TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM

Project Summary Report 4288-S
Project 0-4288: Development of Aesthetic Traffic Rails

Author: D. Lance Bullard, Jr.

PROJECT SUMMARY REPORT

Performance Evaluation of Two Aesthetic Bridge Rails

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. The Texas T411 is an example of an aesthetic rail that has been very successful and has seen widespread implementation at both the state and national levels. Although aesthetic rails are generally more expensive to construct, their cost is only a fraction of the total cost of a bridge.

Typically, aesthetic rails such as the Texas T411 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. Historically, traffic barriers have been designed for high-speed facilities applications (i.e., >60 mph) following *National Cooperative Highway Research Program (NCHRP) Report 350* Test Level 3 (TL-3) impact conditions. However, many locations using aesthetic rails have travel speeds of 45 mph (TL-2) or less. Desired design impact conditions dictate flexibility in geometric design. Potentially more crashworthy traffic rail design options may be available for low-speed designs (e.g., Test Level 2 impact conditions) than for high-speed designs (TL-3), but high-speed designs are also needed.

What We Did...

The objective of this study was to develop two aesthetically pleasing and crashworthy bridge rails for use by TxDOT. Consideration was given to both high-speed and low-speed designs. Texas Transportation Institute (TTI) and TxDOT worked cooperatively to conceptualize several aesthetically pleasing rail designs. Two crash tests were recommended for each prototype bridge rail with an option to perform a third test using a commercial vehicle. The crash tests evaluated the safety performance of the bridge rails in accordance with Test Level 3 conditions as defined in *NCHRP Report 350*. Each rail underwent two full-scale crash tests in accordance with *NCHRP Report 350*. The crash tests performed were as follows (test measurements shown in metric units based on test procedures):

- **Prototype rail no. 1 (Texas F411)**
  Test 1 – *NCHRP Report 350* test 3-11; 2000 kg pickup truck traveling 100 km/h and impacting the installation at 25 degrees.

Texas F411 bridge rail with pickup truck

Texas F411 during Test 2.

Test 2 – Rail was modified and *NCHRP Report 350* test 3-11 was re-run; 2000 kg pickup truck traveling 100 km/h and impacting the installation at 25 degrees.

- **Prototype rail no. 2 (Texas T77)**
  Test 3 – *NCHRP Report 350* test 3-11; 2000 kg pickup truck traveling 100 km/h and impacting the installation at 25 degrees.
  Test 4 – *NCHRP Report 350* test 3-10; 820 kg passenger car traveling 100 km/h and impacting the installation at 20 degrees.

What We Found …

Texas F411 Bridge Rail

The Texas F411 bridge rail is a 10 inch wide by 3 ft-6 inch high parapet wall with two 6 inch wide concrete rails that project 6 inches toward the traffic side. Considering the shape and location of the two concrete rails, the originally tested cross section of the F411 closely resembled the shape of the letter "F". The height to the top of the lower rail is 1 ft-6 inches from the roadway. The height to the top of the upper rail is 3 ft-6 inches from the roadway. The total width of the rail at the top is 1 ft-4 inches. The rail is constructed with rectangular aesthetic openings located between the projecting rails. These openings are 6 inches by 11 inches and are spaced 1 ft-6 inches apart along the entire length of the 76 ft long test specimen.

For the tests, the rail was constructed atop an 8 inch thick by 2 ft-5 inch wide bridge deck cantilever. Due to excessive occupant compartment deformation, the F411 bridge rail did not meet the requirements for occupant risk for *NCHRP Report 350* test 3-11. Researchers modified the rail by enclosing the open space beneath the lower rail with concrete, thus making it flush with the surrounding vertical surfaces. *NCHRP Report 350* test 3-11 was repeated on the modified F411 bridge rail, which did meet the required specifications.


Damage to Texas F411 after pickup test.

Texas T77 Bridge Rail

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 inches by 4-7/8 inches 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 by 12 inch by 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 by 11 inch by 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

Texas T77 bridge railing with small car.

Damage to Texas T77 after small car test.

Texas T77 during Test 4.

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.

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.

The Researchers Recommend…

Texas F411 Bridge Rail

TTI researchers recommend implementation of the modified F411 bridge rail design used in the second crash test. The rail had been modified by enclosing the open space beneath the lower rail face with concrete to make it flush with the lower rail. Enclosing the bottom of the rail increased the effective surface contact area of the installation.

Texas T77 Bridge Rail

TTI researchers and TxDOT personnel will pursue development of modifications to ensure the T77 bridge rail performs in accordance with the evaluation criteria of *NCHRP Report 350*. Tentatively, modifications include improvement in the rail splice connection and increased wall thickness of the rail member. One additional *NCHRP Report 350* crash test (3-11) will be required to evaluate the performance of the T77 bridge rail with these modifications prior to implementation.

For More Details . . .

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

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

Research Supervisor: D. Lance Bullard, Jr., TTI, l-bullard@tamu.edu (979) 845-6153

Researchers: William F. Williams, TTI, w-williams@tamu.edu (979) 862-2297

Wanda L. Menges, TTI, w-menges@tamu.edu, (979) 845-6157

Rebecca R. Haug, TTI, r-haug@tamu.edu, (979) 845-8971

TxDOT Project Director: Mark Bloschock, TxDOT, mbloscho@dot.state.tx.us, (512) 416-2178

To obtain copies of reports, contact Dolores Hott, Texas Transportation Institute, Information and Technology Exchange Center, (979) 845-4853, or e-mail d-hott@tamu.edu. See our online catalog at http://tti.tamu.edu.

TxDOT Implementation Status January 2003

The F411 bridge rail will be implemented through development and dissemination of standard drawings by the TxDOT Bridge Division. The F411 will be available for use statewide in those areas where an aesthetically pleasing, open concrete rail is desired.

Funding for further development and testing of the T77 bridge rail is being pursued. If additional funding is secured, it is anticipated that a modified T77 rail may be ready for statewide use in the latter part of 2003.

For more information, contact Tom Yarbrough, P.E., Research and Techonology Implementation Office, (512) 465-7403.

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Disclaimer

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