SERVICE LIFE ASSESSMENT OF TIMBER HIGHWAY BRIDGES IN USA CLIMATE ZONES

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ABSTRACT: As engineers begin to estimate life-cycle costs and sustainable design approaches with regard to timber bridges, there is a need for more reliable data about their durability and expected service life. This paper summarizes a comprehensive effort to assess the current condition of more than one hundred timber highway bridge superstructures throughout the United States. The Forest Products Laboratory and the Federal Highway Administration jointly administered this national study. In depth inspections were conducted using visual and nondestructive evaluation techniques to characterize the condition of the primary bridge components and detect any structural deficiencies. The inspection results revealed that the most common superstructure system was the multiple sawn stringer and plank deck system. This system was evaluated in a number of climate zones with numerous examples of 60 or 70 year service records. Its member redundancy advantage was undoubtedly a key factor in its longevity. These inspection results eventually will be incorporated into an ongoing national program effort aimed at monitoring the long-term performance of various types of highway bridges in the USA.

KEYWORDS: Life-cycle cost, inspection, durability, bridge, long-term performance, superstructure design, service life, wood deterioration zones

1 INTRODUCTION

Timber is the oldest bridge building material and with proper design, construction, and maintenance practices, it can offer durability comparable with, or exceeding that, of other bridge materials. A combination of chemical preservatives by pressure treatment methods and proper drainage detailing is the best practice for protection of the primary structural bridge components. When these strategies are employed during the design and construction phases, deterioration due to decay can be prevented or delayed indefinitely, resulting in a good service life expectancy. Surprisingly, little information is available that reliably predicts the service life of timber highway bridges in the United States. Many state transportation agencies have developed timber bridge service life estimates of approximately 20-25 years. These are often based on personal experiences and tend to be subjective and overly conservative.

A literature review did not reveal much published information about the expected service life of timber bridges in the United States. However, a recent timber bridge guidance manual [1] claims “using modern application techniques and preservative chemicals, bridge components can now be effectively protected from deterioration for periods of 50 years or longer”. With such wide disparity in service life prediction, there is clearly a need for more reliable data about timber bridge durability to support bridge material decisions during the preliminary design and planning phases. It has become an increasingly important consideration as design engineers began to consider bridge costs over the entire (service) life-cycle to select the most economical bridge alternative. In order to start building a reliable database about timber bridge durability, a rigorous timber bridge inspection study of national scope was developed and mutually agreed upon.

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through a joint agreement between the United States Federal Highway Administration (FHWA) and the United States Forest Service, Forest Products Laboratory (FPL).

2 OBJECTIVE AND SCOPE

The main goal of the study was to assess the condition of timber highway bridges located throughout the United States under varying climate conditions. In-depth, arms length inspections were conducted at more than one hundred timber bridge field sites and included the use various nondestructive inspection tools. The main focus of these bridge inspections was limited to superstructure elements, even though timber substructures supported many of them. The study results will provide a better understanding of the design, performance, and durability characteristics of timber bridge structures, which can impact future bridge design practice, and could potentially help to extend the service life of existing bridge structures.

2.1 BRIDGE LOCATIONS

A total of 132 timber bridges had field assessments performed during 2012 and 2013. The bridges were located in several different climate regions of the United States (Figure 1), which present different hazard levels for exposed timber bridge structures. Several different superstructure design types were evaluated and their comparable durability was estimated. A significant number of bridges were located in the south and southeastern coast regions, which are most hazardous for timber structures in the country.

Figure 1: Map of locations for timber bridges inspected during this study. (by Google Earth)

3 SELECTION OF BRIDGES

3.1 KEY SELECTION CRITERIA

There are estimated to be approximately 50,000 timber highway bridges in-service throughout the United States [2]. A sampling approach identifying clusters of timber bridges was determined to be a prudent approach for identifying bridges that met specific criteria. The timber bridges selected for this study were from states that have significant (> 500) inventories of timber bridges; many of them located in the eastern half of the country. In conducting field work, safe and economical access the bridge underside was a top priority. Selected bridges for inspection had to be located on a public roadway and been in-service for at least 15 years. Finally, records and files were reviewed by inspectors, in order to identify any previous repair or replacement actions.

4 INSPECTION METHODOLOGY

4.1 PROJECT TEAMS

A team approach was utilized to complete the field inspection work. Organizations participating in the study included the U.S. Forest Service, Louisiana Department of Transportation, University of Minnesota Duluth, Iowa State University, Mississippi State University, The University of New Orleans, Laminated Concepts Inc., T.Williamson-Timber Engineering LLC, FPL, and the FHWA Turner-Fairbank Highway Research Center.

4.2 INSPECTION PROCEDURES

All project teams followed the same inspection protocol to ensure consistency in the results. Bridge inspections included a variety of techniques and tools. Visual techniques were employed to detect external indicators of deterioration or distress in bridge components. Hammer sounding, along with probing and picking, was used to assess each superstructure element. A moisture meter was used to identify areas of the superstructure with sufficient moisture to support decay activity. Areas with potential internal deterioration were further investigated with a stress wave timer and/or resistance microdrilling tool.

5 INSPECTION RESULTS

The inspection results revealed that the most common superstructure system was the multiple sawn stringer and plank deck system. This system was evaluated in a number of climate zones with numerous examples of 60-plus year service records. Its member redundancy advantage was undoubtedly a key factor in its longevity. Additional inspection results are available in the full conference paper.

ACKNOWLEDGEMENT

This study was conducted under a joint agreement between the Federal Highway Administration-Turner Fairbank Highway Research Center and the U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. Frank Jalinoos served as the project manager for FHWA.

REFERENCES
