U.S. Department
of Transportation
Federal Highway Administration

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

December 27, 2016

In Reply Refer To:
HSST-1/CC-126F

Mr. Kaddo Kothman
Road Systems, Inc.
3616 Howard County Airport
Big Spring, TX 79720

Dear Mr. Kothman:

This letter is in response to your August, 1, 2016 request for the Federal Highway Administration (FHWA) to review a roadside safety device, hardware, or system for eligibility for reimbursement under the Federal-aid highway program. This FHWA letter of eligibility is assigned FHWA control number CC-126F and is valid until a subsequent letter is issued by FHWA that expressly references this device.

Decision

The following devices are eligible, with details provided in the form which is attached as an integral part of this letter:

- MASH Sequentially Kinking Terminal (MSKT) Powder Coated

Scope of this Letter

To be found eligible for Federal-aid funding, new roadside safety devices should meet the crash test and evaluation criteria contained in the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH). However, the FHWA, the Department of Transportation, and the United States Government do not regulate the manufacture of roadside safety devices. Eligibility for reimbursement under the Federal-aid highway program does not establish approval, certification or endorsement of the device for any particular purpose or use.

This letter is not a determination by the FHWA, the Department of Transportation, or the United States Government that a vehicle crash involving the device will result in any particular outcome, nor is it a guarantee of the in-service performance of this device. Proper manufacturing, installation, and maintenance are required in order for this device to function as tested.

This finding of eligibility is limited to the crashworthiness of the system and does not cover other structural features, nor conformity with the Manual on Uniform Traffic Control Devices.

Eligibility for Reimbursement

Based solely on a review of crash test results and certifications submitted by the manufacturer, and the crash test laboratory, FHWA agrees that the device described herein meets the crash test and evaluation criteria of the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH). Therefore, the device is eligible for reimbursement under the Federal-aid highway program if installed under the range of tested conditions.

Name of system: MASH Sequentially Kinking Terminal (MSKT) Powder Coated
Type of system: Terminal
Test Level: MASH Test Level 3 (TL3)
Testing conducted by: KARCO
Date of request: August 1, 2016

'FHWA concurs with the recommendation of the accredited crash testing laboratory as stated within the attached form.'

Full Description of the Eligible Device

The device and supporting documentation, including reports of the crash tests or other testing done, videos of any crash testing, and/or drawings of the device, are described in the attached form.

Notice

If a manufacturer makes any modification to any of their roadside safety hardware that has an existing eligibility letter from FHWA, the manufacturer must notify FHWA of such modification with a request for continued eligibility for reimbursement. The notice of all modifications to a device must be accompanied by:

- Significant modifications – For these modifications, crash test results must be submitted with accompanying documentation and videos.
- Non-signification modifications – For these modifications, a statement from the crash test laboratory on the potential effect of the modification on the ability of the device to meet the relevant crash test criteria.

FHWA's determination of continued eligibility for the modified hardware will be based on whether the modified hardware will continue to meet the relevant crash test criteria.

You are expected to supply potential users with sufficient information on design, installation and maintenance requirements to ensure proper performance.

You are expected to certify to potential users that the hardware furnished has the same chemistry, mechanical properties, and geometry as that submitted for review, and that it will meet the test and evaluation criteria of the MASH.

Issuance of this letter does not convey property rights of any sort or any exclusive privilege. This letter is based on the premise that information and reports submitted by you are accurate and correct. We reserve the right to modify or revoke this letter if: (1) there are any inaccuracies in the information submitted in support of your request for this letter, (2) the qualification testing was flawed, (3) in-service performance or other information reveals safety problems, (4) the system is significantly different from the version that was crash tested, or (5) any other information indicates that the letter was issued in error or otherwise does not reflect full and complete information about the crashworthiness of the system.

Standard Provisions

- To prevent misunderstanding by others, this letter of eligibility designated as FHWA control number CC-126F 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 upon request.

- This letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented system for which the applicant is not the patent holder.

- If the subject device is a patented product it may be considered to be proprietary. If proprietary systems are specified by a highway agency for use on Federal-aid projects: (a) they must be supplied through competitive bidding with equally suitable unpatented items; (b) the highway agency must certify that they are essential for synchronization with the existing highway facilities or that no equally suitable alternative exists; or (c) they must be used for research or for a distinctive type of construction on relatively short sections of road for experimental purposes. Our regulations concerning proprietary products are contained in Title 23, Code of Federal Regulations, Section 635.411.

Sincerely yours,

Michael S. Griffith

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

Enclosures

Request for Federal Aid Reimbursement Eligibility of Highway Safety Hardware

Submitter			
	Date of Request:	August 1, 2016	◉ New ○ Resubmission
	Name:	Robert Ramirez	
	Company:	KARCO Engineering, LLC,	
	Address:	9270 Holly Road, Adelanto, CA 92301	
	Country:	United States	
	To:	Michael S. Griffith, Director FHWA, Office of Safety Technologies	

I request the following devices be considered eligible for reimbursement under the Federal-aid highway program.

Device & Testing Criterion - Enter from right to left starting with Test Level

!-!-!

System Type	Submission Type	Device Name / Variant	Testing Criterion	Test Level
'CC': Crash Cushions, Attenuators, & Terminals	○ Physical Crash Testing ◉ Engineering Analysis	MSKT Terminal	AASHTO MASH	TL3

By submitting this request for review and evaluation by the Federal Highway Administration, I certify that the product(s) was (were) tested in conformity with the AASHTO Manual for Assessing Safety Hardware and that the evaluation results meet the appropriate evaluation criteria in the MASH.

Individual or Organization responsible for the product:

Contact Name:	Kaddo Kothmann	Same as Submitter ☐
Company Name:	Road Systems, Inc.	Same as Submitter ☐
Address:	3616 Howard County Airport, Big Spring TX 79720	Same as Submitter ☐
Country:	United States	Same as Submitter ☐

Enter below all disclosures of financial interests as required by the FHWA `Federal-Aid Reimbursement Eligibility Process for Safety Hardware Devices' document.

Road Systems, Inc. is the manufacturer and marketer of device.

KARCO Engineering, LLC is an independent research and testing laboratory having no affiliation with any other entity. The company is solely-owned and operated by Mr. Frank D. Richardson and Ms. Jennifer W. Peng (husband and wife) and was established on September 2, 1994. KARCO is actively involved in data acquisition and compliance/certification testing for a variety of government agencies and equipment manufacturers. The principals and staff of KARCO Engineering have no past or present financial, contractual or organizational interest in any company or entity directly or indirectly related to the products that KARCO tests. If any financial interest should arise, other than receiving fees for testing, reporting, etc., with respect to any project, the company will provide, in writing, a full and immediate disclosure to the FHWA.

PRODUCT DESCRIPTION

○ New Hardware or Significant Modification ◉ Modification to Existing Hardware Non-Significant

The MSKT-SP-MGS (MASH Sequential Kinking Terminal - Standard Post - Midwest Guardrail System) terminal, as approved in CC-126 dated June 10, 2016, is a W-beam guardrail terminal consisting of an impact head assembly, a breakaway cable anchorage system and a 12.5 ft (3.8 m) end section. The system requires use of 37.5 ft (11.4 m) of standard guardrail downstream mounted on 8-in. (203-mm) deep wood or composite blocks and 6 ft (1.8 m) long W6x9 (or W6x8.5) steel posts. A 9.4 ft (2.9 m) W-beam rail section is required downstream of Post 3 to transition the rail splices to mid-span.

On some parkways and scenic roadways, guardrails and terminals are powder coated or painted on top of the galvanized surface to a color that better blends in with the environment for esthetics. To accommodate this specific application, it is requested that the use of powder coated or painted rail sections, impact head, and other components be approved for use with the MSKT.

To demonstrate that the SKT and FLEAT terminal would perform satisfactorily with the powder coating or painting over the galvanized surface, a bogie test was conducted to assess its impact performance. A copy of the report is attached to this request. The study concludes that:

"The kinking force for the galvanized rail with a powder coated surface is similar, actually slightly higher, than that of a standard galvanized rail. Given the similarity in kinking force, it is logical to conclude that the impact performance of the powder coated rail would be similar to that of the standard galvanized rail. Thus, it is believed that the powder coated rail and impact heads can be used in place of the standard galvanized rail with no modification to the SKT or FLEAT terminal designs."

Based on the test findings, this modification/variation has been used for the NCHRP 350 SKT terminal. There has not been any indication that this modification/variation has caused any real-world problem in the field.

In summary, results of bogie testing has shown that powder coating or painting on top of the galvanized surface of rail sections and impact head would perform similarly to the standard galvanized rail and impact head from an impact standpoint. Furthermore, there has not been any identified problem with the field performance. Thus, it is reasonable to conclude that the use of powder coated or painted rail and terminal should be approved for the MSKT terminal.

Attachment: Powder Coated Report 08/27/2009

CRASH TESTING

By signature below, the Engineer affiliated with the testing laboratory, agrees in support of this submission that the Modification to Existing Hardware is deemed Non-significant for the device listed above to meet the MASH criteria.

Engineer Name:	Robert Ramirez	
Engineer Signature:	Robert L. Ramirez Digitally signed by Robert L. Ramirez DN: cn=Robert L. Ramirez, o=KARCO Engineering, ou, email=rramirez@KARCO.com, c=US Date: 2016.08.01 17:25:55 -07'00'	
Address:	9270 Holly Road, Adelanto, CA 92301	Same as Submitter ☒
Country:	United States	Same as Submitter ☒

A brief description of each crash test and its result:

Required Test Number	Narrative Description	Evaluation Results
3-30 (1100C)	KARCO Test No. P35125-01. An 1100C (2,425 lb) passenger car impacting the terminal end-on at a nominal impact speed and angle of 100 km/h (62.2 mph) and 0 degrees, respectively, with the quarter point of the vehicle aligned with the center line of the nose of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2009 Kia Rio 4-door sedan weighing 2,390.9 lb (1,084.5 kg), impacted the MASH SKT terminal head on at impact speed and angle of 61.54 mph (99.05 km/h) and 0.9 degree, respectively. The vehicle pushed the impact head down the length of the guardrail past the fifth post, at which point the rail began to buckle and the vehicle began to yaw counter-clockwise until it impacted the rail at the bend before coming to a stop next to the rail on the traffic side. The test vehicle sustained moderate damage to the front end with no occupant compartment deformation. The vehicle remained upright without excessive roll or pitch. The test article was extensively damage from Post 1 through Post 5 and the rail wrapped around Post 6. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. The MSKT-SP-MGS terminal passed all evaluation criteria for Test 3-30.	Modification has no effect on crashworthiness

Required Test Number	Narrative Description	Evaluation Results
3-31 (2270P)	KARCO Test No. P34149-01. A 2270P (5,000 lb) pickup truck impacting the terminal end-on at a nominal impact speed and angle of 100 km/h (62.2 mph) and 0 degrees, respectively, with the center line of the vehicle aligned with the center line of the nose of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2008 Dodge Ram 4-door pickup truck, with a test inertial mass weighing 4,896.4 lb (2,221 kg). impacted the MASH SKT terminal head-on at impact speed and angle of 62.33 mph (100.31 km/h) and 0.4 degrees, respectively. The vehicle pushed the impact head down the length of the guardrail past Post 8 and came to rest 50.5 ft (15.4 m) from the point of initial impact. The test vehicle sustained moderate damage to the front end with no occupant compartment deformation. The vehicle remained upright and stable. The test article was extensively damaged from Post 1 through Post 8. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. The MSKT-SP terminal passed all evaluation criteria for Test 3-31.	Modification has no effect on crashworthiness

3-32 (1100C)	KARCO Test No. P35025-01. An 1100C (2,425 lb) passenger car impacting the terminal end-on at a nominal impact speed and angle of 100 km/h (62.2 mph) and 5 degrees, respectively, with the center line of the vehicle aligned with the center line of the nose of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2010 Kia Rio 4-door sedan weighing 2,457.0 lb (1,114.5 kg), impacted the MASH SKT terminal head-on at impact speed and angle of 61.47 mph (98.93 km/h) and 4.4 degrees, respectively. The vehicle pushed the impact head down the length of the guardrail past the fifth post, at which point the vehicle mounted the guardrail. Upon dismounting the rail, the vehicle proceeded forward and to the left and remained upright throughout the impact sequence. The test vehicle sustained moderate damage to the front and left side with no occupant compartment deformation. The vehicle remained upright and stable. The test article was extensively damaged from Post 1 through Post 5. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. The MSKT-SP-MGS terminal passed all evaluation criteria for Test 3-32.	Modification has no effect on crashworthiness

3-33 (2270P)	KARCO Test No. P34149-04 . A 2270P (5,000 lb) pickup truck impacting the terminal end-on at a nominal impact speed and angle of 100 km/h (62.2 mph) and 5 degrees, respectively, with the center line of the vehicle aligned with the center line of the nose of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2008 Dodge Ram 4-door pickup truck weighing 4,895.3 lb (2,220.5 kg), impacted the MASH SKT terminal head-on at an impact speed and angle of 62.74 mph (100.97 km/h) and 5.7 degrees, respectively. The vehicle pushed the impact head down the guardrail past the fifth post at which point the vehicle mounted the guardrail in a controlled manner without excessive deceleration and proceeded forward. The vehicle then impacted Post 6 before separating from the guardrail. The vehicle impacted the test article again between Posts 23 and 24. The vehicle sustained moderate damage at the front and left side and deformations to the occupant compartment were negligible. The vehicle remained upright and stable. The test article was extensively damaged from Posts 1 through Post 6. Post 7 was not impacted, but separated from the guardrail as a result of the rail buckling. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. The MSKT-SP terminal passed all evaluation criteria for Test 3-33.	Modification has no effect on crashworthiness

3-34 (1100C)	KARCO Test No. P35126-01. An 1100C (2,425 lb) passenger car impacting the terminal at a nominal impact speed and angle of 62.2 mph (100 km/h) and 15 degrees, respectively, with the corner of the vehicle bumper aligned with the critical impact point (CIP) of the length of need (LON) of the terminal. This test is primarily intended to evaluate occupant risk and vehicle trajectory criteria. The test vehicle, a 2010 Kia Rio 4-door sedan weighing 2,436.1 lb (1,105.0 kg), impacted the downstream end of the impact head between Posts 1 and 2 at impact speed and angle of 61.37 mph (98.77 km/h) and 15.3 degrees, respectively. The vehicle was contained and redirected by the guardrail before separating from the test article near Post 6 at a velocity of 27.7 mph and an exit angle of 17.0 degrees and proceeded downstream adjacent to the guardrail. The vehicle remained upright and stable throughout the impact sequence. The test vehicle sustained moderate damage to the front right side with no occupant compartment deformation. The test article was extensively damaged from Post 1 through Post 5. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. The MSKT-SP-MGS terminal passed all evaluation criteria for Test 3-34.	Modification has no effect on crashworthiness

3-35 (2270P)	KARCO Test No. P35103-01. A 2270P (5,000 lb) pickup truck impacting the terminal at a nominal impact speed and angle of 100 km/h (62.2 mph) and 25 degrees, respectively, with the corner of the vehicle bumper aligned with the beginning of the length-of-need (LON) of the terminal. This test is primarily intended to evaluate structural adequacy and vehicle trajectory criteria. The test vehicle, a 2011 Dodge Ram 4-door pickup truck weighing 4,942.6 lb (2,242.0 kg), impacted the guardrail at Post 3, the beginning of length-of-need, at impact speed and angle of 62.36 mph (100.36 km/h) and 26 degrees, respectively. The vehicle was contained and redirected by the guardrail before separating from the test article near Post 9 at a velocity of 32.75 mph (52.71 km/h) and an exit angle of 34.93 degrees and proceeded downstream adjacent to the guardrail on the traffic side. The vehicle then veered back toward the guardrail and impacted Post 20 before coming to rest at Post 26. The vehicle remained upright and stable throughout the impact sequence. The test vehicle sustained moderate damage to the front right side with no occupant compartment deformation. The test article was extensively damaged from Post 1 through Post 9. The maximum static lateral deformation was 30.2 in (768 mm) between Posts 5 and 6. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. The MSKT-SP-MGS terminal passed all evaluation criteria for Test 3-35.	Modification has no effect on crashworthiness
3-36 (2270P)	MASH Test Designation 3-36. A 2270P (5,000 lb) pickup truck impacting the terminal at a nominal impact speed and angle of 100 km/h (62 mph) and 25 degrees, respectively, with the corner of the vehicle bumper aligned with the critical impact point (CIP) with respect to the transition to the stiff barrier or backup structure. This test is primarily intended to evaluate the performance of the terminal when connected to a stiff barrier or a backup structure. As a W-beam guardrail terminal, the MSKT-SP-MGS terminal is designed to attach to W-beam barrier, transitions to alternative barriers downstream of the terminal will require case-by-case evaluation.	Non-Relevant Test, not conducted

3-37 (2270P)	Test No. P35025-02. A 2270P (5,000 lb) pickup truck impacting the terminal at a nominal impact speed and angle of 62.2 mph (100 km/h) and 25 degrees, respectively, midpoint between the nose and the end of the terminal in the reverse direction. This test is intended to evaluate the performance of a terminal for a "reverse" hit. Successful testing of other cable anchor systems with the 1100C indicates that the 2270P is more critical with the concern of override and interaction with the terminal head. The test vehicle, a 2009 Dodge Ram 4-door pickup truck weighing 4,964.7 lb (2,252.0 kg), impacted the guardrail at Post 3 with an impact speed and angle of 63.13 mph (101.6 km/h) and 24.9 degrees, respectively. The vehicle impacted Post 2, the back side of the impact head, and then Post 1 before separating from the test article at an angle of 13.37 degrees clockwise from its original path. The vehicle sustained moderate front end damage with no deformation to the occupant compartment. The test article received extensive damage between Posts 1 and 2. The impact head was forced off the rail element and the cable anchor assembly was separated from the guardrail. The Occupant Impact Velocities (OIV) and ridedown accelerations are within the recommended limits. The MSKT-SP-MGS terminal passed all evaluation criteria for Test 3-37.	Modification has no effect on crashworthiness
3-38 (1500A)	MASH Test Designation 3-38. A 1500A (3,307 lb) passenger car impacting the terminal end-on at a nominal impact speed and angle of 100 km/h (62.2 mph) and 0 degree, respectively, with the center line of the vehicle aligned with the center line of the nose of the terminal. This test is primarily intended to evaluate the performance of the staged attenuator/ terminal when impacted by a mid-size vehicle. The MSKT-SP-MGS terminal is not a staged device, because the force required to move the impact head down the rail does not change. The 3-30 test with the 1100C vehicle makes this test unnecessary.	Non-Relevant Test, not conducted
3-40 (1100C)	Test for non-redirective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted
3-41 (2270P)	Test for non-redirective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted
3-42 (1100C)	Test for non-redirective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted

3-43 (2270P)	Test for non-redirective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted
3-44 (2270P)	Test for non-redirective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted
3-45 (1500A)	Test for non-redirective crash cushion, not applicable for terminals	Non-Relevant Test, not conducted

Testing Laboratory's signature concurs that these modifications are considered Non-Significant.		
Laboratory Name:	KARCO Engineering, INC	
Laboratory Signature:	Robert L. Ramirez Digitally signed by Robert L. Ramirez DN: cn=Robert L. Ramirez, o=KARCO Engineering, ou, email=rramirez@KARCO.com, c=US Date: 2016.08.01 17:26:17 -07'00'	
Address:	9270 Holly Road, Adelanto, CA 92301	Same as Submitter ☒
Country:	United States	Same as Submitter ☒
Accreditation Certificate Number and Dates of current Accreditation period :	TL-371; December 18, 2015 through December 18, 2017	

Submitter Signature*: Robert L. Ramirez Digitally signed by Robert L. Ramirez DN: cn=Robert L. Ramirez, o=KARCO Engineering, ou, email=rramirez@KARCO.com, c=US Date: 2016.08.01 17:26:27 -07'00'

Submit Form

ATTACHMENTS

Attach to this form:

1) Additional disclosures of related financial interest as indicated above.
2) A copy of the full test report, video, and a Test Data Summary Sheet for each test conducted in support of this request.
3) A drawing or drawings of the device(s) that conform to the Task Force-13 Drawing Specifications [Hardware Guide Drawing Standards]. For proprietary products, a single isometric line drawing is usually acceptable to illustrate the product, with detailed specifications, intended use, and contact information provided on the reverse. Additional drawings (not in TF-13 format) showing details that are relevant to understanding the dimensions and performance of the device should also be submitted to facilitate our review.

FHWA Official Business Only:

Eligibility Letter		
Number	Date	Key Words

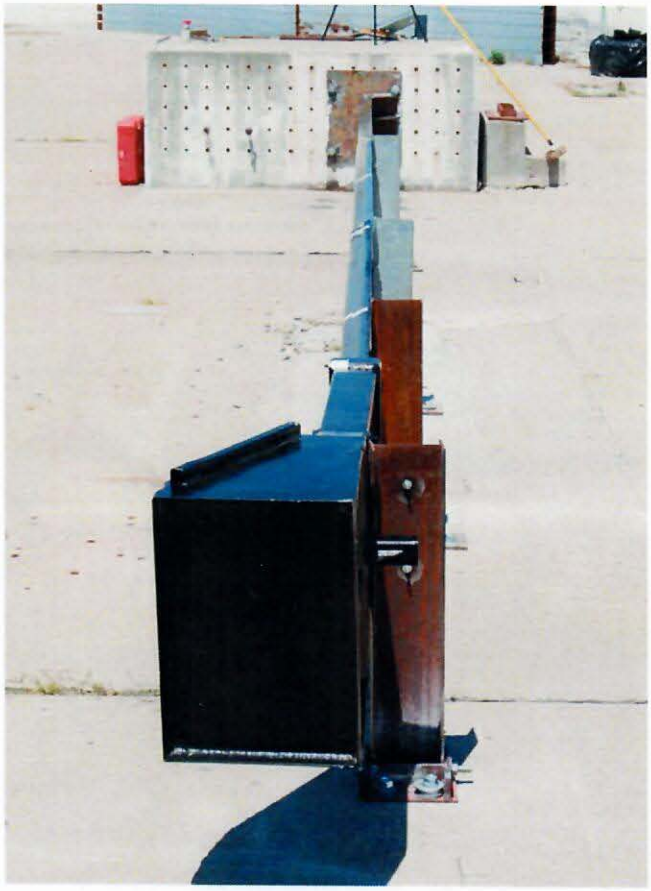
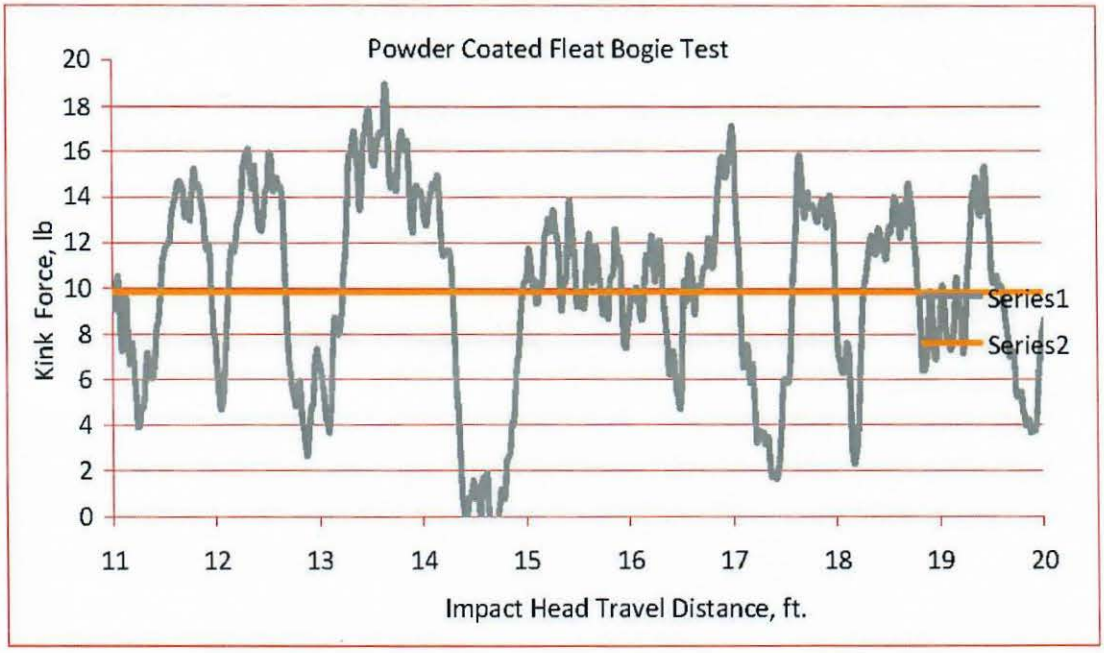


Figure 1. Photographs of Bogie Test Installation

Figure 2. Photographs of Bogie Test Installation After Test

Figure 3. Photograph Showing Kinked Rail



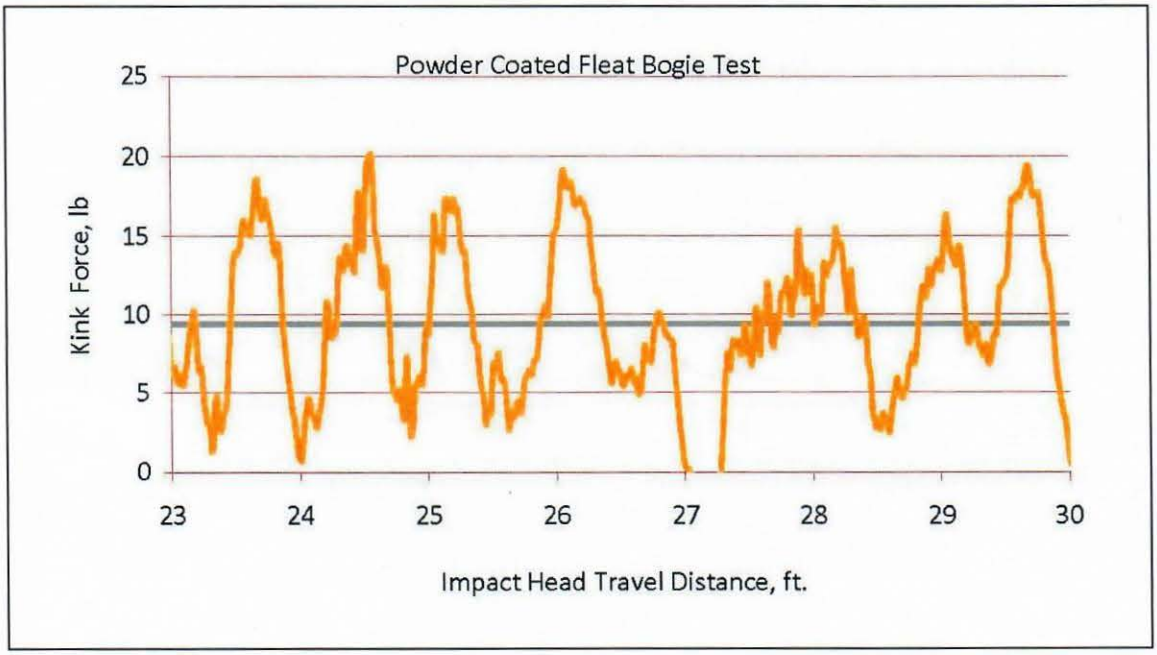


Figure 4. Plot of Kink Force v. Impact Head Travel Distance
Powder Coated FLEAT Bogie Test

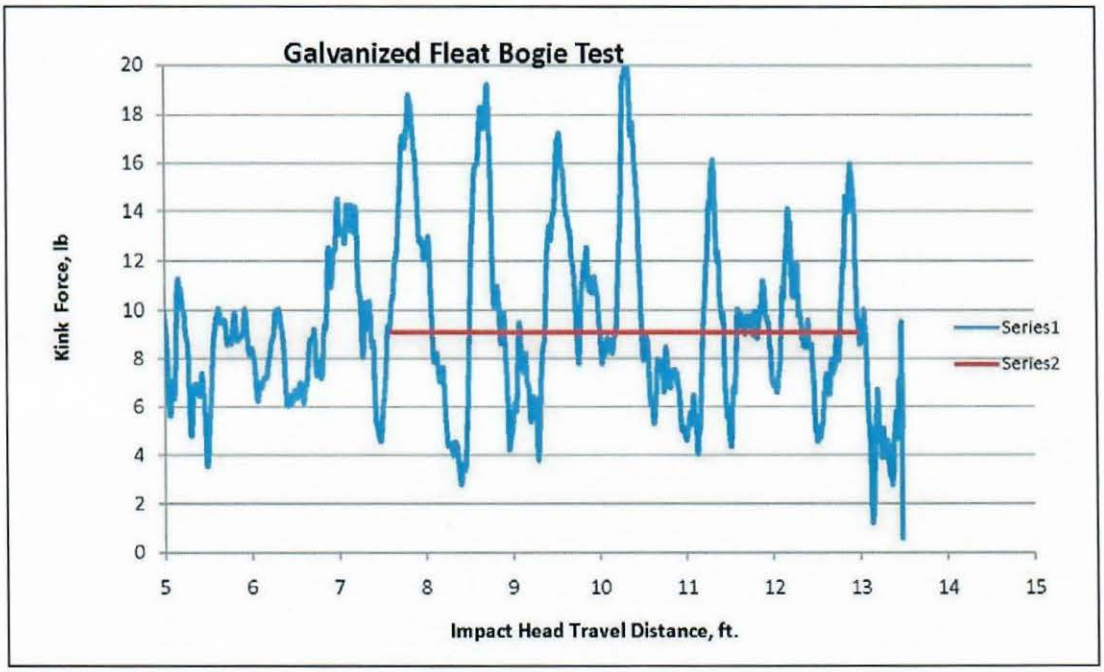


Figure 5. Plot of Kink Force v. Impact Head Travel Distance
Galvanized FLEAT Bogie Test

University of Nebraska
MIDWEST ROADSIDE SAFETY FACILITY

August 27, 2009

Mr. Kaddo Kothmann
Road Systems, Inc.
3616 Old Howard County Airport
Big Spring, TX 79720

Subject: Powder Coated Rail and Impact Heads for FLEAT and SKT W-Beam Terminals

Dear Mr. Kothmann,

This letter report summarizes the results of a bogie test on a powder coated rail and impact heads and provides evaluation of the use of the powder coated rail with the Sequential Kinking Terminal (SKT) and the Flared Energy Absorbing Terminal (FLEAT) terminals.

Purpose. Some agencies have recently discovered problems associated with weathering steel and are considering other options to maintain the aesthetic look of their steel barriers. One of the more common alternatives is to use W-Beam barriers and end treatments that are powder coated over the galvanized surface. In order to confirm the crashworthiness of this powder coated rail for use with the SKT and FLEAT terminals, Road Systems, Inc. requested for an evaluation of the impact performance of the powder coated rail and impact heads. As part of the study, a bogie test was conducted with the powder coated rail and the results were compared to those of previous bogie tests with the standard galvanized rail.

Bogie Test. A bogie test of the powder coated rail was conducted at the Midwest Roadside Safety Facility (MwRSF). The test setup was similar to previous bogie tests conducted with standard galvanized rail. The test installation consisted of 11.43 m (37 ft 6 in.) of straight guardrail installation, as shown in Figure 1. The first 3.81-m (12 ft-6 in.) rail section was a special end rail for the FLEAT terminal with a FLEAT impact head installed at the upstream end. Posts 1 and 2 were terminal end posts spaced at 1.91 m (6 ft 3 in.). Note that the test installation did not have a cable anchor. Posts 3 and 4 were breakaway line posts, spaced at 1.91 m (6 ft 3 in.) and 3.81 m (12 ft 6 in.), respectively. The downstream end of the rail was bolted to an immoveable block of concrete.

A bogie vehicle, weighing 2000 kg (4,405 lbs), impacted the FLEAT impact head head-on at a speed of 78.2 km/h (48.6 mph or 71.3 fps). The center of the bogie vehicle was aligned with the end of the rail. Upon impact, the impact head was pushed forward,

breaking the end post. The rail began to kink as designed. As the vehicle proceeded forward, the kinking continued and the posts broke away upon impact by the impact head. The entire length of 11.43 m (37 ft 6 in.) of rail was kinked and the bogie vehicle came to rest against the concrete block, as shown in Figure 2. A photograph of the kinked rail is shown in Figure 3. Detailed data and a video of the test are also available upon request.

Data Analysis. Figure 4 shows two partial plots of the kinking force over the impact head travel distance, one for 3.4 to 6.1 m (11 to 20 ft) and the second for 7 to 9.1 m (23 to 30 ft). As may be expected, the kinking force varies depending on the locations of the kinks and the breakaway posts. The kinking force averages 4,500 kg (9.9 kips) over the distance 3.4 to 6.1 m (11 to 20 ft) and 4,270 kg (9.4 kips) over the distance of 7 to 9.1 m (23 to 30 ft). In comparison, the average kinking force for a similar bogie test on a galvanized rail is 4,140 kg (9.1 kips), as shown in Figure 5.

Conclusions. The kinking force for the galvanized rail with a powder coated surface is similar, actually slightly higher, than that of a standard galvanized rail. Given the similarity in kinking force, it is logical to conclude that the impact performance of the powder coated rail would be similar to that of the standard galvanized rail. Thus, it is believed that the powder coated rail and impact heads can be used in place of the standard galvanized rail with no modification to the SKT or FLEAT terminal designs.

If you have any questions or comments regarding this matter, please do not hesitate to contact me.

Respectfully,

John Rohde, Ph.D. P.E.
Associate Professor