Chapter 10
Hardwoods for Timber Bridges

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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 dual solution to an over abundance of secondary grade hardwoods and to 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 Specification® (NDS®) for Wood Construction* introduced structural design values for numerous hardwood species and provided the technical stimulus for two national programs aimed at improving the utilization of timber as a structural material for highway bridges.

In 1989, the National Timber Bridge Initiative (Grist 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

[1] The USDA Forest Service administered the National Wood In Transportation (WIT) Program 1989-2004. Additional information is available through the WIT program website: www.fs.fed.us/na/wit.

the primary goals of the WIT program was to foster the utilization of locally available and underutilized wood species for wood transportation structures. These WIT structures include bridges (highway, railroad, pedestrian, trail, portable), guardrails, piers and docks, noise barriers, etc. In many regions of the United States, the underutilized wood species are identified as secondary (structural) grade hardwoods. Traditionally, timber bridges were constructed primarily with Douglas-fir and southern pine due to their comparatively high strength and stiffness properties. 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 chapter 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.

Research Summary

The foundation of the WIT program was 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), its primary 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 FHWA's Turner-Fairbanks Highway Research Center joined resources to conduct a joint national wood transportation structures research program in 1991 that has been maintained to the present. Six main 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 layout research priorities further into the future.

A summary of past research studies that were identified as higher priority areas and are related to the development of hardwood timber bridge technologies is provided in Table 10.1.

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

Demonstration Project Summary

A key component of the WIT program was the construction of demonstration structures as they 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

Table 10.1. — Examples of FPL/FHWA research studies relating to hardwoods for timber transportation structures.

Research areas[a]	Study description	Results
I. System development/design		
	• develop glulam technologies for red oak, red maple, yellow-poplar, and cottonwood	• hardwood glulam options for engineers
	• develop standard bridge plans inclusive of hardwood species	• bridge design aides for engineers
II. Lumber design properties		
	• grade and yield studies of various hardwood species	• new mechanical grading options for engineers
III. Preservatives		
	• efficacy of wood preservatives for hardwoods and secondary softwoods	• hardwood treatment options for engineers
V. Inspection and rehabilitation		
	• field inspection guidelines for timber structures	• new inspection manual for bridge inspectors

[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 chapter for details.

(NWITIC) administers the WIT demonstration structure process by convening an annual review and selection panel that determines which project applications will be offered 50 percent cost-sharing grants to cover associated materials, design, and construction costs.

To date, approximately 140 demonstration hardwood bridges have been constructed in 18 states. Four states have constructed substantial numbers of demonstration hardwood bridges: West Virginia, Pennsylvania, Iowa, and New York. The largest number of demonstration hardwood bridges (60 vehicular) has been constructed in the state of West Virginia **(Table 10.2).** West Virginia University collaborated with the WV 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 factsheets by Dickson (1995). The main bridge superstructure types emphasized in West Virginia were the stress-laminated deck, stress-laminated T-section, and stress-laminated box-section. Much development work has been conducted by West Virginia University on the longer span stress-laminated superstructure types, the T- and box-sections, which involve utilizing hardwood lumber flange sections in conjunction with softwood glulam beams as the web members.

In Pennsylvania, the Department of Transportation (PennDOT) has constructed 17 vehicular bridges and 1 pedestrian demonstration hardwood bridge primarily with red oak and red maple **(Table 10.3).** PennDOT has 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 have worked with the Iowa Department of Transportation and have constructed 10 vehicular demonstration hardwood bridges **(Table 10.4)** using the 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 have been constructed by various county highway departments using a variety of hardwood species **(Table 10.5).** Several other states have constructed fewer than 5 demonstration hardwood bridges and are summarized in **Table 10.6.**

A key component in states that have constructed a significant number of hardwood demonstration bridges (WV, PA, and IA) appears to be acceptance

Table 10.2. — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in West Virginia.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preservative treatment[s]	Design live load
			---- (ft) ----						
West Virginia Vehicular									
Mason	WV1-01-89	NA-001-89-COM	42	18	stress-laminated box-beam	1	red oak/southern pine	creosote	HS20
Mason	WV1-02-89	NA-001-89-COM	42	40	stress-laminated box-beam	1	red oak/southern pine	creosote	HS20
Wayne	WV2-02-89	NA-001-89-COM	30	29	stress-laminated deck	1	red oak	creosote	HS20
Logan	WV2-04-89	NA-001-89-COM	52	25	stress-laminated box-beam	1	red oak/southern pine	creosote	HS20
Mingo	WV2-07-89	NA-001-89-COM	53	15	stress-laminated box-beam	1	red oak/southern pine	creosote	HS20
Mingo	WV2-08-89	NA-001-89-COM	220	15	stress-laminated deck/ steel truss	3	red oak	creosote	HS20
Wood	WV3-01-89	NA-001-89-COM	35	19	stress-laminated deck	1	red oak	creosote	HS20
Jackson	WV3-02-89	NA-001-89-COM	42	22	stress-laminated box-beam	1	red oak/southern pine	creosote	HS20
Wirt	WV3-03-89	NA-001-89-COM	29	17	stress-laminated deck	1	red oak	creosote	HS20
Ritchie	WV3-04-89	NA-001-89-COM	39	18	stress-laminated box-beam	1	red oak/southern pine	creosote	HS20
Marion	WV4-03-89	NA-001-89-COM	30	18	stress-laminated deck	1	red oak	creosote	HS20
Marion	WV4-04-89	NA-001-89-COM	36	18	stress-laminated deck	1	red oak	creosote	HS20
Monongalia	WV4-09-89	NA-001-89-COM	40	28	stress-laminated box-beam	1	red oak/southern pine	creosote	HS20
Grant	WV5-01-89	NA-001-89-COM	52	17	stress-laminated box-beam	1	red oak/southern pine	creosote	HS20
Jefferson	WV5-02-89	NA-001-89-COM	52	21	stress-laminated box-beam	1	red oak/southern pine	creosote	HS20
Jefferson	WV5-03-89	NA-001-89-COM	33	18	stress-laminated deck	1	red oak	creosote	HS20
Hancock	WV6-04-89	NA-001-89-COM	42	17	stress-laminated box-beam	1	red oak/southern pine	creosote	HS20
Wetzel	WV6-04-89	NA-001-89-COM	23	19	stress-laminated deck	1	red oak	creosote	HS20

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Table 10.2 *(continued).* — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in West Virginia.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preservative treatment[s]	Design live load
			---- (ft) ----						
Gilmer	WV7-01-89	NA-001-89-COM	109	20	stress-laminated box-beam	2	red oak/southern pine	creosote	HS-20
Lewis	WV07-02-89	NA-001-89-COM	40	22	stress-laminated box-beam	2	red oak/southern pine	creosote	HS-20
Webster	WV07-04-89	NA-001-89-COM	35	18	stress-laminated deck	1	red oak	creosote	HS-20
Upshur	WV07-05-89	NA-001-89-COM	29	26	stress-laminated deck	1	red oak	creosote	HS-20
Pendelton	WV08-01-89	NA-001-89-COM	31	20	stress-laminated deck	1	red oak	creosote	HS-20
Pendelton	VVV08-01A-89	NA-001-89-COM	33	20	stress-laminated deck	1	red oak	creosote	HS-20
Randolph	WV08-02-89	NA-001-89-COM	44	18	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-20
Fayette	WV09-01-89	NA-001-89-COM	78	26	stress-laminated deck	3	red oak	creosote	HS-20
Greenbrier	WV09-05-89	NA-001-89-COM	28	19	stress-laminated deck	1	red oak	creosote	HS-20
McDowell	WV10-01-89	NA-001-89-COM	48	20	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-20
Mercer	WV10-02-89	NA-001-89-COM	63	24	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-20
Wyoming	WV10-03-89	NA-001-89-COM	54	18	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-20
Wyoming	WV10-04-89	NA-001-89-COM	46	21	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-20
Lewis	WV-08-90	NA-002-90-COM	76	26	stress-laminated T-beam	2	red oak/southern pine	creosote	HS-25
Pendelton	WV-09-90	NA-002-90-COM	47	24	stress-laminated T-beam	1	red oak/southern pine	creosote	HS-25
Fayette	WV-10-90	NA-002-90-COM	63	34	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-25
McDowell	WV-11-90	NA-002-90-COM	38	26	stress-laminated T-beam	1	red oak/southern pine	creosote	HS-25
Jefferson	WV-07-90	NA-002-90-COM	32	26	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-25
Roane	WV-01-90	NA-002-90-COM	53	24	stress-laminated T-beam	1	red oak/southern pine	creosote	HS-25
Boone	WV-02-90	NA-002-90-COM	25	26	stress-laminated T-beam	1	red oak/southern pine	creosote	HS-25

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Table 10.2 *(continued).* — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in West Virginia.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preservative treatment[s]	Design live load
			----- (ft) ----						
Clay	WV-03-90	NA-002-90-COM	34	21	stress-laminated T-beam	1	red oak/southern pine	creosote	HS-25
Cabell	WV-04-90	NA-002-90-COM	64	24	stress-laminated T-beam	1	red oak/southern pine	creosote	HS-25
Putnam	Hamlin	NA-036-91-VEH	45	21	stress-laminated T-beam	1	red oak/southern pine	creosote	HS-25
Lewis	Lightburn	NA-035-91-VEH	119	21	stress-laminated T-beam	2	red oak/southern pine	creosote	HS-25
Ohio	Potomac	NA-047-91-VEH	73	17	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-25
Fayette	Glen Jean	NA-045-91-VEH	57	43	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-25
Roane	Wellington	NA-043-91-VEH	41	17	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-25
Harrison	Lost Creek	NA-058-92-VEH	55	16	stress-laminated box-beam	1	red oak/southern pine	creosote	HS-25
Lewis	Weston	NA-056-92-VEH	45	18	stress-laminated T-beam	1	red oak/southern pine	creosote	HS-25
McDowell	Bishops Rd	NA-001-99-COM	25	16	plank deck on steel beams	1	mixed oak	CCA	HS-20
Mercer	Weese Mtn	NA-001-99-COM	25	16	plank deck on steel beams	1	mixed oak	CCA	HS-20
Mercer	Laurel Creek	NA-001-99-COM	25	16	plank deck on steel beams	1	mixed oak	CCA	HS-20
Raleigh	Potomac Ct	NA-001-99-COM	25	16	plank deck on steel beams	1	mixed oak	CCA	HS-20
Raleigh	Dogma Ct	NA-001-99-COM	40	16	plank deck on steel beams	1	mixed oak	CCA	HS-20
Raleigh	Sunflower Ln	NA-001-99-COM	25	16	plank deck on steel beams	1	mixed oak	CCA	HS-20
Preston	Bruceton Mill	NA-001-00-COM	30	14	spike-laminated eng. wood composite deck	1	yellow-poplar -	creosote	HS-20
Ritchie	Slab Creek	NA-007-00-COM	41	13	nail-laminated deck on steel stringers	2	mixed oak	CCA	HS-20
Ritchie	Big Fonzo	NA-007-00-COM	124	16	plank deck on steel truss	1	mixed oak	CCA	HS-20

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Table 10.2 *(continued).* — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in West Virginia.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preservative treatment[a]	Design live load
			----- (ft) -----						
Braxton	Left Fork Holly River	NA-001-01-COM	151	18	plank deck on steel truss	1	mixed oak	CCA	HS-20
Barbour	Hacker Creek	NA-001-03-COM	33	15	trans. eng. wood composite deck on steel beams	1	yellow-poplar	creosote	HS-20
Braxton	Mill Fork	NA-001-03-COM	46	15	trans. eng. wood composite deck on steel beams	1	yellow-poplar	creosote	HS-20
Barbour	Peeltree	NA-001-03-COM	40	15	trans. eng. wood composite deck on steel beams	1	yellow-poplar	creosote	HS-20

[a] CCA is chromated copper arsenate.

Table 10.3. — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in Pennsylvania.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preservative treatments	Design live load
			- - - - (ft) - - - -						
Pennsylvania Vehicular									
Greene	Davistown	NA-002-89-COM	47	33	trans. glulam deck on steel stringers	1	red maple	creosote	HS-25
Centre	Stoney Run Rd	No FS grant	30	18	king post	1	red oak	borate	HS-20
Bradford	County #4	NA-007-90-VEH	35	14	stress-laminated sawn lumber/steel plates	1	red oak	creosote	HS-20
Cumberland	Possum Hollow Creek	NA-002-89-COM	27	36	trans. glulam deck on glulam stringers	1	red maple	creosote	HS-25
Huntingdon	Trough Creek State Park	NA-045-95-VEH	77	31	glulam deck/glulam arch	1	red maple/Douglas-fir	creosote/penta	HS-20
Elk	Bear Creek	NA-002-89-COM	50	15	trans. glulam deck on steel stringers	1	red maple	creosote	HS-20
Centre	NA-21-89	NS-002-89-COM	38	28	trans. glulam deck on glulam stringers	1	red oak	creosote	HS-20
Forest	Brookston Rd	NA-002-89-COM	35	20	stress-laminated sawn lumber/steel plates	1	red oak	creosote	HS-25
Huntingdon	Laurel Run	NA-002-89-COM	40	24	stress-laminated sawn lumber/steel plats	1	red oak	creosote	HS-25
Crawford	Dutch Hill Rd	NA-002-89-COM	24	32	stress-laminated sawn lumber	1	red oak	creosote	HS-25
Clarion	Piney Creek	NA-002-89-COM	44	24	stress-laminated sawn lumber/steel plates	1	red oak	creosote	HS-25

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Table 10.3 *(continued).* — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in Pennsylvania.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preservative treatment[a]	Design live load
			- - - - (ft) - - - -						
Huntingdon	Jacobs	NA-002-89-COM	46	27	stress-laminated sawn lumber/steel plates		red oak	creosote	HS-25
Sullivan	Birch Creek	NA-002-89-COM	25	26	stress-laminated sawn lumber		beech	creosote	HS-25
Schuylkill	Dogwood Ln	NA-002-89-COM	36	26	stress-laminated sawn lumber/steel plates		red oak	creosote	HS-25
Lancaster	Camp Rd	NA-001-02-VEH	28	14	trans. sawn lumber plank deck on sawn lumber stringers		mixed oak	creosote	HS-20
Lancaster	Millcross	NA-002-89-COM	21	30	stress-laminated sawn lumber		red oak	creosote	HS-25
Lebanon	Monroe Creek	NA-017-97-SPJ	38	24	trans. glulam deck on steel stringers		red maple	creosote	HS-25
					Pennsylvania Pedestrian				
Armstrong	Crooked Creek Timber	NA-072-93-PED	215	9	steel stringers and transverse sawn lumber plank decks	2	chestnut oak	borates	Pedestrian

[a] Penta is pentachlorophenol.

Table 10.4. — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in Iowa.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preser-vative treatment	Design live load
			----- (ft) -----						
Iowa Vehicular									
Appanoose	Cooper Creek	No FS grant	40	26	stress-laminated deck	2	cottonwood	creosote	HS-20
Appanoose	Dean	No FS grant	24	23	stress-laminated deck	1	cottonwood	creosote	HS-20
Appanoose	Hibbsville	No FS grant	24	17	stress-laminated deck	1	cottonwood	creosote	HS-20
Decatur	Decatur	No FS grant	24	21	stress-laminated deck	1	cottonwood	creosote	HS-20
Appanoose		NA-030-95-VEH	37	24	trans. dowel-lam deck on steel stringers	1	cottonwood	creosote	HS-20
Ida	Ida Grove	NA-007-98-COM	36	26	trans. glulam deck on steel girders	1	cottonwood	creosote	HS-20
Ida	Battle Creek	NA-007-98-COM	30	26	trans. glulam deck on steel girders	1	cottonwood	creosote	HS-20
Ida	Holstein	NA-007-98-COM	30	26	trans. glulam deck on steel girders	1	cottonwood	creosote	HS-20
Ida	Holstein	NA-007-98-COM	30	26	trans. glulam deck on steel girders	1	cottonwood	creosote	HS-20
Ida	Cushing	NA-007-98-COM	48	26	trans. glulam deck on steel girders	1	cottonwood	creosote	HS-20
Iowa Pedestrian									
Johnson	Kirkwood School	NA-002-02-COM	60	12	round timber segmented (warren truss) arch	1	black locust	none	75 psf
Johnson	unnamed	NA-002-02-COM	60	12	round timber segmented (warren truss) arch	1	black locust	none	75 psf

Table 10.5. — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in New York.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preservative treatment[s]	Design live load
			- - - - (ft) - - - -						
New York Vehicular									
Livingston	Stone Falls	NA-025-92-VEH	42	30	stress-laminated box beam	1	beech-birch-maple/ southern pine	creosote	HS-20
Allegany	Local #27-14	NA-393-91-VEH	29	29	trans. sawn lumber nail-laminated deck on steel stringers	1	red maple	creosote	HS-25
Allegany	Local #1-5	NA-392-91-VEH	29	28	trans. glulam deck on steel stringers	1	beech/hickory	penta	HS-25
Allegany	Local #5-1	NA-391-91-VEH	35	32	stress-laminted sawn lumber on steel stringers	1	beech/hickory	creosote	HS-25
Schuyler	Schuyler #1	NA-026-92-VEH	32	30	stress-laminated glued-laminate	1	red maple	penta	HS-20
Cattaraugus	Olean #30	NA-008-89-VEH	26	31	stress-laminated sawn lumber	1	red maple	creosote	HS-20
Alleghany	Local #25-8	NA-045-94-VEH	29	26	trans. glulam deck on glulam stringers	1	red maple	penta	HS-20
Ontario	Railroad Mills Rd	NA-046-94-VEH	55	23	trans. glulam deck on steel stringers	1	sugar maple	penta	HS-20
Washington	C-029 Mettawee St	NA-006-90-VEH	47	26	trans. sawn lumber nail-laminated deck on glued-laminated stringers	1	red oak/southern pine	creosote/ penta	HS-20

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Table 10.5 *(continued).* — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in New York.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preservative treatment[a]	Design live load
			- - - - (ft.) - - - -						
Washington	Tip Lady Rd Timber	NA-021-92-VEH	35	28	trans. glulam deck on steel stringers		red maple	creosote	HS-20
Tioga	Strait Corners	NA-011-95-VEH	25	24	stress laminated "n-frame" system		red maple/southern pine	creosote	HS-25
Washington	Pike Brook Rd Timber	NA-014-95-VEH	39	26	trans. sawn lumber nail-laminated deck on steel stringers		yellow birch	creosote	HS-25
Livingston	Maxwell Station Rd	NA-014-96-SPJ	23	28	longitudinal glued-laminated		sugar maple	penta	HS-25

[a] Penta is pentachlorophenol.

Table 10.6. — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in various other states.

County	Bridge name	Project No.	Bridge length (ft)	Bridge width (ft)	Superstructure type	No. of spans	Wood species	Preservative treatment[s]	Design live load
Arkansas Vehicular									
Washington	Weedy Rough	R08-010-92-VEH	36	27	stress-laminated box beam	1	red oak	creosote	HS-20
Indiana Vehicular									
Perry	County #134	NA-003-90-VEH	28	18	stress-laminated T system	1	red oak	creosote	HS-20
Jefferson	Wolf Run	NA-015-89-VEH	36	26	stress-laminated deck	1	pin oak (red oak)	creosote	HS-20
Kansas Vehicular									
Franklin	#79N-00E	R02-009-92-VEH	90	26	stress-laminated T system	3	red oak	creosote	HS-20
Sumner	County #63-14-3	R02-002-91-VEH	30	26	stress-laminated deck	1	mixed oak	creosote	HS-20
Miami	Pleasant Valley Rd	R02-012-90-VEH	26	31	stress-laminated deck	1	mixed oak	creosote	HS-20
Maryland Vehicular									
Garrett	Buffalo Run Rd	NA-038-89-VEH	30	31	stress-laminated sawn timber	1	red oak	creosote	HS-20
Charles	Suffolk Ln	NA-004-92-VEH	20	25	sawn lumber stringers and trans. sawn lumber plank deck	1	red oak	borate	HS-20
Washington	McFarland Rd	NA-015-93-VEH	23	24	trans. glulam deck on glulam stringers	1	yellow-poplar	creosote	HS-20

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Table 10.6 *(continued).* — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in various other states.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preser-vative treatment[s]	Design live load
			---- (ft) ----						
Massachusetts Vehicular									
Middlesex	Sherman's	NA-001-91-VEH	103	25	plank deck on glulam stringers	7	red oak	penta	HS-20
Michigan Vehicular									
Houghton	Forest #4	NA-003-02-COM	21	18	plank deck on lumber stringers	1	bigtooth aspen	CCA	
Houghton	Forest #5	NA-003-02-COM	21	18	plank deck on lumber stringers	1	red maple	CCA	
Houghton	Forest #1	NA-003-02-COM	22	18	plank deck on lumber stringer	1	red maple	CCA	HS-20
Van Buren	72nd Ave	NA-040-92-VEH	28	30	stress-laminated deck	2	red maple	creosote	HS-20
Crawford	Cameron	NA-043-92-VEH	86	32	stress-laminated box beam	2	pin oak	creosote	HS-25
Missouri Vehicular									
Marion	CART Rd 274	NA-012-90-VEH	78	26	stress-laminated deck	3	mixed oak/Douglas-fir	creosote	HS-20
North Dakota Vehicular									
Richland	124-37	R01-001-01-COM	26	26	trans. glulam deck on steel stringers	1	cottonwood	creosote	HS-20
Richland	124-36.1	R01-001-01-COM	26	26	trans. glulam deck on steel stringers	1	cottonwood	creosote	HS-20

Table continued on the next page.

Table 10.6 *(continued).* — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in various other states.

County	Bridge name	Project No.	Bridge length (ft)	Bridge width (ft)	Superstructure type	No. of spans	Wood species	Preservative treatments	Design live load
Richland	124-35	R01-001-01-COM	30	26	trans. glulam deck on steel stringers	1	cottonwood	creosote	HS-20
Cass	Maple River	R01-005-89-VEH	152	26	stress-laminated deck on steel stringers	7	cottonwood	creosote	HS-20
Cass	Mapleton Township Rd	R01-002-90-VEH	52	34	stress-laminated box beam	1	cottonwood	creosote	HS-20
Ohio Vehicular									
Stark	Paris Ave	NA-048-92-VEH	35	24	stress-laminated T system	1	red oak	creosote	HS-20
Stark	Oak Dr	NA-026-91-VEH	35	24	stress-laminated T system	1	red oak	creosote	HS-20
Ashtabula	Callender Rd	NA-028-94-VEH	52	26	stress-laminated T system	1	red oak	creosote	HS-20
Lawrence	CR 41/#4	NA-005-90-VEH	30	24	stress-laminated deck	1	red oak	creosote	HS-20
Lawrence	County Rd 41/#3	NA-021-91-VEH	20	24	stress-laminated deck	1	red oak	creosote	HS-20
Oklahoma Vehicular									
Noble	Cedar St	R08-016-95-VEH	40	26	trans. glulam deck on glulam stringers	1	cottonwood	creosote	HS-20
Washington	Count Rd NS394	R08-013-90-VEH	40	28	stress-laminated box beam	1	cottonwood	creosote	HS-20
Logan	unnamed	R08-014-95-VEH	30	26	trans. glulam deck on glulam stringers	1	cottonwood	creosote	HS-20

Table continued on the next page.

Table 10.6 *(continued).* — Summary of USDA Forest Service WIT-funded hardwood demonstration bridge projects in various other states.

County	Bridge name	Project No.	Bridge length	Bridge width	Superstructure type	No. of spans	Wood species	Preser-vative treatment[a]	Design live load
			---- (ft) ----						
Rhode Island Vehicular									
Providence	North Rd	NA-008-90-VEH	23	22	stress-laminated deck	1	red oak	creosote	HS-20
Kent	Hudson Pond Rd	NA-018-95-VEH	22	25	stress-laminated deck	1	red oak	creosote	HS-20
Virginia Vehicular									
Smyth	unnamed	R08-008-95-SPJ	32	14	stress-laminated deck	1	hickory	creosote	HS-20
Carroll	unnamed	R08-008-95-SPJ	20	15	stress-laminated deck	1	white oak	untreated	
Virginia Portable									
Tazewell	portable	R08-008-95-SPJ	36	11	stress-laminated deck	1	hickory	creosote	HS-20
Vermont Vehicular									
Windham	Abbott Rd	NA-009-90-VEH	26	24	stress-laminated deck	1	red maple	creosote	HS-20
Windsor	#12	NA-007-89-VEH	38	28	stress-laminated deck	1	red maple	creosote	HS-20

[a] Penta is pentachlorophenol; CCA is chromated copper arsenate.

from their state transportation departments, including the adoption of standardized plans for hardwood timber bridges.

Technology Transfer Summary

The backbone of the WIT program was technology transfer. Technical information on underutilized wood species for bridges, retaining walls, piers, noise barriers, and other structures was 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, disseminated and distributed 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 over 315 publications and a searchable database of 408 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 of the conferences and workshops have 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 ten 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 in 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 in Harrisburg, Pennsylvania. A paper presented by Cesa and Kasey (1997) summarizes the WIT program's history, mission, and organization structure. It also 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) has been compiled and provides users with a comprehensive set of research publications and related resources developed between 1988 and 2001. Also included are WIT program information such as bridge factsheets and newsletters.

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 approximately 18 states. A key component in states that have constructed a 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.

Acknowledgments

Thanks to Chris Grant and Jeff Bejune of the National Wood In Transportation Information Center staff for assistance with compiling data for demonstration bridge tables.

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Financial support for the development of this publication was provided to Northern Initiatives through the USDA Forest Service Northeastern Area's Rural Development Through Forestry Program.

ISBN 1-892529-32-7

Publication No. 7234

Printed in the United States of America.

0510500

Ross, R.J. and J.R. Erickson. 2005. Undervalued Hardwoods for Engineered Materials and Components. Forest Products Society, Madison, WI. 132 pp.