November 5, 2007

In Reply Refer To: HSSD-1/CC-102

Mr. Owen Denman, PE
President, Barrier Systems Inc.
180 River Road
Rio Vista, CA  94571-1208

Dear Mr. Denman:

Thank you for your letter of August 2, 2007, requesting the Federal Highway Administration (FHWA) acceptance of tangent, flared, and median versions of the X-Tension™ Technology End Terminals for use on the National Highway System (NHS). The original system, the X-350™ Guardrail Terminal was developed by Armorflex, Ltd., and accepted by FHWA in our July 9, 2005, letter CC-91. Barrier Systems, Inc. has since acquired the rights to use the X-350™ Guardrail technology and has developed it further. Accompanying your letter were reports of crash testing conducted by Holmes Solutions, an approved test laboratory which was formerly a facility of the University of Canterbury in Christchurch, New Zealand, and DVD video of the tests. You requested that we find the terminals acceptable for use on the NHS under the provisions of National Cooperative Highway Research Program (NCHRP) Report 350 “Recommended Procedures for the Safety Performance Evaluation of Highway Features.”

Introduction

The FHWA guidance on crash testing of roadside safety hardware is contained in a memorandum dated July 25, 1997, titled “INFORMATION: Identifying Acceptable Highway Safety Features.” The original Armorflex X350 tangent terminal for use with strong-post W-beam guardrail includes 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. For side impacts to the rail, tension 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 a convolution in the impact head dissipates crash energy. 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.

Your present request is for: 1) modifications to the original tangent version, 2) a flared version, and 3) a median version, using the name X-Tension™ Technology Guardrail End Terminals. The enclosed chart “National Cooperative Highway Research Program Report 350 Test Matrix – X-Tension Testing Program” details the original matrix of tests used to validate the Armorflex X350 design, a Test Requirement Analysis of the needed impacts to validate the Flared Offset Configuration and the Median Terminal, and a Component Modification Analysis.
**Testing**

You discussed the proposed test matrix with Mr. Nicholas Artimovich of my staff and reached agreement on the tests detailed in the enclosed testing program chart mentioned above. The following tests were conducted and the test data summary sheets are enclosed for reference:

- NCHRP Report 350 test 3-30 for the flared configuration.
- NCHRP Report 350 tests 3-31 and 3-32 for the median configuration.

We concur that these tests are satisfactory to show NCHRP Report 350 compliance with the following:

- The modified tangent, flared, and median configurations using either wood (CRT) or steel line posts (first two posts crimped near the ground line) as shown in the enclosed drawings.
- The tangent, flared and median configurations use a small “kit” of key components that are used in conjunction with standard W-beam guardrail, wood or composite block-outs, steel line posts or CRT wood posts and standard guardrail component hardware to make up any of the noted configurations noted in the enclosed drawings.
- The amount of offset for flared applications can be between the tangent position (no offset) and the fully flared (1.2 m offset) as tested.
- Recognition of the redirective capability of the system from the first post. Therefore, the system qualifies as a “Redirective, Non-Gating” Terminal under the definitions in NCHRP Report 350.

**Findings**

The results of the testing met the FHWA requirements and, therefore, the devices described in the various requests above and detailed in the enclosed drawings are acceptable for use on the NHS under the range of conditions tested, when proposed by a highway agency.

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

- Our acceptance is limited to the crashworthiness characteristics of the devices 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 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 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 they will meet the crashworthiness requirements of FHWA and NCHRP Report 350.
• To prevent misunderstanding by others, this letter of acceptance, designated as number CC-102 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.

• The X-Tension™ products are patented devices and considered "proprietary." The use of proprietary devices specified by a highway agency for use on Federal-aid projects must meet one of the following criteria: (a) it must be supplied through competitive bidding with equally suitable unpatented items; (b) the highway agency must certify that it is essential for synchronization with existing highway facilities or that no equally suitable alternative exists or; (c) it 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 device for which the applicant is not the patent holder. The acceptance letter 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,

George E. Rice, Jr.
Acting Director, Office of Safety Design
Office of Safety

Enclosures
### X-Tension Guardrail Terminal - Tangent Configuration (FHWA Approval Letter HAS-10/CC-91)

<table>
<thead>
<tr>
<th>Test</th>
<th>Vehicle</th>
<th>Speed</th>
<th>Angle</th>
<th>Results</th>
<th>Test Requirement Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-30</td>
<td>815</td>
<td>99.7</td>
<td>0</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-31</td>
<td>2026</td>
<td>99.5</td>
<td>0</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-32</td>
<td>817.5</td>
<td>101.3</td>
<td>14.8</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-33</td>
<td>1975</td>
<td>101.5</td>
<td>14.4</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-34</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3-35</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3-36</td>
<td>1986.5</td>
<td>98.9</td>
<td>20.2</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-37</td>
<td>1988</td>
<td>98.3</td>
<td>16.3</td>
<td>Pass</td>
<td>Required</td>
</tr>
</tbody>
</table>

#### Component Modification Analysis

<table>
<thead>
<tr>
<th>Test</th>
<th>System</th>
<th>Part No.</th>
<th>Description</th>
<th>Component Modification Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-30, 31, 32, 33, 34, 35, 37, 39</td>
<td>Tangent</td>
<td>Posts</td>
<td>All X-Tension testing on the Tangent configured system used steel wide flange posts notched at ground level. The system is repeated three times (3-30, 3-31, 3-32) as well. Reference FHWA Letter HAS-10/CC-91. On system details.</td>
<td></td>
</tr>
<tr>
<td>3-30*</td>
<td>Offset</td>
<td>B081099, B051100</td>
<td>Post 1 (top), Post 2</td>
<td>The flanges of Post 1, 2, and 3 were &quot;crimped&quot; at ground level to weaken the post for head-on impacts with light vehicles. The crimped posts perform similar to those tested during the original X-Tension Tangent testingchos. Steel posts or timber on system. The lateral strength of the post is reduced for crimped posts. As crimped post is unstable, the post is not stable. All other posts on the system were standard wide flange steel posts, unweakened.</td>
</tr>
<tr>
<td>3-32</td>
<td>Median</td>
<td>B081099, B051100</td>
<td>Post 1 (top), Post 2</td>
<td>The flanges of Post 1, 2, and 3 were &quot;crimped&quot; near ground level as in test 3-30. The crimps on Post 1 were lowered to allow the post to fold closer to the ground. Post 2 was also notched on the reverse side of the blockout/pallet attachment hole. This was only on the reverse side and does not effect the system as previously tested in tangent or offset configurations.</td>
</tr>
<tr>
<td>3-33</td>
<td>Median</td>
<td>B081098</td>
<td>Post 1 (bottom)</td>
<td>The top receiver channel for Post 1 was modified to allow Post 1 to fold lower to the ground and reduce the potential of interaction with the floor pan of light vehicles. The modification removed a portion of the back side of the receiving channel. The channel was made flatter and reinforced to provide driving the post. The modification does not effect the lateral strength of the post and only benefits the longitudinal break-away function of Post 1.</td>
</tr>
<tr>
<td>3-34</td>
<td>Median</td>
<td>Posts</td>
<td>In this test, only Posts 1 and 2 were crimped and all other posts were standard wide flange steel posts unweakened. Posts used are Wide I-bar. The crimping is accomplished in accordance with Ford Motor Company Specification F2UE31. The crimping was removed from Post 3 because the light car was proven to not significantly interact with post 3.</td>
<td></td>
</tr>
</tbody>
</table>
### General Information
- **Test Agency**: Holmes Solutions Limited
- **Test Designation**: NCHRP 350 Test 3-30
- **Test No.**: 057083301
- **Date**: 13th December 2006

### Test Article
- **Type**: Flared Guardrail Terminal End
- **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 M147-90 (1990)

### Test Vehicle
- **Type**: Production Model
- **Designation**: 820C
- **Model**: 1997 Toyota Starlet
- **Mass (kg)**
  - Curb: 873.0
  - Test Inertial: 837.0
  - Dummy: 75.0
  - Gross Static: 912.0

### Impact Conditions
- **Impact Velocity**: 98.7 km/h
- **Speed (km/h)**: 98.7
- **Angle (deg)**: 0
- **Exit Conditions**: Speed (km/h): 27.5, Angle (deg): n/a

### Occupant Risk Values
- **Impact Velocity (m/s)**
  - x-direction: 9.4
  - y-direction: 3.8
  - z-direction: 3.8
- **Ride-down Accelerations (g's)**
  - x-direction: 5.8
  - y-direction: 3.0
- **PHD (g's)**: 19.5
- **ASI**: 1.09
- **Max. 0.050-s Average (g's)**
  - x-direction: -13.0
  - y-direction: -4.0
  - z-direction: 7.3

### Vehicle Damage
- **Exterior**: VDS: 12-FC-5, CDC: 12FLEN2
- **Maximum Exterior Vehicle Crush (mm)**: 300
- **Interior**: OCDI: AS0000000
- **Max. Occ. Compartment Deformation (mm)**: 30

### Post-Impact Behaviour
- **Max. Yaw Angle (deg)**: 497.1
- **Max. Pitch Angle (deg)**: 47.0
- **Max. Roll Angle (deg)**: 27.7
6X SHEAR BOLTS
PART OF ITEM 2.

ATTACH SLIDER BRACKET SYSTEM TO END OF GUARDRAIL PANEL AS SHOWN. ENSURE THAT HEX NUTS ARE AWAY FROM TRAFFIC SIDE.

POST & BLOCKOUT
PART OF ITEM 4.

TIGHTEN CABLE ASSEMBLIES UNTIL THEY ARE NOT VISIBLY SAGGING BETWEEN POSTS. (THERE IS NO TORSION REQUIREMENT FOR THE CABLES).

CABLE BRACKET
PART OF ITEM 1.

ENSURE THAT HEX NUTS ARE ON INSIDE OF GUARDRAIL PANEL.

PASS 2X CABLE ASSEMBLIES BETWEEN GUARDRAIL PANELS AND BLOCKOUTS.

SEE DETAIL 'C'.

POST & BLOCKOUT
PART OF ITEM 4.

SEE DETAIL 'C'.

OFFSET POST 3 1/2" AWAY FROM TRAFFIC TO MAKE IT EASIER TO PUSH GUARDRAIL WITH SLIDER PANEL OVER GUARDRAIL 2.

SEE DETAIL 'D'.

NOTE: UNLESS OTHERWISE SPECIFIED
1. SYSTEM TO BE INSTALLED PER MANUFACTURER SPECIFICATIONS.
3. WHEN DRIVING STEEL POST, ENSURE THAT A DRIVING CAP WITH TIMBER OR PLASTIC INSERT IS USED TO PREVENT DAMAGE TO THE GALVANIZED TO THE TOP OF THE POST.

SEE ECN# 942
SEE ER# 531

CHANGES

TITLE: X-TENSION GUARDRAIL TERMINAL SYSTEM
STEEL POST WITH COMPOSITE BLOCKOUT

ARCHIVED FOR RESEARCH AND HISTORICAL PURPOSES ONLY
NOTES: UNLESS OTHERWISE SPECIFIED
1. X-TENSION SYSTEM TO BE INSTALLED PER MANUFACTURER SPECIFICATIONS.
2. SYSTEM SHOWN USING STEEL WIDE FLANGE POST (PWE01) WITH TIMBER BLOCKOUTS (ROUTED, PDB01). IF STEEL WIDE FLANGE POSTS ARE USED, POST 2 MUST BE A BREAKAWAY STYLE POST CRIMPED (AS SHOWN), TIMBER CRT POST, OR EQUIVALENT.
3. SYSTEM MAY ALSO USE TIMBER CRT POSTS (PDE09) WITH TIMBER BLOCKOUTS (PDB01a).
4. SYSTEM MAY ALSO USE COMPOSITE OR PLASTIC BLOCKOUTS.
NOTES: UNLESS OTHERWISE SPECIFIED

1. X-EXTENSION MEDIAN SYSTEM TO BE INSTALLED PER MANUFACTURER SPECIFICATIONS.
   SYSTEM SHOWN USING STEEL WIDE FLANGE POST (PWE01) WITH TIMBER BLOCKOUTS (ROUTED, PDB01b). IF STEEL WIDE FLANGE POSTS ARE USED, POST 2 MUST BE A BREAKAWAY STYLE POST CRIMPED (AS SHOWN), TIMBER CRT POST, OR EQUIVALENT.
   SYSTEM MAY ALSO USE TIMBER CRT POSTS (PDE09) WITH TIMBER BLOCKOUTS (PDB01a).
   SYSTEM MAY ALSO USE COMPOSITE OR PLASTIC BLOCKOUTS.

2. [Details of design specifications and dimensions are shown in the diagram, with various parts labeled and scaled drawing numbers.]