Field Testing and Evaluation of a Demonstration Timber Bridge

tech transfer summary

As part of an ongoing research study, this demonstration project showcases the retrofit detail that was determined to provide the best field performance given the results to date.

Problem Statement

Asphalt wearing surfaces on timber bridges are designed not only to protect the timber deck components from vehicular wear and tear, but also to provide a moisture barrier and protect the deck from the elements. However, premature failure and/or degradation of the wearing surface have been common problems associated with glued-laminated timber girder bridges with transverse glued-laminated decks.

This failure/degradation of the wearing surface can result in the accelerated deterioration of the timber beneath due to water infiltration, and often incorrectly implies structural inadequacy.

Objective

The primary objective of this research was to construct and test a demonstration timber bridge utilizing new design details developed to reduce the magnitude of the asphalt wearing surface deterioration to acceptable levels and therefore increase the durability of the entire bridge system.

In support of this objective, lessons learned from previous bridge field tests, along with details developed during laboratory testing, were applied to a field demonstration bridge.

Completed demonstration timber bridge

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RESEARCH PROJECT TITLE
Field Testing and Evaluation of a Demonstration Timber Bridge

SPONSORS
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The Bridge Engineering Center (BEC) is part of the Institute for Transportation (InTrans) 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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Background

Previous load tests conducted on glued-laminated timber bridges with asphalt wearing surfaces found that the bridges with the most significant amount of wearing surface deterioration had two characteristics in common: 1) average to moderate relative deflections between adjacent glued-laminated deck panels and 2) cupped deck panels resulting from differences in moisture content between the top and bottom of the deck panels.

Subsequent laboratory testing of a full-scale glued-laminated timber bridge concluded that relative deck panel deflections could be reduced by means of physical connection at the deck panel joints.

Various connection details were investigated, including steel dowels, glass fiber dowels, a steel plate placed at mid-panel depth, and a plywood overlay. It was concluded that, based on the test results and the constructability of all the alternatives considered, the plywood overlay was the most viable option.

Project Description

Given the findings of the field and laboratory testing, there was a need to test the plywood overlay alternative on a structure with an asphalt wearing surface to determine if this alternative impacted the deterioration of the asphalt.

The bridge specifically designed for this project consists of two 38 ft simple spans; each span consists of six glued-laminated timber girders and 5 1/8 in. by 4 ft transverse glued-laminated timber deck panels lag screwed to the girders.

Span 1, the south span, has a layer of 3/4 in. treated plywood screwed directly to the deck panels; Span 2, the north span, was not covered with plywood and would be used as a control. The decks of both spans were overlaid with asphalt.

Erection of south span girders

Deck panel placement

Construction of abutments and pier

Deck panel connection to girders

Key Findings

Inspection of the wearing surface one month following bridge construction noted transverse cracking at the deck panel joints on Span 2 with less noticeable cracks on Span 1 over the deck panel joints. However, cracking over the plywood joints was also observed in Span 1.

Global girder deflection measurements from 2009 indicate that the global response of the structure is as would be expected. The peak tensile strain in the girders measured during the 2009 and 2010 tests was approximately 250 microstrain (0.45 ksi), well below the design bending stress (calculated based on HS20 truck) of approximately 2.2 ksi.

Wearing surface inspection in 2010 noted that the cracking at the panel joints on Span 2 was becoming more prevalent; cracking on Span 1 was now evident at both the transverse and longitudinal plywood joints, as well as at the transverse deck panel joints.

Differential panel deflection data measured in both 2009 and 2010 indicated differential panel deflections were within the recommended limit of 0.10 in. and slightly larger differential panel deflections were evident on Span 1 than on Span 2, which was opposite of what was expected.

Application of asphalt binder

Bridge after plywood and guardrail posts installed

Placement of asphalt wearing course

Completed demonstration bridge

Implementation Benefits

This research is ongoing and the research team is still working on how to improve the effectiveness and long-term use of asphalt wearing surfaces on glued-laminated timber deck bridges:

Implementation Readiness

Currently, work is being completed on the redesign and evaluation of the asphalt mix design being used, and other asphalt overlay "systems" are being developed for implementation and evaluation this spring.

These were the tasks/areas identified to pursue:

1. Perform follow-up field tests on the bridge to better assess and understand the performance
2. Consider reorienting the plywood to mimic what was tested on the laboratory bridge
3. If available, utilize tongue and groove treated plywood
4. Design an asphalt deck overlay mix design, and/or asphalt overlay "system," that is optimum for this application

Typical instrumentation setup

Transverse cracking on Span 1 (with plywood) two months post construction

Transverse cracking on Span 2 (no plywood) two months post construction

Transverse cracking on Span 1 (with plywood) one year post construction; visible cracking evident at the transverse plywood joints as well as at the panel joints