Evaluation of a Timber Bridge for the Secondary Road System Using FRP-Reinforced, Glued-Laminated Girders

tech transfer summary

The construction of a timber bridge in Delaware County, Iowa, was largely successful using FRP construction materials.

Objectives

This report provides details of the construction process, including setbacks and solutions, of a timber bridge constructed of FRP materials. The report also discusses annual evaluations of the bridge's structural performance after its completion over a three-year period. The work was completed in three phases:

- Inspection of glued-laminated girder fabrication, including the FRP installation
- Condition inspections of the bridge
- Static field-load testing of the bridge in 2004, 2005, and 2006.

Problem Statement

In recent years, county engineers have sought an economical, durable, short-span bridge that reduces construction time. In addition, county engineers are seeking these same qualities for bridge repairs and improvements on secondary roadway systems. In the past, FRP materials have been used successfully to strengthen and repair steel and concrete bridges. However, limited information exists regarding the application of FRP to timber bridges. This research project evaluates the construction process and subsequent inspections of a timber bridge constructed with FRP materials in Delaware County, Iowa.

Background and Research Description

The Delaware County bridge was the first of its kind in Iowa. The bridge is a 64-foot by 28-foot, two-lane, simple-span, longitudinal, glued-laminated timber girder structure located on a low-volume gravel road spanning Lime Creek, east of Ryan, Iowa. The bridge was designed with an HS20 design loading to be consistent with available standard concrete bridge alternatives.

Bridge construction was delayed due to a legal dispute over patent rights regarding the FRP superstructure materials and later delivery of the materials to the site. In addition, shop drawings were not included in the material shipment, and the project plans were somewhat unclear in the directions for drilling shear plates for the bridge rail posts. These factors

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The Bridge Engineering Center (BEC) is part of the Center for Transportation Research and Education (CTRE) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.

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added additional time and costs to the bridge project. Nevertheless, after all the materials arrived, construction of the bridge progressed smoothly with a successful, aesthetically attractive structure as the result.

To evaluate the structural performance and superstructure components of the timber bridge, instrumentation and loading tests were completed several times over a three-year period. These tests involved measuring girder and deck deflections at critical points on the bridge to detect strains in the structure. The engineer also tested the bridge by driving a fuly loaded, tandem-axle dump truck across it to help measure and ensure consistent load distribution.

Key Findings

Post-construction inspection of the girders noted that Girder G1 had apparently been bumped during installation causing slight delamination. The damage occurred in the timber itself, and not the bond between the timber and the FRP. It is anticipated that this issue will have little to no effect on the effectiveness of the FRP reinforcement, given the location of the damage.

The deck panels appeared to be relatively well seated on the girders in most locations; however, there were minor problems evident in the placement and attachment of the panels to the girders, specifically the deck clips. These minor problems were immediately addressed, and no further problems were evident with the deck clips after adjustment.

Inspection of the asphalt wearing surface revealed that no moisture-blocking membrane appeared to have been placed between the glued-laminated deck and the wearing surface. In addition, the wearing surface did not cover the entire deck surface, but instead terminated just inside the metal base plates used to attach the guardrail posts to the deck, leaving approximately one foot of the deck surface exposed. As a result, small, noticeable, transverse cracks occurred in the asphalt wearing surface at each panel joint and at both abutments.

Results of the final tests in 2006 found that all girders were in good condition, good bearing was evident at all girder ends, and the condition of the asphalt wearing surface showed little change since the initial cracks had been found two years earlier.

Structurally, the geometry and load-carrying capacity of the bridge are consistent with current county standard bridge designs. Costs may decrease as this bridge design and experience in building it become more prevalent. In addition, pubic comments regarding the bridge's attractive construction prompted the county engineer to consider building a timber bridge in a park or rustic setting where it would fit in aesthetically. In such a case, the additional cost may be justified.

Bridge in Delaware County comprised of fiber-reinforced polymer (FRP), reinforced glued-laminated timber girders, and a transverse glued-laminated timber deck

Glued-laminated girders after FRP installation