Modern Timber Highway Bridges —State of the Art

PAUL T. NICHOLAS
Manager, Engineering Services
American Institute of Timber Construction
Englewood, Colorado

INTRODUCTION

The versatility and durability of timber make it an important engineering material for bridge construction but it's potential for such use is not generally recognized. Timber is widely used in bridge construction on the secondary road systems, in the National Forests, in railroad structures and to a limited extent in major bridges on primary road systems. Timber bridges, properly designed and treated with modern preservatives will give many years of minimal maintenance service.

The covered timber bridges, a part of our national heritage, are good examples of the service longevity achieved by timber bridges when proper design and maintenance principles are applied. Many covered timber bridges over 100 years old are still being used in the eastern United States. These covered bridges precede modern preservative treatments, with the secret to their longevity being their design. The covered bridge protected the superstructure from the elements and thus these bridges had a life expectancy of 80 years or more. The design and construction of timber bridges has progressed significantly from the early days of the covered bridges. Today the use of properly preservatively treated, structural-glued-laminated timber members provides the bridge engineer with a modern construction material applicable to his design needs.

TIMBER BRIDGE COMPONENTS

Any type of bridge system is generally considered to be composed of three basic components, these being the substructure, superstructure, and the deck system. Within each of these basic components, different construction materials can be utilized to provide the most efficient and economical design.

Timber Substructures

Timber bridges can be placed on virtually any type of substructure. One of the most common types of bridge substructure are round pressure treated timber pilings. Timber is also often used in crib walls or wing walls adjacent to main abutment structures. These cribs can be prefabricated units and shipped to the jobsite ready for installation.

Timber Superstructures

The simplest, lowest cost and most widely used of all timber bridge superstructures is the longitudinal stringer or straight girder bridge. These can be used for both single and multiple lane roads and are commonly simple span structures; however, multispan bridges with intermediate pier supports can also be used. Straight girder bridges are normally more economical for spans of from 20 to 60 feet, but considerably longer spans, up to 100 feet or more, are practical in certain design situations using glulam stringers.

A second quite common superstructure configuration is the truss bridge. Truss components can be fabricated in different configurations with the most common being either the bowstring truss or the parallel chord trusses. The trusses are completely prefabricated at a laminating plant and are then assembled at the jobsite and raised into position as completed trusses, thus reducing total erection time.

For long clear-span timber bridge construction, the deck-arch bridge has been efficiently utilized. With this type of construction, pier height is held to a minimum yet the bridge is raised well above the water-line or traffic lanes. With no overhead members of any type, road clearance is unlimited. The deck-arch bridge is practical for spans of from 60 to 300 feet, and is particularly applicable when bedrock foundations are encountered to eliminate the need for construction of heavy foundation abutments which must take the horizontal thrust of the load.

Structural Deck Systems

Historically, the most common timber bridge deck is a nail-laminated assembly of nominal two-inch dimension lumber fastened with through nailing of the laminations and toe-nailing of the laminations to the stringers. This system dates back 50 or more years and was basically quite satisfactory when first designed and used. For many years, such decking was used on solid sawn stringers spaced relatively close together. In this type of construction the decking deflected very little between stringers, so service performance was acceptable. However, with the advent of glued-laminated timbers, the spacing of stringers more than doubled while the decking system remained unchanged. This magnified the necessary structural requirements of the decking, and thus on wide stringer spacings, the bending strength of the decking was still adequate, but deflection increased significantly. These deflections can cause a working within the fastener systems resulting in an overall loosening of the deck. This loosening is exaggerated by a shrinking and swelling of deck members through repeated wetting by the elements. As a result, for certain designs of bridges using glued-laminated stringers on wide spacings, the nail-laminated deck can become excessively loose and in turn this loose deck undermines confidence in the structural performance and often reduces service life.

The latest development in glulam-timber-bridge construction is the glued-laminated panel deck, designed as an orthotropic plate. Construction of a glued-laminated panel deck is illustrated in Figure 1.

Due to fabrication, transportation, and erection limitations, it is recommended that the glued bridge panels be fabricated in widths of approximately four feet. In order for the panels to act as a continuous orthotropic plate, it is necessary to install load transfer devices having the structural capacity to prevent relative displacement and rotation between adjacent panels. In a research program conducted at the U. S. Forest Products Laboratory to investigate bridge decking systems the use of a solid steel dowel proved to be the superior type of load transfer device.

Details of the research leading to the development of the design criteria for the glulam-panel bridge deck is given in FPL Report Num-

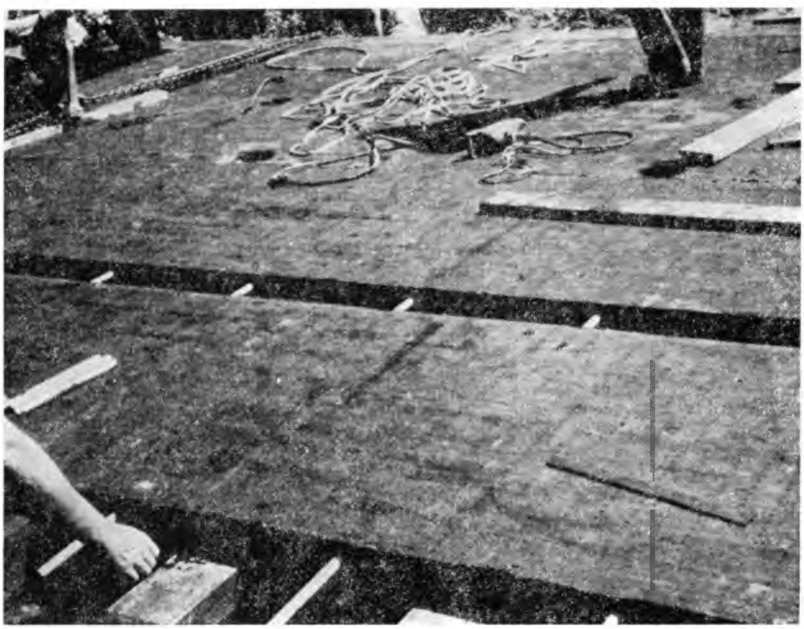

Figure 1

ber 210 "Procedure for Design of Glued-Laminated Orthotropic Bridge Decks" by William J. McCutcheon and Roger L. Tuomi.

The field applications for Forest Service bridges over the past five years have proven successful in the application of the glulam-panel deck concept to modern timber bridge construction. The Forest Service Division of Engineering has indicated that all future timber bridge decks will utilize the glued-laminated panels, based on their prior satisfactory experience in actual bridge installations.

Provisions for the design and construction of glulam-panel decks have been approved by AASHTO and will be included in a supplement to their specifications.

The AITC has developed typical details and plans for girder bridges utilizing the glulam-deck panels and these are available upon request.