U.S. Department of Transportation
Federal Highway Administration

July 27, 2009

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

In Reply Refer To:
HSSD/B-193
(REVISED)

Mr. Rick Mauer
Outside National Sales Representative
Nucor Steel Marion
P.O. Box 837
Greenland, NH 03840

Dear Mr. Mauer:

This letter is in response to your request for the Federal Highway Administration (FHWA) acceptance of a roadside safety system for use on the National Highway System (NHS).

Name of system: Nu-Cable 4-Cable Median Barrier on 1V:4H Slopes
Type of system: Median Cable Barrier (TL-4 design)
Test Level: NCHRP Report 350 TL-3
Testing conducted by: Texas Transportation Institute and Holmes Solutions
Date of request: April 9, 2009
Date of completed package: May 18, 2009

You requested that we find this Test Level 4 (TL-4) median cable system acceptable for use on the NHS on 1V:4H slopes under TL-3 conditions of the National Cooperative Highway Research Program (NCHRP) Report 350 "Recommended Procedures for the Safety Performance Evaluation of Highway Features."

Requirements
Roadside safety systems should meet the guidelines contained in the NCHRP Report 350. FHWA Memorandum "Identifying Acceptable Highway Safety Features" of July 25, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

Description
The Nucor 4-Cable Nu-Cable TL-4 wire rope barrier system consists of the following components:

All steel line posts were AASHTO designator CLP-06 Rib-Bak 4-pounds-per-foot (6-kg/m) cable line posts, manufactured from 80,000-psi (552-MPa) yield / 100,000-psi (690-MPa) tensile hot rolled steel. The posts were perforated full length with 3/8-in (9.5-mm) holes on 1-in (25-mm) centers. The overall length of the line posts was 5 ft, 3 in (1600 mm). The line posts were placed inside HDPE (high density polyethylene) plastic or steel sockets which were cast into 12-in (300-mm) by 30-in (750-mm) reinforced concrete foundations.

The restraints consisted of four cables constructed using 3/4-in (19-mm) 3 x 7 strand galvanized pre-stretched cable with a breaking strength in excess of 36,800 lbs (16,700 kg). The actual cable breaking strength was approximately 41,500 lbs (18,825 kg). The cables were tensioned to a nominal 5600 lbs (25 kN) at an ambient temperature of 70°F (21°C). The cables were designed to be placed at heights of 18.5 in (470 mm), 30.5 in (770 mm), 38.5 in (980 mm) and 41.5 in (1065 mm) above ground. The actual placement varied minimally between the three tests due to construction tolerance of plus or minus 2 in (50 mm). The top and bottom cables were placed on the side of the post closest to traffic while the two middle cables were on the ditch side.

The posts were located in a line, offset 4 ft (1220 mm) horizontally and 12 in (305 mm) vertically below the top edge of the backslope of the depressed median placing them 11 ft (3350 mm) from the centerline of the median ditch. The line post spacing was 20 ft (6.1 m). The soil was NCHRP Report 350 “Standard” soil.

All cable terminations used cable grip fittings which consisted of three tapered ‘jaws’ that fit inside a tapered casing and a tail piece screwed into the rear of the casing. The cable tension adjustment was achieved with turnbuckle-like devices, fabricated from 3/8-in (10-mm) x 3/4-in (20-mm) low tensile steel side arms, welded to 1 1/8-in (30-mm) thick end-washers.

A top clip was used to secure the top two cables (cables 1 and 2) to the steel line posts. The clip was fabricated from 3/4-in (19-mm) x 1/4-in (6-mm) mild steel flat. The clip is retained by a triangular shaped band manufactured from 0.1-in (2.4-mm) flat steel, folded and spot welded together at the ends. Two locking hook bolts were used to secure the lower two cables (cables 3 and 4) to the steel line posts. The locking hook bolts were manufactured from 5/16-in (8-mm) steel rod.

Crash Testing
Three tests were performed in order to capture the “worst practical conditions”. All of the tests were performed in 30-ft wide ditches. The overall length of the runs tested were all approximately 340 ft (104 m). The critical impact point (CIP) was chosen to have the impact occur directly on a line post.

1. NCHRP Report 350 Test Designation 3-10 [TTI Test # 400001-NSM11]
   An 1808-lb (820-kg) passenger car impacted the critical impact point (CIP) of the length-of-need (LON) at 61.8 mph (99.5 km/h) and 21.4 degrees. The impact occurred on the **near** side of the 1V:4H slope with the barrier located 4 ft (1220 mm) down from the breakpoint. The vehicle engaged all four cables, with the top cable contacting the "A" pillar and causing a 1.8-inch (46-mm) tear in the windshield before sliding briefly up onto the roof. The test vehicle was smoothly redirected parallel to the barrier and remained upright.

2. NCHRP Report 350 Test Designation 3-10 [Holmes Solutions Test # 102350.01-3]
   An 1808-lb (820-kg) passenger car was directed towards the CIP of the LON at 63.9 mph (102.8 km/h) and 20 degrees. The impact occurred on the **far** side 1V:4H slope with the barrier located 11 ft (3350 mm) beyond the centerline of the median ditch. The test vehicle initially impacted near the base of the slope, slowing the vehicle such that the subsequent impact with the test article occurred at a speed of 55.9 mph (89.9 km/h). The front of the vehicle engaged all four cables with no contact in the windshield area, and was redirected upright.

3. Manual for Assessing Safety Hardware (MASH) Test Designation 3-11
   [TTI Test # 400001-NSM10]
   A 5100-lb (2313-kg) quad cab pickup truck impacted the CIP of the LON at 63.2 mph (101.7 km/h) and 26.6 degrees. The impact occurred on the **near** side of the 4:1 slope with the barrier located 4ft (1220 mm) down from the breakpoint. The test vehicle engaged all four cables and was smoothly redirected parallel to the barrier while remaining upright. The maximum dynamic deflection was 9.6 ft (2.93 m).

The test data summary sheets for these three tests are enclosed for reference.

Findings

The results of the 3-10 tests conducted under the guidance of NCHRP Report 350 and the 3-11 test conducted under the guidance of MASH met the respective test and evaluation criteria with the exception of the test article length. We considered allowing the use of the NCHRP Report 350 Test 3-10 (with a lighter small car) and the MASH Test 3-11 (with the heavier pickup truck) to represent the "worst case scenario" for qualifying the device to be compliant under both Report 350 and MASH. We agreed with you prior to the testing that you could submit this request under both criteria, however the 3-11 test using the quad cab pickup truck was conducted on an installation of 343 feet of barrier which does not meet the MASH minimum of 600 feet. Therefore, the system described above and detailed in the enclosed drawings is acceptable for use on 1V:4H median slopes on the NHS under the range of conditions tested agreeable to NCHRP Report 350 only, when such use is acceptable to a highway agency.

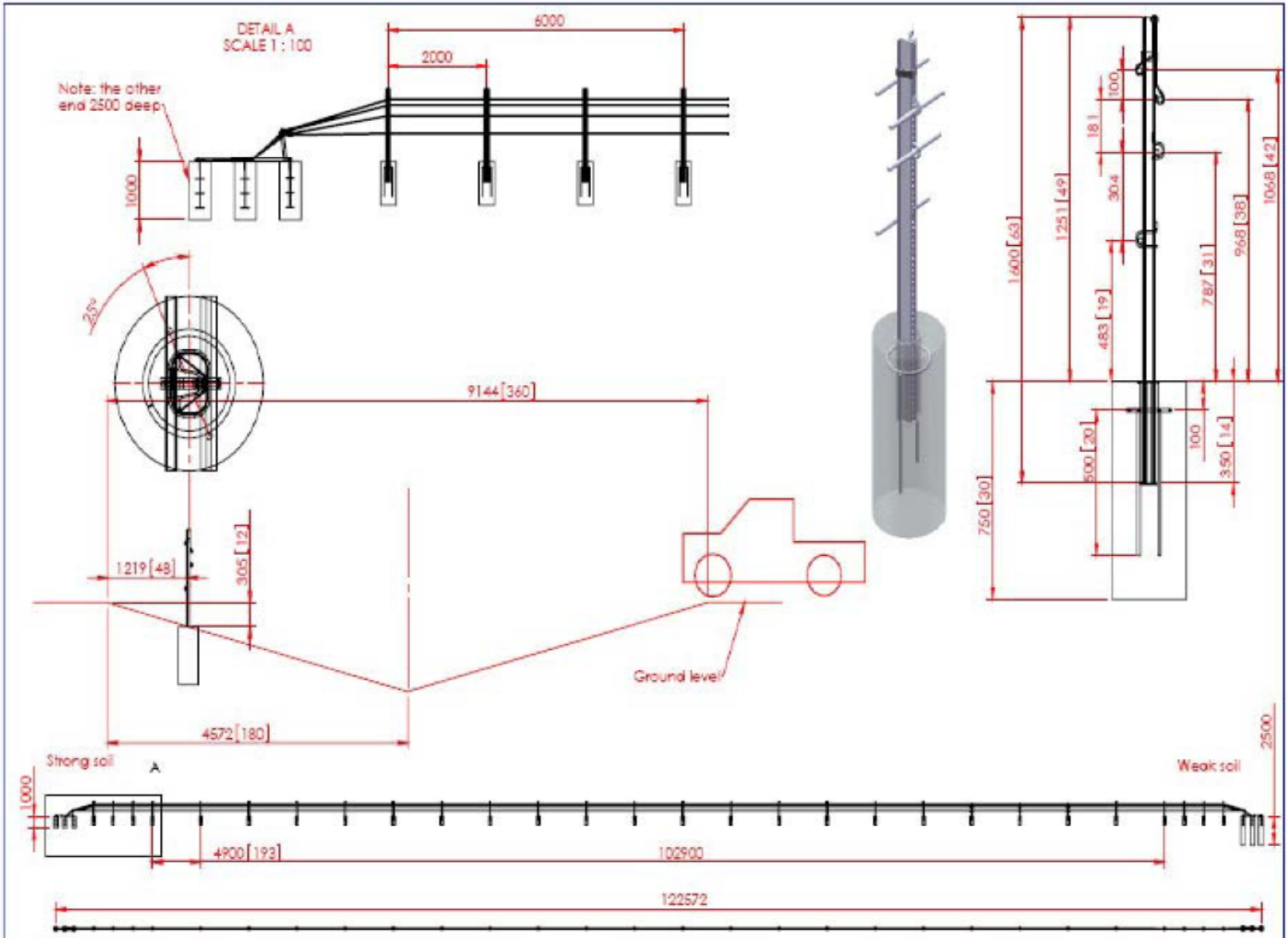
Please note the following standard provisions that apply to FHWA letters of acceptance:

- This acceptance is limited to the crashworthiness characteristics of the systems and does not cover their structural features, nor conformity with the Manual on Uniform Traffic Control Devices. Any changes that may adversely influence the crashworthiness of the system will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the system being marketed is significantly different from the version that was crash tested, we reserve the right to modify or revoke our acceptance.
- 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 acceptance, and that it will meet the crashworthiness requirements of the FHWA and the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance is designated as number B-193 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.
- The Nu-Cable barriers are patented products and considered proprietary. If proprietary systems are specified by a highway agency for use on Federal-aid projects, except exempt, non-NHS 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.
- This acceptance 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. The acceptance letter is limited to the crashworthiness characteristics of the candidate system, 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,

David A. Nicol, P.E.
Director, Office of Safety Design
Office of Safety

Enclosures



REV.	CHANGES	DATE

SCALE: 1:500

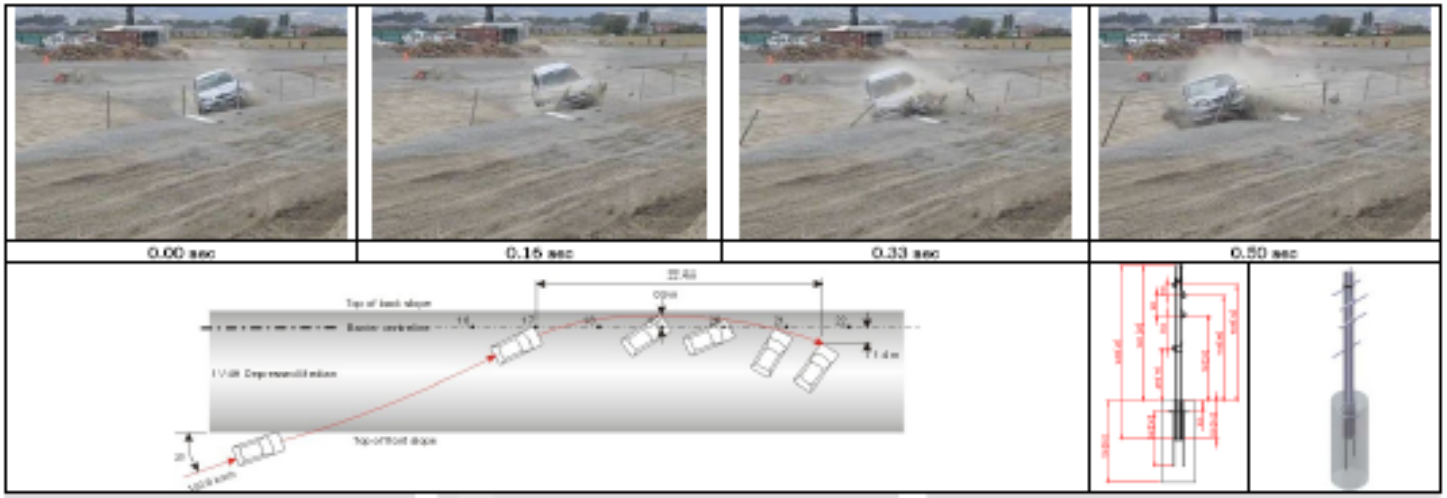
Standard Tolerance

	DATE	INIT.
DRAWN BY		AD
APPR'D BY		DJ

Nucor Wire
Ditch test

ARMORFLEX New Zealand
8 Paul Matthews Rd.
Albany, Auckland, NZ
tel. 64 9 415 2991
fax. 64 9 415 2993
info@armorflex.co.nz

SHEET	DRAWING NUMBER	REV.
1 OF 1		



TEST ARTICLE

Nucor 4-Wire Rope Barrier with 4 lb line posts installed on the backslope of a 1H:4V depressed median.

Test Level	NCHRP 350 TL 3-10
Length.....	102.0 m barrier LON
	122.6 m overall
Rope Heights.....	470/770/980/1065 mm
Post Centres.....	4900 mm
Soil Type.....	AASHTO M 147-65 Standard Soil

TEST VEHICLE

Designation.....	820C - Small Car
Make/Model.....	Toyota Starlet EP91
Dimensions (lwh)....	3790 x 1625 x 1400
Gross Weight.....	894 kg

CIP

300 mm upstream from line post 17.

IMPACT CONDITIONS

Impact Speed*.....	102.8 km/h*
Impact Angle*.....	20 degrees*

* Exit speed and angle from road surface at top of frontslope.

TEST ARTICLE DEFLECTIONS (METRES)

Test Article Damage...	Significant
Dynamic.....	700 mm
Permanent.....	nil
Working Width.....	900 mm

VEHICLE DAMAGE - EXTERIOR

VDS.....	11-FL-4
CDC.....	11FLEL3
Max Deformation	200 mm

VEHICLE DAMAGE - INTERIOR

OCDI.....	AS000000000
Max. Deformation	10 mm to LH floor area

POST IMPACT BEHAVIOUR

Vehicle Stability.....	Good
Stopping Distance...	22.4 metres
Max. Roll angle.....	34.3° at 1.1723 sec
Max. Pitch angle.....	-14.6 ° at 3.5639 sec
Max. Yaw angle.....	33.8 at 3.3648 sec

OCCUPANT RISK VALUES

IMPACT VELOCITY (m/s – LEFT SIDE OF INTERIOR)

x-direction.....	-1.1 m/s at 0.6292 sec
y-direction.....	-0.8 m/s at 0.6292 sec
THIV	1.4 m/s at 0.6234 sec

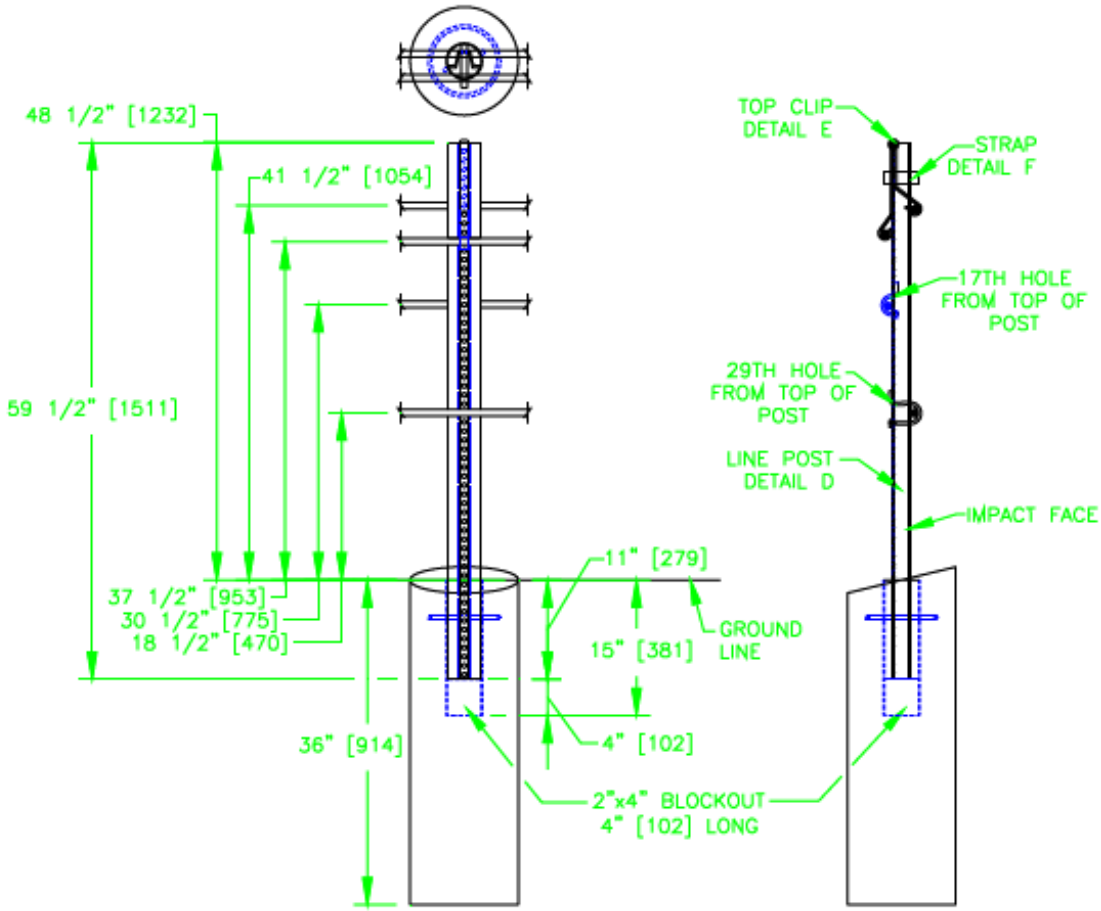
RIDEDOWN ACCELERATIONS (G)

x-direction.....	-8.5 at 1.0231 – 1.0331 sec
y-direction.....	-3.8 at 09765 – 0.9865 sec
PHD	8.5 g at 1.0231 – 1.0331 sec
ASI	0.70 at 1.0088 – 1.0588 sec

MAX. 0.050 SECOND AVERAGE (G)

x-direction.....	-5.8 at 1.0092 – 1.0592 sec
y-direction.....	-2.0 at 2.5751 – 2.6251sec
z-direction.....	6.0 at 1.0981 – 1.1481 sec

Figure 3-5: Summary of results for test 2-810



LENGTH OF NEED POSTS
11-21

NOTE: CABLE HEIGHTS ARE TO THE MIDDLE OF THE CABLE.

The Texas A&M University System

Revisions			
No.	Date	By	CK.
1.	05/27	AC	
2.			
3.			
4.			
5.			

TEXAS TRANSPORTATION INSTITUTE
COLLEGE STATION, TEXAS 77843

Project No.	Date	Drawn By	Scale
400001	2008/03/06	AWC	

NSM 11

Sheet No. 7 of 10

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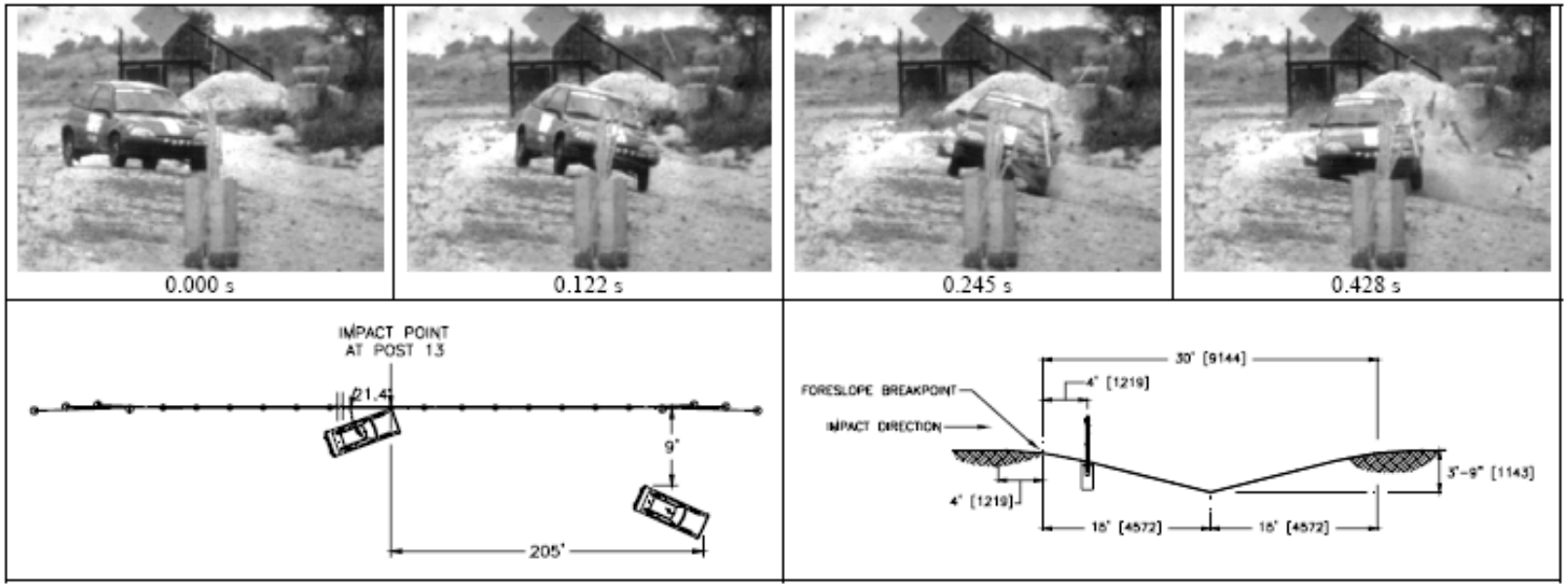
Jul 23, 2008 - 11:44am

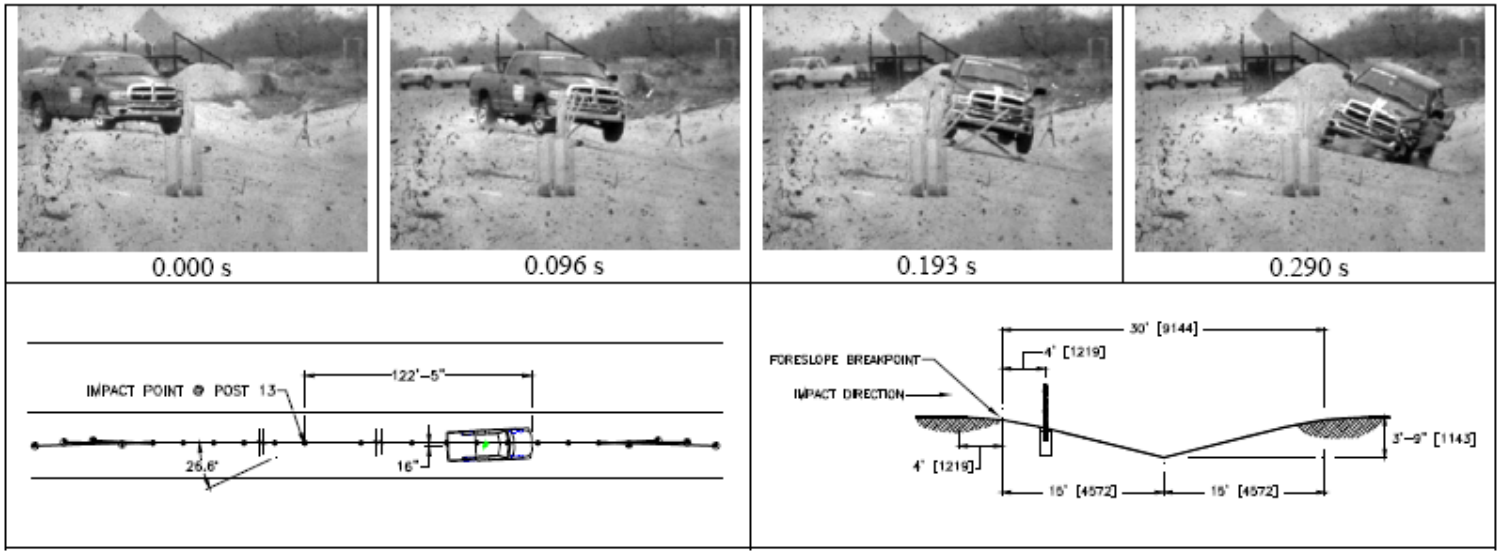


General Information	
Test Agency	Texas Transportation Institute
Test No.	400001-NSM11
Date	2008-04-10
Test Article	
Type	Longitudinal Barrier
Name	Nucor Steel Marion 4-Cable High-Tension
Installation Length (ft)	343.5
Material or Key Elements	4-cable barrier system with 0.75-inch dia. 3x7 pre-stretched wire rope anchored with Nucor Steel Marion proprietary cable terminal
Soil Type and Condition	Standard Soil, Dry, on Foreslope
Test Vehicle	
Designation	820C
Model	1998 Chevrolet Metro
Mass (lb)	
Curb	1786
Test Inertial	1799
Dummy	170
Gross Static	1969

Impact Conditions	
Speed (mi/h)	99.4
Angle (deg)	21.4
Exit Conditions	
Speed (mi/h)	N/A
Angle (deg)	0
Occupant Risk Values	
Impact Velocity (m/s)	
Longitudinal	1.4
Lateral	4.3
THIV (km/h)	15.3
Ridedown Accelerations (g's)	
Longitudinal	-6.5
Lateral	3.9
PHD (g's)	6.6
ASI	0.50
Max. 0.050-s Average (g's)	
Longitudinal	-2.7
Lateral	4.4
Vertical	-1.3

Test Article Deflections (ft)	
Dynamic	3.23
Permanent	N/A
Working Width	3.58
Vehicle Damage	
Exterior	
VDS	11LFQ3
CDC	11LFDW3
Max. Exterior Vehicle Crush (inches)	6.7
Interior	
OCDI	LF0000000
Max. Occupant Compartment Deformation (inches)	0.39
Post-Impact Behavior	
(during 1.0 sec after impact)	
Max. Yaw Angle (deg)	-54
Max. Pitch Angle (deg)	15
Max. Roll Angle (deg)	22

Summary of results for *NCHRP Report 350/MASH08* test 3-10 on the Nucor Steel Marion 4-cable high tension cable barrier.



General Information	
Test Agency	Texas Transportation Institute
Test No.	400001-NSM10
Date	2008-03-06
Test Article	
Type	Longitudinal Barrier
Name	Nucor Steel Marion 4-Cable High-Tension
Installation Length (ft)	343.5
Material or Key Elements	4-cable barrier system with 0.75-inch dia. 3x7 pre-stretched wire rope anchored with Nucor Steel Marion proprietary cable terminal
Soil Type and Condition	Standard Soil, Dry, on 4:1 Foreslope
Test Vehicle	
Designation	2270P
Model	2002 Dodge 1500 Quad-Cab Pickup
Mass (lb)	
Curb	4818
Test Inertial	5100
Dummy	No dummy
Gross Static	5100

Impact Conditions	
Speed (mi/h)	63.2
Angle (deg)	26.6
Exit Conditions	
Speed (mi/h)	Did not
Angle (deg)	exit
Occupant Risk Values	
Impact Velocity (ft/s)	
Longitudinal	7.9
Lateral	11.2
THIV (km/h)	14.1
Ridedown Accelerations (g's)	
Longitudinal	-3.2
Lateral	5.4
PHD (g's)	5.5
ASI	0.4
Max. 0.050-s Average (g's)	
Longitudinal	-2.7
Lateral	3.5
Vertical	-2.5

Test Article Deflections (ft)	
Dynamic	9.6
Permanent	N/A
Working Width	10.9
Vehicle Damage	
Exterior	
VDS	11LF2
CDC	11LFEW2
Max. Exterior Vehicle Crush (inches)	7.1
Interior	
OCDI	LF0000000
Max. Occupant Compartment Deformation (inches)	0
Post-Impact Behavior (during 1.0 sec after impact)	
Max. Yaw Angle (deg)	36
Max. Pitch Angle (deg)	7
Max. Roll Angle (deg)	-32

Figure 5.6. Summary of results for *MASH08* test 3-11 on Nucor Steel Marion 4-cable high-tension barrier.

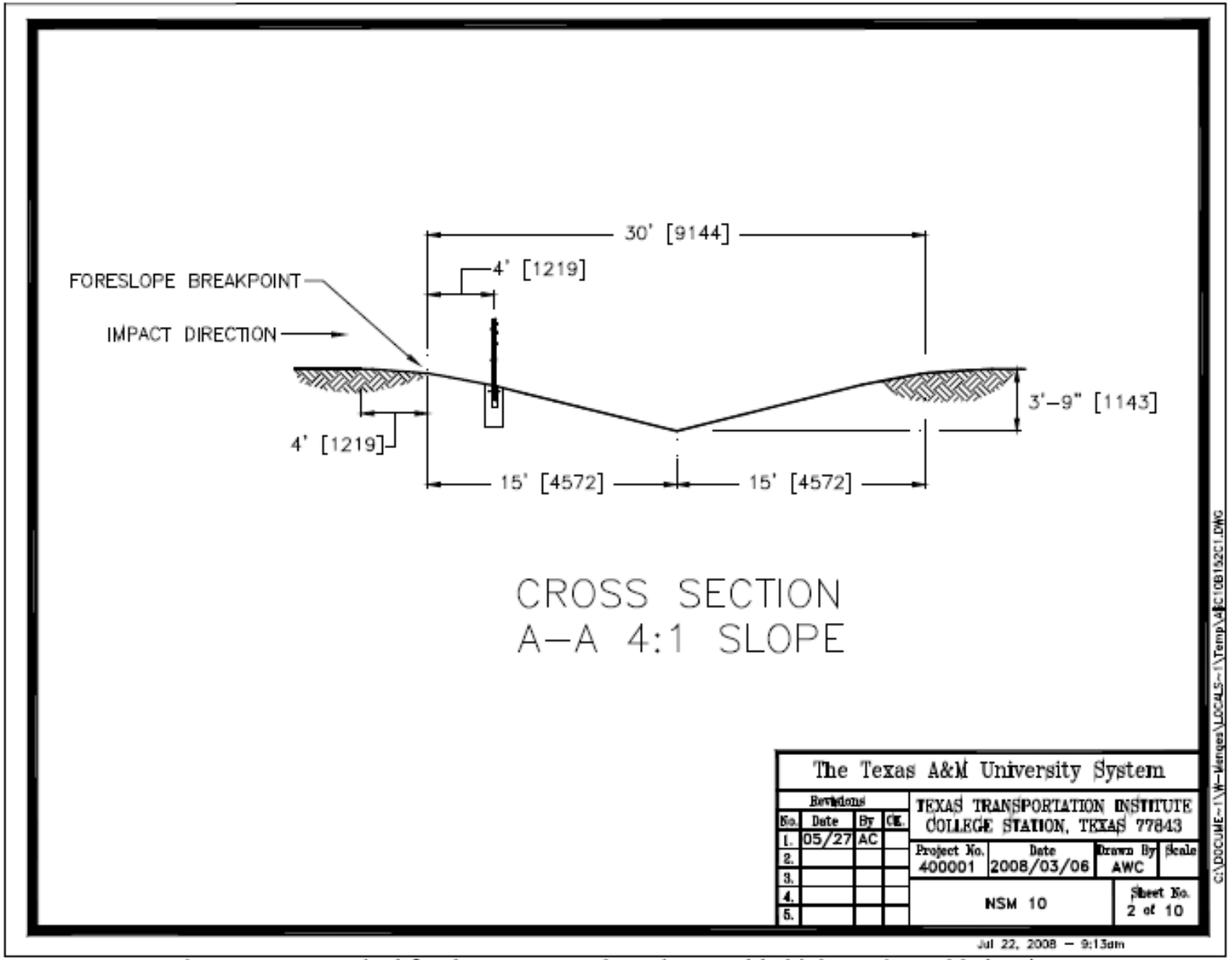


Figure A-2. Terminal for the Nucor Steel Marion 4-cable high-tension cable barrier.