Standard Plans for Timber Highway Structures

Paula D. Hilbrich Lee and James P. Wacker, Forest Products Laboratory, USDA Forest Service

Abstract

Approximately 41% of the 578,000 highway bridges in the United States are currently in need of repair or replacement (USDA 1995). Many of these bridges are short span crossings on rural roads and are ideally suited for wood construction. However, wood is seldom considered in the selection of a structural material for bridge construction because many engineers are unfamiliar or inexperienced with wood design. For wood to be a viable material for highway structures, engineers must have access to design tools that make timber design an easy and more familiar process. One such tool is standard plans that present a clear and concise design and are adaptable to a variety of parameters. This paper presents a summary of three sets of standard plans for timber highway structures developed through cooperative research at the USDA Forest Service, Forest Products Laboratory: *Standard Plans for Southern Pine Bridges, Standard Plans for Timber Bridge Superstructures,* and *Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks*. Copies of these plans are available through the USDA Forest Service.

Keywords: Timber, bridge, design, railing, standard plans, superstructures, wood.

Introduction

As the 21st century approaches, a large number of highway bridges will be built to maintain critical links in the national transportation infrastructure. In designing these bridges, engineers will face a choice of structural materials. Of these materials, most engineers are least familiar with the design aspects of timber structures. This is partly due to a lack of educational training in wood design, because most colleges and universities do not offer such courses. In addition, many engineers do not see the need to invest or do not have the time to become familiar with wood design. As a result, a large percentage of short- to intermediate-span bridges are constructed with concrete and/or steel. For wood to be a viable material for future highway structures, engineers must have access to design tools that make timber design an easy and familiar process.

One such design tool is standard plans. Effective standard plans present clear and concise designs that are adaptable to numerous circumstances and parameters and meet structural and serviceability requirements. Standard plans provide an immediate overview of a design, indicating the appropriate circumstances for use and requirements for execution. By assembling design information and presenting it in the form of

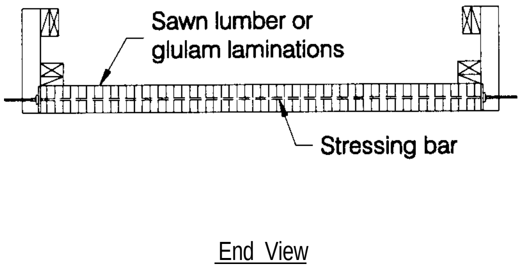


Figure 1 -Typical configuration of a stress-laminated deck system.

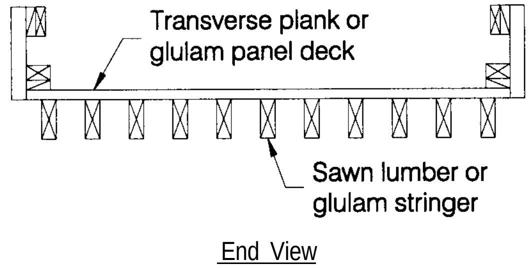


Figure 2 -Typical configuration of a longitudinal stringer bridge.

standard plans, preparation and investigation time required by an engineer is greatly reduced while their knowledge base increases.

Many standard plans are available for steel and concrete bridges; therefore, most engineers are familiar with these plans for highway structures. However, until recently, standard plans for timber highway structures were very limited and were typically outdated in terms of design requirements. This void has been identified by engineers throughout the United States as an area requiring improvement (Wipf and others 1993). To improve technology transfer regarding wood use in transportation structures, three sets of standard plans for timber highway structures, resulting from cooperative research conducted at the USDA Forest Service, Forest Products Laboratory (FPL), have been developed: *Standard Plans for Southern Pine Bridges, Standard Plans for Timber Bridge Superstructures,* and *Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks.*

The standard plans for timber highway structures developed through cooperative research at FPL are intended to serve as a useful guide to state, county, and local highway departments, as well as private engineering firms in the development of practical and economical timber bridge designs. In these plans, complete design, fabrication, and construction information are provided for several timber bridge superstructures and railing systems. Each system is adaptable to various span length and width combinations, although specific site conditions may require modifications.

The bridge superstructures included in the standard plans are either longitudinal deck systems or stringer systems. For the longitudinal deck systems, a series of laminations are placed on edge and fastened to one another with nails, spikes, steel bars, or glued-laminated sections are used. Longitudinal decks can be assembled in-place or laminations can be prefabricated into panels for easy installation. For stringer systems, longitudinal stringers support a transverse deck.

The designs were developed in accordance with the American Association of Highway Transportation Officials (AASHTO) Standard Specifications for Highway Bridges and Guide Specifications for Bridge Railings and are presented in a manner intended to clearly communicate content in an efficient and understandable manner. All designs should be reviewed by a registered professional engineer prior to construction. An overview of the three sets of standard plans that are now published for timber highway structures follows.

Southern Pine Bridges

Published in September 1995, *Standard Plans for Southern Pine Bridges* was developed under a cooperative research agreement with FPL, the University of Alabama, and the Southern Forest Products Association (Lee and others 1995). The publication includes designs for three Southern Pine timber bridge superstructures: stress-laminated sawn lumber bridges, stress-laminated glued laminated timber (glulam) bridges (Figure 1), and longitudinal stringer with transverse plank deck bridges (Figure 2).

In devising this set of plans, the objective was to provide complete information regarding all aspects of the design and construction of the bridge superstructure, enabling an engineer unfamiliar with timber bridges to easily understand and implement the design. The plans include deck details, railing and curb configurations, suggested substructure attachments, material lists, fabrication details, construction recommendations, and design examples. The designs are based on AASHTO HS 20-44 and HS 25-44 vehicle loading, and two live-load deflection criteria options, including

L/360 and L/500. The superstructure designs are applicable for single- and double-lane, nonskewed, simple-span bridges. A summary of each superstructure type included in *Standard Plans for Southern Pine Bridges* is presented in Table 1. (See Table 2 for metric conversion factors.) Specific details pertaining to each design follows.

Stress-Laminated Sawn Lumber Decks

Laminations in the stress-laminated sawn lumber deck are Southern Pine, visually graded No. 2, dimension lumber. The laminations are full span (no butt joints) measuring 2 in. in nominal thickness and 8, 10, or 12 in. in nominal width, depending upon the span length. Bridge lengths included in this design range from 10 to 20 ft. The minimum required nominal deck thickness (lamination width) is determined after the span, loading, and deflection criteria are defined. A materials list, fabrication details for all superstructure components, construction recommendations and procedures, and design examples are included.

Stress-Laminated Glued Laminated Timber Decks

Laminations in the stress-laminated glulam timber decks are Combination 24F-V3 Southern Pine glulam. The deck laminations may be any standard glulam width up to 6.75 in. or a combination thereof. The minimum required deck thickness (depth of the glulam beams) is selected when the span, loading, and deflection criteria are established, and ranges from 11 to 16.5 in. This set of plans includes bridge lengths ranging from 20 to 32 ft. As with the sawn lumber stress-laminated system, all bridge details, a materials list, fabrication details, construction recommendations, and design examples for the superstructure are presented.

Longitudinal Stringer with Transverse Plank Deck

Designs for the longitudinal stringer with transverse plank deck require the stringers and plank decking to be Southern Pine, visually graded No. 1 Dense or No. 2. The allowable stringer sizes are nominal 6 x 14 in., 6 x 16 in., and 8 x 16 in., and the nominal plank sizes are 3,4, or 5 in. wide and 8, 10, or 12 in. thick. These plans include bridge lengths ranging from 5 to 23 ft and are intended only for the AASHTO HS 20-44 vehicle loading and a live-load deflection of L/500. All details for the superstructure are presented, although fabrication details are given only for steel plate and angle components. Design examples are not presented as with the stress-laminated systems, but design considerations and assumptions are outlined.

Table 1 -Summary of superstructures included in *Standard Plans for Southern Pine Bridges.*

Bridge type	Material grade	Member size (in.)	Bridge length (ft)
Stress-laminated sawn lumber	No.2	2 by 8 2 by 10 2 by 12	10-20
Stress-laminated glulam	24F-V3	up to 6.75 by 11 - 16.5	20-32
Longitudinal stringer with transverse plank deck	No.1 Dense or No.2	6 by 14 6 by 16 8 by 16	5-23

Table 2-SI conversion factors.

English unit	Conversion factor	SI unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)

Timber Bridge Superstructures

Standard Plans for Timber Bridge Superstructures (Wacker and others [in press]) was developed through a cooperative research project with FPL, Laminated Concepts Incorporated, and the Federal Highway Administration (FHWA). Scheduled for publication in September 1996, the standards include designs and details for seven superstructure types. The longitudinal deck systems included in the plans consist of nail-laminated (Figure 3) and spike-laminated decks (Figure 4), sawn lumber and glulam stress-laminated decks (Figure l), and longitudinal glulam panel decks (Figure 4). The longitudinal stringer systems included in the plans are a glulam stringer system (Figure 2) and a steel stringer system (Figure 5), both with transverse glulam decks. For the steel stringer system, details are given only for the transverse glulam panel deck and its attachment to the steel stringers. Table 3 provides a summary of the deck systems included in these standard plans.

Table 3-Summary of deck systems included in *Standard Plans for Timber Bridge Superstructures.*

Superstructure type	Bridge length (ft)	Deck thickness (in.)
Sawn lumber deck systems		
Nail-laminated	10 - 28	8 - 16
Spike-laminated	10 - 34	8 - 16
Stress-laminated	10-34	8 - 16
Glulam deck systems		
Longitudinal panel	12-38	8 - 16
Stress-laminated	10-60	9 - 24
Stringer with transverse deck	20 - 80	5.125
Transverse deck for steel stringers	N/A	5 - 8.75

The intent of this set of plans is to provide basic information and specifications for a wide range of timber bridge superstructures to an engineer somewhat familiar with timber design. Detailed information for the deck configuration and design tables for numerous geometry and material combinations are provided. For a given bridge system, the user establishes the design load (AASHTO HS 20 or HS 25), span length, number of lanes (single or double), orientation of the crossing (rectangular or skewed), and deflection limit (L/360 or L/500). When these factors are defined, the standard plans yield the appropriate material requirements and corresponding member sizes. The plans are not limited to a specific species.

Crash-Tested Bridge Railings for Longitudinal Wood Decks

Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks, published in September 1995, presents five bridge railing plans that reflect the results of a cooperative research project with the Midwest Roadside Safety Facility, University of Nebraska, Lincoln,

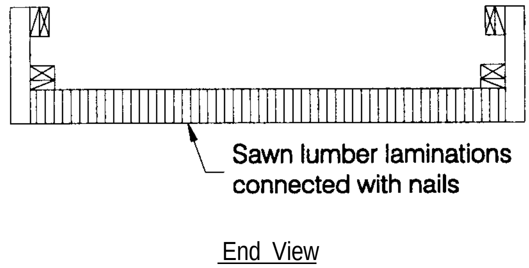


Figure 3-Typical configuration of a nail laminated deck system.

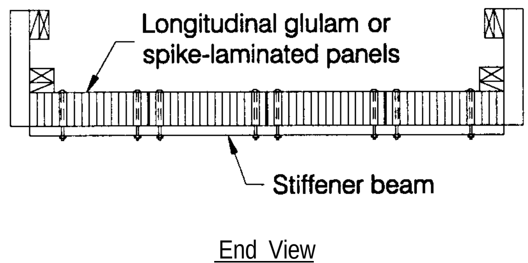


Figure 4-Typical configuration of a longitudinal glulam or spike-laminated panel deck system.

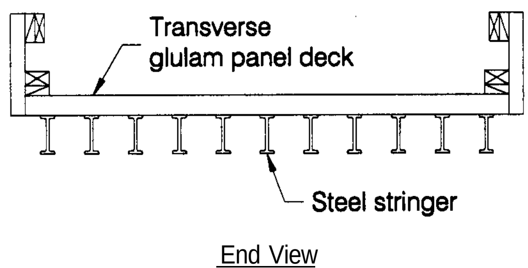


Figure 5-Typical configuration of a steel stringer deck system with a transverse glulam panel deck.

FPL, and FHWA (Ritter and others 1995). The project objective was to develop and crash test bridge railings and approach railings for longitudinal wood decks. Historically, bridge railings have been designed based on static-load design criteria. Because full-scale vehicle crash testing is becoming recognized as a more reliable method of evaluating bridge railing acceptability, the development of crash-tested rail systems for timber bridges is a critical component in advancing the approval and use of timber highway structures.

The bridge railings included in the project were designed in accordance with the requirements of AASHTO Performance Level 1 (PL-1), AASHTO Performance Level 2 (PL-2), and the National Cooperative Highway Research Program (NCHRP) Report 350 Test Level 4 (TL-4). The approach railings were tested or adapted from previous testing in accordance with NCHRP Report 230. The sets of railing plans presented in the publication are illustrated in Figures 6 and 7. Figure 6 depicts the rails that were crash-tested to meet AASHTO PL-1 requirements, including a glulam timber rail with curb, a glulam timber rail without curb, and a steel rail. Figure 7 illustrates the steel rail that was crash-tested in accordance with AASHTO PL-2, and the glulam timber rail with curb that met NCHRP 350 TL-4 requirements.

The railings are adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued laminated timber decks of any length. The AASHTO PL-1 glulam timber rail with curb is applicable to superstructures with a minimum deck thickness of 8 in., and all other railings included in the plans require a minimum deck thickness of 10.5 in. The timber components may be any species as long as they comply to specified bending and modulus of elasticity requirements. Each set of plans provides detailed information that illustrates rail layout, curb and rail splices, and fabrication details for all steel components. Full drawing sets are provided in customary U.S. and SI units of measure, and the testing procedures, results, and drawings have been approved by the Federal Highway Administration Federal-Aid and Design Office for use on Federal-Aid highway projects.

Concluding Remarks

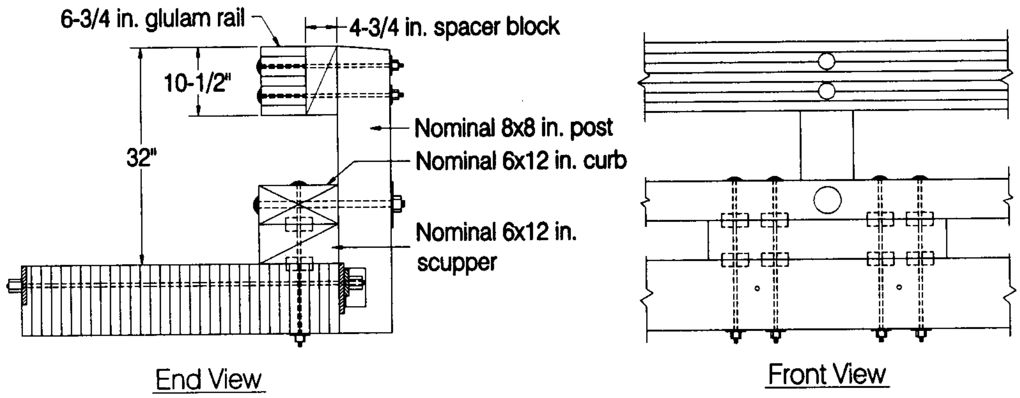
The standard plans presented in this paper are intended to be a competitive choice for the replacement of deteriorating and construction of new short- to intermediate-span highway bridges. In developing standard plans for timber highway structures, engineers are immediately provided a wealth of clearly presented information, which familiarizes them with timber highway structures. By making wood design a less cumbersome process, timber highway structures become a viable choice.

Standard Plans for Southern Pine Bridges provides complete information for three superstructure types from the design phase through the construction phase. The designs are specifically for Southern Pine lumber or glulam. *Standard Plans for Timber Bridge Superstructure* presents designs for seven types of superstructures. The bridges may be constructed from any species that meets the material requirements defined by the deck geometry. Details of the structure are given, but a materials list, fabrication details, and detailed construction notes must be assembled by the user. These plans provide a starting point for the user who must adapt them to a specific site. *Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks* provides the configuration and layout of five crash-tested bridge railings and approach transition railings. They are easily adaptable for use on longitudinal wood decks and are critical to the acceptance of timber bridges.

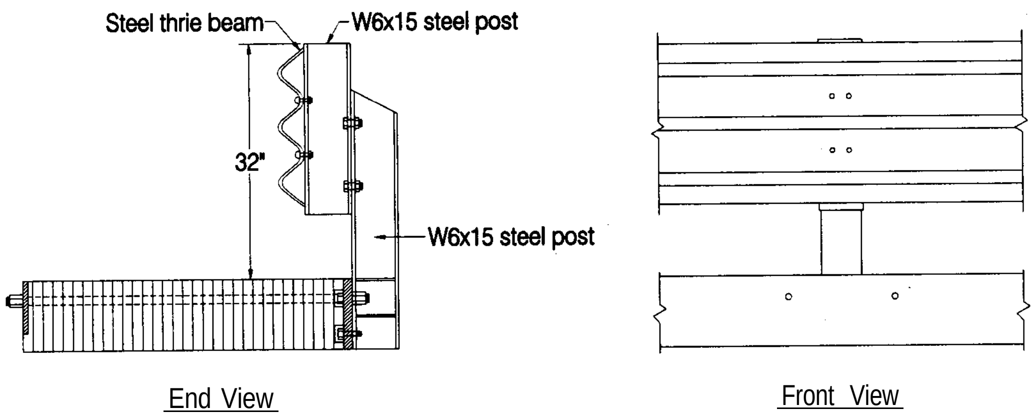
These three sets of standard plans advance technology transfer regarding timber highway structures, helping engineers to become familiar with wood design and to consider it as an option when designing highway structures. These plans are available to the public at no charge and can be obtained by contacting the following:

Timber Bridge Information Resource Center
USDA Forest Service
NA State & Private Forestry
P.O. Box 4360
180 Canfield Street
Morgantown, WV 26505
(304) 285-1591 voice
(304) 285-6505 fax

Glulam Timber Rail with Curb



Steel Rail



Glulam Timber Rail without Curb

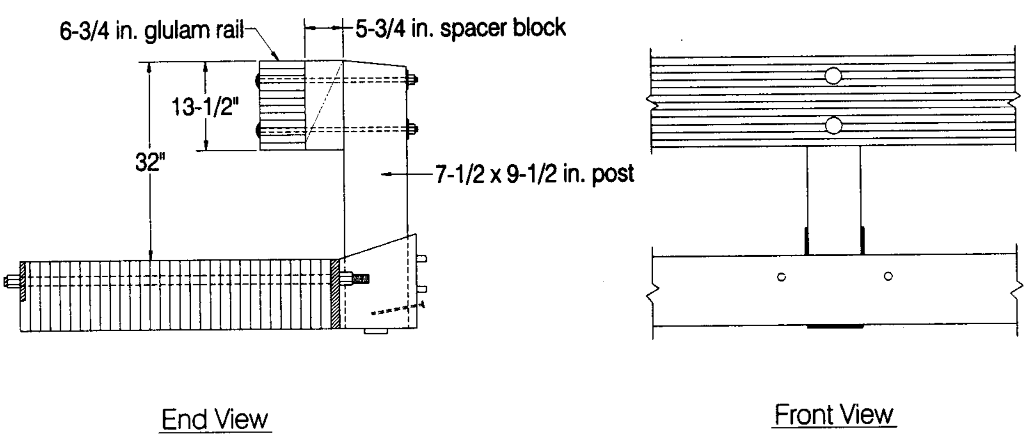
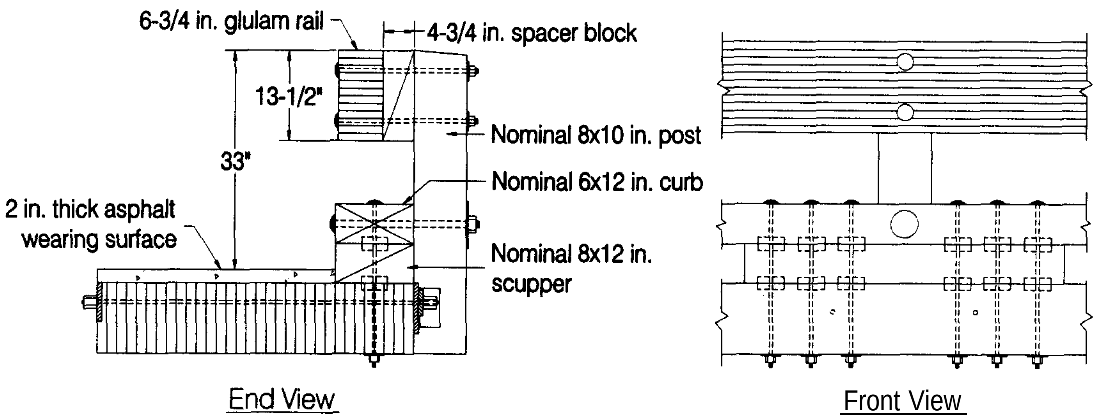


Figure 6-Railing configurations crash-tested to meet AASHTO PL-1 requirements included in *Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks.*

Glulam Timber Rail with Curb



Steel Rail

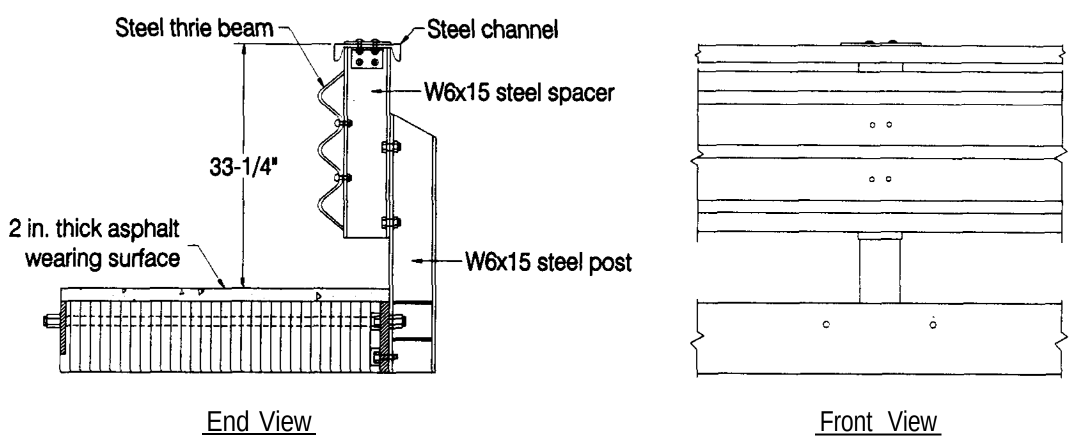


Figure 7-Railing configurations crash-tested to meet AASHTO PL-2 (steel rail) and NCHRP Report 350 TL-4 (glulam timber rail with curb) requirements included in *Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks.*

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