Texas A&M Transportation Institute
Proving Ground

Test Report No. 620331-01-1

DESIGN AND EVALUATION OF *MASH* TL-5 CONCRETE MEDIAN BARRIER WITH SHALLOW EMBEDMENT

Sponsored by
Roadside Safety Pooled Fund

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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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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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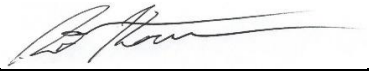

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REVISION LOG

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

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

APPROXIMATE CONVERSIONS FROM SI UNITS

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

*SI is the symbol for the International System of Units

Chapter 1. INTRODUCTION

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*

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.

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* *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.

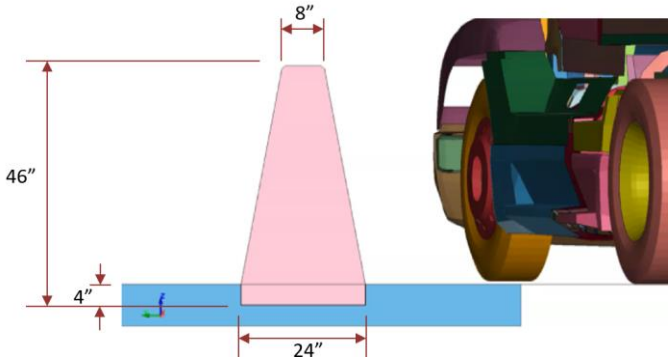


Figure 2.1. Cross-section of Simulation Model.

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.

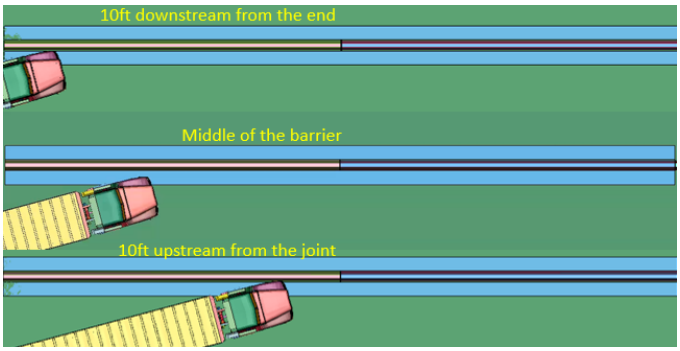


Figure 2.2. Impact Points Shown on First Segment of the Barrier System.

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.

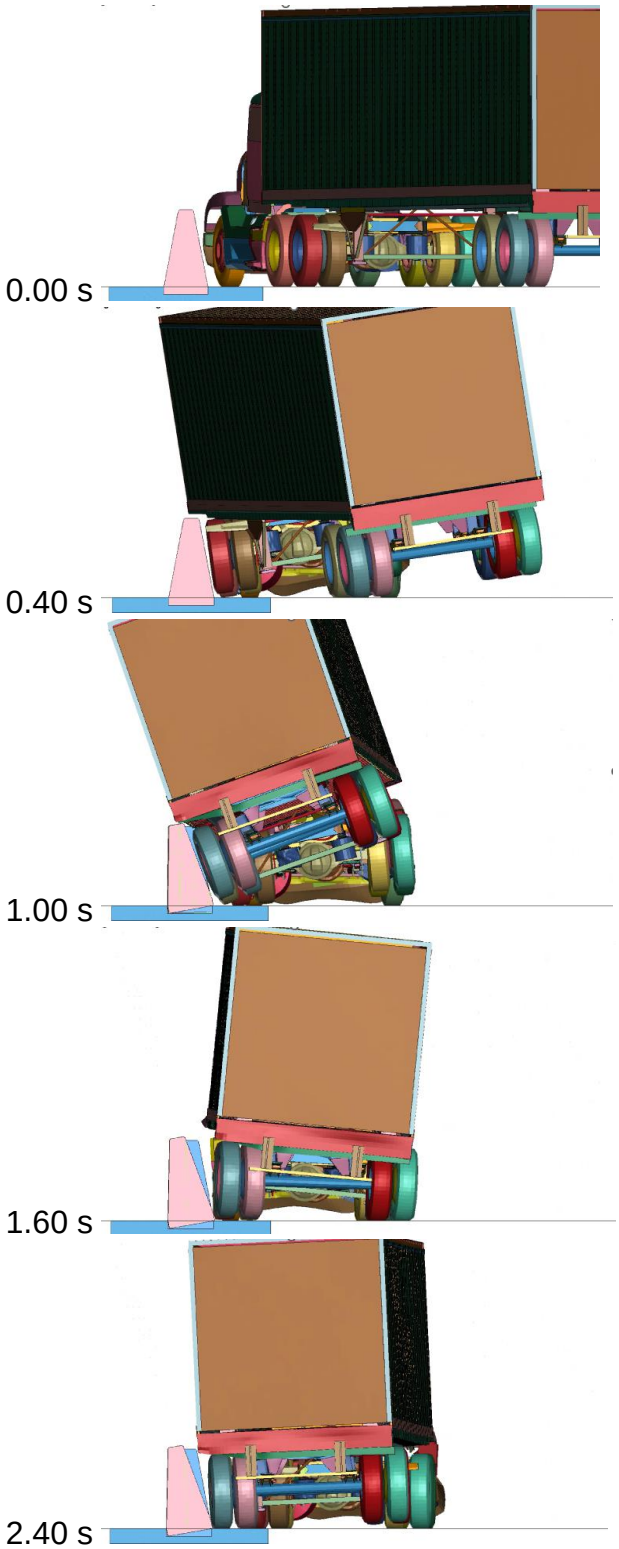


Figure 2.3. Results of Simulation with Impact at Middle of the Segment.

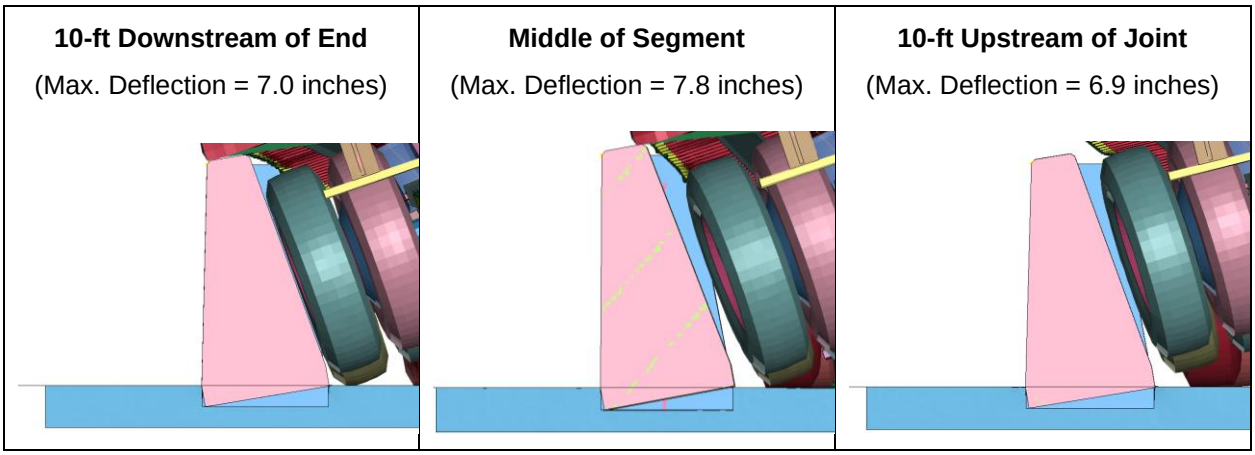


Figure 2.4. Impact Points Shown on First Segment of the Barrier System.

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.

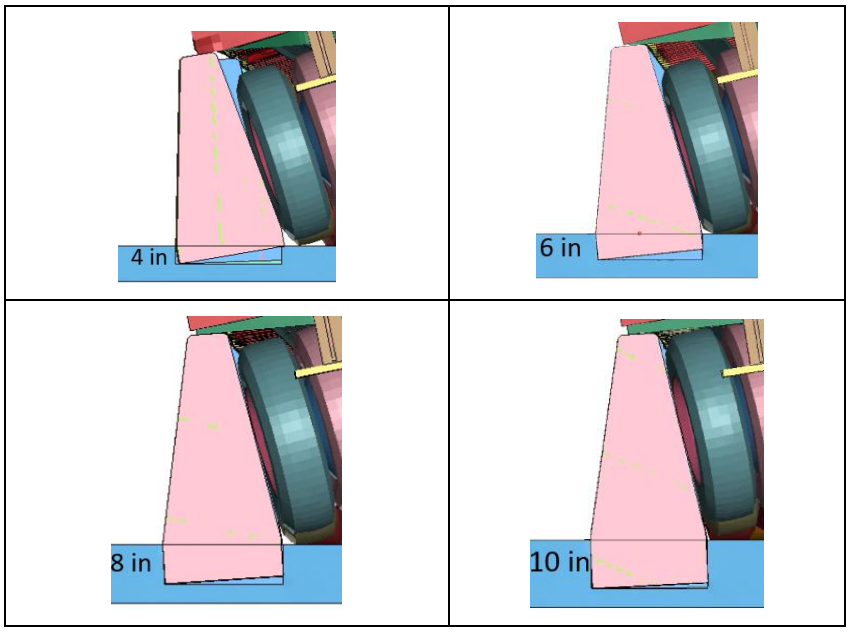


Figure 2.5. Comparison of Maximum Dynamic Barrier Deflection for Different Embedment Depths.

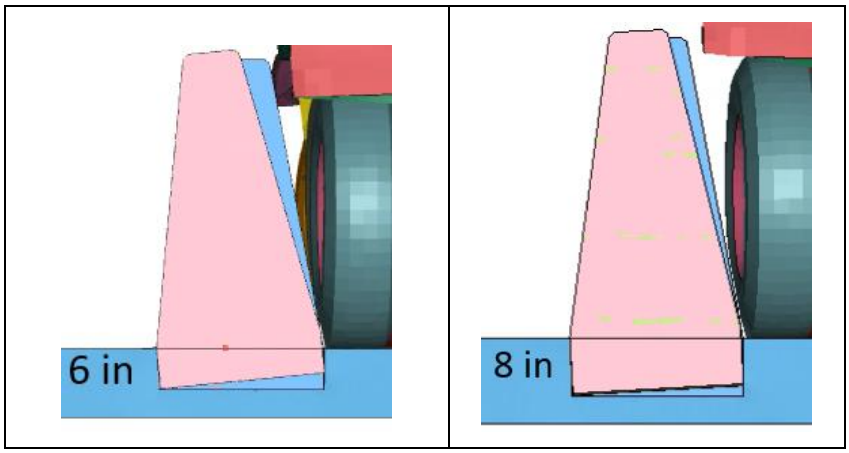


Figure 2.6. Comparison of Permanent Barrier Deflection of 6-inch and 8-inch Embedment Depths.

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.

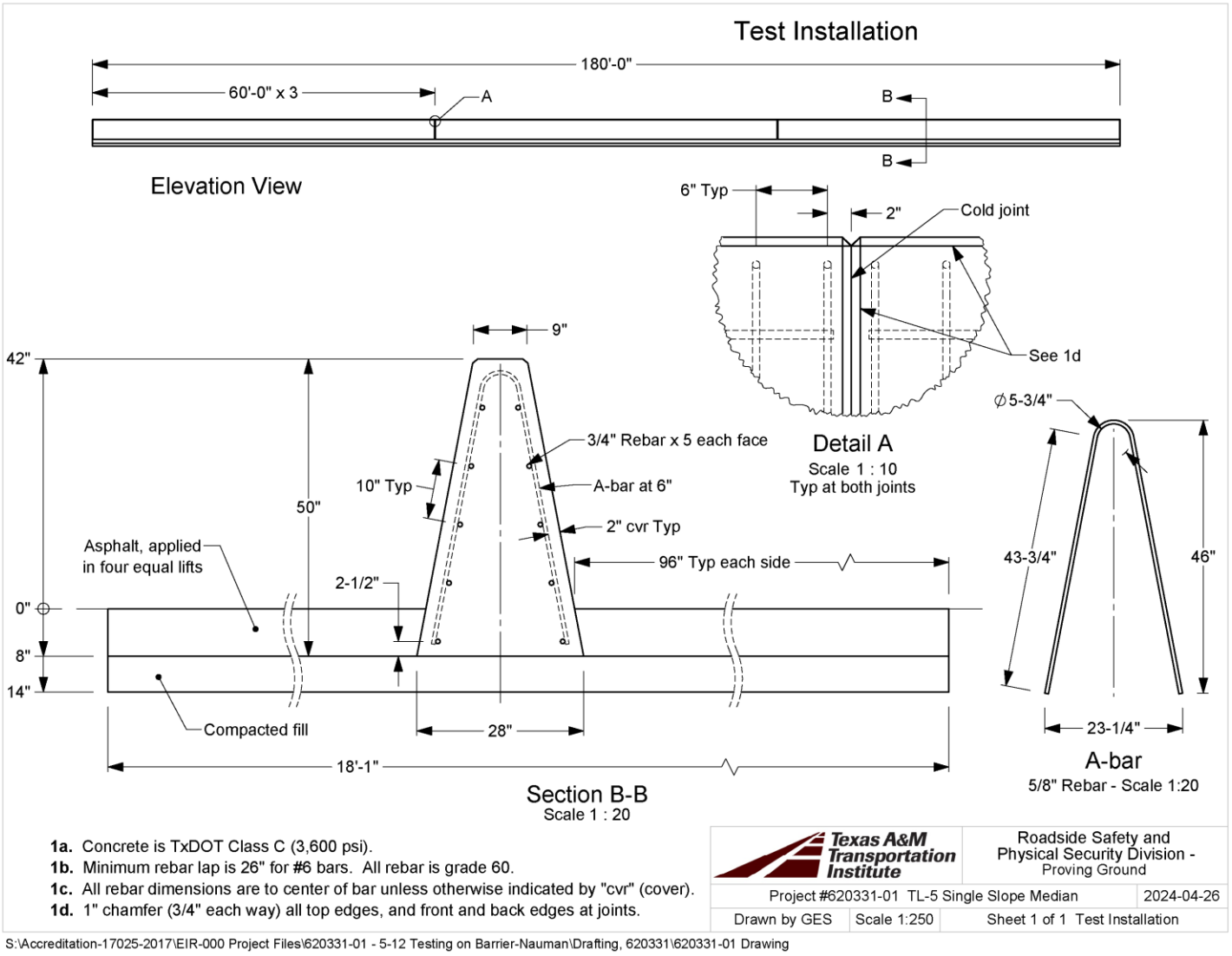


Figure 3.1. Details of TL-5 Concrete Median Barrier with Shallow Embedment.

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.

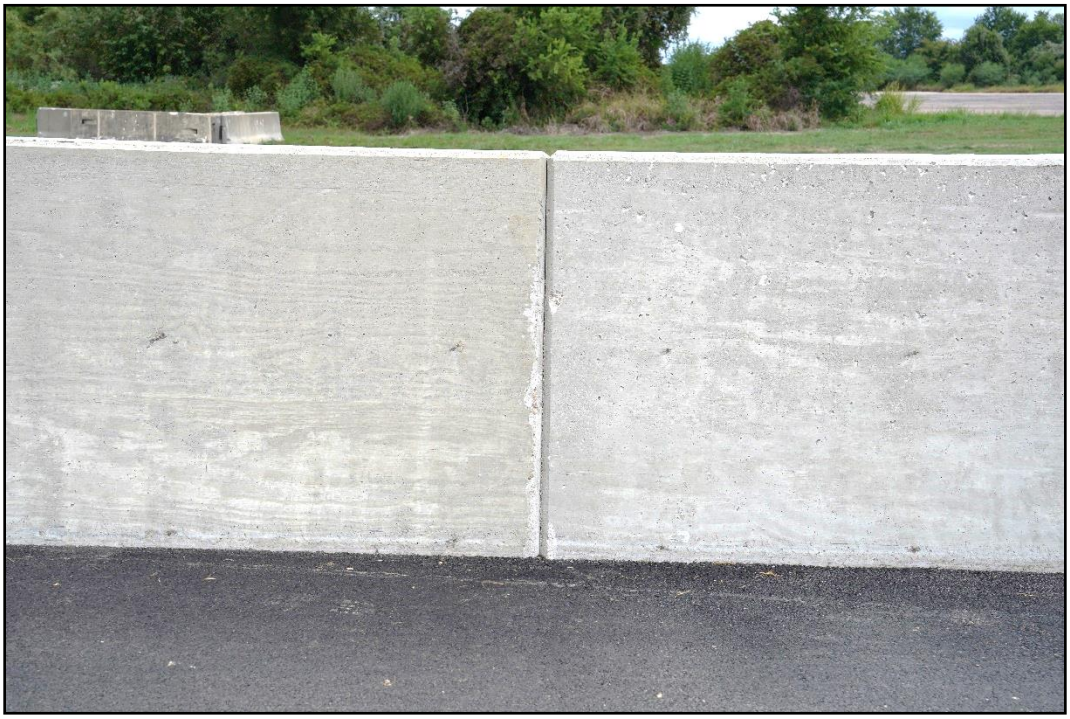


Figure 3.5. TL-5 Concrete Median Barrier with Shallow Embedment at Unconnected Cold Joint Prior to Testing.

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.

Table 3.1. Concrete Strength.

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

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	25º	A, D, F, H, I
5-11	2270P	62 mi/h	25º	A, D, F, H, I
5-12	36000V	50 mi/h	15º	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.

Table 4.2. Evaluation Criteria Required for *MASH* Testing.

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

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.

Table 5.1. Instrumentation Package Location.

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

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.

Table 6.2. Exit Parameters for *MASH* TEST 5-12, Crash Test 620331-01-1.

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.

Table 6.3. 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°

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.

Table 6.4. Vehicle Measurements for 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[i]	50 inches	±2 inches	50 inches
CG of Ballast above Ground[e]	73 inches	±2 inches	72 inches

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.

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

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

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 with Shallow 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 [a] and Height	44.5 inches, at a height of 135.2 inches, at the top rear passenger corner of trailer

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

Figure 6.6. 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.

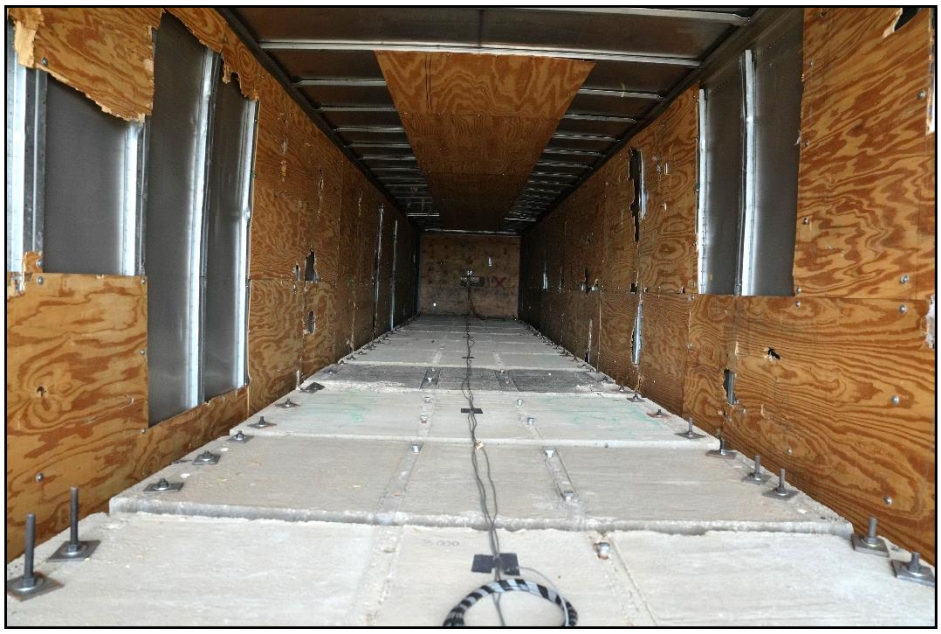


Figure 6.16. Trailer Interior of Test Vehicle after Test 620331-01-1.

Table 6.7. Occupant Compartment Deformation 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 6.8. 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.

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

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

6.8. TEST SUMMARY

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

0.0000 s

0.4000 s

0.8000 s

1.2000 s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 5-12
Project No.:	620331-01-1
Test Date:	2024-09-06

TEST ARTICLE	
Type:	Longitudinal Barrier
Name:	TL-5 Concrete Median Barrier with Shallow Embedment
Length:	180 feet
Key Materials:	Three, 60 foot long single slope concrete barrier sections, embedded in 8-inch thick asphalt pad
Soil Type and Condition:	Asphalt, damp

TEST VEHICLE	
Type/Designation:	36000V
Year, Make and Model:	2012 International Trans Star
Curb Mass:	21,450 lbs
Inertial Mass:	79,920 lbs

IMPACT CONDITIONS	
Impact Speed:	50.7 mi/h
Impact Angle:	13.9°
Impact Location:	376.9 inches downstream from the upstream end of barrier 1.
Kinetic Energy:	396.3 kip-ft

EXIT CONDITIONS	
Stopping Distance:	336 ft downstream 16 ft to the field side

TEST ARTICLE DEFLECTIONS	
Dynamic	2.1 inches
Permanent	0.5 inches
Working Width / Height	44.5 inches / 135.2 inches

VEHICLE DAMAGE	
VDS:	01FRQ6
CDC:	01FRGW6
Max Exterior Deformation:	16 inches at the front bumper
Max Occupant Deformation:	None

OCCUPANT RISK VALUES	
Long. OIV	3.6 ft/s
Lat. OIV	15.6 ft/s
Long. Ridedown	6.3 g
Lat. Ridedown	26.8 g
THIV	5.4 m/s
ASI	1.3
Max 50-ms Long.	-2.8 g
Max 50-ms Lat.	-7.2 g
Max 50-ms Vert.	11.4 g
Max Roll	51.4°
Max Pitch	11.1°
Max Yaw	22.4°

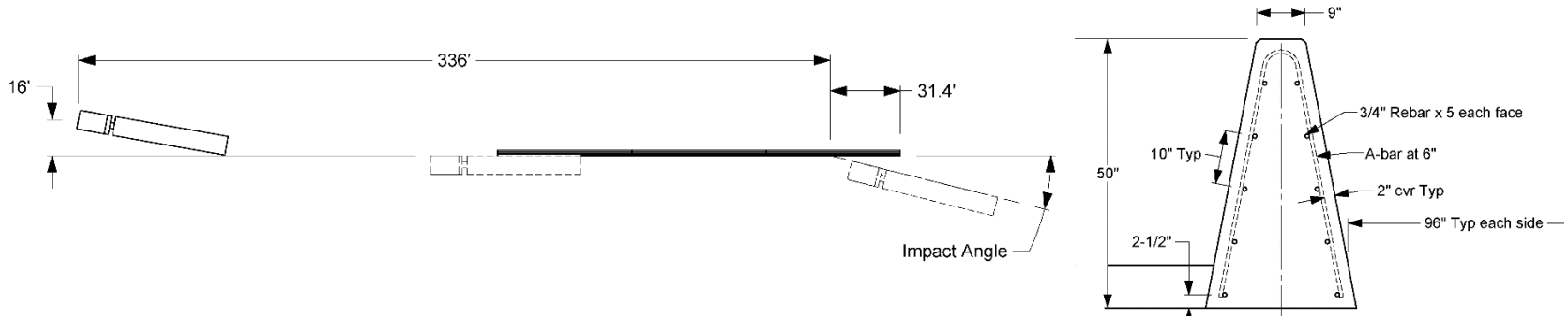


Figure 6.17. Summary of Results for *MASH* Test 5-12 on TL-5 Concrete Median Barrier with Shallow Embedment.

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

Note: S = Satisfactory

7.2. IMPLEMENTATION*

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.

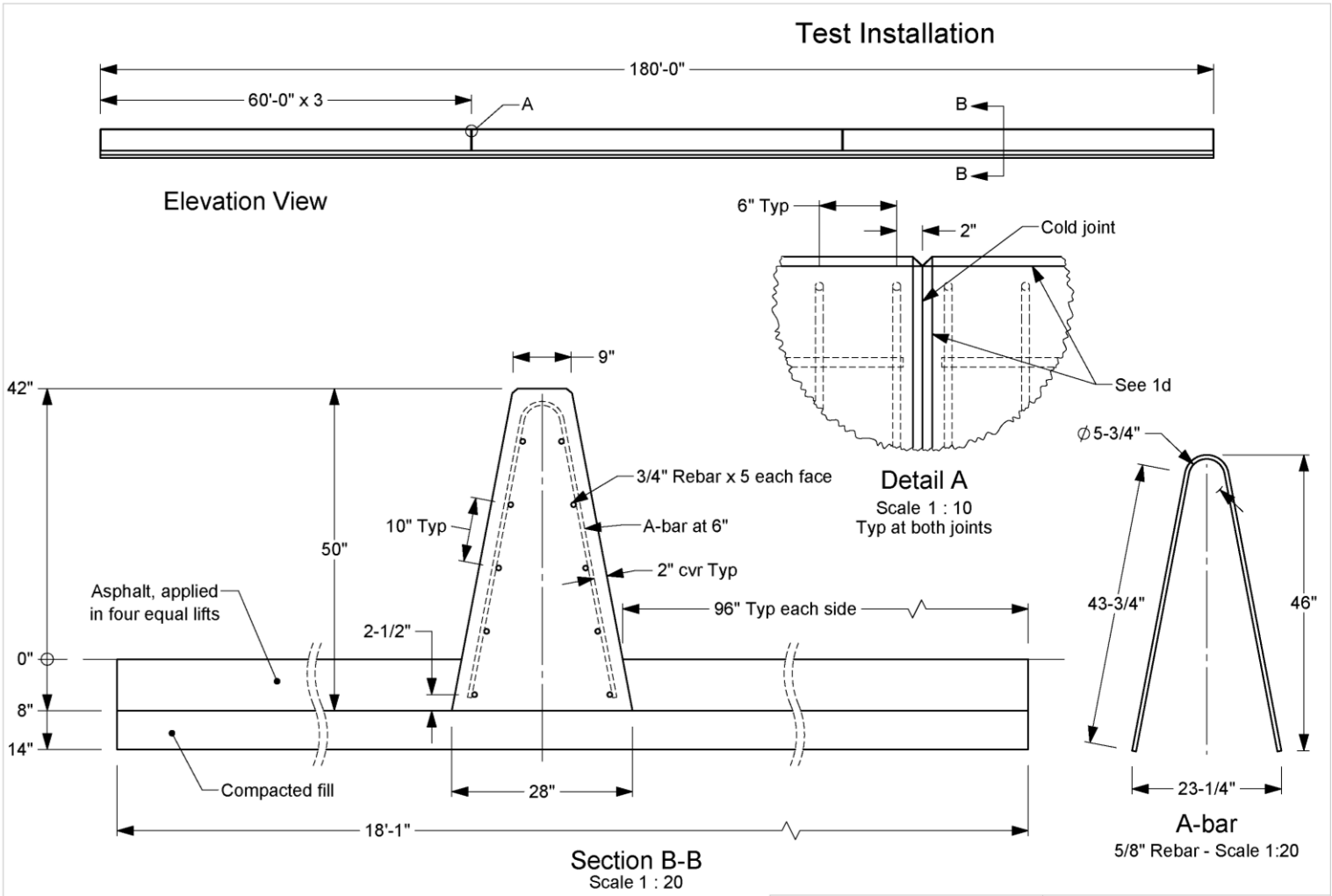
The barrier was tested while embedded in the 8 inches of asphalt. Embedding the barrier in asphalt thickness greater than 8 inches will also be acceptable as long as the above-grade height of 42 inches is maintained. Similarly, the barrier may be embedded in the concrete footing with minimum 8-inch lock 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.

* *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.
2. Bligh, R.P., W.L. Menges, and D.L. Kuhn. *MASH Evaluation of TxDOT Roadside Safety Features – Phase 1.*" Texas A&M Transportation Institute, Report 0-6946-1, College Station, Texas, 2018.
3. N.M. Sheikh, B.L. Griffith, and D.L. Kuhn. *MASH Test 4-12 on Keyed-in Single-Slope Barrier with 40-ft Segment Length.* Texas A&M Transportation Institute, Report 610221-01-1, College Station, Texas, 2020.
4. Sheikh, N.M., J.C. Kovar, S. Cakalli, W.L. Menges, G.E. Schroeder, and D.L. Kuhn. *Analysis of 54-Inch Tall Single-Slope Concrete Barrier on a Structurally Independent Foundation.* Texas A&M Transportation Institute, Report 0-6948-R1, College Station, Texas, 2019.
5. Kovar, J.C., N.M. Sheikh, R.P. Bligh, S. Cakalli, T. Retterer, and J. Ries. *Development and Testing of Structurally Independent Foundations for High-Speed Containment Concrete Barrier.* Transportation Research Record. Volume 2437. Transportation Research Record, Washington, DC, 2021.
6. Federal Highway Administration (FHWA) Safety Eligibility Letter HSST-1-B-388. Texas A&M Transportation Institute Test Number 690900-ITG4.
7. Whitesel, D., J. Jewell, and R. Meline, *Compliance Crash Testing of the Type 60 Median Barrier*, Test 140MASH3C16-04. Research Report FHWA/CA17-2654, Roadside Safety Research Group, California Department of Transportation, Sacramento, CA, May 2018.
8. Federal Highway Administration (FHWA) Safety Eligibility Letter HSST-1-B-388. Texas A&M Transportation Institute Test Number 690900-ITG5.
9. Williams, W.F., R.P. Bligh, and W.L. Menges, *Mash Test 3-11 of the TxDOT Single Slope Bridge Rail (Type SSTR) on Pan-Formed Bridge Deck.* Report 9-1002-3. Texas A&M Transportation Institute, College Station, Texas, 2011.
10. Sheikh, N.M., R.P. Bligh, and W.L. Menges, *Development and Testing of a Concrete Barrier Design for use in Front of Slope or on MSE Wall.* Report 405160-13-1. Texas A&M Transportation Institute, College Station, Texas, 2009.

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



1a. Concrete is TxDOT Class C (3,600 psi).
1b. Minimum rebar lap is 26" for #6 bars. All rebar is grade 60.
1c. All rebar dimensions are to center of bar unless otherwise indicated by "cvr" (cover).
1d. 1" chamfer (3/4" each way) all top edges, and front and back edges at joints.

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground
Project #620331-01 TL-5 Single Slope Median		2024-04-26
Drawn by GES	Scale 1:250	Sheet 1 of 1 Test Installation

APPENDIX B. SUPPORTING CERTIFICATION DOCUMENTS

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

CERTIFIED MILL TEST REPORT

For additional copies call
800-227-6489

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

Drew M Fischer
Quality Assurance Manager

HEAT NO.:3129277 SECTION: REBAR 16MM (#5) 20'0" 420/60 GRADE: ASTM A615-22 Gr 420/60 ROLL DATE: 03/10/2024 MELT DATE: 03/05/2024 Cert. No.: 85752703 / 129277A371	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 85752703 BOL#: 75890436 CUST PO#: 978303 CUST P/N: DLVRY LBS / HEAT: 32048.000 LB DLVRY PCS / HEAT: 1536 EA

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.43%	Bend Test Diameter	2.188IN		
Mn	0.90%				
P	0.006%				
S	0.039%				
Si	0.16%				
Cu	0.27%				
Cr	0.10%				
Ni	0.18%				
Mo	0.079%				
V	0.000%				
Cb	0.001%				
Sn	0.008%				
Al	0.002%				
Yield Strength test 1	64.5ksi				
Tensile Strength test 1	104.0ksi				
Elongation test 1	15%				
Elongation Gage Lgth test 1	8IN				
Tensile to Yield ratio test1	1.61				
Bend Test 1	Passed				

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

REMARKS :

620331-01

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

CERTIFIED MILL TEST REPORT

For additional copies call
800-227-6489

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

Drew M Fischer
Quality Assurance Manager

HEAT NO.:3128269 SECTION: REBAR 19MM (#6) 20'0" 420/60 GRADE: ASTM A615-22 Gr 420/60 ROLL DATE: 01/23/2024 MELT DATE: 01/14/2024 Cert. No.: 85694944 / 128269A619	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 85694944 BOL#: 75801150 CUST PO#: 973207 CUST P/N: DLVRY LBS / HEAT: 47586.000 LB DLVRY PCS / HEAT: 1584 EA

Characteristic	Value
C	0.45%
Mn	0.84%
P	0.007%
S	0.063%
Si	0.17%
Cu	0.31%
Cr	0.09%
Ni	0.18%
Mo	0.069%
V	0.000%
Cb	0.001%
Sn	0.011%
Al	0.002%
Yield Strength test 1	65.3ksi
Tensile Strength test 1	105.3ksi
Elongation test 1	16%
Elongation Gage Lgth test 1	8IN
Tensile to Yield ratio test1	1.61
Bend Test 1	Passed

Characteristic	Value
Bend Test Diameter	3.750IN

Characteristic	Value

The Following is true of the material represented by this MTR:

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

REMARKS :

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

Project No: 620331-01 **Casting Date:** 7/29/2024 **Mix Design (psi):** 3600

Name of Technician Taking Sample	Terracon	Name of Technician Breaking Sample	Terracon
Signature of Technician Taking Sample	Terracon	Signature of Technician Breaking Sample	Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	Hosey,Justin1	95149	100% of Bottom half of barrier
T2	Goosby,Raymo3	95162	100% of top half of Barrier

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

TEXCRETE
Redi-mix Concrete Company

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

5222 Sandy Point RD.
Bryan, TX 77807

18935 Circle Lake Dr.
Pinehurst, TX 77362

17534 SH 6 South
College Station, TX 77845

17263 Hwy 75N
Willis, TX 77378

2687 HWY 105
Montgomery, TX 77333

233532

PINEHURST DISPATCH - 936-232-5815
BCS DISPATCH - 979-316-2906
OFFICE - 979-985-3636

TEXAS A&M TRANSPORTATIO
RELLIS CAMPUS, BRYAN TX

RT 2818, RT HWY 21, LT SILVER HILL, RT AT
THE "T", RT HWY 47, LT INTORELLIS ENTRANCE,
RT 1ST EXTT OUT OF ROUNDABOUT, LT
WAREHOUSE LOOP RD, RT 4TH ST, TO GATE 5

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
6:35	TXC3600	10.00	16.00	PO#	HOSEY,	JUSTIN1	96948
DATE		**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
7/29/24	PROJECT TTIRELL	10.00	10.00			5.00 in	95149

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
10.00	yd	TXC3600	DOTC, 3600, RR, 5",	
1.00	ea	FUEL	Fuel Charge	

Thank you for your business

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

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

TESTED	AIR	CYLINDERS
☐ YES ☐ NO		

Tax
Prev. AMT
Ticket Total

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

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

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

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

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

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

X_____

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

_____GAL X_____
WEIGHMASTER

Surcharge for credit cards

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

LOAD RECEIVED BY

x_____

233532

TEXCRETE
Redi-mix Concrete Company

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

5222 Sandy Point RD.
Bryan, TX 77807

18935 Circle Lake Dr.
Pinehurst, TX 77362

17534 SH 6 South
College Station, TX 77845

17263 Hwy 75N
Willis, TX 77378

2687 HWY 105
Montgomery, TX 77333

233545

PINEHURST DISPATCH - 936-232-5815
BCS DISPATCH - 979-316-2906
OFFICE - 979-985-3636

TEXAS A&M TRANSPORTATIO
RELLIS CAMPUS, BRYAN TX

RT 2818, RT HWY 21, LT SILVER HILL, RT AT
THE "T", RT HWY 47, LT INTORELLIS ENTRANCE,
RT 1ST EXIT OUT OF ROUNDABOUT, LT
WAREHOUSE LOOP RD., RT 4TH ST., TO GATE 5

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
7:41	TXC3600	6.00	16.00	PO#	GODSBY, RAYMO3		96961
DATE		**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
7/29/24	TTIRELL	6.00	16.00			5.00 in	95162

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
6.00 yd	TXC3600	DOTC, 3600, RG, 5"		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
7:51	8:10				
FINISH UNLOADING	**LEFT JOB**	**ARRIVED AT PLANT**	**ON SITE TESTING**		
			TESTING LAB: TERRACON GESSNER CME OTHER		
	TESTED		**AIR**	**CYLINDERS**	
	☐ YES ☐ NO				

Tax
Prev. AMT
Ticket Total

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

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

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

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

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

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

X _____

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

_____GAL X_____
WEIGHMASTER

Surcharge for credit cards

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

LOAD RECEIVED BY

X _____

233545

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

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

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

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

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength: 3,500 psi @ 28 days

Mix ID: Txc3600
Supplier: Texcrete
Batch Time: 0634 **Plant:** 2
Truck No.: RAYM03 **Ticket No.:** 95149

Sample Information

Sample Date: 07/29/24 **Sample Time:** 0720
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

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.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	4.00	12.57	08/30/24	09/04/24	37 F	53,449	4,250		JLR
1	B	Good	4.00	12.57	08/30/24	09/04/24	37 F	40,346	3,210	2	JLR
1	C	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 Cure: Outside Plastic Lids **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.: Brian Maass **Start/Stop:** 0600-1000
Reported To: Bill w/ TTI
Contractor:
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

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

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

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

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

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information

Specified Strength: 3,500 psi @ 28 days

Mix ID: Txc3600
Supplier: Texcrete
Batch Time: 0741 **Plant:** 2
Truck No.: JUSTIN1 **Ticket No.:** 95162

Sample Information

Sample Date: 07/29/24 **Sample Time:** 0825
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

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.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
2	A	Irregular	6.00	28.27	08/30/24	09/04/24	37 F	143,240	5,070	2	JLR
2	B	Good	6.00	28.27	08/30/24	09/04/24	37 F	135,713	4,800	2	JLR
2	C	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 Cure: Outside Plastic Lids **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.: Brian Maass **Start/Stop:** 0600-1000
Reported To: Bill w/ TTI
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

Reviewed By:
Justin Maass
Assistant Project Manager

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

Photo Log

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

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

(P1) North Barrier Reinforcement

Photo Log

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

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

(P2) North Barrier Placement

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

Project No: 620331-01 **Casting Date:** 8/9/2024 **Mix Design (psi):** 3600

Name of Technician Taking Sample: Terracon

Name of Technician Breaking Sample: Terracon

Signature of Technician Taking Sample: Terracon

Signature of Technician Breaking Sample: Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	Hosey,justin1	95672	100% of Bottom half of barrier section furthest north
T2	Will,Camson,1R5	95685	100% of top half of Barrier section furthest north

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

TEXCRETE
Redi-mix Concrete Company

231052

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

5222 Sandy Point RD.
Bryan, TX 77807

18935 Circle Lake Dr.
Pinehurst, TX 77362

17534 SH 6 South
College Station, TX 77845

17263 Hwy 75N
Willis, TX 77378

2687 HWY 105
Montgomery, TX 77333

PINEHURST DISPATCH - 936-232-5815
BCS DISPATCH - 979-316-2906
OFFICE - 979-985-3636

TEXAS A&M TRANSPORTATIO
RELLIS CAMPUS,BRYAN TX

RT 2818,RT HWY 21,LT SILVER HILL,RT AT
THE "T",RT HWY 47,LT INTORELLIS ENTRANCE,
STAY STRAIGHTALL THE WAY DOWN TO THE GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
6:32	TXC3600	10.00	16.00	PO# C20331	HOSEY, JUSTIN1		97471
DATE		**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
8/9/24	TTIRELL	10.00	10.00			5.00 in	95672

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
10.00 yd	TXC3600	DOTC,3600,R6,5",		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
643	709				
FINISH UNLOADING	**LEFT JOB**	**ARRIVED AT PLANT**	**ON SITE TESTING**		
			TESTING LAB: TERRACON GESSNER CME OTHER		
TESTED			**AIR**	**CYLINDERS**	
☐ YES ☐ NO					

Tax
Prev. AMT
Ticket Total

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

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

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

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

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

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

X_____

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

_____GAL X_____
WEIGHMASTER

Surcharge for credit cards

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

LOAD RECEIVED BY

X_____

231052

TEXCRETE
Redi-mix Concrete Company

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

5222 Sandy Point RD.
Bryan, TX 77807

18935 Circle Lake Dr.
Pinehurst, TX 77362

17534 SH 6 South
College Station, TX 77845

17263 Hwy 75N
Willis, TX 77378

2687 HWY 105
Montgomery, TX 77333

231064

PINEHURST DISPATCH - 936-232-5815
BCS DISPATCH - 979-316-2906
OFFICE - 979-985-3636

TEXAS A&M TRANSPORTATIO
RELLIS CAMPUS, BRYAN TX

RT 2818, RT HWY 21, LT SILVER MILL, RT AT
THE "T", RT HWY 47, LT INTORELLIS ENTRANCE.
STAY STRAIGHTALL THE WAY DOWN TO THE GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
7:41	TXC3600	6.00	16.00	PO# 620331	WILLIAMSON, IRS		97484
DATE		**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
8/9/24	PROJECT TTIRELL	6.00	16.00			5.00 in	95685

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
6.00 yd	TXC3600	DOTC, 3600, RG, 5"		
1.00 ea	FUEL	Fuel Charge		

Thank you For your business

Tax
Prev. AMT
Ticket Total

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
8:00	8:16				
FINISH UNLOADING	**LEFT JOB**	**ARRIVED AT PLANT**	**ON SITE TESTING**		
			TESTING LAB: TERRACON GESSNER CME OTHER		
TESTED			**AIR**	**CYLINDERS**	
☐ YES ☐ NO					

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

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

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

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

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

X _____

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

_____GAL X_____

WEIGHMASTER

Surcharge for credit cards

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

LOAD RECEIVED BY

X _____

231064

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

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

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

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

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information
Specified Strength: 3,600 psi @ 28 days

Mix ID: TXC3600
Supplier: Texcrete
Batch Time: 0632 **Plant:** Bryan
Truck No.: JUSTIN1 **Ticket No.:** 95672

Sample Information
Sample Date: 08/09/24 **Sample Time:** 0715
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
Sample Location: Bottom Portion of Wall, Southwest End
Placement Location: Reinforced Singe Slope Wall.
Sample Description: 4-inch diameter cylinders

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.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	4.00	12.57	08/12/24	09/03/24	25 F	53,102	4,230	2	JLR
1	B	Good	4.00	12.57	08/12/24	09/03/24	25 F	46,004	3,660	2	JLR
1	C	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 Cure: Outside Plastic Lids **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 **Start/Stop:** 0630-1015
Reported To: Adam Mayer w/ TTI
Contractor:
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

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

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

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

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

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information
Specified Strength: 3,600 psi @ 28 days

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

Sample Information
Sample Date: 08/09/24 **Sample Time:** 0900
Sampled By: Jonathan Cole
Weather Conditions: Sunny, Light Wind
Accumulative Yards: 16/16 **Batch Size (cy):** 6
Placement Method: Direct Discharge
Water Added Before (gal): 20
Water Added After (gal): 5
Sample Location: Top Portion of Wall, Northeast End
Placement Location: Reinforced Singe Slope Wall.
Sample Description: 4-inch diameter cylinders

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.**

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	B	Good	4.00	12.57	08/12/24	09/03/24	25 F	45,517	3,620	2	JLR
2	C	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	A				08/12/24		Hold				

Initial Cure: Outside Plastic Lids **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 **Start/Stop:** 0630-1015
Reported To: Adam Mayer w/ TTI
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

Reviewed By:
Alexander Dunigan, P.E.
Department Manager

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

Sample Placement Location

Sample Storage Location

Texas Transportation Institute	Project Number:	A1171057	Terracon
Attn: Bill Griffith	Report Number:	A1171057.0304	
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:	A1171057.0304
Service Date:	08/09/24
Report Date:	09/05/24 Revision 1 - 25-day results
Task:	PO# 620061

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

(P1) Single slope wall portion pour.

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

Project No: 620331-01 **Casting Date:** 8/19/2024 **Mix Design (psi):** 3600

Name of Technician Taking Sample: Terracon

Name of Technician Breaking Sample: Terracon

Signature of Technician Taking Sample: Terracon

Signature of Technician Breaking Sample: Terracon

Load No.	Truck No.	Ticket No.	Location (from concrete map)
T1	Worthington.77	96116	100% of Bottom half of barrier section furthest south
T2	Burns,Christ8	96122	100% of top half of Barrier section furthest north

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

Redi-mix Concrete Company

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

5222 Sandy Point RD.
Bryan, TX 77807

18935 Circle Lake Dr.
Pinehurst, TX 77362

17534 SH 6 South
College Station, TX 77845

17263 Hwy 75N
Willis, TX 77378

2687 HWY 105
Montgomery, TX 77333

231492

PINEHURST DISPATCH - 936-232-5815
BCS DISPATCH - 979-316-2906
OFFICE - 979-985-3636

TEXAS A&M TRANSPORTATIO
RELLIS CAMPUS, BRYAN TX (CHECK MI
X)

RT 2818, RT HWY 21, LT SILVER HILL, RT AT
THE "T", RT HWY 47, LT INTORELLIS ENTRANCE,
STAY STRAIGHT ALL THE WAY DOWN TO THE GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
7:58	CN940CC050	10.00	16.00	PUM	WORTHINGSTON, 77		97915
DATE		**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
8/19/24	TTIRELL	10.00	10.00			5.00 in	96116

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
10.00 yd	CN940CC0500	COM, 4000, BLND, 5"		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

Tax
Prev. AMT
Ticket Total

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
8:05	8:30				
FINISH UNLOADING	**LEFT JOB**	**ARRIVED AT PLANT**	**ON SITE TESTING**		
			TESTING LAB: TERRACON GESSNER CME OTHER		
	TESTED		**AIR**	**CYLINDERS**	
	☐ YES ☐ NO				

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

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

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A $25.00 Service Charge and Loss of the Cash Discounted will be Collected on all Returned Checks. Demerge charge after 90 min. will be $100.00/hr.

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

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

X _____

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

_____GAL X_____
WEIGHMASTER

Surcharge for credit cards

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

LOAD RECEIVED BY

x _____

231492

TEXCRETE
Redi-mix Concrete Company

231498

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

5222 Sandy Point RD.
Bryan, TX 77807

18935 Circle Lake Dr.
Pinehurst, TX 77362

17534 SH 6 South
College Station, TX 77845

17263 Hwy 75N
Willis, TX 77378

2687 HWY 105
Montgomery, TX 77333

PINEHURST DISPATCH - 936-232-5815
BCS DISPATCH - 979-316-2906
OFFICE - 979-985-3636

TEXAS A&M TRANSPORTATIO RT 2818, RT HWY 21, LT SILVER HILL, RT AT
RELLIS CAMPUS, BRYAN TX (CHECK MI THE "T", RT HWY 47, LT INTORELLIS ENTRANCE.
X) STAY STRAIGHTALL THE WAY DOWN TO THE GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
8:45	CN940CC050	6.00	16.00	PO#	BURNS, CHRIST8		97921
DATE		**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
8/19/24	TTIRELL	6.00	16.00			5.00 in	96122

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
6.00	yd	CN940CC0500 COM, 4000, BLND, 5"		
1.00	ea	FUEL Fuel Charge		

Thank you for your business

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
856	919	926			

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

TESTED		AIR	CYLINDERS
☐ YES	☐ NO		

Tax
Prev. AMT
Ticket Total

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

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

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(TO BE SIGNED IF DELIVERY TO BE MADE INSIDE CURB LINE)

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X_____

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

_____GAL X_____
WEIGHMASTER

Surcharge for credit cards

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

LOAD RECEIVED BY

X_____

231498

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

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

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

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

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information
Specified Strength: 4,000 psi @ 28 days

Mix ID: CN940CC0500
Supplier: Texcrete
Batch Time: 0758 **Plant:** Bryan
Truck No.: 177 **Ticket No.:** 96116

Sample Information
Sample Date: 08/19/24 **Sample Time:** 0835
Sampled By: Vince Thomas
Weather Conditions: Partly Cloudy, Light Wind
Accumulative Yards: 10/16 **Batch Size (cy):** 10
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: Bottom Half of Barrier Wall
Placement Location: 50ft Concrete Barrier Wall
Sample Description: 4-inch diameter cylinders

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.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	4.00	12.57	08/20/24	09/06/24	18 F	44,630	3,550	2	JLR
1	B	Good	4.00	12.57	08/20/24	09/06/24	18 F	43,425	3,460	2	JLR
1	C	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 Cure: Outside in shade **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.: Vince Thomas **Start/Stop:** 0830-1145
Reported To: Bill Griffith with TTI
Contractor:
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

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

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

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

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

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information
Specified Strength: 4,000 psi @ 28 days

Mix ID: CN940CC0500
Supplier: Texcrete
Batch Time: 0845 **Plant:** Bryan
Truck No.: 188 **Ticket No.:** 96122

Sample Information
Sample Date: 08/19/24 **Sample Time:** 0945
Sampled By: Vince Thomas
Weather Conditions: Partly Cloudy, Light Wind
Accumulative Yards: 16/16 **Batch Size (cy):** 6
Placement Method: Direct Discharge
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: Top Half of Barrier Wall
Placement Location: 50ft Concrete Barrier Wall
Sample Description: 4-inch diameter cylinders

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.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
2	A	Good	4.00	12.57	08/20/24	09/06/24	18 F	41,557	3,310	2	JLR
2	B	Good	4.00	12.57	08/20/24	09/06/24	18 F	40,313	3,210	2	JLR
2	C	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 Cure: Outside in shade **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.: Vince Thomas **Start/Stop:** 0830-1145
Reported To: Bill Griffith with TTI
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

Reviewed By:
Justin Maass
Assistant Project Manager

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

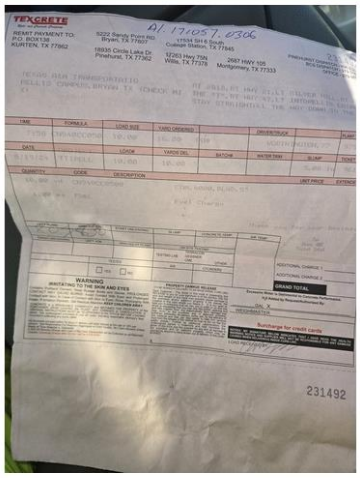
Photo Log

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

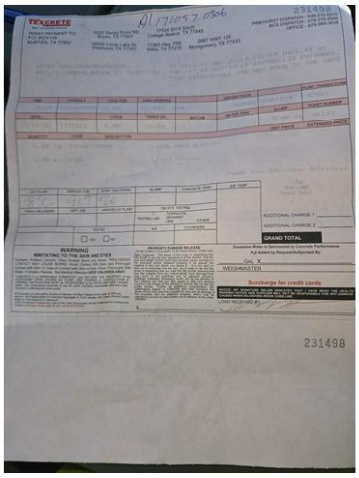
Terracon
6198 Imperial Loop
College Station, TX 77845-5765
979-846-3767 Reg No: F-3272

(P1) Sample Placement Location

(P3) Cylinder Storage Location



(P2) Batch Ticket 10/16



(P4) Batch Ticket 16/16

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

C.1. VEHICLE PROPERTIES AND INFORMATION

Vehicle Inventory Number: 1796

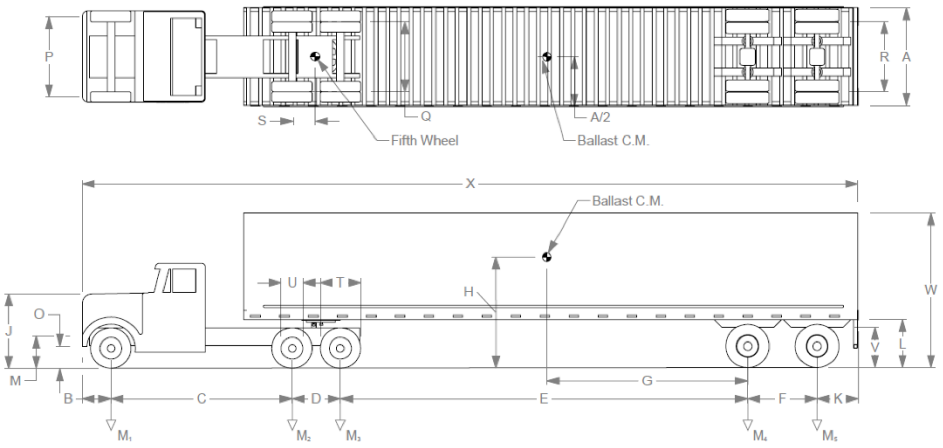
DATE: 2024-09-06 **TEST NO.:** 620331-01-1

TRACTOR
YEAR: 2012 MAKE: INTERNATIONAL MODEL: TRANS STAR

VIN No.: 1HSHXSHR1CJ609200 ODOMETER: 473664

TRAILER
YEAR: 1993 MAKE: FREU MODEL: FB-91-NF2-53

VIN No.: IH2V05328NB021620



GEOMETRY (inches)

A	102.00	D	52.00	G	0.00	K	49.00	O	15.75	R	77.50	U	22.50	X	810				
B	45.00	E	470.50	H	72.50	L	50.00	P	82.00	S	25.50	V	48.50						
C	144.50	F	49.00	J	65.00	M	30.75	Q	73.50	T	41.50	W	160.00						

Allowable Range: C = 200 inches max.; L = 50 ±2 inches; Overall Trailer Length = 636 inches max.; Overall Combination Length = 816 inches max.; Trailer Overhang = 87 inches max.; Ballast Center of Mass Ht = 73 ±2 inches above ground;

MASS (lb)	CURB		TEST INERTIAL	
M_1	8,620		10670	
M_2	6,230		13170	
M_3	6,600		23130	
M_4	4270		17500	
M_5	5190	Allowable Range	15450	Allowable Range
M_{Total}	30910	29,000 ±3100 lb	79920	79,300 ±1100 lb

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

Date: 2024-09-06 Test No.: 620331-01-1 VIN No.: 1HSHXSHR1CJ609200

TRACTOR
Year: 2012 Make: INTERNATIONAL Model: TRANS STAR

TRAILER
Year: 1993 Make: FREU Model: FB-91-NF2-53

A:

28 inches from the ground

☒ Left ☐ Right of centerline 20 inches

☐ In front of ☒ behind the front axle 18 inches

B:

33 inches from the ground

Distance from front axle: 122 inches

C:

50 inches from the ground

Distance from front axle: 684.5 inches

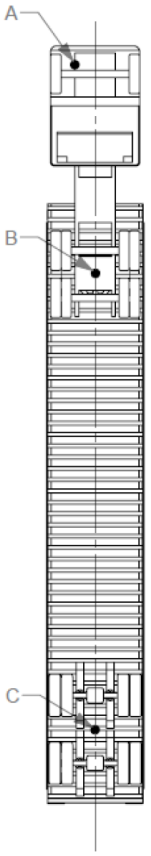
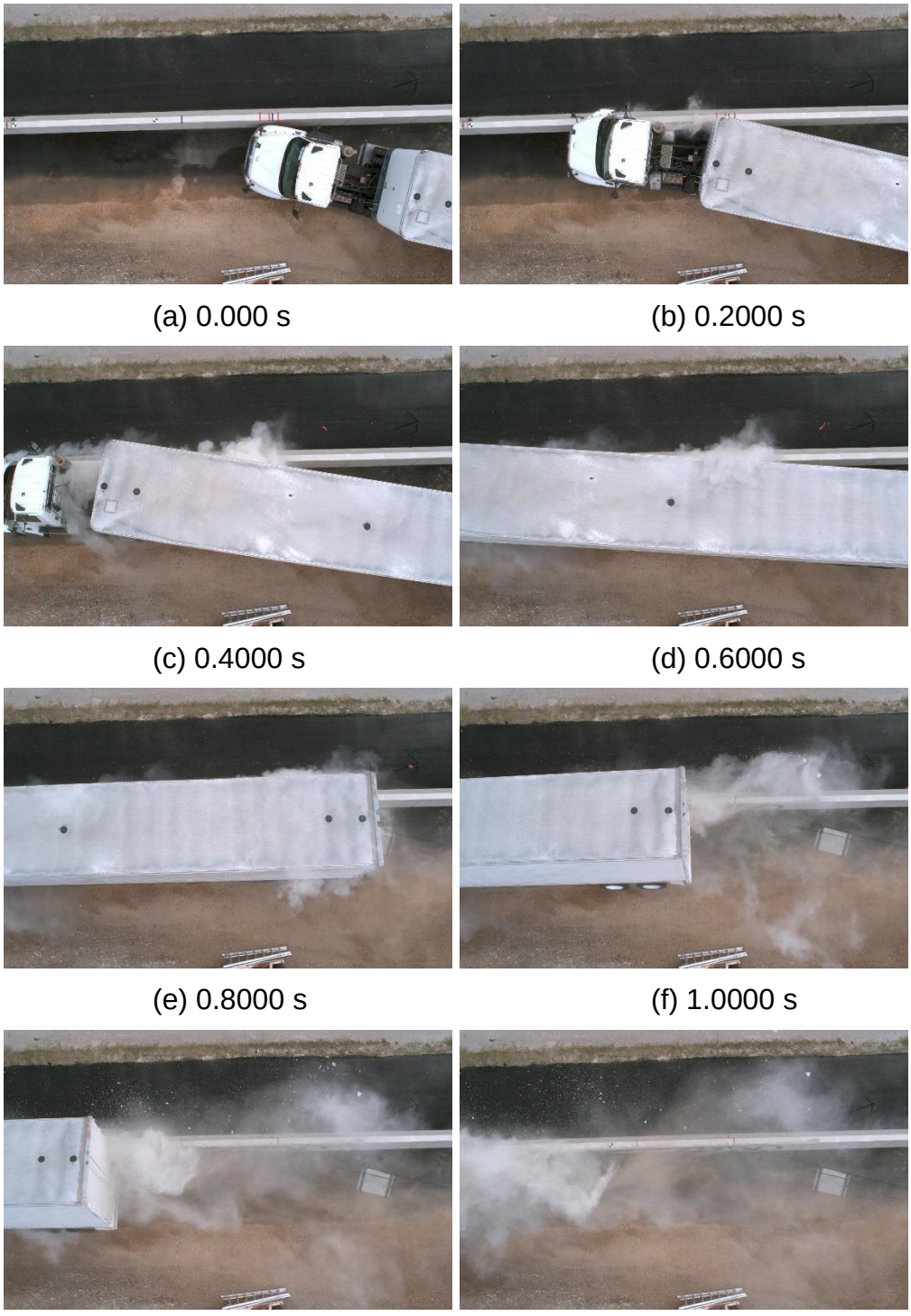


Figure C.1. Vehicle Properties for Test 620331-01-1. (continued)

C.2. SEQUENTIAL PHOTOGRAPHS



(a) 0.000 s (b) 0.2000 s

(c) 0.4000 s (d) 0.6000 s

(e) 0.8000 s (f) 1.0000 s

(g) 1.2000 s (h) 1.4000 s

Figure C.2. Sequential Photographs for Test 620331-01-1 (Overhead Views).

(a) 0.000 s

(b) 0.2000 s

(c) 0.4000 s

(d) 0.6000 s

(e) 0.8000 s

(f) 1.0000 s

(g) 1.2000 s

(h) 1.4000 s

Figure C.3. Sequential Photographs for Test 620331-01-1 (Upstream In-line Views).

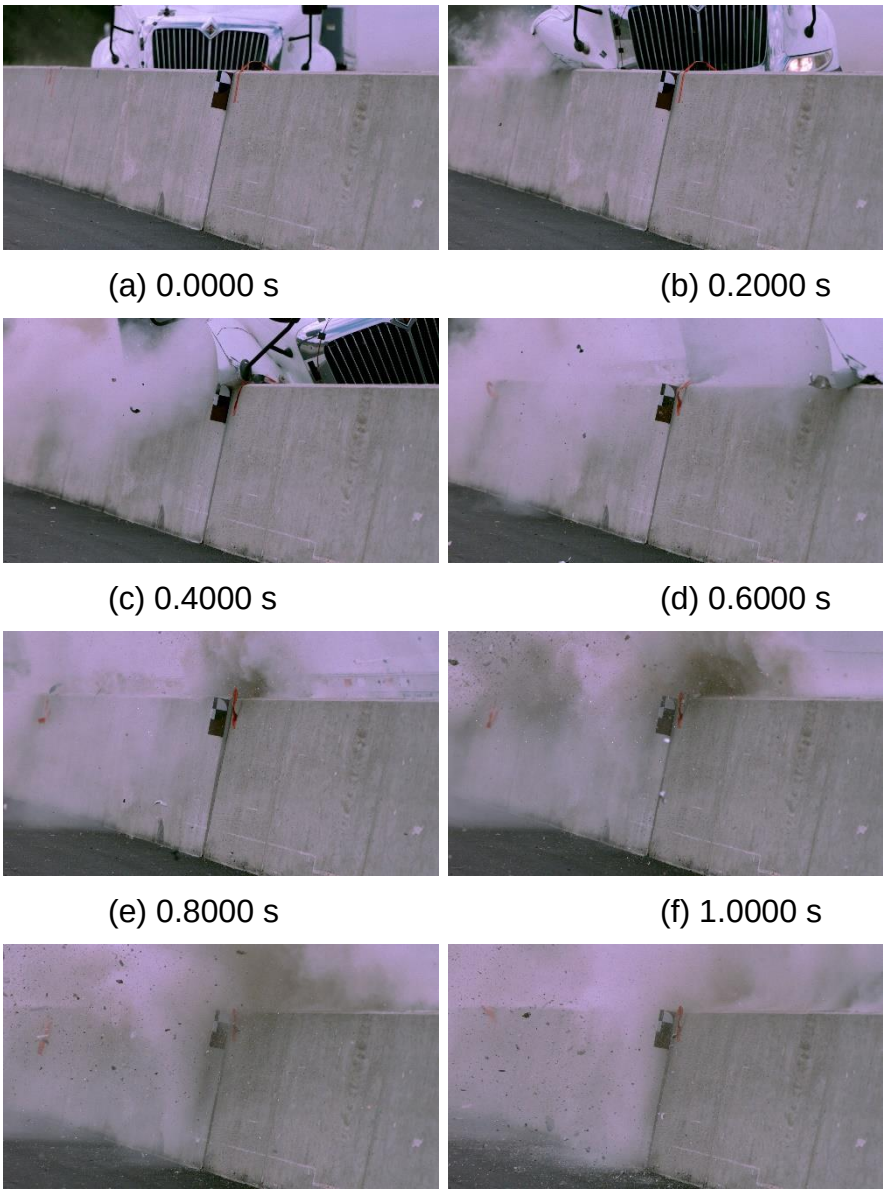
(a) 0.000 s (b) 0.2000 s

(c) 0.4000 s (d) 0.6000 s

(e) 0.8000 s (f) 1.0000 s

(g) 1.2000 s (h) 1.4000 s

Figure C.4. Sequential Photographs for Test 620331-01-1 (Downstream In-line Views).



(a) 0.0000 s (b) 0.2000 s

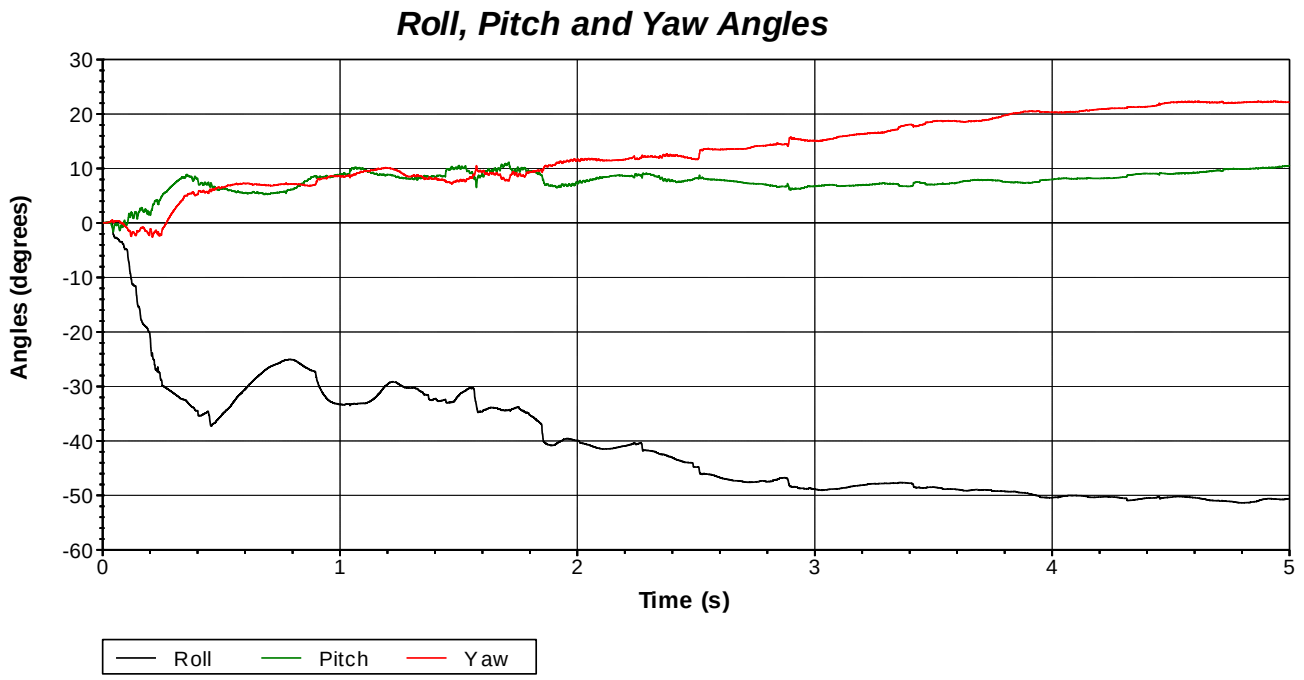
(c) 0.4000 s (d) 0.6000 s

(e) 0.8000 s (f) 1.0000 s

(g) 1.2000 s (h) 1.4000 s

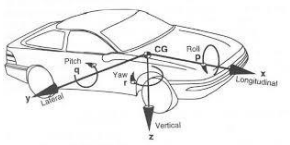
Figure C.5. Sequential Photographs for Test 620331-01-1 (Upstream Oblique Field Side Views)

C.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

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



Test Number: 620331-01-1
Test Standard Test Number: *MASH* Test 5-12
Test Article: TL-5 Concrete Median Barrier with Shallow Embedment
Test Vehicle: 2021 International Trans Star
Curb Mass: 30,910 lbs
Inertial Mass: 79,920 lbs
Impact Speed: 50.7 mi/h
Impact Angle: 13.86°

Figure C.5. Vehicle Angular Displacements for Test 620331-01-1.

C.4. VEHICLE ACCELERATIONS

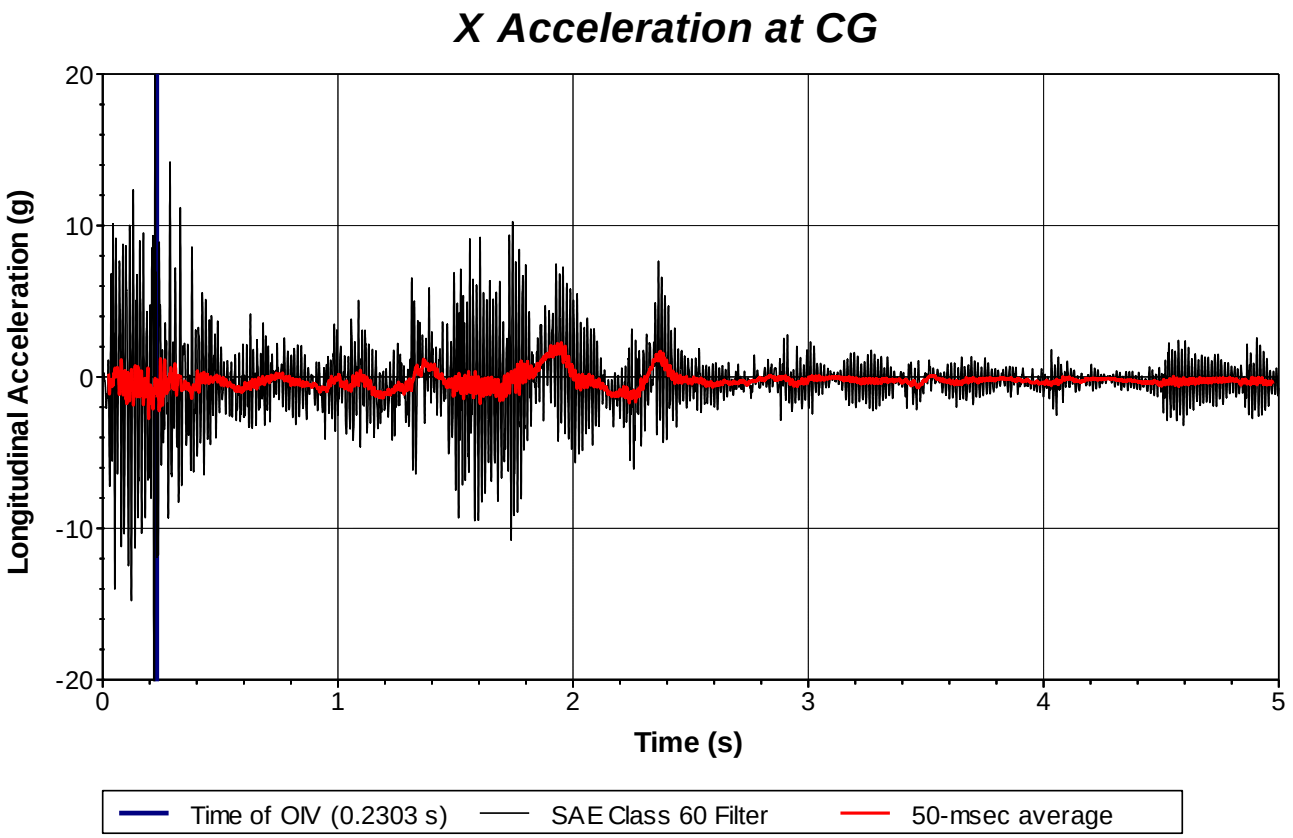


Figure C.6. Vehicle Longitudinal Accelerometer Trace for Test 620331-01-1 (Accelerometer Located at Center of Gravity).

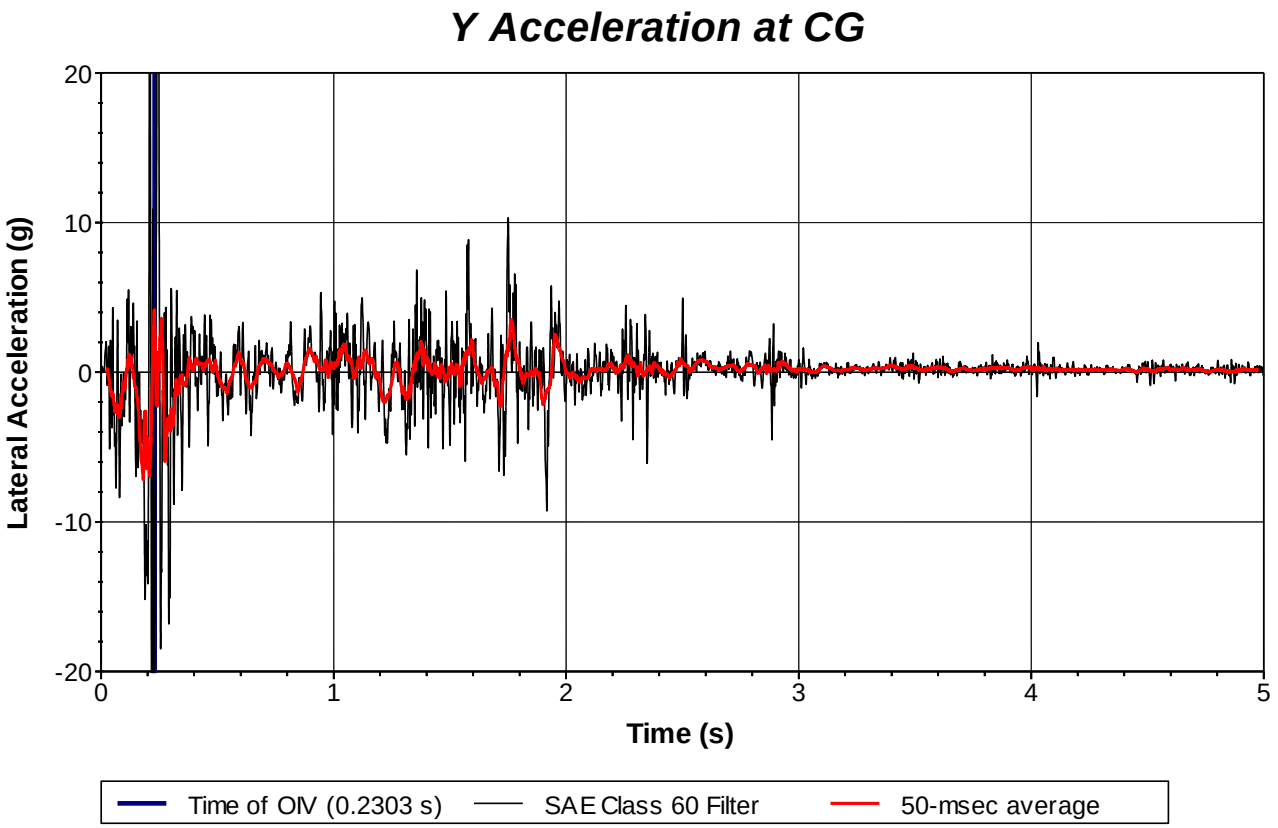


Figure C.7. Vehicle Lateral Accelerometer Trace for Test 620331-01-1 (Accelerometer Located at Center of Gravity).

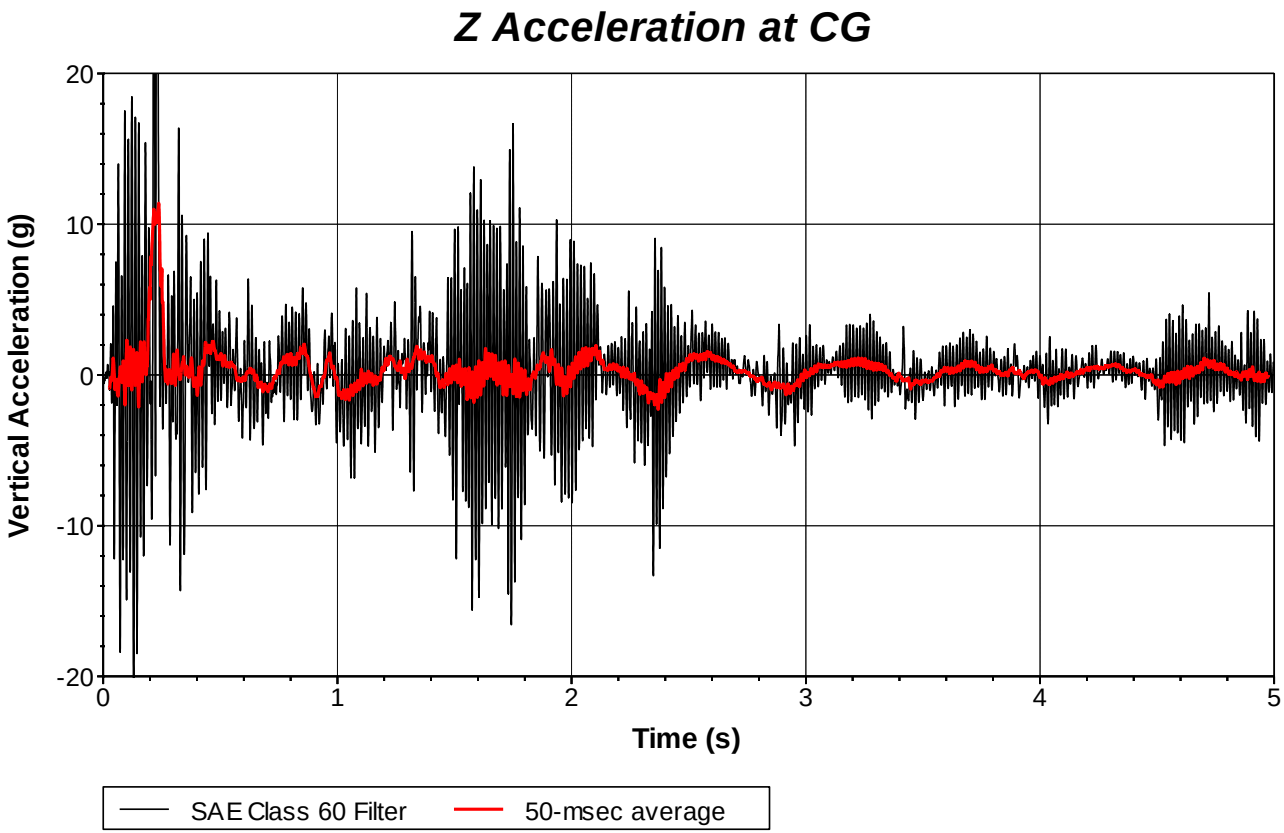


Figure C.8. Vehicle Vertical Accelerometer Trace for Test 620331-01-1 (Accelerometer Located at Center of Gravity)