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Research Shows Glulam Timber Bridges May be an Economical, Fast, and Sustainable Solution for Local Roads

With thousands of bridges structurally deficient or functionally obsolete across the nation, owners need replacement options that are affordable, require minimal skilled labor to construct, especially in rural areas, and are sustainable. Glued laminated timber, or glulam timber, bridges provide an answer for local roads, research at South Dakota State University (SDSU) shows. SDSU is a member of the Region 8 Mountain Plains Consortium led by North Dakota State University. "Timber has been used as a building material for hundreds of years," noted Mostafa Tazarv, SDSU assistant professor of civil and environmental engineering and one of the principal investigators for the project. There are approximately 25,000 timber bridges in the United States. However, data on the structural and long-term performance of timber bridges, especially those built with glulam, are scarce.

Figure 1. Glulam girder timber bridge in Buchanan County, Iowa.
(Photo credit: Zach Carnahan)

"Most DOTs, including the South Dakota DOT, don't usually use timber bridges, most likely, because of a lack of performance data and the misconception that wood is not a durable material," Tazarv said. "However, we found five glulam bridges in Minnesota that have survived for 60 years and are still in good condition. Our study is the first system testing to confirm that glulam bridges are also structurally viable." The study was funded by the South Dakota Department of Transportation and the Mountain-Plains Consortium University Transportation Center.

Figure 2. Glulam slab timber bridge.
(by: Zach Carnahan)

Modern glulam construction material is pound-for-pound stronger than steel according to the Engineered Wood Association (formerly the APA)[1]. The SDSU research indicates that bridges constructed with glulam timber may be an option for replacing bridges on local roads. The Federal Highway Administration estimated that 25% of the nation's bridges need rehabilitation, repair, or total replacement. Of South Dakota's 5,870 bridges, 20% (1,208) are structurally deficient and 4% (237) are functionally obsolete. About 70% of South Dakota's bridges are owned by local governments, many of which face funding shortages and limited access to skilled labor.

What is the benefit?

The study identified several advantages of glulam timber bridges over concrete and steel bridges:

- they are sustainable and environmentally friendly;
- economical with superstructure costing up to 50% less than similarly sized concrete bridges;
- light-weight, easy to transport, and installable in a day, making them excellent candidates for accelerated bridge construction (ABC);
- relatively easy to install, minimizing requirements for skilled labor or special equipment;
- naturally resistant to deicing agents; and
- can be constructed in almost any weather condition.

[1] American Plywood Association

Two options tested

Tazarv, graduate research assistant Zacharay Carnahan, and Nadim Wehbe, professor of civil and environmental engineering, studied the performance and feasibility of two primary forms of glulam timber bridges as alternatives to steel and concrete bridges.

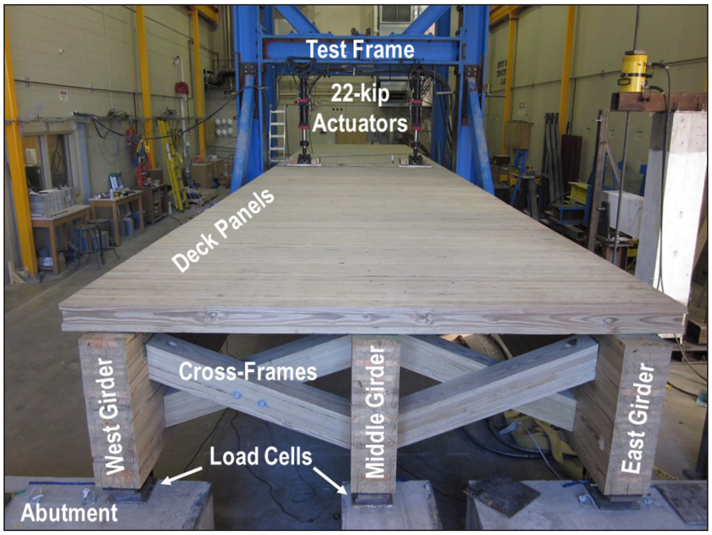

Figure 3. Glulam girder bridge test specimen.
(Photo credit: Mostafa Tazarv)

A girder bridge consists of transverse glulam deck panels supported on longitudinal glulam girders (Fig. 1) and is usually used for spans of up to 80 ft. The second bridge type, a slab bridge, consists of longitudinal glulam deck panels connected together by transverse glulam stiffeners (Fig. 2) and can be used for shorter spans of up to 30 ft. The system performance of both bridge types was experimentally investigated for the first time in this study.

Full-scale glulam timber bridges, one of each type, were constructed and tested for structural performance. The girder bridge (Fig. 3) was 50-ft long and 9.5-ft wide. The slab bridge (Fig. 4) was 16.5-ft long and 9.5-ft wide. The width of the test bridges, which was approximately equal to the width of one lane of a typical road, was limited due to the test setup. The girder bridge test specimen (Fig. 3) was constructed with 3 girders each 30.25 in. deep, by 8.75 in. wide, by 50 ft. long; and 13 deck panels each 5.5 in. deep, by 110.75 in. wide, by 48 in. long. The deck panels were connected to the girders by a strong epoxy. The slab bridge test specimen (Fig. 4) was constructed using two longitudinal glulam deck panels each 10.75 in. deep, 48 in. wide, and 16.5 ft. long. Three glulam beams were used underneath the bridge deck as stiffeners. Each stiffener was 5.5 in. deep, by 5 in. wide, by 7.5 ft. long. The deck panels were connected to the stiffeners using four lag bolts.

Both bridges were first tested for 75 years of service loads (based on a fully loaded truck) then loaded to failure at the J. Lohr Structures Laboratory at SDSU.

Both bridges showed satisfactory structural performance and minimal damage under the service loads. The test results confirmed that current timber bridge design specifications by American Association of State Highway and Transportation Officials (AASHTO LRFD, 2014) are adequate. Furthermore, the two types of glulam timber bridges were found to be viable solutions for local roads with low traffic volume.

Figure 4. Glulam slab bridge test specimen.
(Photo credit: Zach Carnahan)

"Both girder and slab glulam timber bridges are structurally viable and cost effective choices for local roads and deserve consideration by local governments striving to make the best investments of public funds," Tazarv said.

For more information, including videos of the bridge testing at the SDSU Structures laboratory, visit the project website at: https://sites.google.com/people.unr.edu/mostafa-tazarv/research/alternative-to-dt-bridges .

About This Project

The Mountain-Plains Consortium University Transportation Center and the South Dakota Department of Transportation sponsored this research, which was performed by South Dakota State University graduate student Zachary Carnahan with co-PIs Mostafa Tazarv and Nadim Wehbe. Additional information may be obtained from: mostafa.tazarv@sdstate.edu, nadim.wehbe@sdstate.edu, or zachary.carnahan@jacks.sdstate.edu. The Mountain-Plains Consortium, administered by the Upper Great Plains Transportation Institute at North Dakota State University, includes consortium members Colorado State University, South Dakota State University, University of Colorado Denver, University Denver, University of Utah, University of Wyoming, and Utah State University. For information on the consortium's work, visit www.mountain-plains.org.