March 1, 2005

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor
Midwest Roadside Safety Facility
P.O. Box 880601
Lincoln, NE 68588-0601

Dear Dr. Faller:

In your letter dated January 24, 2005, you requested formal Federal Highway Administration acceptance of a non-proprietary strong-post W-beam guardrail, named the Midwest Guardrail System (MGS), as an NCHRP Report 350 test level 3 (TL-3) longitudinal barrier. In support of this request, you sent copies of your September 2004 report prepared under the direction of the Midwest States’ Regional Pooled Fund Program, entitled “Development of the Midwest Guardrail System (MGS) for Standard and Reduced Post Spacing and in Combination with Curbs” and video and digital films of the tests you conducted.

The MGS barrier, as shown in Enclosure 1, consists of standard 12-gauge W-beam sections installed with the top of the rail set at a nominal height of 787 mm (31 inches). Note that this drawing depicts the rail element at its recommended maximum height rather than at its nominal height. It is mounted on standard W152x13.4 steel posts that are 1829-mm (6-feet) long and set on 1905-mm (75-inch) centers. To obtain the additional rail height, each post is raised approximately 100 cm (4 inches), resulting in slightly less embedment than the posts in a standard W-beam installation. The rail is offset from these posts with 152-mm wide x 305-mm deep x 356-mm long (6-inch x 12-inch x 14-inch) wood offset blocks. For the test installation, these blocks were made from two separate blocks screwed together to obtain the design depth, but it is anticipated that production blocks will be a single piece. Routed or toenailed blocks may also be used to prevent block rotation over time, but neither feature was used in your tests. Finally, the rail splices are located at mid-span between adjacent posts rather than at each post as in a traditional W-beam installation.

The MGS barrier was tested successfully with the 820-kg car and the 2000-kg pickup truck in its standard configuration, behind a 152-mm (6-inch) AASHTO Type B curb with the pickup truck (Enclosure 2), and with a reduced post spacing of 476 mm (18.75 inches). Summaries of each test are shown on Enclosure 3. I noted that the initial test with the 820-kg car was run with the top of rail set at 813 mm (32 inches) thus establishing the maximum recommended height of the MGS to preclude wheel snagging by the small car. Since standard W-beam remains acceptable at a nominal top rail height of 686 mm (27 inches), the recommended minimum height of the MGS barrier is likewise 686 mm (27 inches). I noted also that in the test with the curb, the face of the MGS barrier was set 178 mm (7 inches) from the toe of the curb. In a separate discussion, you advised that the face of the rail could be moved forward over the toe of the curb, but advised against moving it further back without additional testing.
Using a BARRIER VII analysis calibrated from the standard and ¼ post spacing tests; you estimated the design deflection of the MGS barrier with a 953-mm (37.5-inch) or half-post spacing. From your testing and analysis, you recommended that the minimum distances at which the face of an MGS installation be placed from the face of a rigid obstacle (e.g., bridge pier or overhead sign support) be 1.25 m (49 inches), 1.12 m (44 inches), and 0.90 m (35 inches) for standard, ½, and ¼ post spacings, respectively. These offsets are based on the “working width” deflections seen in the crash tests/analysis and include some degree of pickup truck penetration beyond the vertical plane of the barrier’s dynamic deflection. As with all traffic barriers, larger offset distances would be required to shield similar features from vehicles with higher centers of gravity, such as single-unit trucks or as buses, because of the relatively high roll angles seen with these vehicles in rigid and semi-rigid barrier tests of similar height.

Based on staff review of the information you submitted, I agree that the tested designs satisfy NCHRP Report 350 evaluation criteria for a longitudinal barrier at TL-3 and that each of these designs may be used on the National Highway System. Based on your discussions with and recommendations to Mr. Richard Powers of my staff, I also agree the MGS system, in any of the configurations described herein, may be used with standard 1829-mm (6-foot) long timber posts in lieu of the tested steel post design.

Sincerely yours,

/Original Signed by Richard Powers/

~for~

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

3 Enclosures
Test Number .................. NPG-1
Date .............................. 6/29/01
Appurtenance .................. Midwest Guardrail System
Key Elements .................. increased mounting height, blockout depth, and bolt slot length, mid-span splices

Total Length .................. 55.25 m
Steel W-beam
Thickness .................. 2.66 mm
Top Mounting Height .......... 813 mm
Bolt Slot Length ............. 102 mm
Steel Posts
Post Nos. 3 - 27 ............. W152 x 13.4 by 1,829-mm long
Spacing .................. 1,905 mm
Wood Posts
Post Nos. 1 - 2, 28 - 29 (BCT) . 140 mm x 190 mm by 1,080-mm long
Wood Spacer Blocks
Post Nos. 3 - 27 ............. 152 mm x 305 mm by 356-mm long
Soil Type ........................ Grading B - AASHTO M 147-65 (1990)
Vehicle Model .................. 1994 Geo Metro
Curb .......................... 746 kg
Test Inertial .................. 812 kg
Gross Static .................. 887 kg
Vehicle Speed
Impact .................. 102.9 km/h
Exit (resultant) ............ 92.3 km/h

Vehicle Angle
Impact (trajectory) ........... 20.0 deg
Exit (trajectory) .............. 9 deg
Vehicle Stability ............... Satisfactory
Occupant Ridedown Deceleration (10 msec avg.)
Longitudinal .................. 6.13 g’s < 20 g’s
Lateral (not required) ........... 7.97 g’s
Occupant Impact Velocity
Longitudinal .................. 3.52 m/s < 12 m/s
Lateral (not required) ........... 5.68 m/s
Vehicle Damage .................. Moderate
TAD^31 .................. 11-LFQ-3
SAE^32 .................. 11LFEW3
Vehicle Stopping Distance ....... 41.53 m downstream
0.71 m traffic-side face
Barrier Damage .................. Moderate
Maximum Rail Deflections
Permanent Set ................. 238 mm
Dynamic .................. 443 mm
Working Width .................. 1,023 mm

Vehicle Speed
Impact .................. 102.9 km/h
Exit (resultant) ............ 92.3 km/h

Figure 37. Summary of Test Results and Sequential Photographs, Test NPG-1
<table>
<thead>
<tr>
<th>Test Number</th>
<th>NPG-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>6/14/02</td>
</tr>
<tr>
<td>Appurtenance</td>
<td>Midwest Guardrail System</td>
</tr>
<tr>
<td>Key Elements</td>
<td>increased mounting height, blockout depth, and foundation tube length, mid-span splices</td>
</tr>
<tr>
<td>Total Length</td>
<td>55.25 m</td>
</tr>
<tr>
<td>Steel W-beam</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>2.66 mm</td>
</tr>
<tr>
<td>Top Mounting Height</td>
<td>787 mm</td>
</tr>
<tr>
<td>Bolt Slot Length</td>
<td>64 mm</td>
</tr>
<tr>
<td>Steel Posts</td>
<td></td>
</tr>
<tr>
<td>Post Nos. 3 - 27</td>
<td>W152 x 13.4 by 1,829-mm long</td>
</tr>
<tr>
<td>Spacing</td>
<td>1,905 mm</td>
</tr>
<tr>
<td>Wood Posts</td>
<td></td>
</tr>
<tr>
<td>Post Nos. 1 - 2, 28 - 29 (BCT)</td>
<td>140 mm x 190 mm by 1,080-mm long</td>
</tr>
<tr>
<td>Steel Foundation Tube Length</td>
<td>1,829 mm</td>
</tr>
<tr>
<td>Wood Spacer Blocks</td>
<td></td>
</tr>
<tr>
<td>Post Nos. 3 - 27</td>
<td>152 mm x 305 mm by 356-mm long</td>
</tr>
<tr>
<td>Soil Type</td>
<td>Grading B - AASHTO M 147-65 (1990)</td>
</tr>
<tr>
<td>Vehicle Model</td>
<td>1995 GMC 2500 ¾-ton pickup</td>
</tr>
<tr>
<td>Curb</td>
<td>1,913 kg</td>
</tr>
<tr>
<td>Test Inertial</td>
<td>1,986 kg</td>
</tr>
<tr>
<td>Gross Static</td>
<td>1,986 kg</td>
</tr>
<tr>
<td>Vehicle Speed</td>
<td></td>
</tr>
<tr>
<td>Impact</td>
<td>98.1 km/h</td>
</tr>
<tr>
<td>Exit (resultant)</td>
<td>55.1 km/h</td>
</tr>
<tr>
<td>Vehicle Angle</td>
<td></td>
</tr>
<tr>
<td>Impact (trajectory)</td>
<td>25.6 deg</td>
</tr>
<tr>
<td>Exit (trajectory)</td>
<td>19.3 deg</td>
</tr>
<tr>
<td>Vehicle Stability</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>Occupant Ridedown Deceleration (10 msec avg.)</td>
<td></td>
</tr>
<tr>
<td>Longitudinal</td>
<td>9.50 g’s &lt; 20 g’s</td>
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<tr>
<td>Lateral (not required)</td>
<td>6.94 g’s</td>
</tr>
<tr>
<td>Occupant Impact Velocity</td>
<td></td>
</tr>
<tr>
<td>Longitudinal</td>
<td>5.58 m/s &lt; 12 m/s</td>
</tr>
<tr>
<td>Lateral (not required)</td>
<td>3.89 m/s</td>
</tr>
<tr>
<td>Vehicle Damage</td>
<td>Minimal</td>
</tr>
<tr>
<td>TAD$^{31}$</td>
<td>1-RFQ-4</td>
</tr>
<tr>
<td>SAE$^{32}$</td>
<td>01RFEW5</td>
</tr>
<tr>
<td>Vehicle Stopping Distance</td>
<td>23.31 m downstream</td>
</tr>
<tr>
<td>0.51 m traffic-side face</td>
<td></td>
</tr>
<tr>
<td>Barrier Damage</td>
<td>Moderate</td>
</tr>
<tr>
<td>Maximum Deflections</td>
<td></td>
</tr>
<tr>
<td>Permanent Set</td>
<td>652 mm</td>
</tr>
<tr>
<td>Dynamic</td>
<td>1,094 mm</td>
</tr>
<tr>
<td>Working Width</td>
<td>1,260 mm</td>
</tr>
</tbody>
</table>

Figure 87. Summary of Test Results and Sequential Photographs, Test NPG-4
**Test Number** ................... NPG-5  
**Date** ............................ 9/4/02  
**Appurtenance** .................. Midwest Guardrail System with Curb  
**Key Elements** .................. increased mounting height, blockout depth, and foundation tube length, mid-span splices, and curb  
**Total Length** .................. 55.25 m  
**Steel W-beam** ..................  
- Thickness ...................... 2.66 mm  
- Top Mounting Height .......... 787 mm  
- Bolt Slot Length .............. 64 mm  
**Steel Posts** ..................  
- Post Nos. 3 - 27 .............. W152 x 13.4 by 1,829-mm long  
- Spacing .......................... 1,905 mm  
**Wood Posts** ..................  
- Post Nos. 1 - 2, 28 - 29 (BCT) . 140 mm x 190 mm by 1,080-mm long  
**Steel Foundation Tube Length** . 1,829 mm  
**Wood Spacer Blocks** ..........  
- Post Nos. 3 - 27 .............. 152 mm x 305 mm by 356-mm long  
**Curb** ..................  
- 152-mm tall Type B mounted 152 mm in front of guardrail face  
**Soil Type** .................. Grading B - AASHTO M 147-65 (1990)  
**Vehicle Model** ............... 1997 Chevrolet C2500 ¾-ton pickup  
- Curb .................. 1,813 kg  
- Test Inertial .................. 1,991 kg  
- Gross Static .................. 1,991 kg  

**Vehicle Speed** ..................  
- Impact .................. 96.6 km/h  
- Exit (resultant) .............. 48.0 km/h  
**Vehicle Angle** .................  
- Impact (trajectory) ............ 25.8 deg  
- Exit (trajectory) .............. 6.7 deg  
**Vehicle Stability** ............. Satisfactory  
**Occupant Ridedown Deceleration (10 msec avg.)**  
- Longitudinal .................. 10.50 g’s < 20 g’s  
- Lateral (not required) ........ 8.66 g’s  
**Occupant Impact Velocity** ......  
- Longitudinal .................. 5.23 m/s < 12 m/s  
- Lateral (not required) ........ 3.93 m/s  
**Vehicle Damage** ............... Moderate  
- TAD$^{31}$ ....................... 1-RFQ-4  
- SAE$^{32}$ .......................... 01RFEW5  
**Vehicle Stopping Distance** .... 14.15 m downstream  
- 4.47 m traffic-side face  
**Barrier Damage** ............... Moderate  
**Maximum Deflections** ........  
- Permanent Set .................. 611 mm  
- Dynamic ...................... 1,024 mm  
**Working Width** ............... 1,453 mm  

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Figure 105. Summary of Test Results and Sequential Photographs, Test NPG-5
Test Number: NPG-6
Date: 10/18/02
Appurtenance: Midwest Guardrail System with reduced post spacing

Key Elements: reduced post spacing, increased mounting height, blockout depth, and foundation tube length

Total Length: 55.25 m
Steel W-beam
- Thickness: 2.66 mm
- Top Mounting Height: 787 mm
- Bolt Slot Length: 64 mm
Steel Posts
- Post Nos. 3 - 59: W152 x 13.4 by 1,829-mm long
Steel Post Spacing
- Post Nos. 3 - 8, 54 - 59: 1,905 mm
- Post Nos. 9 - 10, 52 - 53: 953 mm
- Post Nos. 11 - 51: 476 mm
Wood Posts
- Post Nos. 1 -2, 60 - 61 (BCT): 140 mm x 190 mm by 1,080-mm long
Steel Foundation Tube Length: 1,829 mm
Wood Spacer Blocks
- Post Nos. 3 - 59: 152 mm x 305 mm by 356-mm long
Soil Type: Grading B - AASHTO M 147-65 (1990)
Vehicle Model: 1997 GMC C2500 ¾-ton pickup
Curb: 1.971 kg
Test Inertial: 2,001 kg
Gross Static: 2,001 kg

Vehicle Speed
- Impact: 96.8 km/h
- Exit (resultant): 59.5 km/h

Vehicle Angle
- Impact (trajectory): 25.6 deg
- Exit (trajectory): 12.9 deg

Vehicle Stability: Satisfactory

Occupant Ridedown Deceleration (10 msec avg.)
- Longitudinal: 10.67 g’s < 20 g’s
- Lateral (not required): 8.97 g’s

Occupant Impact Velocity
- Longitudinal: 7.62 m/s < 12 m/s
- Lateral (not required): 5.61 m/s

Vehicle Damage: Moderate
- TAD: 1-RFQ-5
- SAE: 01RYEW7

Vehicle Stopping Distance: 30.86 m downstream 0.61 m laterally

Barrier Damage: Moderate

Maximum Deflections
- Permanent Set: 305 mm
- Dynamic: 447 mm
- Working Width: 931 mm

Figure 124. Summary of Test Results and Sequential Photographs, Test NPG-6