U.S. Department
of Transportation
Federal Highway
Administration

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

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.

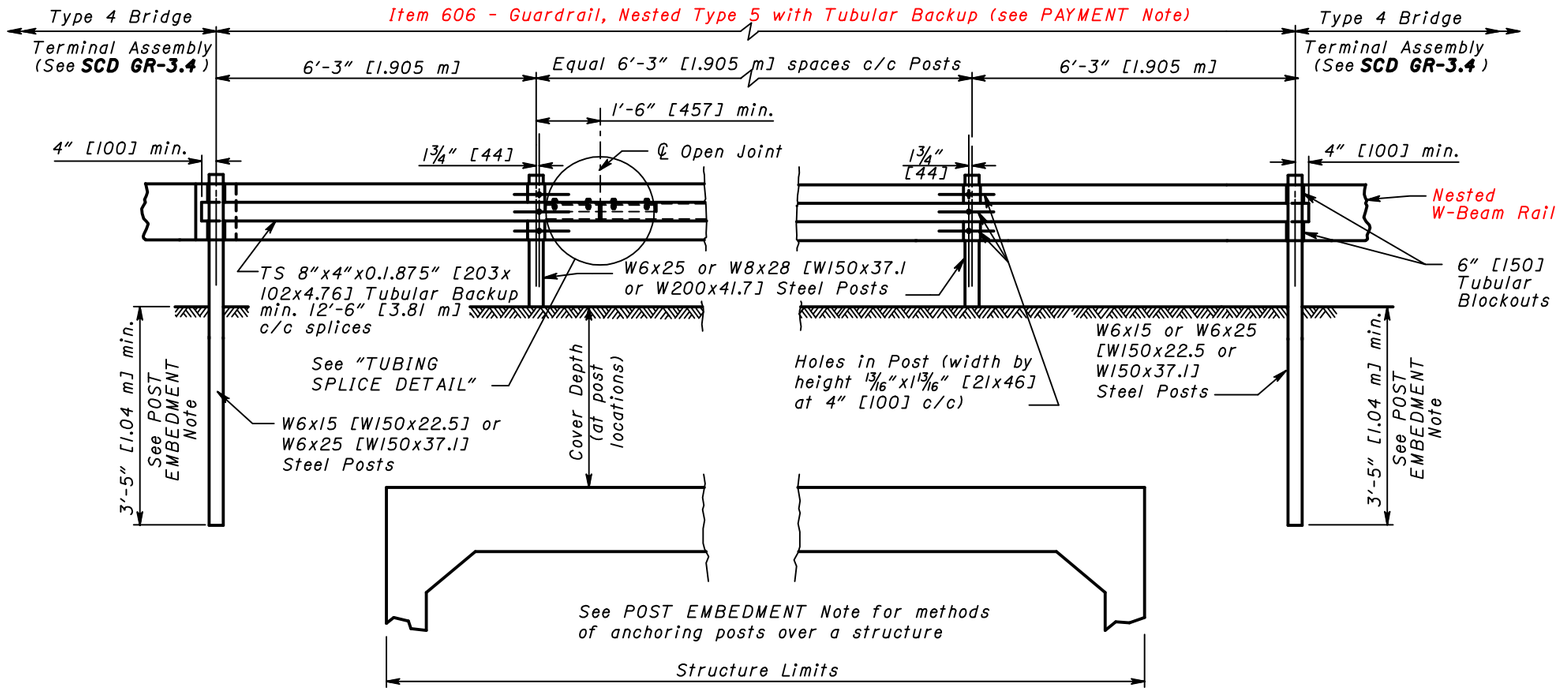
Based on your analyses, I agree that the modified ODOT GR-2.2 and ODOT GR-3.4 designs, as described above and used together, may be considered the NCHRP Report 350 TL-3 designs and used on the National Highway System at the State's discretion.

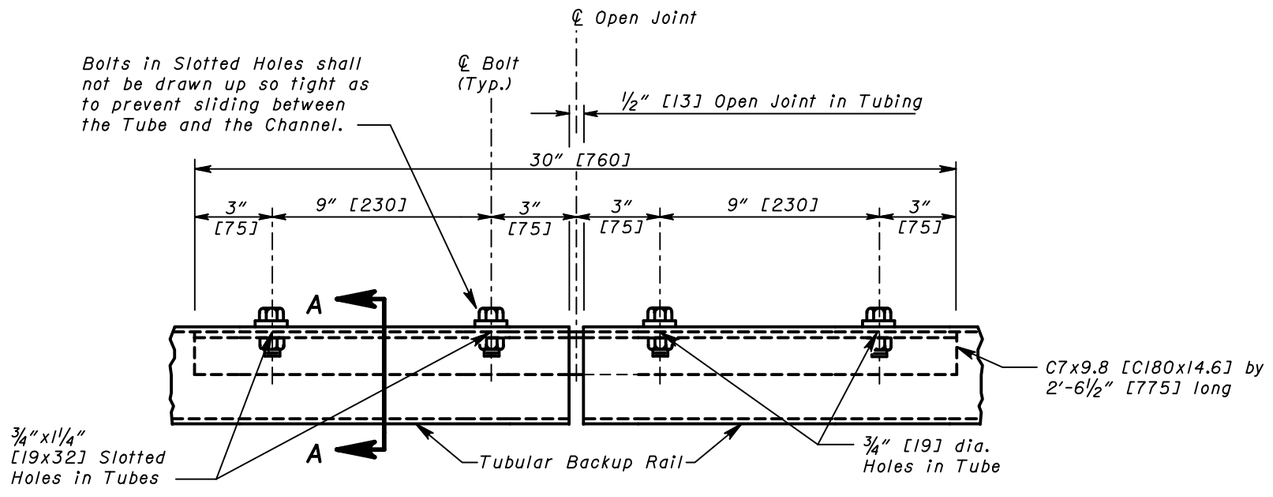
Sincerely yours,

/original signed by/

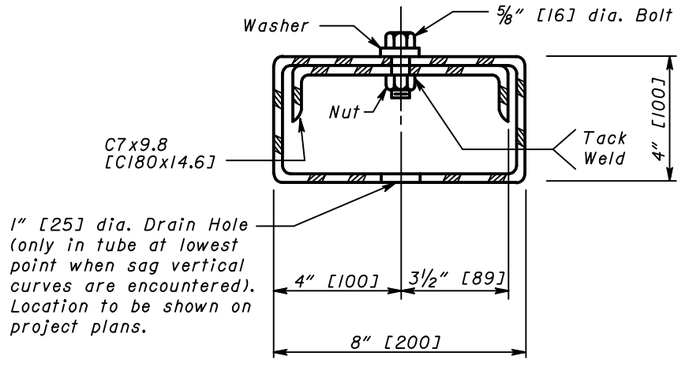
John R. Baxter, P.E.
Director, Office of Safety Design
Office of Safety

Enclosure





TUBING SPLICE DETAIL



SECTION A-A

NOTES

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

GALVANIZING: *Rails, posts, base plates, bolts, nuts, washers and all tubular steel are to be galvanized as specified in CMS 711.02.*

POST EMBEDMENT: *Normal embedment depth is 3'-5" [1.04 m] (See **SCD GR-1.1**). 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-shrink, non-metallic grout as specified in CMS 705.20. Minimum embedment depths are 9" [225] for ⅞" [22] bolts and 10" [250] for 1¼" [32] bolts.*

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

SIDE-MOUNTED POST ANCHORAGES TO STRUCTURES: *Install anchorages according to **Structural Engineering's Standard Drawing DBR-2-73** and is paid under **Item 517 - Railing.***

PAYMENT: ***Item 606 - Guardrail, Nested Type 5 w/Tubular Backup** is paid in Feet [Meters] for the length specified in the plans and shall include tubular backup as per Item 707.10, 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'-6" [3.81 m].*

THIS DRAWING REPLACES GR-2.2 DATED 4-18-03.

OHIO DEPARTMENT OF TRANSPORTATION
ROADWAY DESIGN ENGINEER
X-XX-XX DATE

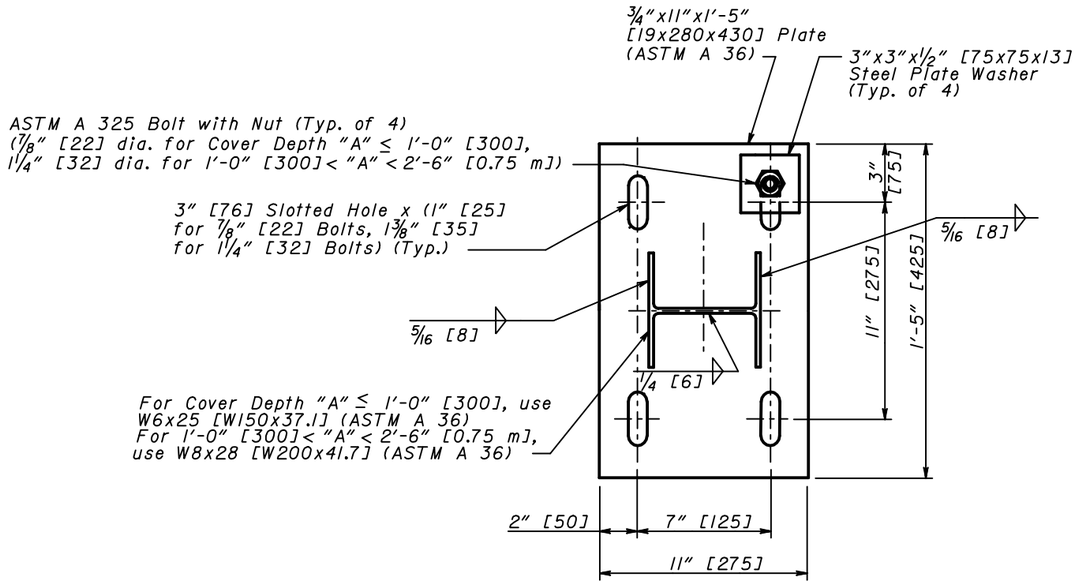
STDS. ENGR. D. Focke

All metric dimensions (in brackets [ ]) are in millimeters unless otherwise noted.

ROADWAY ENGINEERING SERVICES

STANDARD ROADWAY CONSTRUCTION DRAWING
NESTED TYPE 5 GUARDRAIL WITH TUBULAR BACKUP

NUMBER **GR-2.2**

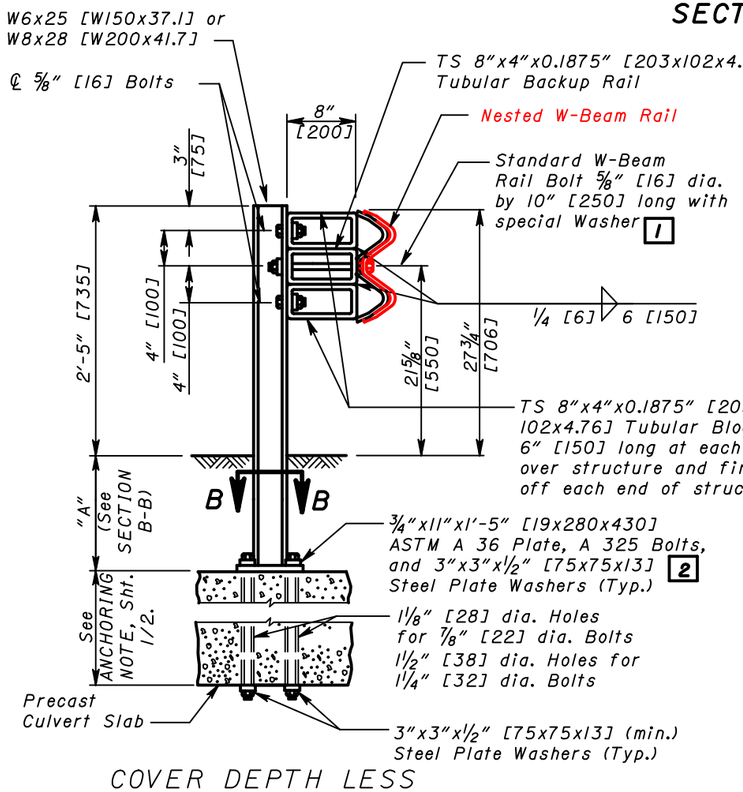


SECTION B-B

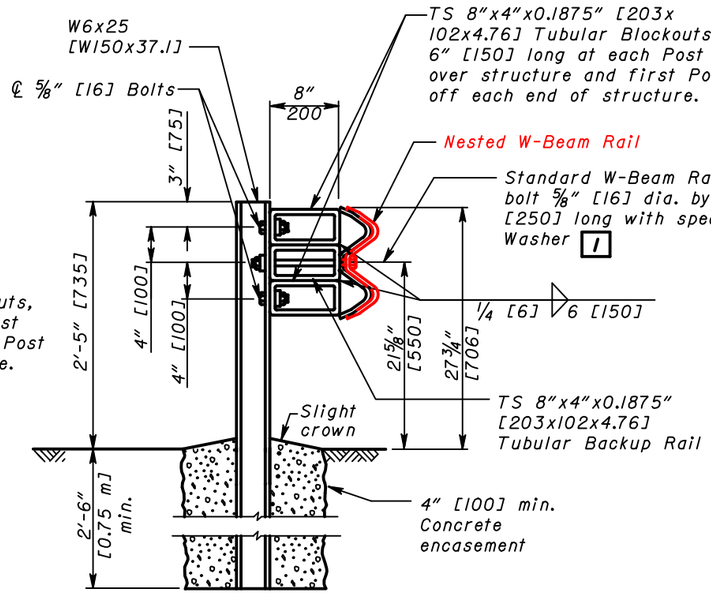
LEGEND

1 For details of special washer, see AASHTO M 180.

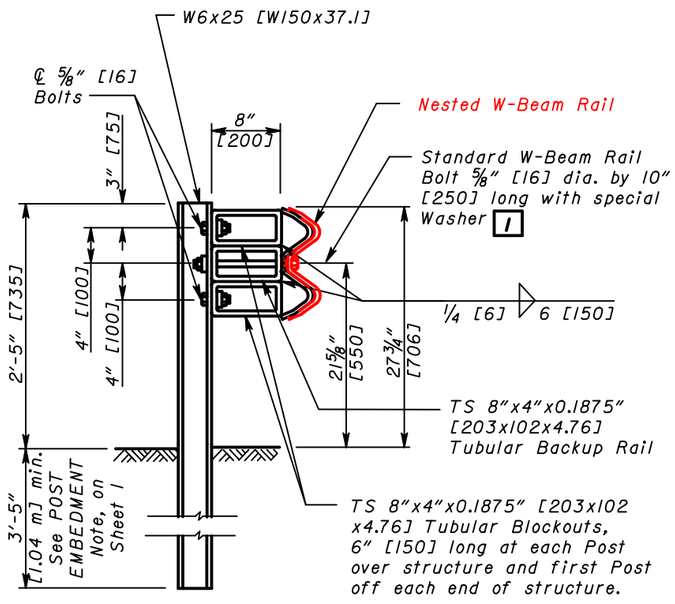
2 Embed plate in sealant as per Federal Specification TT-S-00230C, Type II.



COVER DEPTH LESS THAN 2'-6" [0.75 m]



COVER DEPTH EQUAL TO OR GREATER THAN 2'-6" [0.75 m], BUT LESS THAN 3'-5" [1.04 m]



COVER DEPTH GREATER THAN OR EQUAL TO 3'-5" [1.04 m]

METHODS FOR ANCHORING POSTS

THIS DRAWING REPLACES GR-2.2 DATED 4-18-03.

OHIO DEPARTMENT OF TRANSPORTATION
X-XX-XX
ROADWAY DESIGN ENGINEER — DATE

STDS. ENGR. D. Focke

All metric dimensions (in brackets [ ]) are in millimeters unless otherwise noted.

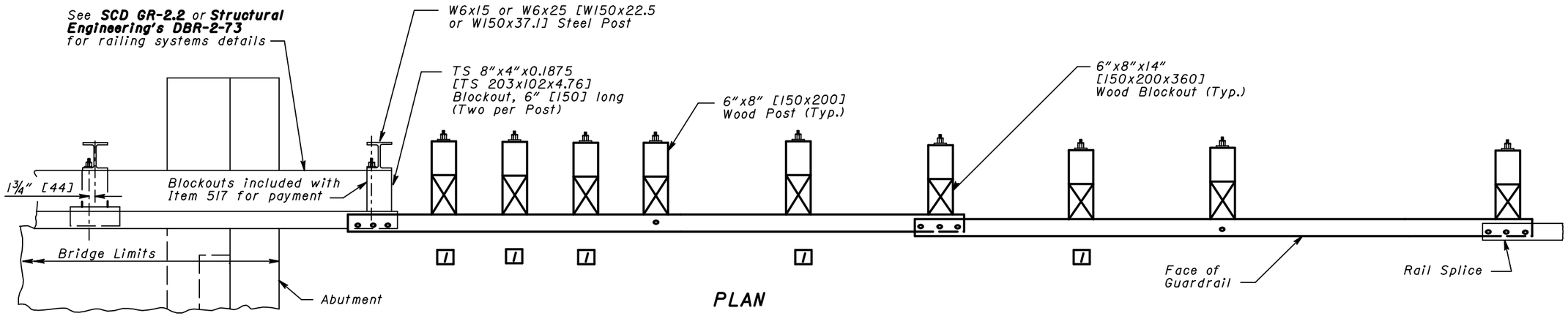
ROADWAY ENGINEERING SERVICES

STANDARD ROADWAY CONSTRUCTION DRAWING

NESTED TYPE 5 GUARDRAIL WITH TUBULAR BACKUP

NUMBER GR-2.2

2 / 2



NOTES

GENERAL: For additional details, see **SCD GR-1.1.**

APPLICATION: The Type 4 Bridge Terminal Assembly shall connect Type 5 Guardrail runs to Type 5 Guardrail with Tubular Backup or to Deep Beam Bridge Guardrail (as shown on **Structural Engineering SCD DBR-2-73**). **Do not use on the NHS.**

DETAIL INFORMATION: The first post off the bridge shall be steel (W6x15 or W6x25 [W150x22.5 or W150x37.1]). All holes in the off-structure end of the approach panel rail section spanning the abutment are slotted ¾"x2½" [19x64]. Tighten the bolts as specified for expansion joints in Item 606.05.

POSTS: Posts may be set in drilled holes or driven to grade. See **SCD GR-1.1** for additional Post embedment details. Guardrail is not attached to certian posts (see LEGEND).

WOOD POSTS - Use square sawed pressure treated wood as specified in CMS 710.14 and fabricated with square ends. Bore bolt holes and trim the tops of posts, if required, after the posts are set.

STEEL POSTS - are allowed as an alternate. Use W6x9 [W150x13.5] or W6x8.6 [W150x12.6] in lieu of the 6"x8" [150x200] wood post. Use same post material throughout assembly.

BLOCKOUTS: Use wood blockouts only. Steel or plastic blockouts are not permitted. Notched wood blockouts are used with steel posts.

FLARED GUARDRAIL: Start Standard Guardrail Flares as shown on **SCD GR-5.1** at or beyond Post No. 10; however, the flare may begin at Post No. 7.

PAYMENT: **Item 606 - Bridge Terminal Assembly, Type 4, Each,** includes the cost of extra componets, in excess of normal guardrail, for additional posts and other hardware. The TS 8"x4" [200x100] spacers and tubular backup rail extending to the first post off the bridge is included with **Item 517 - Railing,** or **Item 606 - Guardrail, Nested Type 5, with Tubular Backup,** for payment.

LEGEND

[1] Guardrail is not attached to posts at Posts 2, 3, 4, 6, and 8. Blockout is fastened to post with standard Post Bolt.

THIS DRAWING REPLACES GR-3.4 DATED 4-18-03.

OHIO DEPARTMENT OF TRANSPORTATION
ROADWAY DESIGN ENGINEER
X-XX-XX DATE

STDS. ENGR. D. Focke

All metric dimensions [in brackets] are in millimeters unless otherwise noted.

ROADWAY ENGINEERING SERVICES

STANDARD ROADWAY CONSTRUCTION DRAWING

BRIDGE TERMINAL ASSEMBLY, TYPE 4

NUMBER GR-3.4

1 / 1