The Tale of Two Bridges and a Bean

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Iowa farmers raise a lot of corn, soybeans, and hogs. The fertile soil of Iowa also grows trees and nourishes ideas. Ideas for tapping the abundant soybean crop and the abundant underutilized tree species have resulted in wise use of both agricultural and wood resources for structures that are particularly attuned to regional transportation needs.

Farming country throughout the Nation depends on a transportation infrastructure to get materials to the land and produce to market. Many of the farm-to-market roads require bridges across streams and irrigation ditches. Usually the crossings are short, no more than 20 to 50 feet, and a bridge may be as wide as the crossing to accommodate oversized farm equipment.

Figures 4 and 5. *Typical bridges on farm-to-market roads in North Dakota that need to be replaced.*

One goal of the Forest Service is to promote the use of underutilized wood species. The Wood in Transportation grant program (WIT), which is funded through State and Private Forestry (S&PF), encourages the use of underutilized species in transportation structures. Cottonwood is a common underutilized species found in Iowa and in other States. While somewhat weak structurally, it treats well with oil-based preservatives. To promote cottonwood as a bridge-building material, WIT funded five cottonwood panel bridges in Iowa.

One bridge design featured an all-wood superstructure of cottonwood and southern yellow pine for the glulaminated (glulam) stringers with cottonwood panel decking. A second design incorporated recycled steel stringers with cottonwood panel decking. Designers specified a creosote treatment for all wood used in the structures. Bridges employed either guardrails or wheel guards based on the bridge width and on the type of vehicles that would be crossing the bridge. To accommodate oversized farm equipment, designers paired a low wheel guard with "knockover" warning panels (panels that return to a vertical position).

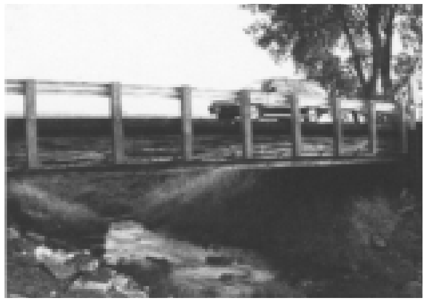 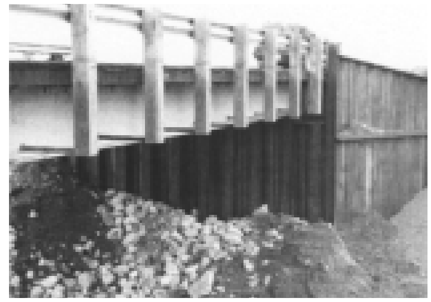

Figure 6 (left). *Panel deck with wood beam design.*
Figure 7 (right). *Panel deck with recycled steel girder design and sheet pile abutment.*

Bridge designs specify crib walls of either concrete, only for pre-existing abutments in good condition, or sheet pile steel. For the steel crib walls, the beams were placed on "H" piles. The crew placed sheet pile steel on the edge of the end panels to keep dirt from flowing over the crib wall. By using steel, a county crew can quickly remove and replace the bridge without waiting for concrete to harden. After installing the deck, the crew applied a rubber membrane and 3 inches of asphalt pavement. To replace a bridge using cottonwood panels took 2 to 3 days.

Designers specified full-dimension 2 by 8, 4-foot wide, 26-foot long kiln-dried wood lumber. Decking was placed on edge and glued into 4-foot wide, 8-inch deep and 26-foot long panels and coated with a creosote preservative. These panel dimensions were chosen for two reasons. First, to allow multiple panels to be treated at one time with the preservative in the treatment pressure vessels. Second, to truck multiple panels side-by-side and maximize space on highway legal transport vehicles.

Builders constructed southern pine and cottonwood wood glulam beams--six pine outside boards on the top and bottom of the beams with a cottonwood middle portion of the beam. They used full-dimension 2 by 8s for beams with a slight camber and treated with creosote. Final beam dimensions were 8 inches wide, 4 feet deep, and the length of the the bridge.

 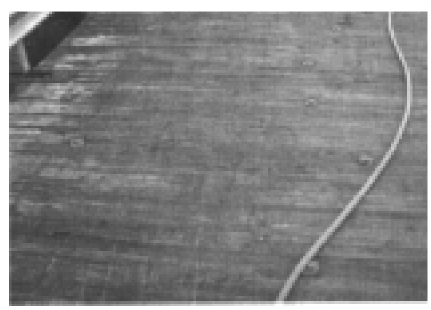

Figure 8 (left). *End view of deck panel attached to steel girder with clips.*
Figure 9 (right). *Bridge deck showing lag bolt attachment.*

The crew drilled and lagged the deck panels to the wooden beams, using friction as the only restraint at the edge where the panels meet. On the steel girder bridges, the crew drilled and attached the deck to the girders with steel clips made from mohr board that had a bolt welded on to go through the wood deck panel with a nut and washer attachment. Workers treated all drilled holes with creosote.

The crew attached guardrails or wheel guards, placed the deck, and glued an impermeable membrane to it. A 3-inch bed of asphalt coated the membrane for a running surface.

Figure 10 (left). *Bridge deck with moisture barrier being placed.*

Figure 11 (right). *Finished bridge with asphalt running surface, guardrails, and knockdown warning signs.*

To provide for efficient use of crew time, the cottonwood bridge deck panels can be ordered and stockpiled before any scheduled construction. The weight of the panels is light enough for a single crane to lift and place them.

All bridges were designed for an HS-20 loading. Design software and instructions for the cottonwood bridges are available from the Forest Products Laboratory. Contact Lola Hislop at 505-572-4505, or by e-mail at lhislop@fs.fed.us. Contact Ed Tice, Ida County engineer, in Ida Grove, IA, at 712-364-2920 for the details and costs for each bridge. A summary of bridge costs and design specifications are also available on the WIT Web site http://wit.fsl.wvnet.edu. The WIT Web site has articles about the use of wood in transportation structures, bridge design plans, and costs.

Another goal of the Forest Service is to promote the use of small-diameter wood. A light prestressed segmented arch (LPSA) design, which employs small-diameter wood, and was used in the recycled steel stringer bridge mentioned previously, is also suitable for many other structures. The pedestrial bridge shown in the photographs uses round wood members, steel connectors, and cables for tensioning the structure. The bridge can be erected rapidly, even at remote sites, because of its simplicity of design and construction. Untreated wood found onsite can be used, if it is debarked. The bridge parts, which may consist only of connectors and cable, can be transported easily to the site by all-terrain vehicles (ATV), by animal, or by helicopter.

This LPSA bridge design uses the wood members in compression and a cable to establish tension for the whole structure. The round wood members have better strength qualities than rectangular members of equal size because the structure and stresses of the round wood are unchanged. The structure consists of small-diameter, short wood members, which eliminates the slenderness factor. The calculations are identical with those used for short columns. In fact, round post material from the local lumberyard or fence supplier works well in these structures.

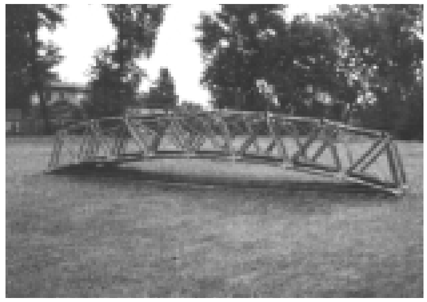

Figure 12 (left). *Side view of LPSA bridge with 35 foot span.*

Figure 13 (right). *End view of bridge.*

The structure shown is an arched truss, 35 feet long with a 4-foot wide deck. It appears to be a combination of a "warren" truss and a "three-hinged arch" without the middle hinge, comprised of interlocking equilateral triangles with a cable tensioning chord. The 222 wood members (posts) of the bridge, which are approximately 2.5 inches in diameter by 4.5 feet in length, are primarily hybrid-polar from a thinned riparian buffer with some additional black walnut poles. The deck is made from 1/2 by 6 inch white oak nailed to deck poles. The bridge is designed to handle a uniformly placed total load of more than 1,500 pounds.

The critical construction elements of an LPSA structure are (1) square ends on the members and (2) a firm, but not tight, fit in the connectors. Therefore, each wood member must have the ends sized to the diameter of the metal connector, which can be done with a handtool onsite or with automated equipment in a processing plant.

The bridge can sit on wood sills or on the ground and can be tied down using any Forest Service standard anchoring methods. Bridge erection is a simple process that can be done from one end of the structure because of the poles' firm fit into the connectors. The structure will support itself and a small erection crew before it is tensioned with the steel cable. The steel cable conforms to American Society for Testing and Materials (ASTM) A-416 standard 7-wire, low-relaxation strand, 270,000 pounds per square inch (psi). The cable is available in 1/4 to 1/2 inch diameters. It is identical to the cable used in construction pretensioned concrete beams, which has little stretch or relaxation once it has been tensioned.

The LPSA technology is partly funded through a grant from S&PF and is in the business incubator program at the University of Iowa. The University of Northern Iowa Recycling and Reuse Technology Transfer Center funded further development of the LPSA technology. See their Web site for ongoing projects at www.rrttc.uni.edu.

The innovation and bridge design were done by Dr. Ibrahim Al-Khattat of Sustainable Science International, which is located on the Oakdale Research Campus, University of Iowa. The LPSA design won the British Design Council's National Business Invention Award in the Toshiba Year of Invention competition and the Merit Award from the British Farm and Rural Buildings Center. Contact Dr. Khattat at 319-335-4505, or by e-mail at ssi@avalon.net. The Web site for this information is www.avalon.net/˜ssi.

Two bridges and a bean? What can a bean have to do with wooden bridges? Now it is time to focus on the combination of wood and agricultural products. Perhaps agricultural products show up in several places, or they could be urban or industrial products. The cottonwood and hybrid poplar came from farm land riparian buffers. The black walnut came either from thinning a farm woodlot or from tree trimming in town.

Can we enhance our bridge by using an agricultural product like soybeans? It might take a lot of glue to make them into a bridge, but what about making them into a wood preservative to make the bridge last longer? We do not have to stretch our minds too far on this; just to Louisiana State University where John Lu and Quinglin Wu combined soy protein with copper to produce a low-toxicity wood preservative They say that the soy protein wood preservative is less costly and has less environmental impact than other preservatives.

The soy wood preservative is being tested on an LPSA bridge that uses eight to ten different species of wood in the construction. Most of the bridge is constructed with hardwood from the South and includes some lodgepole pine from Idaho. The LPSA bridge will be built with a treated and an untreated side so that each species of wood can be compared, treated and untreated, side by side.

As we look at more uses for underutilized wood species and small-diameter wood, remember these two bridges and a bean. Thinking out of the box and expanding our horizons allows us to do more with our underutilized resources. As forest and grassland managers, we have long complained about the weed trees and small wood that remain after management projects are completed.

We've described two uses for small and underutilized wood and a potential, environmentally friendly wood preservative. How many other ideas can help transform our agricultural and wood resources into improved forest products?