



December 19, 2011

In Reply Refer To:  
HSST/ B-228

Mrs. Karla A. Lechtenberg  
Midwest Roadside Safety Facility  
130 Whittier Research Center  
P. O. Box 830853  
Lincoln, NE 68583-0853

Dear Mrs. Lechtenberg:

This letter is in response to your request for the Federal Highway Administration (FHWA) to review a roadside safety system for eligibility for reimbursement under the Federal-aid highway program.

Name of system: 31-inch (787-millimeter) Midwest Guardrail  
System (MGS) Bridge Rail  
Type of system: Permanent Bridge Barrier  
Test Level: AASHTO Manual for Assessing Safety Hardware, TL-3  
Testing conducted by: Midwest Roadside Safety Facility  
Date of request: July 20, 2011  
Task Force 13 Designator: SBW04c

Based on a review of crash test results submitted by the manufacturer certifying the device described herein meets the crashworthiness criteria of the American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware (MASH), the device is eligible for reimbursement under the Federal-aid highway program. Eligibility for reimbursement under the Federal-aid highway program does not establish approval or endorsement by FHWA for any particular purpose or use.

The FHWA, the Department of Transportation, and the United States Government do not endorse products or services and the issuance of a reimbursement eligibility letter is not an endorsement of any product or service

### **Decision**

The following device is eligible, with details provided below:

- 31-inch (787-millimeter) Midwest Guardrail System (MGS) Bridge Rail

### **Requirements**

Roadside safety devices should meet the guidelines contained in the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH).

The FHWA Memorandum “Identifying Acceptable Highway Safety Features” of July 25, 1997 provides further guidance on crash testing requirements of longitudinal barriers.

### **Description**

The test installation consisted of 68 feet 9 inches (21.0 meters) of bridge rail installed between two approach sections of MGS measuring 50 feet (15.2 meters) and 56 feet 3 inches (17.1 meters) in length, for a total system length of 175 feet (53.3 meters). Standard 12-gauge (2.66 millimeters thick) W-beam guardrail was used throughout, and no approach guardrail transition sections were used at the guardrail-to bridge rail interfaces. All lap-splice connections in the W-beam rail were configured to reduce vehicle snag at the splice during the test.

The MGS was constructed in two sections with a total of seventeen guardrail posts. Post nos. 3 through 8 and 32 through 38 were galvanized ASTM A36 steel W6x8.5 (W152x12.6) sections measuring 72 inches (1,829 millimeters) long, as shown in Figures 86 through 88. Post nos. 1, 2, 39, and 40 were timber posts measuring 5½ inches wide x 7½ inches deep x 46 inches long (140 millimeters x 191 millimeters x 1,168 millimeters) and were placed in 72 inches (1,829 millimeters) long steel foundation tubes. The timber posts and foundation tubes are used on many tangent guardrail terminals. Post nos. 1 through 8 and 32 through 40 were spaced 75 inches (1,905 millimeters) on center with a soil embedment depth of 40 inches (1,016 millimeters). The posts were placed in a compacted, coarse, crushed limestone material that met Grading B of AASHTO M147-65 (1990) as described in MASH. For post nos. 3 through 8 and 32 through 38, 6 inches wide x 12 inches deep x 14¼ inches long (152 millimeters x 305 millimeters x 362 millimeters) wood spacer blockouts were used to block the rail away from the front face of the steel posts.

Standard 12-gauge (2.66 millimeters thick) W-beam rails with post bolt slots at 75 inches (1,905 millimeters) intervals were placed between post nos. 1 through 8 and 32 through 40. The W-beam’s top rail height was 31 inches (787 millimeters), with a 24⅞ inches (632 millimeters) center mounting height. Rail splices were located at the center of the guardrail span locations.

The bridge rail was constructed with twenty-three guardrail posts. Post nos. 9 through 31 were ASTM A36 steel S3x5.7 (S76x8.5) sections measuring 44 inches (1,118 millimeters) long. Post nos. 9 through 31 were spaced 37½ inches (953 millimeter) on center and mounted in steel socket assemblies. A steel bolt was passed through the web of the post and both sides of the socket to support the bridge rail and posts. The sockets were anchored to the deck with a through-deck bolt that passed through the upper strap of the socket and a lower angle plate which was bolted to the socket.

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bridge rail. A 75 feet long x 4 feet wide x 8 inches thick (22.86 meters x 1.22 meters x 203 millimeters) concrete bridge deck was designed and built for crash testing the bridge rail.

The thickness of the bridge deck was increased to 12 in. (305 mm) for a width of 12 in. (305 millimeters) adjacent to the rigid concrete surface and was anchored to the outer vertical edge of the rigid pavement. This deck was intended to simulate a slab-on-girder bridge deck. Anchorage consisted of bent no. 5 (16 millimeters diameter) upper dowels spaced 9 inches (229 millimeters) on center that were embedded in epoxy. Additional no. 4 (13 millimeters diameter) lower dowels were spaced 18 inches (457 millimeters) on center. All dowels and deck reinforcement were comprised of ASTM A615 steel.

The concrete deck was designed according to the Nebraska Department of Roads (NDOR) *Bridge Operations, Policies, and Procedures Manual* and the empirical design guidelines presented in the *AASHTO LRFD Bridge Design Specifications*. A deck thickness of 8 inches (203 millimeters) was used with concrete having a minimum specified 28-day compressive strength of 4,000 psi (27.6 MPa). Longitudinal reinforcement consisted of upper no. 4 (13 millimeters diameter) bars on 12 inches (305 millimeters) centers and lower no. 5 (16 millimeters diameter) bars on 12 inches (305-millimeters) centers, with the upper reinforcement offset 6 inches (152 millimeters) from the lower reinforcement. Transverse reinforcement consisted of upper no. 4 (13 millimeters diameter) bars on 12 inches (305 millimeters) centers and lower no. 5 (16 millimeters diameter) bars on 12 inches (305 millimeters) centers, with the upper and lower layers also offset 6 inches (152 millimeters). Top concrete clear cover was 2½ inches (64 millimeters), edge concrete clear cover was 2 inches (51 millimeters), and bottom concrete clear cover was 1-inch (25 millimeters).

Details of this system are included in this correspondence as an enclosure.

### **Crash Testing**

The barrier was crash tested at the test facilities at the Midwest Roadside Safety Facility. Longitudinal barriers, such as W-beam bridge rails, must satisfy the impact safety standards provided in MASH in order to be accepted by the Federal Highway Administration (FHWA) for use on National Highway System (NHS) new construction projects or as a replacement for existing designs not meeting current safety standards. According to TL-3 of MASH, longitudinal barrier systems must be subjected to two full-scale vehicle crash tests. The two full-scale crash tests are as follows:

1. Test Designation 3-10 consisting of a 2,425-lb (1,100-kg) passenger car impacting the system at a nominal speed and angle of 62 mph (100 km/h) and 25 degrees, respectively.
2. Test Designation 3-11 consisting of a 5,000-lb (2,268-kg) 4-door, half-ton pickup truck impacting the system at a nominal speed and angle of 62 mph (100 km/h) and 25 degrees, respectively.

### **Findings**

Test no. MGSBR-1 featured a 5,174-lb (2,347-kg) 4-door pickup truck that impacted the barrier at a speed of 61.9 mph (99.6 km/h) and at an angle of 24.9 degrees. The bridge rail successfully redirected the vehicle while meeting all required safety criteria and sustaining a maximum

deflection of 48.9 inches (1,242 millimeters), compared to 43.9 inches (1,114 millimeters) for MGS testing under similar impact conditions. In test no. MGSBR-2, a 2,585-lb (1,173-kg) small car impacted the barrier at a speed of 62.3 mph (100.2 km/h) and at an angle of 24.9 degrees. The barrier again successfully redirected the vehicle while meeting all required safety criteria and sustaining a maximum deflection of 28.0 inches (712 millimeters). This deflection was very similar to the 35.9 inches (913 millimeters) deflection measured during testing of the MGS under similar impact conditions. Crash Test Summary details of this system are provided as enclosures to this correspondence.

Therefore, this system as described is eligible for reimbursement and should be installed under the range of conditions tested, when such use is acceptable to a highway agency. Please note the following standard provisions that apply to the FHWA eligibility letters:

- This letter includes an AASHTO/ARTBA/AGC Task Force 13 designator that should be used to identify any new or updated Task Force 13 drawings.
- This finding of eligibility is limited to the crashworthiness characteristics of the devices and does not cover their structural features, or conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may adversely influence the crashworthiness of the device will require a new letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the device being marketed is significantly different from the version that was crash tested, we reserve the right to modify or revoke this letter.
- You will be expected to supply potential users with sufficient information on design and installation requirements to ensure proper performance.
- You will be expected to certify to potential users that the hardware furnished has essentially the same chemistry, mechanical properties, and geometry as that submitted for review, and that it will meet the crashworthiness requirements of the FHWA and the AASHTO MASH.
- To prevent misunderstanding by others, this letter is designated as number B-228, and shall not be reproduced except in full. This letter and the test documentation upon which it is based are public information. All such letters and documentation may be reviewed at our office upon request.
- This letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented device for which the applicant is not the patent holder. The finding of eligibility is limited to the crashworthiness characteristics of the candidate device, and the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Sincerely yours,

Michael S. Griffith

Director, Office of Safety Technologies  
Office of Safety

Enclosures



U.S. Department  
of Transportation  
**Federal Highway  
Administration**

1200 New Jersey Ave., SE  
Washington, D.C. 20590

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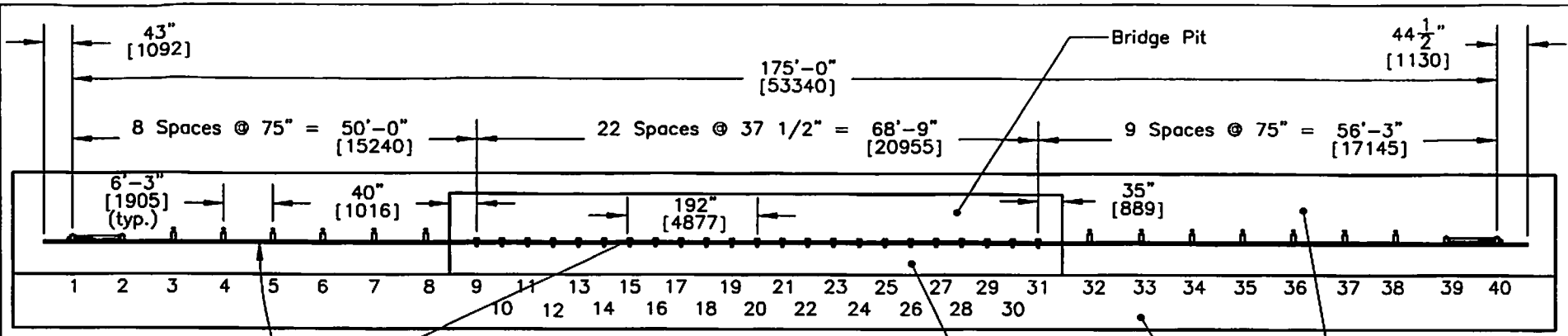
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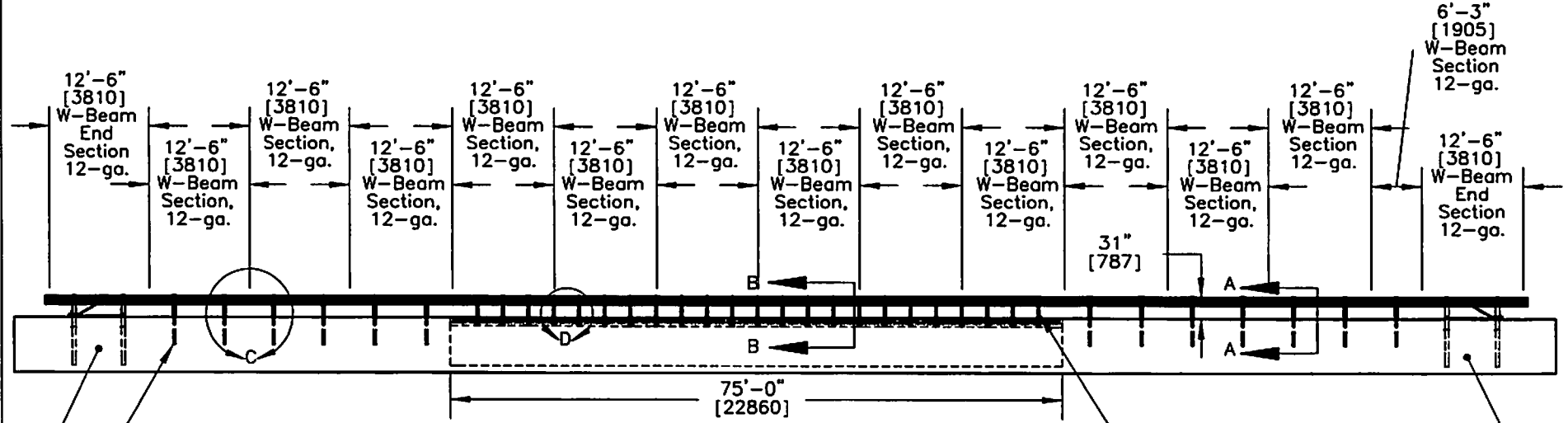
Michael S. Griffith  
Director, Office of Safety Technologies  
Office of Safety

Enclosures



PLAN VIEW

Impact: 16' [4877]  
Upstream of Centerline of  
the Splice at Post No. 20.  
Impact Line Referenced to  
Left Side of (MASH-08)  
2270P Truck.



ELEVATION VIEW

W6x8.5 [W152x12.6] 72" [1829] Long Posts  
with 6x12x14 1/4" [152x305x362] Blockouts

BCT post in 6' [1829] Long  
(Galvanized) Foundation  
Tubes, Ground Line Strut,  
and BCT Cable Anchor

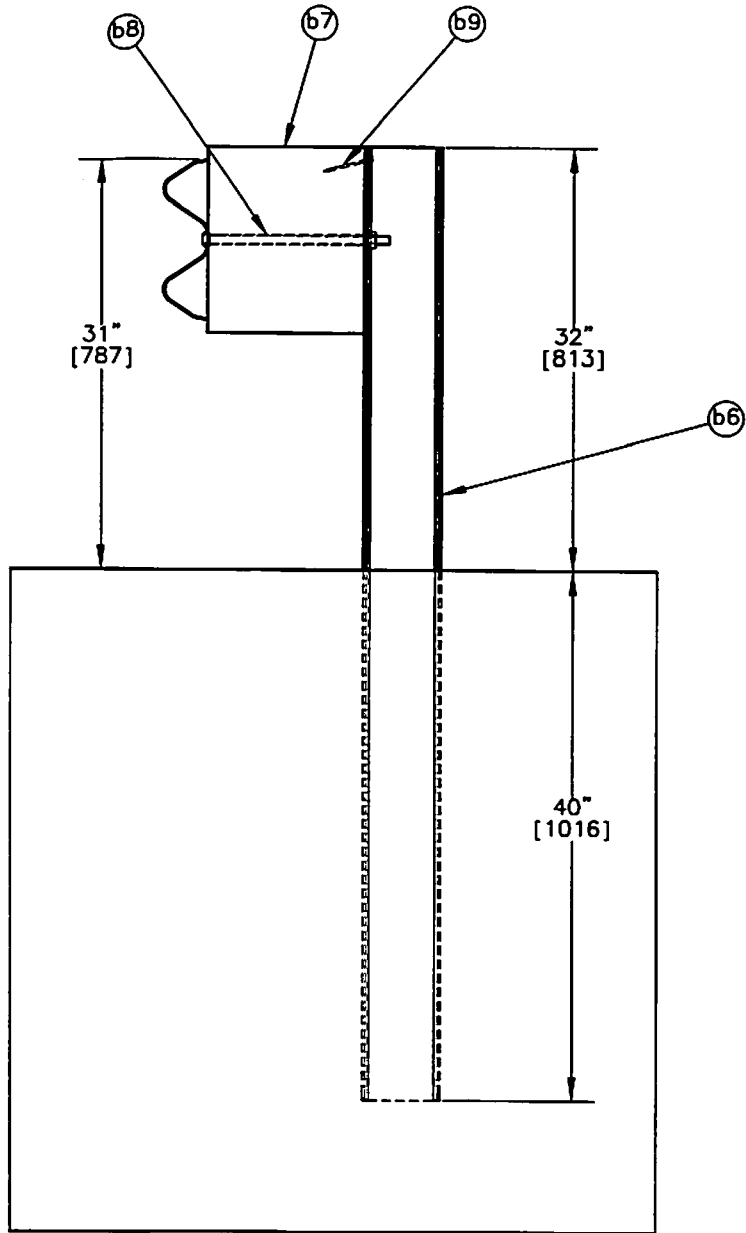
BCT post in 6' [1829] Long  
(Galvanized) Foundation  
Tubes, Ground Line Strut,  
and BCT Cable Anchor

- Notes: (1) Posts nos. 7, 32, and 33 are placed in 3' [914] diameter holes. Post no. 8 has to be placed in a 2' [610] diameter hole due to the location of the bridge pier, the center of post is 1' [305] away from bridge pier.
- (2) All remaining posts in the transition have 2' [610] diameter holes.

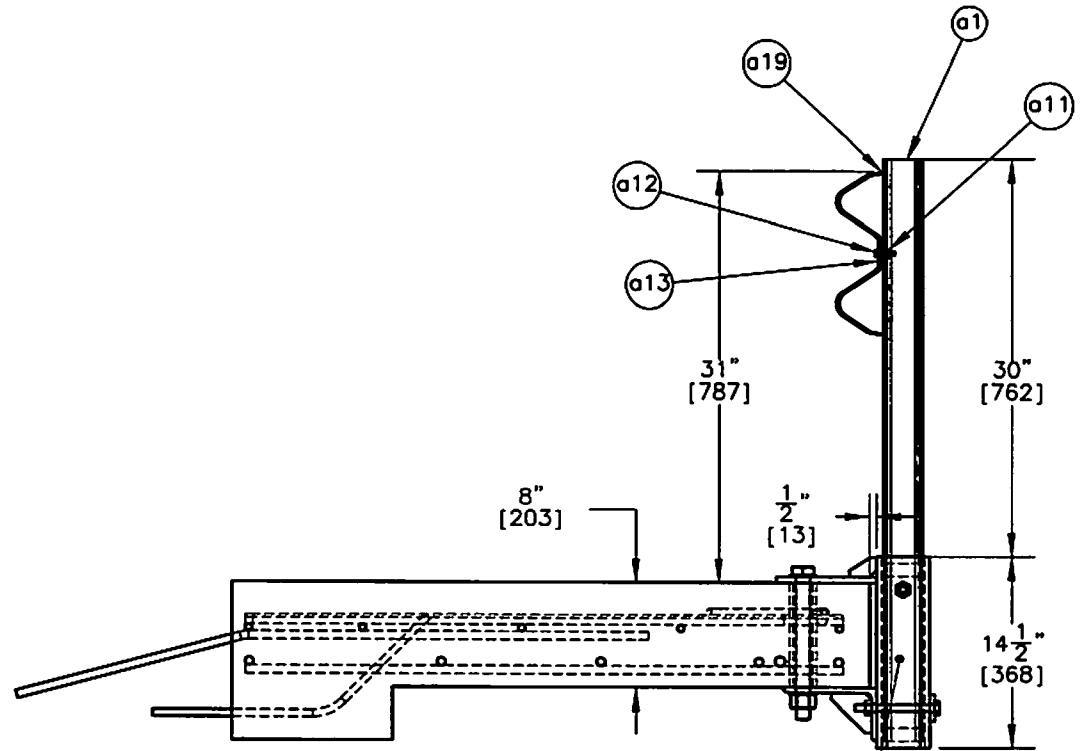


Midwest Roadside  
Safety Facility

MGS Bridge Rail System Layout		SHEET: 1 of 26
		DATE: 11/19/2009
		DRAWN BY: MW/RJT
DWG. NAME: MGS Bridge Rail_V13	SCALE: 1:225 UNITS: In./mm	REV. BY: KAL/EJ/PF



SECTION A-A



SECTION B-B

Weak Post Assembly



Midwest Roadside  
Safety Facility

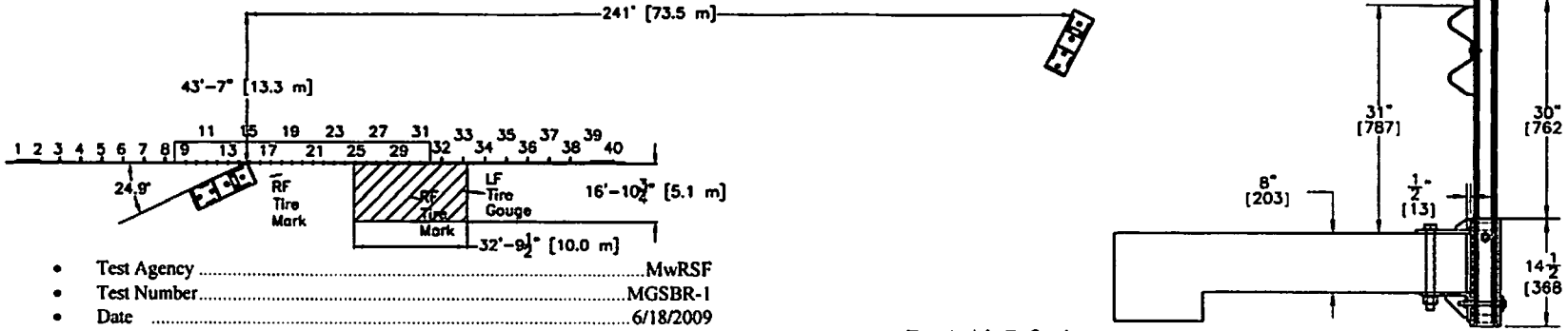
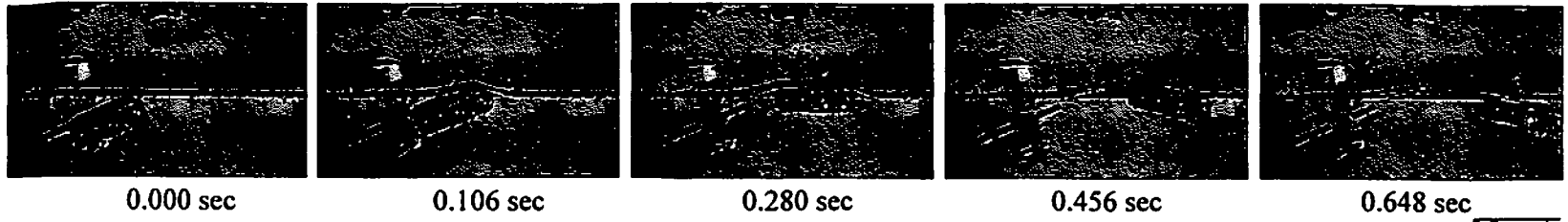
MGS Bridge Rail  
Post Details

DWG. NAME:  
MGS Bridge Rail\_V13

SCALE: 1:14  
UNITS: In./mm

SHEET:  
2 of 26  
DATE:  
11/19/2009  
DRAWN BY:  
MW/RJT

REV. BY:  
KAI /F./RF



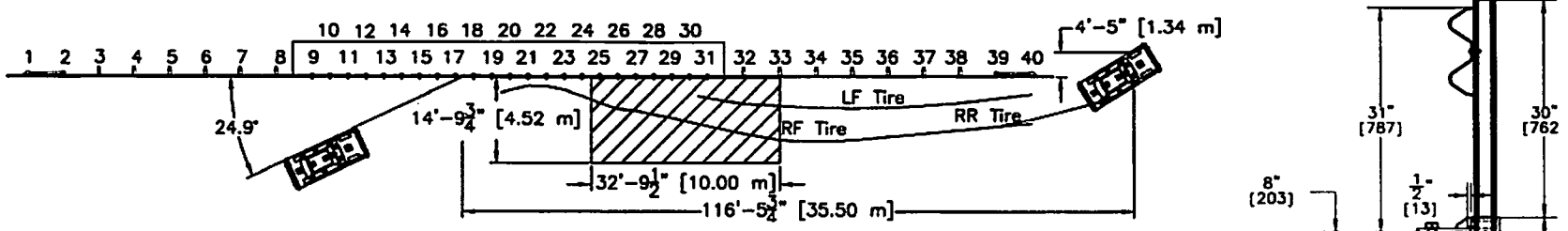
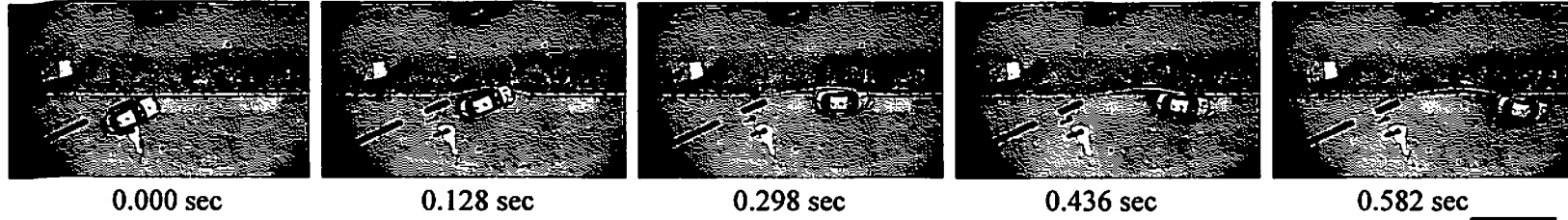
- Test Agency ..... MwRSF
- Test Number ..... MGSBR-1
- Date ..... 6/18/2009
- MASH Test Designation ..... 3-11
- Test Article ..... MGS Bridge Rail with approach MGS Guardrails
- Total Length ..... 175 ft (53.3 m)
- Key Component – MGS Bridge Rail
  - Post Type ..... S3x5.7 (S76x8.5)
  - Post Spacing ..... 3 ft - 1/2 in. (953 mm)
  - Post-to-Rail Connection ..... 3/16-in. (7.9-mm) dia. ASTM A307A Bolt
- Key Component – Simulated Bridge Deck
  - Thickness (outer edge) ..... 8 in. (203 mm)
  - Concrete Strength (minimum) ..... 4,000 psi (27.6 MPa)
- Vehicle Model ..... 2004 Dodge Ram 1500 Quad Cab Pickup Truck
  - Curb ..... 5,134 lb (2,329 kg)
  - Test Inertial ..... 5,005 lb (2,270 kg)
  - Gross Static ..... 5,174 lb (2,347 kg)
- Impact Conditions
  - Speed ..... 61.9 mph (99.6 km/h)
  - Angle ..... 24.9 degrees
  - Impact Location ..... 15 ft - 9 1/2 in. (4.81 m) US of post no. 20 splice
- Exit Conditions
  - Speed ..... 34.5 mph (55.5 km/h)
  - Angle ..... 20.4 degrees
  - Exit Box ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 241 ft (73.5 m) downstream  
43 ft - 7 in. (13.3 m) behind edge of bridge deck
- Vehicle Damage ..... Moderate
  - VDS<sup>(75)</sup> ..... 11-LFQ-3
  - CDC<sup>(76)</sup> ..... 11-LYEW-4
  - Maximum Interior Deformation ..... 1 1/4 in. (44 mm), left side panel
- Test Article Damage ..... Moderate

- Test Article Deflections
  - Permanent Set ..... 31 1/4 in. (810 mm)
  - Dynamic ..... 48.9 in. (1,242 mm)
  - Working Width ..... 53.2 in. (1,351 mm)
- Angular Displacements (EDR-4)
  - Roll ..... -15.3 degrees
  - Pitch ..... -5.6 degrees
  - Yaw ..... 37.8 degrees
- Angular Displacements (DTS)
  - Roll ..... -14.0 degrees
  - Pitch ..... -5.4 degrees
  - Yaw ..... 39.8 degrees
- Transducer Data

Evaluation Criteria		Transducer			MASH Limit
		EDR-4	DTS	EDR-3	
OIV ft/s (m/s)	Longitudinal	-16.94 ft/s (-5.16 m/s)	-16.86 ft/s (-5.14 m/s)	-18.84 ft/s (-5.74 m/s)	≤ 40 (12.2)
	Lateral	13.27 ft/s (4.04 m/s)	14.23 ft/s (4.34 m/s)	14.18 ft/s (4.32 m/s)	≤ 40 (12.2)
ORA g's	Longitudinal	-10.61	-10.44	-12.55	≤ 20.49
	Lateral	5.42	6.33	5.61	≤ 20.49
THIV – ft/s (m/s)		20.66 ft/s (6.30 m/s)	21.03 ft/s (6.41 m/s)		not required
PHD – g's		10.64	10.50		not required
ASI		0.53	0.57	0.64	not required

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Figure 127. Summary of Test Results and Photographs, Test No. MGSBR-1



- Test Agency ..... MwRSF
- Test Number ..... MGSBR-2
- Date ..... 6/26/2009
- MASH Test Designation ..... 3-10
- Test Article ..... MGS Bridge Rail with approach MGS Guardrails
- Total Length ..... 175 ft (53.3 m)
- Key Component – MGS Bridge Rail
  - Post Type ..... S3x5.7 (S76x8.5)
  - Post Spacing ..... 3 ft - 1 1/2 in. (953 mm)
  - Post-to-rail Connection ..... 1/16-in. (7.9-mm) dia. ASTM A307A Bolt
- Key Component – Simulated Bridge Deck
  - Thickness (outer edge) ..... 8 in. (203 mm)
  - Concrete Strength (minimum) ..... 4,000 psi (27.6 MPa)
- Vehicle Model ..... 2003 Kia Rio Passenger Car
  - Curb ..... 2,408 lb (1,092 kg)
  - Test Inertial ..... 2,416 lb (1,096 kg)
  - Gross Static ..... 2,585 lb (1,173 kg)
- Impact Conditions
  - Speed ..... 62.3 mph (100.2 km/h)
  - Angle ..... 24.9 degrees
  - Impact Location ..... 7 ft - 9 in. (2.36 m) US of the splice at post no. 20
- Exit Conditions
  - Speed ..... 27.7 mph (44.6 km/h)
  - Angle ..... 10.9 degrees
  - Exit Box ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 116 ft - 5 1/2 in. (35.5 m) downstream  
4 ft - 5 in. (1.3 m) behind front face of guardrail
- Vehicle Damage ..... Moderate
  - VDS<sup>(75)</sup> ..... 11-LFQ-4
  - CDC<sup>(76)</sup> ..... 11-LYEW-5
  - Maximum Interior Deformation ..... 1 1/4 in. (32 mm), front of floor pan
- Test Article Damage ..... Moderate

- Test Article Deflections
  - Permanent Set ..... 20 in. (508 mm)
  - Dynamic ..... 28.0 in. (712 mm)
  - Working Width ..... 33.8 in. (859 mm)
- Angular Displacements (EDR-4)
  - Roll ..... -8.7 degrees
  - Pitch ..... -8.2 degrees
  - Yaw ..... 34.7 degrees
- Angular Displacements (DTS)
  - Roll ..... -12.7 degrees
  - Pitch ..... -5.0 degrees
  - Yaw ..... 35.1 degrees
- Transducer Data

Evaluation Criteria		Transducer			MASH Limit
		EDR-4	DTS	EDR-3	
OIV ft/s (m/s)	Longitudinal	-24.40 ft/s (-7.44 m/s)	-22.90 ft/s (-6.98 m/s)	-25.29 ft/s (-7.71 m/s)	≤ 40 (12.2)
	Lateral	16.54 ft/s (5.04 m/s)	16.38 ft/s (4.99 m/s)	17.94 ft/s (5.47 m/s)	≤ 40 (12.2)
ORA g's	Longitudinal	-7.69	-7.41	-8.65	≤ 20.49
	Lateral	6.58	7.34	7.39	≤ 20.49
THIV – ft/s (m/s)		28.50 ft/s (8.69 m/s)	28.04 ft/s (8.55 m/s)		not required
PHD – g's		9.93	9.90		not required
ASI		0.79	0.78	0.88	not required

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Figure 152. Summary of Test Results and Photographs, Test No. MGSBR-2