Testing of the Retrofitted T102R Bridge Railing

IAC No. 88-3DDIA043,
Project No. 409390

2004

Texas Transportation Institute
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Mr. Mark J. Bloschock, P.E.
Texas Department of Transportation
Design Division
125 E. 11th Street
Austin, Texas  78701-2483

RE:  IAC No. 88-3DDIA043, Project No. 409390
      Testing of the Retrofitted T102R Bridge Railing

Dear Mark:

       Transmitted herein are the results for the recent pendulum tests performed on the Retrofit T102R bridge rail post and deck samples. The purpose of this study was to develop an alternative to mounting a T101 type post on a 14-inch thick slab, and perform pendulum tests on two deck specimens supporting the posts. This letter summarizes the alternative design of the T102R Posts, the details of the test specimens constructed for this project, and the results from the pendulum testing.

Test Specimen Description:

       TTI constructed two concrete deck cantilever test specimens using the information provided to us by Mark Bloschock, with TxDOT Bridge Division. In addition, TTI received from Mark a drawing entitled “Texas Highway Department 25'-0" Slab Span (SPL) 28'-0" Roadway No Curbs H-15 Loading, State Project No. P-421-7-1”. The slab details shown on this drawing were used to construct the concrete deck specimens for this project.

       Two identical test specimens were constructed for this project. Each specimen was 8 ft-0 inches wide and 8 ft-3 1/2 inches in length. The specimens were constructed in such a way that they could be firmly anchored to an existing concrete foundation at our pendulum testing facility. To simulate the bridge slab, 3 ft-0 inch of the width of each specimen was constructed 14 inches thick. The remaining width of the specimens (5 ft-0 inches) was 1 ft-5 inches thick. Each specimen was constructed with two layers of steel reinforcement. Transverse reinforcement in the bottom layer (8 ft-0 inch direction) in the specimens consisted of #5 bars located on 12-inch centers. Longitudinal reinforcement in the bottom layer consisted of #8 bars on 6 3/4-inch centers with the four exterior longitudinal bars located on 3 3/4-inch centers. Transverse and longitudinal reinforcement in the top layer of reinforcement consisted of #4 bars located on 2 ft-0 inch centers. The compressive strength of the deck concrete was 4388 psi on the day the pendulum tests were performed.
The T102R posts were fabricated using steel W6x20 structural shape welded to a 11 inches by 11 inches by 1 inch thick baseplate. The total height of the posts were 2 ft -3 inches. The baseplates were fabricated with four 1 5/8 inch by 1 1/8 inch slotted holes. These holes were used to anchor the posts to the concrete using four 7/8-inch diameter by 9 7/8 inches long Hilti Super HAS anchors. The anchors were embedded approximately 7 inches into the concrete and anchored using the Hilti HIT RE500 Epoxy Anchoring System. The posts were offset 5 inches from the edge of the slab to the field side edge of the baseplates. For additional information please refer to the drawings which are included in Attachment A.

TTI performed engineering analyses and designed the T102R post used for this project. The T102R post was designed to have strength comparable to the TxDOT T101 post which incorporates the use of an embedded steel anchor strap in the concrete deck. Two pendulum tests were performed on two T101 posts with embedded steel anchor straps in February, 2002 (see TxDOT IAC Report No. 88-2DDIA06, TTI Project No. 408930, dated June 21, 2002). The peak force recorded from these two tests performed on the T101 post with embedded steel straps in an 8 inches thick concrete deck were 30 kips and 27 kips, respectively. The T102R posts were designed to have a peak force equal to or greater than the peak strength of the T101 post design. In addition, due to the need to retrofit this design to existing structures, the T102R posts were designed to use Hilti epoxy adhesive anchors which could be installed into existing concrete. For additional information on the T102R post design tested for this project please refer to the calculations which are included in Attachment B of this report.

Test Setup:

The impact load was applied with a pendulum with crushable nose. The pendulum bogie, built according the specifications of the Federal Outdoor Impact Laboratory's (FOIL) pendulum. Frontal crush of the aluminum honeycomb nose of the bogie simulates the crush of an actual vehicle and the sweeper plate, constructed of steel angles and a steel plate, is attached to the body of the pendulum with a ground clearance of 6 inches to replicate an automobile's undercarriage. The crushable nose configuration is the FOIL ten-stage bogie nose. Cartridges of expendable aluminum honeycomb material of differing densities are placed in a sliding nose. After a test, the honeycomb material is replaced and the bogie is reused. A sketch of the honeycomb configuration used for the pendulum bogie is shown in Attachment C. Testing was performed in accordance with NCHRP Report 350 and a brief description of the procedures is presented in Attachment D.

The mass of the pendulum bogie was 1848 lb and it was raised to a height to achieve a speed of approximately 25 mi/h. This setup would be capable of generating a force in excess of 35 kips on a “rigid” traffic rail post. Thus the pendulum could apply a load greater than the structural capacity of the post/deck test specimens.
Test Results:

Test 409390-P1

The pendulum bogie impacted the post at a height of 21.5 inches above the slab, at a speed of 24.1 mi/h, and at an impact angle of 90 degrees. At 0.002 s, the post began to deflect toward the field side of the slab, and at 0.012 s, the honeycomb nose of the bogie began to crush. At 0.078 s, the honeycomb was completely crushed and the concrete began to crack around the base of the post. Maximum crush of the honeycomb nose was 20.2 inches. Maximum deflection of the post was 4.6 inches. The front bolts in the baseplate pulled up. Spalling of the concrete deck occurred in front of the post on impact side in an area 68.9 inches wide. Graphs of the pendulum bogie accelerations are shown in Attachment E and photographs of the specimens before and after the test are shown in Attachment F.

Test 409390-P2

The pendulum bogie impacted the post at a height of 21.5 inches above the slab, at a speed of 23.6 mi/h, and at an impact angle of 90 degrees. At 0.002 s, the post began to deflect toward the field side, and at 0.012 s, the honeycomb nose began to crush. At 0.082 s, the honeycomb was completely crushed and the concrete began to crack around the base of the post. Maximum crush of the honeycomb nose was 19.5 inches. Maximum deflection of the post was 9.6 inches. The front bolts in the baseplate pulled up and caused spalling in front of the base plate. Cracks in the top of the concrete deck radiated out from the front anchor bolts of the post baseplate and along the field side of the deck across an area 60.4 inches. Graphs of the pendulum bogie accelerations are shown in Attachment E and photographs of the specimens before and after the test are shown in Attachment F.

Summary and Conclusions:

Results from the testing program are summarized in Table 1. This table was constructed from information from acceleration/force graphs in Attachment D. Values of maximum peak force applied to the post, maximum average force over a 0.010-sec time and maximum average force over a 0.050-sec time are included in the table.

Table 1. Summary of Results.

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The T102R Post with Hilti Super HAS anchors embedded approximately 7 inches and anchored using the Hilti HIT RE 500 Anchoring System is recommended for use in retrofit applications when used in conjunction with the 14-inch thick slab as described herein.

If you have any questions or require any further information, please do not hesitate to contact me.

Sincerely,

William Williams, P.E.
Assistant Research Engineer

Attachments
xc: Gene Buth
Denise Pineda, TTI-RDO
Contract File
Project File