August 10, 2005

In Reply Refer To: HSA-10/B-139

Chuck Plaxico, Ph.D.
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201-2693

Dear Dr. Plaxico:

My April 7 letter to you accepted the Ohio Department of Transportation’s (ODOT) Type 5 Guardrail with Tubular Backup (ODOT GR-2.2) that is used as a barrier across low-fill culverts as a National Cooperative Highway Research Program (NCHRP) Report 350 test level 3 (TL-3) design. This acceptance was based on the similarity of the Ohio design to the Texas T101 Bridge Rail, which is currently classified as a TL-3 design, and on finite element analyses done at your facility. In your July 29 letter to Mr. Richard Powers of my staff, you requested the Federal Highway Administration’s concurrence that a modified version of the ODOT GR-2.2, called the Nested Type 5 Guardrail with Tubular Backup, and a transition to the ODOT GR-2.2, called the ODOT GR-3.4 Transition, also be accepted as TL-3 designs.

**Original ODOT GR-2.2**
The lateral stiffness of the ODOT GR-2.2 varies depending on the type of post mounting condition used; the post mounting conditions range from posts fully encased in concrete (very stiff system) to posts embedded in 3’-5” of soil (a much less stiff system). The finite element analysis of the original ODOT GR-2.2 indicated that the system would meet the NCHRP Report 350 TL-3 requirements for all post mounting conditions specified for the system. However, in subsequent analyses a stiffness incompatibility between the ODOT GR-2.2 and the ODOT GR-3.4 transition system was identified. The results of the finite element analyses indicated that when the ODOT GR-2.2 posts were mounted in soil, there was a significant risk of a vehicle snagging at the connection point of the transition system when the pickup truck impacted at the departure end of the ODOT GR-2.2 at a point 1.6 m upstream of the transition. The snagging was caused by excessive deflection of the ODOT GR-2.2 in relation to the ODOT GR-3.4 transition design and resulted in relatively high ridedown accelerations.

**Modified ODOT GR-2.2**
The modified ODOT GR-2.2 design differs from the original version by using nested 12-gauge sections of W-beam in lieu of the original single rail element. This modification stiffens the ODOT GR-2.2 to make its deflection more comparable to the ODOT GR-3.4 transition at the connection points of the installation. The ODOT GR-3.4 transition uses one 13’-6” nested
W-beam section immediately adjacent and connected to the ODOT GR-2.2 rail and supported by four posts spaced at 1’-6.75”, followed by four posts spaced at 3’-1.5” before changing to the standard 6’-3” spacing for the W-beam approach rail. Either steel or wood guardrail posts can be used in the transition. Design details are shown in the enclosure to this letter.

The results of the finite element analyses indicated that nesting the rail throughout the ODOT GR-2.2 length to match the nested W-beam in the transition design eliminated the potential for snagging at the connection point and, consequently, the ridedown accelerations were significantly reduced. Furthermore, the analysis results of the original design indicated that some wheel snag on guardrail posts might be expected at impact angles greater than 25 degrees, i.e. the lower part of the W-beam in the original design is likely to fold under the tubular backup in higher severity impacts, due to the low stiffness of the single W-beam element, and allow the wheel of the vehicle to pass underneath the rail. The nested W-beam rails of the modified ODOT GR-2.2 sufficiently stiffen the guardrail to prevent the wheel of the pickup truck from pushing underneath the rail, thus reducing the potential for wheel snag on guardrail posts. Based on the results of the analysis, the integrated system of the Nested Type 5 Guardrail with Tubular Backup and the ODOT GR-3.4 transition was recommended as a final design.

Based on your analyses, I agree that the modified ODOT GR-2.2 and ODOT GR-3.4 designs, as described above and used together, may be considered the NCHRP Report 350 TL-3 designs and used on the National Highway System at the State’s discretion.

Sincerely yours,

/origin signed by/

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

Enclosure
NOTES

APPLICATION: Nested Type 5 Guardrail with Tubular Backup is accepted to AASHTO 350 Test Level 3. The only Bridge Terminal Assembly that is permitted to be used with this system is detailed on SCD 6R-3.4. This system cannot be used with any other BTs.

GALVANIZING: Rails, posts, base plates, bolts, nuts, washers and all tubular steel are to be galvanized as specified in CMS T01.00.

POST EMBEDMENT: Normal embedment depth is 3'-5" (1.04 m) (See SCD 6R-1). For installation methods for posts of various cover over structures, see Sheet 2.

ANCHORING: Partial-depth anchoring is preferred to through-bolting. For partial depth anchoring use non-strand, non-metallic grout as specified in CMS T05.20. Minimum embedment depths are 9" (225) for 1/4" (6.35) bolts and 10" (250) for 1/2" (12.7) bolts.

THROUGH-BOLTING: Drilling methods that cause spalling of the concrete where the bit passes through the undersea of the slab is not permitted. In h louver 6 or #8, use beveled plate washers on the bottom surface to compensate for the slope. Through-bolting is not permitted in hunch areas with a slope greater than 6:1.

SIDE-MOUNTED POST ANCHORAGE TO STRUCTURES: Initial anchors according to Structural Engineering’s Standard Drawing DBR-H-73 and is allowed under Item 5F – Rolling.

PAYMENT: Item 606 - Guardrail, Nested Type 5 with Tubular Backup (is paid in Feet (Meters) for the length specified in the plan and shall include tubular backup as per Item 701.00, rails, posts and all other hardware, material and labor required to construct the guardrail as shown. The specified lengths should be for full W-Beam panels, i.e., evenly divisible by 12'-0" (3.66 m).
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GENERAL: For additional details, see SCG GR-1A.

APPLICATION: The Type 4 Bridge Terminal Assembly shall connect Type 5 Guardrail to Type 6 Guardrail with Tubular Backups or to Deep Beam Bridge Guardrail as shown on Structural Engineering SCG DBR-2-73. Do not use on the R3.

DETAIL INFORMATION: The first post off the bridge shall be steel W6x15 or W6x25 (W150x22.5 or W150x37.1). All holes in the stiffening and end of the approach panel shall be drilled 1/4" (6mm) in diameter before welding in the bolts. The bolts are flush to the top of the post beam section and the post beam section is attached with 3/4" (19mm) diameter bolts.

STEEL POSTS: Are detailed in the drawings. Except for the first post off the bridge, the bolts are flush to the top of the post beam section and the post beam section is attached with 3/4" (19mm) diameter bolts. The bolts are inserted into the holes in the stiffening and end of the approach panel and welded in place.

WOOD POSTS: Made of southern yellow pine and other wood grades having similar characteristics (2000). Use square headed pressure treated wood as specified in CMS 710.4 and fabricated with square ends. Drill 1/4" (6mm) diameter holes in the post beam section and the post beam section is attached with 3/4" (19mm) diameter bolts.

STEEL POSTS: Are detailed in the drawings. The bolts are flush to the top of the post beam section and the post beam section is attached with 3/4" (19mm) diameter bolts. The bolts are inserted into the holes in the stiffening and end of the approach panel and welded in place.

FLARED GUARDRAIL: Start Standard Guardrail Flares as shown on SCG GR-3A at or beyond Post No. 7. However, the flare may begin at Post No. 7. The Flare shall be made of steel and shall be attached to the guardrail with 3/4" (19mm) diameter bolts. The bolts are inserted into the holes in the stiffening and end of the approach panel and welded in place.

PAYMENT: Item 506 - Bridge Terminal Assembly Type 4. Each, including the cost of all other components, is based on the normal guardrail. For additional posts and other hardware, add the cost of the normal guardrail, plus the cost of the additional posts and other hardware (506). The Flared Flare is included with Item 506 - Guardrail, Heated Type 5, with Tubular Backup, for payment.

LEGEND: Guardrail is not attached to posts 2, 3, 4, 6, and 8. Flared Flare is not attached to posts 2, 3, 4, 6, and 8. Blockout is fastened to post with standard Post Bolt.