Overview of the National Historic Covered Bridge Preservation (NHCBP) Program

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ABSTRACT

Covered wooden bridges proliferated in the United States in the mid-nineteenth century. Today an estimated 800 covered bridge structures remain, but they are nevertheless cherished links to the technological heritage of the United States. The through-truss designs vary from the Kingpost trusses built in the craft tradition to the engineered Burr arch and Paddleford trusses. Covered bridges are our links to the past and the pioneering bridge-building efforts, and as such, are considered important early American transportation structures to preserve for posterity. This paper provides an update on the National Historic Covered Bridge Preservation (NHCBP) Research Program sponsored by the Federal Highway Administration (FHWA). An overview of the National Program is included along with an update of the latest research activities funded by the recent SAFETEA-LU legislation over the past 3 years. The NHCBP program provides funds to support preservation/restoration efforts for covered bridges that are listed, or are eligible for listing, on the National Register of Historic Places. Program funds also support research and technology transfer activities for restoring, preserving, and protecting covered bridges, including an educational component to disseminate information as a means of preserving our cultural heritage.

INTRODUCTION

Covered wooden bridges once dotted the landscape of the United States, numbering 14,000 at one time, as reported in the Federal Highway Administration's Covered Bridge Manual (Pierce and others 2005). Today only 800 covered bridges remain in the country, having survived hundreds of years largely as a result of the roof structure that kept the bridge timbers dry. Historic covered bridges are primarily in the states located east of the Mississippi River, except for the state of Florida. Historical covered bridges also remain in several states west of the Mississippi River, including Iowa, Missouri, Minnesota, California, Oregon, and Washington. However, a large

majority of surviving historic covered bridges are located in a handful of states including Vermont (100), New Hampshire (57), Pennsylvania (227), Ohio (143), and Indiana (93). Although these bridges have remained and continue to carry both vehicular and pedestrian traffic, many have undergone some restoration and preservation work over their lifetimes. Repairs have included strengthening to increase load capacity; replacing deteriorated members, roofs, and siding; and adding arson prevention systems such as alarms and sprinklers. In a number of cases the bridges have been reengineered, keeping only the external appearance the same. The heavy-timber truss design types vary and include the Town Lattice, the Howe, the Burr Arch, the Kingpost, the Wheeler, the Paddleford, the Queenpost, the Long, and the Warren trusses.

This paper provides an update on the National Historic Covered Bridge Preservation (NHCBP) Research Program sponsored by the Federal Highway Administration (FHWA). An overview of the National Program is included along with an update of the latest research activities funded by the recent SAFETEA-LU legislation over the past 3 years. Additional information about NHCBP program and restoration projects is available at the NHCBP program website (FHWA 2009) and in Duwadi and Wacker 2008. The program provides funding in three categories (1) assisting States in their efforts to rehabilitate, restore, repair, or preserve the Nation's historic covered bridges, and (2) conducting research studies to find improved means of restoring and protecting these structures, and (3) education and technology transfer activities.

NATIONAL PROGRAM EMPHASIS

The thrust of recent preservation effort to save historic covered bridges has been the establishment of the National Historic Covered Bridge Preservation (NHCBP) Program within recent highway legislation. In 1998, the Transportation Equity Act for the 21st Century (TEA-21) established the National Historic Covered Bridge Preservation (NHCBP) program. The program was re-authorized within the Safe, Accountable, Flexible, Efficient Transportation Equity Act (SAFETEA-LU) of 2005. Prior to the NHCBP program, preservation and/or restoration efforts were sponsored by local non-profit groups and by a few states. The bridges that are eligible for funding under this program have to be listed, or be eligible for listing, on the National Register of Historic Places. The program provides funding for preservation, rehabilitation, and restoration as defined in the Secretary of the Interior’s Standards for the Treatment of Historic Properties (NPS 1992). The program, however, does not provide for reconstruction of historic bridges. Therefore, if a bridge is destroyed by arson or a natural event, this funding cannot be used to rebuild the structure.

Both TEA-21 and SAFETEA-LU authorized $10 million each year for the NHCBP program (see Table 1**)**. However, even though funding was authorized, the actual amount given by the U.S. Congress has varied from year to year, with no funds given to the project some years. Of the $50 million authorized over 5 years under TEA-21, approximately $26 million funds became available to fund the program. Of the $40

million authorized under SAFETEA-LU, approximately $27.5 million had become available to fund the program through fiscal year 2008.

Figure 1. Covered bridge in Oregon.

Table 1. Funding levels (million $) for the past 10 years.

	TEA-21						SAFETEA-LU			
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total available	0	8.00	9.98	2.80	5.96	0	0	8.60	9.66	9.23	?
Preserve and restore bridges	0	7.00	9.05	2.80	5.61	0	0	8.60	8.74	8.31	?
Research and educational	0	1.00	0.93	0	0.35	0	0	0	0.92	0.92	?

Annual appropriation was $10 million, but funding was not always available.

There are three distinct NHCBP project categories: (1) Preservation and Restoration Efforts, (2) Research Studies, and (3) Educational and Technology Transfer Activities. The following sections include a summary for each project category.

PRESERVATION AND RESTORATION EFFORTS

A large majority of the NHCBP program funds are provided to assist the States in their efforts to rehabilitate, restore, repair, or preserve their National historic covered bridges (see Figure 1). Preservation, rehabilitation, and restoration efforts must comply with the Secretary of the Interior's Standards for the Treatment of Historic Properties (NPS 1992). To date, 181 bridges in 22 states have been preserved, rehabilitated, or restored with funds from the NHCBP program (see Table 2).

Table 2. Summary of NHCBP Program-funded preservation and rehabilitation projects.

State	2000	2001	2002	2003	2006	2007	2008	Total
AL	1	–	–	–	3	–	–	4
CA	–	1	–	1	–	–	–	2
CT	1			1		1	–	3
DE	–	2	–	–	–	–	–	2
IL	1	3	1	5	–	2	1	13
IN	4	8	–	1	7	2	1	23
IA	6	–	1	1	–	5	–	13
KY	1	2	–	–	–	3	–	6
MA	1	1	1	1	–	–	–	4
MD	–	–	–	–	–	1	–	1
ME	–	1	–	–	–	–	–	1
MO	–	–	–	3	–	–	–	3
NH	–	4	1	1	1	1	1	9
NY	1	3	1	1	–	1	1	8
OH	4	6	–	1	1	4	2	18
OR	1	3	–	1	8	3	7	23
PA	2	2	–	1	2	6	–	13
TN	–	1	1	–	–	1	–	3
VT	2	5	1	4	3	3	3	21
VA	1	–	–	1	–	1	–	3
WA	–	–	1	–	1	–	–	2
WV	4	1	–	1	–	–	–	6
Total	30	43	8	24	26	34	16	181

Additional details about NHCBP covered bridge restoration and preservation projects are available at the NHCBP program website (FHWA 2009).

CURRENT RESEARCH STUDIES

The FHWA is partnering with the National Park Service and the U.S. Forest Service-Forest Products Laboratory (FPL) in the conduct of research activities. Several collaborative studies have been initiated and are summarized below.

Load rating through live-load testing. This study will develop and establish new load-rating procedures (based upon live-load vehicle testing) for reliably determining safe load-carrying capacity of historic covered bridges. A comprehensive final report will document recommended procedures for live-load testing and enhanced load rating of historic covered bridges. The final report will include recommendations for (a) setting the maximum experimental load that can be safely applied to the structure; (b) methods of loading the bridge; (c) selection and placement of instrumentation; (d)

procedures for ensuring quality data; and (e) procedures to analyze collected data and establish load ratings. These recommendations will be prepared in a format similar to existing rating guides.

Improved analytical techniques. This study will develop guidelines for improving the analysis of covered bridges. The vision is that this will be done through collection of specific behavior data so that modeling geometries and configurations can be optimized and validated. Specific areas of interest include intersection/interconnection of lattice members, impact of classic arch behavior, behavior and interaction of bolster beams, floor systems, distribution beams, influence of bracing, and others. To collect the needed behavioral information, a number of covered bridges need to be instrumented and response data (e.g., strain, deflection, etc.) collected while controlled loads cross the bridge. This data is necessary to develop and calibrate modeling methodologies. A publication will recommend modeling procedures that should help improve future structural analyses of historic covered timber bridges.

Laser scanning for as-built drawings. The National Park Service's Historic American Engineering Record (HAER) has efforts under way to document historic structures. Their Level I documentation is defined in the Secretary of the Interior's Standards and Guidelines for Architectural and Engineering Documentation, and consists of measured and interpretive drawings, large-format photographs, and written historical reports. To assist in this effort, newer technologies that can provide as-built records at a faster rate and with more accuracy need to be explored. This study will explore the use of laser scanning technology to scan existing bridges for purposes of obtaining as-built records. Priority would be given to any bridge in danger of collapse or removal. Level I documentation standards would be followed to develop records. This research would lead to the identification and demonstration of laser scanning technology and the development of Level I documentation using this technology.

Guidance manual for wood species identification and field grading. The strength of the timber found in covered bridges can vary considerably, not only because of age and condition, but also because of species and grade. For evaluation purposes, it is necessary that the design values for existing wood members be determined with as much accuracy as possible. The current practice is to assign wood values for strength and stiffness from existing specifications, but often times these values are inaccurate for the specific condition and can result in an unreliable assessment of the structure. This could be hazardous where the type, source, and grade of the existing wood are uncertain. This study will develop methodologies for species identification and approximated field grading of timbers. The study will consider techniques for taking samples as well as identifying and estimating the grade of the wood. The end product will be presented in a guideline or manual for use by engineers.

In-situ moisture content monitoring. One of the key requirements for biodeterioration of wood is the presence of adequate moisture. For most wood

species, that window of opportunity for decay action translates to moisture contents between 20–30 percent. Monitoring structures for pockets of elevated moisture content has been considered for detecting the earliest signs of internal decay activity in bridges and other structures. This study includes identifying or developing suitable sensors and installation methods, as well as web-based monitoring of these sensors to detect decay at critical locations. This topic presumes thorough monitoring and prompt follow-up on the part of the bridge owner. This study would include but not be limited to (a) long term performance monitoring of new or rehabilitated covered bridges using both on-site and remote sensing techniques, (b) development of an embedded sensor to measure the in-situ wood moisture of exposed structural members, and (c) web-based monitoring for early detection of decay at critical locations within covered bridges

Fasteners that minimize corrosion. Metallic fasteners have been used in covered bridges for centuries and have performed well in untreated timbers. However, potential fastener corrosion in these historic structures typically dictates the use of treated wood during the rehabilitation process. Because of environmental considerations, effective wood preservatives that have been used for many years are being replaced with newer wood preservatives that are much more corrosive to iron fasteners. The newer wood preservatives such as ACQ and copper azole are showing accelerated corrosive effects on iron fasteners. The current solution to this problem is to use either thicker galvanized coatings or expensive stainless steel fasteners, both of which are uneconomical, may not meet requirements for historic preservation, and give results that are questionable. This study will (a) evaluate the most commonly used wood preservatives to assess the corrosion potential to conventional steel fasteners; (b) evaluate non-steel metal fasteners as possible alternatives for covered-bridge rehabilitation; (c) evaluate the feasibility and performance of non-metallic fasteners such as those fabricated from polymer or ceramic-based materials that eliminate corrosion potential altogether.

Best practices for bridge security. This study is to design a remote, autonomous security system for protecting the covered bridges of Madison County, Iowa. The goal is to develop a system that can reliably detect, and then alert authorities to, two types of threats to covered bridges: (1) a person's presence at the bridge site during "suspect" hours (late night and early morning) and (2) the ignition of a fire at the bridge site at any time of day. Detection of these events must be nearly instantaneous (to allow as much time for response as possible) and accomplished autonomously, without the need for human interpretation or interaction. A demonstration system will be constructed along with a comprehensive guidance manual for bridge owners.

Naturally durable species for repair of above-ground components. Covered bridges are designed for protection from the elements, but it is difficult to protect all wood components from moisture exposure. Some areas of the structures, such as weatherboarding and wood members near the ends of the bridges, are particularly susceptible to wind-driven precipitation. Consequently, biological deterioration from decay and insects is frequently responsible for replacement of above-ground covered-

bridge components. Naturally durable domestic wood species, particularly underutilized or invasive species, should provide a suitable alternative to chemically treated wood products for repair and replacement of above ground components of covered bridges. Research is needed to isolate, identify, and characterize the chemical compounds believed to be responsible for high resistance to decay and insects in well-known and lesser-known durable domestic wood species. A comparison of chemical properties of well-known and lesser known wood species will improve our understanding of the differences in physical properties and offer opportunities as suitable materials for repair and rehabilitation of covered-bridge components in protected outdoor exposure. The chemical component(s) responsible for imparting durability could also provide new environmentally benign wood protection systems for above-ground components of covered bridges. This study will provide a manual of recommendations for use and application of naturally durable woods as replacement components in covered bridges.

HAER covered-bridge documentation. This study will produce Level I documentation of a select number of bridges to HAER standards. It includes documenting 8 to 10 bridges with measured drawings; 6 to 10 bridges with historical reports and large-format photographs; and documenting 2 to 3 bridges with complementary engineering reports. The Level I documentation is defined in the Secretary of the Interior's Standards and Guidelines for Architectural and Engineering Documentation and consists of measured and interpretive drawings, large-format photographs, and written historical reports.

Design and performance of Howe timber trusses. For a long time, there has been interest in how William Howe built his original Howe Trusses, which had iron verticals. Howe's original design permitted tightening of the metal verticals by turning their nuts to induce compression in the diagonals and tension in the chords. Colonel Long earlier used wedges in the joints of his patented trusses to modify the stresses in the diagonals, verticals, and chords. This research would study the design and performance of Howe truss bridges. The final report would provide understandable, practical information on behavior, modeling, and design for Howe truss bridges. The results could have application to many of the 140 Howe trusses in existence and could also be used in designing new covered bridges.

Context study to nominate historic covered bridges. The Historic American Engineering Record (HAER), with guidance from the National Historic Landmarks (NHL) program, will undertake a context study of historic covered bridges. Context studies assess the national significance of individual resources and are the first step in the development of NHL nominations, the highest official recognition of historic properties designated by the Secretary of the Interior.

Lightweight floor systems for rehabilitation. The floor systems of covered bridges are relatively regularly replaced due to deterioration, structural damage, or excessive wear after approximately 30 to 40 years of service. In many cases, the floor system controls a bridge's capacity and replacement operations present a unique opportunity

to upgrade the entire structural system. This study would develop lightweight floor systems for use on covered bridges. To help ensure that the developed systems meet the needs of the varying floor system geometries, the work will categorize all existing covered bridges by general floor-framing types, as well as review floor systems used in other types of bridges and the development of preliminary floor systems for covered bridges in general. The behavior and strength of the most promising of these systems need to then be verified through controlled laboratory testing.

Determining residual capacity of structural members. Determination of the residual strength of structural members or systems is generally a three-step process: inspection, material properties assignment, and analysis. For timber structures, the majority of previous work has focused on the inspection process. General lack of knowledge exists linking inspection information to member capacity or residual strength, and therefore, the completion of the entire inspection process. This study would relate inspection information to material properties and refines single member and connection analysis procedures to determine capacity. The objective of the study would be to determine methods to translate inspection information into an estimate of individual member capacity. Research shall develop ways to reliably measure or estimate splitting and checking characteristics of bridge timbers (5-in by 5-in or greater) and their remaining capacity. Capacity of fire-damaged timbers shall also be considered. Relationships between inspection data and material characteristics for significant inspection methods shall be developed. The end product of this research shall be a manual or guidelines for evaluating residual capacity of covered-bridge components that can be used for rating covered bridges.

Development of rehabilitation techniques to restore structural integrity. Giving strong consideration to repair and/or rehabilitation of original bridge components is a cornerstone of the NHCBP. Maintaining the structural and architectural fabric of these American bridges is critical to historic preservation goals. However, in assessing the condition of these structures, decisions are usually made more conservatively toward replacing members, as there is more uncertainty about the long-term effectiveness of repair techniques. To make effective decisions, engineers need more information on the effectiveness and durability of various repair techniques for covered bridges to support their replacement and repair decisions. This study would develop effective rehabilitation techniques for covered bridges to restore the structural integrity of structural components and to improve long-term durability. Research would involve development and testing of various repair techniques to support rehabilitation, restoration, and replacement decisions. The end product would be a guidebook for engineers.

EDUCATIONAL AND TECHNOLGY TRANSFER ACTIVITIES

The FHWA is partnering with the National Park Service and the U.S. Forest Service Forest Products Laboratory (FPL) in the conduct of educational and technology transfer activities. Several collaborative studies have been initiated and are summarized below.

Guidance for preservative treatment methods. Several studies have already been completed in separate research efforts identifying preservative treatments, fumigants, fire-retardant treatments, and remedial treatments. These have been separate studies that need to be reviewed and relevant information extracted to produce a guide for engineers in selecting and treating timber members for these historic structures. This study will provide a how-to guide on the selection and use of treatments for field treating covered timber bridge members.

Covered bridge DVD. This project is to re-produce several DVD copies of a popular television documentary program. *Spanning Time* (produced cooperatively with Indiana University) was developed as a broadcast television-ready documentary on the preservation of covered bridges which has been airing on Public Television nationwide.

Educational guide on the history of covered bridges. Conducted by the Institute for the History of Technology and Industrial Archaeology at West Virginia University, this project produced a comprehensive guide and a companion CD with interactive and animated elements on covered bridges in the United States to be used by educators in teaching students in grades K – 12 for math, science, and American history courses. The package contains information appropriately written and formatted in sections for grades K – 5, 6–8, and 9–12. It includes a compilation of all different types and history of covered bridges in the United States. It further includes a pictorial coverage and descriptive drawings including bridge type, year built, design loads, traffic, wood species used, and information on the designer/builder.

World guide to covered bridges/GIS/website. The Cultural Resources Geographic Information Systems (CRGIS), an NPS program that develops geospatial standards and data for cultural resources will create a fully interactive, georeferenced, updatable website on covered bridges with functionality to populate the database with information supplied on-line by covered bridge experts. The website upon completion will be hosted by the National Wood in Transportation Center at Iowa State University (ISU 2009).

National best practices conference for covered bridges. This project involves convening a conference to discuss and review projects and initiatives made possible by the NHCBP. It will also include discussions on challenges that lay ahead in efforts to save these historic covered bridges. This will be the second National Best Practices Conference for Covered Bridges following the inaugural event held at Burlington, VT in 2003.

SUMMARY

The second round of multi-year Federal funding for the National Historic Covered Bridge Preservation (NHCBP) Program is nearing completion. Significant progress has been made over the past 10 years toward preserving, rehabilitating, and protecting

the Nation's historic covered bridges. To date, 181 bridges in 22 states have been preserved, rehabilitated, or restored with funds from the NHCBP program. In addition, a comprehensive program has been initiated through collaborative effort between FHWA and its partners (National Park Service and U.S. Forest Service) to educate the public and develop new technologies for better protection and preservation of these covered bridges for future generations.

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