MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 23-497 (project 576) | March 2023

Sustainable Alternative to Structurally Deficient Bridges

the ISSUE

According to the American Society of Civil Engineers, 9.1% of U.S. bridges are structurally deficient, with the majority of those on low-volume roads. Road agencies are seeking cost-effective sustainable alternatives for replacing those bridges. Products made with cross laminated timber (CLT) offer superior strength, durability, and sustainability leading to commercial production for building applications. However, CLT products have not been applied to bridge systems.

the RESEARCH

CLT is the most advanced wood panel system comprising several sawn lumber layers oriented in alternating directions and bonded holistically with adhesive. Based on a CLT bridge application literature review, researchers conceptualized three new CLT-based bridge systems and selected a CLT girder bridge system as the most promising option. The CLT girder bridge system was designed with traditional timber bridge design codes, CLT building design standards, and the properties of CLT materials provided by a CLT producer. The final CLT girder bridge system, composed of one CLT deck, two CLT girders, and two CLT diaphragms, was 6.40m long by 1.22m wide.

The CLT components required to fabricate the designed bridge system were manufactured at Smartlam and transported to the SDSU Structural Laboratory. The CLT components included one CLT decking (5-ply), eight CLT beams (7-ply each), and two CLT diaphragms (7-ply each). To support the CLT bridge deck and live loads, a higher-strength CLT girder was required. Consequently, two 14-ply CLT girders were developed: one fabricated with two 7-ply CLT beams joined with adhesive, and one 14-ply CLT girder fabricated by joining two 7-ply CLT beams with adhesive and fasteners. The

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South Dakota State University
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the **RESEARCH** cont.

researchers conducted ultimate strength testing on the resulting girders to validate their structural performance. The remaining CLT girders with adhesive were utilized as the main flexural members by connecting them to the CLT bridge decking using adhesive and fasteners. Finally, the CLT bridge system was built with 5-ply CLT decking, two 14-ply CLT girders, and 7-ply CLT diaphragms using connection parts. Note, each of the CLT diaphragms was linked to the CLT girders at the end supports using rods and nuts.

The fabricated CLT girders and CLT bridge system's structural performance was evaluated using a series of ultimate load tests, including 1) CLT girder bonded with only adhesive, 2) CLT girders bonded with adhesive and fasteners, and 3) CLT bridge system. The adhesively bonded CLT girder was first tested to explore its ultimate strength, and then the CLT girder bonded with adhesive and fasteners was tested using monotonic loads until failure.

the **FINDINGS**

The ultimate strength of the 14-ply CLT girder bonded with adhesive and fasteners was 21.47% higher than that bonded with only adhesive. The CLT bridge system, built with CLT girders with adhesive and fasteners, CLT decking, and CLT diaphragms, was tested with a concentric displacement-controlled loading at the mid-span until failure. The tested CLT bridge system was able to resist the concentric load up to 262.50 kN, which means the bridge system will safely withstand an HS20 design truck load equivalent to 177 kN.

the **IMPACT**

The research shows that a new bridge system made with CLT, which exhibits desirable design strength and low environmental impacts, offers a suitable replacement for bridges on low-volume roads. The CLT bridge system can be a sustainable solution for replacing structurally deficient bridges that will expand the use of wood products and create new markets that will stimulate rural economic development.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1122

For more information or additional copies, visit the Web site at www.mountain-plains.org, call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.