



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

400 Seventh St., S.W.
Washington, D.C. 20590

June 9, 2005

In Reply Refer To: HSA-10/CC-91

Mr. Dallas James
Managing Director
Armorflex Ltd.
PO Box 303 177
North Harbour, Auckland, 1330, New Zealand

Dear Mr. James:

In your April 12 letter, you requested Federal Highway Administration acceptance of a W-beam guardrail terminal called the X350 as an National Cooperative Highway Research Program (NCHRP) Report 350 test level 3 (TL-3) design. To support this request, you sent me a March 2005 report prepared by the University of Canterbury in Christchurch, New Zealand, entitled "Armorflex X350 Redirective, Non-gating Guardrail Terminal End," system drawings, and digital videos of the crash tests that were conducted. Specific questions raised by my staff concerning the test vehicle specifications were adequately addressed in Dr. Chris Allington's June 3 letter response.

The Armorflex X350 terminal is designed for use with strong-post W-beam guardrail. Its unique design features include an impact head through which two anchor cables are threaded, breakaway line posts, a slider/slider bracket assembly, a cable anchor bracket, and a foundation anchor. Enclosure 1 shows the general layout of this 1143-cm long terminal and isometric views of its traffic and field sides. For side impacts, tension in the rail is transferred via the cables to the foundation anchor to provide containment and redirection. For head-on and angled impacts directly at the end, friction between the cables and the impact head dissipates crash energy and the slider/slider bracket assembly allows the first W-beam rail segment to slide back along the second segment and away from the impacting vehicle. To verify the crashworthiness of the X350, six NCHRP Report 350 tests were conducted, the summary sheets for each of which are shown in Enclosure 2.

Tests 3-30, 3-31, 3-32, 3-33, and 3-39 are standard tests for barrier terminals and crash cushions. Typically, W-beam terminals are also subjected to test 3-34 at the designated critical impact point (CIP) and test 3-35 to determine the beginning of the length of need (LON) for the barrier. However, since the X350 was believed to have redirection capability from just beyond the first post, you ran test 3-37 to verify the terminal's assumed performance when impacted immediately downstream from post 1. The successful results of test 3-37 indicated that the CIP point and the beginning LON point are at the same location for your terminal, making tests 3-34 and 3-35 redundant and, therefore, unnecessary. Based on the post-crash



trajectories of the vehicles in tests 3-32 and 3-33, the X350 must be classified as a gating terminal requiring a reasonable runout area behind it. Unlike current W-beam terminals, however, the X350 terminal has redirection capability from the first post as demonstrated in test 3-37. Thus, the barrier length of need may be measured from the first post when this terminal is used.

Based on staff review of your submission, I agree that the X350 W-beam terminal meets the appropriate evaluation criteria for an NCHRP Report 350 terminal at TL-3. I also agree that this design would be equally crashworthy if standard CRT posts were used in post positions 2 through 6 in lieu of your proprietary steel post design. If you plan to market this product in the United States (U.S.), all steel components must be manufactured in this country with U.S. steel, pursuant to the provisions of Title 23, Code of Federal Regulations, Section 435.610. Likewise, the use of proprietary products on federally funded projects is subject to the provisions of Section 435.611 of the same Regulations. Copies of both documents are available upon your request.

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

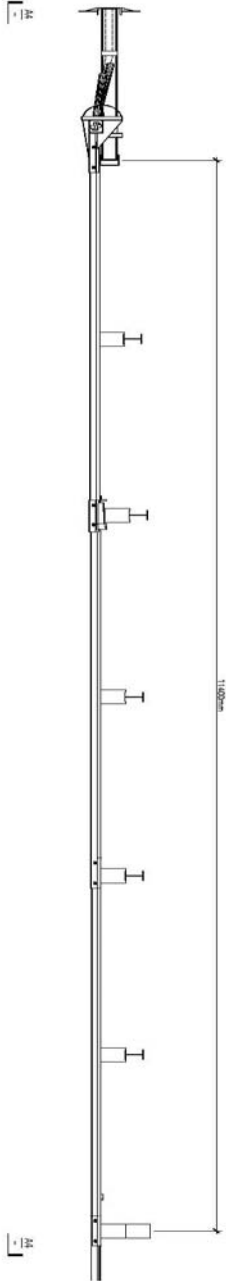
- Our acceptance is limited to the crashworthiness characteristics of the X350 terminal and is not intended to address its structural features or durability.
- Any changes that may adversely influence the crashworthiness of the device will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the device being marketed is significantly different from the version that was crash tested, it reserves the right to modify or revoke its acceptance.
- You will be expected to supply potential users with detailed drawings of the X350 terminal, including all parts, assemblies, and associated hardware, and sufficient information to ensure proper installation and maintenance.
- 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.
- To prevent misunderstanding by others, this letter of acceptance, designated as number CC-91 shall not be reproduced except in full. This letter, and the test documentation upon which this letter is based, is public information. All such letters and documentation may be reviewed at our office upon request.

Sincerely yours,

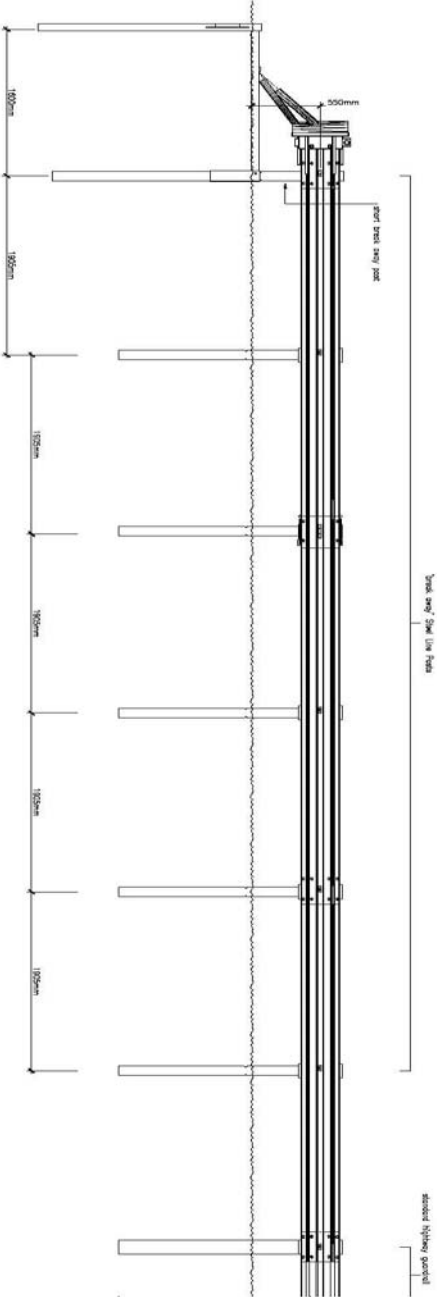
/original signed by/

John R. Baxter, P.E.
Director, Office of Safety Design
Office of Safety

All dimensions to be verified on site before making any change or connection for work. No responsibility is accepted for any work done without checking the drawings.



4 plan

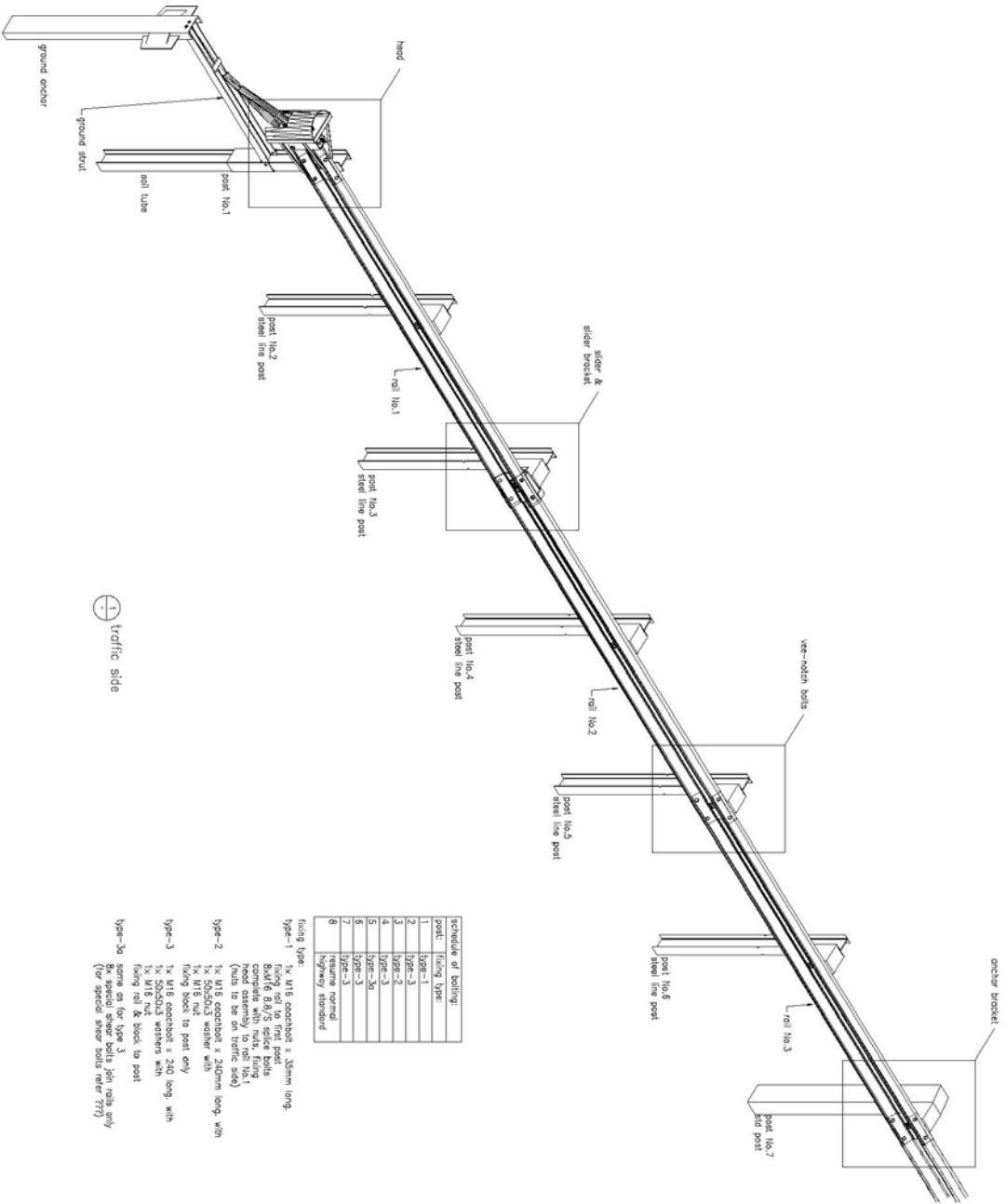


Note:
 1. height to centre of rail No.1 = 350mm
 2. maximum flare over 11400 origin = 400mm
 3. length of fixed ends at Post No.1



ENERGY ABSORBING
 GUARD-RAIL
 BARRIER DESIGN
 for ARMORFLEX Ltd.
 Drawn: JCT Sheet: 5/15
 Approved: [Signature] Date: 30/07/2013
 Sheet: 1/3

Job No.	Sheet No.	No.
893935	SK004-3	1



Schedule of bolting:

post:	bolting type:
1	type-1
2	type-3
3	type-2
4	type-2
5	type-3
6	type-3
7	type-3
8	resume normal highway standard

- Facing type:
- type-1 1/2 M16 anchorbolt x 35mm long. Facing rail to first post. (nuts & washers complete with nuts facing head assembly to rail No.1 (nuts to be on traffic side))
 - type-2 1/2 M16 anchorbolt x 240mm long, with 1/2 M16 nut. Facing back to post only.
 - type-3 1/2 M16 anchorbolt x 240 long, with 1/2 M16 nut. Facing rail & back to post.
 - type-3a same as for type 3. For special shear bolts refer 717)

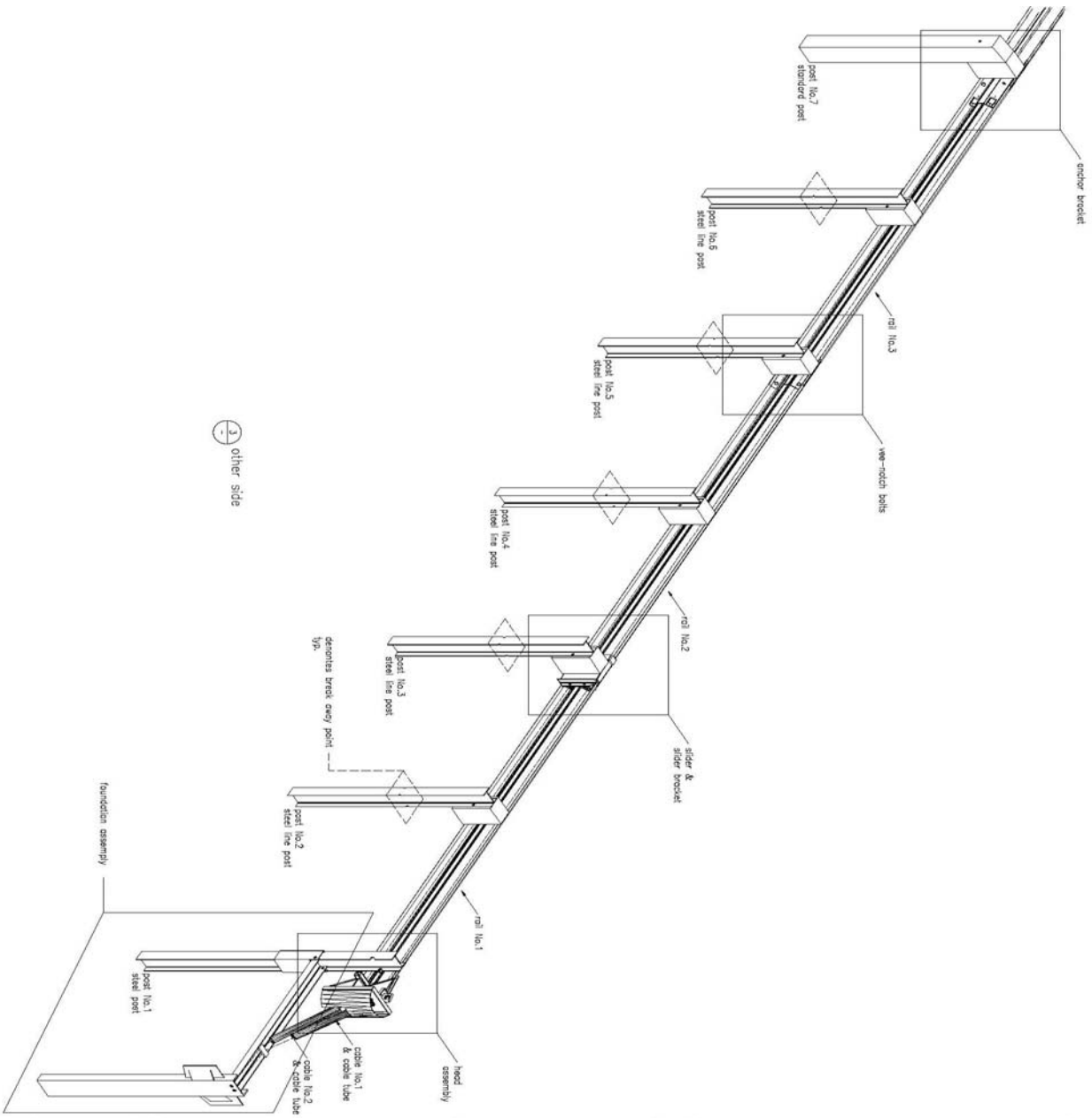
As furnished by the manufacturer, the manufacturer is not responsible for any damage to the structure of the barrier system or any other structure caused by misuse or improper installation.

USE FOR ESTIMATION	
Qty	Weight
1	240



ENERGY ABSORBING
GUARD-RAIL
BARRIER DESIGN
for ARMORFLEX Ltd.

Order No.	89595
Rev.	1
Drawn By	SK002-3
Checked By	



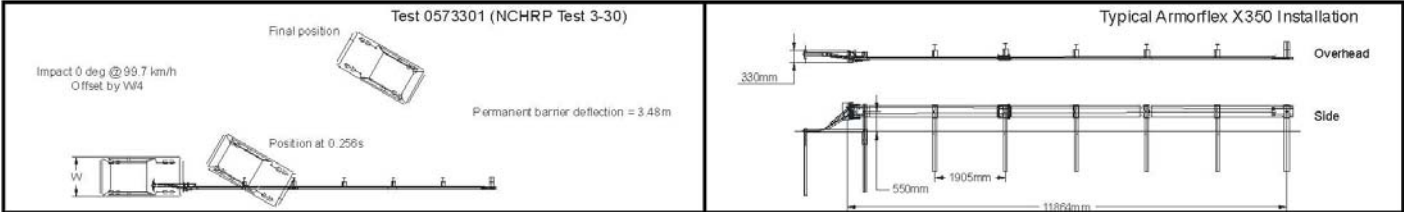
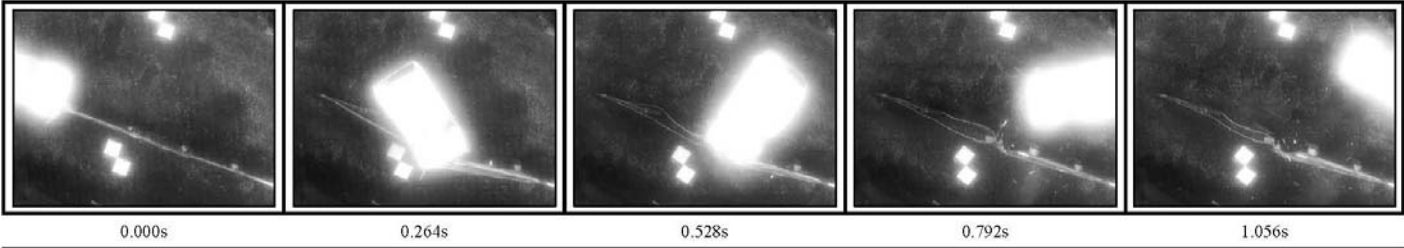
All dimensions in mm unless otherwise stated.
 The manufacturer of the drawing material will
 receive the drawing as shown.

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10



ENERGY ABSORBING
 GUARD-RAIL
 BARRIER DESIGN
 for ARMORFLEX Ltd.
 BARRIER SYSTEM
 OTHER SIDE

89595	SK003-3	1
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General Information

Test Agency..... University of Canterbury, NZ
 Test Designation..... NCHRP 350 Test 3-30
 Test No. 0573301
 Date..... 24 June 2004

Test Article

Type..... Non-gating, redirective guardrail terminal end barrier
 Name or Manufacturer..... Armorflex Ltd
 Installation Length..... 38 m
 Material or Key Elements..... AASHTO SGR04a-b Guardrail with Armorflex X350 Terminal End

Soil Type and Condition.....

AASHTO 'standard' soil M147-64 (1990)

Test Vehicle

Type..... Production Model
 Designation..... 820C
 Model..... 1991 Ford Festiva
 Mass (kg)
 Curb 767
 Test Inertial 816.5
 Dummy 75
 Gross Static 891.5

Impact Conditions

Speed (km/h)..... 99.7
 Angle (deg)..... 0

Exit Conditions

Speed (km/h)..... 21.5
 Angle (deg)..... N/A

Occupant Risk Values

Impact Velocity (m/s)
 x-direction..... 8.9
 y-direction..... -1.0
 THIV (km/h)..... 33.8
 Ridedown Accelerations (g's)
 x-direction..... -11.8
 y-direction..... 6.2
 PHD (g's)..... 11.7
 ASI..... 0.93
 Max. 0.050-s Average (g's)
 x-direction..... -11.0
 y-direction..... 3.9
 z-direction..... -2.8

Test Article Deflections (m)

Dynamic..... 3.48
 Permanent 3.48

Vehicle Damage

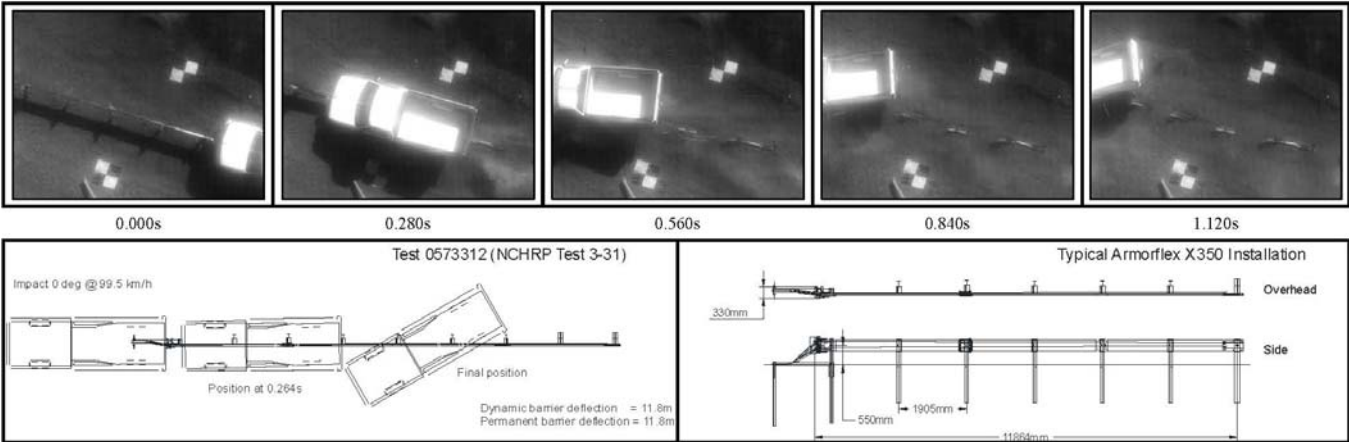
Exterior
 VDS..... 12-FC-5
 CDC 12FREN2

Maximum Exterior
 Vehicle Crush (mm)..... 500mm
 Interior
 OCDI..... RF0001000
 Max. Occ. Comptmit.
 Deformation (mm) 15

Post-Impact Behaviour

Max. Yaw Angle (deg) 209.6
 Max. Pitch Angle (deg)..... -13.6
 Max Roll Angle (deg) 21.6

Figure 2.2.10: Summary of results for test 0573301 (NCHRP 350 Test 3-30).



General Information

Test Agency..... University of Canterbury, NZ
 Test Designation..... NCHRP 350 Test 3-31
 Test No..... 0573312
 Date..... 17 August 2004

Test Article

Type..... Non-gating, redirective guardrail terminal end barrier
 Name or Manufacturer..... Armorflex Ltd
 Installation Length..... 38 m
 Material or Key Elements..... AASHTO SGR04a-b Guardrail with Armorflex X350 Terminal End
 Soil Type and Condition..... AASHTO 'standard' soil M147-64 (1990)

Test Vehicle

Type..... Production Model
 Designation..... 2000P
 Model..... 1995 Chevrolet Cheyenne
 Mass (kg)
 Curb..... 2111
 Test Inertial..... 2025
 Dummy..... N/A
 Gross Static..... 2025

Impact Conditions

Speed (km/h)..... 99.5
 Angle (deg)..... 0

Exit Conditions

Speed (km/h)..... N/A
 Angle (deg)..... N/A

Occupant Risk Values

Impact Velocity (m/s)
 x-direction..... 5.9
 y-direction..... -0.2
 THIV (km/h)..... 21.2
 Ridedown Accelerations (g's)
 x-direction..... -15.1
 y-direction..... -5.4
 PHD (g's)..... 15.1
 ASI..... 1.00
 Max. 0.050-s Average (g's)
 x-direction..... -11.5
 y-direction..... -1.9
 z-direction..... 5.9

Test Article Deflections (m)

Dynamic..... 11.8
 Permanent..... 11.8

Vehicle Damage

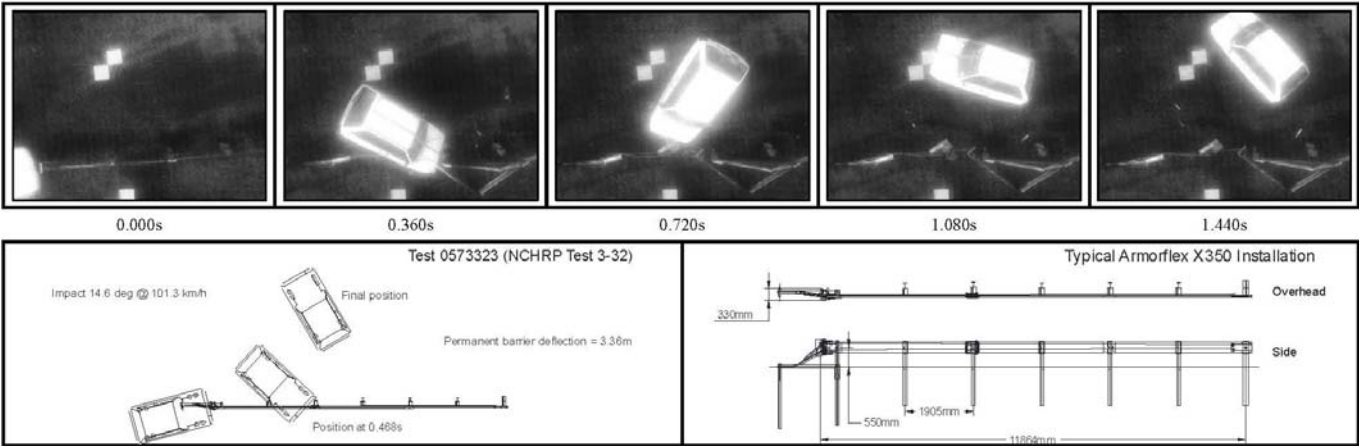
Exterior
 VDS..... 12-FC-4
 CDC..... 12FCEN2

Maximum Exterior
 Vehicle Crush (mm)..... 400mm
 Interior
 OCDI..... AS0000000
 Max. Occ. Comptmnt.
 Deformation (mm)..... 0

Post-Impact Behaviour

Max. Yaw Angle (deg)..... -30.1
 Max. Pitch Angle (deg)..... -7.3
 Max Roll Angle (deg)..... 7.1

Figure 2.2.25: Summary of results for test 0573312 (NCHRP 350 Test 3-31).



General Information

Test Agency University of Canterbury, NZ
 Test Designation NCHRP 350 Test 3-32
 Test No. 0573323
 Date 30 July 2004

Test Article

Type Non-gating, redirective guardrail terminal end barrier
 Name or Manufacturer Armorflex Ltd
 Installation Length 38 m
 Material or Key Elements AASHTO SGR04a-b Guardrail with Armorflex X350 Terminal End
 Soil Type and Condition AASHTO 'standard' soil M147-64 (1990)

Test Vehicle

Type Production Model
 Designation 820C
 Model 1990 Ford Festiva
 Mass (kg)
 Curb 743
 Test Inertial 817.5
 Dummy 75
 Gross Static 892.5

Impact Conditions

Speed (km/h) 101.3
 Angle (deg) 14.6

Exit Conditions

Speed (km/h) 12
 Angle (deg) n/a

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 8.9
 y-direction -0.4
 THIV (km/h) 32.0
 Ridedown Accelerations (g's)
 x-direction -13.9
 y-direction 4.6
 PHD (g's) 14.2
 ASI 1.21
 Max. 0.050-s Average (g's)
 x-direction -14.1
 y-direction 3.4
 z-direction -6.0

Test Article Deflections (m)

Dynamic 3.36
 Permanent 3.36

Vehicle Damage

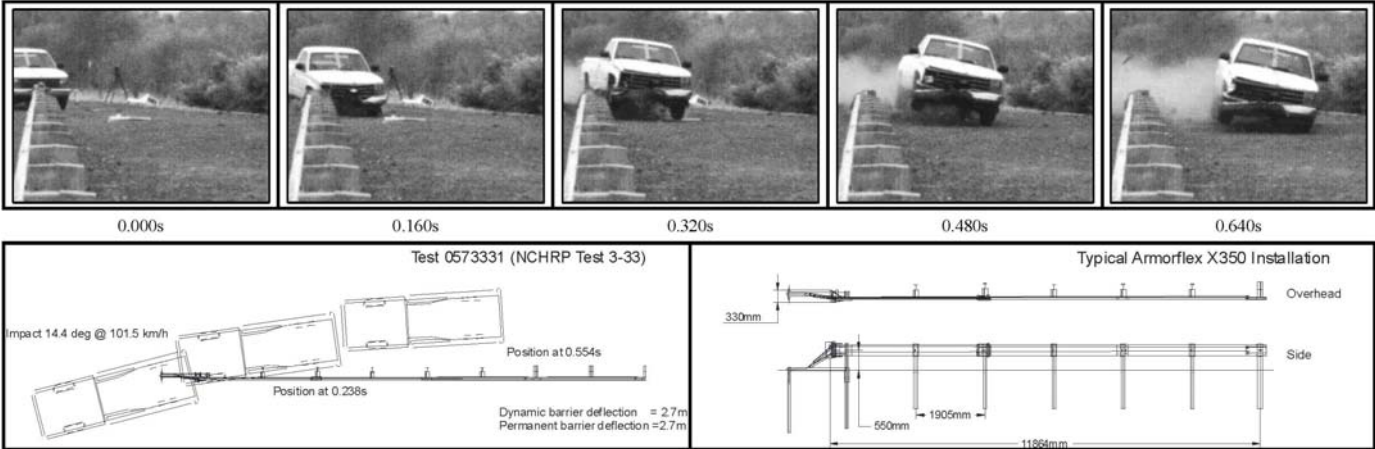
Exterior
 VDS 12-FC-5
 CDC 12FCEN2

Maximum Exterior
 Vehicle Crush (mm) 450mm
 Interior
 OCDI AS000000
 Max. Occ. Comptmnt.
 Deformation (mm) 20

Post-Impact Behaviour

Max. Yaw Angle (deg) 260.4
 Max. Pitch Angle (deg) -39.6
 Max Roll Angle (deg) -14.5

Figure 2.2.15: Summary of results for test 0573323 (NCHRP 350 Test 3-32).



General Information

Test Agency University of Canterbury, NZ
 Test Designation NCHRP 350 Test 3-33
 Test No. 0573331
 Date..... 4 August 2004

Test Article

Type Non-gating, redirective guardrail terminal end barrier
 Name or Manufacturer..... Armorflex Ltd
 Installation Length 38 m
 Material or Key Elements. AASHTO SGR04a-b Guardrail with Armorflex X350 Terminal End
 Soil Type and Condition..... AASHTO 'standard' soil M147-64 (1990)

Test Vehicle

Type..... Production Model
 Designation..... 2000P
 Model..... 1993 Chevrolet Cheyenne
 Mass (kg)
 Curb 1908
 Test Inertial 1975
 Dummy N/A
 Gross Static 1975

Impact Conditions

Speed (km/h)..... 101.5
 Angle (deg)..... 14.4

Exit Conditions

Speed (km/h)..... 75
 Angle (deg)..... n/a

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 7.3
 y-direction -0.3
 THIV (km/h) 26.2
 Ridedown Accelerations (g's)
 x-direction -11.5
 y-direction -6.0
 PHD (g's)..... 13.0
 ASI 0.70
 Max. 0.050-s Average (g's)
 x-direction -6.7
 y-direction 1.8
 z-direction -5.8

Test Article Deflections (m)

Dynamic 2.7
 Permanent 2.7

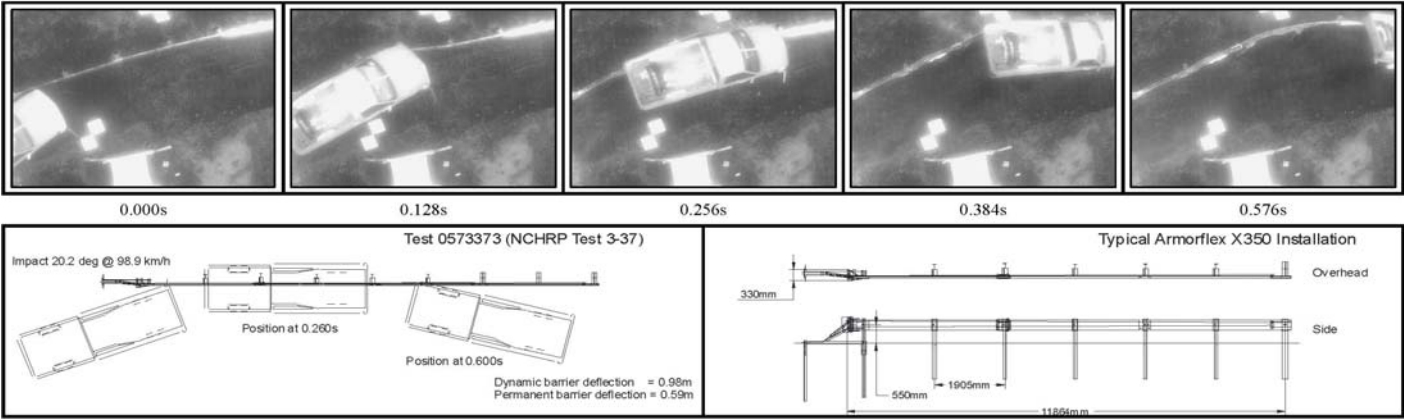
Vehicle Damage

Exterior
 VDS 12-FC-3
 CDC 12FCEN2
 Maximum Exterior
 Vehicle Crush (mm) 350mm
 Interior
 OCDI AS0000000
 Max. Occ. Comptmnt.
 Deformation (mm) 0

Post-Impact Behaviour

Max. Yaw Angle (deg) 37.4
 Max. Pitch Angle (deg) 5.2
 Max Roll Angle (deg) -13.5

Figure 2.2.20: Summary of results for test 0573331 (NCHRP 350 Test 3-33).



General Information

Test Agency University of Canterbury, NZ
 Test Designation NCHRP 350 Test 3-37
 Test No. 0573373
 Date..... 10 June 2004

Test Article

Type Non-gating, redirective guardrail terminal end barrier
 Name or Manufacturer Armorflex Ltd
 Installation Length 38 m
 Material or Key Elements AASHTO SGR04a-b Guardrail with Armorflex X350 Terminal End
 Soil Type and Condition..... AASHTO 'standard' soil M147-64 (1990)

Test Vehicle

Type..... Production Model
 Designation 2000P
 Model..... 1988 Chevrolet Silverado 2500
 Mass (kg)
 Curb 1840
 Test Inertial 1988.5
 Dummy 0
 Gross Static 1988.5

Impact Conditions

Speed (km/h) 98.9
 Angle (deg) 20.2

Exit Conditions

Speed (km/h) 63
 Angle (deg) 12.9

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 4.1
 y-direction -4.1
 THIV (km/h) 18.3
 Ridedown Accelerations (g's)
 x-direction -7.4
 y-direction 11.0
 PHD (g's) 11.5
 ASI 0.62
 Max. 0.050-s Average (g's)
 x-direction -5.3
 y-direction 5.0
 z-direction -4.5

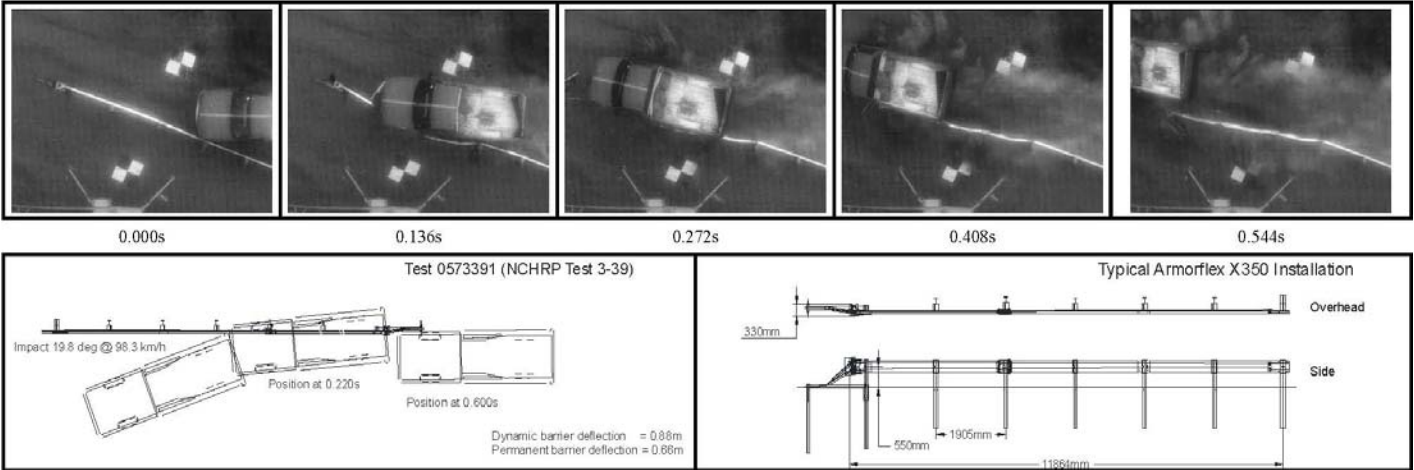
Test Article Deflections (m)

Dynamic 0.98
 Permanent 0.59

Vehicle Damage

Exterior
 VDS 11LFQ-3
 CDC 11FLEK2
 & 01LFEW1
 Maximum Exterior
 Vehicle Crush (mm) 310mm
 Interior
 OCDI AS0000000
 Max. Occ. Compart.
 Deformation (mm) 0
Post-Impact Behaviour
 (during 1.0s after impact)
 Max. Yaw Angle (deg) 35.9
 Max. Pitch Angle (deg) -5.3
 Max Roll Angle (deg) -13.9

Figure 2.2.5: Summary of results for test 0573373 (NCHRP 350 Test 3-37).



General Information

Test Agency University of Canterbury, NZ
 Test Designation NCHRP 350 Test 3-39
 Test No. 0573391
 Date 9 September 2004

Test Article

Type Non-gating, redirective guardrail terminal end barrier
 Name or Manufacturer Armorflex Ltd
 Installation Length 18.2 m
 Material or Key Elements AASHTO SGR04a-b Guardrail with Armorflex X350 Terminal End

Soil Type and Condition.....

AASHTO 'standard' soil M147-64 (1990)

Test Vehicle

Type Production Model
 Designation 2000P
 Model 1990 Chevrolet Cheyenne
 Mass (kg)
 Curb 1817
 Test Inertial 1988
 Dummy 0
 Gross Static 1988

Impact Conditions

Speed (km/h) 98.3
 Angle (deg) 19.8

Exit Conditions

Speed (km/h) 47
 Angle (deg) 0

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 3.9
 y-direction -4.2
 THIV (km/h) 19.3
 Ridedown Accelerations (g's)
 x-direction -13.6
 y-direction 16.2
 PHD (g's) 17.3
 ASI 0.81
 Max. 0.050-s Average (g's)
 x-direction -7.2
 y-direction 4.7
 z-direction 6.9

Test Article Deflections (m)

Dynamic 0.88
 Permanent 0.66

Vehicle Damage

Exterior
 VDS 11LFQ-5
 CDC 11FLEK3
 11LFEW1
 Maximum Exterior
 Vehicle Crush (mm) 800mm
 Interior
 OCDI LF0100000
 Max. Occ. Compart.
 Deformation (mm) 90

Post-Impact Behaviour

(during 1.0s after impact)
 Max. Yaw Angle (deg) -27.8
 Max. Pitch Angle (deg) -9.3
 Max Roll Angle (deg) -9.0

Figure 2.2.30: Summary of results for test 0573391 (NCHRP 350 Test 3-39).