

Test Report No. 440863-03-1



MASH TEST 4-12 EVALUATION OF A LUMINAIRE POLE BEHIND SINGLE SLOPE TRAFFIC RAIL COOPERATIVE RESEARCH PROGRAM

Texas Department of Transportation

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TEXAS A&M TRANSPORTATION INSTITUTE PROVING GROUND

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16. Abstract				
I ne purpose of the test re	eported nerein was to assess the p	errormance of a luminaire pole		
mounted behind a single slope t	rattic rail according to the safety-pe	ertormance evaluation guidelines		
included in the second edition of the American Association of State Highway and Transportation				

Officials *Manual for Assessing Safety Hardware (MASH)* (1). The crash test was performed in accordance with *MASH* Test 4-12, which includes a 10000S vehicle weighing 22,000 lb impacting the longitudinal barrier upstream of the luminaire pole while traveling at a nominal speed of 56 mi/h and nominal angle of 15 degrees.

This report provides details of the Luminaire Pole behind Single Slope Traffic Rail, the crash test and results, and the performance assessment of the Luminaire Pole behind Single Slope Traffic Rail for *MASH* Test 4-12 evaluation criteria.

	The Luminaire	Pole behind	Single Slop	e Traffic R	ail met the	performance	criteria for	MASH
Test 4	·12.							

^{17. Key Words} Longitudinal barrier, bridge rail, crash testing, <i>MASH,</i> luminaire pole, box truck, SUT		 18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service Alexandria, Virginia 		
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MASH Testing of a Luminaire Pole behind Single Slope Traffic Rail

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DISCLAIMER

This research was sponsored by the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

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

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SI* (MODERN METRIC) CONVERSION FACTORS					
	APPROXIMA	TE CONVERSIO	NS 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		2	
in ²	square inches	645.2	square millimeters	mm²	
ft ²	square feet	0.093	square meters	m²	
yd²	square yards	0.836	square meters	m²	
ac	acres	0.405	nectares	ha km²	
mi ²	square miles		square kilometers	Km-	
floz	fluid ounces		milliliters	ml	
	allons	29.57	liters	1	
ft ³	cubic feet	0.028	cubic meters	∟ m ³	
vd ³	cubic vards	0.765	cubic meters	m ³	
۶a	NOTE: volumes of	reater than 1000L	shall be shown in m ³		
		MASS			
oz	ounces	28.35	grams	a	
lb	pounds	0.454	kilograms	ka	
Т	short tons (2000 lb)	0.907	megagrams (or metric ton")	Mg (or "t")	
	TEMPE	RATURE (exac	t degrees)		
°F	Fahrenheit	5(F-32)/9	Celsius	°C	
		or (F-32)/1.8			
	FORCE a	and PRESSURE	or STRESS		
lbf	poundforce	4.45	newtons	N	
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa	
	APPROXIMATI	E CONVERSION	S 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	
2		AREA		• 2	
mm ²	square millimeters	0.0016	square inches	IN ²	
m^2	square meters	10.764	square verde	It ²	
ho	square meters	1.190	square yards	yu-	
km ²	Square kilometers	0.386	square miles	ac mi ²	
		VOLUME			
ml	milliliters	0.034	fluid ounces	07	
L	liters	0.264	gallons	gal	
m ³	cubic meters	35.314	cubic feet	ft ³	
m ³	cubic meters	1.307	cubic yards	yd ³	
	MASS				
g	grams	0.035	ounces	oz	
kg	kilograms	2.202	pounds	lb	
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000lb)	Т	
	TEMPE	RATURE (exac	t degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F	
	FORCE a	and PRESSURE	or STRESS		
N	newtons	0.225	poundforce	lbf	
			•		

*SI is the symbol for the International System of Units

Chapter 1. INTRODUCTION

Luminaire poles provide illumination of the roadway for motorists. When traversing a bridge structure, the luminaire poles are sometimes mounted to a deck extension behind the bridge rail. This makes access to the anchor bolts and electrical hand holes challenging, which can complicate installation, maintenance, and repair.

Another option for structure-mounted luminaire poles is to construct a mounting block on the field side of the bridge rail and mount the luminaire to the top of the block behind the bridge rail. Such a detail improves access for installation, maintenance, and repair, and avoids the need for deck extensions.

In addition to being designed for service loads such as wind, structure-mounted luminaire poles should also be designed for vehicular impact to avoid a large pole from separating from the structure and becoming a hazard to motorists on or below the structure. Additionally, the offset of the pole should be sufficient to avoid significant contact and intrusion into the occupant compartment of the impacting vehicle(s).

Criteria for testing and evaluating roadside safety features are contained in the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware (MASH)*, Second Edition (1). *MASH* describes different test levels of longitudinal barriers such a bridge rails. Bridge rail systems implemented on high-speed facilities are typically Test Level 3 (TL-3) or higher. The higher test levels incorporate various sizes of commercial trucks in addition to the baseline passenger vehicles that comprise TL-3. Bridge rails are commonly designed for Test Level 4 (TL-4), which includes evaluation with a 22,000-lb single unit truck. TL-4 bridge rails may be used based on the percentage of trucks on the facility or other criteria established by the user agency.

The objective of this research is to test and evaluate the impact performance of a luminaire pole anchored to a concrete mounting block integrally constructed behind a single slope traffic rail (SSTR) in accordance with *MASH* TL-4. The critical test for evaluating the strength of the pole and its anchorage, as well as the potential for excessive vehicle intrusion associated with vehicle-pole contact, is *MASH* Test 4-12. This report provides details of *MASH* Test 4-12 performed on a luminaire pole mounted behind a single slope traffic rail and an assessment of *MASH* compliance of the luminaire pole mounting details.

Chapter 2. SYSTEM DETAILS

2.1. TEST ARTICLE AND INSTALLATION DETAILS

The test installation was 130 feet long and consisted of a 36-inch-tall SSTR anchored to an 8-inch thick, 40-inch-wide cantilevered concrete deck. A 21-inch-wide, 21-inch-deep, and 36-inch-tall concrete block was monolithically poured onto the back of the barrier at a distance of 45 feet from the upstream end. A 50-foot-tall steel luminaire pole with a single 12-foot steel mast arm and LED luminaire was mounted onto the top of this concrete block behind the bridge rail. The barrier, deck, and luminaire mounting block were all reinforced with grade 60 rebar. Figure 2.1 presents overall information on the Luminaire Pole behind Single Slope Traffic Rail, and

Figure 2.2 through Figure 2.7 provide photographs of the test installation. Appendix A provides further details on the Luminaire Pole behind Single Slope Traffic Rail. Drawings were provided by the Texas A&M Transportation Institute (TTI) Proving Ground based on details provided by the Texas Department of Transportation (TxDOT), and construction was performed by MBC Management and supervised by TTI Proving Ground personnel.

2.2. DESIGN MODIFICATIONS DURING TEST

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



Figure 2.1. Details of Luminaire Pole behind Single Slope Traffic Rail.

TR No. 440863-03-1



Figure 2.2. Impact Angle on Traffic Side of Luminaire Pole behind Single Slope Traffic Rail Prior to Testing.



Figure 2.3. Field Side of Luminaire Pole behind Single Slope Traffic Rail Prior to Testing.



Figure 2.4. Base of the Luminaire Pole behind Single Slope Traffic Rail Prior to Testing.



Figure 2.5. In-line View of the Luminaire Pole behind Single Slope Traffic Rail Prior to Testing.



Figure 2.6. Overall View of the Luminaire Pole behind Single Slope Traffic Rail at Impact Prior to Testing.



Figure 2.7. Field Side of the Luminaire Pole behind Single Slope Traffic Rail Prior to Testing.

2.3. MATERIAL SPECIFICATIONS

Appendix B provides material certification documents for the materials used to install/construct the Luminaire Pole behind Single Slope Traffic Rail. Table 2.1 shows the average compressive strength of the concrete used in the test installation on the day of the test (2023-06-22).

Location	Design Strength (psi)	Avg. Strength (psi)	Age (days)	Detailed Location
Wall	4000	4447	17	Downstream 100 feet of the wall.
Deck	4000	4297	17	Downstream 100 feet of the deck.
Deck and Wall	4000	3953	17	Remainder of deck and wall.
Barrier and Mounting Block	3600	3363	7	A complete 40-foot section of the barrier was poured starting at the upstream end of the barrier, then 50 percent of the barrier was poured over the next 70 feet. This section included the mounting block.
Barrier and Mounting Block	3600	3667	7	The remaining half of the 70-foot section of barrier from the previous pour, including the mounting block, and 100 percent of the last 20 feet of the barrier on the downstream end.

Table 2.1. Concrete Strength.

Chapter 3. TEST REQUIREMENTS AND EVALUATION CRITERIA

3.1. CRASH TEST CONDITIONS

Table 3.1 shows the test conditions and evaluation criteria for *MASH* Test 4-12 for longitudinal barriers. The target critical impact point (CIP) for the test was determined through film analysis of a previous *MASH* Test 4-12 into a 36-inch-tall SSTR (2). The distance from the luminaire pole was selected to maximize interaction with the single unit truck. Figure 3.1 shows the target CIP for *MASH* Test 4-12 test on the Luminaire Pole behind Single Slope Traffic Rail.

Table 3.1. Test Conditions and Evaluation Criteria Specified for MASH Test 4-12 Longitudinal Barrier.



Figure 3.1. Target CIP for *MASH* Test 4-12 Test on Luminaire Pole behind Single Slope Traffic Rail.

Impact Path

The *MASH* TL-4 test matrix also recommends performing Test 4-10 with the 1100C passenger car and Test 4-11 with the 2270P pickup truck. However, based on the acceptable impact performance of a single-slope barrier of similar profile in previous testing with both design passenger vehicles, these tests were not considered necessary (*3*, *4*). Based on the vehicle working width observed in these tests, neither vehicle would interact with the luminaire pole based on the height of the bridge rail and the offset of the pole assembly from the field side edge of the barrier.^{*}

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

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

3.2. EVALUATION CRITERIA

The appropriate safety evaluation criteria from Tables 2.2 and 5.1 of *MASH* were used to evaluate the crash test reported herein. Table 3.1 lists the test conditions and evaluation criteria required for *MASH* Test 4-12, and Table 3.2 provides detailed information on the evaluation criteria.

Evaluation Factors	Evaluation Criteria
Α.	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.
D.	Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of <i>MASH</i> .
G.	It is preferable, although not essential, that the vehicle remain upright during and after the collision.

Table 3.2. Evaluation Criteria Required for MASH Testing.

Chapter 4. TEST CONDITIONS

4.1. TEST FACILITY

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

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

4.2. VEHICLE TOW AND GUIDANCE SYSTEM

The 10000S 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 around 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 into the test installation. The vehicle remained freewheeling (i.e., no steering or braking inputs) until it cleared the immediate area of the test site.

4.3. DATA ACQUISITION SYSTEMS

4.3.1. Vehicle Instrumentation and Data Processing

The test vehicle was instrumented with a self-contained onboard data acquisition system. The signal conditioning and acquisition system is a multi-channel data acquisition system (DAS) produced by Diversified Technical Systems Inc. The accelerometers, which measure the x, y, and z axis of vehicle acceleration, are strain gauge type with linear millivolt output proportional to acceleration. Angular rate sensors,

measuring vehicle roll, pitch, and yaw rates, are ultra-small, solid-state units designed for crash test service. The data acquisition hardware and software conform to the latest SAE J211, Instrumentation for Impact Test. Each of the channels is capable of providing precision amplification, scaling, and filtering based on transducer specifications and calibrations. During the test, data are recorded from each channel at a rate of 10,000 samples per second with a resolution of one part in 65,536. Once data are recorded, internal batteries back these up inside the unit in case the primary battery cable is severed. Initial contact of the pressure switch on the vehicle bumper provides a time zero mark and initiates the recording process. After each test, the data are downloaded from the DAS unit onto a laptop computer at the test site. The Test Risk Assessment Program (TRAP) software then processes the raw data to produce detailed reports of the test results.

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

TRAP uses the DAS-captured data to compute the occupant/compartment impact velocities, time of occupant/compartment impact after vehicle impact, and highest 10-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 \pm 0.7 percent at a confidence factor of 95 percent (k = 2).

4.3.2. 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 for this test.

4.3.3. Photographic Instrumentation Data Processing

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

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

Chapter 5. MASH TEST 4-12 (CRASH TEST 440863-03-1)

5.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 5.1 for details on *MASH* impact conditions for this test and Table 5.2 for the exit parameters. Figure 5.1 and Figure 5.2 depict the target impact setup.

Test Parameter	Specification	Tolerance	Measured
Impact Speed (mi/h)	56	± 2.5 mi/h	54.4
Impact Angle (deg)	15	± 1.5°	15.0
Impact Severity (kip-ft)	106	≥ 106 kip-ft	146.5
Impact Location	30 ft upstream from centerline of luminaire, on top traffic side edge of barrier	± 1 ft	29 ft 5.2 inches upstream from centerline of luminaire pole

Table 5.1. Impact Conditions for MASH TEST 4-12, Crash Test 440863-03-1.

Table 5.2. Exit Parameters for MASH TEST 4-12, Crash Test 440863-03-1.

Exit Parameter	Measured
Speed (mi/h)	Not measurable, vehicle exited the installation out of frame of the overhead camera
Trajectory (deg)	Along the barrier
Heading (deg)	Along the barrier
Brakes applied post impact (s)	2.1
Vehicle at rest position	269 ft downstream of impact point 3 ft to the traffic side 0° downstream
Comments:	Vehicle remained upright and stable. The box of the single unit truck snagged the luminaire pole, causing the box to deform significantly and pull off the truck frame.



Figure 5.1. Luminaire Pole behind Single Slope Traffic Rail/Test Vehicle Geometrics for Test 440863-03-1.



Figure 5.2. Luminaire Pole behind Single Slope Traffic Rail/Test Vehicle Impact Location 440863-03-1.

5.2. WEATHER CONDITIONS

Table 5.3 provides the weather conditions for 440863-03-1.

Date of Test	2023-06-22
Wind Speed (mi/h)	3.3
Wind Direction (deg)	67
Temperature (°F)	87
Relative Humidity (%)	70
Vehicle Traveling (deg)	185

Table 5.3. Weather	r Conditions	440863-03-1.
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5.3. TEST VEHICLE

Figure 5.3 and Figure 5.4 show the 2011 International 4300 used for the crash test. Table 5.4 shows key vehicle measurements. Figure C.1 in Appendix C.1 gives additional dimensions and information on the vehicle.



Figure 5.3. Impact Side of Test Vehicle before Test 440863-03-1.



Figure 5.4. Opposite Impact Side of Test Vehicle before Test 440863-03-1.

Test Parameter	MASH	Allowed Tolerance	Measured
Dummy (if applicable) ^a (lb)	165	N/A	N/A
Curb Weight (lb)	13200	± 2200 lb	13030
Test Inertial Weight (lb)	22046	± 660 lb	22110
Wheelbase (inches)	240	≤ 240 inches	204.7
Overall Length (inches)	394	≤ 394 inches	331.7
Cargo Bed Height (inches) ⁱ	49	± 2 inches	50.5
CG of Ballast above Ground ^e (inches)	63	± 2 inches	63.0

ents 440863-03-1.
(

Note: N/A = not applicable; CG = center of gravity.

^a If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.

ⁱ Without ballast.

^e See section 4.2.1.2 in *MASH* 2016 for recommended ballasting procedures.

5.4. TEST DESCRIPTION

Table 5.5 lists events that occurred during Test 440863-03-1. Figures C.4, C.5, and C.6 in Appendix C.2 present sequential photographs during the test.

Time (s)	Events
0.0000	Vehicle tire impacted the installation
0.0180	Flash bulb was activated due to the bumper's contact with the installation
0.0490	Vehicle began to redirect
0.1680	Box of the vehicle began to lean towards the field side
0.2930	Vehicle parallel with installation
0.4420	Impact side top of door frame of test vehicle impacted the pole
0.4840	Box of the vehicle impacted the pole
0.4890	Luminaire pole began to deflect downstream
1.3350	Vehicle exited the installation

Table 5.5. Ev	ents during	Test 440863-03-1.
---------------	-------------	-------------------

5.5. DAMAGE TO TEST INSTALLATION

The concrete traffic barrier had a 7-ft gouge beginning near the impact point. The luminaire light pole was leaning 14 degrees downstream from vertical.

Table 5.6 describes the deflection and working width of the Luminaire Pole behind Single Slope Traffic Rail. Figure 5.5 and Figure 5.6 show the damage to the Luminaire Pole behind Single Slope Traffic Rail.

Table 5.6. Deflection and Working Width of the Luminaire Pole behind SingleSlope Traffic Rail for Test 440863-03-1.

Test Parameter	Measured
Permanent Deflection/Location	0 inches
Dynamic Deflection	0 inches
Working Width ^a and Height	57.9 inches, at a height of 123.2 inches, at the back left corner of the box at impact with the luminaire pole

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



Figure 5.5. Perpendicular View of Luminaire Pole behind Single Slope Traffic Rail at Impact Location after Test 440863-03-1.



Figure 5.6.Traffic Side View of the Damage to the Base of the Luminaire Pole after Test 440863-03-1.

5.6. DAMAGE TO TEST VEHICLE

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

Figures C.2 and C.3 in Appendix C.1 provide exterior crush and occupant compartment measurements.



Figure 5.7. Impact Side of Test Vehicle after Test 440863-03-1.



Figure 5.8. Rear Impact Side of Test Vehicle after Test 440863-03-1.



Figure 5.9. Overall Interior of Test Vehicle after Test 440863-03-1.



Figure 5.10. Interior of Test Vehicle on Impact Side after Test 440863-03-1.

Test Parameter	Specification	Measured
Roof	≤ 4.0 inches	0.0 inches
Windshield	≤ 3.0 inches	0.0 inches
A and B Pillars	≤ 5.0 overall/≤ 3.0 inches lateral	0.0 inches
Foot Well/Toe Pan	≤ 9.0 inches	0.0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	7.0 inches
Side Front Panel	≤12.0 inches	0.0 inches
Front Door (above Seat)	≤ 9.0 inches	0.0 inches
Front Door (below Seat)	≤12.0 inches	0.0 inches

 Table 5.7. Occupant Compartment Deformation 440863-03-1.

Side Windows	Side windows remained intact.
Maximum Exterior Deformation	14 inches in the left fender.
VDS	11LFQ7.
CDC	01FLWH3.
Fuel Tank Damage	None.
Description of Damage to Vehicle:	The left front bumper, grill, left front headlight, left fender, left front wheel, left front tire, left side mirror, left door, top left side, top of box, steps, air tanks, and the left rear outer tire and wheel were damaged. There was a 3-inch-wide \times 4-inch-long \times 1-inch-deep dent on the top of the door frame on impact side. The top and sides of the box were pulled off. The floorplan had a 2-ft-long and 7-inch-high separation at a seam. The seam separation in the floor pan of the vehicle was not caused by intrusion of the test article, but due to the flexing of the vehicle during the crash.

5.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk for information purposes, and the results are shown in Table 5.9. Figure C.7 in Appendix C.3 shows the vehicle angular displacements, and Figures C.8 through C.10 in Appendix C.4 show acceleration versus time traces.

Test Parameter	Measured	Time
OIV, Longitudinal (ft/s)	6.4	0.1850 seconds on the left side of interior
OIV, Lateral (ft/s)	10.5	0.1850 seconds on the left side of interior
Ridedown, Longitudinal (g)	4.5	0.4733–0.4833 seconds
Ridedown, Lateral (g)	5.5	0.2929–0.3029 seconds
THIV (m/s)	3.9	0.1785 seconds on left side of interior
ASI	0.5	0.1010–0.1510 seconds
50-ms MA Longitudinal (g)	-1.8	0.0651–0.1151 seconds
50-ms MA Lateral (g)	4.2	0.0819–0.1319 seconds
50-ms MA Vertical (g)	-3.2	1.1993–1.2493 seconds
Roll (deg)	33.0	0.6644 seconds
Pitch (deg)	7.2	0.7783 seconds
Yaw (deg)	17.9	0.5607 seconds

Table 5.9. Occupant Risk Factors for Test 440863-03-1.

^a Values in italics are the preferred *MASH* values.

5.8. TEST SUMMARY

Figure 5.11 summarizes the results of MASH Test 440863-03-1.
					Test Agency		&M Trar	sportation Institute (T	ΓΙ)
				Foot Stop	dard/Test No	MASHO		ot 4 12	(1)
					TL Droiget No.	NASH 2	010, 10	51 4-12	
				1	Tost Date	2022.06	22		
			TEST ADT		Test Date	2023-00	-22		
			TESTART	GLE	Typo	Longitur	linal Bar	rior	
		19			Name	Luminai	ro Polo h	nei Sehind Single Slope Tr	affic Rail
		A		1	Length Spec	130 ft		Senina Olingie Olope Th	
and the second second		200				Steel lur	ninaire p	oole, reinforced concre	te bridge rail, mounting
0.0	00 s				Key Materials	block, a	nd deck		
			S	oil Type a	and Condition	Concret	e, damp		
	-		TEST VEH	CLE					
Comment Office		at		Туре	e/Designation	10000S			
		1		Year, Ma	ke and Model	2011 Int	ernation	al 4300	
					Curb (lb)	13030			
		A STATE OF		Inerti	al Weight (lb)	22110			
0.1	00 s		IMPACT CO	ONDITIO	NS				
				Impact	Speed (mi/h)	54.4			
				Impac	ct Angle (deg)	15.0			
				Im	pact Location	The bun of the lu	nper imp minaire	acted 29 ft 5.2 inches pole.	upstream from centerline
				Impact S	everity (kip-ft)	146.5			
and a second		19	EXIT CON	DITIONS					
- 101 - 1 Mai	. Contract for the	Asses		Exit	Speed (mi/h)	Not mea	surable,	out of frame	
		- Contraction	Trajecto	ry/Headin	g Angle (deg)	Along ba	arrier		
			-	Stop	aing Distance	269 ft do	ownstrea	ım	
				Stop	ping Distance	3 ft to th	e traffic	side	
0.2	00 s		TEST ARTI	CLE DEF	LECTIONS				
			Ba	arrier Dyn	amic (inches)	0			
			Barr	ier Perma	anent (inches)	0			
			Working	Width / H	eight (inches)	57.86 / 1	23.18		
		and the second		DAMAGE					
	2122				VDS	11LFQ7			
		A			CDC	01FLWH	13		
A STREET STORE			Max. Ex	t. Deform	ation (inches)	14			
0.3	00 s	1	Max C	Occupant	Compartment Deformation	7 on left	front sic	le of floor pan, in locati	on of seam separation
				000	CUPANT RISK	VALUES			
Long. OIV (ft/s)	6.4	Long. Ri	idedown (g)	4.5	Max 50-ms L	ong. (g)	-1.8	Max Roll (deg)	33.0
Lat. OIV (ft/s)	10.5	Lat. Ride	edown (g)	5.5	Max 50-ms L	.at. (g)	4.2	Max Pitch (deg)	7.2
THIV (m/s)	3.9	ASI		0.5	Max 50-ms V	/ert. (g)	-3.2	Max Yaw (deg)	17.9
Impact Angle	8: 	3.4' ▶ 9.4'	369' 	/// ///		¶ _ 3'] _ ₹		50 Lum with	inaire Light Pole 12 masl ann



Chapter 6. SUMMARY AND CONCLUSIONS

6.1. ASSESSMENT OF TEST RESULTS

The crash test reported herein was performed in accordance with *MASH* Test 4-12.

6.2. CONCLUSIONS

Table 6.1 shows that the Luminaire Pole behind Single Slope Traffic Rail met the performance criteria for *MASH* Test 4-12 Longitudinal Barrier.

Table 6.1. Assessment Summary for MASH Test 4-12 Test on Luminaire Pole behind Single Slope Traffic Rail.

Evaluation Criteria	Description	Test 440863-03-1
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.	S
D	Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of <i>MASH</i> .	S
G	It is preferable, although not essential, that the vehicle remain upright during and after the collision.	S
Overall	Evaluation result	Pass

Note: S = Satisfactory.

Chapter 7. IMPLEMENTATION^{*}

Based on the results of the crash testing reported herein, the mounting of luminaire poles onto a concrete mounting block poured monolithically behind a 36-inchtall SSTR is considered suitable for implementation as a *MASH* TL-4 system. The *MASH* matrix for TL-4 longitudinal barriers consists of three tests: Test 4-10, 4-11, and 4-12. *MASH* Test 4-12 was performed under this project and successfully met all *MASH* evaluation criteria.

MASH also recommends performing Test 4-10 with the 1100C passenger car and Test 4-11 with the 2270P pickup truck. However, based on the acceptable impact performance of a single-slope barrier of similar profile in previous testing with both design passenger vehicles, these tests were not considered necessary (*3, 4*). The 1100C passenger car would not interact with the luminaire pole behind the 36-inch-tall barrier. In Test No. 420020-3, the maximum extension of the 2270P pickup truck beyond the field side edge of the single slope barrier was 2.5 inches, which corresponded to the side mirror (*4*). In the system tested herein, the edge of the luminaire pole baseplate has an offset of 3 inches from the field side edge of the SSTR, and the base of the luminaire pole has an additional 2.25 inches of offset beyond the baseplate. Therefore, the 2270P pickup truck would have no contact with the luminaire pole assembly.

Statewide implementation of this barrier and luminaire pole combination can be achieved by TxDOT's Bridge Division through development of a standard detail sheet. The details provided in Appendix A can be used for this purpose.

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

REFERENCES

- 1. AASHTO. *Manual for Assessing Safety Hardware*, Second Edition. American Association of State Highway and Transportation Officials, Washington, DC, 2016.
- N.M. Sheikh, R.P. Bligh, W.L. Menges. Determination of Minimum Height and Lateral Design Load for MASH Test Level 4 Bridge Rails. Research Report 9-1002-5, Texas Transportation Institute, College Station, TX, December 2011.
- 3. FHWA Safety Roadway Departure Eligibility Letter B-338, May 26, 2020. (https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-08/b338.pdf)
- 4. W.F. Williams, R.P. Bligh, W.L. Menges. MASH Test 3-11 of the TxDOT Single Slope Bridge Rail (Type SSTR) on Pan-Formed Bridge Deck. Research Report 9-1002-3, Texas Transportation Institute, College Station, TX, March 2011.

APPENDIX A. DETAILS OF LUMINAIRE POLE BEHIND SINGLE SLOPE TRAFFIC RAIL









2c. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).

#	Part Name	QTY.
1	Tie Bar	65
2	L-2 bar	87
3	L-1 bar	260
4	U bar	260
5	S Bar	260
6	UL-1 bar	10
7	UL-2 bar	4
8	C bar	6
9	SL bar	10
10	EA-1 bar	7
11	1/2" Rebar	*
12	Anchor Plate	1
13	Anchor Rod	4
14	Nut, 1-1/4" heavy hex	8
21	Washer, 1-1/4 lock	4

2d. Concrete shall be TxDOT Class S (4000 psi) for the Wall and Deck, and

2f. All steel components, excluding rebar, shall be galvanized unless otherwise

2g. EA-1 bars at 10" spacing, 30" each way from center of Luminaire concrete. Embed 5-1/4" into deck and secure with Hilti HIT RE-500 epoxy adhesive.

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Project #4408	63-01-3 Singl	e S	lope with Luminaire	2023-05-11
Drawn by GES	Scale 1:200		Sheet 2 of 6 Concrete	Details



3a. Thread bottom 4" and top 5-1/2" of Anchor Rods. Leave 1/4" to 1/2" of shank exposed above concrete.

- 3b. Chamfer concrete edges 1" (3/4" each way) where shown.
- 3c. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).

3d. Secure each Tie Bar to existing rebar protruding from the runway (not shown here) with a 3" long weld. Space at maximum 18".

3e. Luminaire concrete block must be placed monolithically with Single Slope parapet.



2024-11-21





37



Ø17-1/2" - \mathcal{F} Ø12-1/2" Ø15" ±10-5/8" Ø1-5/16" Typ ±10-5/8" (12)

Anchor Plate ASTM A36 3/8" Plate Galvanizing not required for this part

Te Tra Ins	xas A&M Insportatio Stitute	Roadside Sa Physical Securi Proving G	afety and ity Division - round
Project #4408	63-01-3 Singl	e Slope with Luminaire	2023-05-11
Drawn by GES	Scale 1:5	Sheet 6 of 6 And	hor Plate

APPENDIX B. SUPPORTING CERTIFICATION DOCUMENTS

QUALITY CERTIFICATE

DITL NO					1		-			1
INV. NO.:		SF2	225		QUAN	NTITY:			2160	0
P.O. NO.:		0-20	9141		TEST	DATE:	2022/4/10			/10
S/C NO.:					ON B	OARD:			2022/6	/20
PART NO.:	Γ	DHWG	A12500	191	SL	ZE:			1-1/4	1
LOT NO.:		HJ4124	246224							
PRODUTION DATE:					DESCR	IPTION	Ha	Hardened Washer F43		
Size: Material and Mechanica	al properties:	ANSI /	ASME B1	8.18-20	011					
1.Chemical Composition	n Of Materia	1 (%)								-
STEEL GRADE/ HEAT NO:	Si	Mn	Р	S	Cr	Ni	Cu			
1045 STEEL/20011404		0.43	0.19	0.55	0.032	0.028	0.24	0.28	0.21	1
2.Dimension										
INSPECTIO		S	PECIFI	CATION	ſ			RESUI	Л	
INSPECTIO		MIN.		MAX.		1		2		
Inside Dia (mm)		34.75		35.69		34.86		35.28	1 1	
Outside Dia (mm)			76.02		76.96		76.43		76.77	
Thickness (mm)			3.45		4.88		3.64		4.25	1
HARDNESS			38		45		38		43	þ
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and the second sec										

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CUSTOME	BRIGHTO	N-BEST	INTERN	ATION	AL (TAIW	AN) INC		PO NUMBER:	MILL	
QNTY SHIP	PED:	10.800M	PCS					PART NO:	313390	
SAMPLE SE	ZE :	ACC. T	O ASMI	EB18.1	8.1-11		MANUFAC	CTURER DATE:	2018/5/29	
SIZE & DES	CRIPTION	1.1/4-7+	0.024"(H	DG)						
FINISH: H. T.	HOT DIP	GAL PER	ASTM AD	53-09/1	ASTM F232	9-13				
STEEL PRO	PERTIES:						TEST FAC	ILITY: S		
STEEL GRA	DE:	45#		SIZE:	<u>36mm</u>			HEAT NO:	2-9	7352
CHEMISTR	Y COMPO	STTION:	D.0/	G 0/	0:0/	C.W	DT: 0/	C 0/	M- 9/	OTUER
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MILL TEST REPORT

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HANGZHOU SPRING WASHER CO.,LTD QUALITY TEST CERTIFICATE OF SPRING LOCK WASHER

Chemical	Print	C	S	i Mn	T	P	S	Cr	Ni	Cu
Composition (%)	n	0.66	0. 1	9 0.58	3	0.01	0.01	0.01	0.01	0.03
Material Typ	c.	65#	I	leat No.		J9310	02805	TE	ST FACILI	TY:S
Specification	1			REGULAR	HELIO	CAL LOC	K WASHER	1 1/4	" HDG	
Quantity				3.6 M						
Lot No.			1	2040439			COL	INTRY OF	ORIGIN:C	HINA
Part No.				350010						
Testing Item	Ac/n	Norm(m	um)	Result(mn	n) []	Reject	Norm	1	Result	Reject
Inside Diameter	2/100	32.02-32	2. 91	32. 29-32.	89	0				
Outside Diameter	1/32	Max52.	51	Max51. 28	8	0			200	
Width	1/32	Min9.2	22	Min9.23		0				
Thickness	1/32	8.02-8.	72	8. 33-8. 4	6	0				
Height										
Section										
Surface Defects	2/100	None		None		0				
Hardness	0/8	HRC38-	46	HRC38-40	0	0				
Springing										
Toughness	0/8	Qualifi	ed	Qualifie	d	0				
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Qualit	y Form	Revised by: B.L. Griffs Approved by: D. L. Ku	ith uhn	Revision: 7	Page: 1 of 1
Project No:	440863-01-3	Casting Date:	2023-05-15	Mix Design (psi)	3600
Name of Technician Taking Sample	, Terracon		Name of Technician Breaking Sample	Terracon	
Signature of Technician Taking Sample	f Terracon		Signature of Technician Breaking Sample	Terracon	
Load No.	Truck No.	Ticket No.	Locat	ion (from concret	e map)
Check	111	80543	Full barrier from south	n end 40ft north、Half l	lift till 20 ft from north
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 Report Number:
 A1171057.0273

 Service Date:
 05/15/23

 Report Date:
 05/25/23

 Task:
 PO# 440863-3

Client

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

Material Information

Specified Strength: 3,600 psi @ 28 days

Result

7 1/2

0.8

 Mix ID:
 TDCLC3600

 Supplier:
 Texcrete

 Batch Time:
 0923
 Plant:

 Truck No.:
 111
 Ticket No.:
 80543

 Sample Information
 0

 Sample Date:
 0

 Sampled By:
 D

 Weather Conditions:
 S

 Accumulative Yards:
 1

 Placement Method:
 D

 Water Added Before (gal):
 5

 Water Added After (gal):
 0

 Sample Location:
 Location:

Sample Description:

Project Number: A1171057

Project

Bryan, TX

Riverside Campus

Riverside Campus

05/15/23 Sample Time: 1021 Daniel Calvo Sunny 10.00/17.0Batch Size (cy): 10 Direct Discharge 5 0

ierracon

College Station, TX 77845-5765

979-846-3767 Reg No: F-3272

6198 Imperial Loop

Luminaire Bridge Deck 20' North of South end Luminaire Bridge Deck 6-inch diameter cylinders

Air Content (%):

Field Test Data

Slump (in):

Test

 Concrete Temp. (F):
 95

 Ambient Temp. (F):
 78

 Plastic Unit Wt. (pcf):
 147.2

 Yield (Cu. Yds.):
 147.2

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (Ibs)	Comp Strength (psi)	Frac Type	Tested By
1	Α	Good	6.01	28.37		05/22/23	7	93,380	3,290	3	TJT
1	В	Good	6.01	28.37		05/22/23	7	97,430	3,430	2	TJT
1	С	Good	6.01	28.37		05/22/23	7	95,680	3,370	2	TJT
							Avera	ige (7 days)	3,370		
1	D						Hold				
Initial C	ure: Cu	re Blanket		Final	Cure: Field (Cured					

Comments: Note: Reported air content does not include Aggregate Correction Factor (ACF).

Specification

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).

Start/Stop: 0830-1245

Terracon Rep.: Daniel Calvo Reported To: Contractor: MBC Management

Report Distribution:

(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

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.

CR0001, 3-31-22, Rev.7

Page 1 of 2

TR No. 440863-03-1

Report Number: A1171057.0273 Service Date: 05/15/23 Report Date: 05/25/23 Task: PO# 440863-3

Client

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

Material Information

Specified Strength: 3,600 psi @ 28 davs

Mix ID: TDCLC3600 Supplier: Texcrete Batch Time: 0941 Plant: Truck No.: 116 Ticket No.: 80544 Sample Information Sample Date: Sampled By: Weather Conditions: Accumulative Yards: Placement Method: Water Added Before (gal): 10

Project

Bryan, TX

Riverside Campus

Riverside Campus

Project Number: A1171057

05/15/23 Sample Time: 1055 Daniel Calvo Sunny 17.00/17.0Batch Size (cy): 7 Direct Discharge 0 Luminaire Bridge Deck 15' South of North

lerracon

College Station, TX 77845-5765

979-846-3767 Reg No: F-3272

6198 Imperial Loop

end

Luminaire Bridge Deck

6-inch diameter cylinders

Result Specification 5 1/4 Air Content (%): 0.9 Concrete Temp. (F): 95 Ambient Temp. (F): 80 Plastic Unit Wt. (pcf): 147.5

Water Added After (gal): Sample Location: Placement Location: Sample Description:

Laboratory Test Data

Yield (Cu. Yds.):

Slump (in):

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (Ibs)	Comp Strength (psi)	Frac Type	Tested By
2	А	Good	6.01	28.37		05/22/23	7	101,700	3,580	3	TJT
2	В	Good	6.01	28.37		05/22/23	7	101,730	3,590	2	TJT
2	С	Good	6.01	28.37		05/22/23	7	108,790	3,830	2	TJT
							Avera	ge (7 days)	3,670		
2	D						Hold				
Initial C	ure: Cui	re Blanket		Final	Cure: Field (Cured					

Comments: Note: Reported air content does not include Aggregate Correction Factor (ACF).

Samples Made By: Terracon

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

Terracon Rep.: Daniel Calvo Reported To: Contractor: MBC Management

Report Distribution:

(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

Start/Stop: 0830-1245

Reviewed By: kander Durigan, P.E.

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.

CR0001, 3-31-22, Rev.7

Page 2 of 2

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Qualit	y Form	Revised by: B.L. Griffi Approved by: D. L. Ku	.th .hn	Revision: 7	Page: 1 of 1
Project No:	440863-3	Casting Date:	2023-05-05	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.	Locat	ion (from concre	te map)
Check	Thomas, Trav13	77078	North Wall to Se	ensors	
Check	Cross, Dwante8	77081	North end of de	ck to sensors	
Check	Burns, Christ0	77085	Remainder of de	eck and wall	
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CONTACT MAY CALLS	se of Contact with Skin or E s. Get Medical Attention.KE	yes, Rinse Thoroughly With EP CHILDREN AWAY.	help you in everyway that we driver is requesting that you s and this supplier from any re may occur to the premise	can, but in order to do this the sign this RELEASErelieving him asponsibility from damage that is and or adjacent property, a curbs etc. by the delivery of	WEIGHMASTER		
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All accounts for the state of the state	No. No. of Concession, Name	DATE 5/5/23 QUANTITY 8.00 yr 1.00 er 1.00 er LEFT PLANT ////////////////////////////////////	PROJECT SINGLES CODE d TDCLS4/2/2 a FUEL ARRIVED JOB LOSSO LEFT JOB TE WARNING ING TO THE SKIN AI WAR NING ING TO THE SKIN AI	LOAD# B. ØØ DESCRIPTION ØØ START UNLOADING LOGG A ARRIVED AT PLANT STED NO NO EYES	VARDS DEL. 28.00 CLASS Fuel C SLUMP ON SITE TESTING LAB: GESS CME AIR PROPERTY DAM (TO BE SIGNED IF DELIVERY TO BRIT COMPANY TO THE OUT OF THE OUT OUT OF THE OUT OUT OF THE OUT OF THE OUT OF THE OUT	S 40100 PS) S 40100 PS) Change CONCRETE TEMP. TESTING ACON NER OTHER CYLINDERS AGE RELEASE BE MADE NABE CURB LIKE) BE MADE NABE CURB LIKE)	Excessive Wate H.p.Ac	SLUMP 5. 00 in UNIT PRICE UNIT PRICE A for your Tax Prev. AM Ticket Tota ADDITIONAL CHARGE ADDITIONAL CHARGE ADDITIONAL CHARGE IS Detrimental to Concre Idde by Request/Authors	te Performance. ed By:
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Report Number:	A1171057.02	272
Service Date:	05/05/23	
Report Date:	05/25/23	Revision 1 - 17-day results
Task:	PO# 440863	-3

Client

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

Material Information

Specified Strength: 4,000 psi @ 28 davs

Mix ID: TDCLS4000 Supplier: Texcrete Batch Time: 1004 Plant: Truck No.: DWANTE8 Ticket No.: 77081

Field Test Data

Test	Result
Slump (in):	6
Air Content (%):	2.0
Concrete Temp. (F):	84
Ambient Temp. (F):	75
Plastic Unit Wt. (pcf):	147.7
Yield (Cu. Yds.):	

Riverside Campus Bryan, TX Project Number: A1171057 Sample Information Sample Date:

Riverside Campus

Project

05/05/23 Sample Time: Sampled By: Justin Maass Weather Conditions: Clear, light wind Accumulative Yards: 20/30 Batch Size (cy): 10 Placement Method: Direct Discharge Water Added Before (gal): 0 Water Added After (gal): 0 Middle of wall Sample Location: Placement Location: Bridge wall deck Sample Description: 6-inch diameter cylinders

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
2	А	Good	6.01	28.37		05/22/23	17 F	124,390	4,380	2	TJT
2	В	Good	6.01	28.37		05/22/23	17 F	120,780	4,260	2	TJT
2	С	Good	6.01	28.37		05/22/23	17 F	120,460	4,250	2	TJT
2	D						Hold				
Initial C	ure: (Outside Plastic Lid	S	Final	Cure: Field (Cured					

Comments: F = Field Cured

Note: Reported air content does not include Aggregate Correction Factor (ACF).

Specification

Samples Made By: Terracon

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

Start/Stop:

Terracon Rep.: Justin Maass Reported To: Bill w/ TTI Contractor: MDC **Report Distribution:**

(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

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.

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Page 2 of 3

Terracon 6198 Imperial Loop

College Station, TX 77845-5765 979-846-3767 Reg No: F-3272

1046

Report Number: A1171057.0272 Service Date: 05/05/23 Report Date: 05/25/23 Revision 1 - 17-day results Task: PO# 440863-3

Client

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

Material Information

Specified Strength: 4,000 psi @ 28 davs

Mix ID: TDCLS4000 Supplier: Texcrete Batch Time: Plant: Truck No.: **TEAVI3** Ticket No.: 77078

Field Test Data

Test	Result
Slump (in):	5 1/2
Air Content (%):	2.2
Concrete Temp. (F):	85
Ambient Temp. (F):	76
Plastic Unit Wt. (pcf):	148.0
Yield (Cu. Yds.):	

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

Riverside Campus

Riverside Campus

Sampled By:

Sample Description:

Bryan, TX

Project Number: A1171057 Sample Information 05/05/23 Sample Time: Sample Date: Justin Maass Weather Conditions: Clear, light wind Accumulative Yards: 10/30 Batch Size (cy): 10 Direct Discharge Placement Method: Water Added Before (gal): 0 Water Added After (gal): 0 Sample Location: East end Placement Location:

Bridge wall deck 6-inch diameter cylinders

lerracon

1010

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	Α	Good	6.00	28.27		05/12/23	7 F	102,700	3,630	2	TJT
1	В	Good	6.01	28.37		05/22/23	17 F	130,610	4,600	2	TJT
1	С	Good	6.01	28.37		05/22/23	17 F	127,730	4,500	2	TJT
1	D	Good	6.01	28.37		05/22/23	17 F	120,400	4,240	3	TJT
Initial C	ure: Ou	itside Plastic Lic	is	Final	Cure: Field (Cured					

Comments: F = Field Cured

Note: Reported air content does not include Aggregate Correction Factor (ACF).

Specification

Samples Made By: Terracon

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

Start/Stop:

Terracon Rep.: Justin Maass Reported To: Bill w/ ⊤TI Contractor: MDC **Report Distribution:**

(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

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.

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Page 1 of 3

Report Number: A1171057.0272 05/05/23 Service Date: Report Date: 05/25/23 Revision 1 - 17-day results Task: PO# 440863-3

Client

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

Material Information

Specified Strength: 4,000 psi @ 28 davs

Result

TDCLS4000 Mix ID: Supplier: Texcrete Batch Time: 1021 Plant: Truck No.: CHEISTO1 Ticket No.: 77085

Field Test Data Test Slump (in):

6 3/4 Air Content (%): 1.5 Concrete Temp. (F): 84 Ambient Temp. (F): 75 Plastic Unit Wt. (pcf): 146.8 Yield (Cu. Yds.):

Project Riverside Campus Riverside Campus Bryan, TX

Sample Date:

Sampled By:

Project Number: A1171057

Sample Information 05/05/23 Sample Time: Justin Maass Weather Conditions: Clear, light wind Accumulative Yards: Cloudy, lig Batch Size (cy): 10 Placement Method: Direct Discharge Water Added Before (gal): 0 Water Added After (gal): 0 West end of wall Sample Location: Placement Location: Bridge wall deck Sample Description: 6-inch diameter cylinders

6198 Imperial Loop

Terracon

1100

College Station, TX 77845-5765

979-846-3767 Reg No: F-3272

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
3	А	Good	6.01	28.37		05/22/23	17 F	113,600	4,000	2	TIT
3	В	Good	6.01	28.37		05/22/23	17 F	112,140	3,950	2	TJT
3	С	Good	6.01	28.37		05/22/23	17 F	110,790	3,910	2	тјт
3	D						Hold				
Initial C	ure: (Outside Plastic Lid	S	Final	Cure: Field (Cured					

Comments: F = Field Cured

Note: Reported air content does not include Aggregate Correction Factor (ACF).

Specification

Samples Made By: Terracon

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

Terracon Rep.: Justin Maass Reported To: Bill w/ ⊤TI Contractor: MDC **Report Distribution:**

(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

Start/Stop:

Reviewed By:

kander Durigan, P.E.

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.

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APPENDIX C. MASH TEST 4-12 (CRASH TEST 440863-03-1)



C.1. VEHICLE PROPERTIES AND INFORMATION

Figure C.1. Vehicle Properties for Test 440863-03-1

Jale	2023-06-22	Test No.:	440863-03-1	VIN No.:	1HTMMAAN	3BH318185
Year:	2011	Make:	INTERNATIONAL	Model:	430	0
	WEIGHTS (√Ib or	S kg)	CURB	TEST	INERTIAL	
	V	Vfront axle	6870		8100	
	V	Vrear axle	6160		14010	
	,	Wtotal	13030		22110	
	Allowable	e Range for CURB =	13,200 ±2200 lb Allowable R	ange for TIM = 22	,046 ±660 lb	
Ba	allast: <u>9080</u>	((as-nee √Ib or kg) (See M/	ded) A <i>SH</i> Section 4.2	.1.2 for recommend	ded ballasting)
Mass Dis (√Ib or	stribution kg): LF	4070	RF: <u>4030</u>	LR: 6990	RR:	7020
Engine T	vpe: DT		Accelero	meter Locatio	ons (🗹 inches d	or 🔲 mm)
Engine S	ize: 466		-	X ¹	У	z²
	· -		- Front:	0.00	0.00	0.00
I ransmis	ision Type: uto or Г	T Manual	Center:	129.00	0.00	50.00
	WD 🔽 RWD	4WD	Rear:	241.22	0.00	50.00
Describe	WD _ RWD any damage to the otes to include bent: BLOCKS 30W X 3	he vehicle prior	Rear:	241.22 ation, center	0.00	50.00
Other no attachme CENTE	WD RWD any damage to the otes to include bent: BLOCKS 30W X 3 ERED IN MIDDLE	AWD he vehicle prior allast type, din 30H X 60L	Rear:	241.22 ation, center	0.00	50.00
Other no attachme TWO E CENTE	WD RWD any damage to the otes to include bent: BLOCKS 30W X 3 ERED IN MIDDLE	AWD he vehicle prior allast type, dir 30H X 60L E OF BED JR 3/8 CABLE	Rear:	241.22 ation, center	0.00	50.00
Describe Describe	WD RWD any damage to the otes to include bent: BLOCKS 30W X 3 ERED IN MIDDLE DOWN WITH FOU CHES FROM GRO	AWD he vehicle prior allast type, dir 30H X 60L E OF BED JR 3/8 CABLES DUND TO CEN	Rear:	241.22 ation, center	0.00	50.00

C.2. **SEQUENTIAL PHOTOGRAPHS**







(c) 0.200 s



(e) 0.400 s

(f) 0.500 s

(d) 0.300 s



(g) 0.600 s (h) 0.700 s Figure C.4. Sequential Photographs for Test 440863-03-1 (Overhead Views).




(b) 0.100 s



(c) 0.200 s

(d) 0.300 s



(e) 0.400 s

(f) 0.500 s



(g) 0.600 s (h) 0.700 s Figure C.5. Sequential Photographs for Test 440863-03-1 (Frontal Views).





(b) 0.100 s



(c) 0.200 s



(e) 0.400 s



(g) 0.600 s (h) 0.700 s Figure C.6. Sequential Photographs for Test 440863-03-1 (Rear Views).

C.3.



Figure C.7. Vehicle Angular Displacements for Test 440863-03-1.





Figure C.8. Vehicle Longitudinal Accelerometer Trace for Test 440863-03-1 (Accelerometer Located at Center of Gravity).



Figure C.9. Vehicle Lateral Accelerometer Trace for Test 440863-03-1 (Accelerometer Located at Center of Gravity).



Figure C.10. Vehicle Vertical Accelerometer Trace for Test 440863-03-1 (Accelerometer Located at Center of Gravity).