U.S. Department
of Transportation
Federal Highway Administration

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

January 27, 2012

In Reply Refer To:
HSST/ B-222

Mr. Dallas James
Armorflex International Ltd
156 Foundry Road
Silverdale 0932
Auckland
New Zealand

Dear Mr. James:

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:	Armorwire
Type of system:	Cable Barrier with 3 or 4 Cable
Test Level:	NCHRP Report 350 TL-3 & TL-4
Testing conducted by:	Holmes Solutions Ltd (HSL)
Date of request:	December 15, 2010
Request initially acknowledged:	December 17, 2010
Task Force 13 Designator:	SGM33 a-b

Decision
The following device is eligible, with details provided below:
• Armorwire Cable Barrier with 3 or 4 Cable

Based on a review of crash test results submitted by the manufacturer certifying the device described herein meets the crashworthiness criteria of the National Cooperative Highway Research Program (NCHRP) Report 350, 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 the 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.

Requirements
Roadside safety devices should meet the guidelines contained in NCHRP Report 350 (Report 350) if tested prior to January 1, 2011, or the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH) if tested after that date. The FHWA Memorandum "Identifying Acceptable Highway Safety Features", dated July 25, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

Description

The Armorwire systems use either 3 (for TL-3) or 4 (for TL-4) 19 millimeters (¾-inch) 3 x 7 strand galvanized pre-stretched cable with a breaking strength in excess of 227kN. The lower 3 cables are the same configuration for each system with cable heights of 530 millimeters (20.8 inches), 650 millimeters (26.0 inches) and 770 millimeters (30.3 inches) to the centre of the cable from ground level. For the 4 cable system, a second cable is added to the top slot in the post at a height of 790 millimeters (31.1 inches) from ground level. The cables are housed in galvanized steel, flat sided oval posts 1220 millimeters (48 inches) long and 3 millimeters (⅛-inch) thick. Once connected to the appropriate terminal ends, the system is tensioned to a nominal 25kN (5,600 pounds) at 21°C (70°F). Each post has a notch on each side and 1 slot cut into the top of the post. All posts used in the Armorwire cable barrier are installed in 350 millimeters (13.8 inches) deep plastic sockets cast into concrete foundation piles 300 millimeters (11.8 inches) in diameter by 750 millimeters (29.5 inches) deep. The soil was AASHTO 'standard' soil. Drawings of both Armorwire designs are provided as an enclosure to this correspondence.

Crash Testing

The following four (4) tests for a re-directive cable barrier as per Report 350 TL-3 and TL-4 were conducted. The barrier was anchored using the ATE-4 cable terminal which was previously accepted by the FHWA Letters CC-105 and CC-105A as either a 3 or 4 cable terminal end.

A. Test 4-10 was conducted with the 820C test vehicle on the 4 cable system which was 115 meters (377 feet) long including two 8 meters (26 feet) long Terminal Ends. The CIP was mid-span between posts 10 and 11, and the posts were installed on 3 meters (9.83 feet) centers in the impact area. The vehicle was smoothly re-directed by the barrier with all 4 cables remaining in contact with the impact side of the vehicle. The occupant risk values were all below the preferred limits. The dynamic deflection was 1280 millimeters (50.4 inches).

B. Test 3-11 was conducted with the 2000P truck on the 3 cable system which was 130 meters (427 feet) long including two 8 meters (26 feet) long Terminal Ends. The CIP was 2 meters (6.56 feet) upstream of post 13, and the posts were again installed on 3 meters (9.83 feet) centers in the impact area. The vehicle was slowed and smoothly re-directed by the barrier. The occupant risk values were all below the Report 350 preferred limits. The dynamic deflection was 1540 millimeters (60.6 inches).

C. Test 4-11 was not conducted since it is identical to test 3-11.

D. Test 4-12 was conducted with the single-unit truck on the 4 cable system which was 130 meters (427-foot) long including two 8-meter (26-foot) long Terminal Ends. The CIP was at post 13, with the posts again installed on 3-meter (9-foot-10-inch) centers in the impact area. The vehicle was slowed and smoothly re-directed and captured by the barrier. The occupant risk values were all below the preferred limits. The dynamic deflection was 1650-millimeter (65.0-inch).

E. Test 3-11 was conducted with the 2000P truck a second time on the 3 cable system which was 115 meters (377feet) long including two 8 meters (26 feet) long Terminal Ends. The CIP was mid-span between posts 10 and 11, this time with the posts installed on 9 meters (29.5 feet) centers in the impact area. The vehicle was smoothly re-directed and captured by the barrier with

all 3 cables remaining in contact with the impact side of the vehicle. The occupant risk values were all below the preferred limits. The dynamic deflection was 3270 millimeters (128.7 inches).

The crash test summary sheets are included as an enclosure to this correspondence.

Findings
The systems described above passed all required Report 350 crash tests. Occupant Impact Velocities (OIV) associated with all tests are below the preferred limit and Occupant Ridedown Acceleration (ORA) for all tests were below the preferred limit.

In your letter, you requested FHWA review of the following configurations for the Armorwire as an NCHRP 350 TL-3 and TL-4 Longitudinal Barrier:

I. Armorwire TL-3 Cable Barrier – 3-cable system, for use with post spacing of 3 meters (9.83 feet) through to 9 meters (29.6 feet).

II. Armorwire TL-4 Cable Barrier – 4-cable system, for use with post spacing of 3-meters (9.83 feet) through to 9 meters (29.6 feet).

We concur that the 3-cable design described above and detailed in the enclosed drawings is eligible for reimbursement as an NCHRP Report 350 barrier at TL-3 with a post spacing ranging from 3 meters (9.84 feet) to 9 meters (29.53 feet) under the range of conditions tested, when such use is acceptable to a highway agency. We further agree that the 4-cable design is eligible for reimbursement as an NCHRP Report 350 barrier at TL-4, but only with the 3 meters (post spacing that was actually tested. Based on that one test, there is no reliable method by which the dynamic deflection of the system with 9 meters post spacing can be accurately predicted for an impact with the single-unit truck. A secondary concern is that with large barrier deflections over non-level (sloping terrain), a high center of gravity vehicle is more likely to overturn, rather than be contained and redirected.

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

- This letter provides a AASHTO/ARTBA/AGC Task Force 13 designator that should be used for the purpose of the creation of a new and/or the update of existing Task Force 13 drawing for posting on the on-line 'Guide to Standardized Highway Barrier Hardware' currently referenced in AASHTO Roadside Design Guide.
- This finding of eligibility 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 influence the crashworthiness of the system will require a new reimbursement eligibility letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals safety problems, or that the system is significantly different from the version that was crash tested, we reserve the right to modify or revoke this letter.

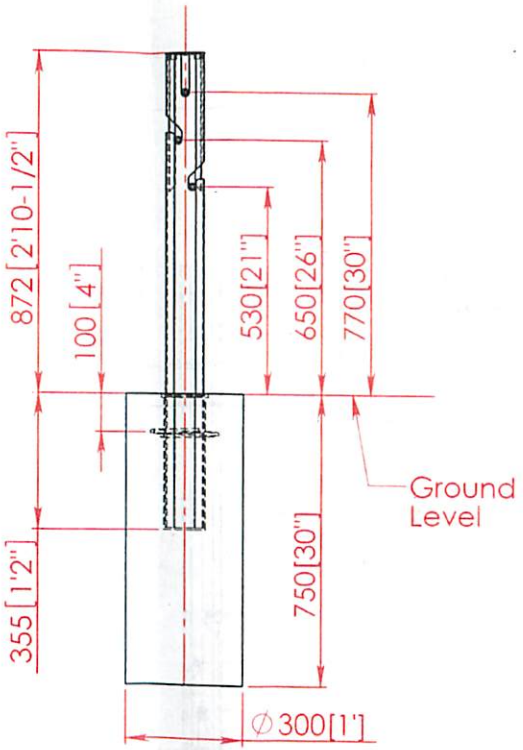
- You will be expected to supply potential users with sufficient information on design and installation requirements to ensure proper performance.
- You will be expected to certify to potential users that the hardware furnished has the same chemistry, mechanical properties, and geometry as that submitted for review, and that it will meet the crashworthiness requirements of the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of eligibility is designated as number B-222 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 system for which the applicant is not the patent holder. The finding of eligibility 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.
- The Armorwire systems are patented products and considered 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.
- Although the barrier performed well under ideal test impact conditions with the two test vehicles, the likelihood of passenger car underrides of any cable system may increase as the post spacing increases, particularly when the barrier is installed on non-level or slightly irregular terrain and the cables are not restrained from lifting at each post. Consequently, some transportation agencies have limited post spacing to approximately 6m (20 feet) for cable barriers. The dynamic deflection of the barrier is likely to increase when it is installed along the convex sides of horizontal curves, and when distances between anchorages exceed the 115- to 130-m (377- to 427-foot) test lengths.

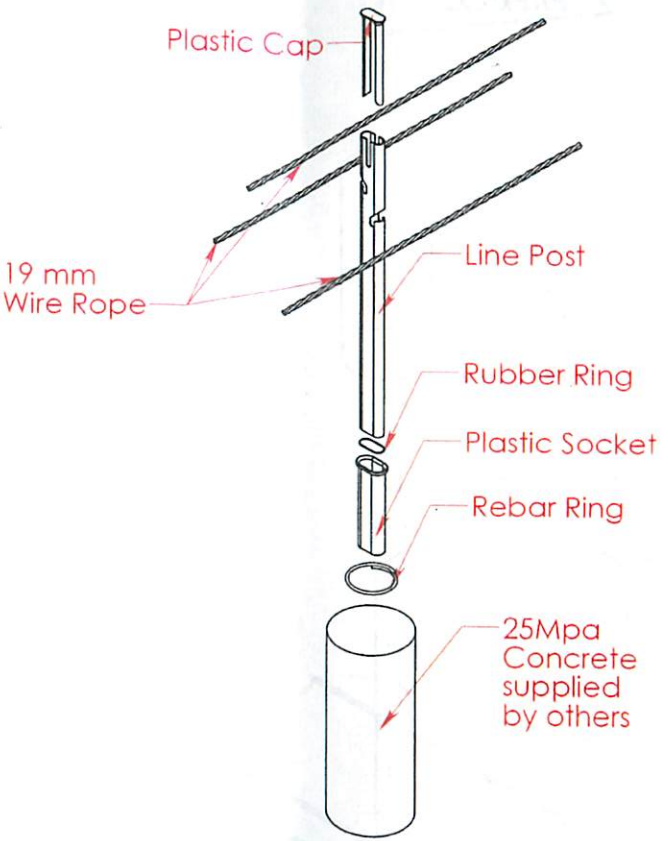
Sincerely yours,

Michael S. Griffith

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

Enclosures





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REV.	CHANGES	DATE

SCALE: 1:15

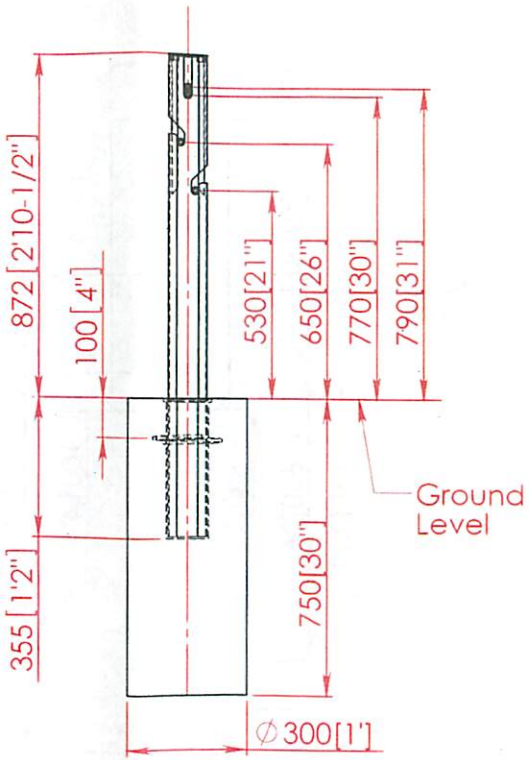
	DATE	INIT.
DRAWN BY	21/12/2010	AD
APPR'D BY	21/12/2010	DJ

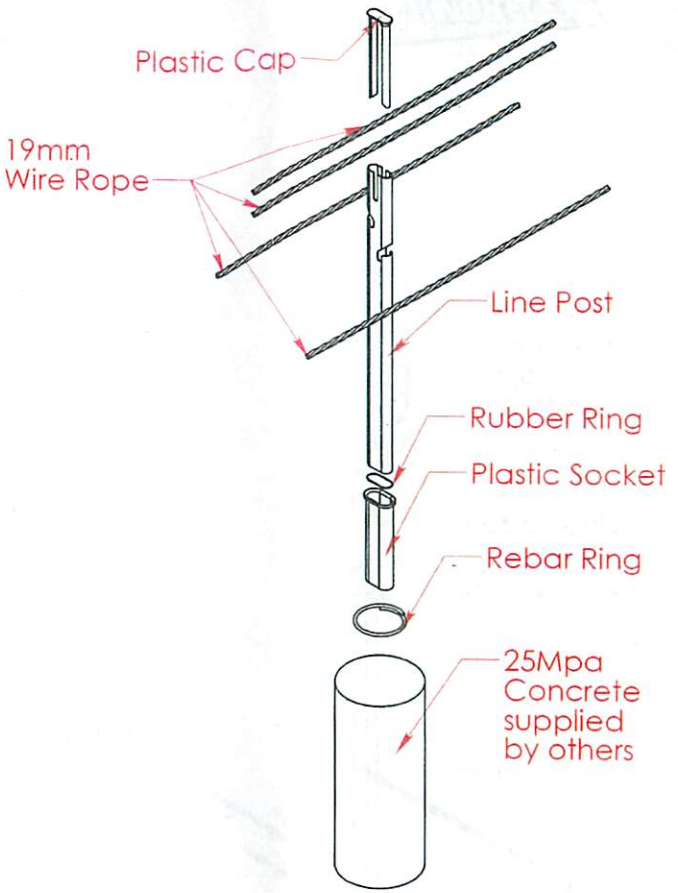
Standard Tolerance

Armorwire TL-3 ,3 cable system

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

SHEET	DRAWING NUMBER	REV.
1 OF 1	C-LP-A4.V2	





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REV.	CHANGES	DATE

SCALE: 1:15

	DATE	INIT.
DRAWN BY	21/12/2010	AD
APPR'D BY	21/12/2010	DJ

Standard Tolerance

Armorwire TL-4 ,4 cable system

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

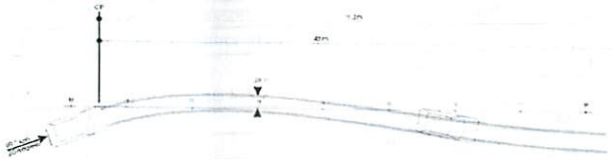
SHEET	DRAWING NUMBER	REV.
1 OF 1	C-LP-A5.V2	

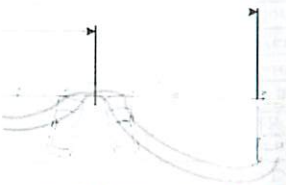
Test Summary

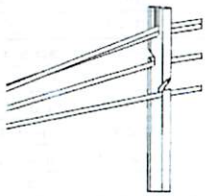
Holmes Solutions Limited, New Zealand

Test No. 102350.02-6 // Test 3-10 // 9 Feb 2010

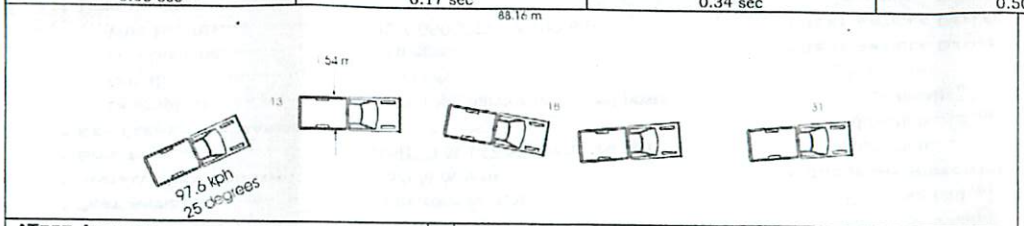
0.00 sec | 0.17 sec | 0.35 sec | 0.52 sec | 0.70 sec

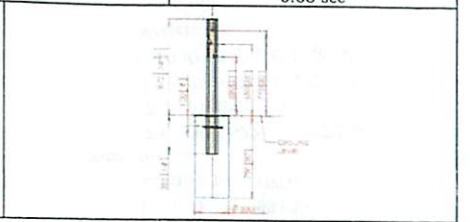






- **Test Agency** ..... Holmes Solutions Ltd
- **Test No.** 102350.02-6 T3
- **Test date** ..... 9 February 2010
- **Test Article** ..... 4-wire rope barrier
- **Installation Length** ..... 118.9 M overall
- **Soil Type** ..... AASHTO M 147-65 Standard soil
- **Key Elements – Barrier**
  - Description..... 4-wire rope barrier with steel posts
  - Length ..... 99 m LON
  - Post Spacing ..... 3.0 metres
  - Wire Heights..... 530 / 650 / 770 / 790 mm
- **Test Vehicle**
  - Designation..... 820C
  - Make/Model..... Toyota Starlet
  - Dimensions (lwh)..... 3700 x 1600 x 1340
  - Curb Wt..... 753 kg
  - Test Inertial Wt..... 834.5 kg
  - Gross Static Wt..... 911.5 kg
- **Impact Conditions**
  - Speed ..... 99.7 kph
  - Angle ..... 20 deg
  - Impact point ..... Midspan between posts 10 and 11
- **Exit Conditions**
  - Exit speed ..... 70.5 kph
  - Exit angle 11º
- **Occupant Impact Velocity (m/s)**
  - Longitudinal ..... 3.5 m/s at 0.1613 s on right of interior
  - Lateral (optional)..... 4.6 m/s at 0.1613 s
  - THIV (optional)..... 5.2 m/s at 0.1570 s
- **Occupant Ridedown Acceleration (g)**
  - x-direction..... -7.0 g (0.1672 – 0.1772 s)
  - y-direction..... -7.1g (0.2906 – 0.3006 s)
  - PHD (optional) ..... 8.2 g (0.1673 – 0.1773 s)
  - ASI (optional) ..... 0.60 (0.1269 0 0.1769 s)
- **Test Article Damage** ..... Moderate
- **Test Article Deflections (m)**
  - Dynamic..... 1280 mm
  - Permanent..... 230 mm
- **Vehicle Damage – Exterior** .....
  - VDS 11-LFQ-5
  - CDC 11EYAW6
  - Maximum Deformation ..... 120 mm
- **Vehicle Damage - Interior**
  - OCDI LF0000100
- **Post Impact Vehicle Behavior**
  - Vehicle stability..... Satisfactory
  - Stopping distance..... 51.7 metres
  - Max. roll angle ..... 13.8º at 1.7587 s
  - Max. pitch angle ..... 5.6º at 0.5590 s
  - Max. yaw angle ..... 35.3º at 1.7790 s

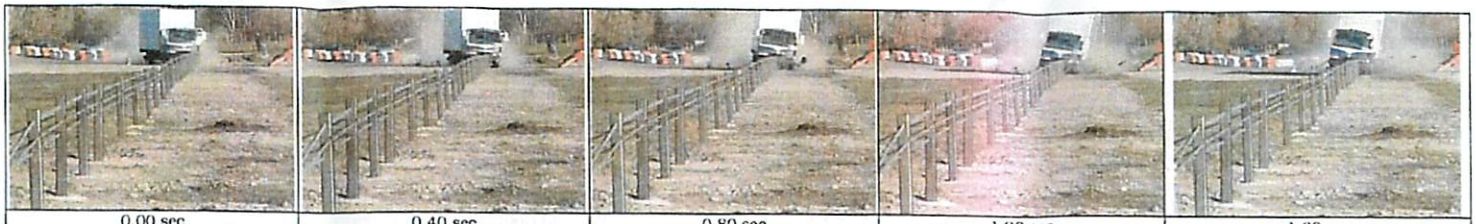




•TEST ARTICLE	
Armorwire Cable Barrier with 3 cables	
Test Level	NCHRP 350 Test 3-11
Length.....	114 metres
Wire Heights.....	530, 650, 770 mm
Post Centres.....	3.0 m in impact area
Soil Type.....	AASHTO Standard Soil
•TEST VEHICLE	
Designation.....	2000P
Make/Model.....	Chevrolet Silverado
Dimensions (lwh)	5560 x 1950 x 1880
Test Inertial Wt...	2044 kg
•CIP	
2.0 metres upstream of line post 13, 36.0 metres downstream of the terminal end trigger post.	

•IMPACT CONDITIONS	
Impact Speed	97.6 kph
Impact Angle	25°
Exit Speed	-
Exit Angle	-
•TEST ARTICLE DEFLECTIONS (METRES)	
Damage.....	Substantial
Dynamic.....	1.54 m
Permanent.....	0.00 m
Working Width.....	1.54 m
•VEHICLE DAMAGE - EXTERIOR	
VDS.....	11-LFQ-3
CDC.....	11FLEE3
Max Deformation	100 mm to LF corner
•VEHICLE DAMAGE - INTERIOR	
OCDI.....	AS00000000
Max. Deformation	0.0 mm

•POST IMPACT BEHAVIOUR	
Vehicle Stability.....	Good
Stopping Distance.....	88.16 metres
Max. Roll angle.....	8.9 at 0.8905 seconds
Max. Pitch angle.....	-4.1 at 0.9397 seconds
Max. Yaw angle.....	-34.3 at 0.5010 seconds
•OCCUPANT RISK VALUES	
IMPACT VELOCITY (M/S – RIGHT SIDE OF INTERIOR)	
x-direction.....	3.7 at 0.1585 seconds
y-direction.....	4.0 at 0.1585 seconds
THIV (m/s).....	5.1 m/s at 0.1585 seconds
RIDEDOWN DECELERATIONS (G)	
x-direction.....	-3.7 (0.3254 – 0.3354 s)
y-direction.....	-4.5 (0.1731 – 0.1831 s)
PHD	4.9 (0.2575 – 0.2675 s)
ASI	0.44 (0.2497 – 0.2997 s)
MAX. 0.050 SECOND AVERAGE (G)	
x-direction.....	-2.0 (0.0668 – 0.1168 s)
y-direction.....	-3.7 (0.2494 – 0.2994 s)
z-direction.....	-1.3 (0.2542 – 0.3042 s)



•Test Article		•Impact Conditions		•Post Impact Behaviour	
Armorwire Cable barrier with 4 cables		Impact Speed	82.5 kph	Vehicle Stability.....	Good
		Impact Angle	15°	Stopping Distance.....	110 metres
Test Level	NCHRP 350 Test 4-12	Exit Speed	-	Max. Roll angle.....	-10.8 (0.8230 seconds)
		Exit Angle	-	Max. Pitch angle.....	-8.9 (4.3279 seconds)
Length.....	114 metres	•Test Article Deflections (metres)		Max. Yaw angle.....	-21.4 (1.2981 seconds)
Wire Heights.....	530, 650, 770 and 790 mm	Damage.....	Substantial	•Occupant Risk Values	
		Dynamic.....	1.65 m**	Impact Velocity (m/s – Right side of interior)	
Post Centres.....	3.0 m in impact area	Permanent.....	0.00 m	x-direction.....	-1.5 m/s at 0.3453 s
Soil Type.....	AASHTO Standard Soil	Working Width.....	2.15 m	y-direction.....	2.0 m/s
		•Vehicle Damage - Exterior		THIV	2.7 m/s
•Test Vehicle		VDS.....	11-LFQ-2	Ridedown Decelerations (g)	
Designation.....	8000S	CDC.....	11FYSL4	x-direction.....	-1.4 (0.6316 – 0.6816 s)
ake/Model.....	Mitsubishi Fuso	Max Deformation	90 mm LF corner	y-direction.....	-1.9 (0.6225 - 0.6325 s)
Dimensions (lwh)	8650 x 2220 x 3610			PHD	2.3 (0.6522 – 0.6622 s)
Test Inertial Wt...	8050 kg	•Vehicle Damage - Interior		ASI	0.17 (0.6129 - 0.6629 s)
		OCDI.....	AS00000000	Max. 0.050 Second Average (g)	
•CIP		Max. Deformation	0.0 mm	x-direction.....	-0.9 (0.6316 – 0.6816 s)
Line post 13, 38.0 metres downstream of terminal end trigger post.				y-direction.....	-1.4 (0.6128 - 0.6628 s)
				z-direction.....	1.6 (1.7309 - 1.7809 s)

** A dynamic deflection of the barrier of 1.10 m occurred as a result of the initial redirection of the vehicle, 1.2 seconds after first contact with the test article. The maximum dynamic deflection was measured at 1.65 m as the vehicle was redirected a second time, 4.00 seconds after first contact with the test article

Test Summary

Holmes Solutions Limited, New Zealand

Test No. 102350.02-6 // Test 3-11 // 9 Feb 2010

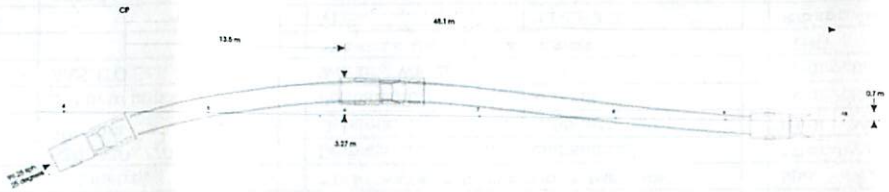

0.00 sec

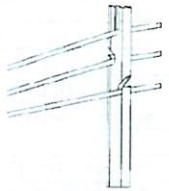

0.17 sec


0.35 sec


0.52 sec


0.70 sec





- **Test Agency** ..... Holmes Solutions Ltd
- **Test No.** 102350.02-6 T4
- **Test Date** ..... 9 February 2010
- **Test Article** ..... 3-wire rope barrier
- **Installation Length** ..... 118.9 m overall
- **Soil Type** ..... AASHTO M147-65 Standard soil
- **Key Elements – Barrier**
  - Description..... 3-wire rope barrier with steel posts
  - Length ..... 99 m LON
  - Post Spacing ..... 9.0 metres
  - Wire Heights..... 530 / 650 / 770 mm
- **Test Vehicle**
  - Designation..... 2000P
  - Make/Model..... Chevrolet C2500 Pick-up
  - Dimensions (lwh)..... 5535 x 1940 x 1840
  - Curb Wt..... 1927 kg
  - Test Inertial Wt..... 2001 kg
  - Gross Static Wt..... 2001 kg
- **Impact Conditions**
  - Speed ..... 99.25 kph
  - Angle ..... 25 deg
  - Impact point ..... Midspan between posts 4 and 5
- **Exit Conditions**
  - Exit speed ..... -
  - Exit angle ..... -

- **Occupant Impact Velocity (m/s)**
  - Longitudinal ..... 1.7 m/sec at 0.2246 s on RS of interior
  - Lateral (optional)..... 3.2 m/sec
  - THIV (optional)..... 3.5 m/sec at 0.2214 s on RS of interior
- **Occupant Ridedown Acceleration (g)**
  - x-direction..... -4.0 g (0.4378 – 0.4478 sec)
  - y-direction..... -4.8 g (0.3176 – 0.3276 sec)
  - PHD (optional) ..... 5.5 g (0.4041 – 0.4141 sec)
  - ASI (optional) .....
- **Test Article Damage** ..... Moderate
- **Test Article Deflections (m)**
  - Dynamic..... 3270 mm
  - Permanent..... 540 mm
- **Vehicle Damage – Exterior** .....
  - VDS 11-LFQ-4
  - CDC 11LFEW3
  - Maximum Deformation ..... 100 mm
- **Vehicle Damage - Interior**
  - OCDI AS0000000
- **Post Impact Vehicle Behavior**
  - Vehicle stability..... Satisfactory
  - Stopping distance..... 48.1 m
  - Max. roll angle ..... 8.1º at 1.1342 sec
  - Max. pitch angle ..... 4.4 º at 8.1499 sec
  - Max. yaw angle ..... -25.5 º at 2.2623 sec