Texas A&M Transportation Institute
Proving Ground

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Test Report Date: December 2022

MASH TL-4 CRASH TESTING OF BICYCLE RAILING ON A CONSTANT SLOPE PARAPET

by

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16. Abstract

The purpose of the test reported herein was to assess the performance of the combination barrier system that consists of a bicycle railing mounted on top of a standard Illinois Department of Transportation (IDOT) concrete parapet according to the safety-performance evaluation guidelines included in the American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware, Second Edition (*MASH*). The crash test was performed in accordance with *MASH* Test Level 4 (TL-4).

This report provides details on the Bicycle Railing on a Constant Slope Parapet, the crash test and results, and the performance assessment of the Bicycle Railing on a Constant Slope Parapet for *MASH* TL-4 longitudinal barrier evaluation criteria.

The Bicycle Railing on a Constant Slope Parapet met the performance criteria for *MASH* TL-4 longitudinal barriers.

17. Key Words
Bicycle Railing, Parapet, Longitudinal Barrier, *MASH*, Crash Testing, Roadside Safety

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in2	square inches	645.2	square millimeters	mm2
ft2	square feet	0.093	square meters	m2
yd2	square yards	0.836	square meters	m2
ac	acres	0.405	hectares	ha
mi2	square miles	2.59	square kilometers	km2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft3	cubic feet	0.028	cubic meters	m3
yd3	cubic yards	0.765	cubic meters	m3
	NOTE: volumes greater than 1000L shall be shown in m3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or metric ton”)	Mg (or “t”)
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm2	square millimeters	0.0016	square inches	in2
m2	square meters	10.764	square feet	ft2
m2	square meters	1.195	square yards	yd2
ha	hectares	2.47	acres	ac
km2	Square kilometers	0.386	square miles	mi2
		VOLUME		
mL	milliliters	0.034	fluid ounces	oz
L	liters	0.264	gallons	gal
m3	cubic meters	35.314	cubic feet	ft3
m3	cubic meters	1.307	cubic yards	yd3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2000lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lb/in2

*SI is the symbol for the International System of Units

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Chapter 1. INTRODUCTION

1.1. PROBLEM

The purpose of this project is to evaluate and test a combination barrier system that consists of a bicycle railing mounted on top of a standard Illinois Department of Transportation (IDOT) concrete parapet. The total height of the system is 54 inches, including a 15-inch tall bicycle railing mounted on top of a 39-inch tall constant slope parapet. The testing was performed in accordance with Test Level 4 (TL-4) criteria of the American Association of State Highway and Transportation Official's (AASHTO) Manual for Assessing Safety Hardware (*MASH*) (1).

1.2. BACKGROUND

IDOT has a significant number of bridges that accommodate bicyclists throughout the state. The department utilizes a railing height of 54 inches as recommended in the early editions of the AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications. *MASH* TL-4 compliant barrier systems are recommended on IDOT bridges whenever possible. Therefore, IDOT wanted to develop and test a 15-inch tall railing mounted on top of a 39-inch tall standard IDOT parapet to accommodate bicyclist and traffic safety.

1.3. OBJECTIVES

The purpose of the testing reported herein was to assess the performance of the railing mounted on top of a standard IDOT constant slope parapet according to the safety-performance evaluation guideline included in AASHTO *MASH* for TL-4 longitudinal barriers.

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Chapter 2. DESIGN AND ANALYSIS

The TTI research team evaluated the railing design details and configuration presented in Figure 2.1 according to AASHTO LRFD Section 13 and concluded that the system is structurally adequate for *MASH* TL-4 impact conditions. Additional recommendations were provided to improve the continuity of the rail at joint locations to reduce the possibility of vehicle snagging.

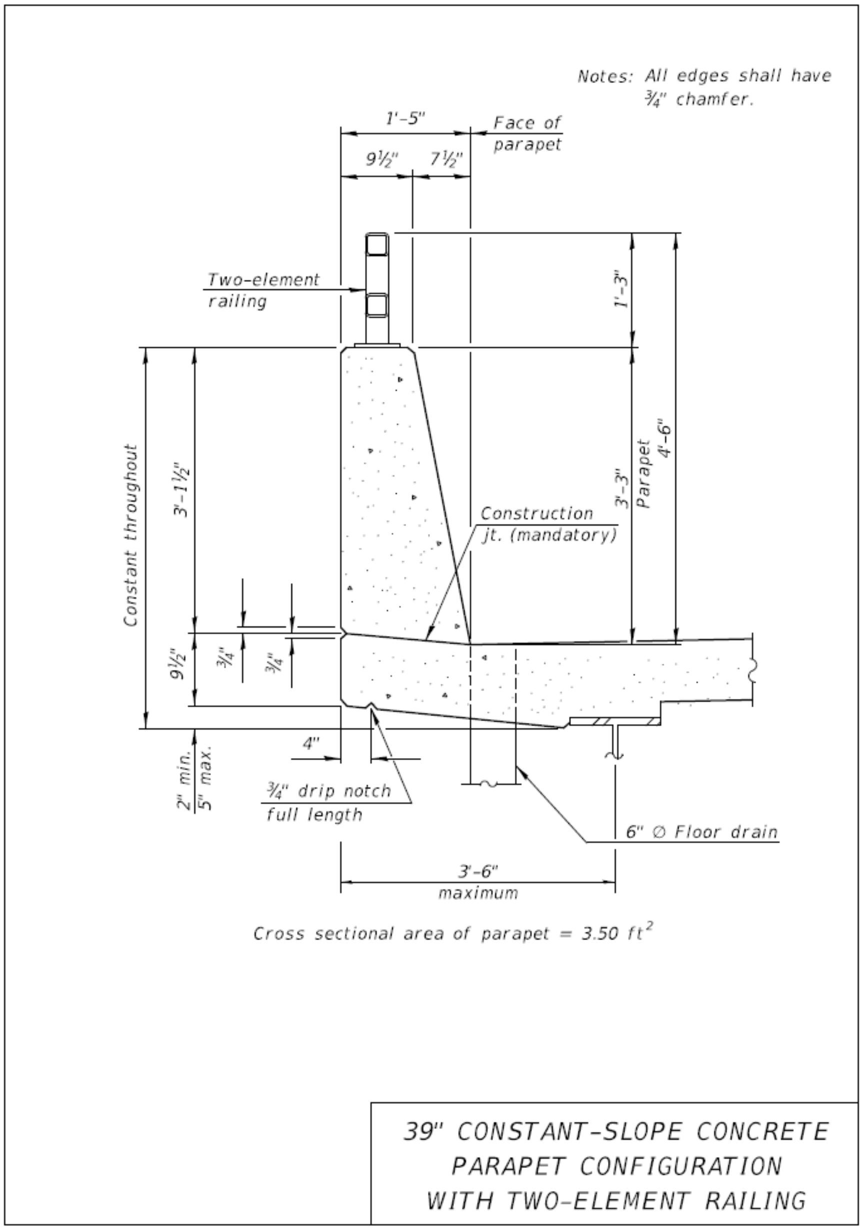


Figure 2.1 Combination Barrier System

Chapter 3. SYSTEM DETAILS

3.1. TEST ARTICLE AND INSTALLATION DETAILS

The installation consisted of a 122 foot - 2 inch long concrete parapet with a double square tube rail mounted on top. The concrete parapet was 39 inches tall, 17 inches wide at the bottom and then sloped towards the field side on the traffic side for a width of 9½ inches at the top. It was anchored into a concrete deck 8 inches thick and 48 inches wide. There was a 2-inch relief joint in the concrete parapet 31 feet and 1 inch from the upstream end of the installation. The double rail and posts mounted on top of the parapet was constructed of HSS 3” x 3” x ¼”, and was 54 inches from the deck to the top of the rail. The posts were anchored to the parapet with two threaded rods on the traffic side of the base plates.

Figure 3.1 presents the overall information on the Bicycle Railing on a Constant Slope Parapet, and Figure 3.2 provides photographs of the installation. Appendix A provides further details on the Bicycle Railing on a Constant Slope Parapet. Drawings were provided by the Texas A&M Transportation Institute (TTI) Proving Ground, and construction was performed by MBC Management and supervised by TTI Proving Ground personnel.

3.2. DESIGN MODIFICATIONS DURING TESTS

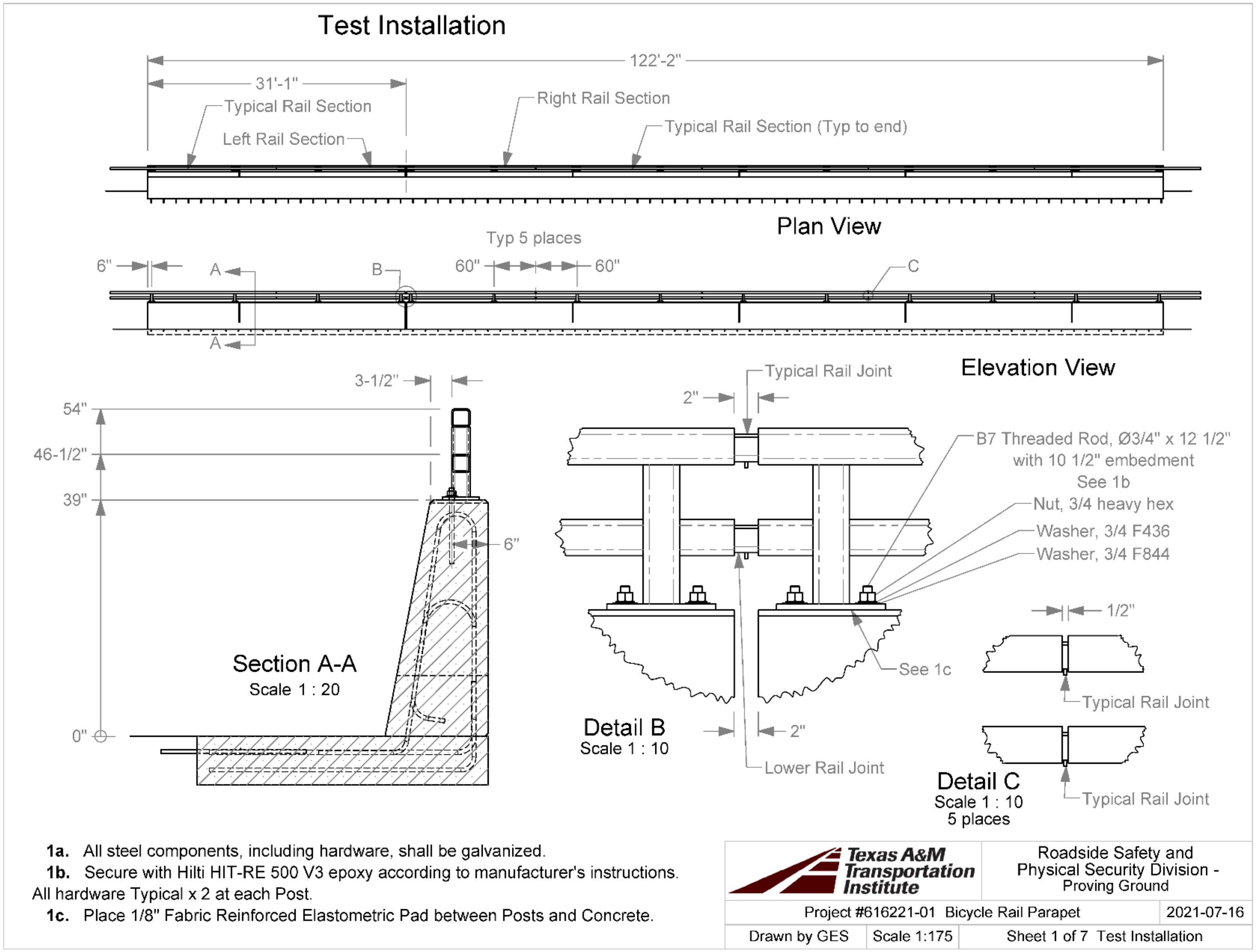
No modifications were made to the installation during the testing phase.

3.3. MATERIAL SPECIFICATIONS

Appendix B provides material certification documents for the materials used to install/construct the Bicycle Railing on a Constant Slope Parapet. Table 3.1 shows the average compressive strengths of the concrete on November 8, 2021, the day of the test:

Table 3.1 Concrete Strength.

Location	Min. Design Strength (psi)	Avg. Strength (psi)	Age (days)	Detailed Location
Deck	4000	4193	20	70 feet of deck starting from south end
Deck	4000	4263	20	Remaining northern section of deck
Barrier	4000	4550	10	70 ft of barrier starting from south end
Barrier	4000	4180	10	Remaining northern section of barrier



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

1b. Secure with Hilti HIT-RE 500 V3 epoxy according to manufacturer's instructions.
All hardware Typical x 2 at each Post.

1c. Place 1/8" Fabric Reinforced Elastometric Pad between Posts and Concrete.

Q:\Accreditation-17025-2017\EIR-000 Project Files\616221-01 TL-4 Bicycle Railing on Constant Slope Parapet - Kiani\Drafting, 616221\616221 Drawing

Figure 3.1 Details of Bicycle Railing on a Constant Slope Parapet.

Figure 3.2 Bicycle Railing on a Constant Slope Parapet prior to Testing.

Chapter 4. TEST REQUIREMENTS AND EVALUATION CRITERIA

4.1. CRASH TEST PERFORMED/MATRIX

Table 4.1 shows the test conditions and evaluation criteria for *MASH* TL-4 for longitudinal barriers.

It should be noted that MASH TL-4 criteria also requires testing with a small passenger car (1100C vehicle) and pickup truck (2270P vehicle). * However, MASH Test 4-10 and MASH Test 4-11 are not critical due to successfully performed tests on similar systems in the past (2-4). Furthermore, the small car and pickup truck will not impart a greater load into the combination barrier system in comparison to the single unit truck of MASH Test 4-12. Thus, only MASH Test 4-12 was performed under this project.

The target critical impact point (CIP) for the test was determined using the information provided in *MASH* Section 2.2.1 and Section 2.3.2. Figure 4.1 shows the target CIP for *MASH* Test 4-12 on the Bicycle Railing on a Constant Slope Parapet.

Table 4.1 Test Conditions and Evaluation Criteria Specified for *MASH* TL-4 Longitudinal Barriers.

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

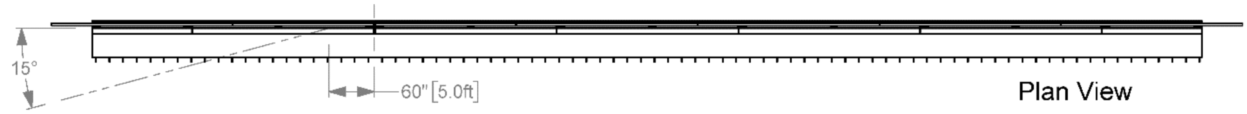


Figure 4.1 Target CIP for *MASH* TL-4 Tests on Bicycle Railing on a Constant Slope Parapet.

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

4.2. 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. Table 4-1 lists the test conditions and evaluation criteria required for *MASH* TL-4, and Table 4.2 provides detailed information on the evaluation criteria.

Table 4.2 Evaluation Criteria Required for *MASH* Testing.

Evaluation Factors	**Evaluation Criteria**		***MASH* Test**
Structural Adequacy	A.	Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.	10, 11, 12
Occupant Risk	D.	Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to other traffic, pedestrians, or personnel in a work zone.	All
		Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of *MASH*.	
	F.	The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	All except those listed in G
	G.	It is preferable, although not essential, that the vehicle remain upright during and after the collision.	12
	H.	Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 30 ft/s, or maximum allowable value of 40 ft/s. Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 10 ft/s, or maximum allowable value of 16 ft/s.	10, 11
	I.	The occupant ridedown accelerations should satisfy the following: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.	10, 11

Chapter 5. TEST CONDITIONS

5.1. TEST FACILITY

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

The test facilities of the TTI Proving Ground are located on The Texas A&M University System RELLIS Campus, which consists of a 2000-acre complex of research and training facilities situated 10 mi northwest of the flagship campus of Texas A&M University. The site, formerly a United States Army Air Corps base, has large expanses of concrete runways and parking aprons well suited for experimental research and testing in the areas of vehicle performance and handling, vehicle-roadway interaction, highway pavement durability and efficacy, and roadside safety hardware and perimeter protective device evaluation. The sites selected for construction and testing are along the edge of an out-of-service apron/runway. The apron/runways 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.

5.2. 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 and through a pulley on the tow vehicle, and then anchored to the ground such that the tow vehicle moved away from the test site. A 2:1 speed ratio between the test and tow vehicle existed with this system. Just prior to impact with the installation, the test vehicle was released and ran unrestrained. The vehicle remained freewheeling (i.e., no steering or braking inputs) until it cleared the immediate area of the test site.

5.3. DATA ACQUISITION SYSTEMS

5.3.1. Vehicle Instrumentation and Data Processing

The test vehicle was instrumented with a self-contained onboard 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 in case the primary battery cable is severed. Initial contact of the pressure switch on the vehicle bumper provides a time zero mark and initiates the recording process. After each test, the data are downloaded from the 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 to ensure that all instrumentation used in the vehicle conforms to the specifications outlined by SAE J211. All accelerometers are calibrated annually by means of an ENDEVCO® 2901 precision primary vibration standard. This standard and its support instruments are checked annually and receive a National Institute of Standards Technology (NIST) traceable calibration. The rate transducers used in the data acquisition system receive calibration via a Genisco Rate-of-Turn table. The subsystems of each data channel are also evaluated annually, using instruments with current NIST traceability, and the results are factored into the accuracy of the total data channel per SAE J211. Calibrations and evaluations are also made anytime data are suspect. Acceleration data are measured with an expanded uncertainty of ±1.7 percent at a confidence factor of 95 percent (k = 2).

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

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

5.3.2. Anthropomorphic Dummy Instrumentation

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

5.3.3. 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 from the installation at an angle to have a field of view of the interaction of the rear of the vehicle with the installation.

A third placed with a field of view parallel to and aligned with the installation at the downstream end.

A flashbulb on the impacting vehicle was activated by a pressure-sensitive tape switch to indicate the instant of contact with the Bicycle Railing on a Constant Slope Parapet. 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 the test vehicle and the installation before and after the test.

Chapter 6. *MASH* TEST 4-12 (CRASH TEST NO. 616221-01)

6.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 6.1 for details on *MASH* impact conditions for this test. Figure 6.1 depicts the target impact setup.

Figure 6.1 Bicycle Railing on a Constant Slope Parapet Test Vehicle Geometrics for Test 616221-01.

Table 6.1 Impact Conditions for *MASH* Test 4-12 / Test 616221-01.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	56	± 2.5	57.9
Impact Angle (deg)	15	± 1.5°	15.2
Vehicle Inertial Weight (lbs)	22,046	± 660	22,590
Impact Severity (kip-ft)	142	≥ 142	174
Impact Location:	5.0 ft upstream of the center of the parapet and rail joint between posts 4 and 5	± 1 foot	5.6 feet upstream of the center of the parapet and rail joint between posts 4 and 5
Exit Parameters			
Speed (mi/h)		Not Measureable (out of view)	
Trajectory (deg)		Along Rail	
Heading (deg)		Along Rail	
Brakes applied post impact (seconds)		3.6	
Vehicle at rest position		327 ft downstream of impact point 8 ft to the traffic side 10° right	
Comments: Vehicle remained upright and stable.			

6.2. WEATHER CONDITIONS

Table 6.2 Weather Conditions 616221-01.

Date of Test	Temperature (°F)	Relative Humidity (%)
November 8, 2021 AM	68	68
Wind Direction (degrees)	**Vehicle Traveling (degrees)**	**Wind Speed (mi/h)**
180	335	9

6.3. TEST VEHICLE

Figure 6.2 shows the 2004 Freightliner M21G6 used for the crash test. Table 6.3 shows the vehicle measurements. Table C.1 in Appendix C.1 gives additional dimensions and information on the vehicle.

Figure 6.2 Test Vehicle before Test 616221-01.

Table 6.3 Vehicle Measurements 616221-01.

Test Parameter	*MASH*	Allowed Tolerance	Actual Measured
Curb Weight (lbs)	13,200	±2,200	14,760
Gross Static (lbs)	22,046	660	22,590
Wheelbase (inches)	240	≤240	207
Overall Length (inches)	394	≤394	332.5
Cargo Bed Height (inches)[a]	49	±2	51
CG of Ballast above Ground[b] (inches)	63	±2	64.8

a– Without Ballast

b – See section 4.2.1.2 in *MASH* 2016 for recommended ballasting procedures

6.4. TEST DESCRIPTION

Table 6.4 lists events that occurred during Test No. 616221-01. Figures C.1 and C.2 in Appendix C.2 present sequential photographs during the test.

Table 6.4 Events during Test 616221-01.

Time (s)	Events
0.0000	Vehicle impacted the installation
0.0160	Front left side tire lifted off of the pavement
0.0170	Flashbulb lit up
0.0340	Vehicle impacted the bicycle rail
0.0590	Vehicle began to redirect
0.1210	Front right side tire lifted off of the pavement
0.2600	Rear right side tire lifted off of the pavement
0.2930	Vehicle parallel with installation
1.1200	Vehicle exited the installation

6.5. DAMAGE TO TEST INSTALLATION

There was scuffing and gouging at the impact location, and spalling on the field side of the joint at posts 4 and 5, which exposed rebar on both sections of the parapet. There was also a major crack on the field side of the parapet at both posts 4 and 5, and the top rail was permanently deformed towards the field side.

Figure 6.3 shows the damage to the Bicycle Railing on a Constant Slope Parapet. Table 6.5 describes the damage to the Bicycle Railing on a Constant Slope Parapet.

Table 6.5 Damage to Bicycle Railing on a Constant Slope Parapet 616221-01.

Test Parameter	Measured
Permanent Deflection/Location	2 inches toward field side at the joint between posts 4 and 5
Dynamic Deflection	6.2 inches toward field side
Working Width* and Height	51.1 inches, at a height of 148.5 inches

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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.

Figure 6.3 Bicycle Railing on a Constant Slope Parapet after Test 616221-01.

6.6. DAMAGE TO TEST VEHICLE

Figure 6.4 and Figure 6.5 shows the damage sustained by the vehicle. Table 6.6 provide details on the interior and exterior damage to the vehicle. Tables C.2 and C.3 in Appendix C.1 provide exterior crush and occupant compartment measurements.

Figure 6.4 Test Vehicle after Test 616221-01.

Figure 6.5 Interior of Test Vehicle after Test 616221-01.

Table 6.6 Damage to Vehicle 616221-01.

<table>
<tr><th colspan="2">Test Parameter</th><th colspan="5">Specification</th><th>Measured</th></tr>
<tr><td colspan="2">Roof</td><td colspan="5">≤ 4.0 inches</td><td>0 inches</td></tr>
<tr><td colspan="2">Windshield</td><td colspan="5">≤ 3.0 inches</td><td>0 inches</td></tr>
<tr><td colspan="2">A and B Pillars</td><td colspan="5">≤ 5.0 overall / ≤ 3.0 inches lateral</td><td>0 inches</td></tr>
<tr><td colspan="2">Foot Well/Toe Pan</td><td colspan="5">≤ 9.0 inches</td><td>0 inches</td></tr>
<tr><td colspan="2">Floor Pan/Transmission Tunnel</td><td colspan="5">≤ 12.0 inches</td><td>3 inches</td></tr>
<tr><td colspan="2">Side Front Panel</td><td colspan="5">≤ 12.0 inches</td><td>0 inches</td></tr>
<tr><td colspan="2">Front Door (Above Seat)</td><td colspan="5">≤ 9.0 inches</td><td>0 inches</td></tr>
<tr><td colspan="2">Front Door (Below Seat)</td><td colspan="5">≤ 12.0 inches</td><td>0 inches</td></tr>
<tr><td colspan="2">Side Windows</td><td colspan="6">The side windows remained intact</td></tr>
<tr><td colspan="2">Maximum Exterior Deformation</td><td colspan="6">12 inches in the front plane at the left front corner at bumper height</td></tr>
<tr><td>VDS</td><td colspan="4">11LFQ6</td><td>CDC</td><td colspan="2">11FLEW4</td></tr>
<tr><td colspan="3">Fuel Tank Damage</td><td>Yes</td><td colspan="4">The left tank was damaged, but was not punctured</td></tr>
<tr><td colspan="8">Description of Damage to Vehicle:
The front bumper, hood, left headlight, left front tire and rim, left spring assembly, left u-bolt, left door, left side step, left side center floor pan, left side lower edge of box, and left rear outer tire and rim were damaged.</td></tr>
</table>

6.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 6.7 Figure C.3 in Appendix C.3 shows the vehicle angular displacements, and Figures C.4 through C.6 in Appendix C.4 show acceleration versus time traces.

Table 6.7 Occupant Risk Factors for Test 616221-01.

Test Parameter	***MASH***	**Measured**	**Time**
OIV, Longitudinal (ft/s)	≤40.0	5.8	0.1890 s on left side of interior
OIV, Lateral (ft/s)	≤40.0	10.7	0.1890 s on left side of interior
Ridedown, Longitudinal (g)	≤20.49	5.9	0.2640 - 0.2740 s
Ridedown, Lateral (g)	≤20.49	12.8	0.2663 - 0.2763 s
THIV (m/s)	N/A	3.8	0.1829 s on left side of interior
ASI	N/A	0.6	0.2686 - 0.3186 s
50ms MA Longitudinal (g)	N/A	-2.0	0.0512 - 0.1012 s
50ms MA Lateral (g)	N/A	4.8	0.2290 - 0.2790 s
50ms MA Vertical (g)	N/A	2.0	0.3714 - 0.4214 s
Roll (deg)	≤75	28	0.7130 s
Pitch (deg)	≤75	9	0.7249 s
Yaw (deg)	N/A	23	0.9622 s
Comments:			

0.000 s

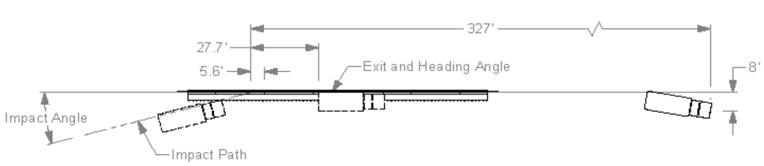
0.100 s

0.200 s

0.300 s

Test Agency	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.	*MASH* 2016, Test 4-12
TTI Project No.	616221-01
Test Date	2021-11-08
TEST ARTICLE	
Type	Concrete Parapet
Name	Bicycle Railing on a Constant Slope Parapet
Length	122 feet 2 inches
Key Materials	39 inch tall concrete parapet with HSS 3” x 3” x 1/4”’ ASTM A500 Grade B Railing
Soil Type and Condition	AASHTO M147-65(2004), Type 1, Grade D Crushed Concrete
TEST VEHICLE	
Type/Designation	10000S
Year, Make and Model	2004 Freightliner M21G6
Curb Weight (lbs)	14 760
Inertial Weight (lbs)	22 590
Dummy (lbs)	N/A
Gross Static (lbs)	22 590
IMPACT CONDITIONS	
Impact Speed (mi/h)	57.9
Impact Angle (deg)	15.2
Impact Location	5.6 feet upstream from the centerline of the parapet and rail joint between posts 4 and 5
Impact Severity (kip-ft)	174
EXIT CONDITIONS	
Exit Speed (mi/h)	Not Measureable
Trajectory/Heading Angle (deg)	Along Rail
Exit Box Criteria	Along Rail
Stopping Distance	327 feet downstream 8 feet to the traffic side
TEST ARTICLE DEFLECTIONS	
Dynamic (inches)	6.2
Permanent (inches)	2
Working Width / Height (inches)	51.1 / 148.5
VEHICLE DAMAGE	
VDS	11LFQ6
CDC	11FLEW4
Max. Ext. Deformation (inches)	12
Max Occupant Compartment Deformation	3 inches in the left side center floor pan

OCCUPANT RISK VALUES							
Long.OIV (ft/s)	5.8	Long. Ridedown (g)	5.9	Max 50ms Long. (g)	-2.0	Max Roll (deg)	28
Lat. OIV (ft/s)	10.7	Lat. Ridedown (g)	12.8	Max 50ms Lat. (g)	4.8	Max Pitch (deg)	9
THIV (m/s)	3.8	ASI	0.6	Max 50ms Vert (g)	2.0	Max Yaw (deg)	23



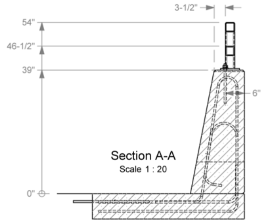


Figure 6.6 Summary of Results for *MASH* Test 4-12 on Bicycle Railing on a Constant Slope Parapet.

Chapter 7. SUMMARY AND CONCLUSIONS

7.1. ASSESSMENT OF TEST RESULTS

The crash test reported herein was performed in accordance with *MASH* Test 4-12, which involved one test, on the Bicycle Railing on a Constant Slope Parapet. Tables at the end of this section provide an assessment of the test based on the applicable safety evaluation criteria for *MASH* TL-4 longitudinal barriers.

7.2. CONCLUSIONS

Table 7.1 shows that the Bicycle Railing on a Constant Slope Parapet met the performance criteria for *MASH* 4-12 longitudinal barriers.

Table 7.1 Performance Evaluation Summary for *MASH* Test 4-12 on Bicycle Railing on a Constant Slope Parapet.

Test Agency: Texas A&M Transportation Institute — Test No.: 616221-01 — Test Date: 2021-11-08

MASH Test 4-12 Evaluation Criteria	Test Results	Assessment
Structural Adequacy A. *Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.*	The Bicycle Rail on a Concrete Parapet contained and redirected the 10000S vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum dynamic deflection during the test was 6.2 inches.	Pass
Occupant Risk D. *Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone.*	No detached elements, fragments, or other debris from the bridge rail were present to penetrate or show potential for penetrating the occupant compartment, or to present undue hazard to others in the area.	Pass
Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH.	No deformation or intrusion of the occupant compartment occurred.	
G. *It is preferable, although not essential, that the vehicle remain upright during and after collision.*	The 10000S vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 28 degrees and 9 degrees.	Pass

Table 7.2 Assessment Summary for *MASH* Test 4-12 on Bicycle Railing on a Constant Slope Parapet.

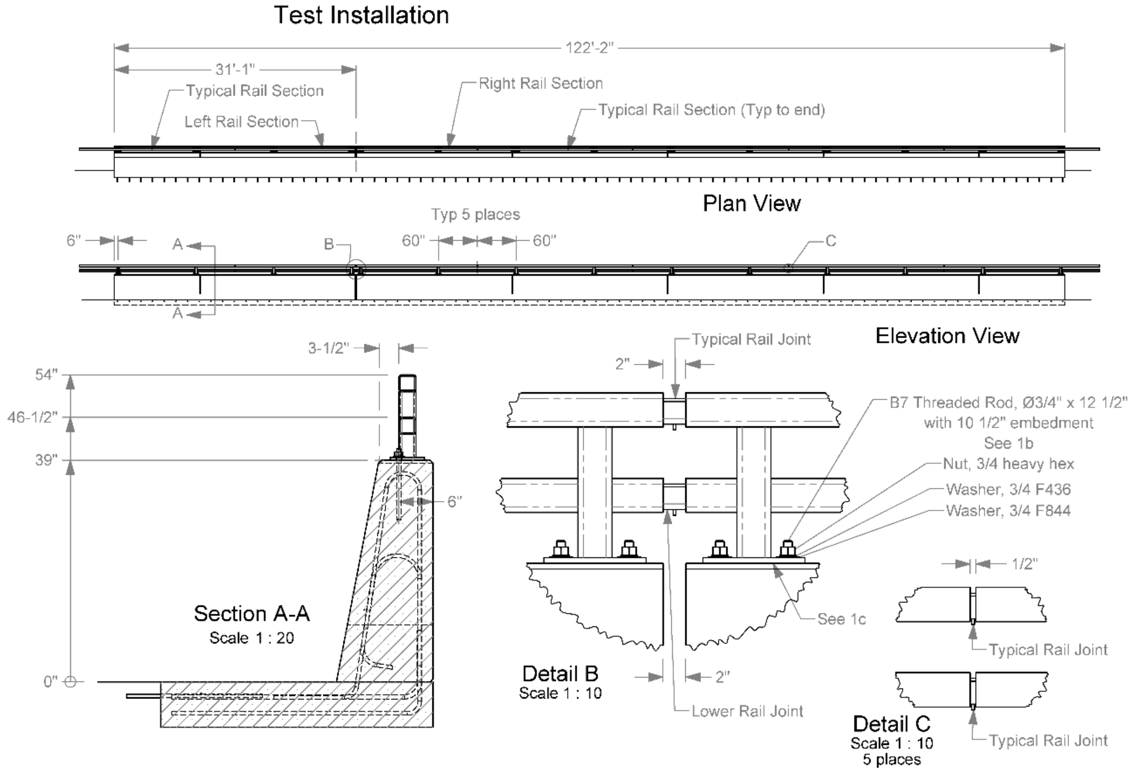
Evaluation Factors	Evaluation Criteria	Test No. 616221-01
Structural Adequacy	A	S
Occupant Risk	D	S
	F	N/A
	G	S
	H	N/A
	I	N/A
Test No.		*MASH* Test 4-12
Pass/Fail		Pass

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

REFERENCES

1. AASHTO. Manual for Assessing Safety Hardware (*MASH*), Second Edition. American Association of State Highway and Transportation Officials, Washington, DC, 2016.
2. W.F. Williams, R.P. Bligh, and W.L. Menges, Mash Test 3-11 of the TxDOT Single Slope Bridge Rail (Type SSTR) on Pan-Formed Bridge Deck. Report 9-1002-3. Texas A&M Transportation Institute, College Station, TX, 2011.
3. D. Whitesel, J. Jewell, and R. Meline, Compliance Crash Testing of the Type 60 Median Barrier, Test 140MASH3C16-04. Research Report FHWA/CA17-2654, Roadside Safety Research Group, California Department of Transportation, Sacramento, CA, May 2018.
4. Sheikh, N.M., Bligh, R. P., and Menges, W.L. (2009). “Development and Testing of a Concrete Barrier Design for Use in Front of Slope or on MSE Wall.” Report 405160-13-1, Texas A&M Transportation Institute, College Station, Texas.

APPENDIX A. DETAILS OF BICYCLE RAILING ON A CONSTANT SLOPE PARAPET



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

1b. Secure with Hilti HIT-RE 500 V3 epoxy according to manufacturer's instructions. All hardware Typical x 2 at each Post.

1c. Place 1/8" Fabric Reinforced Elastometric Pad between Posts and Concrete.

Texas A&M Transportation Institute

Roadside Safety and
Physical Security Division -
Proving Ground

Project #616221-01 Bicycle Rail Parapet | 2021-07-16

Drawn by GES | Scale 1:175 | Sheet 1 of 7 Test Installation

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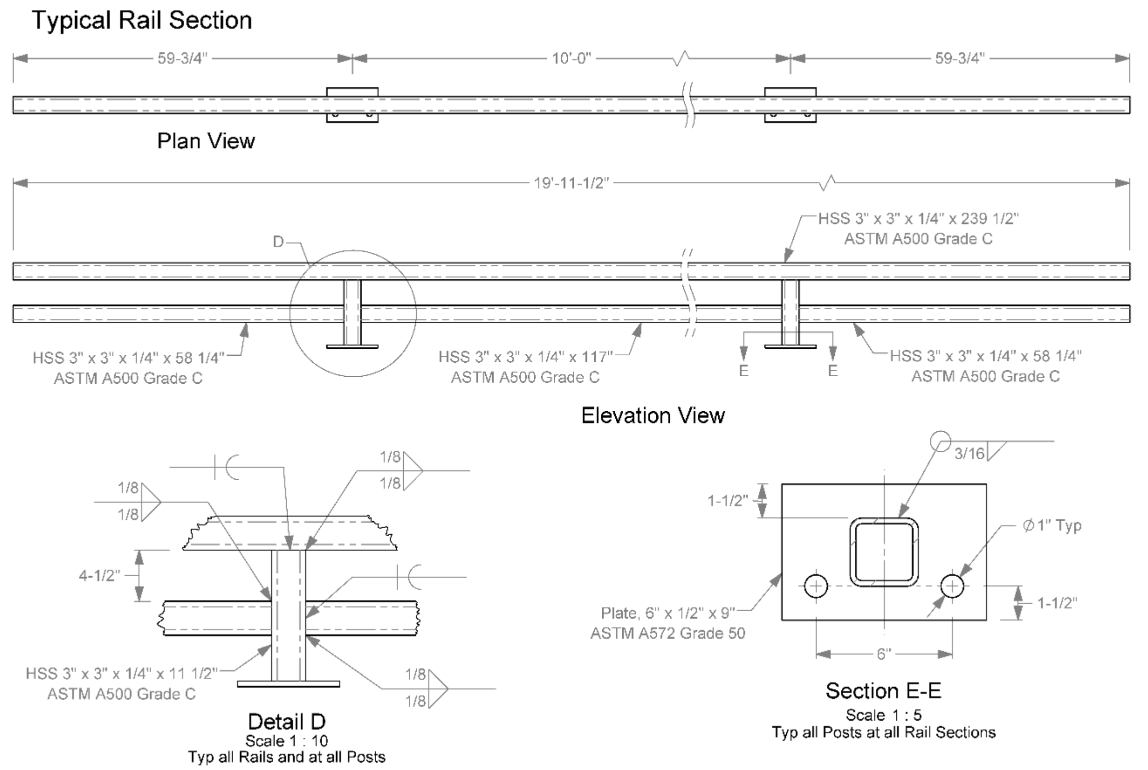

2a. All welding must be performed by certified welders using industry standard practices.
2b. Galvanize all components after fabrication is complete.

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

Project #616221-01 Bicycle Rail Parapet		2021-07-16
Drawn by GES	Scale 1:20	Sheet 2 of 7 Typical Rail Section

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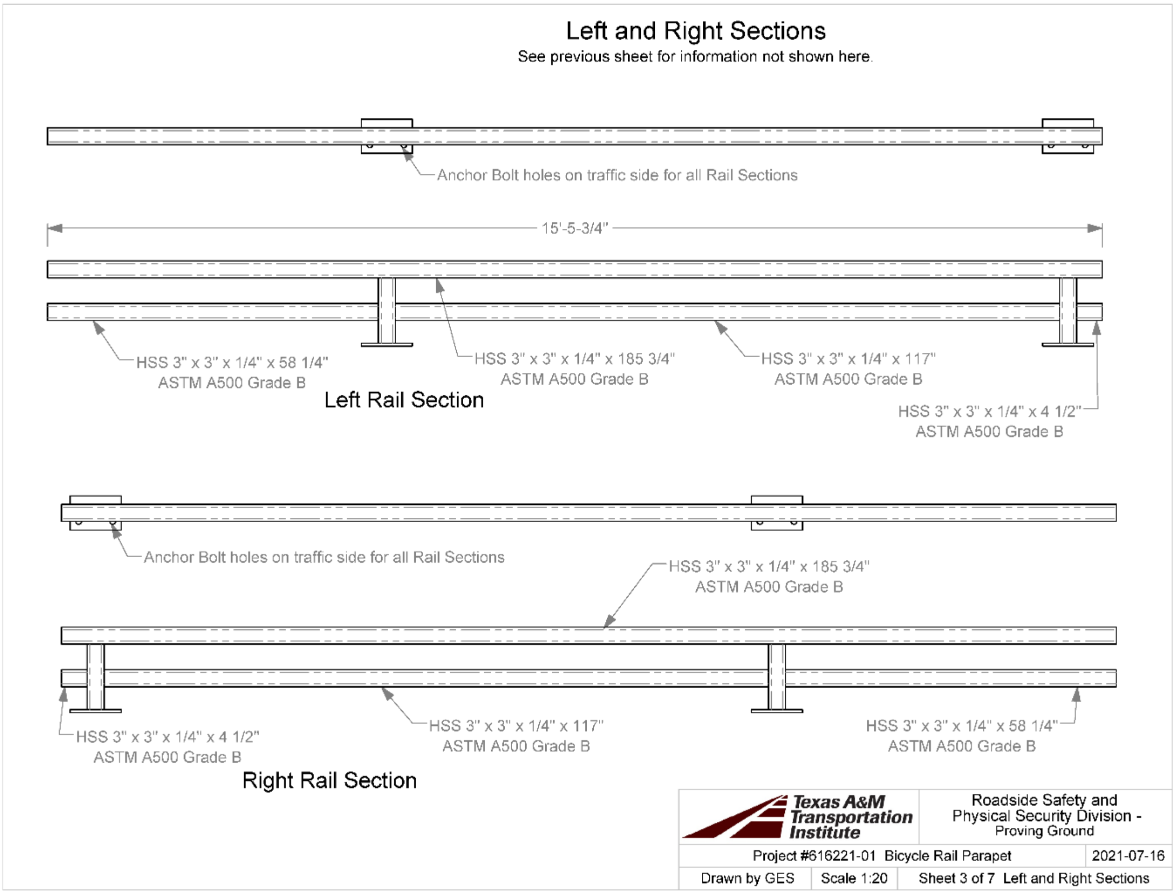

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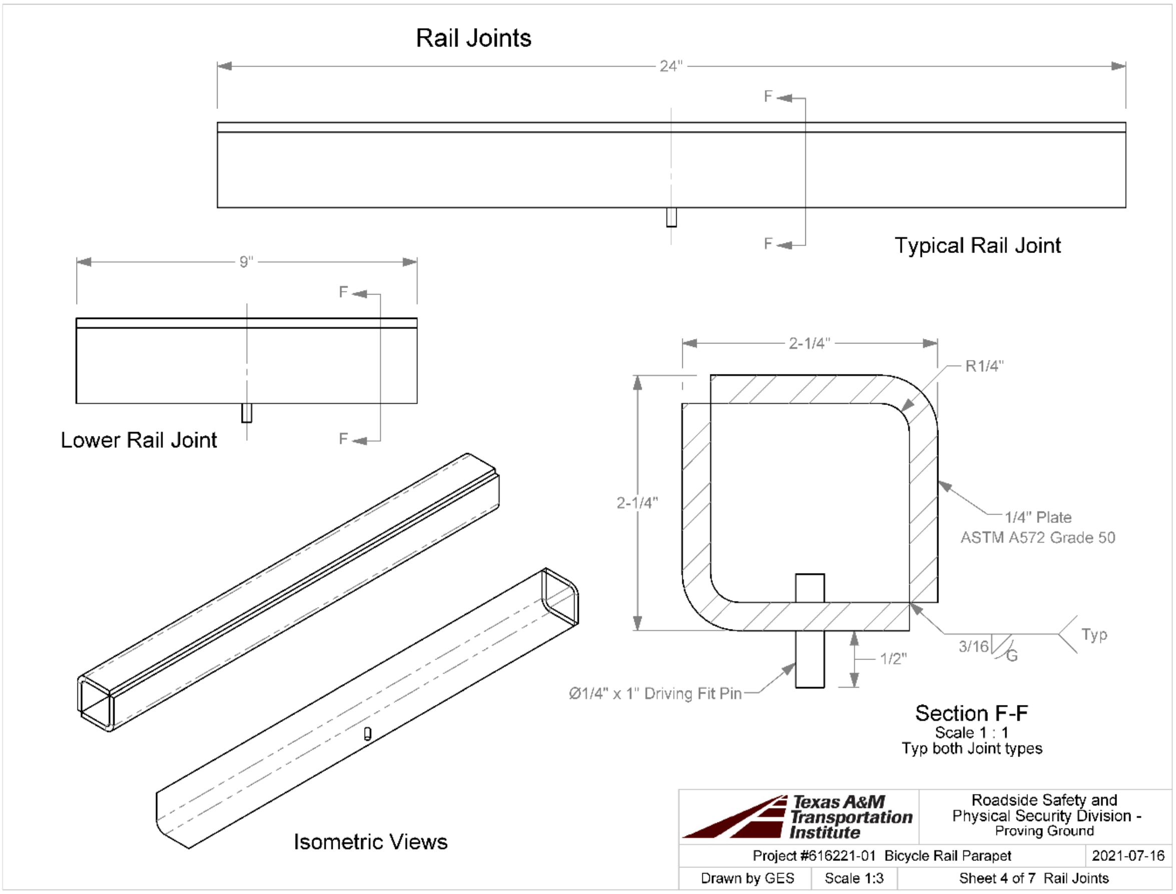

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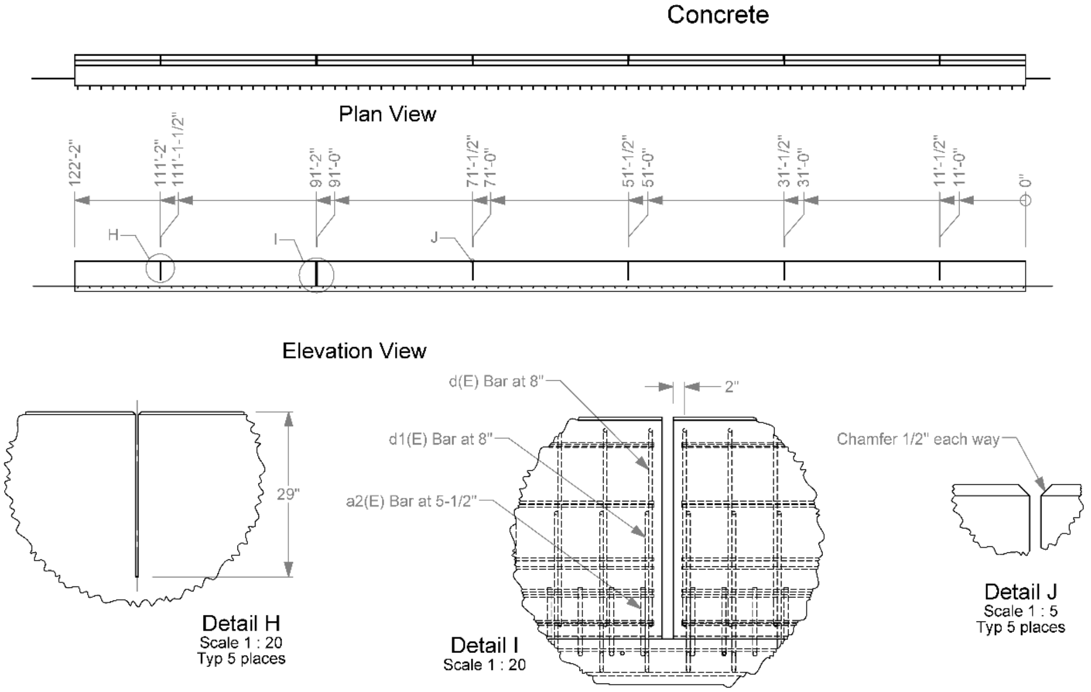

5a. Concrete is 4,000 for the Deck and Parapet.

5b. Minimum rebar lap is 32" for #4 bars and 42" for #5 bars. All rebar is grade 60.

5c. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).

5d. Backfill around moment slab with native soil and compact to 95% of standard proctor density.

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground
Project #616221-01 Bicycle Rail Parapet		2021-07-16
Drawn by GES	Scale 1:175	Sheet 5 of 7 Concrete

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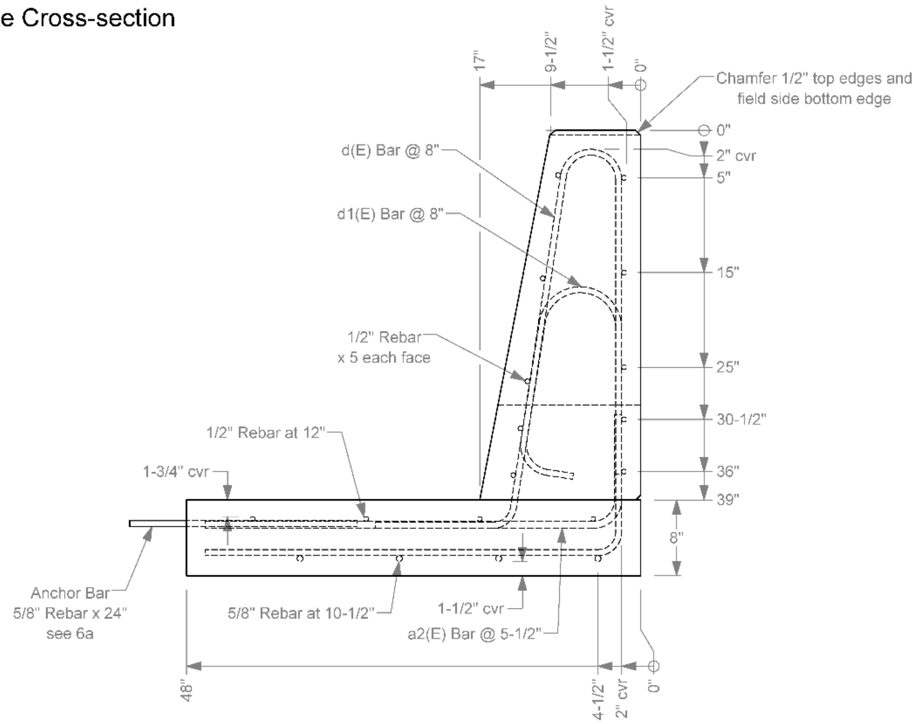
Concrete Cross-section



6a. Secure in existing concrete with Hilti HIT-RE 500 V3 epoxy according to manufacturer's instructions. Maximum spacing is 18".

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #616221-01 Bicycle Rail Parapet		2021-07-16
Drawn by GES	Scale 1:12	Sheet 6 of 7 Concrete Cross-section

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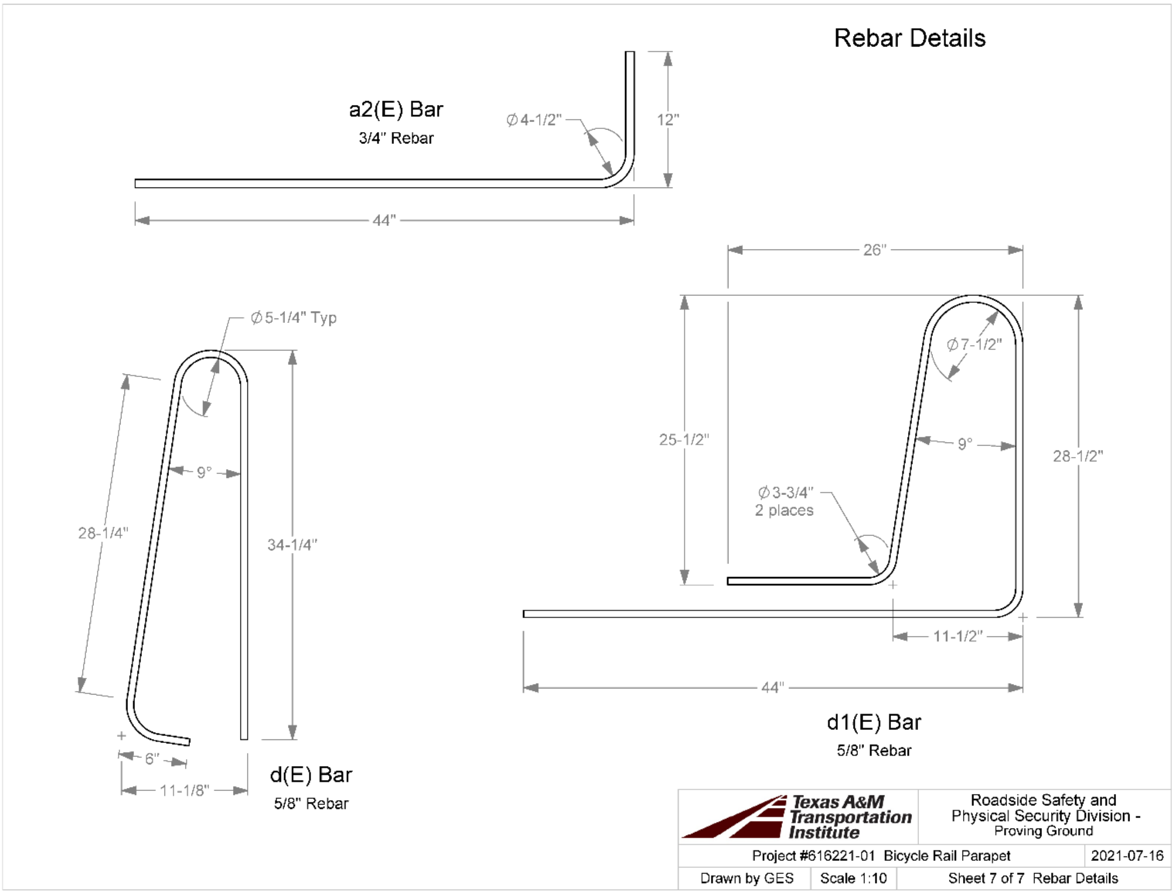

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APPENDIX B. SUPPORTING CERTIFICATION DOCUMENTS

TEXCRETE INC

Date Issued: 10/26/2021
Customer: MBC MANAGEMENT
Project: TTI-BPR

The following concrete mix designs are proposed for use at the above referenced project. The concrete compressive strength historical data submitted was derived from past mix designs produced by our ready-mix plants and analyzed in accordance with ACI 214 or may be by the laboratory trial mixture method.

Mix	Use
FN950200801	Test Barrier

To ensure the correct mix is delivered to your project, please order by the mix design code as indicated above.

The above mixes have been proportioned in accordance with the required sections in ACI 211 and/or your request. The above designs will meet or exceed the indicated specified strength when the concrete is tested in accordance with the applicable and current ASTM Standards and evaluated in accordance with the ACI 318 Building Code. Failure to test concrete specimens in accordance with specifications will void all warranties. Any additional products added to the concrete outside of the normal batching procedure will be at the liability of the purchaser.

Please notify Texcrete of approval of the proposed mix design prior to their use. Failure to notify us prior to the first placement shall constitute acceptance. To ensure that the proper mix designs are ordered, please send a copy of this letter, after approval, to the above referenced project to be used by the person ordering concrete for this job.

Texcrete would like to be included on the mailing list to receive test reports at will@texcrete.net. ASTM C94 and ACI 301 entitles the manufacturer to receive copies of the test reports when the strength of the concrete is used as the basis for acceptance. This will not happen automatically it will require a request on your part to the testing laboratory and owner. This information allows us to monitor your project as well as develop statistical histories for your future projects.

Please contact us if you have any questions or require any additional information.

Respectfully Submitted,

Will Squyres
Director of Technical Services

TEXCRETE INC

Bryan
5222 Sandy Point Road
Bryan, Texas 77807
979-985-3636

Concrete Mix Submittal

Customer:	MBC MANAGEMENT	Date Issued:	10/26/2021
Project:	TTI-BPR	Usage:	Test Barrier
Plant:	Bryan	Design Strength:	5000 psi @ 28 Days
Mix Code:	FN950200801		
Mix Description:	COM,5000,BLND,8",1.5%,T1A20,597,AD1		

Mix Properties

Source	Description	Specific Gravity	Weight lb	Volume ft3
Capitol Cement	TYPE I CEMENT	3.15	477	2.427
Boral	CLASS F FLY ASH	2.3	120	0.836
Arcosa	1" RIVER ROCK	2.64	1392	8.450
Arcosa	3/8" PEA GRAVEL	2.64	515	3.126
Arcosa	NATURAL SAND	2.63	1317	8.025
	WATER	1	233	3.734
Chryso	TYPE F HRWR	1		
	Air			0.405
		TOTALS:	27.00 ft3	4056.3 lb

Design Slump:	6.5-9.5\8	Unit Weight:	150.22 lb/ft3
Design Air:	1.5	Design W/CM Ratio:	0.39

Texcrete has no knowledge or authority regarding where this mix is to be placed, therefore it is the responsibility of the project architect/engineer, and/or the contractor to ensure that the above mix design parameters of compressive strength, water/cementitious ratio, cement content, and air content are appropriate for the anticipated environmental conditions (i.e. ACI 318, ACI 301, and the local Building Codes).

The data enclosed represents the potential of this mix when sampled, cured, and tested per the appropriate and current ACI and ASTM standards.

Chemical Admixtures are added in accordance with the manufacture's recommendations. Texcrete reserves the right to adjust these dosages to meet changes in jobsite conditions and/or demands up to and including the substitution of equivalent products. Designed cementitious content is stated as a minimum. Texcrete reserves the right to increase cementitious content.

Aggregate weights may change depending on gradations or specific gravity of material. Mix Design Proportions and specifications are confidential and proprietary trade secrets of Texcrete. Any use or dissemination without permission is a violation of federal criminal law.

Will Squyres
Director of Technical Services

Capitol Cement
11551 Nacogdoches Rd.
San Antonio, Texas

Type I (LA) Cement - C 150/C 150M

Date : August 9, 2021

Production Period:
Beginning July 1, 2021
Ending July 31, 2021

CHEMICAL		
Item	Spec. Limit	Test Result
SiO_2 (%)	*A*	19.7
Al_2O_3 (%)	*A*	5.6.
Fe_2O_3 (%)	*A*	1.8
CaO (%)	*A*	64.55
MgO (%)	*6.0 maximum*	1.2
SO_3 (%)	*3.5 D*	3.7
Na_2O (%)	*A*	0.18
K_2O (%)	*A*	0.48
Equivalent alkalies (%)		0.48
	minimum	0.45
	maximum	0.54
Ignition Loss (%)	*3.5 maximum*	2.4
Insoluble Residue (%)	*1.5 maximum*	0.56
Limestone (%)	*5.0 maximum*	2.36
CO_2 (%)	*A*	1.00
$CaCO_3$ in Limestone	*70 Minimum*	96
C_3A (%)	*A*	12
C_3S (%)	*A*	62
C_2S (%)	*A*	9
C_4AF (%)	*A*	6

PHYSICAL				
Item			Spec. Limit	Test Result
Air Content of Mortar (volume %)			*12 maximum*	10.6
Blaine Fineness (m^2/kg)			*260 minimum*	403
Autoclave Expansion (%)			*0.80 maximum*	0.01
C 1038 Mortar bar expansion (%)			0.020% max	0.001
Time of Setting (minutes)				
Vicat				
Initial	Not less than		*45*	104
Final	Not more than		*375*	236
Compressive Strength				
1 Day	(psi)		*A*	2130
3 Day	(psi)	*minimum*	*(1740)*	4080
7 Day	(psi)	*minimum*	*(2760)*	5050
28 Day	(psi)	(June)	*A*	6440

A Not Applicable
(D) Permisible to exceed this value provided expansion does not exceed 0.02% at 14 days. (C-1038)
We certify that the above cement, at the time of shipment meets the chemical and physical requirements of the current ASTM C 150 and AASHTO M 85 specifications.
The above data represents the averages of representative samples from production.
This product is made in the U.S.A

Signature _
Douglas Conroy

Title Chief Chemist

BORAL
RESOURCES

PO Box 38
Thompsons, TX 77481-0038
P: 281.343.0079

ASTM C618 / AASHTO M295 Testing of Class “F” Fly Ash Oak Grove Plant Franklin, Texas Unit #1,2

Sample Date:	**May 2021**	**Report Date:**	**7/16/21**
Sample Type:	**Monthly**	**MTRF ID:**	**1396OG**
Sample ID:	**#5-2021**		

Chemical Analysis	**Results**		**ASTM Limit Class F/C**	**AASHTO Limit Class F/C**
Silicon Dioxide (SiO_2)	51.60	%		
Aluminum Oxide (Al_2O_3)	19.93	%		
Iron Oxide (Fe_2O_3)	4.87	%		
Sum (SiO_2+Al_2O_3+Fe_2O_3)	76.40	%	50.0 min	50.0 min
Sulfur Trioxide (SO_3)	0.74	%	5.0 max	5.0 max
Calcium Oxide (CaO)	14.34	%	18.0 max / >18.0	18.0 max / >18.0
Magnesium Oxide (MgO)	2.80	%		
Sodium Oxide (Na_2O)	0.39	%		
Potassium Oxide (K_2O)	0.98	%		
Sodium Oxide Equivalent (Na_2O+0.658K_2O)	1.03	%		
Moisture	0.11	%	3.0 max	3.0 max
Loss on Ignition	0.45	%	6.0 max	5.0 max
Available Alkalies, as Na_2Oe	0.36	%	*Not Required	1.5 max* *when required by purchaser
Physical Analysis				
Fineness, % retained on 45-µm sieve	27.91	%	34 max	34 max
Strength Activity Index - 7 or 28 day requirement				
7 day, % of control	83	%	75 min	75 min
28 day, % of control	90	%	75 min	75 min
Water Requirement, % control	95	%	105 max	105 max
Autoclave Soundness	-0.03	%	0.8 max	0.8 max
Density	2.27	g/cm3		

The test data listed herein was generated by applicable ASTM methods. The reported results pertain only to the sample(s) or lot(s) tested. This report cannot be reproduced without permission from Boral Resources.

AUTHORIZED SIGNATURE:

Arcosa Aggregates
401 South Interstate Highway 45
Ferris, TX, 75125
T 972.544.5900

ARCOSA

Arcosa Aggregates Laboratory Testing

This material (Cameron-1336 / Plant #1) was sampled under on 05/03/21.

Summary of Results:
1" Coarse Aggregate

Sieve Size	Weight Retained	Percent Retained	Percent Passing	Specifications % Passing
1 1/2"	0.0	0.0	100.0	
1"	148.0	2.2	97.8	95-100
3/4"	500.0	7.5	92.5	
1/2"	2845.0	42.9	57.1	25-60
3/8"	4594.0	69.3	30.7	
#4	6545.0	98.7	1.3	0-10
#8	6601.0	99.5	0.5	0-5
Pan	6631.0	100.0	0.0	

Decant = 0.3%

#57 SPECS SHOWING

Sincerely,
Quality Control Department
Arcosa Aggregates
05/06/21

Arcosa Aggregates
401 South Interstate Highway 45
Ferris, TX, 75125
T 972.544.5900

ARCOSA

Arcosa Aggregates Laboratory Testing

This material (Cameron-1336) was sampled under ASTM D-75 on 06/02/21.
The sample was reduced under ASTM C-702.
This test was performed under ASTM C-136 & C-117.

Summary of Results:
3/8” Pea Gravel

Sieve Size	Weight Retained	Percent Retained	Percent Passing	Specifications % Passing
1/2"	0.0	0.0	100.0	
3/8"	23.0	0.7	99.3	
#4	2397.0	75.1	24.9	
#8	3139.0	98.3	1.7	
#16	3170.0	99.3	0.7	
Pan	3192.0	100.0	0.0	

Decant (-200) = 0.3%
Unit Weight = 105.6 lbs pcf

Specific Gravity = 2.54
Absorption = 1.4%

Sincerely,
Quality Control Department
Arcosa Aggregates
06/04/21

Arcosa Aggregates
401 South Interstate Highway 45
Ferris, TX, 75125
T 972.544.5900

ARCOSA

Arcosa Aggregates Laboratory Testing

This material (Cameron-1336 / Plant #1) was sampled under on 06/02/21.

Summary of Results:

Concrete Sand

Sieve Size	Weight Retained	Percent Retained	Percent Passing	Specifications % Passing
3/8"	0.0	0.0	100.0	100
#4	5.0	0.7	99.3	95-100
#8	111.0	15.5	84.5	80-100
#16	222.0	31.0	69.0	50-85
#30	334.0	46.6	53.4	25-60
#50	556.0	77.5	22.5	5-30
#100	699.0	97.5	2.5	0-10
#200	715.0	99.7	0.3	0-3
Pan	717.0	100.0	0.0	

F.M. = 2.69 **Sand Equivalency = 88%**

Load out

SG – 2.63 Unit Weight – 101.4 Absorption – 0.8%

PLANT #1

Sincerely,
Quality Control Department
Arcosa Aggregates
06/04/21

Concrete admixture

CHRYSO® Optima 249

HRWR – enhanced pumpability and strength development for HPC.

CHRYSO® Optima 249 is a new generation high range water reducing admixture based on proprietary polymers.

CHRYSO® Optima 249 is formulated specifically to enhance rheology and strengths characteristics of High and Ultra-high Performance Concrete (HPC & UHPC).

CHRYSO® Optima 249 exclusive formulation allows for extreme easiness of use and robustness.

CHRYSO® Optima 249 is manufactured under rigid quality control measures to provide uniform, reliable results.

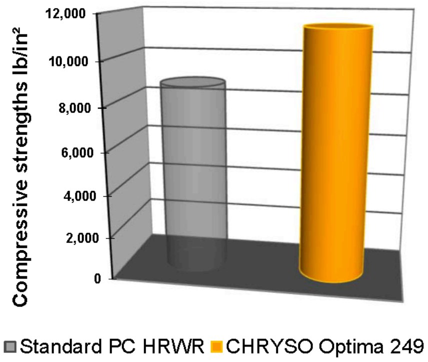
■ Benefits

- Provides enhanced workability retention
- Provides increased slump and flowability without increased water content
- Improves finish, placement and pumpability of concrete
- Allows for ultra high strengths performances at all ages
- Improves concrete quality by reducing the water-cement ratio for a given degree of workability
- Proprietary molecule reduces concrete viscosity (stickiness) allowing for easier placement, better finish and enhanced pumpability
- Reduces cracking and shrinkage
- Improves concrete chemical resistance and durability
- Improves cementitious material performance (more psi/lb)

■ Areas of Application

CHRYSO® Optima 249 is recommended for all concrete mixes where significant water reduction, improved cementitious material performance (more psi/lb), improved finishing and enhanced slump retention characteristics are desirable including SCC.

CHRYSO® Optima 249 is especially recommended for use in high performance concrete applications where very good slump or flow retention characteristics and enhanced pumpability are required.



www.chryso.com

Concrete admixture

Technical Datasheet

CHRYSO® Optima 249

■ Description:

Characteristics:
Physical state: liquid
Color: Amber
Density: Approx 1.07
pH: Approx. 4.5
Cl$^-$ ion content: Nil

CHRYSO® Optima 249 does not contain any purposely added calcium chloride or other chloride based components. It will not promote or contribute to corrosion of reinforcing steel in concrete.

Packaging:
55 gallon (210 L) drums
264 gallon (1000 L) totes
bulk deliveries

Standard specifications:
CHRYSO® Optima 249 meets the requirements of ASTM C494, Types A & F for a high range water reducing admixture.

■ Directions for use:

Dosage
CHRYSO® Optima 249 is recommended for use at a dosage rate of 2 to 5 fluid ounces per 100 pounds (130 to 326 ml per 100 kg) of cementitious material for a Type A and 4 to 12. fluid ounces per 100 pounds (261 to 782 ml per 100 kg) of cementitious material for a Type F.

CHRYSO® Optima 249 can be added at the concrete plant or on the job site. In case of addition in a mixing truck, it is recommended that the concrete be mixed at high speed for 70 to 100 revolutions (approximately 4-6 minutes)

Because local job conditions vary, please contact your local Chryso sales representative for further assistance if using outside recommended dosage ranges.

■ Directions for use:

Compatibility
CHRYSO® Optima 249 is compatible with all types of Portland cement, class C and F fly ash, slag, microsilica, calcium chloride, fibers and approved air entraining admixtures.

CHRYSO® Optima 249 can be used in all white, colored, and architectural concrete. For best results, each admixture must be dispensed separately into the concrete mix.

Precaution:
CHRYSO® Optima 249 may freeze at temperatures below 32° F (0° C). Although freezing does not harm **CHRYSO® Optima 249** , precautions should be taken to protect it from freezing.

If **CHRYSO® Optima 249** should happen to freeze, thaw and reconstitute with mechanical agitation.

Do Not Use Pressurized Air For Agitation

Shelf Life: 9 months

■ Safety:

CHRYSO® Optima 249 is not considered dangerous to handle. Please refer to the material safety data sheet for additional information.

About CHRYSO:
CHRYSO is a worldwide leader for Concrete and Cement additives, **CHRYSO** has been servicing the construction Industry for over half a century with outstanding innovation and service.
As a result, **CHRYSO**'s name and products have been associated with the most prestigious and demanding construction projects worldwide.

CHRYSO Inc. Tel: (800) 936-7553 – Fax: 972-772-6010
Southern Division P.O. Box 190 Rockwall, TX 75032
Midwest Division P.O. Box 129 Charlestown, IN 47111
Western Division 5090 Nome St Denver, CO 80239

www. us.chryso.com/

v. 5/2017

09-22-2021 07:01 **Load - 3937571** **BL - 3906637** **blr466**

Texas Corrugators, Inc **Heat - NL5401**

Cust. PO - M-2921 **Order - 20319253**

Atlas Tube Alabama
171 Cleage Dr
Birmingham Alabama USA
35217
Tel:
Fax:

Atlas *Tube*
A DIVISION OF ZEKELMAN INDUSTRIES

REF.B/L: 81045246
Date: 09/16/2021
Customer: 990

MATERIAL TEST REPORT

Sold To
Kloeckner Metals Corp.
500 Colonial Center Prkwy- Suite 500
ROSWELL GA 30076
USA

Shipped To
Kloeckner Metals Corp.
SOUTH LOOP 4, P.O. BOX 150367
BUDA TX 78715-0367
USA

Material: 3.0x3.0x250x40'0"0(6x3). **Material No:** 300302504000 **Made in:** USA

Melted and Poured In: USA

Sales Order: 1690809 **Purchase Order:** 7673856 **Cust Material#:** T314SQA5000480

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N	Ca
NL5401	0.200	0.810	0.006	0.003	0.024	0.030	0.100	0.001	0.010	0.030	0.050	0.003	0.001	0.0000	0.0060	0.0010

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.36
M403181296	18	068045 Psi	083495 Psi	32 %	ASTM A500-21 GRADE B&C	

Heat	MILL	Mill Location	Method	Recycled_Content	Post_Consumer	Pre-Consumer (Post Industrial)	% Harvested	Within Miles of Location
NL5401	NUCOR	Decatur,AL	EAF	53.70%	23.80%	29.90%	86%	500

Material Note:

Sales Or. Note:

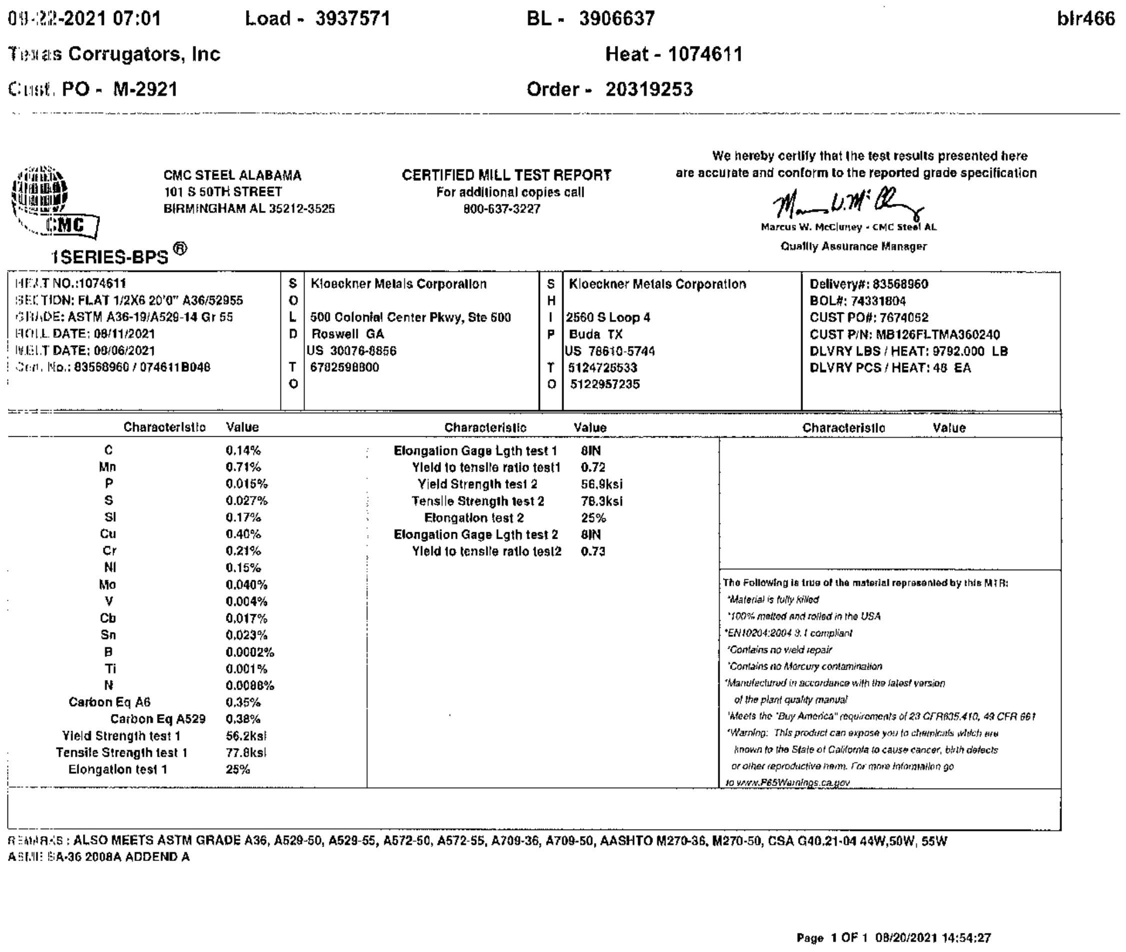
Authorized by Quality Assurance: Jason Richard

The results reported on this report represent the actual attributes of the material furnished and indicate full compliance with all applicable specification and contract requirements.
CE calculated using the AWS D1.1 method. This document is in compliance with the requirements of EN 10204 type 3.1

Steel Tube Institute OF NORTH AMERICA

Metals Service Center Institute

Page: 1 of 1



09-22-2021 07:01 Load - 3937571 BL - 3906637 blr466

Texas Corrugators, Inc Heat - 1074611

Cust. PO - M-2921 Order - 20319253

CMC STEEL ALABAMA
101 S 50TH STREET
BIRMINGHAM AL 35212-3525

CERTIFIED MILL TEST REPORT
For additional copies call
800-637-3227

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

Marcus W. McCluney - CMC Steel AL
Quality Assurance Manager

1SERIES-BPS®

HEAT NO.:1074611 SECTION: FLAT 1/2X6 20'0" A36/52955 GRADE: ASTM A36-19/A529-14 Gr 55 ROLL DATE: 08/11/2021 MELT DATE: 08/06/2021 Cert. No.: 83568960 / 074611B046	S O L D T O	Kloeckner Metals Corporation 500 Colonial Center Pkwy, Ste 500 Roswell GA US 30076-8856 6782598800	S H I P T O	Kloeckner Metals Corporation 2560 S Loop 4 Buda TX US 78610-5744 5124726533 5122957235	Delivery#: 83568960 BOL#: 74331804 CUST PO#: 7674052 CUST P/N: MB126FLTMA360240 DLVRY LBS / HEAT: 9792.000 LB DLVRY PCS / HEAT: 48 EA

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.14%	Elongation Gage Lgth test 1	8IN		
Mn	0.71%	Yield to tensile ratio test1	0.72		
P	0.015%	Yield Strength test 2	56.9ksi		
S	0.027%	Tensile Strength test 2	78.3ksi		
Si	0.17%	Elongation test 2	25%		
Cu	0.40%	Elongation Gage Lgth test 2	8IN		
Cr	0.21%	Yield to tensile ratio test2	0.73		
Ni	0.15%				
Mo	0.040%				
V	0.004%				
Cb	0.017%				
Sn	0.023%				
B	0.0002%				
Ti	0.001%				
N	0.0086%				
Carbon Eq A6	0.35%				
Carbon Eq A529	0.38%				
Yield Strength test 1	56.2ksi				
Tensile Strength test 1	77.8ksi				
Elongation test 1	25%				

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

REMARKS : ALSO MEETS ASTM GRADE A36, A529-50, A529-55, A572-50, A572-55, A709-36, A709-50, AASHTO M270-36, M270-50, CSA G40.21-04 44W,50W, 55W
ASME SA-36 2008A ADDEND A

Page 1 OF 1 08/20/2021 14:54:27

Steel Dynamics®
Flat Roll Group
Columbus Division

1945 Airport Road
Columbus, MS 39701
Phone: 662-245-4200
Fax: 662-245-4297

Metallurgical Certification

Sold To: KLOECKNER METALS (HOUSTON)
HOUSTON, TX 77028

Ship To: KLOECKNER METALS CORP
HOUSTON, TX 77028

Order Number: 425498-1
Order Dimensions: 0.2400X60.0000 (in) (MIN)
Ordered Product: A36 "CONVERSION TO"
PRIME HOT ROLLED BAND - PRIME
Part Number: HR .2400X60.0000 A36
Alt Part#:

Customer PO #: HTX-7427177-3 Load #:S981566 Ship Date: 10/25/2019

Chemical Analysis:

Coil Number:	Heat:	C	Mn	P	S	Si	Cu	Sn	Ni	Cr	Mo	Al	N	V	Nb	Ti	B	Ca	C(eq)
19B671402	B914889 Weight: 45,860 lb.	.21	.48	.011	.004	.03	.19	.0052	.04	.02	.026	.025	.0066	.001	.001	.001	.0001	.0015	.322

Mechanical Properties:	English	Metric
Yield Strength	54.0 ksi	372 MPa
Tensile Strength	76.0 ksi	524 MPa
Elongation	29 %	29 %
N-Value	Not Reported	
Hardness - HRBW	Not Reported	
Direction	Transverse	
Linear Footage	896 ft	273 m
Actual Gauge	.2449 in	6.22 mm

Conversion to - meets chemistry requirements additional testing required

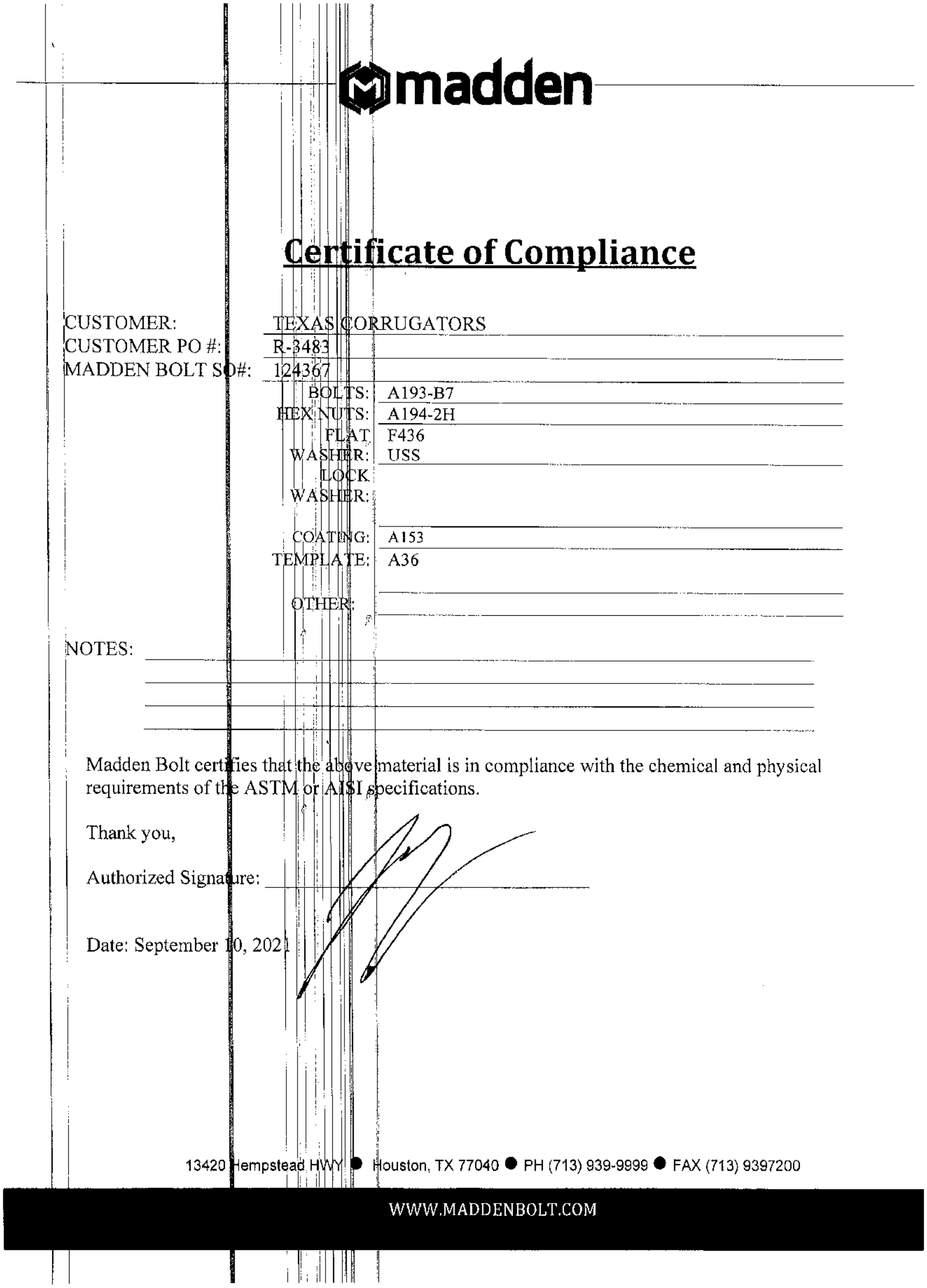
We hereby certify the above is correct as contained in the records of the company. All tests performed according to ASTM standards: E8, A370, E18, E415, E1019, E646, E517 or JIS Z2241 or Din En10325 as required. All Heats are Al Killed and Ca Treated. This product was Melted and Manufactured in the USA in compliance to the American Iron and Steel Step Certification and the Buy American Act, including 46 CFR 381.1 (B) requirements

Certified by: G Traczyk
Greg Traczyk
Hot Mill Metallurgical Engineer

Certificate Date: 10/25/2019

12-09-2019 10:17 Load - 3471076 BL - 81073544 blr466
Kloeckner Metals Corp - SHV Heat - B914889
Cust. PO - 7457703 Order - 18119692

01-10-2020 05:13 Load - 3492401 BL - 3876846 blr466
Texas Corrugators, Inc Heat - B914889
Cust. PO - M-1601 Order - 18214085



madden

Certificate of Compliance

CUSTOMER: TEXAS CORRUGATORS
CUSTOMER PO #: R-3483
MADDEN BOLT SO#: 124367
BOLTS: A193-B7
HEX NUTS: A194-2H
FLAT WASHER: F436 USS
LOCK WASHER:
COATING: A153
TEMPLATE: A36
OTHER:

NOTES:

Madden Bolt certifies that the above material is in compliance with the chemical and physical requirements of the ASTM or AISI specifications.

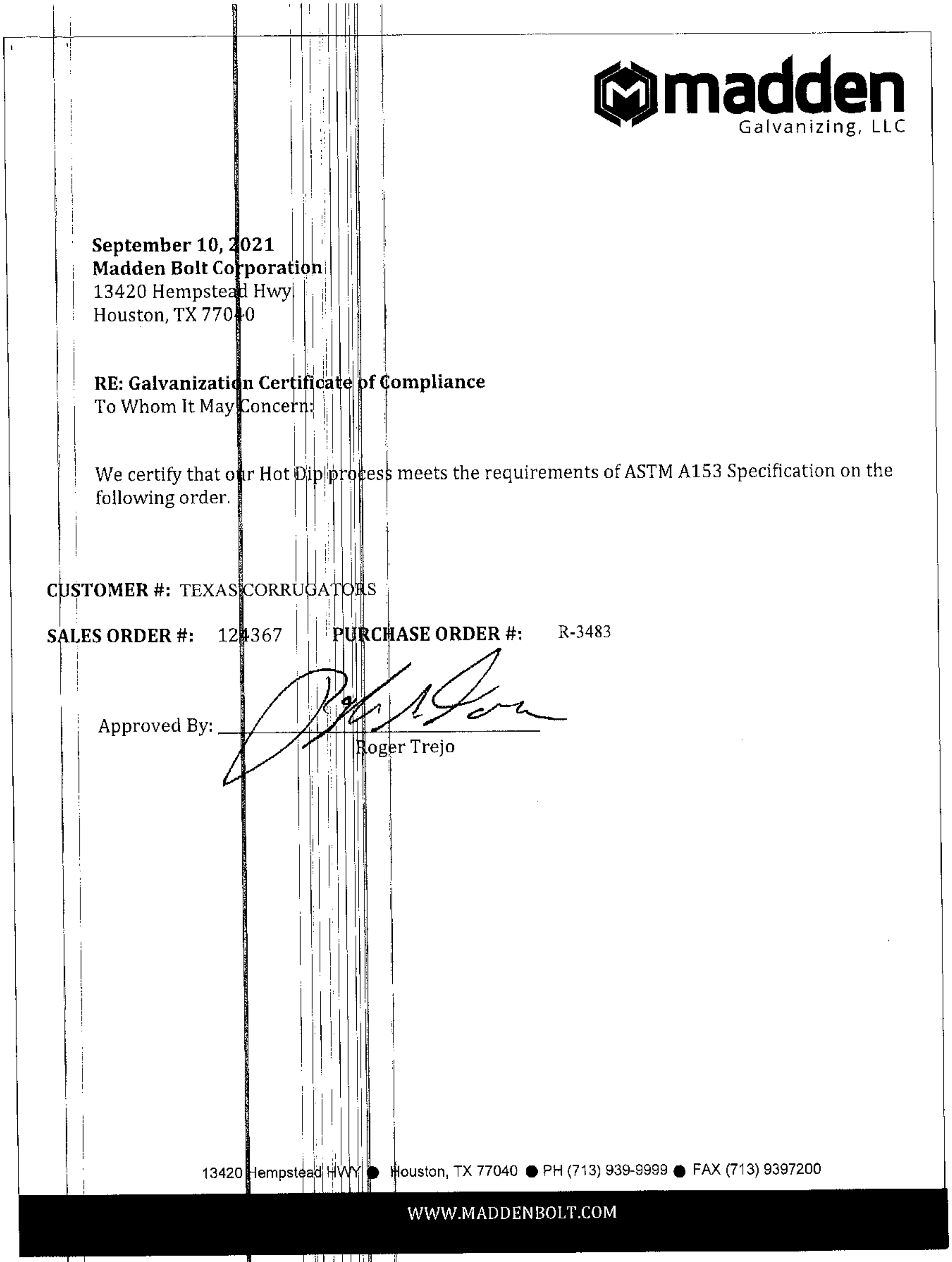
Thank you,

Authorized Signature:

Date: September 10, 2021

13420 Hempstead HWY ● Houston, TX 77040 ● PH (713) 939-9999 ● FAX (713) 9397200

WWW.MADDENBOLT.COM



madden
Galvanizing, LLC

September 10, 2021
Madden Bolt Corporation
13420 Hempstead Hwy
Houston, TX 77040

RE: Galvanization Certificate of Compliance
To Whom It May Concern:

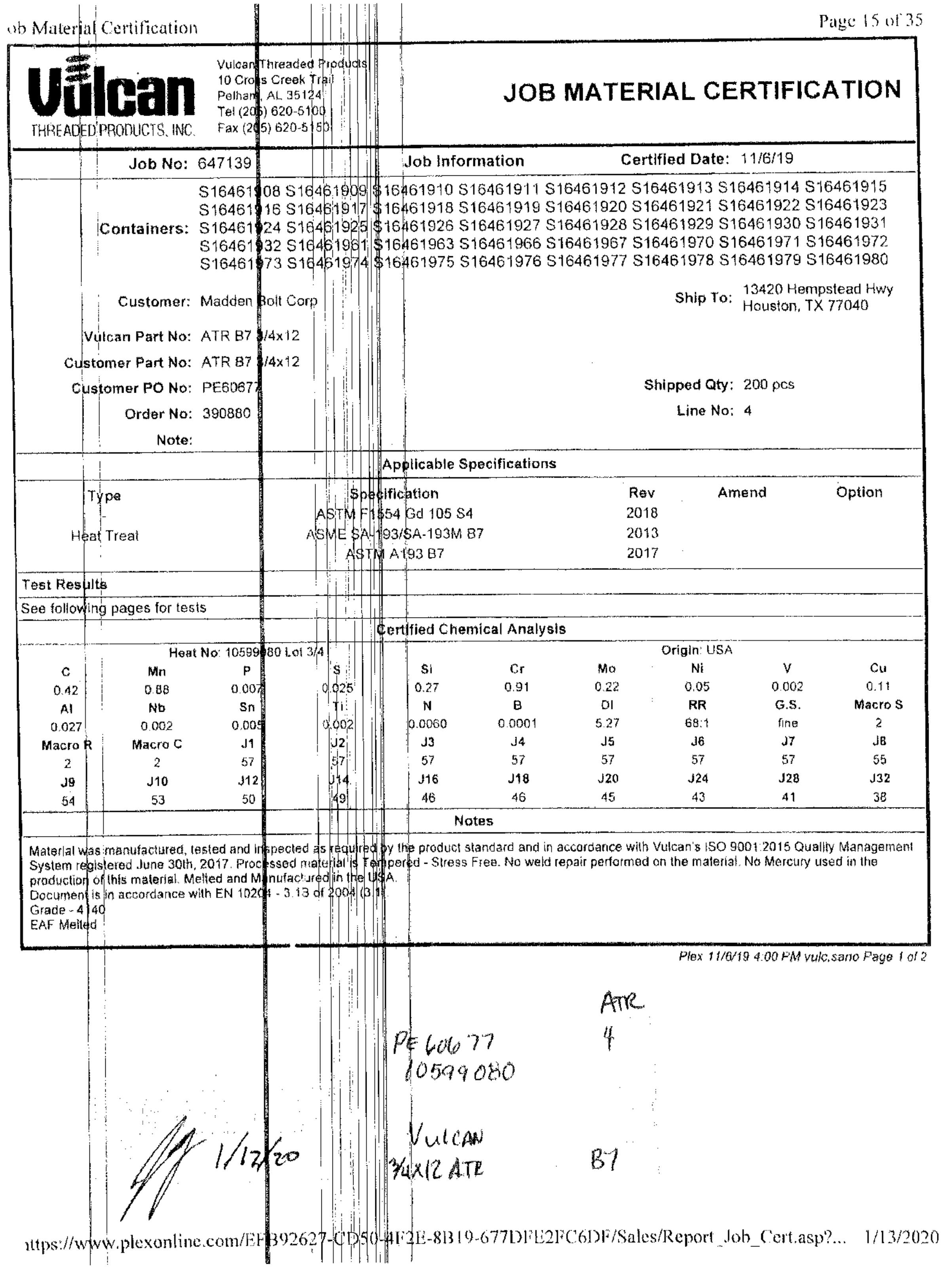
We certify that our Hot Dip process meets the requirements of ASTM A153 Specification on the following order.

CUSTOMER #: TEXAS CORRUGATORS

SALES ORDER #: 124367 **PURCHASE ORDER #:** R-3483

Approved By: ______________________
Roger Trejo

13420 Hempstead HWY ● Houston, TX 77040 ● PH (713) 939-9999 ● FAX (713) 9397200
WWW.MADDENBOLT.COM



Vulcan Threaded Products
10 Cross Creek Trail
Pelham, AL 35124
Tel (205) 620-5100
Fax (205) 620-5150

JOB MATERIAL CERTIFICATION

Job No: 647139 **Job Information** **Certified Date:** 11/6/19

Containers:
S16461908 S16461909 S16461910 S16461911 S16461912 S16461913 S16461914 S16461915
S16461916 S16461917 S16461918 S16461919 S16461920 S16461921 S16461922 S16461923
S16461924 S16461925 S16461926 S16461927 S16461928 S16461929 S16461930 S16461931
S16461932 S16461961 S16461963 S16461966 S16461967 S16461970 S16461971 S16461972
S16461973 S16461974 S16461975 S16461976 S16461977 S16461978 S16461979 S16461980

Customer: Madden Bolt Corp

Ship To: 13420 Hempstead Hwy
Houston, TX 77040

Vulcan Part No: ATR B7 3/4x12

Customer Part No: ATR B7 3/4x12

Customer PO No: PE60677

Shipped Qty: 200 pcs

Order No: 390880

Line No: 4

Note:

Applicable Specifications

Type	Specification	Rev	Amend	Option
-	ASTM F1554 Gd 105 S4	2018		
Heat Treat	ASME SA-193/SA-193M B7	2013		
-	ASTM A193 B7	2017		

Test Results

See following pages for tests

Certified Chemical Analysis

Heat No: 10599080 Lot 3/4 Origin: USA

C	**Mn**	**P**	**S**	**Si**	**Cr**	**Mo**	**Ni**	**V**	**Cu**
0.42	0.88	0.007	0.025	0.27	0.91	0.22	0.05	0.002	0.11
Al	**Nb**	**Sn**	**Ti**	**N**	**B**	**DI**	**RR**	**G.S.**	**Macro S**
0.027	0.002	0.005	0.002	0.0060	0.0001	5.27	68:1	fine	2
Macro R	**Macro C**	**J1**	**J2**	**J3**	**J4**	**J5**	**J6**	**J7**	**J8**
2	2	57	57	57	57	57	57	57	55
J9	**J10**	**J12**	**J14**	**J16**	**J18**	**J20**	**J24**	**J28**	**J32**
54	53	50	49	46	46	45	43	41	38

Notes

Material was manufactured, tested and inspected as required by the product standard and in accordance with Vulcan's ISO 9001:2015 Quality Management System registered June 30th, 2017. Processed material is Tempered - Stress Free. No weld repair performed on the material. No Mercury used in the production of this material. Melted and Manufactured in the USA.
Document is in accordance with EN 10204 - 3.13 of 2004 (3.1)
Grade - 4140
EAF Melted

Plex 11/6/19 4:00 PM vulc.sano Page 1 of 2

ATR
4

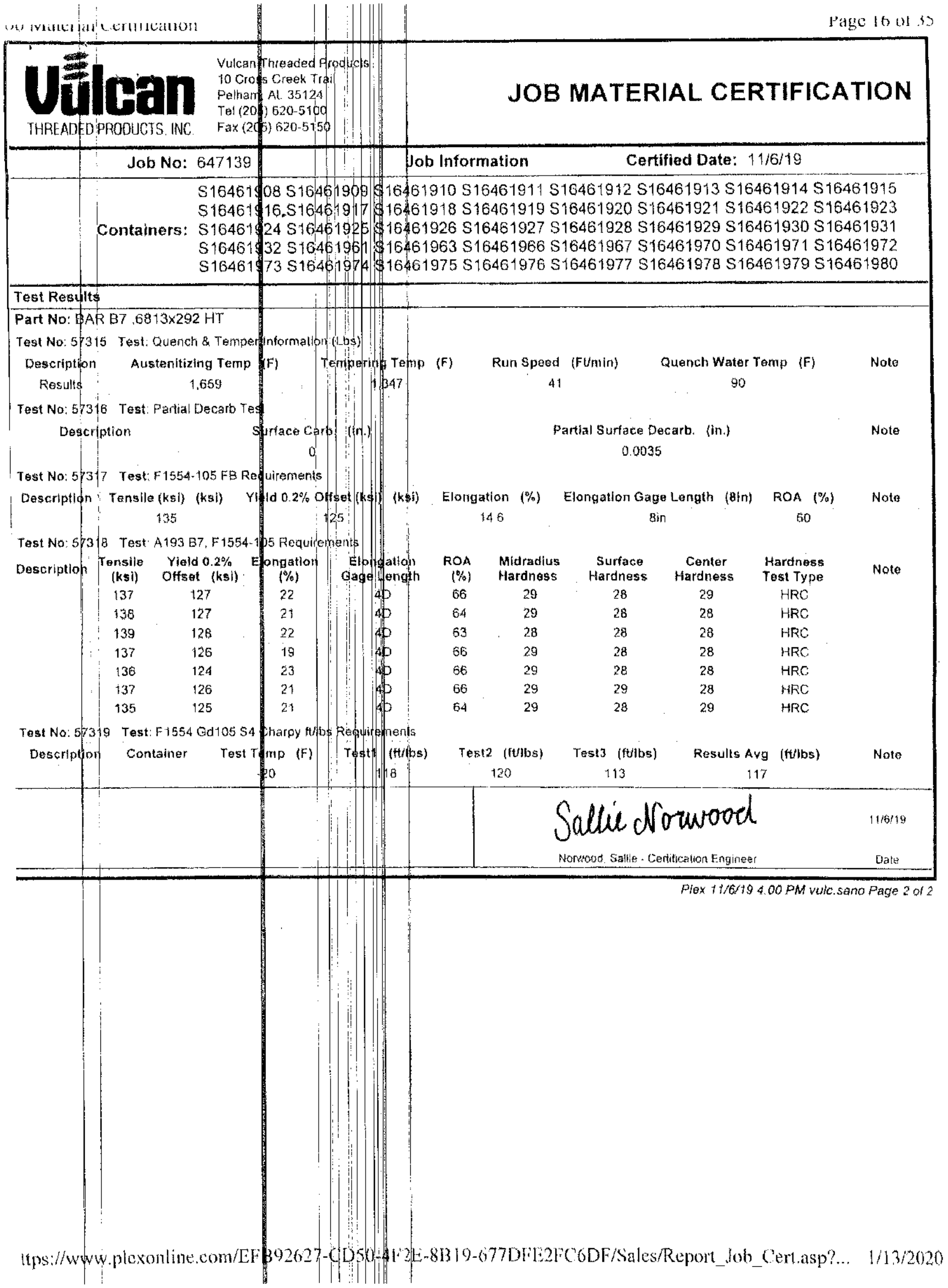
PE 60677
10599080

1/12/20

VULCAN
3/4x12 ATR

B7

ttps://www.plexonline.com/EFB92627-CD50-4F2E-8B19-677DFE2FC6DF/Sales/Report_Job_Cert.asp?... 1/13/2020



Vulcan Threaded Products
10 Cross Creek Trail
Pelham, AL 35124
Tel (205) 620-5100
Fax (205) 620-5150

THREADED PRODUCTS, INC.

JOB MATERIAL CERTIFICATION

Job No: 647139 **Job Information** **Certified Date:** 11/6/19

Containers: S16461908 S16461909 S16461910 S16461911 S16461912 S16461913 S16461914 S16461915 S16461916,S16461917 S16461918 S16461919 S16461920 S16461921 S16461922 S16461923 S16461924 S16461925 S16461926 S16461927 S16461928 S16461929 S16461930 S16461931 S16461932 S16461961 S16461963 S16461966 S16461967 S16461970 S16461971 S16461972 S16461973 S16461974 S16461975 S16461976 S16461977 S16461978 S16461979 S16461980

Test Results

Part No: BAR B7 .6813x292 HT

Test No: 57315 Test: Quench & Temper Information (Lbs)

Description	Austenitizing Temp (F)	Tempering Temp (F)	Run Speed (Ft/min)	Quench Water Temp (F)	Note
Results	1,659	1,347	41	90	

Test No: 57316 Test: Partial Decarb Test

Description	Surface Carb. (in.)	Partial Surface Decarb. (in.)	Note
	0	0.0035	

Test No: 57317 Test: F1554-105 FB Requirements

Description	Tensile (ksi) (ksi)	Yield 0.2% Offset (ksi) (ksi)	Elongation (%)	Elongation Gage Length (8in)	ROA (%)	Note
	135	125	14 6	8in	60	

Test No: 57318 Test: A193 B7, F1554-105 Requirements

Description	Tensile (ksi)	Yield 0.2% Offset (ksi)	Elongation (%)	Elongation Gage Length	ROA (%)	Midradius Hardness	Surface Hardness	Center Hardness	Hardness Test Type	Note
	137	127	22	4D	66	29	28	29	HRC	
	136	127	21	4D	64	29	28	28	HRC	
	139	128	22	4D	63	28	28	28	HRC	
	137	126	19	4D	66	29	28	28	HRC	
	136	124	23	4D	66	29	28	28	HRC	
	137	126	21	4D	66	29	29	28	HRC	
	135	125	21	4D	64	29	28	29	HRC	

Test No: 57319 Test: F1554 Gd105 S4 Charpy ft/lbs Requirements

Description	Container	Test Temp (F)	Test1 (ft/lbs)	Test2 (ft/lbs)	Test3 (ft/lbs)	Results Avg (ft/lbs)	Note
		20	118	120	113	117	

Sallie Norwood

Norwood, Sallie - Certification Engineer

11/6/19

Date

Plex 11/6/19 4.00 PM vulc.sano Page 2 of 2

https://www.plexonline.com/EFB92627-CD50-4F2E-8B19-677DFE2FC6DF/Sales/Report_Job_Cert.asp?... 1/13/2020

Stelfast Inc.

22979 Stelfast Parkway
Strongsville, Ohio

44149

Report of Chemical and Physical Properties

Issued To: Madden Bolt Corp
13420 Hempstead
HOUSTON, TX
77040

Purchase Order: PE62361
Stelfast Order: SO 248672
Certificate #: 844,952

Lot Number: N2019111215HH
Heat Number: 18209639-4
Country of Origin: CN

Quantity: 5,000
Part #: A2HHG0750C
Description: 3/4-10 Hvy Hx Nut 2H HDG/TOS 0.020

Chemical Analysis

C	Mn	P	S	Si	Cr	Mo	V	B	Ni	Cu
0.44	0.69	0.024	0.002	0.2						

Mechanical Properties

Tempering Temp.	540 C
Hardness After 24 HRS At 540 C	98 HRB
Hardness (Core)	27 - 30 HRC
Proof Load	175 KSI
Macro Etch Test	S2/R2/C2
Grade Markings	ASTM A194(16) - 2H

We hereby certify that the above data is a true copy of the data furnished to us by the producing mill or the data resulting from tests performed in approved laboratories. Stelfast does not certify to customer's part number. This certificate applies to the product shown on this document, as supplied by Stelfast Inc. Alterations to the product by our customer or a third party will render this certificate void.

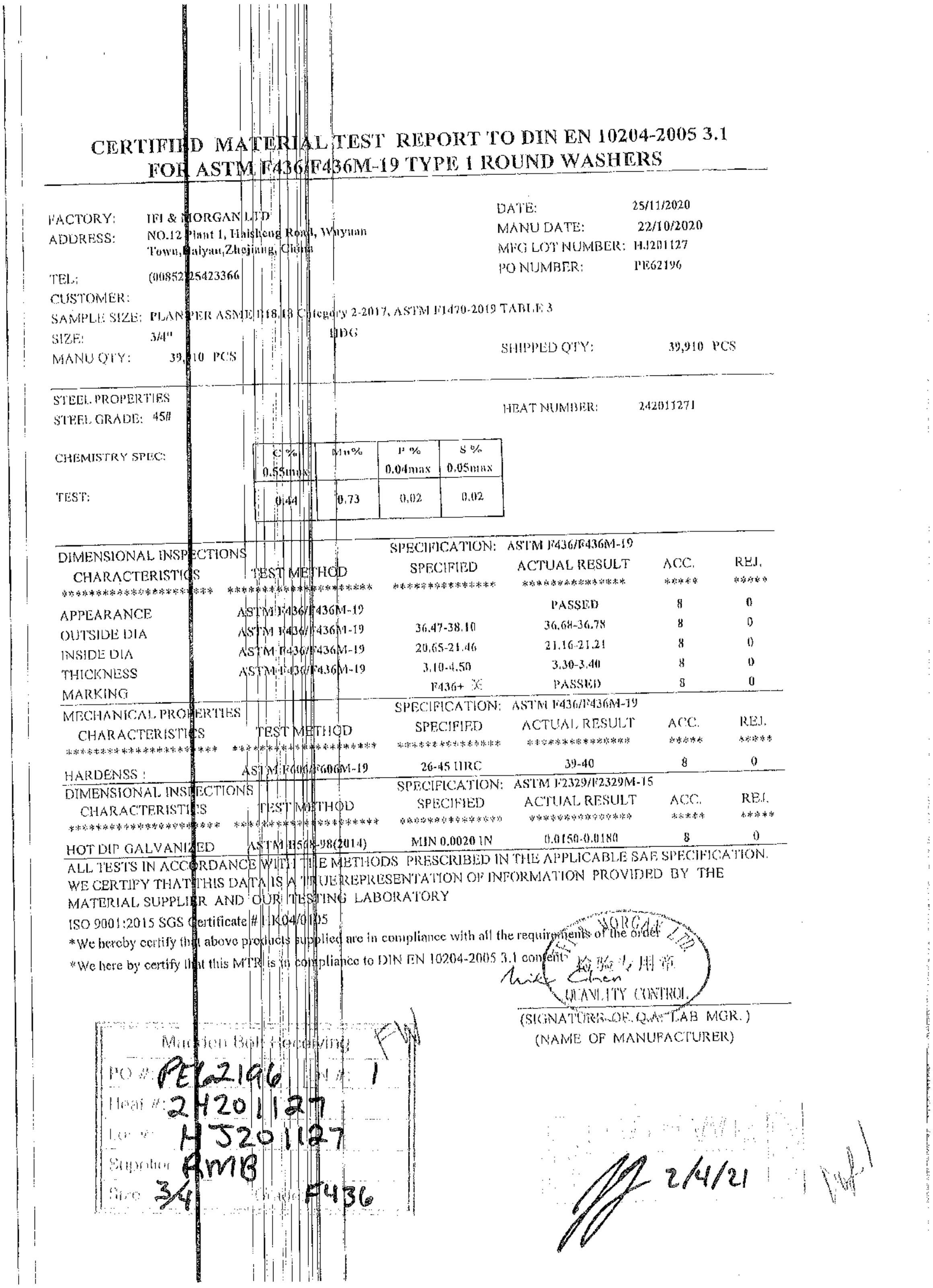
David Biss
Quality Manager

December 01, 2020

Madden Bolt Receiving HN
PE62361 4
18209639-4
N2019111215HH
Supplier: Stelfast
Size: 3/4 Grade: A194

REVIEWED 12/1/20

Page 1 of 1



CERTIFIED MATERIAL TEST REPORT TO DIN EN 10204-2005 3.1 FOR ASTM F436/F436M-19 TYPE 1 ROUND WASHERS

FACTORY: IFI & MORGAN LTD
ADDRESS: NO.12 Plant 1, Haisheng Road, Wuyuan Town, Haiyan, Zhejiang, China
TEL: (00852)25423366
CUSTOMER:
SAMPLE SIZE: PLAN PER ASME B18.18 Category 2-2017, ASTM F1470-2019 TABLE 3
SIZE: 3/4" HDG
MANU QTY: 39,910 PCS

DATE: 25/11/2020
MANU DATE: 22/10/2020
MFG LOT NUMBER: HJ201127
PO NUMBER: PE62196
SHIPPED QTY: 39,910 PCS

STEEL PROPERTIES
STEEL GRADE: 45#
HEAT NUMBER: 242011271

	C %	Mn%	P %	S %
CHEMISTRY SPEC:	0.55max		0.04max	0.05max
TEST:	0.44	0.73	0.02	0.02

DIMENSIONAL INSPECTIONS CHARACTERISTICS	TEST METHOD	SPECIFICATION: ASTM F436/F436M-19 SPECIFIED	ACTUAL RESULT	ACC.	REJ.
**********************	**********************	***************	***************	*****	*****
APPEARANCE	ASTM F436/F436M-19		PASSED	8	0
OUTSIDE DIA	ASTM F436/F436M-19	36.47-38.10	36.68-36.78	8	0
INSIDE DIA	ASTM F436/F436M-19	20.65-21.46	21.16-21.21	8	0
THICKNESS	ASTM F436/F436M-19	3.10-4.50	3.30-3.40	8	0
MARKING		F436+ ※	PASSED	8	0

MECHANICAL PROPERTIES CHARACTERISTICS	TEST METHOD	SPECIFICATION: ASTM F436/F436M-19 SPECIFIED	ACTUAL RESULT	ACC.	REJ.
**********************	**********************	***************	***************	*****	*****
HARDENSS :	ASTM F606/F606M-19	26-45 HRC	39-40	8	0

DIMENSIONAL INSPECTIONS CHARACTERISTICS	TEST METHOD	SPECIFICATION: ASTM F2329/F2329M-15 SPECIFIED	ACTUAL RESULT	ACC.	REJ.
**********************	**********************	***************	***************	*****	*****
HOT DIP GALVANIZED	ASTM B568-98(2014)	MIN 0.0020 IN	0.0150-0.0180	8	0

ALL TESTS IN ACCORDANCE WITH THE METHODS PRESCRIBED IN THE APPLICABLE SAE SPECIFICATION.
WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY
ISO 9001:2015 SGS Certificate # HK04/0105
*We hereby certify that above products supplied are in compliance with all the requirements of the order
*We here by certify that this MTR is in compliance to DIN EN 10204-2005 3.1 content

IFI & MORGAN LTD. 检验专用章 QUALITY CONTROL

Mike Chen

(SIGNATURE OF Q.A. LAB MGR.)
(NAME OF MANUFACTURER)

Ma[illegible]den Bolt Receiving
PO #: PE62196 #: 1
Heat #: 2H201127
Lot #: HJ201127
Supplier AMB
Size 3/4 Grade F436

FW

2/4/21

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

Project No: 616221-01 **Casting Date:** 10/19/2021 **Mix Design (psi):** 4000

Name of Technician Taking Sample: Terracon

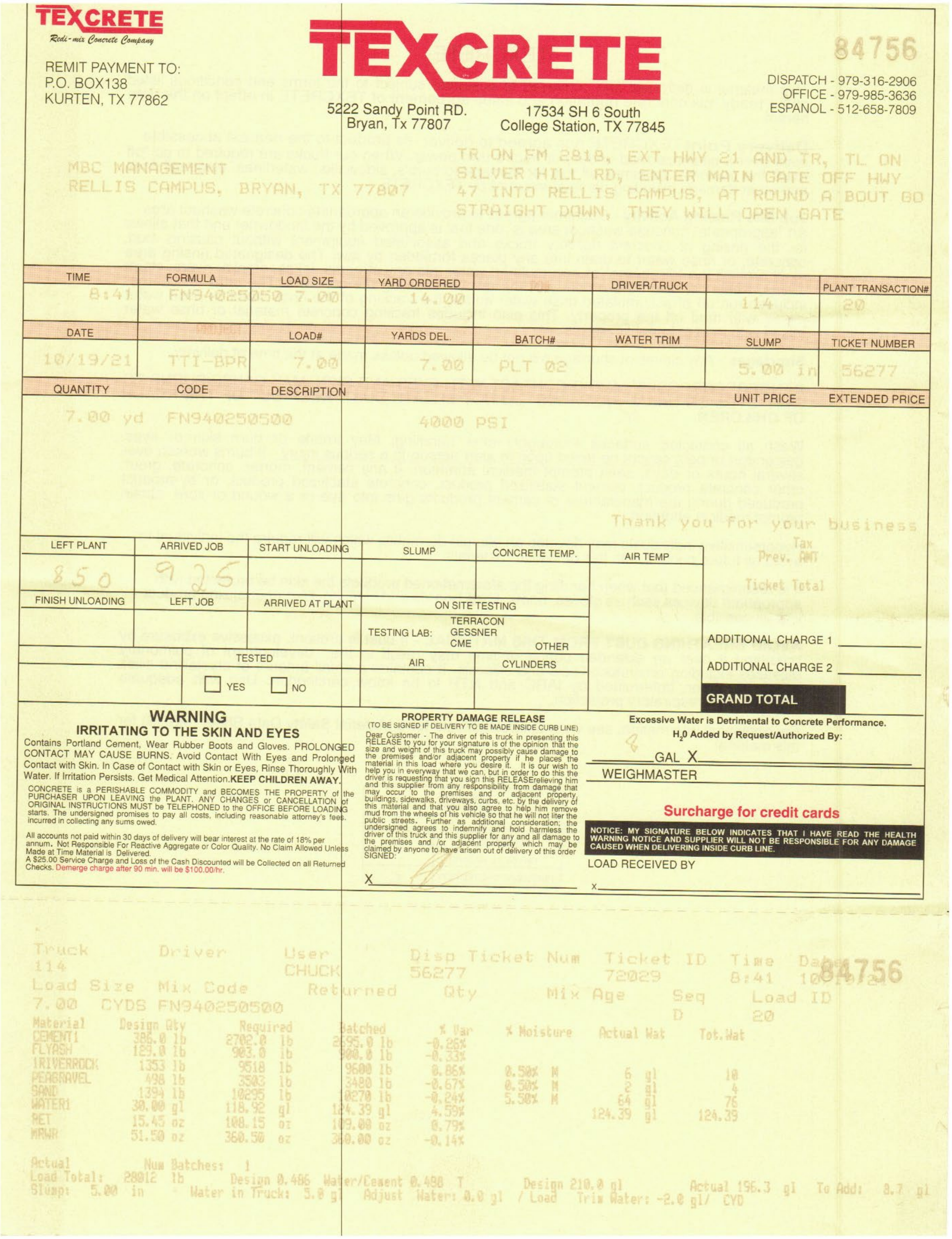
Name of Technician Breaking Sample: Terracon

Signature of Technician Taking Sample: Terracon

Signature of Technician Breaking Sample: Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	114	84756	70 feet of deck starting from South End
T2	122	89330	Remaining northern section of deck

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



TEXCRETE
Redi-mix Concrete Company

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

TEXCRETE

5222 Sandy Point RD.
Bryan, Tx 77807

17534 SH 6 South
College Station, TX 77845

84756

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

MBC MANAGEMENT
RELLIS CAMPUS, BRYAN, TX 77807

TR ON FM 2818, EXT HWY 21 AND TR, TL ON SILVER HILL RD, ENTER MAIN GATE OFF HWY 47 INTO RELLIS CAMPUS, AT ROUND A BOUT GO STRAIGHT DOWN, THEY WILL OPEN GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
8:41	FN94025050	7.00	14.00			114	20

DATE		LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
10/19/21	TTI-BPR	7.00	7.00	PLT 02		5.00 in	56277

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
7.00 yd	FN940250500	4000 PSI		

Thank you for your business

Tax
Prev. AMT
Ticket Total

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
850	925				

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

TESTED ☐ YES ☐ NO

AIR	CYLINDERS

ADDITIONAL CHARGE 1 ______

ADDITIONAL CHARGE 2 ______

GRAND TOTAL

WARNING

IRRITATING TO THE SKIN AND EYES

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

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

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

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

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

X______

Excessive Water is Detrimental to Concrete Performance.

H_2O Added by Request/Authorized By:

4 GAL X______

WEIGHMASTER

Surcharge for credit cards

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

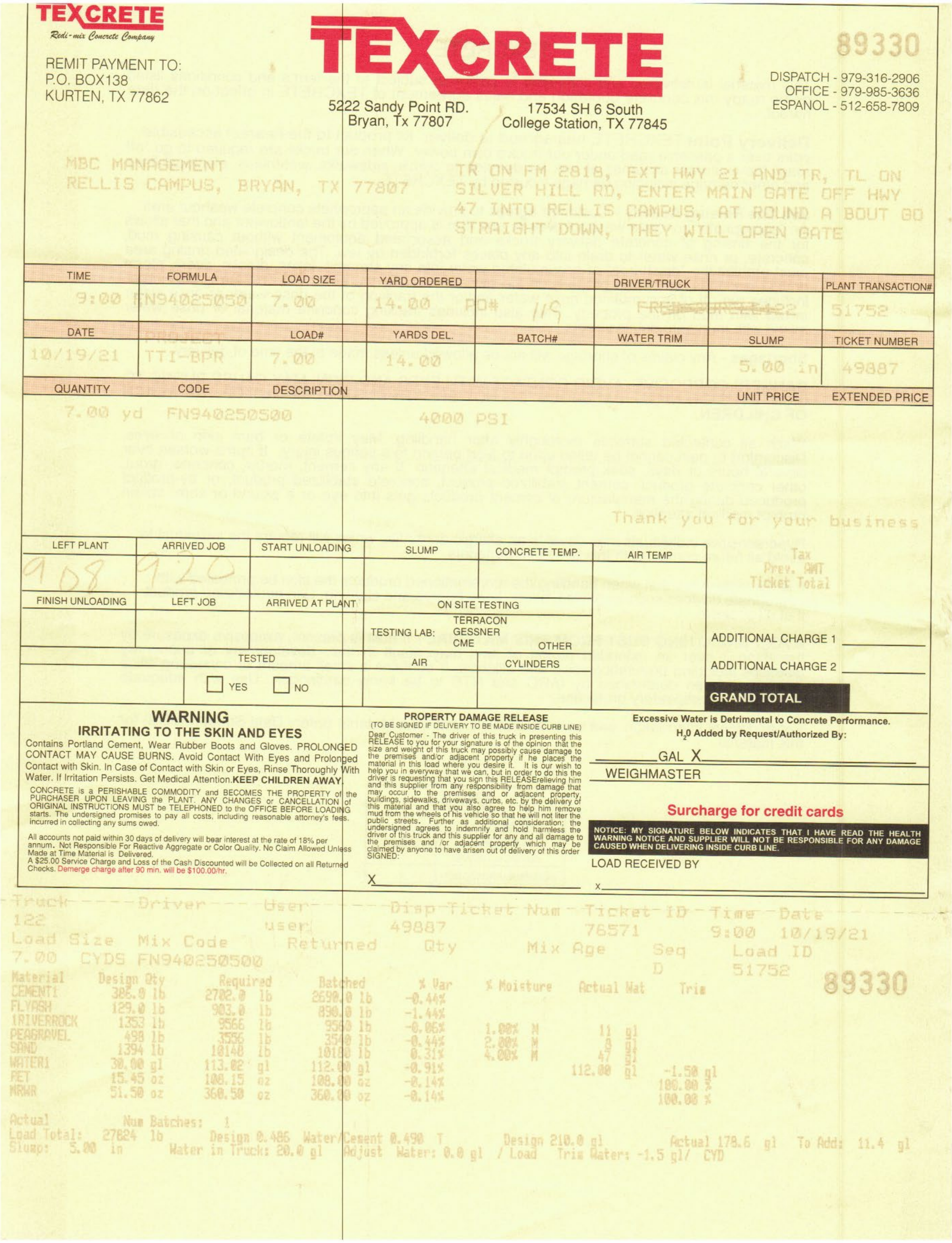
LOAD RECEIVED BY

x______

```
Truck        Driver      User          Disp Ticket Num   Ticket ID   Time   Date
114                      CHUCK         56277             72029       8:41   10/19/21
Load Size    Mix Code       Returned      Qty          Mix Age      Seq     Load ID
7.00  CYDS FN940250500                                               D       20
Material      Design Qty    Required      Batched       % Var    % Moisture   Actual Wat    Tot.Wat
CEMENT1        386.0 lb     2702.0  lb    2695.0 lb     -0.26%
FLYASH         129.0 lb      903.0  lb     900.0 lb     -0.33%
1RIVERROCK      1353 lb       9518  lb      9600 lb      0.86%   0.50%  M          6  gl        10
PEAGRAVEL        498 lb       3503  lb      3480 lb     -0.67%   0.50%  M          2  gl         4
SAND            1394 lb      10295  lb     10270 lb     -0.24%   5.50%  M         64  gl        76
WATER1         30.00 gl     118.92  gl    124.39 gl      4.59%                124.39  gl    124.39
RET            15.45 oz     108.15  oz    109.00 oz      0.79%
MRWR           51.50 oz     360.50  oz    360.00 oz     -0.14%

Actual             Num Batches:   1
Load Total:   28012  lb       Design 0.486  Water/Cement 0.488  T          Design 210.0 gl           Actual 196.3  gl   To Add:   8.7  gl
Slump:    5.00  in        Water in Truck:  5.0 gl   Adjust  Water: 0.0 gl  / Load   Trim Water: -2.0 gl/  CYD
```

84756



TEXCRETE
Redi-mix Concrete Company

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

TEXCRETE

5222 Sandy Point RD.
Bryan, Tx 77807

17534 SH 6 South
College Station, TX 77845

89330

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

MBC MANAGEMENT
RELLIS CAMPUS, BRYAN, TX 77807

TR ON FM 2818, EXT HWY 21 AND TR, TL ON SILVER HILL RD, ENTER MAIN GATE OFF HWY 47 INTO RELLIS CAMPUS, AT ROUND A BOUT GO STRAIGHT DOWN, THEY WILL OPEN GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
9:00	FN94025050	7.00	14.00	PO# 119	~~FRE[illegible]~~22		51752

DATE		LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
10/19/21	PROJECT TTI-BPR	7.00	14.00			5.00 in	49887

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
7.00 yd	FN940250500	4000 PSI		

Thank you for your business

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
908	920				

Tax
Prev. AMT
Ticket Total

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

TESTED

☐ YES ☐ NO

AIR	CYLINDERS

ADDITIONAL CHARGE 1 ____________

ADDITIONAL CHARGE 2 ____________

GRAND TOTAL

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X____________________

Excessive Water is Detrimental to Concrete Performance.

H_20 Added by Request/Authorized By:

________GAL X____________________

WEIGHMASTER

Surcharge for credit cards

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

LOAD RECEIVED BY

x____________________

```
-Truck-----Driver---User-----Disp Ticket Num - Ticket ID - Time  Date ------
122                 user     49887              76571      9:00  10/19/21
Load Size  Mix Code      Returned    Qty       Mix Age    Seq    Load ID
7.00  CYDS FN940250500                                    D      51752
Material   Design Qty   Required    Batched    % Var   % Moisture  Actual Wat   Trim
CEMENT1    386.0 lb     2702.0 lb   2690.0 lb  -0.44%
FLYASH     129.0 lb     903.0  lb   890.0 lb   -1.44%
1RIVERROCK  1353 lb      9566  lb    9560 lb   -0.06%  1.00%  M        11 gl
PEAGRAVEL    498 lb      3556  lb    3540 lb   -0.44%  2.00%  M         8 gl
SAND        1394 lb     10148  lb   10180 lb    0.31%  4.00%  M        47 gl
WATER1     30.00 gl     113.02 gl   112.00 gl  -0.91%             112.00 gl   -1.50 gl
RET        15.45 oz     108.15 oz   108.00 oz  -0.14%                         100.00 %
MRWR       51.50 oz     360.50 oz   360.00 oz  -0.14%                         100.00 %

Actual          Num Batches:  1
Load Total:  27824  lb     Design 0.486  Water/Cement 0.490  T        Design 210.0 gl        Actual 178.6  gl   To Add:  11.4  gl
Slump:   5.00  in     Water in Truck: 20.0 gl   Adjust  Water: 0.0 gl  / Load   Trim Water: -1.5 gl/  CYD
```

89330

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0213
Service Date: 10/19/21
Report Date: 11/10/21
Task: PO# 616221-01

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

Client

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

Project

Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength: 4,000 psi @ 20 days

Mix ID: FN94025050
Supplier: Texcrete
Batch Time: 0841 **Plant:** Bryan
Truck No.: 114 **Ticket No.:** 56277

Sample Information

Sample Date: 10/19/21 **Sample Time:** 0935
Sampled By: Randy Rippstein
Weather Conditions: Partly Cloudy, moderate wind
Accumulative Yards: 7 **Batch Size (cy):** 7
Placement Method: Direct Discharge
Water Added Before (gal): 8
Water Added After (gal): 0
Sample Location: See GPS Location
Placement Location: Sidewalk for future guardrail attachments

Field Test Data

Test	Result	Specification
Slump (in):	6 1/2	
Air Content (%):	1.5	
Concrete Temp. (F):	78	
Ambient Temp. (F):	66	
Plastic Unit Wt. (pcf):	148.0	
Yield (Cu. Yds.):	7.0	

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	6.01	28.37		11/08/21	20 F	110,330	3,890	3	SLS
1	B	6.01	28.37		11/08/21	20 F	128,440	4,530	3	SLS
1	C	6.01	28.37		11/08/21	20 F	117,990	4,160	2	SLS
1	D					Hold				

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

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

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).
Terracon Rep.: Randy Rippstein **Start/Stop:** 0900-1300
Reported To: Bill with TTI
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke
(1) Terracon Consultants, Inc., Alex Dunigan, P.E.
(1) Texas Transportation Institute, Bill Griffith

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

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.

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

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

Report Number: A1171057.0213
Service Date: 10/19/21
Report Date: 11/10/21
Task: PO# 616221-01

Client

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

Project

Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength: 4,000 psi @ 20 days

Mix ID: FN94025050
Supplier: Texcrete
Batch Time: 0900 **Plant:** Bryan
Truck No.: 122 **Ticket No.:** 49887

Sample Information

Sample Date: 10/19/21 **Sample Time:** 1005
Sampled By: Randy Rippstein
Weather Conditions: Partly Cloudy, moderate wind
Accumulative Yards: 14 **Batch Size (cy):** 7
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: See GPS Location
Placement Location: Sidewalk for future guardrail attachments

Field Test Data

Test	Result	Specification
Slump (in):	6 1/4	
Air Content (%):	1.6	
Concrete Temp. (F):	82	
Ambient Temp. (F):	69	
Plastic Unit Wt. (pcf):	147.4	
Yield (Cu. Yds.):	7.0	

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
2	A	6.01	28.37		11/08/21	20 F	120,320	4,240	3	SLS
2	B	6.01	28.37		11/08/21	20 F	121,600	4,290	1	SLS
2	C	6.01	28.37		11/08/21	20 F	120,820	4,260	3	SLS
2	D					Hold				

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

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

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).
Terracon Rep.: Randy Rippstein **Start/Stop:** 0900-1300
Reported To: Bill with TTI
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke
(1) Terracon Consultants, Inc., Alex Dunigan, P.E.
(1) Texas Transportation Institute, Bill Griffith

Reviewed By:
Alexander Dunigan
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.

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

Project No: 616221-01 **Casting Date:** 10/29/2021 **Mix Design (psi):** 4000

Name of Technician Taking Sample: Terracon

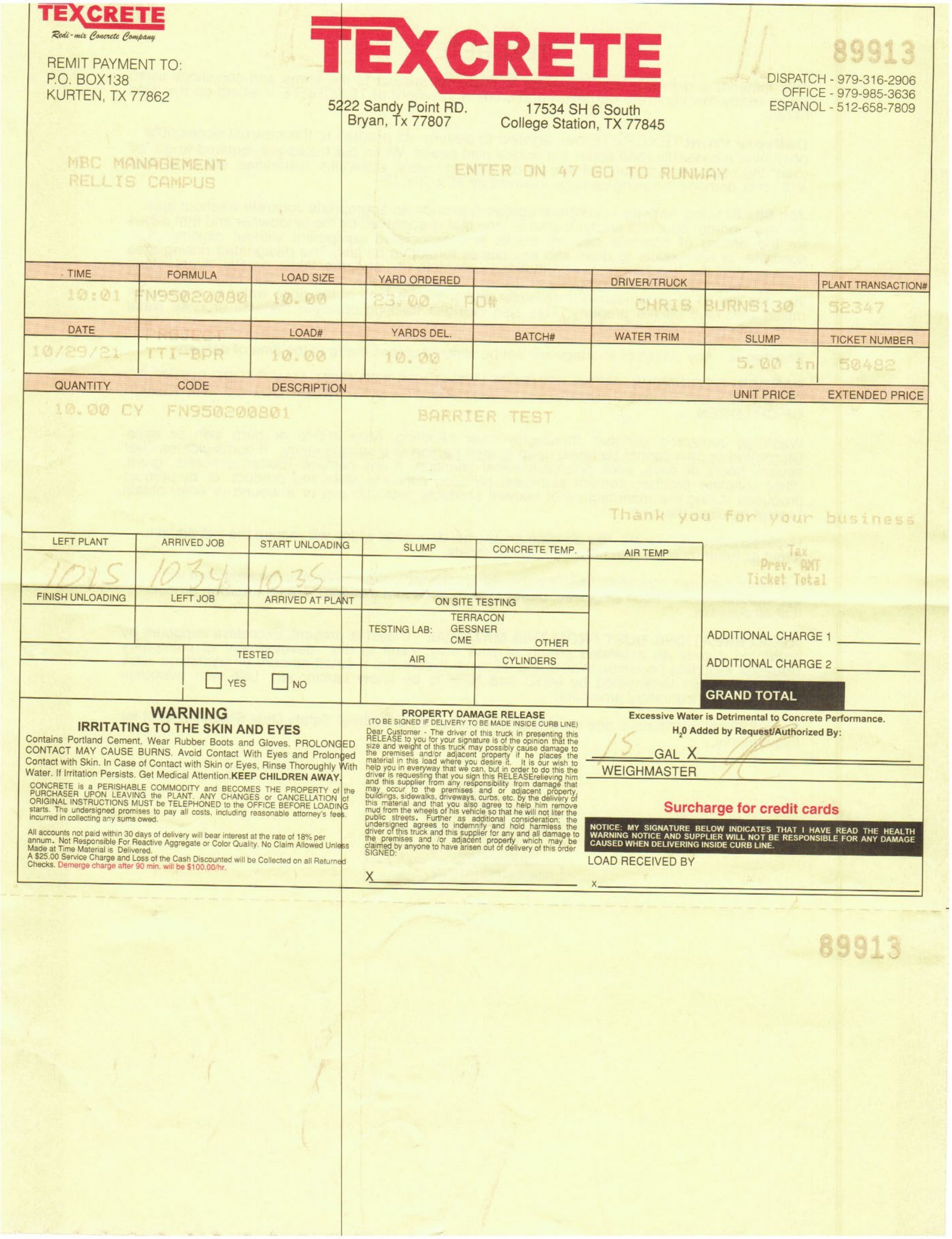
Name of Technician Breaking Sample: Terracon

Signature of Technician Taking Sample: Terracon

Signature of Technician Breaking Sample: Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	130	89913	70 feet of barrier starting from South End
T2	101	89917	Remaining northern section of barrier

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



TEXCRETE

Redi-mix Concrete Company

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

TEXCRETE

5222 Sandy Point RD.
Bryan, Tx 77807

17534 SH 6 South
College Station, TX 77845

89913

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

MBC MANAGEMENT
RELLIS CAMPUS

ENTER ON 47 GO TO RUNWAY

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
10:01	FN95020080	10.00	23.00	PO#	CHRIS BURNS130		52347
DATE	**PROJECT**	**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
10/29/21	TTI-BPR	10.00	10.00			5.00 in	50482

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
10.00 CY	FN950200801	BARRIER TEST		

Thank you for your business

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
1015	1034	1035			

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

TESTED ☐ YES ☐ NO

AIR

CYLINDERS

Tax
Prev. AMT
Ticket Total

ADDITIONAL CHARGE 1 ____________

ADDITIONAL CHARGE 2 ____________

GRAND TOTAL

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SIGNED:

X____________________

Excessive Water is Detrimental to Concrete Performance.

H_20 Added by Request/Authorized By:

15 GAL X____________________

WEIGHMASTER

Surcharge for credit cards

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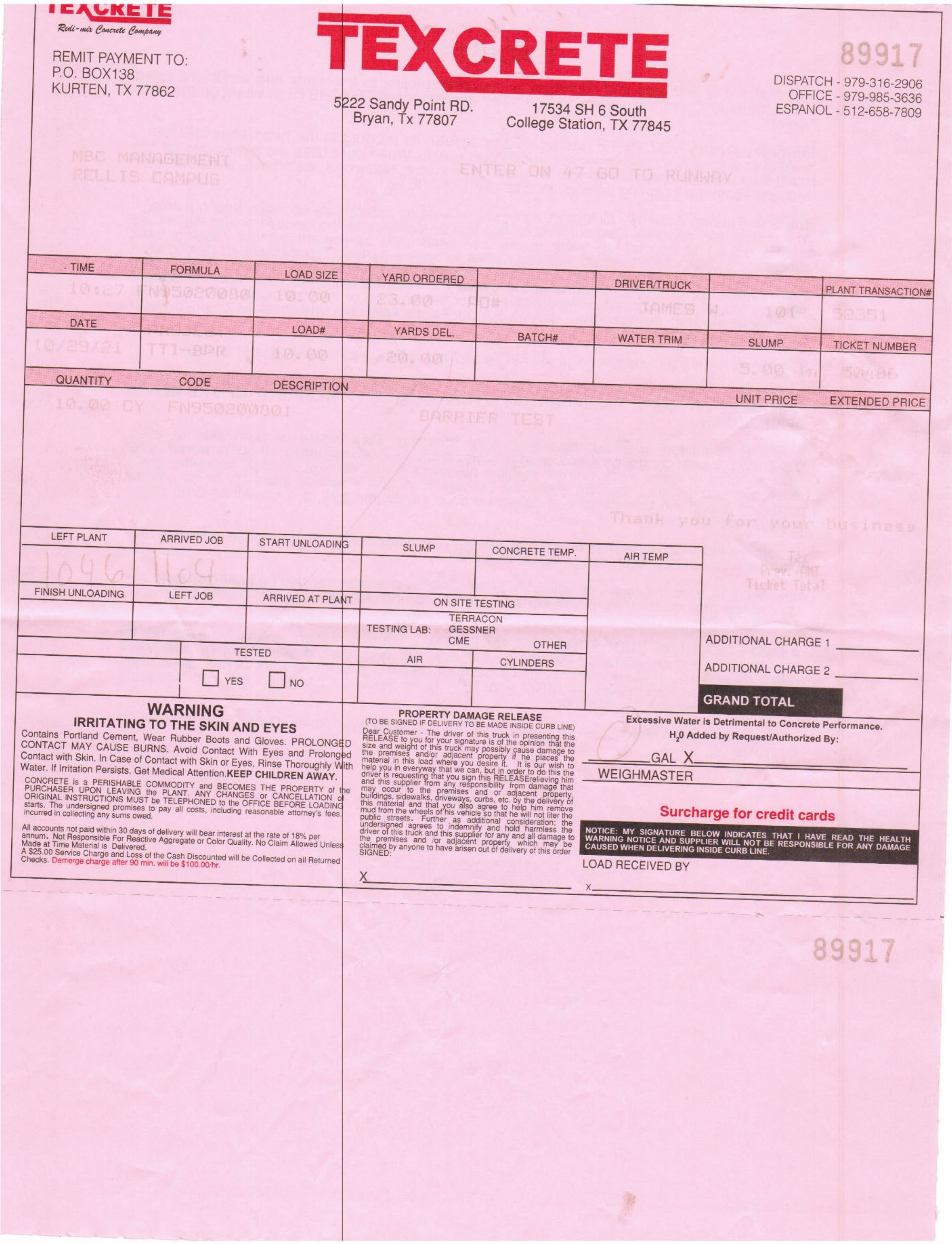
LOAD RECEIVED BY

x____________________

89913



TEXCRETE
Redi-mix Concrete Company

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P.O. BOX138
KURTEN, TX 77862

TEXCRETE

5222 Sandy Point RD.
Bryan, Tx 77807

17534 SH 6 South
College Station, TX 77845

89917

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

MBC MANAGEMENT
RELLIS CAMPUS

ENTER ON 47 GO TO RUNWAY

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
10:27	FN95020080	10.00	23.00	PO#	JAMES W.	101	52351
DATE		**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
10/29/21	TTI-BRR	10.00	20.00			5.00 In	50486

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
10.00 CY	FN950200801	BARRIER TEST		

Thank you for your business

Tax
Prev. AMT
Ticket Total

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
1046	1104				
FINISH UNLOADING	**LEFT JOB**	**ARRIVED AT PLANT**	**ON SITE TESTING**		
			TESTING LAB: TERRACON GESSNER CME	OTHER	

TESTED ☐ YES ☐ NO

AIR

CYLINDERS

ADDITIONAL CHARGE 1 ____________

ADDITIONAL CHARGE 2 ____________

GRAND TOTAL

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X____________________

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

________GAL X____________________

WEIGHMASTER

Surcharge for credit cards

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

LOAD RECEIVED BY

X____________________

89917

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0216
Service Date: 10/29/21
Report Date: 11/10/21
Task: PO# 616221-01

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

Client

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

Project

Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength: 4,000 psi @ 28 days

Mix ID: FN950200801
Supplier: Texcrete
Batch Time: 1001 **Plant:** Bryan
Truck No.: 130 **Ticket No.:** 50482

Field Test Data

Test	Result	Specification
Slump (in):	5 1/4	
Air Content (%):	1.4	
Concrete Temp. (F):	80	
Ambient Temp. (F):	65	
Plastic Unit Wt. (pcf):	145.2	
Yield (Cu. Yds.):		

Sample Information

Sample Date: 10/29/21 **Sample Time:** 1045
Sampled By: Justin Maass
Weather Conditions: Clear, heavy wind
Accumulative Yards: 10/20 **Batch Size (cy):** 10
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: 5ft from south end
Placement Location: Bicycle rail

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	6.01	28.37		11/08/21	10 F	129,380	4,560	4	SLS
1	B	6.01	28.37		11/08/21	10 F	130,520	4,600	2	SLS
1	C	6.01	28.37		11/08/21	10 F	127,490	4,490	4	SLS
1	D					Hold				

Initial Cure: Outside Plastic Lids **Final Cure:** Water Storage Tank

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

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).
Terracon Rep.: Justin Maass **Start/Stop:** 0900-1330
Reported To: Bill TAMU
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Alex Dunigan, P.E.
(1) Texas Transportation Institute, Bill Griffith

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

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0216
Service Date: 10/29/21
Report Date: 11/10/21
Task: PO# 616221-01

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

Client

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

Project

Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength: 4,000 psi @ 28 days

Mix ID: FN950200801
Supplier: Texcrete
Batch Time: 1027 **Plant:** Bryan
Truck No.: 101 **Ticket No.:** 52451

Sample Information

Sample Date: 10/29/21 **Sample Time:** 1115
Sampled By: Justin Maass
Weather Conditions: Clear, heavy wind
Accumulative Yards: 20/20 **Batch Size (cy):** 10
Placement Method: Direct Discharge
Water Added Before (gal): 5
Water Added After (gal): 0
Sample Location: 3ft from North end
Placement Location: Bicycle rail

Field Test Data

Test	Result	Specification
Slump (in):	4 1/2	
Air Content (%):		
Concrete Temp. (F):	81	
Ambient Temp. (F):	65	
Plastic Unit Wt. (pcf):	145.7	
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
2	A	6.01	28.37		11/08/21	10 F	114,930	4,050	4	SLS
2	B	6.01	28.37		11/08/21	10 F	124,150	4,380	4	SLS
2	C	6.01	28.37		11/08/21	10 F	116,480	4,110	4	SLS
2	D					Hold				

Initial Cure: Outside Plastic Lids **Final Cure:** Water Storage Tank

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

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).
Terracon Rep.: Justin Maass **Start/Stop:** 0900-1330
Reported To: Bill TAMU
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Gary Gerke (1) Terracon Consultants, Inc., Alex Dunigan, P.E.
(1) Texas Transportation Institute, Bill Griffith

Reviewed By:
Alexander Dunigan
Project Manager

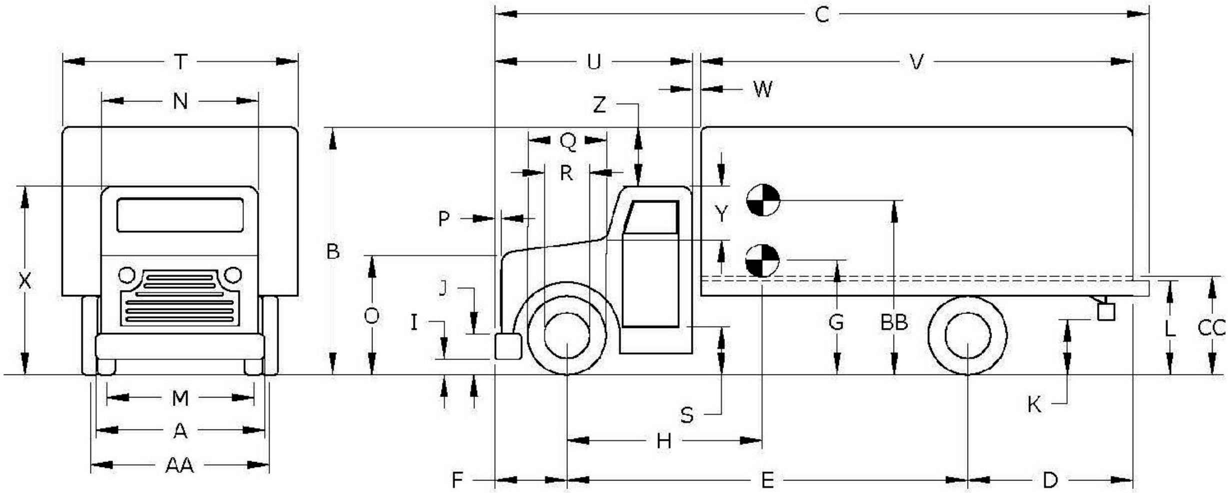
Test Methods: ASTM C 31, ASTM C143, ASTM C231, ASTM C1064

APPENDIX C. *MASH* TEST 4-12(CRASH TEST NO. 616221-01)

C.1 VEHICLE PROPERTIES AND INFORMATION

Table C.1. Vehicle Properties for Test No. 616221-01.

Date:	2021-11-8	Test No.:	616221-01	VIN No.:	1FVACXCS14HM27927
Year:	2004	Make:	FREIGHTLINER	Model:	M21G6
Odometer:	330170	Tire Size Front:	275/80R22.5	Tire Size Rear:	275/80R22.5



Vehicle Geometry: ☑ inches or ☐ mm

A	Front Bumper Width:	92.5	K	Rear Bumper Bottom:		U	Cab Length:	106.5
B	Overall Height:	140	L	Rear Frame Top:	39	V	Trailer/Box Length:	222.5
C	Overall Length:	332.5	M	Front Track Width:	82.75	W	Gap Width:	3.75
D	Rear Overhang:	85.5	N	Roof Width:	72	X	Overall Front Height:	101
E	Wheel Base:	207	O	Hood Height:	58	Y	Roof-Hood Distance:	35
F	Front Overhang:	40	P	Bumper Extension:	1	Z	Roof-Box Height Difference:	39
G	C.G. Height:		Q	Front Tire Width:	40.5	AA	Rear Track Width:	74
H	C.G. Horizontal Dist. w/Ballast:	133.32	R	Front Wheel Width:	23.5	BB	Ballast Center of Mass:	64.75
I	Front Bumper Bottom:	19.5	S	Bottom Door Height:	36.25	CC	Cargo Bed Height:	51
J	Front Bumper Top:	33.5	T	Overall Width:	96			

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

Wheel Center Height Front	19.5	Wheel Well Clearance (Front)	9.5	Bottom Frame Height (Front)	28
Wheel Center Height Rear	19.5	Wheel Well Clearance (Rear)	4.5	Bottom Frame Height (Rear)	28.25

Table C.1. Vehicle Properties for Test No. 616221-01. (Continued)

Date: 2021-11-8 Test No.: 616221-01 VIN No.: 1FVACXCS14HM27927

Year: 2004 Make: FREIGHTLINER Model: M21G6

WEIGHTS
(☑ lb or ☐ kg)

	CURB	**TEST INERTIAL**
$W_{\text{front axle}}$	7560	8040
$W_{\text{rear axle}}$	7200	14550
W_{TOTAL}	14760	22590

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

Ballast: 7830 (☑ lb or ☐ kg) **(as-needed)**
(See *MASH* Section 4.2.1.2 for recommended ballasting)

Mass Distribution
(☑ lb or ☐ kg): **LF:** 3970 **RF:** 4070 **LR:** 7530 **RR:** 7020

Engine Type: MERCEDES-BENZ

Engine Size: 6.4

Transmission Type:

☑ Auto or ☐ Manual

☐ FWD ☑ RWD ☐ 4WD

Accelerometer Locations (☐ inches or ☐ mm)

	x[1]	**y**	**z**[2]
Front:			
Center:	133	0	50
Rear:	229	0	50

Describe any damage to the vehicle prior to test: NONE

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

TWO BLOCKS H 30 W 60 L 30
CENTERED IN MIDDLE OF BED
TIED DOWN WITH FOUR 3/8 CABLES PER BLOCK
64.75 FROM GROUND TO CENTER OF BLOCK

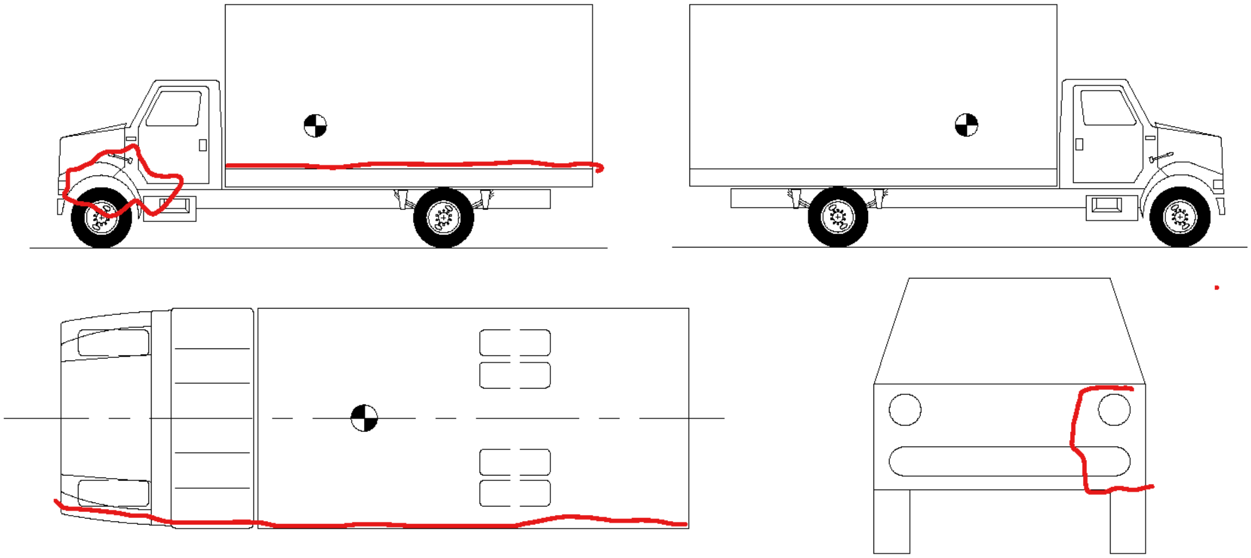
Table C.2. Exterior and Occupant Compartment Measurements for Test No. 616221-01.

Date: 2021-11-8
Test No.: 616221-01
VIN No.: 1FVACXCS14HM27927
Year: 2004
Make: FREIGHTLINER
Model: M21G6
Mileage: 330170

Please shade damage areas and note type of damage.

Driver's Side

Passenger Side

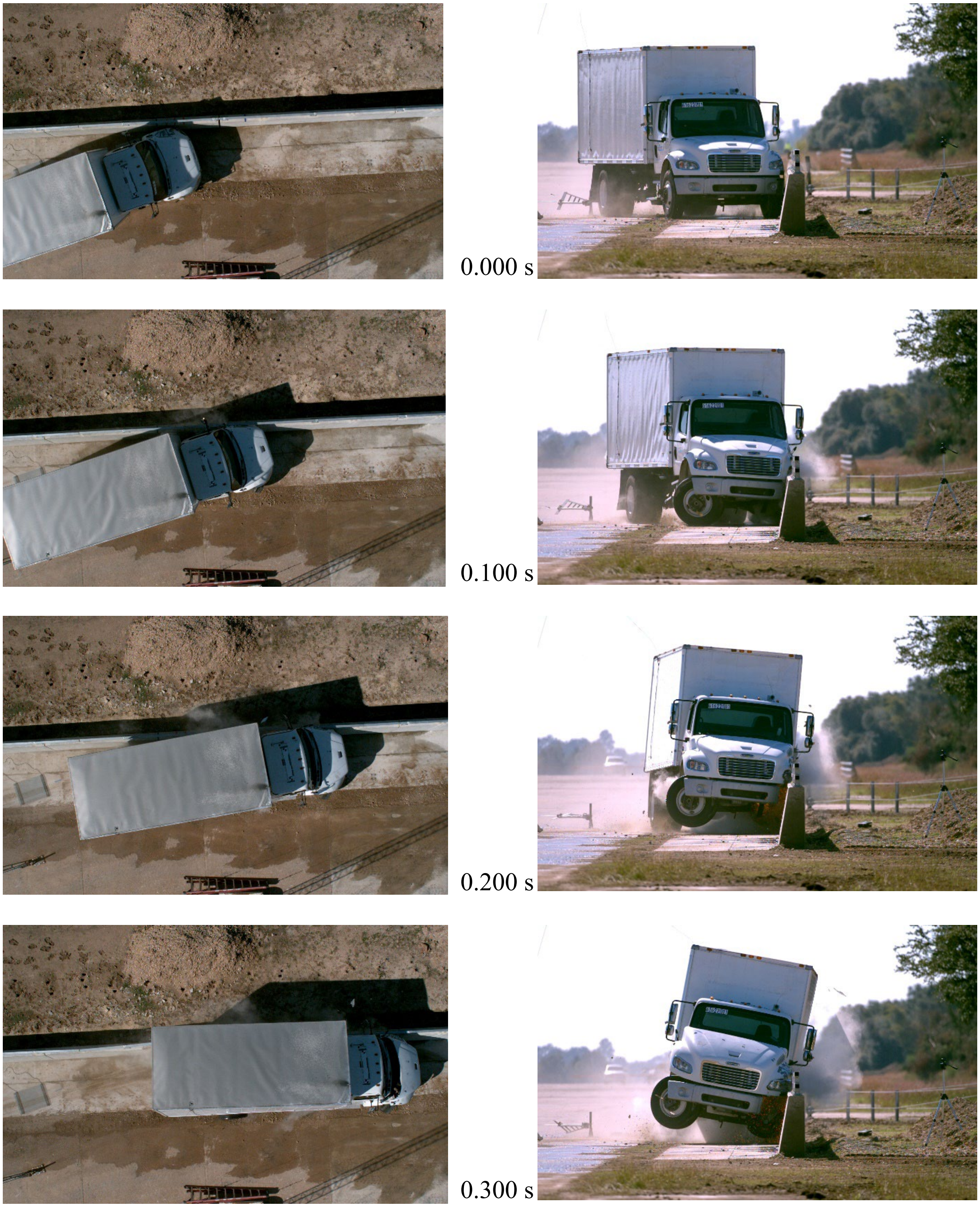


List vehicle damage:

FT BUMPER
HOOD LT HEAD LIGHT
LT FT TIRE AND RIM
LT SPRING ASSEMPLY
LT U-BOLT
LT DOOR
LT SIDE STEP
LT FUEL TANK NO HOLE / CUT

Max Exterior Crush: 12 inches
Location: LT FT CORNER
Max Interior Deformation: 3 inches
Location: LT SIDE CENTER
LT SIDE CENTER FLOOR PAN 17 X 24 X 3 DE
LT SIDE LOWER EDGE OF BOX
LT REAR OUTER TIRE AND RIM

C.2. SEQUENTIAL PHOTOGRAPHS



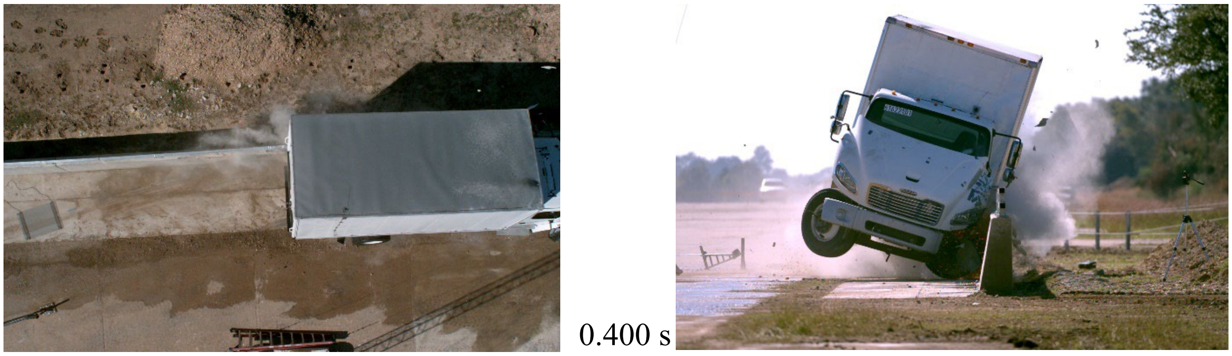
0.000 s

0.100 s

0.200 s

0.300 s

Figure C.1. Sequential Photographs for Test No. 616221-01 (Overhead and Frontal Views).



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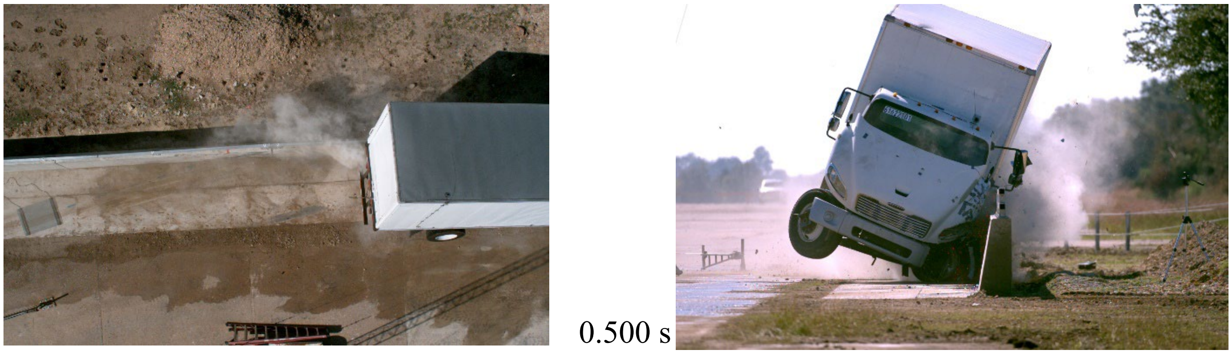
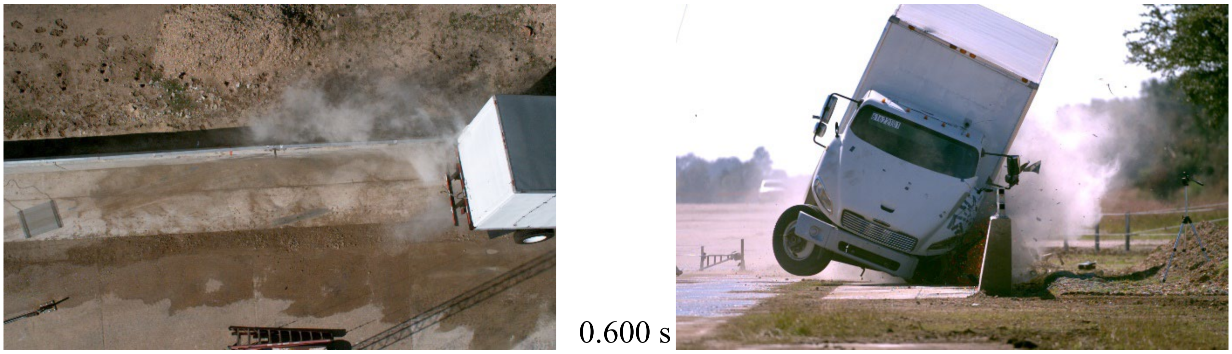
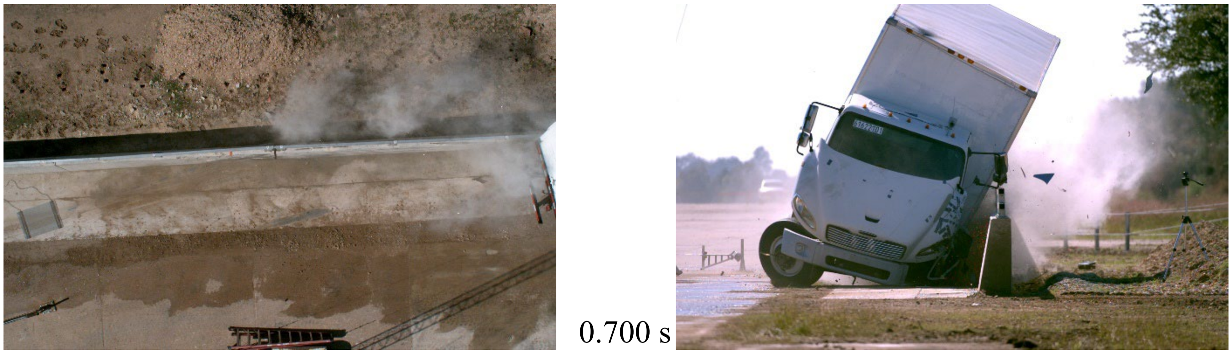


0.500 s



0.600 s



0.700 s

Figure C.1. Sequential Photographs for Test No. 616221-01 (Overhead and Frontal Views) (Continued).

0.000 s

0.100 s

0.200 s

0.300 s

0.400 s

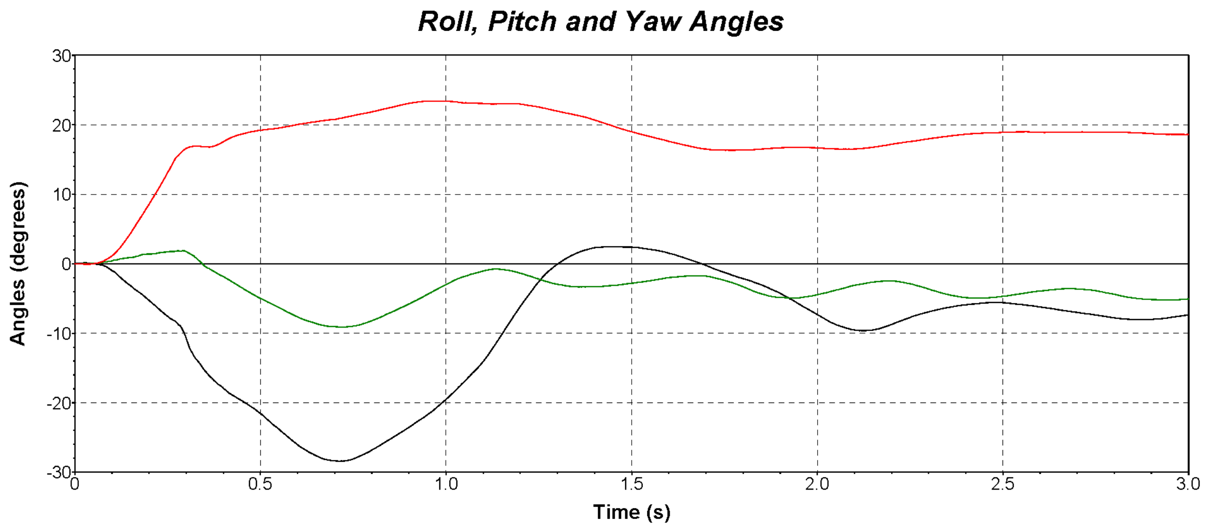
0.500 s

0.600 s

0.700 s

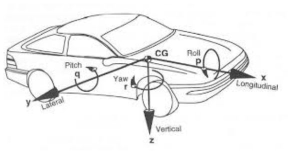
Figure C.2. Sequential Photographs for Test No. 616221-01 (Rear View).

C.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for
determining orientation:

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



Test Number: 616221-01
Test Standard Test Number: *MASH* Test 4-12
Test Article: Bicycle Rail on a Concrete Parapet
Test Vehicle: 2004 Freightliner M21G6
Inertial Mass: 22 590
Gross Mass: 22 590
Impact Speed: 57.9

Figure C.3. Vehicle Angular Displacements for Test No. 616221-01.

C.4. VEHICLE ACCELERATIONS

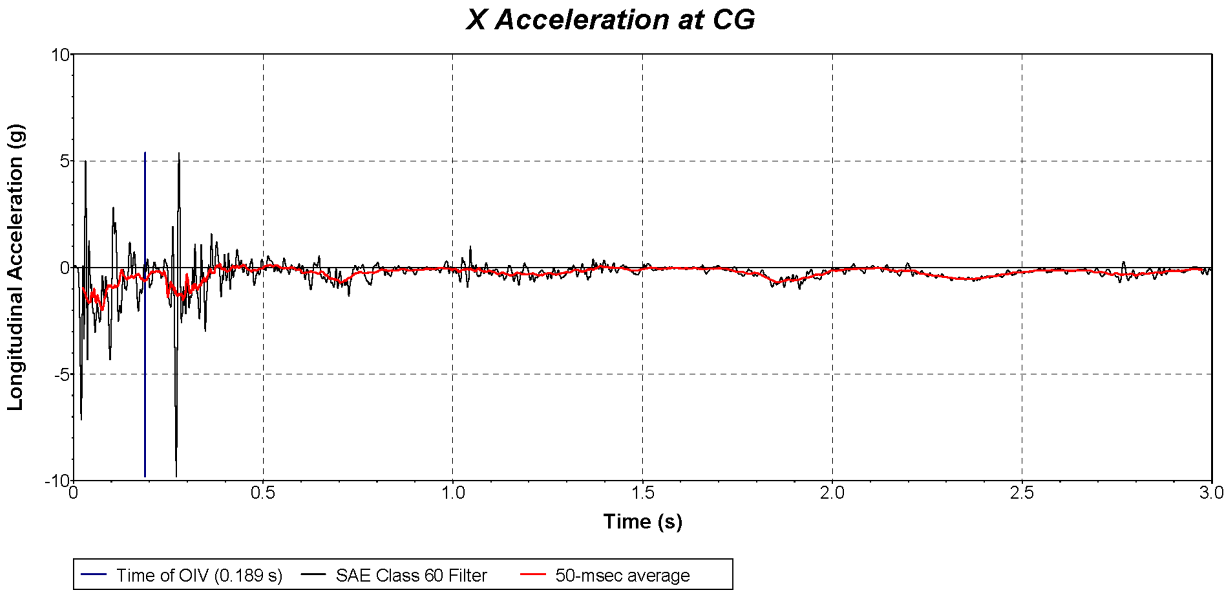


Figure C.4. Vehicle Longitudinal Accelerometer Trace for Test No. 616221-01 (Accelerometer Located at Center of Gravity).

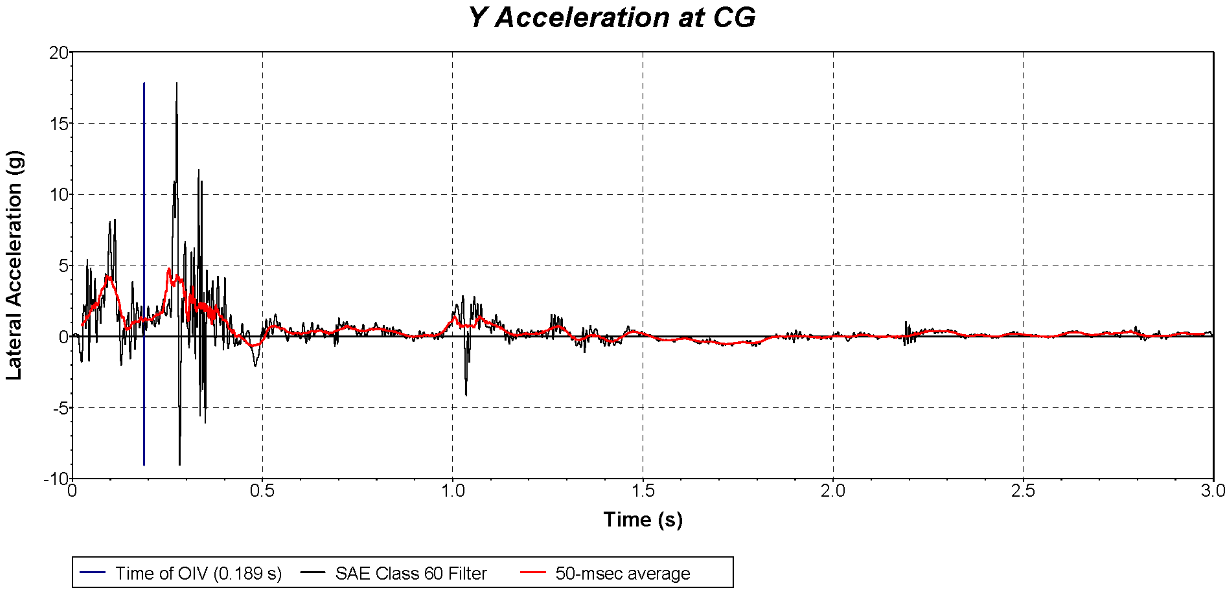


Figure C.5. Vehicle Lateral Accelerometer Trace for Test No. 616221-01 (Accelerometer Located at Center of Gravity).

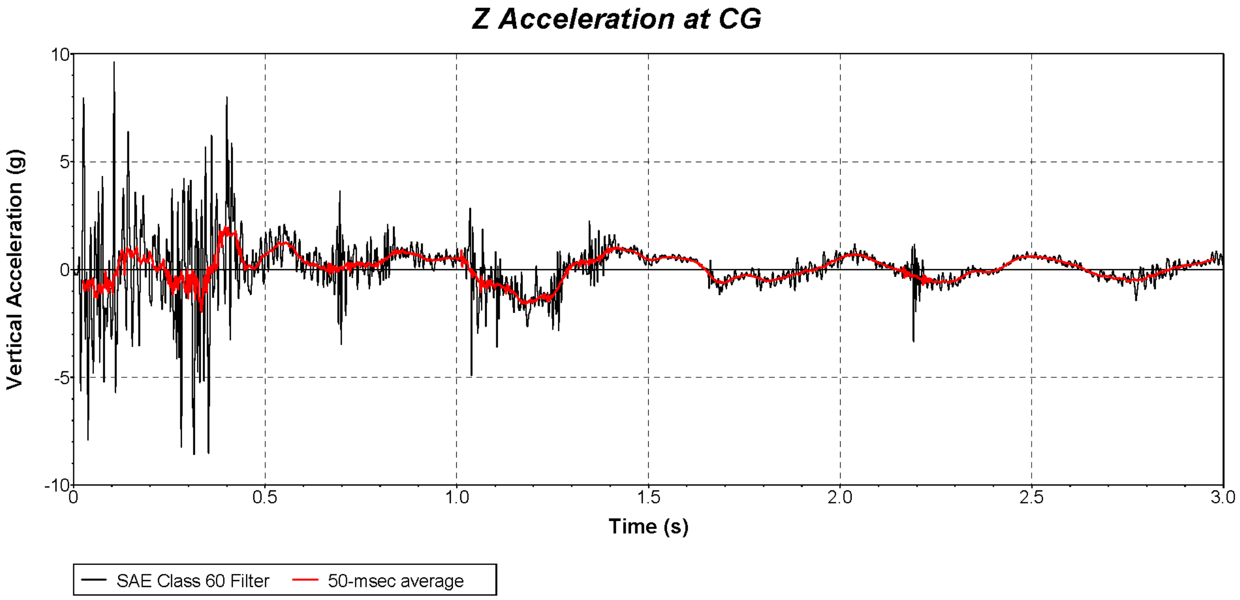


Figure C.6. Vehicle Vertical Accelerometer Trace for Test No. 616221-01 (Accelerometer Located at Center of Gravity).