

Project Title

Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges

University

Colorado State University

Principal Investigators

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Research Needs

Wood bridge deck replacement using glue laminated timber panels has been investigated (see e.g. Moody et al, 1990) and shown to be effective. However, that body of research focuses on classical loading in bridge decks, namely vehicle loading, which is critical when considering bridge deck rehabilitation. The advent of cross laminated timber (CLT) in Europe and its introduction to North America brings with it the potential for application to bridge deck rehabilitation. CLT differs from traditional glue laminated timber in that each lamination layer is rotated 90 degrees to provide desirable mechanical properties in both directions. For bridges located in moderate seismic regions such as some locations within the mountain plains region the ability to resist and transfer in-plane shear in any directions is critical. Currently, no design procedure exists in North America for in-plane connections of CLT panels.

Research Objectives

The research objectives are:

- (1) Experimentally quantify the ability of flat plate connectors to transfer in-plane shear forces at full-scale.
- (2) Develop a design approach for connector placement and sizing based on the results of objective (1) and mechanics.

Research Methods

The PI has a number of CLT panels which will be used in the experimental portion of the study. However, they will be slightly shorter than those that would typically be used in bridge decks, so some level of extrapolation may be needed. The design method will be based on the National Design Specification for Wood (NDS, 2015) using an allowable stress design approach for the inter-panel connectors; namely the number of panels on a line will be determined using basic

mechanics. Testing will be conducted at full-scale in the Structural Engineering Laboratory at Colorado State University using the CUREE reversed-cyclic protocol to determine the in-plane deck hysteresis. This overall in-plane hysteretic response of the bridge deck will be determined and the strength and stiffness quantified for comparison to that needed.

Expected Outcomes

The expected outcomes include:

- (1) A limited, but valuable, experimental database on in-plane shear of CLT panel connected with metal plates.
- (2) A preliminary design method for use by engineers; the method may require further refinement but will pave the way for use in the U.S.

Relevance to Strategic Goals

This project is related directly to several of the goals:

- (1) State of Good Repair – Many wood bridge decks are in need of repair, which usually means replacement.
- (2) Safety – The ability to transfer in-plane shear effectively is critical to the safety of bridges in seismic regions.
- (3) Environmental Sustainability – Wood is a renewable resource and one of the most sustainable materials available for construction.

Educational Benefits

A graduate student will participate on the project including writing several papers and a report.

Work Plan

The work plan includes four major tasks, each with an interim deliverable/milestone:

Task 1: Literature Review

A literature review will be conducted including (1) test methods and setup for diaphragm testing; (2) in-plane shear transfer for CLT panels; and (3) diaphragm shear design approaches. Although little is available in the U.S. on (2), some literature from European studies is anticipated.

Task 2: Test Program

Testing of between 4 to 6 diaphragms will be conducted in the Structural Engineering Laboratory at CSU. Each of these diaphragms will be designed using a basic procedure developed based on existing principles of wood design and mechanics for a diaphragm. The diaphragms are anticipated to be 24-ft x 24-ft in line with existing ASTM standards. The strength and stiffness of the diaphragms will be measured by their ability to transfer forces to a fixed base instrumented with a load cell across the diaphragm as well as the deformation of the diaphragm measured across the diaphragm.

Task 3: Design Approach

In this Task a design approach for connection of CLT panels within a bridge deck will be articulated based on the results of Task 2. Peer feedback will be solicited in the form of a Webex meeting to refine the design method as needed.

Project Cost

Total Project Costs: \$99,956
MPC Funds Requested: \$49,000
Matching Funds: \$50,956
Source of Matching Funds: Colorado State University

TRB Keywords

Bridge; Wood; Deck; Shear; Design method

References

Moody, R.C., M.A. Ritter, and H. GangaRao. (1990). "Application of Wood Materials for innovative Bridge Systems.", Proc of the 1st materials engineering congress; Aug 13-15, Denver CO; 423-430, Vol. 1. Ed. B.S. Suprenant.