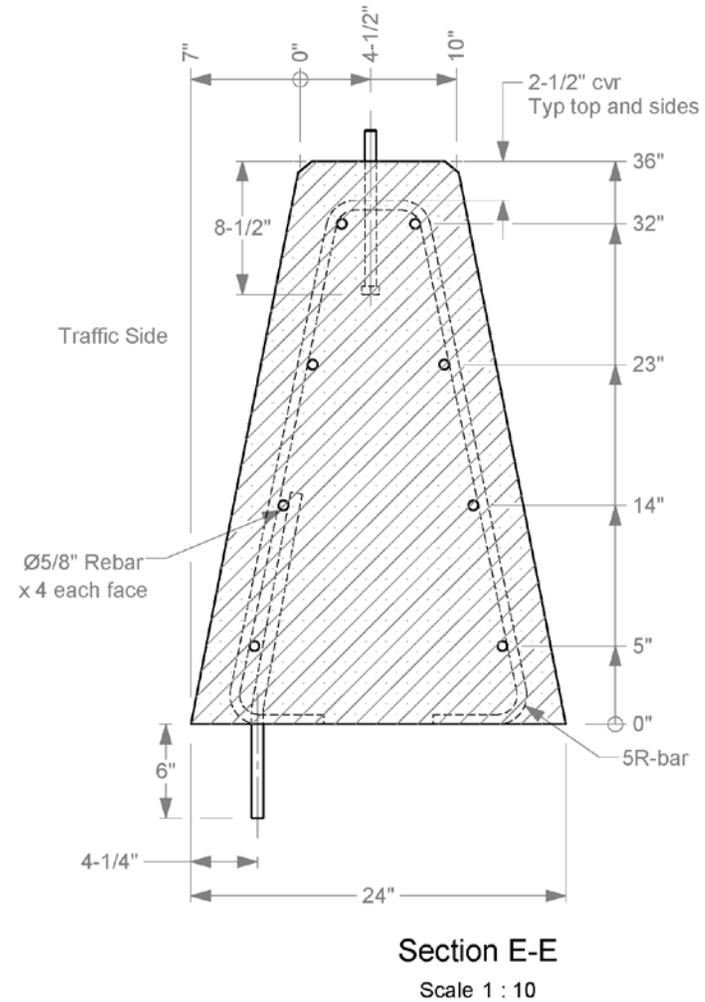
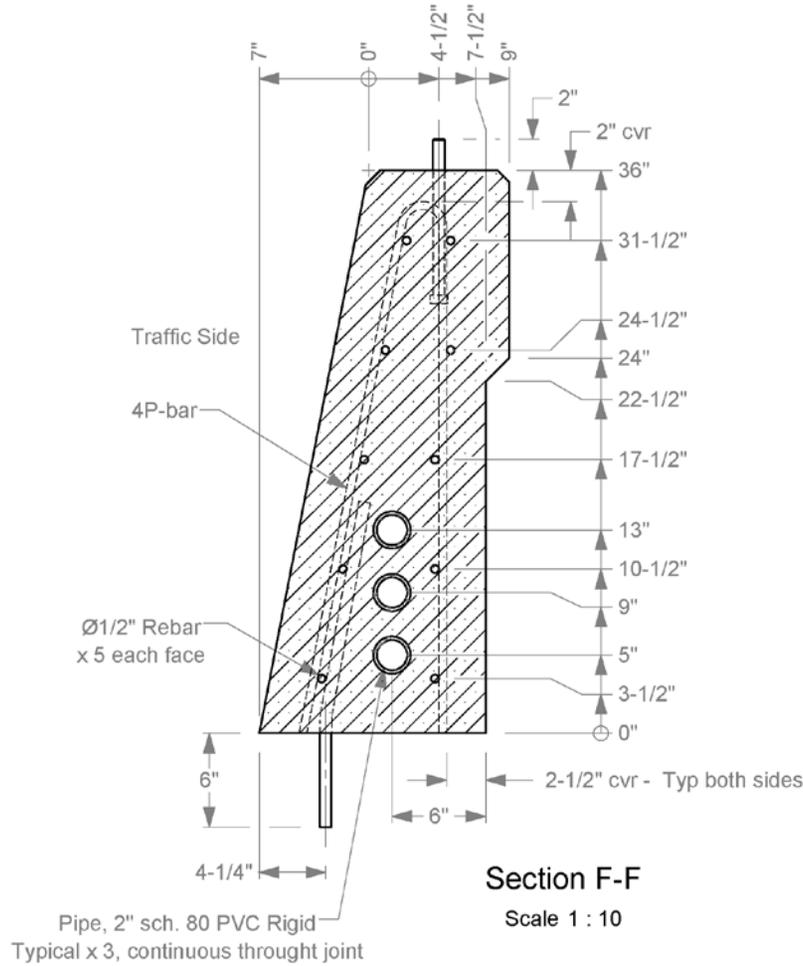
- 2a. Concrete shall be 3400 psi. Chamfer top edges of Parapets 3/4".
- 2b. Rebar dimensions are to the centerline unless otherwise indicated by cvr (cover).
- 2c. Minimum rebar lap is 17" for #4 bars and 21" for #5 bars. All rebar is grade 60.
- 2d. Cold joint between profiles, with no space.
- 2e. Secure in existing concrete with Hilti HIT-RE 500 V3 epoxy according to manufacturer's instructions. See next sheet for additional dimensions.



Roadside Safety and  
Physical Security Division -  
Proving Ground

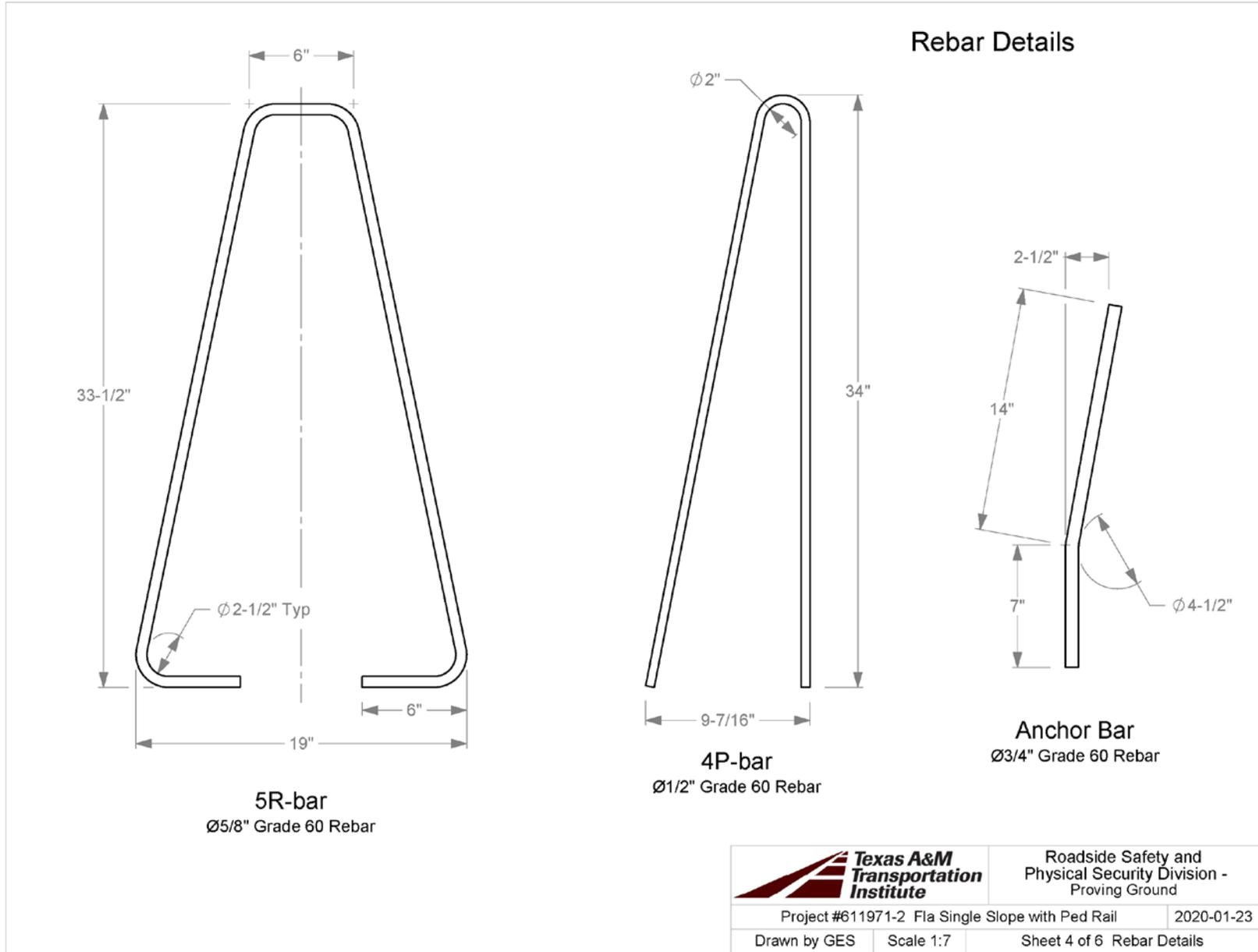
Project #611971-2 Fla Single Slope with Ped Rail		2020-01-23
Drawn by GES	Scale 1:150	Sheet 2 of 6 Concrete Details

### Concrete Section Views

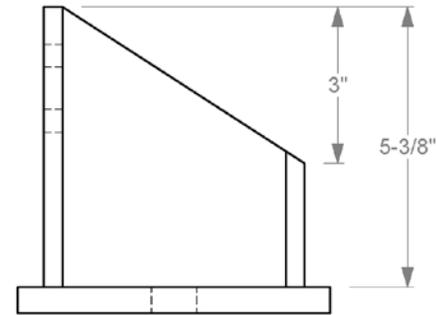
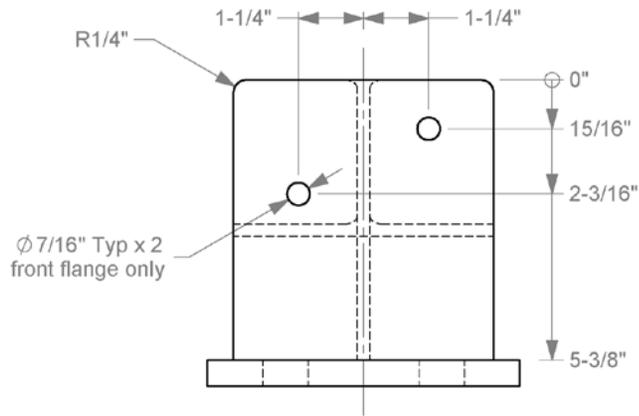
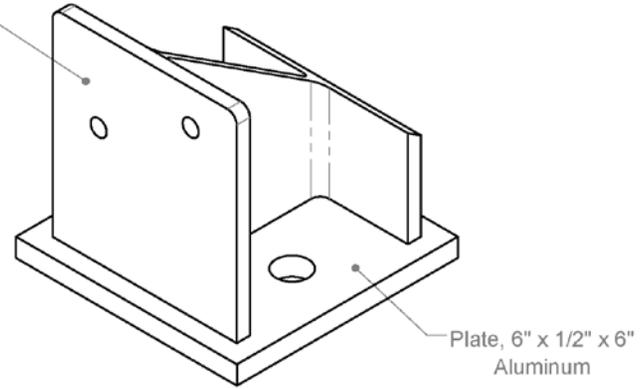
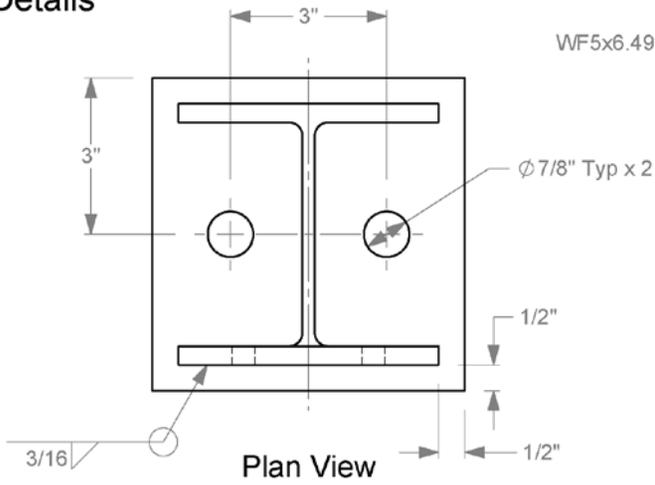


- 3a. Concrete shall be 3400 psi. Chamfer top edges 3/4".
- 3b. Minimum rebar lap is 24" for #4 bars and 26" for #5 bars. All rebar is grade 60.
- 3c. Rebar dimensions are to the centerline unless otherwise indicated by cvr (cover). Bolt locations are to centerline.

	Roadside Safety and Physical Security Division - Proving Ground		
	Project #611971-2 Fla Single Slope with Ped Rail	2020-01-23	
Drawn by GES	Scale 1:10	Sheet 3 of 6 Concrete Section Views	



### Post Details



Roadside Safety and  
Physical Security Division -  
Proving Ground

Project #611971-2 Fla Single Slope with Ped Rail

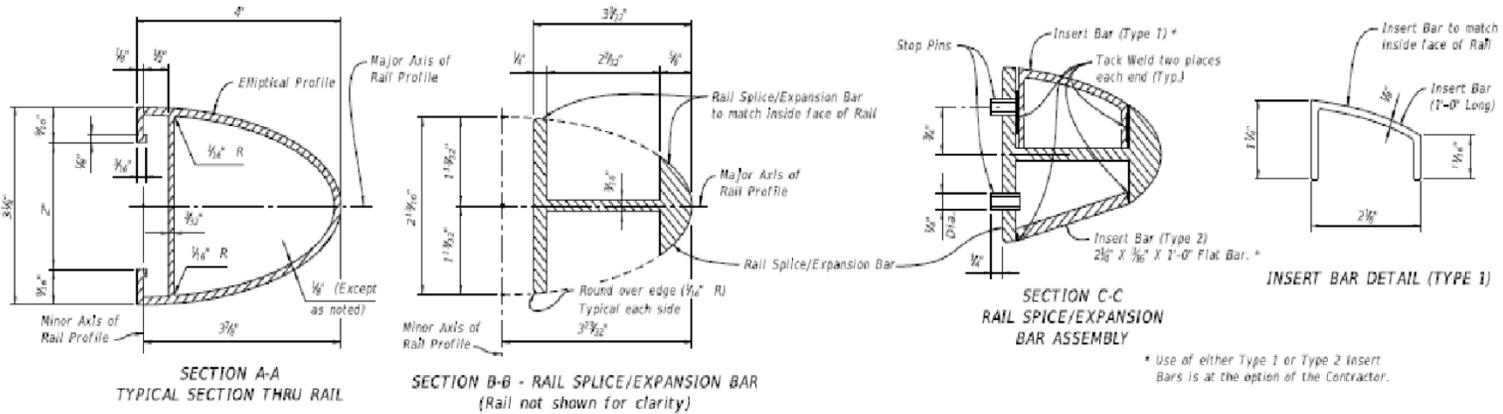
2020-01-23

Drawn by GES

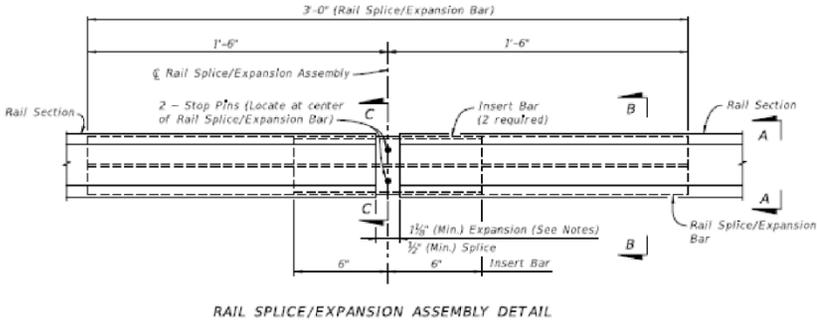
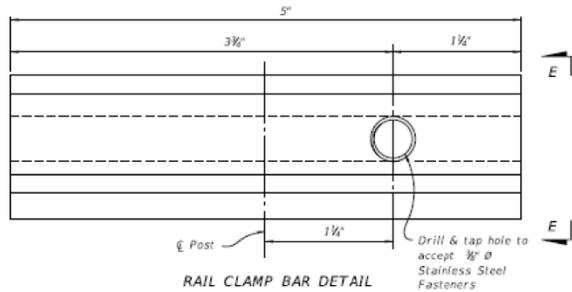
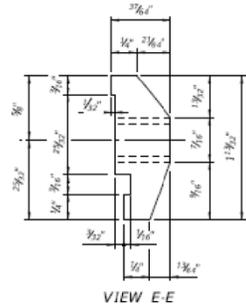
Scale 1:3

Sheet 5 of 6 Post Details

### Rail and Clamp Bar Details



\* Use of either Type 1 or Type 2 Insert Bars is at the option of the Contractor.



- 6a. Details on this sheet are taken from FlaDOT Drawing #515-022.
- 6b. Rails shall be 31'-11-1/4" long.
- 6c. Plates and Bars shall be ASTM B209 Alloy 6061-T6. Rails shall be ASTM B221 Alloy T-6 or T-5. The Stop Pins shall be press-fit, and either aluminum or stainless steel pins or tubes.

	Roadside Safety and Physical Security Division - Proving Ground	
	Project #611971-2 Fla Single Slope with Ped Rail	2020-01-23
Drawn by GES	Scale 1:50	Sheet 6 of 6 Rail and Clamp Bar Details

## APPENDIX B. SUPPORTING CERTIFICATION DOCUMENTS



Phone: 800-547-6758 | Fax: 503-227-4634  
 3441 NW Guam Street, Portland, OR 97210  
 Web: www.portlandbolt.com | Email: sales@portlandbolt.com

+-----+  
 | CERTIFICATE OF CONFORMANCE |  
 +-----+

**For:** CUSTOM FABRICATORS & REPAIRS  
**PB Invoice#:** 128987  
**Cust PO#:** TUCKER 25587  
**Date:** 2/19/2020  
**Shipped:** 2/19/2020

We certify that the following items were manufactured and tested in accordance with the chemical, mechanical, dimensional and thread fit requirements of the specifications referenced.

---

**Description:** 3/4 X 10 GALV ASTM A307A HEX BOLT

Heat#:	1202014242	Base Steel: A36	Diam: .68
Source: NUCOR STEEL		Proof Load:	0
C : .120	Mn: .620	P : .004	Hardness: 0
S : .036	Si: .180	Ni: .120	Tensile: 65,600 PSI RA: 57.00%
Cr: .170	Mo: .030	Cu: .300	Yield: 49,400 PSI Elon: 28.00%
Pb: .000	V : .001	Cb: .000	Sample Length: 8 INCH
N : .000	CE: .2531	Charpy:	CVN Temp:

---

**Nuts:**  
 ASTM A563A HEX

**Washers:**  
 ASTM F436-1 RND

**Coatings:**  
 ITEMS HOT DIP GALVANIZED PER ASTM F2329/A153C

**Other:**  
 ALL ITEMS MELTED & MANUFACTURED IN THE USA

---

By:   
 Certification Department Quality Assurance  
 Dane McKinnon



### Mill Certification

07/12/2019

MTR#:220744-1  
Lot #:120201424260  
W CEMETERY ROAD  
PLYMOUTH, UT 84330 US  
800-453-2886  
Fax: 435-458-2309

Sold To: PORTLAND BOLT & MFG INC  
3441 NW GUAM AVE  
PORTLAND, OR 97208 US

Ship To: PORTLAND BOLT & MFG INC  
3441 NW GUAM AVE  
PORTLAND, OR 97208 US

Customer PO	41273	Sales Order #	12026334 - 1.2
Product Group	Hot Roll - Merchant Bar Quality	Product #	3008569
Grade	F1554 Gr 36	Lot #	120201424260
Size	0.68"	Heat #	1202014242
BOL #	BOL-307820	Load #	220744
Description	Hot Roll - Merchant Bar Quality Round 0.68" F1554 Gr 36 20' 0" [240'] 2001-6000 lbs	Customer Part #	
Production Date	07/09/2019	Qty Shipped LBS	60912
Product Country Of Origin	United States	Qty Shipped EA	2464
Original Item Description		Original Item Number	

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.

Melt Country of Origin : United States

Melting Date: 07/01/2019

C (%)	Mn (%)	P (%)	S (%)	Si (%)	Ni (%)	Cr (%)	Mo (%)	Cu (%)	V (%)	Nb (%)
0.12	0.62	0.004	0.036	0.18	0.12	0.17	0.03	0.30	0.001	0.000

#### Other Test Results

Yield (PSI) : 49400

Yield (PSI) : 48600

Tensile (PSI) : 65600

Tensile (PSI) : 65800

Elongation in 8" (%) : 28.0

Elongation in 8" (%) : 27.0

Reduction of Area (%) : 57

#### Comments:

ASTM A36/A36M-14, ASTM F1554-17e1 Gr36

Nucor-Plymouth is an ISO-9001 and an ABS certified mill. CMTR complies with DIN EN 10204 – 3.1 All manufacturing processes of the steel materials in this product, including melting, casting, and hot rolling have occurred in the United States. All products produced are weld free. Mercury, in any form, has not been used in the production or testing of this material.

Bryden Morris, Chief Metallurgist



# DECKER

SINCE 1927

www.deckernut.com

DECKER MANUFACTURING CORPORATION  
703 N. Clark Street  
Albion, Michigan 49224  
P: 517.629.3555 • F: 517.629.3535

LABORATORY AND TESTING FACILITY

Reaffirmed to be in compliance to current Rev Level, Form 8.0  
ORIGINAL LABORATORY AND/OR INSPECTION REPORT  
**THIS IS A LEGAL DOCUMENT**

NAME AND ADDRESS OF CLIENT: \_\_\_\_\_  
 PAGE 1 OF 2 DATE OF MANUFACTURE: 02-20-19  
 LAB FILE ID NUMBER/LOT NUMBER: 19-40-006  
 DMC PART NUMBER #: 026-1210-26  
 ITEM DESCRIPTION: 3/2 x 1/2 28 HEX NUT + 02.0  
 GRADE ID MARK AND INSIGNIA: DMC  
 NAME (S) OF PERSON (S) SAMPLING: S. Forcella SAMPLING  
 PROCEDURES ARE UNDER THE SUPERVISION OF DECKER MANUFACTURING CORPORATION'S  
 QUALITY DEPARTMENT.  
 PRODUCTION LOT SIZE: <200M SUITABILITY/CONDITION OF TEST SPECIMENS: ACCEPTABLE  
 TOTAL NO. OF SAMPLES INSPECTED AND/OR TESTED: (8) EIGHT  
 INSPECTIONS AND/OR TESTS:  
 INSPECTION/TEST DATE (S): 3-19-19 3-18-19  
 DESCRIPTION (S): ROCKWELL HRB PROOFLOAD  
 SPECIFICATION (S): ASTM E12 ASTM E606  
 REQUIREMENTS: ASTM A563 GRADE B @ HRB @ MIN @ HRS 32 MAX ASTM A563 GRADE B @ @ 30,000 LBF  
 EQUIPMENT ID: # PH10000120120012 # 184280

INSPECTION / TEST RESULTS:

UNIT OF MEASUREMENT: HRB W				UNIT OF MEASUREMENT: LBF			
(1)	86.95	(5)	89.45	(1)	30,800	(5)	31,200
(2)	89.4	(6)	88.75	(2)	31,000	(6)	31,000
(3)	86.9	(7)	89.25	(3)	31,300	(7)	30,800
(4)	89.85	(8)	89.4	(4)	30,900	(8)	31,000

RESULTS OBTAINED FROM: Wearout Tests  
 SPECIFICATION OR MATERIAL GRADE AS EVIDENCED: C-1010  
 REMARKS OR DEVIATIONS: MEET AND EXCEED ASTM A563 (02) GRADE B REQUIREMENTS  
PER ASTM E606 SECTION 4 THE HARDNESS OF EACH SAMPLE IS THE AVERAGE OF TWO READINGS.  
 HEAT TREAT, SURFACE TREATMENT, COATING, ETC.: None seen. Samples were Government  
 All parts reported on this document were manufactured at this location in the United States from domestic materials.

**TO THE SPECIFICATIONS ABOVE, THE SAMPLES INSPECTED AND/OR TESTED**

CONFORM:  ARE RESULTS ONLY: \_\_\_\_\_ DO NOT CONFORM: \_\_\_\_\_  
 APPROVED SIGNATORY \_\_\_\_\_ INSPECTED AND/OR TESTED BY: \_\_\_\_\_  
 QUALITY MANAGER \_\_\_\_\_ Authorized Lab Technician

*Russell L. Wilson*  
 Russell L. Wilson

*Michael J. Heaton*  
 Authorized Lab Technician

I CERTIFY THAT THE ABOVE TEST WAS CONDUCTED IN ACCORDANCE WITH THE APPLICABLE SPECIFICATION (S) AND THAT THE RESULTS ARE CORRECT AS ENTERED. THE ABOVE RESULTS ONLY PERTAIN TO THE SAMPLES TESTED. OFF THE QUALITY MANAGER FOR MANUFACTURING DEPT COMPANY. THIS DOCUMENT SHALL NOT BE REPRODUCED OR COPIED WITHOUT THE APPROVAL OF DECKER MANUFACTURING CORPORATION. DO NOT SIGN OR ALTER ANY ERRORS - DRAW A SEPARATE LINE THROUGH AND INITIAL. SEE REVERSE OF THIS DOCUMENT FOR THE TERMS AND CONDITIONS OF THIS TEST REPORT. THE DECISION MADE IS SIMPLE EXPERIENCE. (BY DECISION RULE IS SIMPLE EXPERIENCE).



TESTING CERT # 0499-01



SINCE 1927

www.deckernut.com

DECKER MANUFACTURING CORPORATION  
783 N. Clark Street  
Albion, Michigan 49224  
P: 517.629.3955 • F: 517.629.3696

LABORATORY AND TESTING FACILITY  
Addendum to FORM 8.x Form 8.4  
ROCKWELL DATA COLLECTION WORKSHEET

PAGE 2 OF 2 DATE OF MANUFACTURE: \_\_\_\_\_  
LAB FILE ID NUMBER/LOT NUMBER: 19-40-006  
DMC PART NUMBER #: 026-1210-16  
ITEM DESCRIPTION: 3/4" x 10 38 HEX NUT + 020  
NAMES(S) OF PERSON(S) SAMPLING: Z. BROOKS S. ESTEVEZ SAMPLING PROCEDURES ARE UNDER THE SUPERVISION OF DECKER MANUFACTURING CORPORATION'S QUALITY DEPARTMENT.  
INSPECTION/TEST DATE (S): 3-17-09  
DESCRIPTION (S): ROCKWELL HRB  
SPECIFICATION (S): ASTM A-563  
REQUIREMENTS: ASTM A-563 B @ HRB 69 MIN & HRC 32 MAX.  
EQUIPMENT ID: # FH-10000170120012

INSPECTION / TEST RESULTS:

UNIT OF MEASUREMENT: <u>HRB</u>	Individual readings	Total	Mean Average
(1)	<u>87.1 . 86.8 :</u>	<u>173.9 :</u>	<u>86.95 :</u>
(2)	<u>89.1 . 89.7 :</u>	<u>178.8 :</u>	<u>89.4 :</u>
(3)	<u>85.6 . 88.2 :</u>	<u>173.8 :</u>	<u>86.9 :</u>
(4)	<u>90.0 . 89.7 :</u>	<u>179.7 :</u>	<u>89.85 :</u>
(5)	<u>88.9 . 90.0 :</u>	<u>178.9 :</u>	<u>89.45 :</u>
(6)	<u>87.5 . 90.0 :</u>	<u>177.5 :</u>	<u>88.75 :</u>
(7)	<u>88.9 . 89.6 :</u>	<u>178.5 :</u>	<u>89.25 :</u>
(8)	<u>88.7 . 90.1 :</u>	<u>178.8 :</u>	<u>89.4 :</u>

READINGS OBTAINED FROM W WRENCH FLATS: \_\_\_\_\_ BEARING SURFACE: \_\_\_\_\_ CORE: \_\_\_\_\_  
PER ASTM F408 PARAGRAPH 4.12 THE REPORTED HARDNESS IS THE AVERAGE OF 2 READINGS OF EACH TEST SAMPLE.  
IN ADDITION ALL READINGS SHALL BE WITHIN HARDNESS VALUES LISTED IN THE PRODUCT SPECIFICATION.

INSPECTED AND/OR TESTED BY:

[Signature]  
Authorized Lab Technician

I CERTIFY THAT THIS REPORT WAS PREPARED BY THE PERSON(S) IDENTIFIED WITH THE ABOVE SIGNED REPRESENTATION (S) AND THAT THE RESULTS ARE CORRECT AS REPORTED. THE ABOVE RESULTS ONLY PERTAIN TO THE SAMPLE(S) IDENTIFIED. USE THE QUALITY MANUAL FOR ADDITIONAL REPORT GUIDANCE. THIS DOCUMENT SHALL NOT BE REPRODUCED IN ANY MANNER WITHOUT THE APPROVAL OF DECKER MANUFACTURING CORPORATION. DO NOT MAKE OR ATTEMPT TO MAKE ANY CHANGES TO THIS REPORT LINE NUMBER AND INITIALS. THE PURPOSE OF THIS DOCUMENT FOR THE USER AND BENEFITERS OF THIS TEST REPORT. THE DECISION MADE IS ENTIRELY UNASSISTED.





# CHARTER STEEL

A Division of  
Charter Manufacturing Company, Inc.

Melted in USA Manufactured in USA

EMAIL

145B Cold Springs Road  
Saukville, Wisconsin 53080  
(262) 269-2400  
1-800-437-8789  
Fax (262) 269-2570

## CHARTER STEEL TEST REPORT

Decker Manufacturing Corp.  
703 N. Clark St.  
Albion, MI-48224

Cust P.O.	997
Customer Part #	1.062 1015
Charter Sales Order	30158420
Heat #	10673200
Ship Lot #	4660626
Grade	1015 A AK FG RHQ 1-1/16 RND COIL
Process	HRCC
Finish Size	1-1/16
Ship date	16-SEP-18

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed below and that it satisfies these requirements. The recording of false, fictitious and fraudulent statements or entries on this document may be punishable as a felony under federal statute.

Lab Code: 7388  
CHEM  
%Wt

Test results of Heat Lot # 10673200											
	C	MN	P	S	SI	NI	CR	MO	CU	SN	V
	.14	.36	.007	.006	.080	.04	.08	.01	.08	.006	.001
	AL	N	B	TI	NS						
	.022	.0060	.0001	.001	.001						

Test results of Rolling Lot # 1252038					
	# of Tests	Min Value	Max Value	Mean Value	
ROCKWELL B (HRBW)	1	84	84	84	RB LAB = 0368-02
ROD SIZE (Inch)	4	1.056	1.086	1.061	
ROD OUT OF ROUND (Inch)	2	.009	.010	.010	

REDUCTION RATIO=34:1

Specifications: Manufactured per Charter Steel Quality Manual Rev Date 06/12/17  
Charter Steel certifies this product is indistinguishable from background radiation levels by having process radiation detectors in place to measure for the presence of radiation within our process & products.  
Meets customer specifications with any applicable Charter Steel exceptions for the following customer documents:  
Customer Document = ASTM A29/A29M Revision = 16 Dated = 01-DEC-16

Additional Comments:

Melt Source:  
Charter Steel  
Saukville, WI, USA

Trip: 1305334



Page 1 of 2

This MTR supersedes all previously dated MTRs for this order

*Janice Barnard*  
Janice Barnard Division Mgr. of Quality Assurance  
barnard.j@chartersteel.com  
Printed Date : 09/18/2018

The following statements are applicable to the material described on the front of this Test Report:

1. Except as noted, the steel supplied for this order was melted, rolled, and processed in the United States meeting DFARS compliance, LEEDS compliance, REACH compliance, ROHS-WEEE compliance, and Conflict Materials Restrictions.
2. Mercury was not used during the manufacture of this product, nor was the steel contaminated with mercury during processing.
3. Unless directed by the customer, there are no welds in any of the coils produced for this order.
4. The laboratory that generated the analytical or test results can be identified by the following key:

Certificate Number	Lab Code	Laboratory	Address
0358-01	7388	CSSM Charter Steel Melting Division	1658 Cold Springs Road, Saukville, WI 53080
0358-02	8171	CSSR/ CSSP Charter Steel Rolling/ Processing Division	1658 Cold Springs Road, Saukville, WI 53080
0358-03	123633	CSFP Charter Steel Ohio Processing Division	6255 US Highway 23, Rising Sun, OH 43457
0358-04	125544	CSCM/ CSCR Charter Steel Cleveland	4300 E. 49th St., Cuyahoga Heights, OH 44125-1004
*	*	Subcontracted test performed by laboratory not in Charter Steel System	

5. When run by a Charter Steel laboratory, the following tests were performed according to the latest revisions of the specifications listed below, as noted in the Charter Steel Laboratory Quality Manual:

Test	Specifications				
		CSSM	CSSR/ CSSP	CSFP	CSCM/ CSCR
Chemistry Analysis	ASTM E415; ASTM E1019	X			X
Macroetch	ASTM E381	X			X
Hardenability (Jominy)	ASTM A255; SAE J406; JIS G0561	X			X
Grain Size	ASTM E112	X	X	X	X
Tensile Test	ASTM E8; ASTM A370		X	X	X
Rockwell Hardness	ASTM E18; ASTM A370	X	X	X	X
Microstructure (spheroidization)	ASTM A892		X	X	
Inclusion Content (Methods A, E)	ASTM E45		X		X
Decarburization	ASTM E1077		X	X	X

Charter Steel has been accredited to perform all of the above tests by the American Association for Laboratory Accreditation (A2LA). These accreditations expire 01/31/19. All other test results associated with a Charter Steel laboratory that appear on the front of this report, if any, were performed according to documented procedures developed by Charter Steel and are not accredited by A2LA.

6. The test results on the front of this report are the true values measured on the samples taken from the production lot. They do not apply to any other sample.
7. This test report cannot be reproduced or distributed except in full without the written permission of Charter Steel. The primary customer whose name and address appear on the front of this form may reproduce this test report subject to the following restrictions:
  - It may be distributed only to their customers
  - Both sides of all pages must be reproduced in full
8. This certification is given subject to the terms and conditions of sale provided in Charter Steel's acknowledgement (designated by our Sales Order number) to the customer's purchase order. Both order numbers appear on the front page of this Report.
9. Where the customer has provided a specification, the results on the front of this test report conform to that specification unless otherwise noted on this test report.



✓ Same C  
JMK

# INDIANA GALVANIZING, LLC

Hot-Dip Galvanizing  
51702 Lovejoy Dr.  
Middlebury IN, 46540  
Phone: 574-822-9102 Fax: 574-822-9106

**Customer**  
Decker Manufacturing Corporation  
703 North Clark Street  
Albion MI 49224

PO: 1757  
DATE: 4/1/2019

### Hot-Dip Galvanizing Certification

Indiana Galvanizing certifies that samples representing listed lot(s) have been tested and inspected as required by applicable specifications. The results of this inspection and testing demonstrates that the requirements for ASTM F2329, including the requirements ASTM A153 Class D, Class C that are referenced within the specification, have been met and have been galvanized in Middlebury, Indiana of the United States of America. Indiana Galvanizing LLC is RoHS compliant.

Kettle Temperature (Must be between 815 and 850 Degrees Fahrenheit)

840

### Mil Readings

Part Number	Lot Number	Quantity	High	Low	Average
035-1031-92	19-42-007	20,126	3.90	2.40	3.30
035-1031-92	19-52-012	40,684	3.95	2.45	3.25
035-1031-92	19-52-013	20,103	3.95	2.40	3.30
035-1031-92	19-52-017	19,598	4.00	2.30	3.20
026-1608-92	19-44-001	12,085	3.90	2.40	3.25
026-1210-92	19-40-006	77,782	3.95	2.10	3.15
026-0813-92	19-39-006	39,250	3.80	2.15	3.10
026-0813-92	19-39-008	41,639	3.85	2.25	3.25
026-0616-92	19-36-008	228,134	3.90	2.25	3.15

*Amy Jarzynski*

Quality Manager or Assignee



**TECHNICAL STAMPING, INC.**

50600 E. RUSSELL SCHMIDT BLVD.  
 CHESTERFIELD TWP., MI 48051  
 PH(580)948-3285 / FX(580)948-3286

**MATERIAL  
 CERTIFICATION**

CUSTOMER NAME		CUSTOMER ORDER NUMBER				DATE		
Portland Bolt & Mfg Co		43577				11/25/19		
PART NUMBER - CUSTOMER LOT NO.		LOT NUMBER				QUANTITY		
3/4" F436 Hdg 16445		0719-210				20,000		
STEEL GRADE	HEAT	C	MN	P	S	SI	AL	REVISION
	B53150	.52	.68	.011	.001	.17	.046	ASTM F436-10
SPECIFICATION		ACTUAL				GAUGE		
O.D - 1.436 - 1.500		1.445 - 1.448				CALIPER		
I.D - .813 - .845		.824 - .827				CALIPER, PIN GAUGE		
THICKNESS- .122 - .177		.128 - .131				MICROMETER		
FLAT- Max .010		.004				CALIPER		
HEAT TREAT - 38 - 45 HRC		40 - 42						
PLATING-		See Attached Cert						
OTHER		N/A						

WE HEREBY CERTIFY THIS PRODUCT WAS PRODUCED UNDER A ISO-9001: QUALITY ASSURANCE SYSTEM. ISO-9001: CERTIFICATION NUMBER-1266 - DATE OF REGIS. JAN. 9, 2003  
 ALL MATERIALS ARE MADE AND MELTED IN THE U.S.A. THIS PRODUCT WAS MANUFACTURED IN CHESTERFIELD, MICHIGAN, U.S.A. THIS PRODUCT CONFORMS TO ALL REQUIREMENTS  
 FOR WASHERS AS PRODUCED ACCORDING TO A.S.T.M. F-436-10. THE ABOVE TEST RESULTS APPLY ONLY TO THE ITEMS TESTED. THIS TEST REPORT MUST NOT BE REPRODUCED  
 EXCEPT IN FULL WITHOUT PRIOR WRITTEN APPROVAL.

*Shirley Nelson*

AUTHORIZED SIGNATURE

CERTIFIED ISO 9001:

"MADE AND MANUFACTURED IN THE USA"

104V-3008 Rev. 2 11/26/01

43577-3

1529

# INDUSTRIAL STEEL TREATING COMPANY, INC

613 Carroll Street Jackson, MI 49202  
P.O. Box 98 Jackson MI, 49204  
Voice: 517-787-6312 Fax: 517-787-6441

## HEAT TREAT CERTIFICATION

Customer:  
**TECHNICAL STAMPING, INC.**  
Attn: SHANNON COX  
50600 E. RUSSELL SCHMIDT  
CHESTERFIELD, MI 48051

Certification Date:  
**07/31/2019**

Page: 1 of 1

### Order Details

Part Number: F0034  
Packing Slip: 7184  
Purchase Order:  
IST Order Number: 762970-1  
Lot Number: 0719-210  
Heat Number: B53150

Blue Print Rev: 1279  
Material Type: 1030 - 1050  
Quantity: 296,569  
Net Weight: 11,151.0  
Part Desc: WASHER  
Comments: 7 TUBS#988, C110, 104, B601,  
1214, C44, C117

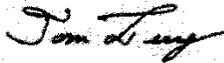
### SPECIFICATIONS

HRC 38 - 45  
HEAT TREATED IN THE USA

### RESULTS

HRC 40 - 42  
HEAT TREATED IN THE USA

Approval:



Tom Levy - Quality Assurance Supervisor

Contact

Tom Levy - Quality Assurance Supervisor  
Voice: 517-780-9043 Fax: 517-787-6441  
E-Mail: tolevy@indstl.com

This Certification cannot be reproduced except in full, without written authorization from Industrial Steel Treating Company, LLC.

9291

CERTIFICATE OF CONFORMANCE

SABRE STEEL INC.  
23680 RESEARCH DRIVE  
FARMINGTON HILLS, MI 48335  
248-615-0500



7/9/2019 2:52:13 PM

Sold To: TECHNICAL STAMPING  
50800 E. RUSSELL SCHMIDT BLVD.  
CHESTERFIELD TWP., MI 48051

Ship To: TECHNICAL STAMPING  
50800 RUSSELL SCHMIDT BLVD.  
CHESTERFIELD TWP., MI 48051

Cust PO: S91526

Ship Date: 7/11/2019

Sales Order: 76481

Weight: 98,770#

CHEMICAL ANALYSIS

Heat Number:	B53150		
C:	.52	Mn:	.68
Si:	.17	Ti:	.006
Cu:	.02	Al:	.045
Ni:	.01	B:	
		P:	.011
		Cr:	.06
		Co:	.001
		Sr:	
		S:	.001
		Mo:	
		Va:	.005
		N:	

PHYSICAL PROPERTIES

YS: TS: E:

Chemistry: C1050

Line: 1 Item: .122min x 5.88 HRPO C1050  
Grade: HRP&O High Carbon  
Cust Part: F0034M

Comment: Tags 65467 A thru Z Made & Melted in US

WE HEREBY CERTIFY THE ABOVE FIGURES ARE ACCURATELY STATED, MEET YOUR MATERIAL REQUIREMENTS AND ARE TRACEABLE IN OUR RECORDS BACK TO THE PRODUCER AND/OR AN ACCREDITED TEST LABORATORY.

Quality Assurance Manager

9291

5/20/2019

**CERTIFIED REPORT OF CHEMICAL ANALYSIS  
AND MECHANICAL TESTS**



This report shall not be reproduced in whole or in part without the prior written approval from ArcelorMittal USA LLC.

Page 1 of 1

SOLD TO		VENDOR										
SABRE STEEL 23680 RESEARCH DRIVE FARMINGTON HILLS MI		ArcelorMittal Riverdale LLC. 13500 South Perry Avenue Riverdale, IL 60827										
SHIP TO		ORDER INFORMATION										
SABRE STEEL C/O VOSS TAYLOR C/O VOSS STEEL CORP 7925 BEECH DALY RD TAYLOR MI		PO#: 65174/8 LoadID # 03162368 SO#: 162695 Carrier: COMMON CARRIER Date Of Issuance/ 5/14/2019 Invoice # 0500280566 Shipped:										
ORDERED DIMENSIONAL INFORMATION												
Heat	Coil	Thickness (in)	Width (in)	Weight (tons)	Reduction Ratio							
B53150	604418	0.124	48,000	23.9	94.27% (17:1)							
<small>HEAT NUMBER IS BEING USED AS CERTIFICATE NUMBER. Thickness and Width are ordered size. Weight of steel is not an ASTM accepted measurement. COUNTRY OF ORIGIN/EXPORT COUNTRY IS USA. FOR QUESTIONS CONCERNING IMPORTATION OF THIS MATERIAL PLEASE CONTACT: JOSE CASHEROS, 1 SOUTH DEARBORN ST., CHICAGO, IL, 60683; TEL: 1-813-769-3756 E-MAIL: Jose.Casheros@arcelormittal.com</small>												
PRODUCT INFORMATION												
Grade	Part Number	Product Description	Comments									
SAE 1050	HB1244800-	Hot Band Prime										
<small>This material was melted and manufactured in the USA. All products are strain cast and free of mercury or radioactive elements. Elongation based on 2" gage length.</small>												
MECHANICAL / PHYSICAL TEST RESULTS*												
Heat	Coil	Yield (ksi)	Tensile (ksi)	El (%)	Dir	N-Value	N-Range	Hardness	Ft-lbs	*E	See	Dir
<small>* Material tested in accordance with ISO-17025 by an accredited lab.</small>												
CHEMICAL TEST RESULTS												
Heat	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Cb	V	Al
B53150	.52	.68	.011	.001	.17	.02	.01	.05	.00	.000	.005	.046
	N	Sn	B	Ti	Ca	Sb						
	.0033	.005	.0001	.0060	.0013	.0010						

Chemical analysis was performed by ArcelorMittal Riverdale, Inc. in accordance with the Current Version of ASTM E415 and E1019.

We hereby certify the above is correct as contained in the records of the corporation and in compliance with the requirements of the order. All tests performed to the current standard to date unless otherwise noted. Uncertainties of measurements estimated and are available upon request. These results relate only to the items tested. Test results marked with an asterisk (\*) were reported by an external accredited lab. Test certificates are prepared in accordance with procedures outlined in DIN EN 10204:2006 Type 3.1.

Web: [www.arcelormittal.com](http://www.arcelormittal.com)

*Timothy S. Kaurich*  
 Timothy S. Kaurich | Manager - Quality  
 13500 South Perry Ave., Riverdale IL 60827  
 T (708)392-1016 | Tim.Kaurich@ArcelorMittal.com



September 17, 2019

Technical Stamping  
50600 E. Russell Schmidt  
Chesterfield TWP, MI 48051

To Whom It May Concern:

This is to certify that the hot dip galvanizing of the following washers on your Purchase Order number 1648 conforms to specification ASTM A-153. The following sizes and lot numbers comply with the coating, workmanship, finish, and appearance requirements of ASTM F2329 specifications. The hot dip galvanizing is ROHS compliant. The galvanizing process was conducted in a temperature range of 830F to 855F.

<u>PIECES</u>	<u>PART # &amp; SIZE</u>	<u>LOT NUMBER</u>	<u>AVERAGE ZINC COATING IN MILS.</u>
294910	F0034 3/4" Washer	0719-210	5.76

This certification in no way implies anything other than the quality of our hot dip galvanizing as it pertains to your order.

This product was galvanized in Rockford, IL USA

Yours very truly,

AZZ Galvanizing Rockford, IL

A handwritten signature in cursive script that reads 'Peggy Doering'.

Peggy Doering  
Office Manager

PD:mt

TR No. 611971-02-1

44

2020-06-24



Phone: 800-547-6758 | Fax: 503-227-4634  
 PO Box 2866 | Portland, OR 97208

CERTIFICATION	ORDER	128987
MTR - EMAIL ONLY		

JT

S H I P P E R S	CUSTOM FABRICATORS & REPAIRS 1379 HARVEY MITCHELL PKWY BRYAN TX 77803 979-775-4297	009888		2/19/20 13:15:41
--------------------------------------	---	--------	--	---------------------

	EXTRAS: N REF# 40997
--	-------------------------

CUSTOMER ORDER NUMBER	TUCKER 25587	ORDERED BY	BRANDON	ORDERED	2/18/20	PROM-ISED	2/19/20		2	SALES-MAN	KAILEY	PAGE NO.	1 - 1
SHIP VIA	FREIGHT		FILLED BY	HOLDING AREA			CARTONS	KEGS	SACKS	BUNDLES	SKIDS		
UPS	PREPAID												
QTY ORDERED	B.O.	PRODUCT NO.	DESCRIPTION			P.O.	LINE	WT	STK CHK	QTY SHIPPED	INV SRC		
01	24	18008	3/4 X 10 DOM HEX GAL BOLT A307A 6"RT					28				1	
02			**REMOVE BLUE PAINT**										
03		14188	FREIGHT CHARGES									2	
04	24	16275	3/4 DOMESTIC GAL A563-A HEX NUT			39371	3	3				1	
05	48	16445	3/4 DOMESTIC GAL F436-1 RND WASHER			43577	3	2				1	
TOTAL WEIGHT		DATE SHIPPED		FREIGHT		B/O FROM INVOICE NUMBER		B/O TO INVOICE NUMBER		SALES TAX	TOTAL QTY SHIPPED		
										N			

33#

**CERTIFICATION COPY**

RECEIVED BY X  
 TOT QTY 96



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

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

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

Rolando A. Davila

Quality Assurance Manager

HEAT NO.:3094043		S	CMC Construction Svcs College Stati	S	CMC Construction Svcs College Stati	Delivery#: 82958476
SECTION: REBAR 13MM (#4) 20'0" 420/60		O		H		BOL#: 73382608
GRADE: ASTM A615-18e1 Gr 420/60		L	10650 State Hwy 30	I	10650 State Hwy 30	CUST PO#: 838790
ROLL DATE: 01/13/2020		D	College Station TX	P	College Station TX	CUST P/N:
MELT DATE: 01/11/2020			US 77845-7950		US 77845-7950	DLVRY LBS / HEAT: 41629.000 LB
Cert. No.: 82958476 / 094043A130		T	979 774 5900	T	979 774 5900	DLVRY PCS / HEAT: 3116 EA
		O		O		

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.44%	Bend Test Diameter	1.750IN		
Mn	0.73%				
P	0.008%				
S	0.039%				
Si	0.17%				
Cu	0.34%				
Cr	0.11%				
Ni	0.21%				
Mo	0.088%				
V	0.000%				
Cb	0.002%				
Sn	0.014%				
Al	0.001%				
Yield Strength test 1	64.5ksi				
Tensile Strength test 1	100.9ksi				
Elongation test 1	17%				
Elongation Gage Lgth test 1	8IN				
Tensile to Yield ratio test1	1.56				
Bend Test 1	Passed				

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

REMARKS :



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

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

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

Rolando A Davila

Quality Assurance Manager

HEAT NO.:3093615 SECTION: REBAR 13MM (#4) 40'0" 420/60 GRADE: ASTM A615-18e1 Gr 420/60 ROLL DATE: 12/30/2019 MELT DATE: 12/23/2019 Cert. No.: 82948507 / 093615A371	S O L D T O	GMC Construction Svcs College Stati  10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	S H I P T O	GMC Construction Svcs College Stati  10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 82948507 BOL#: 73368452 CUST PO#: 837870 CUST P/N: DLVRY LBS / HEAT: 19881.000 LB DLVRY PCS / HEAT: 744 EA																																											
<table border="1"> <thead> <tr> <th>Characteristic</th> <th>Value</th> </tr> </thead> <tbody> <tr><td>C</td><td>0.43%</td></tr> <tr><td>Mn</td><td>0.87%</td></tr> <tr><td>P</td><td>0.011%</td></tr> <tr><td>S</td><td>0.042%</td></tr> <tr><td>Si</td><td>0.24%</td></tr> <tr><td>Cu</td><td>0.31%</td></tr> <tr><td>Cr</td><td>0.11%</td></tr> <tr><td>Ni</td><td>0.09%</td></tr> <tr><td>Mo</td><td>0.029%</td></tr> <tr><td>V</td><td>0.000%</td></tr> <tr><td>Ch</td><td>0.001%</td></tr> <tr><td>Sn</td><td>0.008%</td></tr> <tr><td>Al</td><td>0.001%</td></tr> <tr><td>Yield Strength test 1</td><td>66.8ksi</td></tr> <tr><td>Tensile Strength test 1</td><td>102.8ksi</td></tr> <tr><td>Elongation test 1</td><td>14%</td></tr> <tr><td>Elongation Gage Lgth test 1</td><td>8IN</td></tr> <tr><td>Tensile to Yield ratio test1</td><td>1.54</td></tr> <tr><td>Bend Test 1</td><td>Passed</td></tr> </tbody> </table>		Characteristic	Value	C	0.43%	Mn	0.87%	P	0.011%	S	0.042%	Si	0.24%	Cu	0.31%	Cr	0.11%	Ni	0.09%	Mo	0.029%	V	0.000%	Ch	0.001%	Sn	0.008%	Al	0.001%	Yield Strength test 1	66.8ksi	Tensile Strength test 1	102.8ksi	Elongation test 1	14%	Elongation Gage Lgth test 1	8IN	Tensile to Yield ratio test1	1.54	Bend Test 1	Passed	<table border="1"> <thead> <tr> <th>Characteristic</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Bend Test Diameter</td> <td>1.750IN</td> </tr> </tbody> </table>		Characteristic	Value	Bend Test Diameter	1.750IN	<p><b>The Following is true of the material represented by this MTR:</b></p> <ul style="list-style-type: none"> <li>*Material is fully killed</li> <li>*100% melted and rolled in the USA</li> <li>*EN10204:2004 3.1 compliant</li> <li>*Contains no weld repair</li> <li>*Contains no Mercury contamination</li> <li>*Manufactured in accordance with the latest version of the plant quality manual</li> <li>*Meets the "Buy America" requirements of 23 CFR635.410, 49 CFR 661</li> <li>*Warning: This product can expose you to chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information go to <a href="http://www.P65Warnings.ca.gov">www.P65Warnings.ca.gov</a></li> </ul>
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CMC STEEL TEXAS  
1 STEEL MILL DRIVE  
SEGUIN TX 78155-7510

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

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

Rolando A. Davila

Quality Assurance Manager

HEAT NO.:3093124 SECTION: REBAR 16MM (#5) 40'0" 420/60 GRADE: ASTM A615-18e1 Gr 420/60 ROLL DATE: 12/27/2019 MELT DATE: 12/03/2019 Cert. No.: 82940286 / 093124A765	S O L D T O	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	S H I P T O	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 82940286 BOL#: 73355222 CUST PO#: 837155 CUST P/N: DLVRY LBS / HEAT: 48060.000 LB DLVRY PCS / HEAT: 1152 EA																																												
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GMC STEEL TEXAS  
 1 STEEL MILL DRIVE  
 SEGUIN TX 78155-7510

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

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

Rolando A Davila

Quality Assurance Manager

HEAT NO.:3093404 SECTION: REBAR 19MM (#6) 40'0" 420/60 GRADE: ASTM A615-18e1 Gr 420/60 ROLL DATE: 12/16/2019 MELT DATE: 12/15/2019 Cert. No.: 82948507 / 093404A307	S O L D T O	GMC Construction Svcs College Stati  10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	S H I P T O	GMC Construction Svcs College Stati  10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 82948507 BOL#: 73368452 CUST PO#: 837870 CUST P/N: DLVRY LBS / HEAT: 23793.000 LB DLVRY PCS / HEAT: 396 EA																																												
<table border="1"> <thead> <tr> <th>Characteristic</th> <th>Value</th> </tr> </thead> <tbody> <tr><td>C</td><td>0.42%</td></tr> <tr><td>Mn</td><td>0.84%</td></tr> <tr><td>P</td><td>0.012%</td></tr> <tr><td>S</td><td>0.046%</td></tr> <tr><td>Si</td><td>0.19%</td></tr> <tr><td>Cu</td><td>0.35%</td></tr> <tr><td>Cr</td><td>0.14%</td></tr> <tr><td>Ni</td><td>0.25%</td></tr> <tr><td>Mo</td><td>0.101%</td></tr> <tr><td>V</td><td>0.000%</td></tr> <tr><td>Cb</td><td>0.001%</td></tr> <tr><td>Sn</td><td>0.012%</td></tr> <tr><td>Al</td><td>0.000%</td></tr> <tr><td>Yield Strength test 1</td><td>70.3ksi</td></tr> <tr><td>Tensile Strength test 1</td><td>105.8ksi</td></tr> <tr><td>Elongation test 1</td><td>15%</td></tr> <tr><td>Elongation Gage Lgth test 1</td><td>8IN</td></tr> <tr><td>Tensile to Yield ratio test1</td><td>1.50</td></tr> <tr><td>Bend Test 1</td><td>Passed</td></tr> </tbody> </table>		Characteristic	Value	C	0.42%	Mn	0.84%	P	0.012%	S	0.046%	Si	0.19%	Cu	0.35%	Cr	0.14%	Ni	0.25%	Mo	0.101%	V	0.000%	Cb	0.001%	Sn	0.012%	Al	0.000%	Yield Strength test 1	70.3ksi	Tensile Strength test 1	105.8ksi	Elongation test 1	15%	Elongation Gage Lgth test 1	8IN	Tensile to Yield ratio test1	1.50	Bend Test 1	Passed	<table border="1"> <thead> <tr> <th>Characteristic</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Bend Test Diameter</td> <td>3.750IN</td> </tr> </tbody> </table>		Characteristic	Value	Bend Test Diameter	3.750IN	<p><b>The Following is true of the material represented by this MTR:</b></p> <ul style="list-style-type: none"> <li>*Material is fully killed</li> <li>*100% melted and rolled in the USA</li> <li>*EN10204:2004 3.1 compliant</li> <li>*Contains no weld repair</li> <li>*Contains no Mercury contamination</li> <li>*Manufactured in accordance with the latest version of the plant quality manual</li> <li>*Meets the "Buy America" requirements of 23 CFR635.410, 49 CFR 661</li> <li>*Warning: This product can expose you to chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information go to <a href="http://www.P65Warnings.ca.gov">www.P65Warnings.ca.gov</a></li> </ul>	
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REMARKS :



**Customer:**  
Eastern Metal Supply  
3600 23rd Ave South  
Lake Worth FL, 33461

**Sale Order - Item:** 109638 - 1  
**Customer PO:** 362376  
**Manifest:** 678863

**Material Certification**

**KEYMARK CORP.**  
2540 Knights Station Rd.  
Lakeland, FL 33810  
Phone: (863) 858-5500  
Fax: (863) 858-1800  
[WWW.KEYMARKCORP.COM](http://WWW.KEYMARKCORP.COM)

**Die:** FS04157  
**Part:** DOT-61-130  
**Description:** 3.093 X 2.75  
BULLET RAIL INNER  
SPLICE

**Specification Codes:**

ASTM: B221  
MILITARY: N/A  
AMS: 4150, 4160, 4161, 4172, 4173,  
AMS-QQ-A-200/8  
ASME: SB-221

Complies with all applicable chemical composition and mechanical property limits as specified by ASTM B221, ASTM B308/B308M, ASTM B429/B429M, and the Aluminum Association Aluminum Standards & Data Manual. Complies with all dimensional tolerances as specified by ANSI B3.2 and the Aluminum Association Aluminum Standards & Data Manual. CONFORMS TO EUROPEAN UNION DIRECTIVE "Restrictions on the use of certain Hazardous Substances" (RoHS) AND ALL AMENDMENTS

**Chemical Composition**

The material produced on the item number(s) shown below were made from the alloy specified. The following chemical properties have been provided by the original manufacturer of the ingot supplied to extrude this material. It is compared to the standards for the specified alloy as set forth by the Aluminum Association:

Cast Number	Alloy	Type	Silicon (Si)	Iron (Fe)	Copper (Cu)	Manganese (Mn)	Magnesium (Mg)	Chromium (Cr)	Zinc (Zn)	Titanium (Ti)	Other	Aluminum
E8D5777A	6061	P	= 0.60	= 0.18	< 0.17	= 0.05	= 0.82	< 0.06	< 0.01	= 0.01	= 0.00	Remaining
Country Of Origin: DUBAI												
THIS PRODUCT IS MERCURY FREE												
RS797061	6061	P	= 0.67	= 0.20	= 0.20	= 0.07	= 0.90	= 0.07	= 0.00	= 0.21	= 0.00	Remaining
Country Of Origin: Bahrain												
This product is mercury free												

**Mechanical Properties**

Compositions are shown as a percentage by weight maximum unless shown as a range or a minimum. Representative samples of the material produced on this order from the section listed above have been tested according to the procedures set forth by the American Society for Testing Material Method listed below, and have attained or exceeded the minimum mechanical properties for this alloy and temper as specified by the Aluminum Association, and by the American Society for Testing Materials. Actual test result values are as follows:

Sample ID	Lot	Alloy / Temper	Test Date	Ultimate Tensile	Yield Tensile	Elongation % (min 2")	Hardness	Conductivity	Bend Test
1	1	6061 - T6	07/07/18	40.576	36.955	9.850	15.0		
2	1	6061 - T6	07/11/18	42.290	40.145	8.100	15.0		

SPLICE

Signed By: \_\_\_\_\_

Howard E. Pierce III

Quality Control Supervisor  
Keymark Corporation  
Lakeland, Florida

Post



Hydro Extrusion USA, LLC  
53 POTTSVILLE STREET

CRESSONA, PA  
17929-0187

**Certified Test Report**

Sales Order Number		Line No.	Customer P/O	Cert Number	Page
1101509239		1	387939	HYDRO3059837	Page 1 of 2
Delivery Id			Cert Creation Date	Cert Print Date	
5096333			02-MAY-19	02-MAY-19	

**Invoice To Customer**  
EASTERN METAL SUPPLY  
3600 23RD AVENUE SOUTH  
ATTN: ACCOUNTS PAYABLE  
  
LAKE WORTH, FL - 33461

**Ship To Customer**  
EASTERN METAL SUPPLY  
2224 4TH AVENUE NORTH  
  
LAKE WORTH, FL - 33461

Quantity Shipped	Unit	Date Shipped	Item Description	Specification
2092	LB	02-MAY-19	Extruded Structural Angle 5.000 B x 5.000 H x 0.500 TK	ASTM B221 REV 14 Table 1 Chemical Composition Limits Table 2 Mechanical Property Limits
B/L		Item No.	SECT 78RR 300.000 IN LN FIN M-MILL	ASME SB 221 REV 17 Table 1 Chemical Composition Limits Table 2 Mechanical Properties Limits
1012689		Item No.	WT 5.378 F3 CS 7.1 6061/T6	AMS QQ-A-200/8 REV A AMS QQ-A-200/8 REV A
Delivery Id		Item No. Rev		
5096333				
Customer Part No.				
11-61-335				

**Applicable Specifications, Revisions and Exceptions**  
COMPOSITION NOTE: The values for 'Others Each' and 'Others Total' have met the limits as shown on this certified inspection report. Remainder is Aluminum.

Hydro Extrusion USA, LLC hereby certifies that the extrusions covered in this report are within the acceptable ranges of the specification tables identified herein (excluding footnotes). Chemical composition may be based on results provided by external billet suppliers. Further information on processing, testing including ASTM B557, and inspection is available at [www.hydroextrusions.com/industry-specifications](http://www.hydroextrusions.com/industry-specifications). Sales are governed by the Extrusion North America Standard Terms and Conditions of Sale available at [www.hydroextrusions.com/terms-conditions](http://www.hydroextrusions.com/terms-conditions), unless otherwise mutually agreed in writing.

**Signature And Title**  
  
Darrell Weirich  
Quality Manager  
02-MAY-19

**Quantities per Lot / Packages**

Package Number	Lot Number	Quantity	UOM	Weight	Net
G12-PKG3464154	23529754	9	PCS	1263	1255
G12-PKG3471822	R23529754	6	PCS	845	837

**Composition Limits**

Alloy	Mg (%)		Cu (%)		Zn (%)		Mn (%)		Si (%)		Fe (%)		Ti (%)	
	Min	Max												
6061	0.40	0.80	—	0.70	0.15	0.40	—	0.15	0.80	1.20	0.04	0.35	—	0.25



Hydro Extrusion USA, LLC  
 53 POTTSVILLE STREET  
 CRIPSSON, PA  
 17929-0187

**Certified Test Report**

Sales Order Number 1101509239		Line No. 1	Customer P/O 387939	Cert Number HYDRO3059837	Page 2 of 2
				Cert Creation Date 02-MAY-19	Cert Print Date 02-MAY-19

Alloy	PC1 (%)	Other Each	PC1 (%)	Other Each
6061	0.15	0.05	0.15	

**Composition Results**

Heat/Exam	Si	Mg	Fe	Mn	Cu	Zn	Al	Other Each	Other Total
2003192	0.71	0.34	0.28	0.05	0.90	0.05	0.04	0.02	
3049001	0.75	0.31	0.29	0.05	0.91	0.06	0.04	0.02	

**Mechanical Property - Test Limits**

Temp	T6	R23529754	1	UTS - L		TYS - L		EL 4D-Long	
				KSI	MPa	KSI	MPa	PC1	PC2
				MIN VALUE	MAX VALUE	MIN VALUE	MAX VALUE	MIN VALUE	MAX VALUE
T6	23529754	1		41.0	41.9	38.9	38.9	18.0	18.0
				UTS - L		TYS - L		EL 4D-Long	
				KSI		KSI		PC1	
				MIN VALUE		MAX VALUE		MIN VALUE	
T6	R23529754	1		44.6	44.6	42.1	42.1	19.0	19.0

**Notes**  
 Mercury is not a normal contaminant in aluminum alloys and we do not knowingly use it in the manufacture of our goods  
 Excluded in the DSA  
 Extrusions produced to -T6H1 temper also meet -T6 temper requirements

RAIL



**WESTERN EXTRUSIONS**  
 1735 Sandy Lake Rd  
 Carrollton, TX 75006-9612  
 (972) 245-7915

**CERTIFIED INSPECTION REPORT AND TEST RESULTS  
 FOR EXTRUDED PRODUCTS**

ORDER NUMBER	ITEM
254548	1

ORDER TO 25465-Eastern Metal Supply	Order# 300	DOC NUMBER 14824	DATE OF SHIPMENT 3/22/2018
SHIP TO 25478-Eastern Metal Supply	CUSTOMER PO 358760	ALLOY/TENSILE 6061/T6	SALESMAN Bill Potty
CUSTOMER CODE AS	Job Name	CUSTOMER PART NUMBER DOT-61-100	DESCRIPTION Bullet Rail Cap

Specifications ASTM B221
-----------------------------

METALLURGIST

*[Signature]*  
 JORGE ENRIQUETA

We hereby certify that the material covered by this report has been inspected in accordance with, and has been found to meet the applicable requirements described herein, including any specifications forming a part of the description, and that samples representative of the material met the composition limits and had the mechanical properties shown.

MANUFACTURED IN THE UNITED STATES OF AMERICA

**Mechanical Properties**

	Test Date	Ultimate Tensile Strength (KSI)	Yield Strength (KSI)	Percent Elongation	Hardness (HRB)
LOT 1A	3/23/18	43.6	39.1	12 %	91
LOT 1A	3/23/18	44.5	38.7	12 %	91
LOT 1B	3/23/18	44.0	39.5	12 %	92

**Chemical Composition for Alloy 6061**

Cast Num	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
E7M6178A	0.54	0.17	0.23	0.03	0.83	0.06	0.01	0.01
E8A5477A	0.55	0.17	0.20	0.01	0.82	0.06	0.01	0.02

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LOCK BARR



**CERTIFIED TEST REPORT  
ALUMINUM EXTRUDED PRODUCTS**

HYDRO EXTRUDER, LLC  
2906 OLD OAKWOOD ROAD  
GAINESVILLE, GA 30604  
(770)535-1349

<b>CUSTOMER SHIP TO</b> EASTERN METAL SUPPLY, LAKE LAND 4675 Drane field road Lakeland, FL 33811	<b>ITEM DESCRIPTION</b> DOT-61-140 HAND-RAIL CLAMP BAR	<b>PCS SHIPPED</b>
<b>CAST#</b> <b>SUPPLIER</b>	<b>ALLOY</b> <b>TEMPER</b> 6061          T6	<b>SALES ORDER</b> <b>PLANT</b> 371018 - 01                              35
<b>CUSTOMER PO</b> 362375	<b>PART REVISION</b>	<b>DIE REVISION</b> 1
<b>PRODUCT SPECIFICATIONS</b> Extruded Rod, Bar, Shape or Tube ASTM B221-14 AMS QQ-A-200/8A		

**MECHANICAL PROPERTIES**

<b>DIE NUMBER</b> 049414	<b>NO. OF TESTS</b> 1	<b>TENSILE STRENGTH*</b> <b>Min-Max</b>		<b>YIELD**</b> <b>Min-Max</b>	
		45.0 - 45.0 ksi	310 - 310 mpa	41.0 - 41.0 ksi	283 - 283 mpa
<b>LOT NUMBER</b> 371018-1		<b>ELONGATION %***</b>		<b>CONDUCTIVITY</b>	
		Min 15.0	Max 15.0	Min	Max

**CHEMICAL COMPOSITION (%)**

ELEMENT	Min	Max	ELEMENT	Min	Max	ELEMENT	Min	Max
SI	.4000	.8000	MN	.0000	1500	ZN	.0000	.2500
FE	.0000	.7000	MG	.8000	1,2000	TI	.0000	1500
CU	1500	.4000	CR	.0400	.3500	B	.0000	.0000

HYDRO EXTRUDER, LLC hereby certifies that the metal shipped under this report has been tested in accordance with the identified ASTM and/or ASME specifications and the results of the chemical analysis and mechanical properties tests are within the acceptable ranges of these specifications. Any product warranty is governed by the Extrusion North America Standard Terms and Conditions of Sale posted at [www.hydroextrusions.com/termsconditions](http://www.hydroextrusions.com/termsconditions). Extruded in the USA. Mercury is not a normal contaminant in aluminum alloys and we do not knowingly use it in the manufacture of our goods.

\* One ksi equals 1000 pounds per square inch.  
\*\* Yield strength determined by 0.2% offset method.  
\*\*\* Gage length measured in 2.000" section.  
\*\*\*\* Elongation taken at fracture.

<b>AUTHORIZED SIGNATURE</b>	5/26/18
Chris Walters	
Quality Manager	

BULLET RAIL END CAP



**WESTERN EXTRUSIONS**  
 1735 Sandy Lake Rd  
 Carrollton, TX. 75006-3612  
 (972) 245-7515

**CERTIFIED INSPECTION REPORT AND TEST RESULTS  
 FOR EXTRUDED PRODUCTS**

OUR ORDER NUMBER	ITEM
254548	1

BILL TO 25465-Eastern Metal Supply	Cut Length 30'0"	DIE NUMBER 14824	DATE OF SHIPMENT 3/22/2018
SHIP TO 25478-Eastern Metal Supply	CUSTOMER PO 356760	ALLOY/TEMPER 6061/T6	SALESMAN Bill Petty
CERT CODE A9	Job Name	CUSTOMER PART NUMBER DOT-61-100	DESCRIPTION Bullet Rail Cap

Specifications: ASTM B221
------------------------------

METALLURGIST

JORGE ENRIQUEZ

We hereby certify that the material covered by this report has been inspected in accordance with, and has been found to meet the applicable requirements described herein, including any specifications forming a part of the description, and that samples representative of the material met the composition limits and had the mechanical properties shown.

MANUFACTURED IN THE UNITED STATES OF AMERICA

**Mechanical Properties**

	Test Date	Ultimate Tensile Strength (KSI)	Yield Strength (KSI)	Percent Elongation	Hardness (HRE)
LOT 1A	3/23/18	43.6	39.1	12 %	91
LOT 1A	3/23/18	44.5	39.7	12 %	91
LOT 1B	3/23/18	44.0	39.5	12 %	92

**Chemical Composition for Alloy 6061**

Cast Num	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
E7MS178A	0.54	0.17	0.20	0.03	0.83	0.06	0.01	0.01
E8AS477A	0.55	0.17	0.20	0.01	0.82	0.06	0.01	0.02

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# TUCKER CONCRETE

8930 LACY WELL RD CS  
979-777-6749 VM1802

Job # TUCKER CONST  
FLORIDA RAIL

TICKET # 289  
START DATE: 03/02/2020 TIME: 08:16:32  
STOP DATE: 03/02/2020 TIME: 08:56:09

MIX DESIGN B1350  
RAW CEMENT COUNTS 4899  
RAW CONVEYOR COUNTS 3717

**TOTAL YARDS 8.45**

MATERIAL	RATE	SETTING	TOTAL
CAPTYPE1	487.4	LBPM	3971.1 LBS
LRMSAND	6.5	GATE	11733.6 LBS
RGBLEND	7.8	GATE	16205.6 LBS
WATER	21.1	GPM	204.6 GAL
SIKA688	1.2	GPM	10.1 GAL
NC4	0.8	GPMM	6.8 OZ
MAX GPM	23.4	MAX GPY	22.53

NAME \_\_\_\_\_  
NOTES:

*Bullet RA4  
611971-02*

**CONCRETE COMPRESSIVE STRENGTH TEST REPORT**

Report Number: A1171057.0100  
 Service Date: 03/02/20  
 Report Date: 04/03/20 Revision 2 - 32-day results  
 Task: PO #611971-02



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: 3,000 psi @ 28 days

Mix ID: B1350  
 Supplier: Tucker Concrete  
 Batch Time: 0833 Plant:  
 Truck No.: 1802 Ticket No.: 289

**Field Test Data**

Test	Result	Specification
Slump (in):	5 1/4	Not Specified
Air Content (%):	1.8	Not Specified
Concrete Temp. (F):	68	40 - 95
Ambient Temp. (F):	66	40 - 95
Plastic Unit Wt. (pcf):	144.0	Not Specified
Yield (Cu. Yds.):		

**Sample Information**

Sample Date: 03/02/20 Sample Time: 0833  
 Sampled By: David Thompson  
 Weather Conditions: Cloudy, no wind  
 Accumulative Yards: 8.45/8.45 Batch Size (cy): 8.45  
 Placement Method: Direct Discharge  
 Water Added Before (gal): 0  
 Water Added After (gal): 0  
 Sample Location: 25' south of north end  
 Placement Location: Barrier (PO #611971-02)

**Laboratory Test Data**

Set No.	Specimen ID	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Maximum Load (lbs)	Compressive Strength (psi)	Fracture Type	Tested By
1	A	6.00	28.27	03/03/20	04/03/20	32 F	123,630	4,370	5	BRS
1	B	6.00	28.27	03/03/20	04/03/20	32 F	123,940	4,380	2	BRS
1	C	6.00	28.27	03/03/20	04/03/20	32 F	135,000	4,770	5	BRS
1	D			03/03/20		Hold				

Initial Cure: Outside

Final Cure: Field Cured

Comments: F = Field Cured

**Samples Made By: Terracon**

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

Terracon Rep.: David Thompson

Start/Stop: 0730-1015

Reported To:

Contractor:

Report Distribution:

(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Andrea Allen  
 (1) Texas Transportation Institute, Bill Griffith

Reviewed By:

Andrea Allen  
 Project Manager

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

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.



# TUCKER Concrete

8930 LACY WELL RD, 77845  
979 777 6749 VM1801

Job # TUCKER CONSTRUCTION  
TTI

TICKET # 11725

START DATE: 03/06/2020 TIME: 08:10:51  
STOP DATE: 03/06/2020 TIME: 08:53:16

MIX DESIGN B1350

RAW CEMENT COUNTS 10235  
RAW CONVEYOR COUNTS 3823

**TOTAL YARDS 8.15**

MATERIAL	RATE	SETTING	TOTAL
CAPTYPE1	448.3	LBPM	3828.9LBS
LRMSAND	6.3	GATE	11348.9LBS
RGBLND	7.5	GATE	15674.2LBS
WATER	19.4	GPM	183.2GAL
SIKA686	1.1	GPM	9.8GAL
SIKANC4	0.8	OZPM	6.5OZ
MAX GPY 22.53		MAX GPM 21.5	

NAME \_\_\_\_\_  
NOTES: \_\_\_\_\_

611571-02

# CONCRETE COMPRESSIVE STRENGTH TEST REPORT



Report Number: A1171057.0101  
Service Date: 03/06/20  
Report Date: 04/03/20 Revision 2 - 28-day results  
Task: PO #611971-02

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: 3,000 psi @ 28 days

Mix ID: B1350  
Supplier: Tucker Concrete  
Batch Time: 0810 Plant:  
Truck No.: Ticket No.: 11725

## Sample Information

Sample Date: 03/06/20 Sample Time: 0820  
Sampled By: Justin Maass  
Weather Conditions: Clear, moderate wind  
Accumulative Yards: 8.15/8.15 Batch Size (cy): 8.15  
Placement Method: Direct Discharge  
Water Added Before (gal): 0  
Water Added After (gal): 0  
Sample Location: East side barrier, center  
Placement Location: Median barrier, east side (PO #611971-02)

## Field Test Data

Test	Result	Specification
Slump (in):	3	Not Specified
Air Content (%):	2.4	Not Specified
Concrete Temp. (F):	62	40 - 95
Ambient Temp. (F):	51	40 - 95
Plastic Unit Wt. (pcf):	149.3	Not Specified
Yield (Cu. Yds.):		

## Laboratory Test Data

Set No.	Specimen ID	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Maximum Load (lbs)	Compressive Strength (psi)	Fracture Type	Tested By
1	A	6.00	28.27	03/09/20	04/03/20	28 F	149,030	5,270	5	BRS
1	B	6.00	28.27	03/09/20	04/03/20	28 F	136,890	4,840	5	BRS
1	C	6.00	28.27	03/09/20	04/03/20	28 F	148,960	5,270	4	BRS
1	D			03/09/20		Hold				

Initial Cure: Outside

Final Cure: Field Cured

Comments: F = Field Cured

## Samples Made By: Terracon

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

Terracon Rep.: Justin Maass

Start/Stop: 0715-0945

Reported To:

Contractor:

Report Distribution:

(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Andrea Allen  
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Test Methods: ASTM C 31, ASTM C143, ASTM C231, ASTM C1064

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

# APPENDIX C. MASH TEST 3-11 (CRASH TEST NO. 611971-02-1)

## C1 VEHICLE PROPERTIES AND INFORMATION

**Table C.1. Vehicle Properties for Test No. 611971-02-1.**

Date: 2020-04-03 Test No.: 611971-02 VIN No.: 1C6RR6FT4ES314674  
 Year: 2014 Make: RAM Model: 1500  
 Tire Size: 265/70 R 17 Tire Inflation Pressure: 35 psi  
 Tread Type: Highway Odometer: 98219  
 Note any damage to the vehicle prior to test: None

• Denotes accelerometer location.

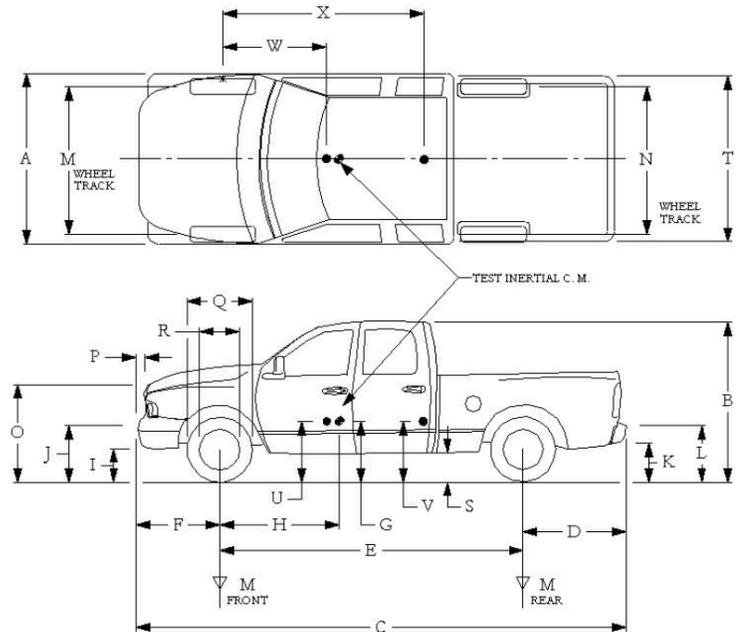
NOTES: None

Engine Type: V-8  
 Engine CID: 5.7 L

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	<u>78.50</u>	F	<u>40.00</u>	K	<u>20.00</u>	P	<u>3.00</u>	U	<u>26.75</u>
B	<u>74.00</u>	G	<u>29.00</u>	L	<u>30.00</u>	Q	<u>30.50</u>	V	<u>30.25</u>
C	<u>227.50</u>	H	<u>61.46</u>	M	<u>68.50</u>	R	<u>18.00</u>	W	<u>61.40</u>
D	<u>44.00</u>	I	<u>11.75</u>	N	<u>68.00</u>	S	<u>13.00</u>	X	<u>79.00</u>
E	<u>140.50</u>	J	<u>27.00</u>	O	<u>46.00</u>	T	<u>77.00</u>		
Wheel Center Height Front	<u>14.75</u>	Wheel Well Clearance (Front)	<u>6.00</u>	Bottom Frame Height - Front	<u>12.50</u>				
Wheel Center Height Rear	<u>14.75</u>	Wheel Well Clearance (Rear)	<u>9.25</u>	Bottom Frame Height - Rear	<u>22.50</u>				

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

	<b>GWWR Ratings:</b>	<b>Mass:</b> lb	<b>Curb</b>	<b>Test Inertial</b>	<b>Gross Static</b>
Front	<u>3700</u>	$M_{front}$	<u>2911</u>	<u>2829</u>	<u>2914</u>
Back	<u>3900</u>	$M_{rear}$	<u>2041</u>	<u>2200</u>	<u>2280</u>
Total	<u>6700</u>	$M_{Total}$	<u>4952</u>	<u>5029</u>	<u>5194</u>

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

<b>Mass Distribution:</b>	lb	LF:	RF:	LR:	RR:
		<u>1388</u>	<u>1441</u>	<u>1142</u>	<u>1058</u>

**Table C.2. Measurements of Vehicle Vertical CG for Test No. 611971-02-1.**

Date: 2020-04-03 Test No.: 611971-02 VIN: 1C6RR6FT4ES314674  
 Year: 2014 Make: RAM Model: 1500  
 Body Style: Quad Cab Mileage: 98219  
 Engine: 5.7L V-8 Transmission: Automatic  
 Fuel Level: Empty Ballast: 172 (440 lb max)  
 Tire Pressure: Front: 35 psi Rear: 35 psi Size: 265/70 R 17

Measured Vehicle Weights: (lb)					
LF:	1388	RF:	1441	Front Axle:	2829
LR:	1142	RR:	1058	Rear Axle:	2200
Left:	2530	Right:	2499	Total:	5029
5000 ±110 lb allowed					
Wheel Base:	140.50	inches	Track: F:	68.50	inches
148 ±12 inches allowed			R:	68.00	inches
Track = (F+R)/2 = 67 ±1.5 inches allowed					
Center of Gravity, SAE J874 Suspension Method					
X:	61.46	inches	Rear of Front Axle	(63 ±4 inches allowed)	
Y:	-0.21	inches	Left -	Right +	of Vehicle Centerline
Z:	29.00	inches	Above Ground	(minimum 28.0 inches allowed)	

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

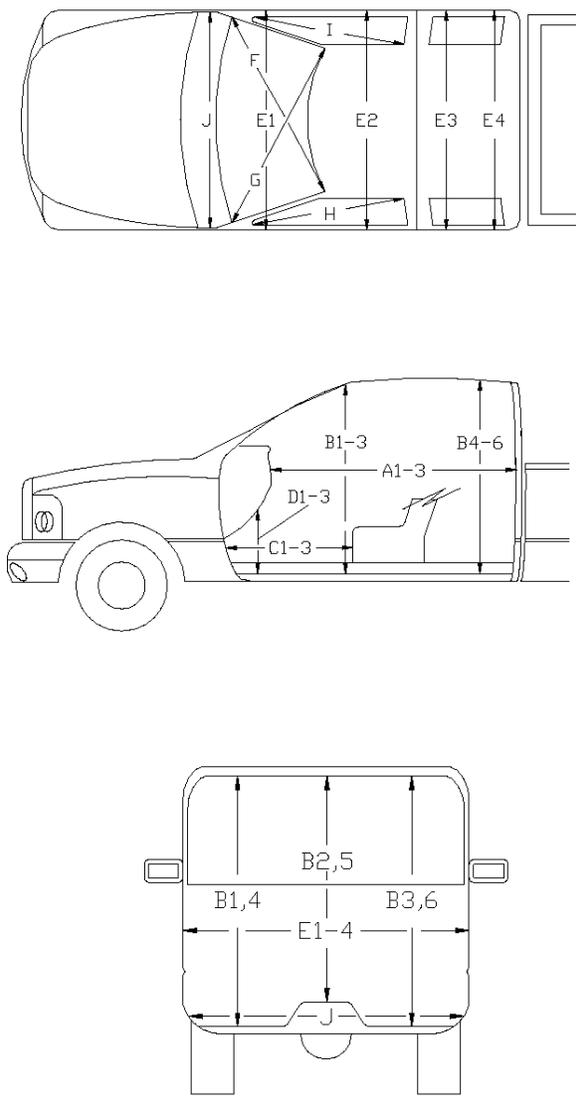
Front Overhang: 40.00 inches Rear Bumper Height: 30.00 inches  
 39 ±3 inches allowed

Overall Length: 227.50 inches  
 237 ±13 inches allowed



**Table C.4. Occupant Compartment Measurements for Test No. 611971-02-1.**

Date: 2020-04-03 Test No.: 611971-02 VIN No.: 1C6RR6FT4ES314674  
 Year: 2014 Make: RAM Model: 1500



**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	22.00	-4.00
D1	11.00	11.00	0.00
D2	0.00	0.00	0.00
D3	11.50	12.00	0.50
E1	58.50	59.50	1.00
E2	63.50	66.00	2.50
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	22.00	-3.00

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

**C2 SEQUENTIAL PHOTOGRAPHS**



0.000 s



0.100 s



0.200 s



0.300 s



**Figure C.1. Sequential Photographs for Test No. 611971-02-1 (Frontal and Rear Views).**



0.400 s



0.500 s



0.600 s

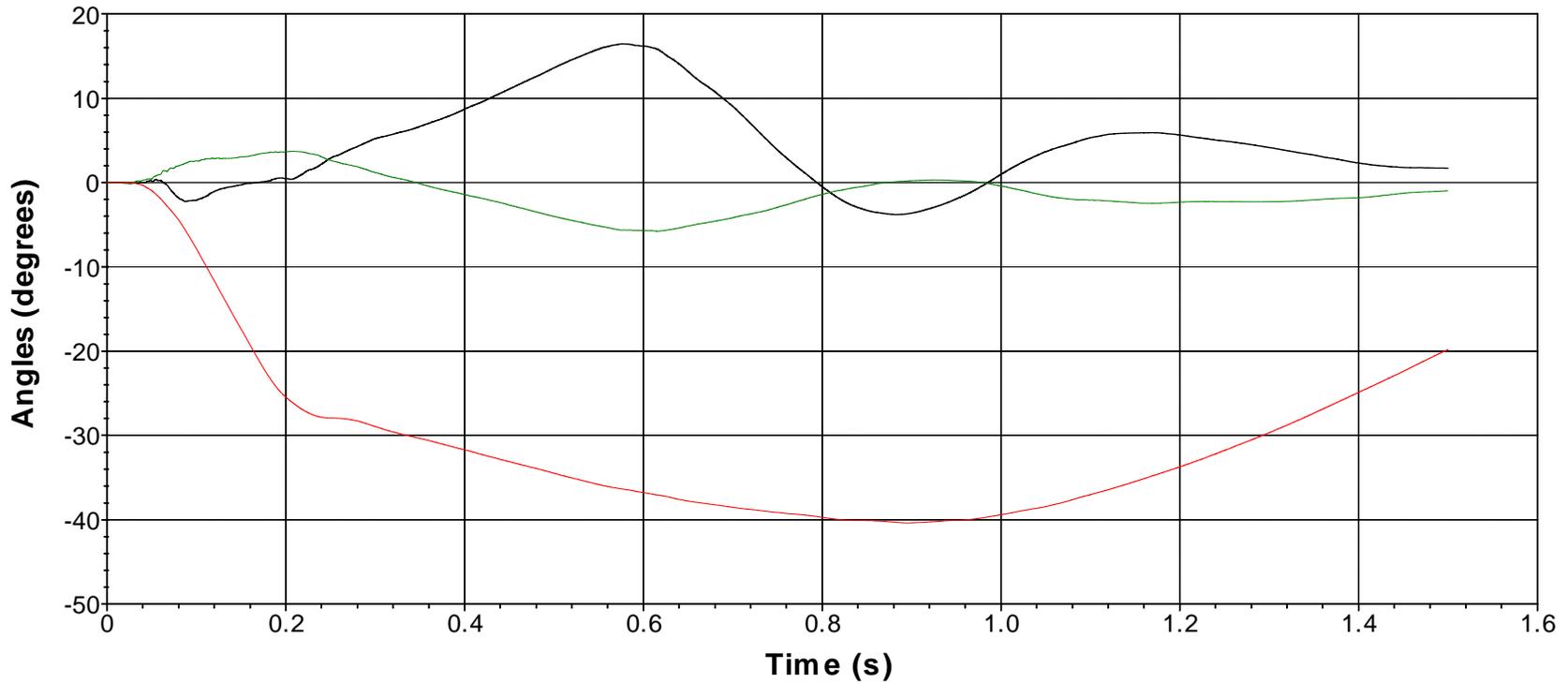


0.700 s



**Figure C.1. Sequential Photographs for Test No. 611971-02-1 (Frontal and Rear Views)  
(Continued).**

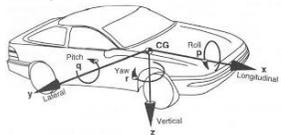
### Roll, Pitch, and Yaw Angles



— Roll — Pitch — Yaw

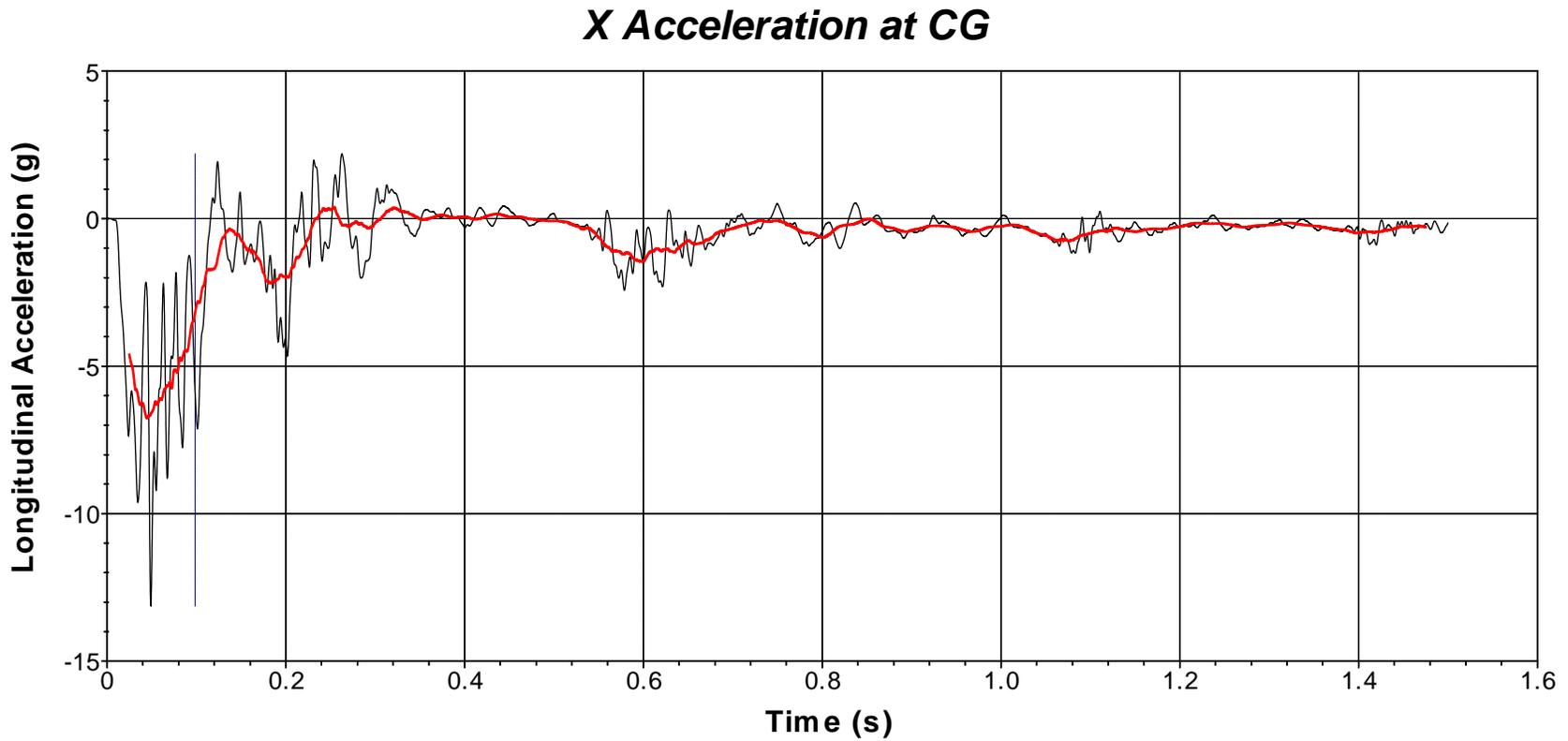
Axes are vehicle-fixed.  
Sequence for determining orientation:

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



Test Number: 611971-02-1  
 Test Standard Test Number: MASH Test 3-11  
 Test Article: 42-inch tall combination traffic-pedestrian-bicycle bridge rail system  
 Test Vehicle: 2014 RAM 1500 Pickup Truck  
 Inertial Mass: 5029 lb  
 Gross Mass: 5194 lb  
 Impact Speed: 61.8 mi/h  
 Impact Angle: 24.5°

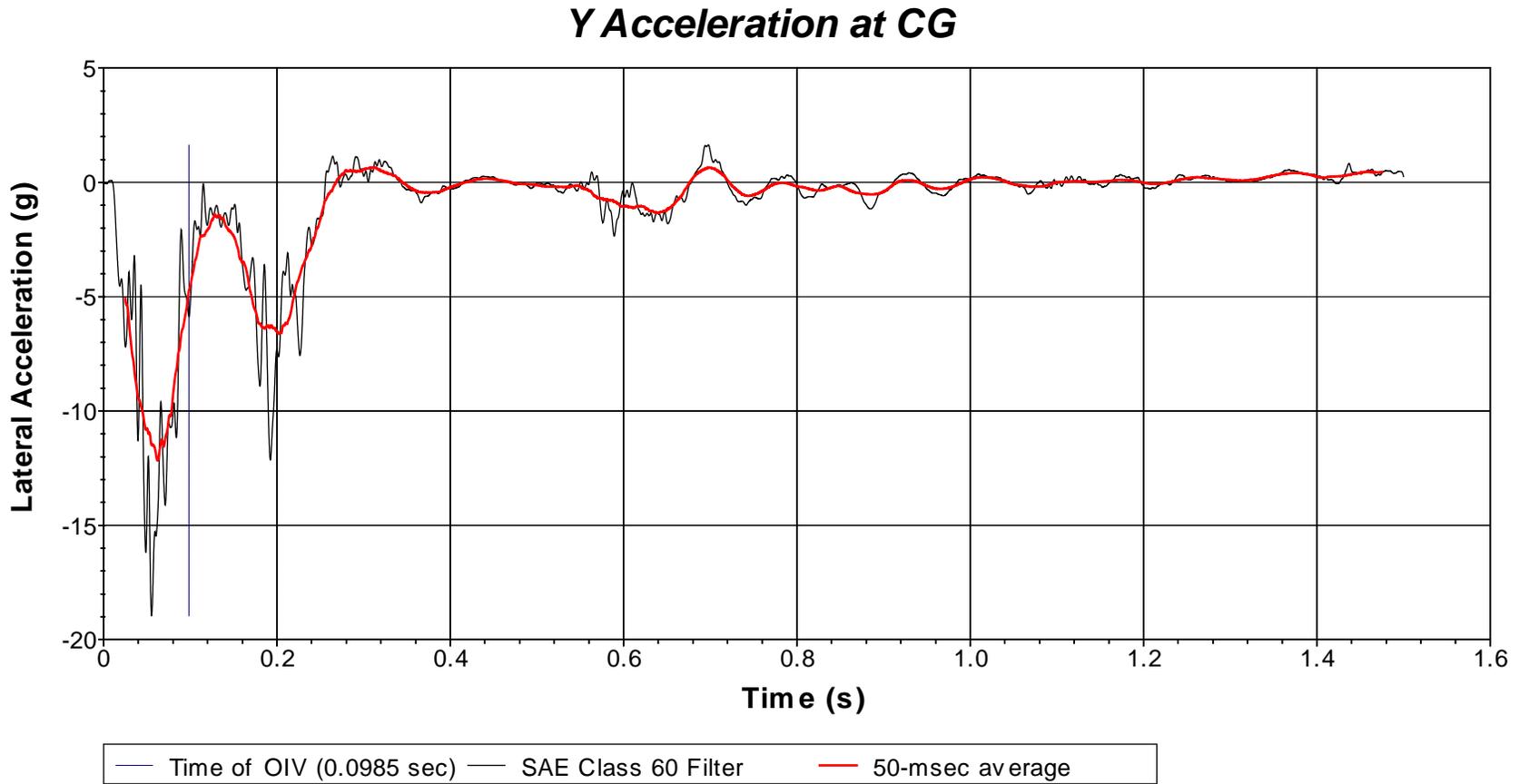
Figure C.2. Vehicle Angular Displacements for Test No. 611971-02-1.



— Time of OIV (0.0985 sec) — SAE Class 60 Filter — 50-msec average

Test Number: 611971-02-1  
 Test Standard Test Number: MASH Test 3-11  
 Test Article: 42-inch tall combination traffic-pedestrian-bicycle bridge rail system  
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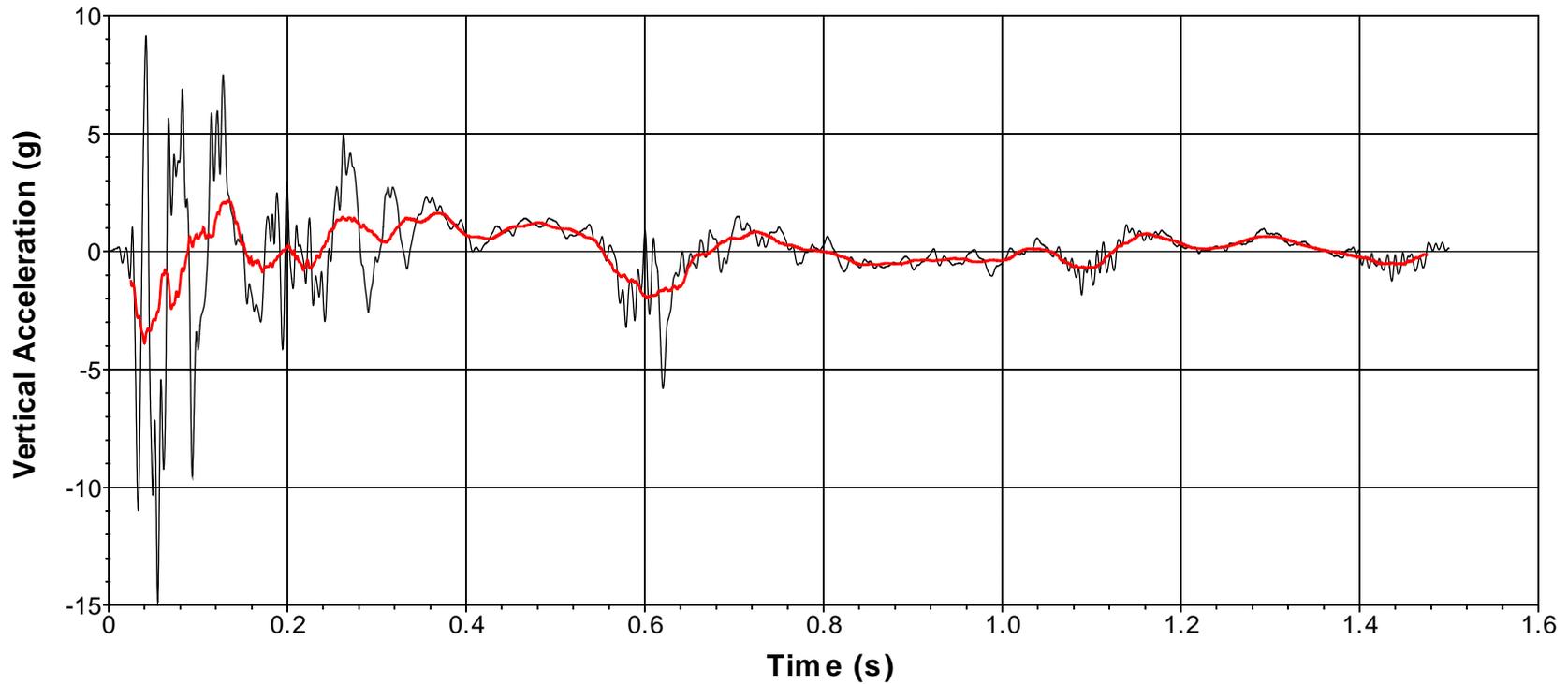
**Figure C.3. Vehicle Longitudinal Accelerometer Trace for Test No. 611971-02-1 (Accelerometer Located at Center of Gravity).**



Test Number: 611971-02-1  
 Test Standard Test Number: MASH Test 3-11  
 Test Article: 42-inch tall combination traffic-pedestrian-bicycle bridge rail system  
 Test Vehicle: 2014 RAM 1500 Pickup Truck  
 Inertial Mass: 5029 lb  
 Gross Mass: 5194 lb  
 Impact Speed: 61.8 mi/h  
 Impact Angle: 24.5°

**Figure C.4. Vehicle Lateral Accelerometer Trace for Test No. 611971-02-1  
(Accelerometer Located at Center of Gravity).**

### Z Acceleration at CG



— SAE Class 60 Filter    — 50-msec average

Test Number: 611971-02-1  
 Test Standard Test Number: MASH Test 3-11  
 Test Article: 42-inch tall combination traffic-pedestrian-bicycle bridge rail system  
 Test Vehicle: 2014 RAM 1500 Pickup Truck  
 Inertial Mass: 5029 lb  
 Gross Mass: 5194 lb  
 Impact Speed: 61.8 mi/h  
 Impact Angle: 24.5°

**Figure C.5. Vehicle Vertical Accelerometer Trace for Test No. 611971-02-1 (Accelerometer Located at Center of Gravity).**