



## Performance Evaluation of the Modified T77 Bridge Rail

The Texas Department of Transportation (TxDOT) frequently receives requests from districts and the public to provide aesthetically pleasing traffic rails for use on select bridges and roadways. Such rails are normally installed along designated scenic or historic routes and various types of urban facilities. Although aesthetic rails are generally more expensive to construct, their cost is still only 2 percent to 5 percent of the total cost of the bridge, and yet they can be the defining feature of a bridge.

Typically, aesthetic rails are ornate and have an open architecture that may compromise their crashworthiness. If not properly designed, vertical and horizontal openings in these barriers provide the opportunity for vehicle snagging, which can produce undesirable decelerations or occupant compartment intrusion. Traffic barriers are frequently designed for high-speed facilities (i.e., > 60 mph), which exacerbates the potential

problems presented by surface asperities. TxDOT is seeking to expand the number of aesthetically pleasing traffic rails available to the motoring public that meet *NCHRP Report 350* Test Level 3 (TL-3) impact conditions.

TxDOT, in response to the need for providing context-sensitive design alternatives for the public, initiated a prior project (Project O-4288) to develop additional aesthetically pleasing rail alternatives. The Texas Transportation Institute (TTI) and TxDOT worked cooperatively to conceptualize and develop two aesthetically pleasing and crashworthy rail designs. The rails were designated the T77 and the F411. Researchers performed and evaluated full-scale crash tests on the new rails in accordance with *NCHRP Report 350* test 3-11.

The TxDOT F411 bridge rail performed acceptably according to the evaluation criteria of *NCHRP Report 350*. However, the T77 design failed to perform acceptably when tested with a pickup



Post Profile on T77 Bridge Rail. Local rail deformation near the rail splice and the sleeve splice itself caused the truck to experience snagging and excessive occupant compartment deformation. As part of the current project, TTI and TxDOT revised the T77 design to make it perform acceptably and in accordance with *NCHRP Report 350*.

### What We Did...

The objective of this project was to modify the TxDOT T77 traffic rail to perform as an aesthetically pleasing and crashworthy traffic rail for use by TxDOT. TTI and





T77 Bridge Rail Prototype Installation.

TxDOT worked cooperatively to modify the rail and sleeve splice connection design to perform satisfactorily. Researchers made design modifications and performed and evaluated full-scale crash tests in accordance with *NCHRP Report 350*.

Two crash tests were recommended for the prototype bridge rail to evaluate its safety performance in accordance with Test Level 3 conditions as defined in *NCHRP Report 350*. The crash tests performed in a previous project and under the current projects, to date, were as follows:

- **Prototype rail Texas T77 under Project 0-4288**

- Test 442882-3 – *NCHRP Report 350* test 3-11; 2000 kg pickup truck traveling 100 km/h and impacting the installation at 25 degrees; performed previously and in which the T77 bridge rail did not perform acceptably.

- Test 442882-4 – *NCHRP Report 350* test 3-10; 820 kg passenger car traveling 100 km/h and impacting the installation at 20 degrees; performed previously and in which the T77 bridge rail did perform acceptably.

- **Prototype rail modified Texas T77 under current projects, Project 0-4852 and Project 409260**

- Test 448523-1 – *NCHRP Report 350* test 3-11; 2000 kg pickup truck traveling 100 km/h and impacting the installation at 25 degrees.
- Test 409260-1 – Further modification of design and repeat of *NCHRP Report 350* test 3-11; 2000 kg pickup truck traveling 100 km/h and impacting the installation at 25 degrees.

### What We Found...

The T77 bridge railing system is a steel rail and post system

consisting of two tubular steel rail elements mounted on 1-1/4 inch thick steel plate posts spaced 8 ft apart. The elliptical-shaped rails are 8 inch x 4-7/8 inch and are manufactured from 6 inch diameter API-5LX52 pipe with a wall thickness of 0.188 inch. The center of the lower rail and the top of the upper rail measure 1 ft-6 inches and 2 ft-9 inches, respectively, from the pavement surface. The rails are welded to the posts. The 1-1/4 inch thick posts are fabricated in the shape of the numeral “7” and are welded to 11-1/2 inch x 12 inch x 1-1/2 inch thick baseplates.

For the tests, each post was anchored to the curb using four 7/8 inch diameter A325 anchor bolts with a 7 inch x 11 inch x 1/4 inch thick anchor plate used for additional anchorage. The bridge railing system was supported by a cast-in-place concrete deck and curb. The curb was 14 inches wide and 9 inches high on the traffic side and 5-1/2 inches high on the field side. The top of the curb sloped downward approximately 14 degrees from horizontal toward the field side. The post plates were sloped in a similar fashion so that the two rail elements were flush with the traffic-side face of the curb. The post plates and base plates were manufactured from A572 grade 50 steel. A simulated concrete bridge deck cantilever and curb was constructed immediately adjacent to an existing concrete runway located at the TTI test facility. The bridge deck cantilever was 2 ft-5 inches in width and 8 inches thick and was rigidly



attached to an existing concrete foundation. A 1 ft-2 inch wide concrete curb, 9 inches high on the traffic side and 5-1/2 inches wide on the field side, was cast on top of the concrete deck.

During the previous study, the T77 bridge rail did not meet the occupant risk requirements for *NCHRP Report 350* test 3-11 due to excessive occupant compartment deformation; however, the T77 bridge rail did perform acceptably during *NCHRP Report 350* test 3-10.

To improve the performance of the T77 rail, TTI increased the wall thickness of the 8 inch x 4-7/8 inch elliptical-shaped rail from 0.188 inch (API-5LX52) to 0.280 inch (ASTM A-53 Grade B, schedule 40). Additionally, the elliptical sleeve splices were chamfered 1.0 inch in the lateral direction in toward the center of the rail.

Crash test 448523-1 was performed, and the rail demonstrated some improved performance. However, the leading edge of the front wheel rim gouged into the lower rail element and snagged in between the rail element and the sleeve splice causing excessive occupant compartment deformation. Thereafter, TTI redesigned the sleeve splice to reduce the potential for snagging.

The railing installation prepared for crash test 409260-1, and the final T77 test installation, used newly developed 3 ft long elliptical-shaped two-part sleeve splices that were manufactured from 6 inch diameter API-5LX52



Successful Pickup Truck Test with T77 Bridge Rail.

pipe formed into an elliptical shape. The two-part sleeve splices were fabricated with an adjusting mechanism within the splice. This adjusting mechanism — which incorporated a 1 inch thick plate with a threaded hole for a 1 inch diameter, Grade 5 machine bolt and a 1 inch thick bearing plate — was used to expand the splice inside the rail to obtain a secure splice fit. The splices were constructed with a close-fitting tolerance and provided approximately 1 inch of rail expansion at each splice. These splices were located 1 ft from posts 4 and 7.

Due to excessive occupant compartment deformation in test 448523-1, the T77 bridge rail did not meet the occupant risk criteria for *NCHRP Report 350* test 3-11. However, after increasing the wall thickness of the rail member and using the newly designed rail sleeve splice connection, the T77 bridge rail performed acceptably in test 409260-1 (repeat of test

*NCHRP Report 350* test 3-11).

The T77 bridge rail had performed acceptably for *NCHRP Report 350* test 3-10 (as test 442882-4 under Project 0-4288) and therefore was not repeated under the current projects.

### **The Researchers Recommend...**

TTI researchers and TxDOT personnel have developed modifications to ensure the T77 bridge rail performs in accordance with the evaluation criteria of *NCHRP Report 350*. Modifications included improvement in the rail sleeve splice connection and increased wall thickness of the rail member.

TTI researchers recommend implementation of the modified Texas T77 bridge rail design. The T77 bridge rail will be implemented through development and dissemination of standard drawings by the TxDOT Bridge Division. The T77 will be available for use statewide.



## For More Details . . .

The research conducted under this project is documented in the following reports:

Report 0-4852-1, *Crash Testing and Evaluation of the Modified T77 Bridge Rail*

Report 4288-1, *Design and Evaluation of the TxDOT F411 and T77 Aesthetic Bridge Rails*

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## TxDOT Implementation Status February 2004

Subsequent work on the T77 bridge rail has corrected the vehicle snag point at the rail splice, and the TxDOT Bridge Division will incorporate the T77 rail into its bridge rail standards. At this point in time, the T77 rail will be used only on straight (noncurved) bridges. Use of the T77 rail on curved bridges will depend on developing sufficient fabrication experience with this type of rail. The first use of the T77 rail is planned for structures in the Waco District.

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