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CROSSINGS

NEWSLETTER OF THE NATIONAL TIMBER BRIDGE INITIATIVE

Editor - Tinathan Coger Issue 20 August 1995

A Manufactured Modern Timber Bridge for Rural Roads

(A Bridge in a Box)

This article is a result of work in-progress on a Special Project Grant cooperatively funded by Mississippi State University and the USDA Forest Service, National Timber Bridge Initiative.

Martin P. Burke, Jr. recently reviewed the 1991 book, *Bridge Aesthetics Around the World,* that was written by 24 of the world's renowned authorities on bridge-design aesthetics and summarized their views on the contextual design aspects of bridges by the following quotations;

"we must have respect for the natural balance and form of our structure in a manner which leads to the least possible disturbance of the landscape". "It is therefore important to plan then in such a way that they will not disturb the natural environment." "Because a bridge is built in a certain environment, it should not only preserve the existing landscape but should also complement its setting and even enhance it." [1,2]

When writing about bridges/aesthetics and place integration, wood stands out as a natural tacit conclusion to be used as a construction material in rural areas. Wood was probably the first material used by humans to construct bridges. It is a part of the environment and

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Maintenance Practices for Wood Bridges

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Abstract

Proper maintenance is necessary for the continued safe performance of bridges. In times of fiscal constraint, maintenance becomes increasingly important as funding for bridge replacement decreases and existing bridges must continue to safely support traffic loads. Many bridges in our transportation system are made of wood and require specific maintenance unique to wood structures. This paper summarizes several inexpensive maintenance practices for wood bridges, including moisture control, surface treatments, and fumigants.

Introduction

Pressure-treated wood is one of the most durable bridge materials, but over extended periods it may be subject to deterioration from decay, insect attack, or mechanical damage. Wood bridges must be periodically maintained in order to keep them in a condition that will give optimum performance and service life. Effective bridge maintenance programs improve public safety, extend the service life of the structure, and reduce the frequency and cost of repairs. When tied to a competent bridge inspection program, regular maintenance represents the most cost-effective approach for achieving long service life from existing structures. Unfortunately, maintenance is often neglected until critical problems develop which require costly repairs.

In general terms, bridge maintenance includes those activities necessary to preserve the utility of a bridge and ensure the safety of road users. In practice, all maintenance is either preventative or remedial. Preventative maintenance involves keeping the structure in a good state of repair before decay or deterioration has started.

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Early remedial maintenance is performed when decay or other deterioration is present but does not affect the capacity or performance of the bridge in normal service. These types of maintenance are very important to prevent costly future repairs. Three inexpensive practices for preventative and early remedial maintenance involve moisture control, surface treatments, and fumigants.

Moisture control

Moisture control is the simplest, most economical method of reducing the decay hazard in wood bridges. It can be used as an effective and practical maintenance technique to extend the service life of many existing bridges. When exposure to wetting is reduced, members can dry to moisture contents below that required to support most fungal and insect attack (approximately 25 percent). Moisture control was the only method used for protecting many covered wood bridges constructed of untreated wood, some of which have been in service for more than 100 years. Although modern wood bridges are protected with preservative treatments, decay can still occur in areas where the preservative layer is shallow or broken.

Moisture control involves a common sense approach of identifying areas with visible wetting or high moisture contents, locating the source of water, and taking corrective action to eliminate the source. For example, drainage patterns on approach roadways can be rerouted to channel water away from the bridge rather than onto the deck. Cleaning dirt and debris from the deck surface, curbs, drains, abutment caps, and other horizontal components also reduces moisture trapping and improves air circulation. Common roofing cement can be applied to wood end-grain and around openings at joints and fasteners to provide a watertight seal. Another option is to place protective covers over exposed end-grain to restrict direct exposure to the elements.

One of the most effective approaches to moisture control is restricting or preventing water passage through the deck. Decks that are impervious to moisture penetration will protect critical structural members and substantially reduce the potential for decay. On many wood decks, the addition of an asphalt wearing surface with a watertight geotextile membrane provides a moisture barrier that protects not only supporting members but also the deck. If cracks develop in the asphalt surface, they should be thoroughly cleaned with a stiff brush and compressed air, then filled with an emulsion slurry or liquid asphalt mixed with sand. If pavement is broken or missing, surrounding pavement must be removed to the point where it is sound and tightly bonded to the deck, and a patch must be applied.

Surface treatments

Surface treatments are applied to existing bridge members to protect newly exposed, untreated wood from decay or to supplement the initial treatment after installation. This type of treatment is most effective when applied before decay begins and is commonly used for treating areas with checks, splits, delaminations, mechanical damage, or areas that were field-fabricated during construction. The ease of application and effectiveness of surface treatments as toxic barriers make them useful in preventive maintenance; however, the shallow penetration limits their effectiveness against established internal decay.

Surface treating normally involves conventional liquid wood preservatives that are applied by brushing, squirting, or spray-flooding of the wood surface. The wood surface should be thoroughly saturated with preservative so that all cracks and crevices are treated; however, care must be exercised to prevent excessive amounts from spilling or running off the surface and contaminating water or soil. In addition to preservative liquids, some preservative compounds are available in semisolid greases or pastes. These preservatives are useful for treating vertical surfaces or openings because larger quantities of preservative can be locally applied in heavy coatings that adhere to the wood. Preservative adsorption over an extended period can produce deeper penetration than single surface applications of liquid treatments. Semisolid preservatives are commonly used at the groundline of posts, poles, and piling, where they are brushed on the surface; the wood is then wrapped with an impervious material to exclude moisture and prevent leaching of the treatment into the surrounding soil.

The effectiveness of surface treatments depends on the thoroughness of application, wood species, wood size, and moisture content at the time of treatment.

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Wet wood absorbs less preservative than does dry wood. This factor is significant in wood bridges because many areas requiring treatment are subject to wetting. Although field tests show that surface treatments in aboveground locations can prevent decay infections for more than 20 years (Scheffer & Eslyn 1982), it is recommended that treatments used for bridge applications be systematically reapplied at intervals of 3 to 5 years to ensure adequate protection from decay.

Fumigants

Fumigants are specialized preservative chemicals in liquid or solid form that are placed in prebored holes to arrest internal decay. In time, the fumigants volatilize into toxic gases that move through the wood, eliminating decay fungi and insects. Fumigants can diffuse in the direction of the wood grain for 3 m or more from point of application in vertical members, such as poles. In horizontal members, the distance of movement is approximately 0.5 to 1 m from the point of application. The most common fumigants are liquids, but solid fumigants are also available. Solid fumigants are normally easier to use, provide increased safety, and reduce risk of environmental contamination.

To be most effective, fumigants must be applied to sound wood. When applied in very porous wood or close to surfaces, some of the fumigant is lost by diffusion to the atmosphere. Before applying fumigants, the condition of the member should be carefully assessed to identify the optimal boring pattern that avoids fasteners, seasoning checks, badly decayed wood, and other openings to the atmosphere. In vertical members such as piles, holes should be bored at a steep downward angle toward the center of the member to avoid crossing seasonal checks. For horizontal members, holes are bored in pairs straight down to within 40 to 50 mm of the bottom side. If large seasoning checks are present in horizontal members, holes should be bored on each side of the check to more completely protect the wood. The amount of chemical and the size and number of treatment holes depend on member size and orientation. Information on fumigants and recommended dosages may be obtained from the chemical manufacturers.

Liquid fumigants are applied using commercial equipment, but they can also be applied from polyethylene squeeze bottles (Morrell and others 1984). Solid fumigants are inserted directly into the prebored holes. Both types of fumigants will eventually diffuse from wood. Fumigants can be reapplied at periodic intervals in the same holes used for the initial treatment. The retreatment interval depends on the condition of the wood and the presence of checks, splits, fasteners, and other features that allow the fumigant to escape. In the absence of specific site information, it is recommended that a 10-year treatment cycle be used with a regular inspection program at 5-year intervals.

As with other preservatives and pesticides, fumigants for in-place treating are toxic to humans and must be used in accordance with State and Federal laws. When properly applied, the treatments pose no environmental or health hazard; however, the potential for environmental damage can be higher in some field locations because of variable conditions and the proximity to streams and other water sources. In-place treatments must be applied only by trained and licensed personnel who fully understand their use and the required safeguards.

References

1. Morrell, J. J.; Helsing, G. G.; Graham, R. D. 1984. Marine wood maintenance manual: a guide for proper use of Douglas fir in marine exposure. Res, Bull. 48. Corvallis, OR: Oregon State University, Forest Research Laboratory. 62 p.

2. Scheffer, T. C.; Eslyn, W. E. 1982. Twenty-year test of on-site preservative treatments to control decay in exterior wood of buildings. Material and Organismen 17(3): 181 - 198.

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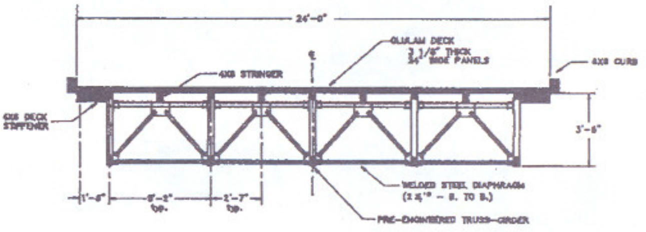
ecologically sound. The on-going National Timber Bridge Initiative coupled with the successful application of recent innovations in the field of timber engineering and construction have indeed revitalized the use of timber for structural framing of bridges.

The project, which remains in-progress at the present time, was initiated by a study prepared in 1994 by a team of experts at Mississippi State University for the Mississippi Agribusiness Council entitled *"The Potential of Producing Prefabricated, Modern Timber Bridge Components in Mississippi."* [3,4] It was noted in this study that the subject of bridges on rural roadways in Mississippi is extremely important in order to sustain the State's income from forestry products, but these bridges are presently in disrepair. In the fall of 1994, 5,920 of Mississippi's16,682 rural roadway bridges, (36 percent) had a sufficiency rating of 50 or less. A 50 or less sufficiency rating means a bridge cannot support its full design load and needs to be replaced. Also in 1994, an additional 2,800 rural roadway bridges were classified as functionally obsolete meaning that they can carry the design loads, but should be replaced because of other considerations such as too narrow, low overhead clearances, etc. The report concluded that "Mississippi needs to improve its bridge infrastructure for sustained economic growth" and "an investment in the research and development of innovative designs and manufacturing techniques of prefabricated modern timber bridge components is timely. It will lead to bringing forward competitive alternatives to the presently used structural materials in bridge construction."

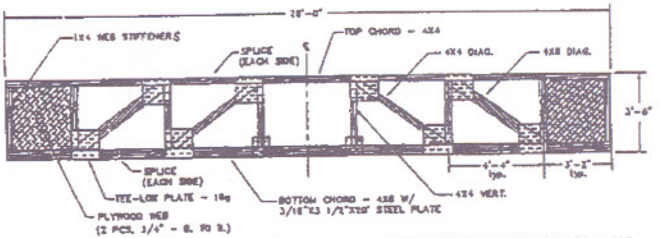
In 1993, the Southwest Mississippi Resource Conservation and Development, Inc. (RC&D) with assistance from the Department of Civil Engineering at Mississippi State University (MSU) and with partial funding provided by the USDA Forest Service through its National Timber Bridge Initiative sponsored the First National Timber Bridge Design Competition among interested undergraduate civil engineering, agricultural, forestry, and other interested student groups. A special prize was awarded to the ASCE-Student Chapter at MSU for the "Most Cost-Competitive Design". The proposed conceptual design was further studied and developed by the writers for bridges placed on rural roadways having span lengths 18-30 feet. The outstanding features of the design are found in the application of modern timber bridge components for constructing the timber bridges. Pre-engineered and prefabricated units made of readily available standard timber elements, to be manufactured, packed, and transported to the bridge site are used exclusively. The package of prefabricated bridge components should therefore be ready to assemble at the bridge site with minimum labor, machinery, and technical expertise. The concept was labeled *"A Bridge in a Box"*.

A cross-section of the proposed bridge is shown in the figures with a typical prefabricated truss-beam element. Testing of a completed full-scale prototype bridge is shown in the photograph.



TYPICAL BRIDGE PROFILE

The bridge deck was made from readily available commercial glulam panels manufactured for standard use as beam elements for the building construction industry. The 2 foot wide bridge deck panels were made using Southern pine 2x4-No. 1 grade. However, cost-saving measures were allowed to be used in the fabrication of the bridge deck panels, namely by easing the need for using select structural grade lumber for the top and bottom elements of the glulam beam units. The glulam bridge deck units were laid transversely on top of



NOTE: 1) ALL WOOD IS SOUTHERN YELLOW PINE NUMBER ONE GRADE OR BETTER
2) STEEL PLATE AFFIXED TO BOTTOM CHORD W/ (14) 5/8" LAG SCREWS
3) SPLICE REINFORCED W/ TEEL-LOK PLATES ON ALL FOUR SIDES

PRE-ENGINEERED TRUSS-GIRDER

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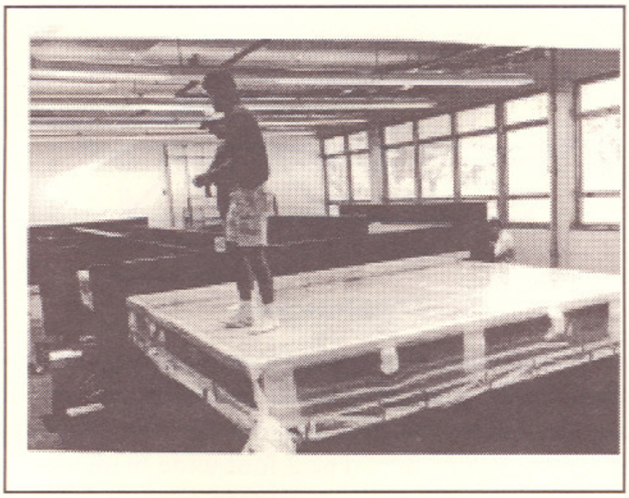
the beams and stringers. The panels were also allowed to have a rough finish on the top surface and only the bottom surface was specified to have a smooth finish. A minimum thickness of 3-1/8 inches for the bridge deck was achieved. The rough surface finish is believed to supply improved bonding characteristics for the planned asphaltic wearing surface overlay for the bridge. Each bridge deck panel was fixed to the beam truss girders and stringers by two 5/8 inch in diameter galvanized lag screws spaced at 12 inches apart.

The stringers were standard 4x6 pieces placed on top of the cross-diaphragms. The truss-girders were prefabricated by Trim Joist of Columbus, Mississippi, using their automated wood joist manufacturing assembly layout. The automated prefabrication proved to be extremely cost efficient, and allowed for accurate manufacturing including cambering for dead load deflection of the bridge itself and the weight of the anticipated asphaltic wearing surface. It is also provided superior fit at joints and splices which proved to be stronger than the wood itself when tested independently. Fabrication time was suprisingly very low. Further reduction in fabrication costs was also envisioned to be possible with mass production of such trusses.



The full size proto-type timber bridge was manufactured and erected inside an air pressure chamber in the structural laboratory at MSU. The bridge was erected in place by undergraduate civil engineering students using a hand pushed mobile lift crane and simple hand tools. The bridge was successfully tested using AASHTO HS20-44 loading for uniform loads and concentrated loads to simulate lane and truck loading; respectively and then combination thereof. Uniform loads were applied using air pressure differential between top and bottom of the deck, and wheel truck loadings were applied using individual jacks. Variable alternative critical layouts, or truck and lane loadings, were used in testing the full-scale bridge.

A full-scale real life demonstration bridge using this bridge in a box concept is planned for the later part of this year to be placed in Pearl River County located in the Southern part of Mississippi.

References

1. Burke, Martin P., Jr. (1995). *"Bridge Aesthetics: World View."*, J. Struct. Engrg., ASCE, 1211(8), 1252-1257.
2. *"Bridge Aesthetics Around the World."*, (1991). Transp. Res. Board, Nat. Res. Council, Washington, D.C.
3. *"The potential of producing prefabricated, modern timber bridge components in Mississippi"* (1994). MSU, Co-op ext.. Service, Food and Fiber Center, MSU, MS 39762.
4. *"Modern Timber bridges in Mississippi"*, (1995). MSU, Co-op Ext. Service, Food and Fiber Center, MSU, MS 39762.

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NEW PUBLICATIONS

In cooperation with the National Timber Bridge Initiative, work to examine the potential application of modern timber bridges in Mississippi has been proceeding at Mississippi State University (MSU) for several years. The latest report, ***Modern Timber Bridges in Mississippi: An Examination of Critical Issues,*** was prepared by a project committee at MSU that examined the issues of costs of modern timber bridges and longevity of timber structures in Mississippi.

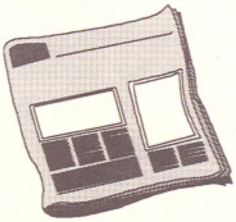
The study identifies the difficulties of obtaining cost figures directly comparable to concrete. Estimated costs are not as useful as site-specific comparisons. The study does provide case studies from Alabama that illustrate the advantage of modern timber bridges in some situations.

Another aspect of the study that most engineers will find interesting is the examination of the causes of timber pile failure on a group of Chickasaw County bridges. The study indicates that deterioration of piles was the result of either damage of the pile during installation or inadequate preservation treatments of the piles before they were installed. These findings indicate a lack of quality control during construction of the bridge not that treated timber is an unsuitable material.

Copies of this publication may be obtained by contacting Dr. Bob Daniels, Extension Forester, Mississippi state University, Cooperative Extension Service, Box 9681, Mississippi State, Mississippi 39762-9681; Phone: (601) 325-3150.

Two technology transfer publications have recently been completed on bridges in West Virginia. They are called: **Modern Timber Bridges of West Virginia, Volume I; and Modern Timber Bridges of West Virginia, Volume II**. Volume I contains a photograph, map, and some key information on each of the 54 modern timber bridges constructed in WV since 1989. This publication is primarily for individuals who plan to visit West Virginia and personally visit some of bridges. Volume II contains detailed information about the four bridge types that have been built in WV. The four types are stress-laminated, stress-laminated box beam, stress-laminated T-beam, and glued-laminated panel and beam bridges. Information on these bridge types include design, construction, and performance. The publications were a cooperative effort between the USDA Forest Service, West Virginia Department of Transportation,Federal Highway Administration, and Constructed Facilities Center-WVU.

Copies can be obtained by contacting TBIRC, USDA Forest Service, 180 Canfield Street, Morgantown, West Virginia 26505;
Phone: (304) 285-1591.



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