RESEARCH in Progress

NATIONAL CENTER FOR WOOD TRANSPORTATION STRUCTURES

Improved Analytical Techniques for Historic Covered Bridges

Figure 1. Arch truss and long truss covered bridges

Covered bridges are complex structures containing eccentric connections, various load paths, connection uncertainty between the subassemblies (trusses and arches), and interaction between trusses and their housing (Figure 1). When these factors are combined with material variability, the conclusion that some bridges just shouldn't be standing is an understandable option. As noted in the Federal Highway Administration (FHWA) publication FHWA-HRT-04-098, *Covered Bridge Manual*, there are inconsistencies with the assumptions of traditional simple, static analyses of trusses that are frequently used to analyze covered bridges. For example, timber trusses tend to behave more like frames than as trusses; both axial and bending forces are carried in their members and across joints. As such, over-simplified and inaccurate analyses are often performed and overly conservative safety factors applied to account for known inaccuracies. This frequently leads to the conclusion that a historic covered bridge is inadequate to carry the required design load or to the use of inappropriate rehabilitation recommendations.

Background

Most engineers are relatively comfortable with completing a standard truss analysis but are unprepared to complete a sophisticated nonlinear frame analysis required for understanding the structural performance of covered bridges. One aspect of this study will be to better understand and model the intersection or interconnection of members, be it frame, frame and arch, or frames and ties. Covered bridges typically use traditional timber framing techniques that rely on bearing contact between members and are highly redundant (Figure 2). They are not easily classified as an "ideally" pinned or rigid connection and typically lie between the two extremes. Connection models for traditional joinery techniques will be developed for use in nonlinear frame analysis. This study will work in tandem with the load rating and testing part of the Covered Bridge Research Program to develop field data to validate improved modeling techniques.

Objectives

The objective of this research is to develop techniques and provide recommendations for improving the analysis of historic covered timber bridges, specifically the intersection and interconnection of lattice members, impact of classic arch behavior, behavior and interaction of bolster beams, and floor systems.

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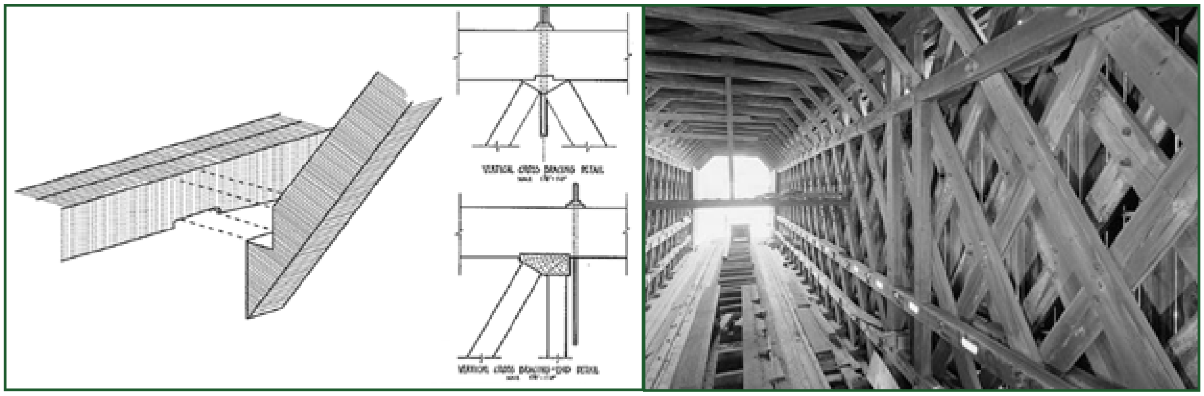

Figure 2. Connection that relies on bearing and redundancy.

Approach

1. Review past modeling approaches for covered bridges
2. Review wood connection modeling approaches
3. Identify dominant bridge types
4. Identify modeling weaknesses in dominant bridge types
5. Identify two dominant connection types
6. Test and develop connection models for dominant connection types
7. Model selected bridges using nonlinear connection models
8. Compare analysis model with load test data

Expected Outcomes

- Publication recommending modeling procedures that will improve the structural analysis of historic covered timber bridges
- Assessment of modeling procedures to field evaluation reports

Timeline

Preliminary planning for both field and analytical work will take place in fall 2009. Review of current modeling approaches and identification of associated weaknesses of the models will take place in winter of 2009–2010. Experiments to model specific connection behavior are scheduled for summer 2010 while models of field bridges are developed. During winter 2010–2011, developed models will be compared to field load tests. A final report will be drafted in 2011.

Cooperators

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