

# Test Report No. 620331-01-1



# DESIGN AND EVALUATION OF MASHTL-5 CONCRETE MEDIAN BARRIER WITH SHALLOW EMBEDMENT

# Sponsored by Roadside Safety Pooled Fund

TEXAS A&M TRANSPORTATION INSTITUTE PROVING GROUND

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16. Abstract

This research project designed and tested a single slope concrete median barrier installed with shallow embedment in asphalt. The barrier was required to meet the crash performance criteria of Test Level 5 (TL-5) of American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware (MASH) (1). Researchers developed the design of the barrier anchorage in asphalt using dynamic finite element impact simulations. Results of the simulations were used to optimize the embedment depth needed to anchor the barrier segments. Researchers recommended the final design for crash testing.

A full-scale MASH Test 5-12 was performed. This test involved the 79,300-lb MASH 36000V tractor-trailer vehicle impacting the median barrier while traveling at a nominal speed of 50 mi/h and 15 degrees impact angle. This report provides details of the simulation analysis, design of the TL-5 concrete median barrier with shallow embedment, details of the crash test performed, crash test results, and the performance assessment of the barrier for MASH TL-5 criteria for longitudinal barriers. The concrete median barrier with shallow embedment met the performance criteria for MASH Test 5-12 for longitudinal barriers.

MASH Tests 5-10 and 5-11 were not performed. They were considered less critical due to successful past testing of similar single slope barrier systems. Based on the results of the new Test 5-12, the embedded single slope median barrier is considered a MASH TL-5 barrier system.

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# Design and Evaluation of *MASH* TL-5 Concrete Median Barrier with Shallow Embedment

by

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The results reported herein apply only to the article tested. The full-scale crash test was performed according to TTI Proving Ground quality procedures and American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware, Second Edition (*MASH*) guidelines and standards.

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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 <sup>2</sup>	square inches	645.2	square millimeters	mm²	
ft <sup>2</sup>	square feet	0.093	square meters	m²	
yd²	square yards	0.836	square meters	m²	
ac	acres	0.405	nectares	ha km²	
mi <sup>2</sup>	square miles	2.59	square kilometers	Km²	
floz	fluid ounces		milliliters	ml	
	allons	29.57	liters	1	
ft <sup>3</sup>	cubic feet	0.028	cubic meters	∟ m <sup>3</sup>	
vd <sup>3</sup>	cubic vards	0.765	cubic meters	m <sup>3</sup>	
۶a	NOTE: volumes of	reater than 1000L	shall be shown in m <sup>3</sup>		
		MASS			
oz	ounces	28.35	arams	a	
lb	pounds	0.454	kilograms	kg	
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 <sup>2</sup>	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 <sup>2</sup>	square millimeters	0.0016	square inches	IN <sup>2</sup>	
$m^2$	square meters	10.764	square verde	II <sup>2</sup>	
ha	square meters	1.195		yu-	
km <sup>2</sup>	Square kilometers	0 386	square miles	ac mi <sup>2</sup>	
ml	milliliters	0.034	fluid ounces	07	
L	liters	0.264	gallons	gal	
m <sup>3</sup>	cubic meters	35.314	cubic feet	ft <sup>3</sup>	
m <sup>3</sup>	cubic meters	1.307	cubic yards	yd <sup>3</sup>	
		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	
LIDA	kilopascals	0.145	poundforce per square inch	lb/in <sup>2</sup>	

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

# **Chapter 1. INTRODUCTION**

American Association of State Highway and Transportation Official's (AASHTO) *Manual for Assessing Safety Hardware (MASH*) Test Level 5 (TL-5) designs for single-slope concrete median barriers typically have a large moment slab, a continuous shallow footing, and/or deep footings to provide sufficient anchorage to the barrier (1). Construction constraints, such as buried utilities or bridge pier footings, can make some footing designs impractical.

Texas A&M Transportation Institute (TTI) has successfully tested a *MASH* Test Level 4 (TL-4) single-slope cast-in-place concrete median barrier with a 1-inch asphalt embedment depth for both 75-ft and 40-ft long segments (2,3). TTI has also completed *MASH* TL-5 design and testing of 54-inch tall single slope barrier with structurally independent foundations. Foundation designs include a drilled shaft footing, a continuous moment slab footing, and a continuous concrete beam footing that are not ideal for sites with constraints on foundation depth and width (4,5).

There was a need to develop a design of a shallow embedment or footing for a median cast-in-place barrier that can perform at TL-5 of *MASH*.

### 1.1. OBJECTIVE

The objective of this research was to determine a shallow embedment depth needed in asphalt, or an alternate shallow footing design, for sufficiently anchoring a cast-in-place median concrete barrier to meet *MASH* TL-5 criteria. The barrier was required to have a single slope barrier profile and above-grade height of 42 inches.

### 1.2. SCOPE OF WORK

This report presents the research performed to design and evaluate the TL-5 single slope barrier system. The barrier was designed using finite element impact simulations. The design was further evaluated by performing a full-scale *MASH* Test 5-12 in accordance with MASH evaluation criteria for longitudinal barriers (1).

Details of the modeling and simulation analysis performed to design the barrier are presented in Chapter 2. Subsequent chapters of the report present design details of the single slope concrete median barrier with shallow embedment, details of the crash test performed, crash test results, and the performance assessment of the barrier for *MASH* TL-5 criteria for longitudinal barriers.

# Chapter 2. DESIGN AND SIMULATION<sup>\*</sup>

Researchers developed the design of the embedded single slope concrete median barrier using finite element (FE) modeling and simulation. A barrier model was embedded into different thicknesses of asphalt to determine the appropriate thickness that was likely to result in acceptable *MASH* TL-5 performance. Impact simulations were performed using a 79,300-lb tractor-trailer vehicle model, impacting the embedded barrier under *MASH* Test 5-12 impact conditions (i.e., impact speed and angle of 50 mi/h and 15 degrees, respectively). Using these simulations, the researchers determined the appropriate minimum thickness of asphalt needed to properly anchor the barrier for impact with the vehicle. This chapter presents details of the design parameters, simulation modeling, simulation results, and design recommendations for crash testing.

# 2.1. DESIGN PARAMETERS

In consultation with the Technical Representative, the following parameters were selected for the barrier design.

- Segment Length A minimum 60-ft segment length of cast-in-place barrier was selected as a starting point. This length could be increased if needed, however, the final design did not exceed the 60-ft length.
- Barrier Slope Face of the single slope barrier was sloped at 11 degrees from the vertical. This is the most common slope used by the states participating in the Roadside Safety Pooled Fund Program.
- *Barrier Height* An above grade barrier height of 42 inches was selected since it is the most common barrier height for TL-5 barriers.
- Segment Connections Adjacent barrier segments are sometime connected using dowel bars. The research team did not connect adjacent barrier segments since it is a more critical design condition.
- Anchorage The barrier was anchored by means of embedding in asphalt. If the simulation results had shown that sufficient anchoring could not be achieved by embedding in asphalt, the researchers were to develop a shallow concrete footing to provide proper anchorage.

# 2.2. SIMULATION MODELING AND ANALYSIS

All simulations were performed using the finite element method. LS-DYNA, which is a commercially available general-purpose FE analysis software, was used for the analyses.

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

Figure 2.1 shows the initial model of the single slope barrier embedded four inches in asphalt. The total barrier length was comprised of three unconnected 60-ft barrier segments. The barrier segments were 8 inches wide at the top and 24 inches wide at the base. Due to the 4-inch barrier embedment, the above-grade barrier height was 42 inches.

The barrier segments were modeled using rigid material representation. The asphalt around the barrier was modeled as a solid continuum with viscoelastic deformable material model (LS-DYNA material MAT\_VISCOELASTIC). The boundaries of the asphalt continuum were constrained; however, the asphalt was free to deform due to the interaction with the barrier on impact from the tractor trailer. The total barrier length was 180 ft, and the vehicle impacted the first barrier segment.



Figure 2.1. Cross-section of Simulation Model.

Researchers performed three simulations with the vehicle impacting the first barrier segment at 10-ft downstream from segment end, at middle of the segment, and at 10-ft upstream of the first joint, as shown in Figure 2.2. The objectives of these simulations were to assess the performance of the barrier with the 4-inch embedment and to determine the critical impact point on the barrier segment.



# Figure 2.2. Impact Points Shown on First Segment of the Barrier System.

The vehicle was successfully contained and redirected in all simulations in a similar manner. Figure 2.3 shows the impact and redirection of the vehicle for the simulation with impact at the middle of the first barrier segment. Figure 2.4 shows the first barrier segment at the time of maximum dynamic deflection. The maximum dynamic deflection of each simulation is also shown in the figure. The barrier remained upright after impact in all simulations.



Figure 2.3. Results of Simulation with Impact at Middle of the Segment.





Even though the barrier was contained and redirected with the 4-inch embedment in asphalt, the 7.8-inch barrier deflection observed in the simulation was high. Being temperature dependent, asphalt softens in hot climate conditions, which can make the barrier anchorage weaker. Researchers therefore considered making the design more conservative by increasing the embedment depth.

Three additional models were developed and simulated. In these models, barrier embedment was increased to 6 inches, 8 inches, and 10 inches. Above-grade height of the barriers was maintained at 42 inches in all simulations. The vehicle impacted the center of the first barrier segment in all simulations, which was previously determined to be slightly more critical than other impact locations. The vehicle was contained and redirected in all simulations. Figure 2.5 compares the lateral movement of the barrier at the time of maximum dynamic deflection for all four embedment depths.



Figure 2.5. Comparison of Maximum Dynamic Barrier Deflection for Different Embedment Depths.



Figure 2.6. Comparison of Permanent Barrier Deflection of 6-inch and 8-inch Embedment Depths.

As expected, dynamic deflection of the barrier was proportional to the embedment depth. The 10-inch embedment depth resulted in very little movement of the barrier segment. The maximum dynamic deflection of the 6-inch and 8-inch barrier embedment depths was close, but the 6-inch embedment had a higher permanent deflection (Figure 2.6). This deflection was not desired as it resulted in significant exposure of the face of the adjacent barrier segment to oncoming traffic after a crash and was likely to require higher maintenance effort to reset the barrier. The 8-inch barrier embedment was therefore selected for the final design.

A full-scale test installation was constructed and crash tested to verify performance of the embedded barrier system. For ease of construction, barrier profile

was changed to single slope on each side of the barrier (instead of vertical slope below grade). Barrier width was increased by an inch to accommodate steel reinforcement needed to sustain MASH TL-5 loads. Details of the test installation, including final shape and reinforcement design of barrier segments, and other crash testing information and test results are presented in following chapters.

# Chapter 3. SYSTEM DETAILS

# 3.1. TEST ARTICLE AND INSTALLATION DETAILS

The installation consisted of three 50-inch tall, 60-foot long reinforced single slope barrier sections placed end to end with unconnected cold joints. The barrier sections were cast in place on top of 6 inches of compacted fill material and then embedded in 8 inches of asphalt. The asphalt pad extended 96 inches on both the impact and non-impact sides of the barrier. The single slope barriers were 9 inches wide at the top and sloped down symmetrically on either side for a final width of 28 inches at the base. The overall length of the installation was 180 feet.

Figure 3.1 presents the overall information on the single slope concrete median barrier, and Figure 3.2 thru Figure 3.7 provide photographs of the installation. Appendix A provides further details on the barrier. Drawings were developed by TTI Proving Ground. Construction was also performed by TTI Proving Ground personnel.

# 3.2. DESIGN MODIFICATIONS DURING TESTS

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



S:\Accreditation-17025-2017\EIR-000 Project Files\620331-01 - 5-12 Testing on Barrier-Nauman\Drafting, 620331\620331-01 Drawing

Figure 3.1. Details of TL-5 Concrete Median Barrier with Shallow Embedment.



Figure 3.2. Overall View of the TL-5 Concrete Median Barrier with Shallow Embedment Prior to Testing.



Figure 3.3. TL-5 Concrete Median Barrier with Shallow Embedment at Impact Location Prior to Testing.



Figure 3.4. Upstream Oblique View of the TL-5 Concrete Median Barrier with Shallow Embedment Prior to Testing.



Figure 3.5. TL-5 Concrete Median Barrier with Shallow Embedment at Unconnected Cold Joint Prior to Testing.



Figure 3.6. Detail of Cold Joint at Grade of the TL-5 Concrete Median Barrier with Shallow Embedment Prior to Testing.



Figure 3.7. Detail of the Top of the Cold Joint of the TL-5 Concrete Median Barrier with Shallow Embedment Prior to Testing.

# 3.3. MATERIAL SPECIFICATIONS

Appendix B provides material certification documents for the materials used to install/construct the TL-5 Concrete Median Barrier with Shallow Embedment. Table 3.1 shows the average compressive strengths of the concrete on the day of the test 2024-09-06. Asphalt was specified to be Texas Department of Transportation's Hot-Mix Asphaltic Concrete (HMAC) Type D.

Location	Design Strength	Avg. Strength	Age	Detailed Location
Barrier	3600 psi	3537 psi	37 days	100% of top of middle barrier
Barrier	3600 psi	5030 psi	37 days	100% of bottom of middle barrier
Barrier	3600 psi	4203 psi	25 days	100% of top barrier furthest north
Barrier	3600 psi	4013 psi	25 days	100% of bottom barrier furthest north
Barrier	3600 psi	3388 psi	18 days	100% of top barrier furthest south
Barrier	3600 psi	3475 psi	18 days	100% of bottom barrier furthest south

Table 3.1. Concrete Strength.

# 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-5 for Longitudinal Barriers. Tests 5-10 and 5-11 were not performed as they are not critical for this barrier system. Past testing has demonstrated successful performance of the single slope barrier system with the 1100C and 2270P vehicles (6,7,8,9,10). Furthermore, lower mass of these vehicles is not expected to impart greater load into the shallow-embedment barrier compared to the 36000V vehicle. For these reasons, only Test 5-12 was performed.

The target critical impact point (CIP) for the test was determined using simulation analyses presented in Chapter 2. Figure 4.1 shows the target CIP for *MASH* Test 5-12 on the TL-5 Concrete Median Barrier with Shallow Embedment.

 Table 4.1. Test Conditions and Evaluation Criteria Specified for MASH TL-5

 Longitudinal Barrier.

Test Designation	Test Vehicle	Impact Speed	Impact Angle	Evaluation Criteria
5-10	1100C	62 mi/h	25°	A, D, F, H, I
5-11	2270P	62 mi/h	25°	A, D, F, H, I
5-12	36000V	50 mi/h	15°	A, D, G



# Figure 4.1. Target CIP for *MASH* TL-5 Test on TL-5 Concrete Median Barrier with Shallow Embedment.

The crash tests and data analysis procedures were in accordance with guidelines presented in *MASH*. Chapter 5 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* Test 5-12, and Table 4.2 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 4.2. Evaluation Criteria Required for MASH Testing.

# 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 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 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/runway consists of an unreinforced jointed-concrete pavement in 12.5-ft × 15-ft blocks nominally 6 inches deep. The aprons were built in 1942, and the joints have some displacement but are otherwise flat and level.

# 5.2. VEHICLE TOW AND GUIDANCE SYSTEM

The 36000V test vehicle was placed in ninth gear for the test. With the vehicle idling, the clutch was remotely engaged to allow the truck to be pushed to speed. Once at speed, within the power band of the gear, the clutch was remotely released. The accelerator was then remotely depressed, and the vehicle accelerated under its own power to the required speed. 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. The vehicle was released and ran unrestrained just prior to impact with the installation. 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 multi-channel data acquisition system (DAS) produced by Diversified Technical Systems Inc. The accelerometers, which measure the x, y, and z axis of vehicle acceleration, are strain gauge type with linear millivolt output proportional to acceleration. Angular rate sensors, measuring vehicle roll, pitch, and yaw rates, are ultra-small, solid-state units designed

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

Each DAS is returned to the factory annually for complete recalibration and to ensure that all instrumentation used in the vehicle conforms to the specifications outlined by SAE J211. All accelerometers are calibrated annually by means of an ENDEVCOÒ 2901 precision primary vibration standard. This standard and its support instruments are checked annually and receive a calibration traceable to the International System of Units (SI). Measurement Uncertainties have been determined for critical parameters involved in this testing and are available upon request by the Sponsor.

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

TRAP uses the data from the yaw, pitch, and roll rate transducers to compute angular displacement in degrees at 0.0001-s intervals, and then plots yaw, pitch, and roll versus time. These displacements are in reference to the vehicle-fixed coordinate system with the initial position and orientation being initial impact. Measurement Uncertainties have been determined for critical parameters involved in this testing and are available upon request by the Sponsor.

Placement of the electronic instrumentation packages in the 36000V vehicle is shown in Table 5.1.

Instrument Package	Height from Ground	Distance from Vehicle Centerline	Distance from Front Axle Centerline
Front	28 inches	20 inches left	18 inches back
Rear of Tractor	33 inches	0 inches	122 inches
Rear Axle	50 inches	0 inches	684.5 inches

 Table 5.1. Instrumentation Package Location.

# 5.3.2. Anthropomorphic Dummy Instrumentation

*MASH* does not recommend or require use of a dummy in the 36000V vehicle, and no dummy was placed in the vehicle.

### 5.3.3. Photographic Instrumentation Data Processing

Photographic coverage of the test included 4 digital high-speed cameras:

- One placed overhead with a field of view perpendicular to the ground and directly over the impact point.
- One placed with a field of view parallel to and aligned with the installation at the downstream end.
- One placed with a field of view parallel to and aligned with the installation at the upstream end.
- One placed at an oblique angle upstream from the installation on the field side.

A flashbulb on the impacting vehicle was activated by a pressure-sensitive tape switch to indicate the instant of contact with the TL-5 Concrete Median Barrier with Shallow Embedment. 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 6. MASH TEST 5-12 (CRASH TEST 620331-01-1)

# 6.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 6.1 for details on *MASH* impact conditions for this test and Table 6.2 for the exit parameters.

Figure 6.1 and Figure 6.2 depict the target impact setup.

Table 6.1. Impact Conditions for MASH TEST 5-12, Crash Test 620331-01-1.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	50 mi/h	±2.5 mi/h	50.7 mi/h
Impact Angle	15°	±1.5°	13.9°
Impact Severity	404 kip-ft	≥404 kip-ft	396.3 kip-ft*
Impact Location	372 inches downstream from the upstream end of barrier 1.	±12 inches	376.9 inches downstream from the upstream end of barrier 1.

\* AASHTO has revised minimum Impact Severity for Test 5-12 to ≥382 kip-ft. This erratum will be included in the upcoming MASH Specification. Impact Severity of Test 620331-01-1 is therefore considered acceptable for MASH Test 5-12.

|--|

Exit Parameter	Measured
Brakes applied post impact	After 5 seconds
Vehicle at rest position	336 ft downstream of impact point 16 ft to the field side
Comments:	Vehicle remained upright and stable



Figure 6.1. TL-5 Concrete Median Barrier with Shallow Embedment/Test Vehicle Geometrics for Test 620331-01-1.



Figure 6.2. TL-5 Concrete Median Barrier with Shallow Embedment/Test Vehicle Impact Location 620331-01-1.

# 6.2. WEATHER CONDITIONS

Table 6.3 provides the weather conditions for Test 620331-01-1.

Date of Test	2024-09-06
Wind Speed	12 mi/h
Wind Direction	24°
Temperature	81°F
Relative Humidity	83%
Vehicle Traveling	350°

 Table 6.3. Weather Conditions for Test 620331-01-1.

# 6.3. TEST VEHICLE

Figure 6.3 and Figure 6.4 show the 2012 International Trans Star used for the crash test. Figure 6.5 shows the interior of the trailer prior to impact. Table 6.4 shows the vehicle measurements. Figure C.1 in Appendix C.1 gives additional dimensions and information on the vehicle.



Figure 6.3. Impact Side of Test Vehicle before Test 620331-01-1.



Figure 6.4. Opposite Impact Side of Test Vehicle before Test 620331-01-1.



Figure 6.5. Interior of Test Vehicle Trailer before Test 620331-01-1.

Test Parameter	Specification Tolerance		Measured
Curb Mass	29,000 lb	±3100 lb	30,910 lb
Vehicle Inertial Mass	79,300 lb	±1100 lb	79,920 lb
Wheelbase	200 inches	≤200 inches	144.5 inches
Trailer Length	636 inches	≤636 inches	636 inches
Trailer Overhang	87 inches	≤87 inches	49 inches
Overall Length	816 inches	≤816 inches	810 inches
Cargo Bed Height <sup>i</sup>	50 inches	±2 inches	50 inches
CG of Ballast above Ground <sup>e</sup>	73 inches	±2 inches	72 inches

 Table 6.4. Vehicle Measurements for Test 620331-01-1.

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

i – Without Ballast

e – See section 4.2.1.2 in MASH for recommended ballasting procedures

### 6.4. TEST DESCRIPTION

Table 6.5 lists events that occurred during Test 620331-01-1. Figures C.2, C.3, and C.4 in Appendix C.2 present sequential photographs during the test.

Time (s)	Events
0.0000 s	Vehicle impacted the installation
0.0590 s	Vehicle began to redirect
0.1350 s	Front drivers side tire came off the pavement
0.7590 s	Vehicle was parallel with installation
0.7810 s	Rear passenger side trailer bumper impacted the barrier

Table 6.5. Events during Test 620331-01-1.

# 6.5. DAMAGE TO TEST INSTALLATION

There was gouging on the impact side, up to 1-inch deep, along the length of the barrier till loss of vehicle contact at the end of the installation. There was also considerable gouging on top of the installation on the non-impact side.

Table 6.6 describes the deflection and working width of the TL-5 Concrete Median Barrier with Shallow Embedment. Figure 6.6 shows the TL-5 Concrete Median Barrier with Shallow Embedment at maximum deflection during the test. Figure 6.7 through Figure 6.12 show the damage to the barrier after the test.

Table 6.6. Deflection and Working Width of the TL-5 Concrete Median Barrier withShallow Embedment for Test 620331-01-1.

Test Parameter	Measured
Permanent Deflection/Location	0.5 inches toward field side, at the joint between barrier sections 1 and 2
Dynamic Deflection	2.1 inches at the top of barrier section 1
Working Width <sup>a</sup> and Height	44.5 inches, at a height of 135.2 inches, at the top rear passenger corner of trailer

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



Figure 6.6. TL-5 Concrete Median Barrier with Shallow Embedment at Maximum Deflection during Test 620331-01-1.



Figure 6.7. Overall View of TL-5 Concrete Median Barrier with Shallow Embedment after Test 620331-01-1.



Figure 6.8. Right Angle View of TL-5 Concrete Median Barrier with Shallow Embedment at Impact Location after Test 620331-01-1.



Figure 6.9. TL-5 Concrete Median Barrier with Shallow Embedment at Impact Location after Test 620331-01-1.



Figure 6.10. Oblique View of Downstream Damage and Cold Joint of TL-5 Concrete Median Barrier with Shallow Embedment after Test 620331-01-1.



Figure 6.11. Oblique Downstream Field Side View of TL-5 Concrete Median Barrier with Shallow Embedment at Impact Location after Test 620331-01-1.



Figure 6.12. Downstream In-line View of TL-5 Concrete Median Barrier with Shallow Embedment after Test 620331-01-1.

# 6.6. DAMAGE TO TEST VEHICLE

Figure 6.13 through Figure 6.16 show the damage sustained by the exterior of the vehicle. Figure 6.16 shows the interior of the trailer. Table 6.7 and Table 6.8 provide details of the occupant compartment deformation and exterior vehicle damage.



Figure 6.13. Impact Side of Test Vehicle after Test 620331-01-1.



Figure 6.14. Opposite Impact Side of Test Vehicle after Test 620331-01-1.



Figure 6.15. Rear Impact of Test Vehicle after Test 620331-01-1.



Figure 6.16. Trailer Interior of Test Vehicle after Test 620331-01-1.

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 lateral inches	0.0 inches
Foot Well/Toe Pan	≤9.0 inches	0.0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0.0 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 6.7. Occupant Compartment Deformation 620331-01-1.

# Table 6.8. Exterior Vehicle Damage 620331-01-1.

Side Windows	Side windows remained intact	
Maximum Exterior Deformation	16 inches at right front bumper	
VDS	01FRQ6	
CDC	01FRGW6	
Fuel Tank Damage	Yes	
Description of Damage to Vehicle:	The bumper, fender, and lower portion of the right door were deformed. The wheels on the right side of the tractor and trailer were deformed. The right tire on the tractor and the outer and inner right front tires on the trailer ruptured. The back right inner and outer tires on the trailer were deflated. The fifth wheel was dislodged, and the right fuel tank was ruptured. There were abrasions and deformations all down right side of trailer. The king pin was deformed and there was a tear in the trailer starting 19 inches from the front of the trailer that measured 12 inches wide × 20 inches high.	

# 6.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 6.9. Figure C.5 in Appendix C.3 shows the vehicle angular displacements, and Figures C.6 through C.8 in Appendix C.4 show acceleration versus time traces.

Test Parameter	Measured	Time
OIV, Longitudinal	3.6 ft/s	0.2303 seconds on right side of interior
OIV, Lateral	15.6 ft/s	0.2303 seconds on right side of interior
Ridedown, Longitudinal	6.3 g	0.2379 - 0.2479 seconds
Ridedown, Lateral	26.8 g	0.2390 - 0.2490 seconds
Theoretical Head Impact Velocity (THIV)	5.4 m/s	0.2305 seconds on right side of interior
Acceleration Severity Index	1.3	0.2246 - 0.2746 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	-2.8 g	0.1705 - 0.2205 seconds
50-ms MA Lateral	-7.2 g	0.1560 - 0.2060 seconds
50-ms MA Vertical	11.4 g	0.2121 - 0.2621 seconds
Roll	51.4°	4.8038 seconds
Pitch	11.1°	1.7110 seconds
Yaw	22.4°	4.9361 seconds

Table 6.9. Occupant Risk Factors at CG for Test 620331-01-1.

# 6.8. TEST SUMMARY

Figure 6.17 summarizes the results of MASH Test 620331-01-1.

33







1.2000 s

	GENERAL INFORMATION		EXIT CONDITIONS
Test Agency:	Texas A&M Transportation Institute (TTI)	Stopping Distance	336 ft downstream
Test Standard/Test No.:	MASH 2016, Test 5-12	Stopping Distance.	16 ft to the field side
Project No.:	620331-01-1		TEST ARTICLE DEFLECTIONS
Test Date:	2024-09-06	Dynamic	2.1 inches
	TEST ARTICLE	Permanent	0.5 inches
Type:	Longitudinal Barrier	Working Width / Height	44.5 inches / 135.2 inches
Name:	TL-5 Concrete Median Barrier with Shallow Embedment		VEHICLE DAMAGE
Length:	180 feet	VDS:	01FRQ6
	Three, 60 foot long single slope concrete barrier sections.	CDC:	01FRGW6
Key Materials:	embedded in 8-inch thick asphalt pad	Max Exterior Deformation:	16 inches at the front bumper
Soil Type and Condition:	Asphalt, damp	Max Occupant Deformation:	None
	TEST VEHICLE		OCCUPANT RISK VALUES
Type/Designation:	36000V	Long. OIV	3.6 ft/s
Year, Make and Model:	2012 International Trans Star	Lat. OIV	15.6 ft/s
Curb Mass:	21,450 lbs	Long. Ridedown	6.3 g
Inertial Mass:	79,920 lbs	Lat. Ridedown	26.8 g
	IMPACT CONDITIONS	THIV	5.4 m/s
Impact Speed:	50.7 mi/h	ASI	1.3
Impact Angle:	13.9°	Max 50-ms Long.	-2.8 g
Impact Location:	376.9 inches downstream from the upstream end of barrier 1.	Max 50-ms Lat.	-7.2 g
Kinetic Energy:	396.3 kip-ft	Max 50-ms Vert.	11.4 g
		Max Roll	51.4°
		Max Pitch	11.1°
		Max Yaw	22.4°



Figure 6.17. Summary of Results for MASH Test 5-12 on TL-5 Concrete Median Barrier with Shallow Embedment.

# Chapter 7. SUMMARY AND CONCLUSIONS

# 7.1. ASSESSMENT OF TEST RESULTS AND CONCLUSIONS

The crash test reported herein was performed in accordance with *MASH* Test 5-12 evaluation criteria for longitudinal barriers.

Table 7.1 shows that the TL-5 Concrete Median Barrier with Shallow Embedment met the performance criteria for *MASH* Test 5-12 for longitudinal barriers.

# Table 7.1. Assessment Summary for MASH Test 5-12 on TL-5 Concrete Median Barrier with Shallow Embedment.

Evaluation Criteria	Description	<b>Test</b> 620331-01-1 (MASH Test 5- 12)
A	Contain, Redirect, or	S
	Controlled Stop	
D	No Penetration into Occupant Compartment	S
G	Rolling is acceptable	S
Overall	Evaluation	Pass

Note: S = Satisfactory

### 7.2. IMPLEMENTATION<sup>\*</sup>

Based on the results of the Test 5-12 performed herein and other past test of single slope barrier meeting 5-11 and 5-10 testing criteria, the embedded barrier system is considered MASH TL-5 compliant and is ready for implementation in the field (6,7,8,9,10).

The barrier was tested with 60-ft sections in the research. Longer barrier sections will also be acceptable since additional weight of the barrier segments is expected to reduce barrier movement and not influence the crash performance in a negative manner.

The barrier was tested while embedded in the 8 inches of asphalt. Embedding the barrier in asphalt thickness greater than 8 inches will also be acceptable as long as the above-grade height of 42 inches is maintained. Similarly, the barrier may be embedded in the concrete footing with minimum 8-inch lock in without negatively impacting the performance of the barrier. The additional embedment depth, or use of stiffer concrete material provide additional anchorage to the barrier, which are not expected to influence the barrier performance in a negative manner.

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

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# APPENDIX A. DETAILS OF TL-5 CONCRETE MEDIAN BARRIER WITH SHALLOW EMBEDMENT



# APPENDIX B. SUPPORTING CERTIFICATION DOCUMENTS

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CMC STEEL TEXAS 1 STEEL MILL DRIVE SEGUIN TX 78155-7510 CMC STEEL TEXAS CERTIFIED MILL TEST REPORT For additional copies call 800-227-6489 Market Steel Texas For additional copies call Built Test Report Seguin TX 78155-7510 Seguin	Drew M Fischer					
CMC STEEL TEXAS CERTIFIED MILL TEST REPORT are accurate and conform to the reported grade specificati SEGUIN TX 78155-7510 800-227-6489	allen Junche					
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CMC STEEL TEXAS CEDITIES MILL TEST DEDOT TO THE PREVE CENTRY that the test results presented he	nitorm to the reported grade specificati		For additional conice of	RIVE	MILL DR	CMC 1 STEE
	artiry that the test results presented he		CERTIEIED MILL TECT DE	AS	TEEL TEX	CMC S

Page 1 OF 1 02/08/2024 04:42:12

	exas A&M ransportation stitute	QF 7.3-01 Samj	Concrete pling	Doc. No. QF <b>7</b> .3-01	Revision Date: 2020-0 <b>7-</b> 29
Qualit	y Form	Revised by: B.L. Griffi Approved by: D. L. Ku	th hn	Revision: 7	Page: 1 of 1
Project No:	620331-01	Casting Date:	7/29/2024	Mix Design (psi):	3600
Name of Technician Taking Sample	Terr	acon	Name of Technician Breaking Sample	Terr	acon
Signature of Technician Taking Sample	Terr	acon	Signature of Technician Breaking Sample	Terr	acon
Load No.	Truck No.	Ticket No.	Locat	ion (from concrete	e map)
Т1	Hosey,Justin1	95149	100%	of Bottom half of b	parrier
Т2	Goosby, Raymo3	95162	100	0% of top half of Ba	rrier
Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average

	Rodi-mix Concrete Comp REMIT PAYMEL P.O. BOX138 KURTEN, TX 7	ичу NT TO: 7862	5222 Sandy Po Bryan, TX 7 18935 Circle La Pinehurst, TX	oint RI '807 ke Dr 77362	D. 17534 Si College Stati • 17263 Hwy 7 Willis, TX 773	H 6 South on, TX 77845 5N 2687 H 378 Montgomer	P IWY 105 ry, TX 77333	INEHURST DISPAT BCS DISPAT	233532 CH - 936-232-5815 CH - 979-316-2906 CE - 979-985-3636
	TEXAS ( RELLTS	CAMPUS.	ISPORTATIO		רא וד רא און	- 2818, RT   HE "T". RT   - 18T EXIT AREHQUSE LI	HAY 21.LT S HAY 47.LT I OUT OF ROU JOP RD, RT		. RT AT ENTRANCE, T GATE 5
	TIME	FORMULA	LOAD SI	ZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
	6134		10.00		16.00 F	0#	HOSEY.	JUSTINI	96948
	DATE		LOAD#		YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
	7/29/24		10.00		10.00	A DECEMBER OF	and a start of the	5.00 in	95149
	QUANTITY	CODE	DESCRIP	FION				UNIT PRICE	EXTENDED PRICE
									business
	LEFT PLANT	ARRIVED JOI	3 START UNLO	ADING	SLUMP	CONCRETE TEMP.	AIR TEMP	]	- 1 / C
								Prev. AM Ticket Int	T
	FINISH UNLOADING	LEFT JOB	ARRIVED AT	PLANT	ON SITE	ETESTING		and another age	
1					TESTING LAB: GES	RACON	a alter alter	ADDITIONAL CHARG	E1
		HITCH I	TESTED	100	AIR	CYLINDERS	-	ADDITIONAL CHARG	E 2
			YES NO	Stark.				GRAND TOTAL	
	IRRITATION Contains Portland Cemer CONTACT May CAUSE Contact with Skin, In Case Water. If Initiation Persists. CONCRETE is a PERISHAE PURCHASE VHON LEAV ORIGINAL INSTRUCTIONS A URCHASE VHON LEAVING ORIGINAL INSTRUCTIONS A URCHASE AND A STATUS ORIGINAL INSTRUCTIONS A Magnetic Control of the Status All accounts not past within 30 annum. Net Responsible For Made at Time Material is Delvi A 525 0.0 Service Charge at d Checks. Demerge charge atter	WARNING GTOTHESK BURNS. Avoid Co of Contact with Skil Get Medical Attenti Le COMMODITY and No the PLANT. ANY Let COMMODITY and No the PLANT. ANY Let COMMODITY and No the PLANT. ANY Commodities and the Common and Common and Common and Common and Common and Common and Common and Common and Common and Common a	G IN AND EYES bots and Gloves. PROI nor Eyes, Rinse Thorou on KEEP CHILDREN A BECOMES THE PROPER CHANGES or CANCELLA b the OFRICE BEFORE L CHANGES or CANCELLA b the OFRICE BEFORE L CHANGES or CANCELLA b other CANCELLA b other CANCELLA b other CANCELLA b other CANCELLA BECOMES THE PROPER BECOMES THE PROPER BECOMES THE PROPER D OT CANCELLA D OT CA	ONGED rolonged ghly With <b>NAY.</b> TY of the FION of DADING 's feds. er d Unless etumed	PROPERT DA Cro BE SIGNED # DELUMERY Den Customer - The drive and weight of this funct the premises and/or adjust here is requesting that you drive is requesting that you drive is requesting that you any occur to the premise buildings discussion. The second many occur to the premise buildings discussion of the second many occur to the premise buildings discussion. For the any occur to the the premise drive of this funck and this as the premises and for adjust SIGNED.	WAGE RELEASE TO BE MADE INSUE CURB LINE; of this fruck in presenting this may possibly cause damage to may possibly cause damage to may possibly cause damage to any but in order to do this the again this RELEASE Relevang have the actual of adjacent property, as and or adjacent property, as and or adjacent property, additional consideration, the additional consideration the padditional consideration the set of any and all damage to orden property which may be teen cut of delivery of this order	Excessive Wate H <sub>2</sub> 0 Ar GAL X. GAL X. 	r is Detrimental to Concre dded by Request/Authoriz	te Performance. ed By: ards lave Read the Health SiBle FOR ANY DAMAGE
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	REMIT PAYME P.O. BOX138	ENT TO:	522 E	22 Sandy Poin Bryan, TX 7780	t R	D. 17534 S College Stat	H 6 South ion, TX 77845		PINEHURST DISPAT	233545
	KURTEN, TX	77862	189 Pin	35 Circle Lake	D	17263 Hwy	75N 2687 H	HWY 105	BCS DISPAT	CH - 936-232-5815 CH - 979-316-2906 CE - 979-985-3636
					502	VVIIIIS, IX //	378 Montgome	ery, TX 77333		
	TEXAS	A&M TRA CAMPUS								RT AT ENTRANCE, T BATE 5
-	TIME	FORMULA		LOAD SIZE		YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
-	/:41	EXC3600		6.00		16.00	0#	GODSB	A RAYMOS	96961
	DATE	Stra Presi		LOAD#		YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
_	1/22/24	TTIRELL		6,00		16.00			5.00 in	95168
	QUANTITY	CODE	Contrasting of	DESCRIPTION	V				UNIT PRICE	EXTENDED PRICE
										business
	LEFT PLANT	ARRIVED JOE	3	START UNLOADIN	G	SLUMP	CONCRETE TEMP	AID TEND	Tax	
1	751							AIRTEMP	Prev, AM Ticket Tota	
-	FINISH UNLOADING	LEFT JOB		ARRIVED AT PLAN	NT	ON SITE	TESTING	- Internet a new second		
						TESTING LAB: GESS	RACON			
			TES	TED		AIR	OTHER CYLINDERS	TRUD OLOG		
			YES	NO NO				Designed of the		
	IRRITATIN	WARNING				PROPERTY DAM		Excessive Wate	r is Detrimental to Concrete	Performance.
Co	ntains Portland Cemen	t. Wear Rubber Boo BURNS, Avoid Con	ts and	Gloves. PROLONGE	D	Dear Customer - The driver o RELEASE to you for your signa size and weight of this truck m	f this truck in presenting this ature is of the opinion that the ay possibly cause damage to	H <sub>2</sub> 0 Ac	Ided by Request/Authorized	d By:
Co Wa	ntact with Skin. In Case iter. If Irritation Persists.	of Contact with Skin Get Medical Attentio	or Eyes	CHILDREN AWAY.	ed /ith	material in this load where you help you in everyway that we co driver is requesting that you sig and this supplies that you sig	an, but in order to do this the n this RELEASE relieving him	WEIGHMASTER		
PLOF	IRCHASER UPON LEAVIN RIGINAL INSTRUCTIONS M Ints. The undersigned promi	LE COMMODITY and E IG the PLANT, ANY C UST be TELEPHONED	HANGES to the OF	S THE PROPERTY of 1 S or CANCELLATION of FICE BEFORE LOADING	he f	may occur to the premises buildings, sidewalks, driveways this material and that you also	and or adjacent property, curbs, etc. by the delivery of agree to help him remove	Surch	argo for andit	
All	accounts not paid within 30 d	owed. ays of delivery will bear i	nterest at	the rate of 18% per		public streets. Further as a undersigned agrees to indem driver of this truck and this supp the premises and /or adiase	ce so that he will not liter the cditional consideration; the hify and hold harmless the eller for any and all damage to	NOTICE: MY SIGNATURE B	ELOW INDICATES THAT I HA	CIS
Ma A S Che	de at Time Material is Delive 25.00 Service Charge and Lo acks. Demerge charge after 9	red, oss of the Cash Discounte 0 min. will be \$100.00/hr	or Quality.	No Claim Allowed Unles Collected on all Returned	5	claimed by anyone to have arise SIGNED:	nt property which may be in out of delivery of this order	CAUSED WHEN DELIVERING	INSIDE CURB LINE.	BLE FOR ANY DAMAGE
-						X		x		
									2:	33545

### CONCRETE COMPRESSIVE STRENGTH TEST REPORT

 Report Number:
 A1171057.0302

 Service Date:
 07/29/24

 Report Date:
 09/06/24

 Task:
 PO# 620331

### Client

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

#### Material Information

Specified Strength:3,500psi @28daysMix ID:Txc3600Supplier:TexcreteBatch Time:0634Plant:2Truck No.:RAYM03Ticket No.:95149

### Field Test Data

Test	Result	Specification
Slump (in):	6 1/2	
Air Content (%):	2.3	
Concrete Temp. (F):	85	40 - 95
Ambient Temp. (F):	81	40 - 95
Plastic Unit Wt. (pcf):	147.2	
Yield (Cu. Yds.):		

6198 Imperial Loop College Station, TX 77845-5765

979-846-3767 Reg No: F-3272

Sample Information 07/29/24 Sample Time: 0720 Sample Date: Sampled By: Brian Maass Weather Conditions: Cloudy, Light 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: North Barrier, North End at The Bottom Placement Location: North Barrier Sample Description: 4-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 (Ibs)	Comp Strength (psi)	Frac Type	Tested By
1	А	Good	4.00	12.57	08/30/24	09/04/24	37 F	53,449	4,250		JLR
1	В	Good	4.00	12.57	08/30/24	09/04/24	37 F	40,346	3,210	2	JLR
1	С	Good	4.00	12.57	08/30/24	09/04/24	37 F	39,543	3,150	2	JLR
1	D				08/30/24		Hold				
Initial C	ure: Ou	tside Plastic Li	ds	Final	Cure: Field (	Cured					

Project

Bryan, TX

Riverside Campus

**Riverside Campus** 

Project Number: A1171057

Comments: F = Field Cured

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 compressive strength samples (ASTM C 31, C 39, C 1231).

Start/Stop: 0600-1000

Terracon Rep.: Brian Maass

#### Reported To: Bill w/ TTI Contractor:

#### contractor:

Services:

Report Distribution: (1) Texas Transportation Institute, Bill Griffith Mayer
(1) Texas Transportation Institute, Adam

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

### CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0302 Service Date: 07/29/24 Report Date: 09/06/24 Task: PO# 620331

### Client

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

### Material Information

Specified Str	ength: 3,500	psi@2	3 days
Mix ID:	Txc3600		
Supplier:	Texcrete		
Batch Time:	0741	Plant:	2
Truck No.:	JUSTIN1	Ticket No.:	95162

### Field Test Data

Test	Result	Specification
Slump (in):	7 1/2	
Air Content (%):	2.1	
Concrete Temp. (F):	87	40 - 95
Ambient Temp. (F):	81	40 - 95
Plastic Unit Wt. (pcf):	144.2	
Yield (Cu. Yds.):		

**Terracon** 6198 Imperial Loop

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

0825

Project Number: A1171057 Sample Information 07/29/24 Sample Time: Sample Date: Sampled By: Brian Maass Weather Conditions: Cloudy, Light Wind Accumulative Yards: 20/20 Batch Size (cy): 10 Placement Method: Direct Discharge Water Added Before (gal): 0 Water Added After (gal): 0 Sample Location: North Barrier, North End at The Top Placement Location: North Barrier Sample Description: 6-inch diameter cylinders

Laboratory '	Test Data
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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	Irregular	6.00	28.27	08/30/24	09/04/24	37 F	143,240	5,070	2	JLR
2	В	Good	6.00	28.27	08/30/24	09/04/24	37 F	135,713	4,800	2	JLR
2	С	Irregular	6.00	28.27	08/30/24	09/04/24	37 F	147,476	5,220	2	JLR
2	D				08/30/24		Hold				
Initial C	ure: (	Outside Plastic Lid	s	Final	Cure: Field (	Cured					

Project

Bryan, TX

Riverside Campus

**Riverside Campus** 

Comments: F = Field Cured

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

#### Samples Made By: Terracon

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

Terracon Rep.: Brian Maass Reported To: Bill w/ ⊤⊤I

### Contractor:

**Report Distribution:** (1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

**Reviewed By:** 

Start/Stop: 0600-1000

Justin Maass Assistant 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

### Photo Log

Report Number: Service Date: Report Date: Task: A1171057.0302 07/29/24 09/06/24 PO# 620331



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



CT0001, 10-16-13, Rev.10

Page 1 of 2

### Photo Log

Report Number: Service Date: Report Date: Task: A1171057.0302 07/29/24 09/06/24 PO# 620331



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



CT0001, 10-16-13, Rev.10

Page 2 of 2

		exas A&M ransportation istitute	QF 7.3-01 Sam	Concrete pling	Doc. No. QF <b>7.3-</b> 01	Revision Date: 2020-0 <b>7-</b> 29		
	Qualit	y Form	Revised by: B.L. Griffit Approved by: D. L. Ku	th hn	Revision: 7	Page: 1 of 1		
I	Project No:	620331-01	Casting Date:	8/9/2024	Mix Design (psi):	3600		
Name o Ta	of Technician aking Sample	Terr	acon	Name of Technician Breaking Sample	Terracon			
Signature of Technician Taking SampleTer			acon	Signature of Technician Breaking Sample	Terracon			
Lo	oad No.	Truck No.	Ticket No.	Location (from concrete map)				
Т1		Hosey,justin1	95672	100% of Bottom	half of barrier section	on furthest north		
т2		Will,Camson,1R5	95685	100% of top ha	alf of Barrier section furthest north			
Lo	ad No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average		
<u> </u>								
<u> </u>								
	Redit wite Concrete Compa REMIT PAYMEN P.O. BOX138 KURTEN, TX 77	NT TO: 522 7862 189 Pin	2 Sandy Point RD iryan, TX 77807 35 Circle Lake Dr. ehurst, TX 77362	. 17534 SH College Statio 17263 Hwy 7 Willis, TX 773	H 6 South on, TX 77845 5N 2687 HV 78 Montgomery	Pi VY 105 , TX 77333	INEHURST DISPATO BCS DISPATO OFFIC	31052 CH - 936-232-5815 CH - 979-316-2906 CE - 979-985-3636
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			ORTATIO YAN TX	RT TH ST	2818.RT H WE "T".RT H AY STRAIGH	WY 21,LT S WY 47,LT I TALL THE W	ILVER HILL NTORELLIS AY DOWN TO	,RT AT ENTRANCE, THE GATE
	TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
	6:32	LXC3600	10.00	16.00 0	(日朝) 62(033)	HOSEY,	JUSTIN1	97471
	DATE	Proster	LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
	879724	TTIRELL	2710.00	10.00	and the second second		5.00 in	95672
	1.00 e.	FUEL	START IN COMM	Fuel	Charge	Thank yo	u fan yeur	
	LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP	Finley, AN	
		LEET IOR		ON SITE	TESTING		FICKET IDI	¢1
	TINIGITORECADING	LEITIGD	ANNUED ATTERNT	TER TESTING LAB: GES	RACON			E 1
		TT	STED	CME	OTHER	C. C. S. S. S. S.	ADDITIONAL CHARG	E 2
		YES		AIR	CTLINDERS			
		WARNING		PROPERTY DA	MAGE RELEASE	Excessive Wate	GRAND TOTAL er is Detrimental to Concre	te Performance.
	IRRITATII Contains Portland Cemer	NG TO THE SKIN A nt, Wear Rubber Boots a	ND EYES	(TO BE SIGNED IF DELIVERY Dear Customer - The driver RELEASE to you for your sig size and weight of this truck	of this truck in presenting this nature is of the opinion that the may possibly cause damage to	H <sub>2</sub> 0 A	dded by Request/Authoriz	ed By:
	CONTACT MAY CAUSE Contact with Skin. In Case Water, If Irritation Persists	BURNS. Avoid Contact e of Contact with Skin or E	With Eyes and Prolonged yes, Rinse Thoroughly With	the premises and/or adjace material in this load where y help you in everyway that we driver is requesting that you :	ent property if he places the rou desire it. It is our wish to can, but in order to do this the sign this RELEASE relieving him	WEIGHMASTER		
	CONCRETE is a PERISHAI PURCHASER UPON LEAV ORIGINAL INSTRUCTIONS	BLE COMMODITY and BECO ING the PLANT, ANY CHAN MUST be TELEPHONED to the	MES THE PROPERTY of the GES or CANCELLATION of OFFICE REFORE LOADING	and this supplier from any may occur to the premise buildings, sidewalks, drivewa this material and that you a	esponsibility from damage that as and or adjacent property, ys, curbs, etc. by the delivery of ilso agree to help him remove	Surcharge for credit cards		
	starts. The undersigned pron incurred in collecting any sum	mises to pay all costs, includin s owed.	g reasonable attorney's fees.	public streets. Further as undersigned agrees to inde driver of this truck and this su	additional consideration; the emnify and hold harmless the applier for any and all damage to	NOTICE: MY SIGNATURE WARNING NOTICE AND SU	BELOW INDICATES THAT I I	HAVE READ THE HEALTH NSIBLE FOR ANY DAMAGE
	annum. Not Responsible For Made at Time Material is Delin A \$25.00 Service Charge and	Reactive Aggregate or Color Qu vered. Loss of the Cash Discounted wi	ality. No Claim Allowed Unless	claimed by anyone to have an SIGNED:	risen out of delivery of this order	LOAD RECEIVED BY	INSIDE CORB LINE.	
l	oneurs, pernerge charge after	r eo min: will be \$100.00/hr.		X		x		
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	7							

	Reti- wit Consete Comp Reti- wit Consete Comp REMIT PAYME P.O. BOX138 KURTEN, TX 7	калу NT TO: 52: 7862 185 Ріг	22 Sandy Point R 3ryan, TX 77807 355 Circle Lake D nehurst, TX 7736	RD. 17534 S College Sta Dr. 17263 Hwy 2 Willis, TX 77	GH 6 South tion, TX 77845 75N 2687 HV '378 Montgomery	F VY 105 r, TX 77333	NEHURST DISPATO BCS DISPATO OFFIC	231064 CH - 936-232-5815 CH - 979-316-2906 CE - 979-985-3636
			ORTATIC YAN TX		T ZBIB, RT H HE "T", RT H TAY STRAIGH			RT AT ENTRANCE. THE GATE
	TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
1	7:41	FXC3600	6.00	16:00	01 62033		MSON, 1R5	97484
	DATE	PROJECT	LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
	0/9/24	TTIRELL	M6.00	16:00	a setti si sarragen		5.00 in	95685
and the second sec	6.00 v	d TXÇ3600 a FUEL		DOTC Fuel	. 3600, RG, 5" Charge	Thank yo	u fon sour	business
	LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP	Tax	
	8'00	8:1h					Prev. AM Ticket Tot	T al
	FINISH UNLOADING	LEFT JOB	ARRIVED AT PLANT	r ON SIT	E TESTING			
				TESTING LAB: GE	RRACON SSNER		ADDITIONAL CHARG	E1
		TE	STED	AIR	CYLINDERS		ADDITIONAL CHARG	E 2
		YES	NO NO				GRAND TOTAL	
	VES VES     VES VES     V			PROPERTY D. (TO BE SIGNED IF DELIVERY Dear Customer - The draw size and weight of this truck and the size and weight of this truck thelp you in veryway that we drawed is requesting that you emay occur. To the prema buildings, sidewalks, drawn this material and that you public streets. Further an undersigned agrees to ind	AMAGE RELEASE TO BE MADE INSIDE CURR LINE) or of this truck in presenting this grature is of the opinion that the may possibly cause damage to anti property if he places the damage of the places the sign this RELEASE releving thim responsibility from damage that est and but in order to do this the sign this RELEASE releving thim responsibility from damage that data agrees to help thim remove reflects so that he will not iter the saddhonal consideration; the	Excessive Wate H20 Ac GAL X WEIGHMASTER Surcl	r is Detrimental to Concre Ided by Request/Authorize	te Performance. ad By:
	All accounts not paid within 30 annum. Not Responsible For F Made at Time Material is Deliv A \$25.00 Service Charge and L Checks. Demerge charge after	days of delivery will bear interes Reactive Aggregate or Color Que ered. Joss of the Cash Discounted will 90 min. will be \$100.00/hr.	at at the rate of 18% per ality. No Claim Allowed Unless be Collected on all Returned	driver of this truck and this s the premises and /or adji claimed by anyone to have a SIGNED:	upplier for any and all damage to acent property which may be rrisen out of delivery of this order	NOTICE: MY SIGNATURE E WARNING NOTICE AND SUP CAUSED WHEN DELIVERING LOAD RECEIVED BY	BELOW INDICATES THAT I H PLIER WILL NOT BE RESPON INSIDE CURB LINE.	AVE READ THE HEALTH SIBLE FOR ANY DAMAGE
	All accounts not paid within 30, annum. Not Reponsible For Made at Time Material is Deliv A 525.00 Service Charge at L Checks. Demerge charge after	days of delivery will best interest seachtre Aggregate or Color Cour ered. Cos of the Cash Discounted will 90 mm. will be \$100.00mr.	I at the rate of 18% per likely. No Calm Alweed Unless	there of this accel and this is started the second	uppele for any and all damage to assent poppet, which may be insen out of deevery of this order	NOTICE: MY SIGNATURE : AVAILABLE AND SIGNATURE : A NEED WHEN DELIVERING LOAD RECEIVED BY X	RELOW INDICATES THAT I H PULER WILL NOT BE RESPON INSIDE CURB LINE.	AVE READ THE HEALTH SIBLE FOR ANY DAMAGE

Report Number:	A1171057.03	04
Service Date:	08/09/24	
Report Date:	09/05/24	Revision 1 - 25-day results
Task:	PO# 620061	

#### Client

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

#### Material Information

Specified Str	ength: 3,60	0 psi@ 28	3 days
Mix ID:	TXC3600		
Supplier:	Texcrete		
Batch Time:	0632	Plant:	Bryan
Truck No.:	JUSTIN1	Ticket No.:	95672

Field Test Data		
Test	Result	Specification
Slump (in):	6	
Air Content (%):	1.0	
Concrete Temp. (F):	93	40 - 95
Ambient Temp. (F):	78	40 - 95
Plastic Unit Wt. (pcf):	146.0	
Yield (Cu. Yds.):		

Ferracon

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

Sample Information 08/09/24 Sample Time: 0715 Sample Date: Sampled By: Jonathan Cole Weather Conditions: Sunny, Light Wind Accumulative Yards: 10/16 Batch Size (cy): 10 Placement Method: Direct Discharge Water Added Before (gal): 20 Water Added After (gal): 0 Bottom Portion of Wall, Southwest End Sample Location: Placement Location: Reinforced Singe Slope Wall. Sample Description: 4-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 (Ibs)	Comp Strength (psi)	Frac Type	Tested By
1	А	Good	4.00	12.57	08/12/24	09/03/24	25 F	53,102	4,230	2	JLR
1	В	Good	4.00	12.57	08/12/24	09/03/24	25 F	46,004	3,660	2	JLR
1	С	Good	4.00	12.57	08/12/24	09/03/24	25 F	52,150	4,150	3	JLR
1	D				08/12/24		Hold				
Initial C	ure: Ou	tside Plastic Lie	ds	Final	Cure: Field (	Cured					

Project

Bryan, TX

Riverside Campus

Riverside Campus

Project Number: A1171057

Comments: F = Field Cured

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 compressive strength samples (ASTM C 31, C 39, C 1231).

Start/Stop: 0630-1015

 Terracon Rep.:
 Jonathan Cole

 Reported To:
 Adam Mayer w/ TTI

. Contractor:

Services:

### **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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Report Number:	A1171057.03	04
Service Date:	08/09/24	
Report Date:	09/05/24	Revision 1 - 25-day results
Task:	PO# 620061	

#### 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
---------------------	-------	-------	----	------

Mix ID:	TXC3600		
Supplier:	Texcrete		
Batch Time:	0741	Plant:	Bryan
Truck No.:	WILLIAM1R5	Ticket No.:	95685

## Field Test Data

Test	Result		Specification
Slump (in):	6		
Air Content (%):	0.8		
Concrete Temp. (F):	97	*	40 - 95
Ambient Temp. (F):	83		40 - 95
Plastic Unit Wt. (pcf):	146.0		
Yield (Cu. Yds.):			

\* = Field Test Results do not meet project specifications.

Project Number: A1171057 Sample Information Sample Date: Sampled By: Weather Conditions:

Accumulative Yards:

Placement Method:

Sample Location: Placement Location:

Sample Description:

Water Added After (gal):

Riverside Campus

Riverside Campus

Project

Bryan, TX

08/09/24 Sample Time: 0900 Jonathan Cole Sunny, Light Wind 16/16 Batch Size (cy): 6 Direct Discharge Water Added Before (gal): 20 -5

**Terracon** 

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

6198 Imperial Loor

Top Portion of Wall, Northeast End Reinforced Singe Slope Wall. 4-inch diameter cylinders

Labora	tory Te	est 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
2	В	Good	4.00	12.57	08/12/24	09/03/24	25 F	45,517	3,620	2	JLR
2	С	Good	4.00	12.57	08/12/24	09/03/24	25 F	57,142	4,550	2	JLR
2	D	Good	4.00	12.57	08/12/24	09/03/24	25 F	55,822	4,440	2	JLR
2	А				08/12/24		Hold				
Initial C	<b>ure:</b> Ot	itside Plastic Li	ds	Final	Cure: Field (	Cured					

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.: Jonathan Cole Reported To: Adam Mayer w/ TTI Contractor:

## **Report Distribution:**

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

## **Reviewed By:**

Start/Stop: 0630-1015

Alexander Dunigan, P.E. Department 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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Sample Storage Location

Texas Transportation Institute	Project Number: A1171057	Forracon
Attn: Bill Griffith	Report Number: A1171057.0304	<b>m</b> ienacon
TTI Business Office	Technician: Jonathan Cole	6198 Imperial Loop
3135 TAMU	Date: 08/09/24	College Station, TX 77845-5765
College Station, TX 77843-3135	Scale: Not to Scale	979-846-3767 Reg No: F-3272

ES-2.1-21, 12-02-2017, Rev. 1

## Photo Log

Report Number: Service Date: Report Date: Task: A1171057.0304 08/09/24 09/05/24 Revision 1 - 25-day results PO# 620061



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



CT0001, 10-16-13, Rev.10

Page 1 of 1

	exas A&M ransportation stitute	QF 7.3-01 Sam	Concrete pling	Doc. No. QF <b>7</b> .3-01	Revision Date: 2020-0 <b>7-</b> 29	
Qualit	y Form	Revised by: B.L. Griffit Approved by: D. L. Ku	th hn	Revision: 7	Page: 1 of 1	
Project No:	620331-01	Casting Date:	8/19/2024	Mix Design (psi):	3600	
Name of Technician Taking Sample	Terr	acon	Name of Technician Breaking Sample	Terr	acon	
Signature of Technician Taking Sample	Terr	acon	Signature of Technician Breaking Sample	Terracon		
Load No.	Truck No.	Ticket No.	Locat	tion (from concrete	map)	
T1	Worthington.77	96116	100% of Bottom	half of barrier section	on furthest south	
Т2	Burns,Christ8	96122	100% of top ha	alf of Barrier section	furthest north	
Load No.	Break Date	Cylinder Age	Total Load (lbs)	Break (psi)	Average	

	Redi-mix Concrete C REMIT PAYN P.O. BOX138	?ompany IENT T(	0: 5	222 Sandy Poin Bryan, TX 7780	t RD. 17	17534 College Sta	SH 6 South			231492
	KURTEN, TX	77862	18	935 Circle Lake	Dr.	17263 444	7EN 0007	too bos benevitate	PINEHURST DISPAT	TCH - 936-232-5815
			Р	inehurst, TX 773	62	Willis, TX 7	7378 Montgom	HWY 105 herv, TX 77333	OFF	ICE - 979-985-3636
				no the relation						
	RELLIS			PORTATIO						
				YAN TX (						ENTRAL
				ning and an						THE GATE
				Million Inormal						
	TIME	FC	ORMULA	LOAD SIZE		YARD ORDERED			in the selection of the	
		CN94		10.00		16.00	- A-	DRIVER/TRUCK		PLANT TRANSACTION#
	DATE			LOAD#		YARDS DEI	The electric	WURTH	INGTON, 77	97915
		TTI	RELL	10,000		TARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
	QUANTITY		CODE	DESCRIPTION		1.01.00		y dialms of sharts	1-25-00din	96116
	10.00 0	d C	N94acc	DESCRIPTION					UNIT PRICE	EXTENDED PRICE
				0000						
				Shon Joen						
				TRA IS IS HE						
+	LEFT PLANT									business
-	20Z	ARR	IVED JOB	START UNLOADING		SLUMP	CONCRETE TEMP.	AIR TEMP	and interior Tax	
-	00/	D	20	al die ont a	-		and and		Prev. AMT	
-	FINISH UNLOADING	LEI	FT JOB	ARRIVED AT PLANT	-	ON SITE	TESTING	The second second second	The second second	
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+	10	scionic	TES	TED		AIR	OTHER CYLINDERS	TENG DUET	ADDITIONAL CHARGE	1
		upebr	YES	NO NO	voi			ding preumoco	ADDITIONAL CHARGE	2
		WAR	RNING			PROPERTY DAM		along vanterlane	GRAND TOTAL	
C	IRRITATIN	G TO TH	HE SKIN AN		(TO E Dear RELE	BE SIGNED IF DELIVERY TO Customer - The driver of ASE to you for your signal	BE MADE INSIDE CURB LINE) this truck in presenting this	Excessive Water H <sub>2</sub> 0 Ad	is Detrimental to Concrete ded by Request/Authorized	Performance. By:
Co	ontact with Skin. In Case of ater. If Irritation Persister	BURNS. AN	void Contact Wi with Skin or Eyes	th Eyes and Prolonged Rinse Thoroughly With	size a the p mater	and weight of this truck ma premises and/or adjacent rial in this load where you	ay possibly cause damage to property if he places the desire it. It is our wish to	GAL X_	this material	-9.
CPO	ONCRETE is a PERISHABL URCHASER UPON LEAVING	E COMMOD G the PLAN	ITY and BECOME	S THE PROPERTY of the	driver and the may	is requesting that you sig his supplier from any resp occur to the premises	an, but in order to do this the n this RELEASE relieving him bonsibility from damage that and or adjacent property	WEIGHMASTER		
st	arts. The undersigned promis curred in collecting any sums of	JST be TELE ses to pay all owed.	PHONED to the OF I costs, including re	FICE BEFORE LOADING asonable attorney's fees.	this m mud fr public	naterial and that you also rom the wheels of his vehi streets. Further as a	curbs, etc. by the delivery of agree to help him remove cle so that he will not liter the ditional	Surch	arge for credit care	ds
All an Ma	accounts not paid within 30 da num. Not Responsible For Re de at Time Material is Deliver	ays of delivery active Aggreg	v will bear interest at gate or Color Quality	the rate of 18% per No Claim Allowed Unless	driver the pr	signed agrees to indemn of this truck and this supp remises and /or adjacen	ify and hold harmless the lier for any and all damage to it property which may be	NOTICE: MY SIGNATURE BE WARNING NOTICE AND SUPP	LOW INDICATES THAT I HAV	E READ THE HEALTH
Ch	25.00 Service Charge and Lot ecks. Demerge charge after 90	ss of the Cash min. will be \$	h Discounted will be \$100.00/hr.	Collected on all Returned	SIGNE	ED:	n out of delivery of this order	LOAD RECEIVED BY	SIDE CURB LINE.	DE FOR ANY DAMAGE
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									20	TADE
				11/10/2007						
							150			
		-	-							

TEXAS REMIT PAYMEI P.O. BOX138 KURTEN, TX T TEXAS RELLIS	NT TO: 522 NT TO: 522 7862 189 Pin R&M TRANSPICAMPUS, BR	22 Sandy Point RD Bryan, TX 77807 35 Circle Lake Dr. ehurst, TX 77362 ORTATIO YAN TX CH	College Stati 17263 Hwy 7 Willis, TX 773	H 6 South on, TX 77845 5N 2687 HV 378 Montgomery 2818, RT H IE TT RT H NY STRAIBH	Pi NY 105 y, TX 77333 WY 21, LT 9 WY 47, LT 1 ITALL THE W	NEHURST DISPATO BCS DISPATO OFFIC	31498 CH - 936-232-5815 CH - 979-316-2906 CE - 979-985-3636 CE - 979-985-3636 CE - 979-985-3636
TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
8:45	CN940CC050	6.00	16.00 F		BURNS,	CHR1ST8	97921
DATE	PHOTEL	LOAD#	YARDS DEL.	BATCH#	WATER TRIM	SLUMP	TICKET NUMBER
8/19/24	TTIRELLO	6.005	16.00	rege will (init bo)	ny claims of she	5.00 in	96122
QUANTITY	CODE	DESCRIPTION				UNIT PRICE	EXTENDED PRICE
1.00 ez	an FUEL and an FUEL and any alanano any alanano any alanano any alanano any alanano any alanano any alanano any alanano alano alano alano alano alano alano alano alano alano alano alano alano alano	n natata yu nanon nana nanon nana natata pad natata yu nang	Fuel	Change Chang Chang Chang Change Change Change Change Chang	Thank yo		business
LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP	Drav, OM	-
826	917	92C	dana behalanas	ende ant prime	d ded that when h	Ticket Tota	a1
FINISH UNLOADING	LEFT JOB	ARRIVED AT PLANT	ON SITE	E TESTING			
	altopes ofer	and the second	TESTING LAB: GES CME	SNER OTHER	a reua piunt	ADDITIONAL CHARG	E 1
	TE	STED	AIR	CYLINDERS		ADDITIONAL CHARG	E 2
Ed.	YES	NO	TP TO BE KITCH	1 Line DEIAL yo	ne dilemmento ne	GRAND TOTAL	
IRRITATIN Contains Portland Cemer CONTACT MAY CAUSE Contact Whits Kin. In Case Water. If Irritation Persists CONCRETE is a PERISHAR FORCIMAL INSTRUCTIONS INSTRUCTIONS Status The undersigned prom incurred in Collecting any sums All Accounts net paid within 30 annum. Not Responsible For Mede at Time Material is Deixi A 525.00 Service Charge ad I Checks. Demerge charge after	WARNING NG TO THE SKIN A THE WEAR SUbber Boots are BURNS. Avoid Contact V of Contact with Skin or Ey. Get Medical Attention.KEI SLE COMMODITY and BECO Most the FLBAT, ANY CHARV State State State State State (days of deliveny will bees interes Reactive Ageregate or Color Cas vered. Des of the Cash Discounted will 20 min. will be \$100.00hr.	ND EYES Ind Gloves. PROLONGED With Eyes and Prolonged res, Rinse Thoroughly With EP CHILDREN AWAY. WES THE PROPERTY of the SES or CANGELATION, of COCCC BEFORE LOANS reasonable attinomys feas. I at the rate of 18% per ality. No Claim Allowed Unless be Collected on all Returned	PROPERTY DA TO BE SINCH DI POLIVIENT Dear Customer - The driver RELEASE to you for your by the premises and/or adjace material in this load where you help you in everyway that we and this supplier from any or may occur to the premise and the supplier from any or any doing the wheels of the you police streads. For the you driver of this truck and this su the premises and /or adjace strong the your of the supplier stread of the police streads and you go the supplier to the supplier to the supplier the premises and /or adjace SUPPLIER to the supplier the premises and /or adjace to the supplier to the supplier to the supplier to the supplier to the supplier to the supplier to the sup	MAGE RELEASE IN TUCK in presenting this nature is of the optime that they are the optime that they are provided to the they and properly if the places the our desire it. It is our with to can, but in order to do this they esponsibility from damage that is and or adjacent property. It is a property is an experiment is and or adjacent property, is agreed to hab him remove and they are the they are they are additional consideration, they be then out of delivery of this order	Excessive Wate H <sub>0</sub> Ac GAL XGAL X WEIGHMASTER Surce WARNING NOTICE AND SUP CAUSED WITH DELIVERING LOAD RECEIVED BY X	r is Detrimental to Concre Ided by Request/Authorizu arage for credit ca HELOW INDICATES THAT I PUER WILL NOT BE RESPON INSIDE CURB LINE.	er Performance. ed By: ards have read the health isible for any damage
						2	31498

Report Number:	A1171057.03	06
Service Date:	08/19/24	
Report Date:	10/15/24	Revision 1 - 56-day results
Task:	PO# 620331	

#### 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:	CN940CC0500		
Supplier:	Texcrete		
Batch Time:	0758	Plant:	Bryan
Truck No.:	177	Ticket No.:	96116

## **Field Test Data**

Test	Result	Specification
Slump (in):	7	
Air Content (%):	1.3	
Concrete Temp. (F):	96	
Ambient Temp. (F):	79	
Plastic Unit Wt. (pcf):	146.4	
Yield (Cu. Yds.):		

6198 Imperial Loor

Bryan, TX Project Number: A1171057 Sample Information 08/19/24 Sample Time: Sample Date: Sampled By: Vince Thomas Weather Conditions: Partly Cloudy, Light Wind Accumulative Yards: 10/16 Batch Size (cy): 10 Direct Discharge Placement Method: Water Added Before (gal): 0 Water Added After (gal): 0 Bottom Half of Barrier Wall Sample Location: Placement Location: 50ft Concrete Barrier Wall Sample Description: 4-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 (Ibs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	4.00	12.57	08/20/24	09/06/24	18 F	44,630	3,550	2	JLR
1	В	Good	4.00	12.57	08/20/24	09/06/24	18 F	43,425	3,460	2	JLR
1	С	Good	4.00	12.57	08/20/24	09/06/24	18 F	41,383	3,290	2	JLR
1	D	Good	4.00	12.57	08/20/24	10/14/24	56 F	45,203	3,600	3	JLR
Initial C	ure: Out	tside in shade		Final	Cure: Field (	Cured					

Project

Riverside Campus

Riverside Campus

Comments: F = Field Cured

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 compressive strength samples (ASTM C 31, C 39, C 1231).

Start/Stop: 0830-1145

Terracon Rep.: Vince Thomas Reported To: Bill Griffith with TTI

Contractor:

Services:

### **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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**Terracon** 

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

0835

Report Number:	A1171057.03	06
Service Date:	08/19/24	
Report Date:	10/15/24	Revision 1 - 56-day results
Task:	PO# 620331	

#### 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:	CN940CC0500		
Supplier:	Texcrete		
Batch Time:	0845	Plant:	Bryan
Truck No.:	188	Ticket No.:	96122

## Field Test Data

Test	Result	Specification
Slump (in):	8	
Air Content (%):	1.1	
Concrete Temp. (F):	97	
Ambient Temp. (F):	80	
Plastic Unit Wt. (pcf):	143.8	
Yield (Cu. Yds.):		

## **Terracon** 6198 Imperial Loor

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

**Riverside Campus** Bryan, TX Project Number: A1171057 Sample Information 08/19/24 Sample Time: Sample Date: Sampled By: Vince Thomas Weather Conditions: Accumulative Yards: 16/16 Placement Method: Direct Discharge Water Added Before (gal): 0 Water Added After (gal): 0 Sample Location: Placement Location:

Partly Cloudy, Light Wind Batch Size (cy): Top Half of Barrier Wall 50ft Concrete Barrier Wall

0945

6

4-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 (Ibs)	Comp Strength (psi)	Frac Type	Tested By
2	А	Good	4.00	12.57	08/20/24	09/06/24	18 F	41,557	3,310	2	JLR
2	В	Good	4.00	12.57	08/20/24	09/06/24	18 F	40,313	3,210	2	JLR
2	С	Good	4.00	12.57	08/20/24	09/06/24	18 F	41,800	3,330	2	JLR
2	D	Good	4.00	12.57	08/20/24	10/14/24	56 F	46,520	3,700	3	JLR
Initial C	ure: Out	tside in shade		Final	Cure: Field (	Cured					

Project

Riverside Campus

Sample Description:

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.: Vince Thomas Reported To: Bill Griffith with TTI

### Contractor:

**Report Distribution:** 

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

**Reviewed By:** 

Start/Stop: 0830-1145

Justin Maass Assistant 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

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## Photo Log

Report Number: Service Date: Report Date: Task: A1171057.0306 08/19/24 10/15/24 Revision 1 - 56-day results PO# 620331



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



(P1) Sample Placement Location

(P3) Cylinder Storage Location



(P2) Batch Ticket 10/16



(P4) Batch Ticket 16/16

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Page 1 of 1

# APPENDIX C. MASH TEST 5-12 (CRASH TEST 620331-01-1)

## C.1. VEHICLE PROPERTIES AND INFORMATION



Figure C.1. Vehicle Properties for Test 620331-01-1.

<sub>Date:</sub> 2024	-09-06	Test No.:	620331-01-1	VIN No.:	1HSHXSHR1CJ609200
TRACTOR Year: 2012		Make:	INTERNATIONAL	Model:	TRANS STAR
TRAILER Year: <u>1993</u>		Make:	FREU	Model:	FB-91-NF2-53
A: 28 Left □ Ri In front of B: 33 Distance from	inches from ght of center ■ behind th inches from front axle:	the grou line <u>20</u> the front a the grou	ind inches ind inches	inches	
C: 50 Distance from	inches from front axle: <u>(</u>	the grou 684.5	ınd inches		

Figure C.1. Vehicle Properties for Test 620331-01-1. (continued)

# C.2. SEQUENTIAL PHOTOGRAPHS



(a) 0.000 s

(b) 0.2000 s

(d) 0.6000 s



(c) 0.4000 s



(e) 0.8000 s

(f) 1.0000 s







(a) 0.000 s



(c) 0.4000 s

(d) 0.6000 s



(e) 0.8000 s



(h) 1.4000 s (g) 1.2000 s Figure C.3. Sequential Photographs for Test 620331-01-1 (Upstream In-line Views).



(a) 0.000 s

(b) 0.2000 s



(c) 0.4000 s

(d) 0.6000 s







(h) 1.4000 s





(a) 0.0000 s

(b) 0.2000 s



(c) 0.4000 s





(g) 1.2000 s



Figure C.5. Sequential Photographs for Test 620331-01-1 (Upstream Oblique Field Side Views)

# C.3. VEHICLE ANGULAR DISPLACEMENTS



# C.4. VEHICLE ACCELERATIONS



Figure C.6. Vehicle Longitudinal Accelerometer Trace for Test 620331-01-1 (Accelerometer Located at Center of Gravity).



Figure C.7. Vehicle Lateral Accelerometer Trace for Test 620331-01-1 (Accelerometer Located at Center of Gravity).



Figure C.8. Vehicle Vertical Accelerometer Trace for Test 620331-01-1 (Accelerometer Located at Center of Gravity)

77

TR No. 620331-01-1