The Federal Highway Administration Timber Bridge Program

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Abstract
The Federal Highway Administration (FHWA), as directed by the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, Section 1039, is addressing the Highway Timber Bridge Research and Demonstration Program. Funding for the program is being made available for six years. The program, in its sixth year of funding, is being coordinated between the FHWA's Office of Engineering, the Office of Engineering Research and Development, and the Office of Technology Applications. This paper presents an overview of the program.

Keywords: Federal Highway Administration, Timber bridge program, ISTEA, Duwadi, Wood.

Introduction
The principle role of the FHWA is administering the federal-aid highway program. The federal-aid program has typically focused on roads and bridges on the more major highways like the interstates, primary roads and major arterials. The FHWA has played less of a direct role on our Nations secondary, local and rural highway systems. Under its Highway Bridge Replacement and Rehabilitation Program (HBRRP) between 15% to 35% of the available funds can be used by the States on local highways. As timber bridges exist mostly on local and rural highways, the FHWA has had less of an involvement in these types of bridge systems until the ISTEA legislation of 1991.

The FHWA requires the states to inventory and inspect all its bridges on public roads. Based on the National Bridge Inventory (NBI) of a total of 576,874 bridges, 41,743 (7.2 percent) are timber bridges. Figure 1 shows the distribution of these bridges nationwide within the 48 continental United States. In addition, in the NBI there are approximately equal number of bridges, 42,102 (7.3 percent) that have timber decks supported by steel stringers, and are therefore classified as steel bridges. The distribution of these are shown in Figure 2. The NBI also provides an assessment of our Nation's bridges. Based on this data, 18.6 percent of our Nation's bridges are structurally deficient. Table 1 gives the proportion of structurally deficient bridges by material type. Approximately 18 percent of the structurally deficient bridges are timber bridges.

States and counties continue to build bridges out of wood as it has numerous characteristics that make it a desirable material for transportation structures:

- It is a renewable resource.
- It is naturally resistant to the effects of deicing agents.

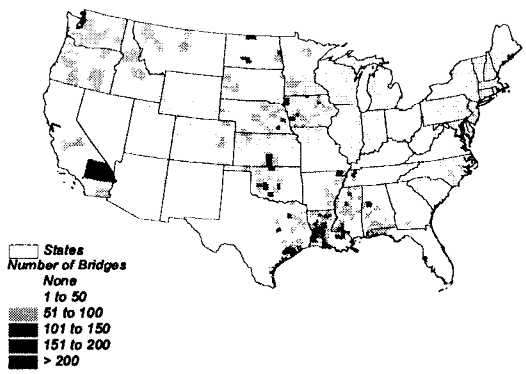

Figure 1—Distribution of Timber Bridges

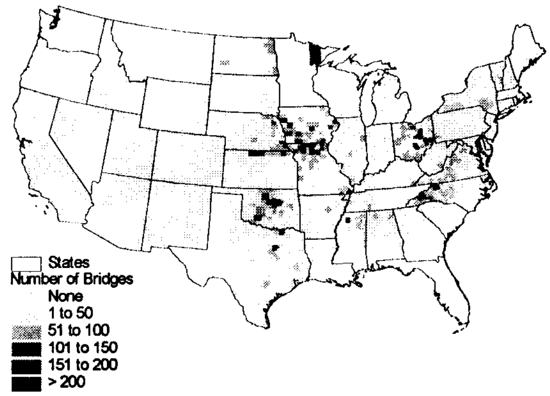

Figure 2—Distribution of Steel Bridges with Timber Decks

Table 1—Structurally deficient bridges by material type.

Material Type	# Structurally Deficient	Percentage
Timber	19,738	18.35 %
Concrete	20,847	19.38%
P/S Concrete	3,328	3.09%
Steel	62,396	58.02%
Other	1,234	1.15%

- Construction can be completed in any type of weather without affecting the material, and with a minimal workforce.

Legislation

In 1989, to encourage the use of wood for bridge construction, Congress established the Timber Bridge Initiative program to include research, technology transfer, and demonstration bridges. The responsibility for administration of the Timber Bridge Initiative was given to the United States Forest Service. In 1991 under ISTEA, Congress established the Highway Timber Bridge Research and Demonstration Program. As with the Timber Bridge Initiative, the program includes research, technology transfer, and demonstration bridges. The responsibility for administration of this Program was given to the FHWA.

The ISTEA, Section 1039(a) authorizes the Secretary to make grants to carry out research on one or more of the following areas:

- Development of new, economical highway timber bridge systems.
- Development of engineering design criteria for structural wood products for use in highway bridges in order to improve methods for characterizing lumber design properties.
- Preservative systems for use in highway timber bridges which demonstrate new alternatives and current treatment processes and procedures and which are environmentally sound with respect to application, use, and disposal of treated timber.
- Alternative transportation system timber structures which demonstrate the development of applications for railing, sign, and lighting supports, sound barriers, culverts, and retaining walls in highway applications.
- Rehabilitation measures which demonstrate

effective, safe, and reliable methods for rehabilitating existing highway timber structures.

The ISTEA, Section 1039(b) authorizes the Secretary to make the information and technology resulting from research available to State and local transportation departments and other interested persons.

The ISTEA, Section 1039(c) authorizes the Secretary to make grants to States for construction of highway timber bridges on rural federal-aid highways. Criteria for approval is to be based on:

- Bridge designs which have both initial and long-term structural and environmental integrity.
- Bridge designs which utilize timber species native to the State or region.
- Innovative bridge designs which have the possibility of increasing knowledge, cost effectiveness, and future use of such designs.
- Environmental practices for preservative treated timber, and construction techniques which comply with all environmental regulations.

One million dollars per year is provided to the Secretary for these programs for research and technology transfer, and $7,500,000 per year ($7,000,000 in FY92) for construction of the bridges. A 20% match is required from any organization receiving research projects and from the States receiving grants for construction of the bridges.

Program Implementation

This section describes the implementation process established by each office of the FHWA responsible for carrying out the program.

Research and Technology Transfer

The FHWA Office of Engineering Research and Development - Structures Division, and the Office of Technology Applications elected to pool funds and resources with the FS - Forest Products Laboratory (FPL) and establish a single coherent national Timber Bridge Research and Technology Transfer program. This interagency cooperation also ensures elimination of duplication of research.

Timber bridge research needs was determined through a committee consisting of government, academia, and industry representatives by the FHWA under its "Outreach Program" in 1989. Anticipating a rise in funding, this list of research needs was further expanded by Iowa State University under a study sponsored by the FHWA, and FPL. The results of this study, included in a report titled, "Development of a Six-Year Research Needs Assessment for Timber Transportation Structures" forms the basis of the six year joint timber bridge program for both the FHWA and FPL. The timber bridge research activity under this national research program is divided into the following six research areas to coincide with the ISTEA Legislation:

- Area I: System Development and Design
- Area II: Lumber Design Properties
- Area III: Preservatives
- Area IV: Alternate Transportation System Timber Structures
- Area V: Inspection/Rehabilitation
- Area VI: Technology and Information Transfer

The program is administered under an Interagency Agreement with the FPL. Under the program joint project identification and prioritization is conducted by the FHWA and FPL. The research studies are cooperative studies with universities, local government agencies, and industry.

Demonstration Bridges

The FHWA demonstration bridge program is administered and managed by the FHWA Office of Engineering - Bridge Division. Candidate projects are selected by State highway agencies and submitted to the FHWA for the final decision. The candidate bridges must meet eligibility criteria of the HBRRP, 23 U.S.C. 144. The ISTEA Legislation lists four additional criteria for selection and approval of the grants. Funds for the program are set aside from the FHWA Bridge Discretionary Program. Funds are required to be obligated and construction contracts awarded during the same fiscal year as the grants. As originally written only those bridges on the federal-aid highway system were eligible for the ISTEA funding. However, as most of the timber bridges are on off system roads, the legislation was modified in the U.S. Department of Transportation 1993 Appropriations Bill to allow construction grants for timber bridges on any public roads if otherwise eligible for the bridge program. During fiscal years 1992 and 1993, applicant bridges were subjectively ranked on how well each fulfilled the above criteria. Since fiscal year 1994, selection has been made based on a Priority Rating Factor (PRF) that is computed by a formula given below.

$$PRF = \frac{10}{(RI+RN)xRSxRE} \quad (1)$$

- RI - is based on consideration of type, length, and width of the bridge for innovative designs.
- RN - is based on sufficiency rating as a measure of need.
- RS - is based on sources of timber species.
- RE - is based on effective use of funds for bridge construction versus approach roadway work (a maximum of 10 percent may be used for approach roadway work).

Special consideration is given to environmentally sensitive designs and those utilizing environmentally approved preservatives. Also, during project selection special attempt is made to obtain a geographical mix nationwide, thus giving all of the states ample opportunity to gain experience in the design and construction of timber bridges. Timber designs for bridges built on the National Highway System (NHS) have to meet the American Association of State Highway and Transportation Officials (AASHTO) standards for highway bridges. Those not on the NHS may be designed in accordance with individual State-approved standards.

Key Studies & Status

This section highlights the studies that are under way in the research and technology applications area, many of which are described in more detail in papers by others in these proceedings. This section also discusses the demonstration bridge projects funded by the FHWA.

Research & Technology Applications

Research studies cover the range of topics identified in the Legislation. This includes development of criteria to improve design and performance of timber structures; development of methods and equipment for inspection and rehabilitation; and transfer of technology through design aids in the form of standard plans, and reports, and through presentations at national conferences. Currently 31 studies are underway in the six broad areas. Studies are being conducted nationwide involving numerous universities, and other organizations. At the conclusion of the program over 46 studies will have been conducted. Summaries of all research studies underway including all the FPL funded projects are described in a paper prepared annually by Duwadi & Ritter titled, "Status of Research on Timber Bridges and Related Topics".

Although ISTEA provided $1,000,00 per year for research and technology transfer activities, the actual available FHWA funding has been $990,000-FY92, $803,050-FY93, $911,000-FY94, $1,000,000-FY95, and $874,576-FY96 due to obligation limitations set forth in the Transportation Appropriations Bills. The following lists specific studies jointly conducted by pooling FPL and FHWA resources that have been underway utilizing the FY92-FY95 funds. Studies utilizing FY96, and FY97 funds are under development.

Area I: System Development and Design–

- Timber bridge monitoring and evaluation including full-scale load testing.
- Field evaluation of a timber bridge constructed with metal plate connected trusses.
- Develop long-span timber bridge systems using glued laminated timber.
- Development of stress-laminated truss bridges using light-frame metal plate connected trusses.
- Evaluate cold temperature effects on stress-laminated timber decks.
- Dynamic evaluation of timber bridges.
- An independent review & analysis of the stressed T & Box design concepts, laboratory works, and field performances.

Area II: Lumber Design Properties-

- Shear strength of sawn lumber beams.
- Load and resistance factor design calibration.

Area III: Preservatives-

- Accelerated laboratory testing of new wood preservatives- ecosystem studies.
- Accelerated laboratory testing of new wood preservatives - pure culture studies.
- Treatments and methods for field treating bridge members.
- Performance characteristics of various wood preservatives for stress-laminated bridge applications.
- Manual on wood preservatives.
- Treatability of heartwood.
- Copper naphthanate preservative for bridge applications.
- Moisture protection for timber members.
- Fumigants for use in preserving wood members.
- Environmental effects (leaching) of commonly used preservatives.

Area IV: Alternate Transportation System Timber Structures-

- Development of crash worthy bridge rail systems; PL-2, longitudinal decks.

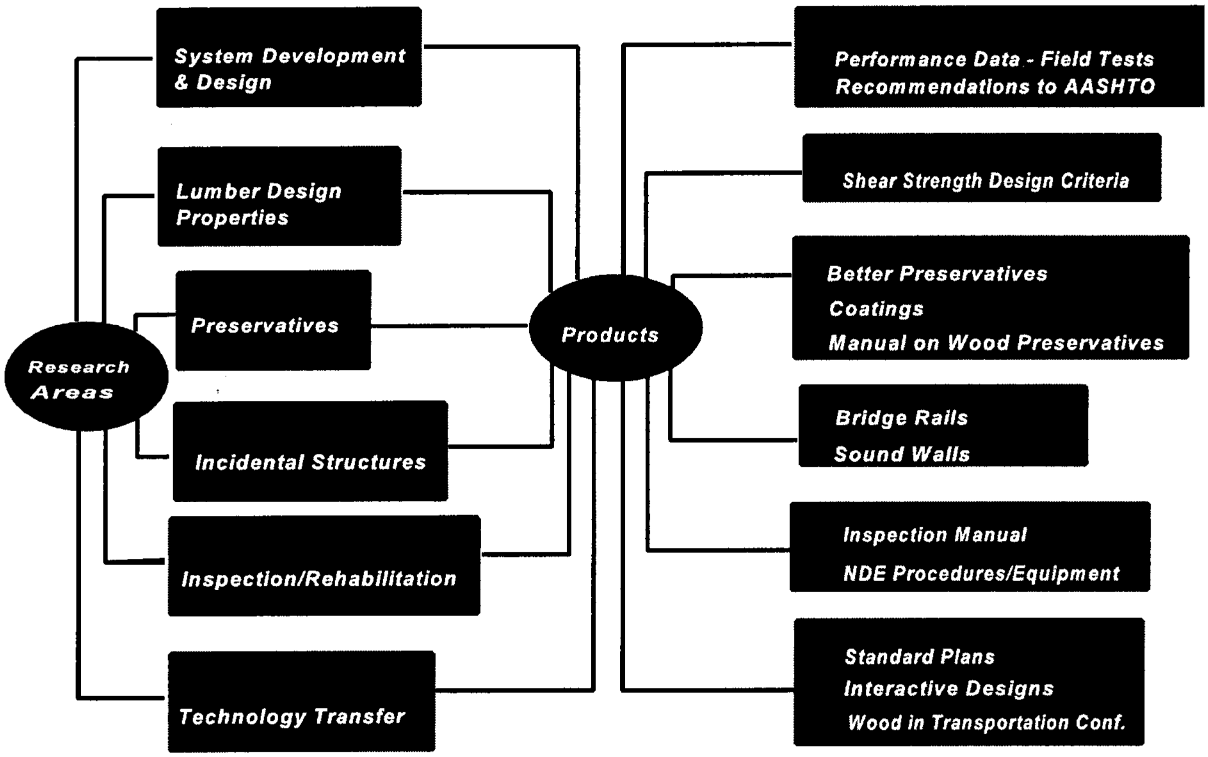

Figure 3-Timber bridge research program highlights.

- Development of sound barriers.
- Development of crash worthy bridge rails -PL2, transverse timber decks.

Area V: Inspection/Rehabilitation-

- In-place evaluation of timber bridges using stress wave technology.
- Equipment and methods for determining the in-place stiffness of stress-laminated timber decks constructed of sawn lumber.
- Guidelines for the design and application of waterproof asphalt wearing surfaces for timber decks.
- Manual for timber inspection - supplement to the Bridge Inspector's Training Manual - 90.
- Development of NDE equipment for inspection of timber bridges.

Area VI: Technology and Information Transfer-

- Meetings toward development of AASHTO Specifications for timber bridge design.
- Standard plans and specifications for timber bridge superstructures.
- Conference on Wood in Transportation Structures - State-of-the-Art.

Figure 3 highlights these research areas and the significant products of the program. Major accomplishments will include: a database on the field performance of timber structures for refining design criteria to update the AASHTO codes; development of crash tested AASHTO/FHWA approved bridge rails for use on transverse, and longitudinal timber deck bridges; standard plans for bridge rails, and for several timber bridge types for use by states, counties, and local authorities; nondestructive evaluation methods and equipment for inspection of timber components; development of better preservatives and coatings, and a manual on wood preservatives; and development of a wood noise barrier for use along the highways.

Demonstration Bridges

Because of the many enhancements that have been made

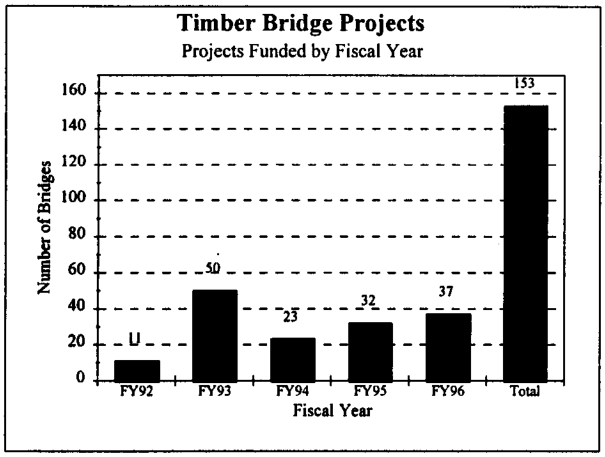

Figure 4—Number of bridges funded by fiscal year.

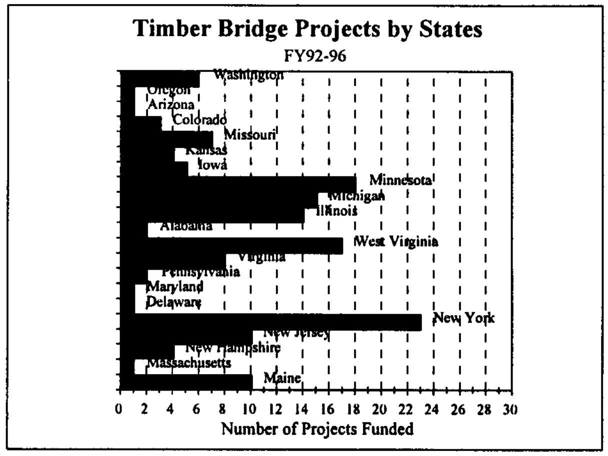

Figure 5—Number of bridges funded by States

over the years in the area of wood treatment and preservation, engineered wood products, and general design provisions the timber bridges constructed today are significantly different than those built centuries ago. Glued-laminated timber (glulam) technology, structural composite lumber, wood reinforced with fiber reinforced composites are all engineered wood products that have made it possible to produce larger members using shorter pieces of lumber, and eliminate strength-reducing characteristics of wood such as knots in sawn lumber. Stress-laminating technology, where sawn lumber laminaes are post-tensioned together to produce a structure that behaves as a unit to distribute the loads has virtually replaced the traditional nail-laminated bridges where problems exist with nails tending to come loose through cyclic loading, and moisture changes.

The majority of bridges being built under the program have been stressed-laminated bridges, dowel laminated bridges, glulam stressed deck bridges, and glulam stringer bridges with transverse glulam deck panels.

Stressed T's and Boxes where the flanges are of sawn lumber and the webs are of glued laminated or laminated veneer lumber are also being built, although there is no AASHTO approved specifications at this time for these bridge types. Few bridges have been built where glulam beams have been reinforced with fiber reinforced plastic composites at the tension flanges.

The number of proposals received at the FHWA Headquarters for funding has varied. In FY1992, FY1993, FY1994, FY1995, and FY1996 around 46, 101, 109, 42, and 54 applications were received, respectively. Of these, grants were given to 34, 45, 27, 36, and 37 projects at the beginning of fiscal years 1992, 1993, 1994, 1995, and 1996, respectively. The Federal share for the 5 years of funding has been $36,991,842. In some cases funding has been returned by the States back to the FHWA. In these cases the funds are carried over to subsequent years. As a result of some States returning funds, and with carry overs to subsequent years, out of the actual number of grants given 11 projects were funded in FY92, 50 projects in FY93, 23 projects in FY94, 32 projects in FY95, and 37 projects in FY96. The number of bridges funded are plotted in Figures 4, and 5 by fiscal year, and by States, respectively.

Conclusion

Awareness of wood as a viable construction material for todays transportation structures has significantly increased in the past few years. This can be attributed to the Timber Bridge Initiative and the ISTEA programs. During the period from 1989 to 1995 approximately 1947 timber bridges were constructed as recorded in the NBI.

As with all materials, the construction of timber bridges is influenced by economical designs and material costs. The ISTEA allows funding for construction of the bridge, approaches, and incidental costs. On application forms many times these costs are combined, and also the actual construction costs may vary. The FHWA does not have a firm data on the actual costs of these bridges at this time. The Forest Service, in monitoring it's demonstration projects, has found that the cost of material varies from region to region depending on the availability of species suitable for bridge construction. The economics depend on the efficiency of design, the availability of a fabricating plant and preservative treatment plant, etc. The two basic trends seen by the

Forest Service are that bridges built in areas of the country where softwood species are produced have a cost advantage over other areas, and species that are readily available as "off-the-shelf items" have a cost advantage over other species (USDA. 1995).

Significant research will have been conducted over the six year period in the area of timber bridges. Some research projects will have direct applications in improving and advancing the timber bridge technology. Projects producing standard designs; crash tested rails; inspection manual; preservatives manual; noise barriers; and a database on the field performance of timber bridges are such studies. Other projects where long term performance is desired to determine its effectiveness such as preservatives, fumigants, and coatings may need further evaluation beyond FY97. Projects involving newer technologies or manufacturing processes may also need further evaluation. Through monitoring of the stressed-laminated bridges, a need to develop alternate stressing systems is being observed. Once developed these systems will need further testing and evaluation. The industry and many universities are conducting research into wood composites where wood is combined with fiber reinforced plastic (FRP) composites to increase member strengths. Performance of these will need to be monitored independently as many of these are proprietary products.

Although timber bridges have been used for hundreds of years, newer technologies are being continuously developed. These need to be adapted and expanded to improve existing systems and develop new systems which allow for efficient use of the material. Wood is one of the traditional materials along with steel, and concrete, that needs enhancements through research. Wood has numerous beneficial properties such as natural damping properties, resistance to deicing chemicals, and it is a renewable resource. Through advances in material science, engineered wood products such as glued-laminated lumber, laminated veneer lumber, parallel strand lumber, and wood reinforced with fiber reinforced plastic (FRP) composites have been developed. Aside from glued-laminated lumber, others are relatively new for bridge applications and need continued research both in the laboratory and in the field through demonstration structures to determine their potential for revitalizing our infrastructure. There are 576,874 bridges in the NBI of which 18% are structurally deficient. Many of these are short span structures suitable for a modern timber bridge.

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