Innovative Inspection Devices Help Extend Timber Bridge Life Spans

How Local Engineers Can Use State-of-the-Art Technology to Address Deterioration and Save Money

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Common in rural areas, timber bridges are an important component of the U.S. highway system. More than 48,000 bridges in the United States contain structural timber in the superstructure or substructure, according to the National Bridge Inventory (NBI) of December 2012. Approximately 2,000 of these timber bridges are located in Minnesota; many of these were built in the 1950s and 1960s and now may be experiencing some level of deterioration.

Problem

Although praised as environmentally friendly in comparison with other bridge types, wooden bridges are prone to deterioration caused by moisture in the wood, as well as by fungi, insects, and mechanical damage. This damage often occurs within the wood, not on the surface, making the deterioration difficult to detect.

A timber cap abutment has collapsed onto a timber piling as a result of decay and bearing loads.

Traditional inspection techniques—such as visual inspection, sounding with a hammer, and coring—often miss early-stage or internal damage in timber bridges. Although providing general findings on the bridge's condition, traditional inspection methods do not supply engineers with accurate information for making confident and informed decisions about corrective measures to extend a bridge's service life safely. Engineers need to assess the load ratings and to plan for replacement or repairs. A research project therefore was initiated to identify inspection techniques that would enable local engineers to address deterioration and extend timber bridge life, saving agencies the costs of detours and bridge replacements.

Solution

Research Objectives

The project developed a comprehensive research and evaluation program to address the evaluation and inspection of timber bridges. Several organizations collaborated on the project, including the Natural Resources Research Institute at the University of Minnesota–Duluth; the State Aid and Bridge offices of the Minnesota Department of Transportation (DOT); the Local Road Research Board; the Iowa Highway Research Board; the Bridge Engineering Center at Iowa State University; the U.S. Department of Agriculture's Forest Products Laboratory in Madison, Wisconsin; and HDR, Inc.

The project sought to achieve the following primary goals:

- Identify state-of-the-art nondestructive evaluation (NDE) techniques and equipment for inspecting timber bridges,
- Develop inspection protocols and procedures for entering the information into Minnesota's Structure Information Management System (SIMS),
- Develop an inspection manual for timber bridges, and
- Train local and state bridge safety inspectors and engineers in each Minnesota DOT district.

A long horizontal split provides an opportunity for moisture to pass through the timber deck and enter the abutment cap, leading to substantial decay.

Scope and Tasks Performed

Researchers first reviewed NDE techniques and technologies for timber bridges and developed a list of equipment. The best methods found for determining deterioration included measuring the moisture in the wood, the velocity of a stress wave across the wood, and the wood's resistance to drilling.

The researchers developed protocols for using the most promising equipment, as well as new forms for reporting data on timber bridges in Minnesota's SIMS. Researchers performed an economic assessment of the proposed protocols, recommended inspection equipment, and developed a short course on timber bridges for local inspectors and engineers. The course was presented to more than 140 participants in Minnesota and Iowa. Finally, researchers described techniques for using inspection tools in the *Timber Bridge Inspection Manual*, which supplements Minnesota DOT's *Bridge Inspection Field Manual*.

Findings and Recommendations

After receiving feedback from Minnesota county engineers and the Minnesota DOT Bridge Office, researchers recommended the following equipment for timber bridge inspection:

◆ **Moisture meter.** Timber generally will not decay if the moisture content is less than 20 percent; as the moisture content increases, decay becomes more likely and more serious. Moisture meters effectively measure the levels of moisture in timber bridges.

◆ **Stress wave timer.** This instrument identifies decay by measuring stress wave propagation across the grain in wood members. Stress waves typically travel more slowly through deteriorated timber than through high-quality timber.

◆ **Resistance microdrill.** This instrument measures the wood's resistance to a drill bit with a small diameter—approximately three millimeters—to identify decay, voids, or termite damage.

The complete timber bridge inspection kit, including more general equipment, such as an inspection hammer and basic safety equipment, ranges in cost from $8,800 to $13,300, primarily depending on the model of microdrill. Less expensive models present data on a paper printout, which some bridge safety inspectors and engineers prefer, but other models collect data electronically for transmission via Bluetooth, or wireless connection.

Application

Several counties have purchased inspection equipment, and Minnesota DOT has purchased three complete sets—each with a different type of microdrill—for counties' use. The Natural Resources Research Institute at the University of Minnesota–Duluth is managing this equipment for counties for two years, while Minnesota DOT collects feedback.

A pin-style moisture meter is used to determine the moisture content of timber elements.

A resistance microdrill is the preferred drilling inspection technique for timber bridge elements.

The Minnesota DOT Bridge Office is creating a portal on its website on the topic of timber bridge inspection, which will include information from this research, along with training materials, videos, the inspection manual, case studies, and a link to request a loan of the Minnesota DOT equipment.[1] Minnesota DOT's refresher sessions in bridge training in each district every spring will incorporate the information from the project. The investigators are working with the Minnesota Local Technical Assistance Program to offer the timber bridge short course annually.[2]

[1] www.dot.state.mn.us/bridge/inspection.html.
[2] www.mnltap.umn.edu/.

Benefits

The recommended methods of timber bridge inspection offer several key benefits.

First, the inspection tools produce definitive and clear results, providing reliable data for engineers in decision making about the repair or replacement of a bridge. The methods allow engineers to understand fully the condition of each bridge and to optimize bridge maintenance plans, deferring noncritical repairs.

Second, an economic assessment found that the NDE techniques could extend the service life of timber bridges by 10 years or more and could improve the safety and reliability of Minnesota's bridges.

Finally, the proper inspection equipment can provide the information needed to identify and implement specific actions to save money by reducing replacement costs—as well as the user costs related to detours,

Economic analysis suggests that in nearly all cases, the extended service life and the reduction in truck detours justify the costs of the inspection tools and techniques. Researchers are conducting a follow-up project to investigate cost-effective timber bridge repair techniques. Results from this study are forthcoming.

For more information, please contact Technical Liaison David Conkel, Minnesota Department of Transportation, Dave.Conkel@state.mn.us.

Resources

Accelerator, March–April 2015, www.dot.state.mn.us/research/accelerator/Accelerator-March2015_WEB.pdf.

Demonstration videos of inspection techniques. https://www.youtube.com/watch?v=opT2N053ToQ&feature=youtu.be.

Development and Integration of Advanced Timber Bridge Inspection Techniques for NBIS, Final Report. www.dot.state.mn.us/research/TS/2015/201501.pdf.

Timber Bridge Life Spans Extended with Innovative Inspection Devices: Technical Summary. Minnesota Department of Transportation Research Services and Library, February 2015. www.lrrb.org/media/reports/201501TS.pdf.

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Suggestions for Research Pays Off topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (202-334-2956; gjayaprakash@nas.edu).