



Truss Bridge Retrofit Railings

In 2003, there were 38 metal truss bridges 50 years of age or older remaining on the State of Texas highway system. Of these 38 bridges, 33 are listed in the National Register of Historic Places. Many of these bridges do not meet current design criteria for rehabilitation due to narrow deck widths, low vertical clearance, and substandard load capacity. In addition, the existing bridge railing

systems on these bridges have not been shown to meet the current requirements for safety and strength.

This project addressed the design and performance of acceptable traffic railings for existing and new truss bridges in Texas. Specific objectives were to:

- 1) design/develop a retrofit railing for low-speed applications on the Roy B. Inks Bridge in Llano, Texas;
- 2) design/develop a retrofit railing for high-speed applications on the U.S. 281 bridge over the Brazos River in Palo Pinto County, Texas;
- 3) identify criteria which can serve as a basis for design exceptions; and
- 4) design/develop a traffic railing for new truss bridges.

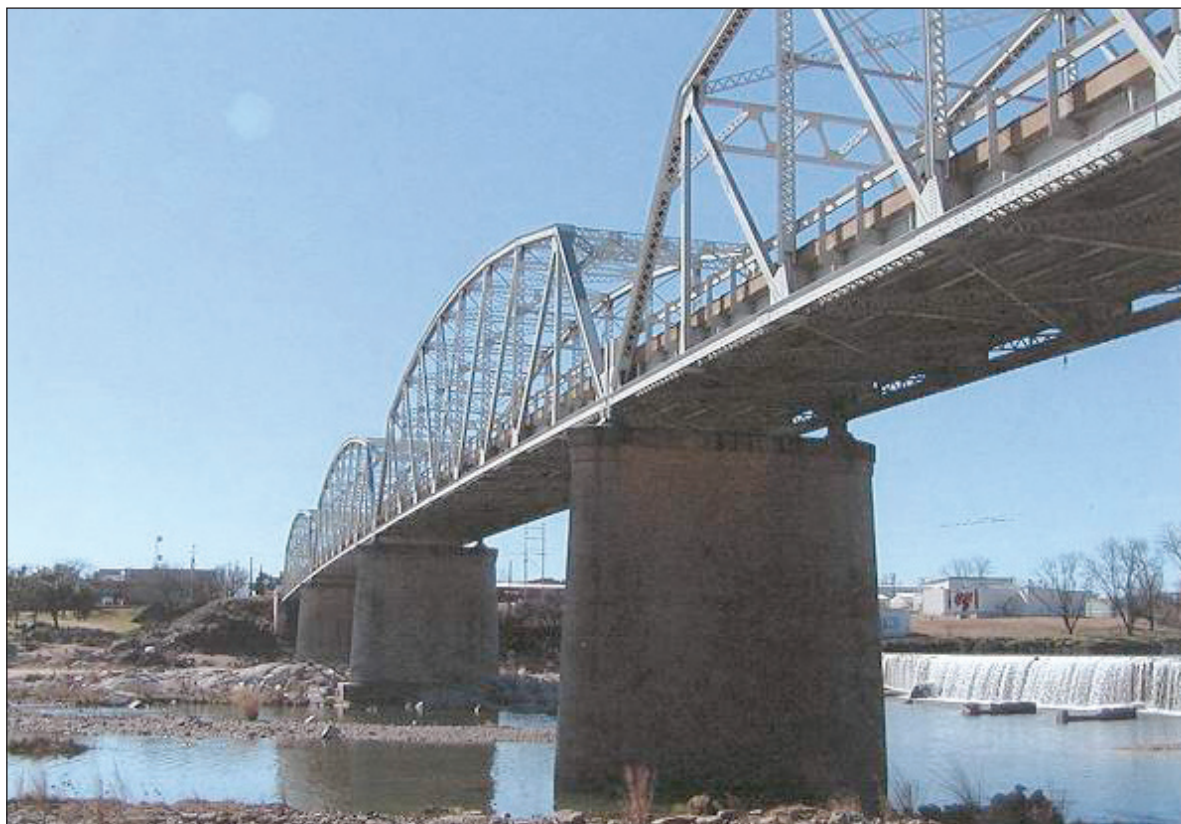


Figure 1. Roy B. Inks Bridge in Llano, Texas.





Figure 2. U.S. 281 over the Brazos River in Palo Pinto County, Texas.

What We Did...

The Roy B. Inks Bridge carries State Highway 16 over the Llano River in Llano, Texas (Figure 1). This bridge is a Parker through-truss structure and was constructed in the early 1930s. This bridge is classified as a historic structure and is listed in the National Register of Historic Places. The existing configuration does not provide a high level of protection of the truss members from errant vehicular impacts. The bridge is to be rehabilitated by the Texas Department of Transportation (TxDOT), and the crashworthiness of the existing traffic railing is considered inadequate by current standards. The posted speed limit on the bridge is 40 mph (64 km/h). *National Cooperative Highway Research Program (NCHRP) Report 350 Test Level 2 (TL-2)* is

appropriate for this posted speed limit. This project developed a TL-2 retrofit railing that is compatible with the appearance of the existing bridge and would require minimum structural modifications to the existing bridge superstructure.

The U.S. 281 bridge over the Brazos River in Palo Pinto County, Texas, is a three-span, steel Warren-type truss bridge with verticals (Figure 2). This bridge was also constructed in the early 1930s, and is also classified as a historic structure and listed in the National Register of Historic Places. The existing configuration does not provide a high level of protection of the truss members from errant vehicular impacts. The bridge is to be rehabilitated by TxDOT, and the crashworthiness

of the existing traffic railing is considered inadequate by current standards. The posted speed limit on the bridge is 60 mph (97 km/h). *NCHRP Report 350 Test Level 3 (TL-3)* is appropriate for this posted speed limit. This project developed a TL-3 retrofit railing that is compatible with the appearance of the existing bridge and requires minimum structural modifications.

Many existing truss bridges are located on highways with posted speed limits greater than 45 mph (72 km/h), and a TL-3 bridge railing would be indicated. Some of these structures are narrow, and the impact speed and angle combination for TL-3 might not be appropriate. For some of these bridges, the design loads for a TL-3 condition would require



extensive and costly modification of the original system. The objective of this portion of the research was to investigate a justification for considering reduced TL-3 design loads based on characteristic roadway geometry.

Several new truss bridges are planned throughout the state. Currently, the bridge railing proposed for these structures is a standard TxDOT railing, the T101, which is supported by a cast-in-place concrete deck. TxDOT would prefer to have the option to support a bridge rail system from the truss members in lieu of supporting the railing from the concrete deck.

The primary advantage of using a truss-supported bridge rail is to allow alternate types of decks. One disadvantage to using a truss-supported bridge rail is that the bridge structure must be adequately designed to resist the crash loads imparted from the bridge rail directly to the truss members. A truss-mounted bridge railing system will provide the bridge designer with more options and greater flexibility in designing steel truss bridges. A TL-3 bridge railing system was designed that would impart minimum forces to the supporting truss members and be acceptable for span lengths up to 20 ft (9.1 m) between supporting truss members.

What We Found ...

The new design for the retrofit bridge railing for the Roy B. Inks Bridge in Llano, Texas, reuses the existing C12×20.7 (C310×31) rail element and provides a TS8×4×1/2 (TS203×103×13) backup rail element to distribute load in the longitudinal. Short lengths of 5-inch (127 mm) and 6-inch (152 mm) diameter Schedule 40 pipe are used for crushable blockouts to limit forces

imposed on the truss members. A prototype of this railing was constructed and subjected to a full-scale crash test for TL-2 conditions. The prototype for the retrofit of the Llano truss bridge performed acceptably according to the criteria specified for *NCHRP Report 350 Test 2-11*.

A retrofit bridge railing was also designed for the U.S. 281/Brazos River bridge. The existing railing consists of a C12×20.7 (C310×31) mounted on truss members and intermediate posts. The retrofit design reused the existing channel rail element in combination with a W6×20 (W150×30) rail element to back up and stiffen the channel. New posts were designed to mount on the concrete safety walk. This design distributes load through the concrete deck rather than applying it directly to the truss members. A prototype of the railing was constructed and subjected to a full-scale crash test for TL-3 conditions. The prototype for the retrofit of the U.S. 281 truss bridge performed acceptably according to the criteria specified for *NCHRP Report 350 Test 3-11*.

The relatively narrow roadway widths of some truss bridges located on high-speed highways justify modification of the design crash test conditions and design loads for bridge rails for those structures. The analysis showed that the approach angle for TL-3 conditions can be reduced from 25 degrees to 20 degrees for a roadway width of 28 ft (8.5 m) or less. The resulting transverse force imposed on the rail can be reduced from 54 kips (240 kN) to 42 kips (187 kN).

A new railing design for TL-3 was designed and is proposed for use on new truss bridges. It provides two tubular steel rail elements mounted on crushable blockouts made from 10-inch (254 mm) diameter, Schedule 80 pipe. The total height

of the railing above the top of the deck is 2 ft-6 inches (0.8 m), and the traffic face presents suitable geometry. The railing is adequate for spans up to 20 ft (6.1 m) between supporting truss members. The crushable blockouts limit the lateral force applied to truss members to 15 kips (67 kN) or less.

The Researchers Recommend...

A structural analysis of the retrofit traffic railing designed for the Roy B. Inks Bridge on State Highway 16 over the Llano River in Llano indicated that it is adequate to resist collision loads from the railing. With additional detailing, the retrofit railing will be suitable for installation on the Roy B. Inks Bridge.

Tests of the retrofit traffic railing designed for the U.S. 281 bridge over the Brazos River in Palo Pinto County determined that its performance was acceptable. With additional detailing, the retrofit railing will be suitable for installation on the U.S. 281 bridge.

The new bridge railing designed for new truss bridges and based on this research meets the strength requirements of *AASHTO LRFD Bridge Design Specifications*. This railing design is suitable for implementation on new truss bridges provided the truss bridge members and all associated components are adequate to resist the collision loads imposed on the members and associated components of the structure.



For More Details . . .

The research is documented in the following report:

Report 0-4419-5, *Retrofit Railings for Truss Bridges* (pending)

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TxDOT Implementation Status—July 2004

The retrofit rail designs for the Roy B. Inks State Highway 16 bridge and U.S. 281 bridge are being implemented by the TxDOT Bridge Division in conjunction with the rehabilitation of these two structures.

TxDOT anticipates that most new truss bridges will be of the pre-fabricated, fabricator-designed type. Implementation of the new □ the rail crash load case as determined from this research project.

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