Project Summary Report 0-1741-S
Project 0-1741-S: Preservation Alternatives for Historic Truss Bridges
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August 2005

PROJECT SUMMARY REPORT

Preservation Alternatives for Historic Truss Bridges

Introduction

Texas has a large inventory of older metal truss bridges that were constructed in the late 19th and early 20th century. Many of these bridges play an important role in the historical fabric of the communities they serve, and the bridges frequently have strong community support. Older metal truss bridges, while of historic interest, also pose significant challenges for bridge engineers. Many of these bridges have potential strength and geometric deficiencies that must be addressed if they are to be kept in service. The objective of Project 0-1741 was to develop rehabilitation solutions to keep Texas historic metal truss bridges in vehicular service.

Historic metal truss bridges in Texas can be divided into two broad categories: "on-system" bridges and "off-system" bridges. On-system bridges are those on the state highway system, and are found on state highways, US highways, farm-to-market routes, ranch-to-market routes, interstate frontage roads, etc. The surviving on-system historic trusses were typically constructed in the 1920s and 1930s, and were designed by TxDOT for H10 to H15 loads. The off-system bridges are those not on the state highway system, and are typically found on county roads or city streets. Many of the off-system historic truss bridges in Texas were constructed in the late 1800s or early 1900s. Project 0-1741 addressed both off-system and on-system truss bridges.

The primary focus of this project has been the development of tools to better load rate older truss bridges. An additional facet of this project was the development of information on historic preservation principles for use by bridge engineers.

What We Did…

This project primarily addressed structural issues involved in the evaluation and rehabilitation of older metal truss bridges, but also examined preservation issues aimed at maintaining the historical integrity of these bridges. This work was divided into four major phases: 1) collect and summarize existing

Figure 1: Case Study on CR 188 in Shackelford County, Texas

information on structural evaluation and rehabilitation of older metal truss bridges; 2) conduct a case study of structural issues for an off-system historic metal truss bridge; 3) conduct a case study of structural issues for an on-system historic metal truss bridge; and 4) collect information on historical preservation practices and options for metal truss bridges.

The first phase of the project was to collect and summarize existing information on structural issues related to older truss bridges. This phase included a literature search as well as a survey of Departments of Transportation. Results of this phase of the study are documented in Report 0-1741-1, "Evaluation and Rehabilitation of Historic Metal Truss Bridges: Survey of Literature and Current Practices."

The second major phase of the project was a case study of an off-system historic metal truss bridge. The case study bridge (Figure 1) is located in Shackelford County, Texas, on County Road 188 near Fort Griffin, and crosses the North Fork of the Brazos River. This single-lane bridge was originally constructed in 1885 by a private bridge company. The bridge is a wrought iron pin-connected Pratt through truss with a span of 109 feet and is the oldest surviving Pratt through truss in Shackelford County and one of the oldest in the state of Texas.

The third major phase of the project was a case study of an on-system historic metal truss bridge. The case study bridge (Figure 2) is located in Llano, Texas. Known as the Roy Inks Bridge, the main structure spans approximately 800 ft. over the Llano River, and was constructed in 1936. The bridge consists of four main spans, each approximately 200 ft. in length. Each span is a Parker through-truss, with a non-composite slab on steel beam and stringer floor system. The study of on-system truss bridges was further supplemented by additional analysis and testing of a truss bridge located in Goliad, Texas, and by laboratory testing of a full-scale portion of a non-composite slab on steel girder bridge deck.

Figure 2: Case Study Bridge in Llano, Texas

For both the on-system and off-system case study bridges, the primary focus of the research was to identify techniques that go beyond standard load rating methods that would permit the most realistic assessment of the structural condition and capacity of the bridges. Techniques that were examined included materials testing and evaluation, the use of advanced structural analysis, and the use of field load testing.

The fourth major phase of this project examined preservation issues related to historic metal truss bridges. The primary activity for this phase was a survey of twenty Departments of Transportation to collect information on alternative approaches for addressing historical preservation concerns when evaluating and rehabilitating metal truss bridges.

What We Found...

Research on the case study bridges indicated that an improved load rating for an older metal truss bridge can often be achieved through materials evaluation and testing combined with the use of improved structural analysis techniques.

Efforts directed towards testing and evaluation of the materials in a historic metal truss bridge can provide a great deal of valuable information that can aid in realistically load rating a bridge, in assessing damage and deterioration, and in developing a rehabilitation plan. Further, material evaluation work can often be conducted at relatively low cost. The Shackelford County case study bridge was constructed of wrought iron, an archaic material no longer used in bridge construction. As part of the investigation of this bridge, background studies were conducted to better understand the composition and key characteristics of wrought iron. This was followed by laboratory testing of small samples of material removed from the bridge. Laboratory tests included tension tests, hardness tests, chemical analysis, and metallographic examination. This was supplemented by field hardness testing at numerous locations on the bridge. For the Llano case study bridge, an improved estimate of the actual yield stress of critical members was obtained by recovering the original mill certificates for the steel and by removal and testing of samples of steel removed from the bridge. For both case study bridges, materials data provided a great deal of information useful for evaluating the structural condition of the bridges.

A major portion of this research project examined whether an improved load rating can be achieved through the use of more advanced methods of structural analysis. The application of more advanced structural analysis techniques was applied to the trusses and the floor systems of the case study bridges. For both the on-system and off-system case study bridges, the research indicated that the use of advanced computer models offered no significant advantages for the trusses. Simple hand methods of analysis or simple computer models of the trusses appear quite adequate. However, in the case of the bridge floor systems, the results of the research showed that the use of somewhat more advanced methods of structural analysis offered significantly improved estimates of floor system capacity.

For the Llano case study bridge, the load rating for the bridge was controlled by the steel floor beams and stringers. A finite element model was developed for the bridge floor system to determine if a higher load rating could be justified by using analysis methods that are more advanced and more exact than those used in conventional load rating. The model was constructed using commercially available finite element analysis software. The finite element analysis showed significantly lower moments in the stringers and beams than conventional AASHTO calculations.

The results of the finite element analysis of the Llano bridge floor system were then compared to the results of an extensive series of field load tests on the bridge. In these tests, selected portions of the floor system were instrumented with strain gages. Trucks of known weight and geometry were then driven slowly over the bridge, and the response of the instrumented members was measured. The field test data showed live load stresses in the floor beams and stringers that were significantly lower than predicted by the standard AASHTO load rating. The field test data also confirmed that the finite element analysis provided a significantly more accurate, although still somewhat conservative, estimate of live load stresses. These observations were subsequently confirmed by field load tests on a truss bridge located in Goliad, Texas, and by laboratory testing of a full-scale portion of a non-composite slab on a steel girder bridge deck.

Overall, the results of this research indicated that the use of standard AASHTO load rating techniques can substantially underestimate the strength of the floor beams and stringers. A significantly more accurate prediction of the structural response of the floor members to truck live load can be achieved by conducting an elastic finite element analysis of the bridge floor system. Comparisons with extensive field load test results and with laboratory test results showed that the finite element analysis provides a more realistic but still somewhat conservative prediction of floor member response.

With improved materials evaluation and improved structural analysis methods, it may be possible to demonstrate a satisfactory load rating for a historic metal truss bridge, thereby precluding the need for replacement or rehabilitation. This was the case for the Llano case study bridge. On the other hand, even with improved analysis methods, some bridges will require repair or strengthening to improve the load rating. Repair and strengthening measures must be undertaken in a manner that will preserve the historical integrity of the bridge, and these measures must normally be approved by the State Historic Preservation Officer (SHPO). As part of this project, information has been summarized to assist in identifying preservation methods that are likely to address concerns of the SHPO.

The Researchers Recommend…

To develop an accurate and realistic load rating for an older metal truss bridge, two approaches are recommended. The first approach is to invest additional effort in evaluation and testing of the steel or other metals that make up the critical members of the bridge. Materials evaluation and testing can often provide a great deal of useful information at relatively low cost. The second approach is to invest additional effort in structural analysis of the bridge. Analysis of the bridge floor systems using simple elastic finite element models can be used to support a significantly improved load rating.

Not all historic metal truss bridges can be saved. In some cases, the deterioration, damage, or inherent lack of strength will be so severe as to practically preclude structural rehabilitation. However, in many other cases, only a small additional effort may be all that is required to save an important historical resource.

For More Details...

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The research is documented in the following reports:

0-1741-1 *Evaluation and Rehabilitation of Historic Metal Truss Bridges: Survey of Literature and Current Practices.*

0-1741-2 *Analysis, Testing and Load Rating of Historic Steel Truss Bridge Decks.*

0-1741-3 *Evaluation and Rehabilitation of Historic Metal Truss Bridges: A Case Study of an Off-System Historic Metal Truss Bridge in Shackelford County, Texas.*

0-1741-4 *Evaluation and Rehabilitation of Historic Metal Truss Bridges: Preservation Issues.*

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3126, email: ctrlib@uts.cc.utexas.edu

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Disclaimer

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