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Hardwoods for Timber Bridges: A National Program Emphasis by the USDA Forest Service

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Introduction

Hardwood timbers have been used extensively as track ties, or sleepers, in the U.S. railroad industry for over a hundred years. However, the structural use of hardwood timbers for highway bridges was a new idea proposed in the 1980s as a solution to two issues: an overabundance of secondary grade hardwoods and an aging highway bridge inventory with many needs for replacement options. In 1988, a special supplement (AF&PA 1988) to the 1986 edition of the *National Design Specifcation® (NDS®) for Wood Construction* introduced structural design values for numerous hardwood species and provided the technical stimulus for two national programs aimed at improving utilization of timber as a structural material for highway bridges.

In 1989, the National Timber Bridge Initiative (Crist 1990) was created by Congressional legislation with the primary goal of enhancing forest-based economies in rural communities of the United States. A national Wood in Transportation (WIT) program evolved from these efforts and was administered by the USDA Forest Service from a new information center located in Morgantown, West Virginia. The Forest Service established three main emphasis areas: research, demonstration structures, and technology transfer. One of the primary goals of the WIT program was to foster utilization of locally available and underutilized wood species for wood transportation structures. These WIT structures primarily include highway bridges, pedesman and trail bridges, and portable bridges. In many regions of the United States, underutilized wood species are identified as secondary (structural) grade hardwoods. Traditionally, timber bridges were constructed primarily with Douglas-fir and southern pine because of their comparatively high mechanical properties and good availability. Therefore, research was needed to overcome many technical obstacles associated with efficiently utilizing hardwood species for timber bridge applications.

In 1991, the Federal Highway Administration (FHWA) established a parallel national program for WIT-related research and demonstration projects (Duwadi and Wood 1996). Very few demonstration hardwood bridges were built as part of the FHWA efforts because program emphasis was for conventional designs and not for localized and/or hardwood species.

This paper describes the joint efforts of the Forest Service and the FHWA to administer national programs including research, demonstration bridges, and technology transfer components. Summary information on a number of Forest Service–WIT demonstration bridges constructed with hardwoods is also provided.

Table 1.—Examples of FPL/FHWA research studies related to hardwoods for timber transportation structures.

Research category[a]	Study description	Study outcome
I. Design	Develop glulam technologies	Glulam options
	Develop standard bridge plans	Bridge design aides
II. Lumber properties	Grade and yield studies	Mechanical grading
III. Preservatives	Efficacy of wood preservatives	Treatment specifications
V Inspection and rehabilitation	Field inspection guidelines	New inspection manual[b]

[a] For Area IV–Alternative transportation system structures, there were no hardwood-related studies; for Area VI–Technology and Information Transfer, see following section in this paper for details.
[b] Currently being edited for publication.

Research Summary

The foundation of the WIT program is various research efforts related to wood transportation structures. The Forest Service has traditionally constructed more than half of their forest road bridges using timber, and the Forest Products Laboratory (FPL), a primary Forest Service research facility for wood and paper products, has a long history of studying new timber bridge structural systems in the laboratory and conventional timber bridge systems in the field. In the wake of the establishment of two national programs emphasizing wood for transportation structures, FPL and the FHWA Turner-Fairbanks Highway Research Center joined resources in 1991 to conduct a joint national wood transportation structures research program, which has been maintained to the present. Six research categories, established by Congressional legislation, were the basic framework for establishing research priorities within an initial needs assessment study (Wipf et al. 1993). Efforts are currently underway to update the initial needs assessment to lay out research priorities further into the future. Table 1 summarizes past studies that were identified as higher priority areas and are related to the development of hardwood timber bridge technologies.

Another report (Ritter and Duwadi 1998) includes a comprehensive summary of various FPL-FHWA WIT joint research projects and accomplishments. The outcome of these hardwood-related research projects is the elimination of major technical barriers to the application and use of hardwood species for highway bridges and other transportation structures. This work has resulted in the construction of numerous demonstration bridge projects throughout the country.

Demonstration Project Summary

A key component of the WIT program is the construction of demonstration structures, which provide real-world examples to potential users of the capabilities of timber as a structural material for bridges and other transportation structures. The National Wood in Transportation Information Center (NWITIC) administers the WIT demonstration structure process by convening an annual review and selection panel that determines which project applications are offered cost-sharing (50%) grants to cover associated materials, design, and construction costs within budgetary constraints.

Table 2.—Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in various states.

State	No. of bridges	Wood species
WV	60	Red oak/yellow-poplar
PA	17	Red oak/red maple
IA	14	Cottonwood/black locust
NY	13	Red maple/mixed hardwood
MI	5	Red maple/red oak
ND	5	Cottonwood
OH	5	Red oak
KS	3	Mixed oak
MD	3	Red oak
OK	3	Cottonwood
VA	3	Hickory/white oak
IN	2	Red oak
RI	2	Red oak
VT	2	Red maple
AR	1	Red oak
MA	1	Red oak
MO	1	Mixed oak

To date, approximately 140 demonstration hardwood bridges have been constructed in 17 states (Table 2). Four states - West Virginia, Pennsylvania, Iowa, and New York - have constructed substantial numbers of demonstration hardwood bridges. The most demonstration hardwood bridges (60 vehicular) were constructed in West Virginia. West Virginia University (WVU) collaborated with the West Virginia Division of Highways to design and construct several red oak, mixed oak, and yellow-poplar demonstration bridges. Most of the bridges constructed in West Virginia are summarized in a two-volume set of fact sheets by Dickson (1995). The main bridge superstructure types emphasized in West Virginia were the stress-laminated deck (Fig. 1), stress-laminated T-section, and stress-laminated box-section. Much development work has been conducted by WVU on the longer span stress-laminated superstructure types, the T-beam and box-beam sections, which utilize hardwood lumber flange sections in conjunction with softwood glulam beams as the web members.

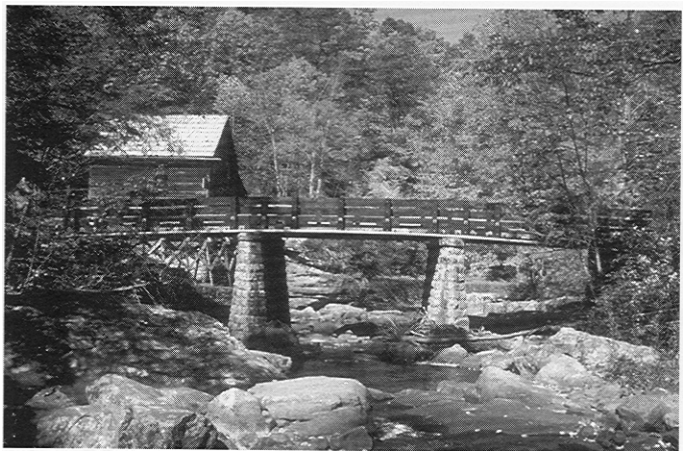

Figure 1.—Glade Creek Mill stress-laminated deck bridge located in West Virginia's Babcock State Park.

Figure 2.—A three-pin arch bridge located in Pennsylvania's Trough Creek State Park.

In Pennsylvania, the Department of Transportation (PennDOT) constructed 1 pedestrian and 17 vehicular demonstration hardwood bridges, primarily with red oak and red maple (Fig. 2). PennDOT cooperatively worked with the Pennsylvania State University to develop red maple and red oak hardwood species for bridge applications, including the adaptation of glulam beam technologies. This collaboration also resulted in hardwood glulam bridge design standards being developed and recently adopted by PennDOT (Manbeck et al. 1994).

In Iowa, several counties worked with the Iowa Department of Transportation and constructed 14 vehicular demonstration hardwood bridges using low-valued cottonwood species. The main bridge superstructure types emphasized in Iowa were the stress-laminated deck (Ritter et al. 1995) and transverse glulam decks on steel beam girders.

In New York, 13 vehicular demonstration hardwood bridges were constructed by various county highway departments using a variety of hardwood species (Fig. 3). Several other states constructed fewer than five demonstration hardwood bridges.

A key component in those states that have succeeded in constructing significant numbers of hardwood demonstration bridges (West Virginia, Pennsylvania, and Iowa) appears to be acceptance from their state transportation departments, including the adoption of standardized plans for hardwood timber bridges.

Figure 3.—Christian Hollow stress-laminated box-beam timber bridge located in Steuben County, New York.

Technology Transfer Summary

The backbone of the WIT program is technology transfer. Technical information on underutilized wood species for bridges, retaining walls, piers, noise barriers, and other structures must be made available to potential user groups to successfully increase the utilization of timber as structural material in transportation structures. The NWITIC, formerly known as the Timber Bridge Information Resource Center, disseminates and distributes information on all aspects of wood in transportation structures from its Morgantown, West Virginia, location. Their program website (www.fs.fed.us/na/wit) includes an abundance of information, including more than 300 publications and a searchable database of 400 funded projects. Since federal funding for the National Wood in Transportation Program ended in federal fiscal year 2004, the Forest Service, as a courtesy to its customers, is maintaining the website and library of information on a short-term basis.

NWITIC also organized various conferences and workshops as an effective means of transferring information to targeted user groups. Several conferences and workshops included significant information related to hardwood timber bridge technologies. The following represents a cursory literature review related to hardwood timber transportation structures technology transfer efforts.

In 1992, the *National Hardwood Timber Bridge Conference* was held in State College, Pennsylvania. Although a formal conference proceeding was not produced from this conference, one resulting publication describes the material design considerations for hardwood glulam bridges (Manbeck and Shaffer 1994).

In 1994, the *Engineered Wood for Transportation Structures National Workshop* was held in Morgantown, West Virginia (CFC 1996). During the two-day workshop, participants were organized into 10 discussion groups on various topics, including hardwood bridge materials, and were asked to focus on key issues facing bridge designers and builders.

In 1996, the *National Conference on Wood Transportation Structures* was held in Madison, Wisconsin, and the conference proceeding is available (Ritter et al. 1996). During this two-day conference, more than 10 technical papers were presented covering various topics related to the application of hardwoods for timber bridges.

In 1997, a conference entitled *Eastern Hardwoods, Resources, Technologies, and Markets* was held at Hamsburg, Pennsylvania. A paper presented by Cesa and Kasey (1997) summarizes the WIT program's history mission, and organizational structure and provides specific examples of how the WIT program is addressing the needs of the hardwood industry.

Also, a new *National Wood in Transportation Program Compact Disk* (NA 2001) was compiled, providing users with a comprehensive set of research publications and related resources developed between 1988 and 2001. Also included are WIT program information fact sheets and newsletters. Additional hardwood-related publications are available at the WIT program website.

Concluding Remarks

Recent research and development work for structural hardwood species has eliminated the major technical barriers to their application and use for highway bridges and other transportation structures. To date, nearly 140 demonstration hardwood bridges have been built in 17 states. A key component in those states that have constructed significant numbers of hardwood demonstration bridges appears to be acceptance from their state transportation departments, including the adoption of standardized plans for hardwood timber bridges.

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