CROSSINGS

NEWSLETTER OF THE WOOD IN TRANSPORTATION PROGRAM

Issue 43 *Winter 2002*

In This Issue

WINNERS OF THE 2002 NATIONAL TIMBER BRIDGE AWARDS PROGRAM

The National Timber Bridge Competition is held annually to recognize those structures that represent the best in timber bridge design and construction. The 2002 Competition has been completed and 15 winners were chosen. The following list identifies the First Place winners for each structure type, as well as Web sites that provide additional information.

Long Span Timber Bridge (Over 40 feet)

Military Road Bridge
Herkimer and Oneida Counties, NY

Related Web links:

- *www.unalam.com/herkimer.htm*
- *www.bartonandloguidice.com/announcements.htm*

Covered Bridge

Embarras River Bridge
Cumberland County, IL

Related Web links:

- *www.preservedwood.com/pod/pod_bridge.html*
- *http://207.63.58.66/hanksbridge.html*
- *www.rr1.net/bridge/History/history.html*

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Winners of the 2002 National Timber Bridge Awards Program . . . *continued from page 1*

Rehabilitation of an Existing Bridge

Tohickon Aqueduct
Point Pleasant, PA

Related Web links:

- *www.fs.fed.us/na/wit/WITPages/tohickon.html*
- *www.galyonlumber.com/example4.htm*
- *www.aewc.umaine.edu/projects/demodetail.asp?locnum=32*

Pedestrian Bridge

Bemis Bridge
Hart's Location, NH

Related Web links:

- *www.hebcivil.com/Bridges.htm*
- *www.geocities.com/nawicnh/achieve.html*

Vehicular Bridge (Less than 40 feet)

Il Poggio Bridge,
Washington, CT

Major sponsors of the 2002 National Timber bridge Awards Program included: APA – The Engineered Wood Association, the American Institute of Timber Construction, the USDA Forest Service, and the Federal Highway Administration. The American Wood Preservers Institute and Roads & Bridges Magazine were supporting sponsors.

A CASE STUDY OF A NATIONAL TIMBER BRIDGE AWARD WINNER: THE TOHICKON AQUEDUCT

On January 15, 2003, the Tohickon Aqueduct was awarded the National Timber Bridge Award for the Rehabilitation of an Existing Bridge for its innovative use of modern timber technology in a 19th Century design.

The Tohickon Aqueduct in Bucks County, Pennsylvania, was rebuilt to carry the historic Delaware Canal more than 220 feet across the Tohickon Creek. The project was completed in June 2001 as a public-private partnership to improve the aesthetics and extend the life of the historical structure that dates back more than 170 years.

Commercial navigation on the Delaware Canal began in 1834 and ceased in 1931 due to a failure in the Tohickon Aqueduct. After World War II the canal was rehabilitated as a Pennsylvania state park, and soon thereafter the Tohickon Aqueduct was rebuilt as a concrete and steel superstructure that remained functional until the early 1980s.

In 1991, a community group set in motion a plan to reconstruct the aqueduct as it was done in the 19th Century, using wood. Between 1992 and 1999, the project advanced through preliminary, pre-final, final engineering and construction documentation as a traditional "timber frame" timber superstructure designed with mortise and tenon joinery to connect solid timber members.

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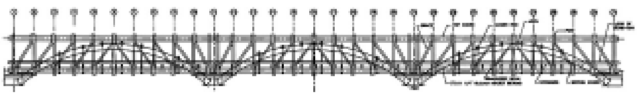
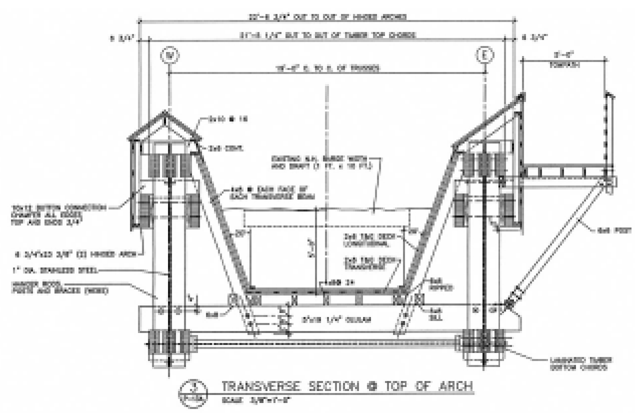
A Burr truss-arch system was employed in the aqueduct's design. It was calculated that the Burr truss-arch system would provide the stiffest traditional timber structure and be more suitable for an aqueduct. The Burr trusses were designed as a redundant system so that the trusses or the arches could carry the loads independently.



The canted trunk post design that is still visible today in the famous Roebling Aqueduct over the Upper Delaware River was re-employed in the Tohickon Aqueduct design. The trapezoid cross section of waterway reduced the design load and the posts served as transverse braces for the trusses. An impermeable liner system was envisioned to hold the water with a wood façade liner to hide and protect the geotextile.



The original superstructure specifications featured several timber species, kiln drying, and treatment processes to meet the particular demands for each member. Protecting structural members from water was paramount in the design. Mechanical detailing was used to create a "covered bridge" design – using the impermeable liner within the trunk waterway to also serve as a "roof" to protect the trusses, arches, and transverse members. Truss roofing caps and siding completed the structural sheathing.

When the bidding concluded in 1999, the lowest bid to construct the timber aqueduct was $3.1 M, surpassing the available budget for the project. The Pennsylvania Department of Conservation and Natural Resources (DCNR) ordered another round of bidding, but this time with two alternates - timber and concrete.

The USDA Forest Service provided financial support to "value engineer" the aqueduct. The goal of the project development partners was to remove uncertainties for potential bidders that might attribute to higher bid prices, and to target a reduction of costs by $.5M from the original $3.1 M low bid. Areas were identified where the timber construction could be simplified, while still retaining the traditional Burr truss "form" as the character-defining feature of the timber aqueduct. The specifications and details were value-engineered as follows:

- All timber framing labor qualifications were eliminated.
- All traditional handcrafted mortise and tenon joinery (including lightning bolt splices) were eliminated and replaced with steel fasteners.
- Solid timbers were eliminated and replaced with glued-laminated (glulam) materials for major members. (This was extremely effective for the shouldered truss posts to eliminate the problems of material supply and cross-section tolerances.)
- Multiple species were eliminated and southern pine was specified.
- Arches were redesigned as glulam members (Shear blocks, stitch bolts, dual species, and special treatment of the bearing laminations were eliminated.)
- Pentachlorophenol (Penta) wood preservative was specified as the preservative treatment for all glulam members. (Except for the arches that were too large to treat after fabrication, so a Penta type C was used - which is a penta in light petroleum solvent instead of oil - that allows gluing after treatment.)
- The Park did not want creosote treatment in the structure, so bearing sills and sleepers were treated with CCA.
- The half-lap joints at the interfaces of the arches and trusses were eliminated.
- The different span lengths between existing foundations were made similar by re-engineering the concrete caps on the pier tops. Forming and placing the concrete thrust pads

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The Tohickon Aqueduct . . . *continued from page 3*

after the arches were suspended in place accommodated the remaining differences.

- The continuous 3-span truss of the original design was replaced by three separate and identical span trusses (to simplify fabrication.)

- The primary suspension rods and transverse rods remained stainless steel, but some stainless steel hardware items were replaced with galvanized steel. The Park requested that the decking hardware remain as stainless steel as a remedy to the local acid rain.

- Contractors were permitted to submit shop drawings for the superstructure and fasteners.

In the next round of bidding, the low bid for the timber aqueduct had been reduced by approximately $1M, down to $2.1M. Given that this bid was competitive with the concrete alternative, the State chose to reconstruct the aqueduct from wood.

At this stage of the project, the USDA Forest Service proposed to financially support the inclusion of fiber-reinforced polymer (FRP) in the aqueduct's construction. It has been shown in laboratory studies that applying FRP to the underside of a beam as tensile reinforcement can increase a beam's strength by as much as 100 percent (Dagher et al., 1998). The use of FRP-glulam beams in the aqueduct would offer an opportunity to further study this topic, and would provide valuable data on the performance of these members under realistic service loads in an uncontrolled environment. With laboratory studies also showing that the addition of FRP reinforcement to glulam beams has little effect on relative creep (Breton and Dagher, 1999), the opportunity to instrument and monitor FRP-glulam beams and non-reinforced beams allowed for a comparison of in-service loads to a laboratory setting.

Negotiations between the State and the project partners found a compromise solution that would include FRP-glulam specifications in the construction documents. FRP-glulams could be used for transverse beams, provided that they were sized to bear the full load without FRP reinforcement. This opened the possibility to monitor FRP-glulam performance in the Tohickon Aqueduct.

Twenty-four transverse beams and six floor beams were reinforced with FRP. The traverse beams were used in the construction of one span of the aqueduct and the floor beams were used for laboratory testing.

When the aqueduct was completed, instrumentation was attached to eight of the FRP-glulam beams and eight of the non-reinforced glulams to measure beam deflection under sustained load over time.

Daily readings continued for 2 weeks, and then were slowly spaced out throughout the year from twice a week to once a week to finally once a month. This schedule was decided upon based on a study by Breton and Dagher (1999), which found that the majority of creep deflection occurred within the first weeks of the testing. The data will be analyzed to determine the amount of creep that occurred, both for the reinforced and non-reinforced beams. The data will then be used to confirm Breton and Dagher's (1999) laboratory study on creep in FRP-glulam beams, which found that the relative creep in glulam beams does not change with the addition of FRP.

Conclusions

The reconstruction of the Tohickon Aqueduct combined the nostalgic dreams of a community's history with the economic realities of building modern timber structure. In addition, it showcases the possibilities to combine traditional construction methods with modern forest products technology.

As a demonstration structure, it provides a real world laboratory for future timber technology. The data collected from the creep study will give further insight on the effects of FRP on glulam members. At this time, there is not sufficient data to provide any meaningful

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results, but the data collected to date has been in close agreement with the expected elastic deflections.

For more information on the Tohickon Aqueduct go to the WIT Web page *www.fs.fed.us/na/wit/WITPages/tohickon.html.*

This article was adapted for publication in *Crossings* by Jeffery Bejune, of the National Wood In Transportation Program, USDA Forest Service, from a paper originally published and presented at the Second International Conference of Advanced Engineered Wood Composites in Bethel, Maine on August 14-16, 2001 with permission from University of Maine AWECC. The authors of the original article were:

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Literature Cited

Breton, J.M. and H.J. Dagher. 1999. Creep Behavior of FRP-Reinforced Douglas Fir and Western Hemlock Glulam Beams. University of Maine Research Report Number AEWC 99-9, May.

Dagher, H.J.; B. Abdel-Magid; R.F. Lindyberg; J. Poulin; and S.M. Shaler. 1998. Test Results: Douglas Fir and Western Hemlock FRP-Reinforced Glulam Beams. Advanced Engineered Wood Composites Center Report no. 98-4. Orono: University of Maine.

THE WOOD IN TRANSPORTATION PROGRAM BUDGET FOR FISCAL YEAR 2003

The federal fiscal year 2003 Wood In Transportation budget is $1 million, a reduction of $900,000 from fiscal year 2002. Even though our budget is reduced, we are continuing to focus on three critical objectives. They are:

1. Commercialization of modern timber bridge technology,

2. Innovation that leads to:

   √ Cost saving strategies,
   √ Improving the performance of exiting designs.

3. Improving customer services through the program's Web site.

THE NATIONAL LIBRARY

Charged with improving the availability of transportation-related information needed by federal, state, and local decision-makers, the National Transportation Library's (NTL) mission is to increase timely access to the information that supports transportation policy, research, operations, and technology transfer activities. The NTL was established in 1998 through the Transportation Equity Act for the 21st Century and serves as a repository of materials from public, academic and private organizations.

The National Transportation Library is administered by the Bureau of Transportation Statistics in cooperation with its federal, state, and local partners. The Web site address is: *http://ntl.bts.gov/about_ntl.html.*

NEW PUBLICATIONS

Effects of Water Flow Rate and Temperature on Leaching From Creosote-Treated Wood

Creosote has a long history of use as a preservative, particularly in industrial wood products. However, its use has come under increasing scrutiny as a result of concerns about potential effects on aquatic and terrestrial non-target organisms. Despite the long use of creosote, there is relatively little data on the rates of creosote loss in many exposures, including aquatic applications. To address this concern, the Federal Highway Administration has funded a series of studies to evaluate the environmental impact of creosote-treated wood used in timber bridges. In the study reported here,the leaching of creosote from rough sawn Douglas-fir lumber under simulated river flow conditions was investigated. Treated wood samples were contained in a metal tank, and deionized water passed through the box at three determined flow rates and temperatures. The water was periodically sampled for the concentration of five major creosote components. The leach rates were highly variable, but in general they tended to increase with both flow rate and temperature. The possible onset of turbulent flow in the tank may have been responsible for the high leach rates observed at high flow rates. In general, the rates of leaching determined in this study were greater than previously reported for creosote-treated piling. Longer exposures may be needed to better predict creosote release rates during of in-service use.

To obtain a copy, please contact the National Wood In Transportation Information Center at 304-285-1591 and request publication number WIT-05-0030, or visit the Wood In Transportation Web site at *www.fs.fed.us/na/wit*; and search for the publication under the "Publications" button.

Cold Temperature Effects on Stress-Laminated Timber Bridges

Stress-laminated bridges perform well if adequate bar force is maintained to provide the interlaminar friction and load transfer between adjacent deck laminations. Stress-laminated decks are made of both wood and steel components; therefore, different material thermal properties may cause bar force to change as the temperature changes. In response to concerns about the performance of stress-laminated bridges in extremely cold climates, a cooperative research project between the University of Minnesota, the USDA Forest Service Forest Products Laboratory, and the Federal Highway Administration was initiated to evaluate system performance at temperatures ranging from 21.1°C to –34.4°C. Stress laminated bridge deck sections, constructed of red pine lumber and high-strength steel truss bars, were placed in cold temperature settings of –12.2°C, -17.8°C, -23.3°C, -28.9°C, and –34.4°C, while bar force measurements were collected. Testing was completed at three different moisture contents:>30%, 17%, and 7%. At –34.4°C, bar force losses were high when the deck moisture content was above fiber saturation and were moderate to low when the moisture content was below 18%. In all cases, bar force loss was fully recovered after temperatures rose to 21.1°C.

To obtain a copy, please contact the National Wood In Transportation Information Center at 304-285-1591 and request publication number WIT-06-0043, or visit the Wood In Transportation Web site at *www.fs.fed.us/na/wit*; and search for the publication under the "Publications" button.

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