Engineered Wood Products for Transportation Structures-An Overview of the Obstacles and Opportunities

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Abstract

The opportunities for engineered wood products in the transportation field are numerous. Innovative bridges, geotechnical structures, poles, and sight/sound barriers are some of the existing opportunities. In all probability, more opportunities will emerge in the future as engineered wood products become more versatile and durable. Unfortunately, some very real obstacles exist as well. Engineer's perception of wood as a second-class material, poorly executed designs and construction, and intense competition are only a few of the obstacles facing the industry. A workshop of industry, government and research experts from the field of engineered wood products was held in Morgantown, West Virginia in December 1994 to discuss the opportunities and obstacles facing the industry. The record created from the workshop provides the basis for this paper.

Keywords: Engineered wood products, bridges, transportation structures

Background

The use of wood for transportation structures is as old as human history. Certainly our first bridges were logs felled across streams. Readily available throughout most of the world and easily worked, wood has served mankind well for thousands of years.

In 18th and early 19th century America, our rural economy was heavily dependent on wood for fuel, building, furniture, machinery, and probably thousands of other uses. Even then transportation was an essential portion of the economy, and wood was the material of choice for most transportation structures. Some of our early wood bridges still stand today as a testament to the durability and strength of wood structures when designed and protected well. Later in our country's history, railroads were the dominant force in the economy- wood products such as crossties, poles, and bridge timbers allowed the railroads to transport heavy loads economically and quickly across the country.

The development of cast iron, steel, and eventually prestressed concrete in the late 19th and 20th centuries made wood products less desirable for some transportation structures. In particular, bridges built of these new materials were longer, stronger, and more durable than traditional wood bridges. In only a few decades the dominance of these newer materials was virtually complete. Not only was the use of wood for transportation structures decreased, but the skills required to use wood effectively diminished also. Engineers and constructors were trained to work primarily with concrete and steel and the few wood bridges that were built were often of poor design and quality.

Many less visible markets for wood products in the transportation field were retained, however. Wood railroad crossties were made much more durable with the development of preservative treating techniques. Poles for the transport of electrical power and communication lines sprung up in every comer of the country. Timber piles continue to be used extensively for the support of bridge abutments and piers. Formwork and falsework are necessary for the construction of almost all transportation structures and use large quantities of wood products.

A Renaissance of Wood?

With concrete, steel and a variety of structural plastic materials now available for the construction of transportation structures, why would today's engineers choose wood? The answer is in both the old and the "new" properties of wood. Wood, as always, is light-weight, strong, and easily worked-properties which attract an engineer's attention. Wood also is in plentiful supply and is likely to remain so. Our forests are remarkably resilient and, despite public opinion to the contrary, "forest growth nationally has exceeded harvest by 37% and the volume of forest growth was 350% greater than it had been in 1920". (MacCleery, 1995) The "new" properties of wood are a result of years of technological advances to meet market needs. Newly developed wood-based composites and engineered wood products have strength, stiffness, durability, and reliability properties vastly superior to their sawn-lumber ancestors. The engineer's choice of materials is no longer as clear-cut as it once was.

The Workshops

In an attempt to expedite the use of new wood products engineered specifically for transportation structures, a workshop for interested engineers, manufacturers, researchers, and policy-makers was sponsored by the USDA Forest Service, State and Private Forestry. The Constructed Facilities Center of West Virginia University administered and hosted the *Engineered Wood for Transportation Workshop* in December, 1994. Workshop participants formed several working groups and were asked to generate lists of opportunities for and obstacles to the use of engineered wood for various types of transportation structures. The discussions of that meeting were recorded to generate a document, the *Engineered Wood for Transportation Structures Workshop Record* (CFC, 1996). In order to organize the experts into productive groups for discussion, the meeting was divided into ten workshops. Each workshop was assigned a topic and the experts were assigned to the workshops where their expertise would be most useful. On the first day of the meeting, workshops were held to discuss the opportunities for and obstacles facing engineered wood in five applications-bridge superstructures; guide rails, posts and poles; noise/sight barriers and formwork/falsework; retaining walls, piles, culverts, and drop inlets; and repair and rehabilitation. On the second day, the experts were asked to form five different groups and confine their discussions to the issues related to material characterization; evaluation and design; construction; marketing and technology transfer: and environmental concerns.

Each of the workshops' leaders maintained a record of the group discussions and made a brief presentation to the entire meeting to summarize the groups' findings. The following is a synopsis of the group leaders' presentations.

Workshop 1- Bridge Superstructures

Opportunities for the expansion of engineered wood are abundant in the area of bridges. The USDA Forest service's Timber Bridge Initiative and the Intermodal Surface Transportation Efficiency Act of 1991 have allowed several states to test the newest wood bridge types. Innovative designs have been given opportunities that they otherwise might never have had. The performance of the new bridges has been mixed - some of the new wood bridges are performing well and are reasonably cost-competitive, but others are not. The TBI has had a sufficient life-span to revise and improve many of the original innovative designs. However, in order for this potentially large market to be fully realized, the quality will have to be more consistent and the costs more competitive.

Other opportunities for the expanded use of engineered wood for bridges include:

- Newly developed engineered wood materials which have improved structural performance may be well-suited to bridge construction
- Improved prefabrication methods for wood bridge components have the potential to reduce costs
- The public retains a preference for wood structures in specific settings
- Stress-laminated ballasted deck bridges for railroad trestle bridges

Obstacles limiting the expanded use of engineered wood for bridges include:

- A history of poorly engineered wood bridges which

has reduced many engineer's confidence in wood
- Environmental concerns resulting from improper creosote treatment
- Lack of comprehensive inspection methods and accurate inspection devices
- Well-established competition from other materials

Workshop 2- Guide Rails, Posts, and Poles

The best properties of wood have long been utilized for posts and poles and, more recently, for guide rail components. These properties include high strength and energy absorbing characteristics. The greatest opportunities for expansion of the market for guide rails, posts, and poles exist in the timber producing areas where costs would be most competitive with other materials. The expanding number of "Greenways" (environmentally sensitive highways) also should be a natural market for engineered wood guide rails, posts and poles.

Other opportunities for guide rails, posts, and poles include:
- Composite posts and poles which combine wood and plastics
- New wood bridge rail designs that have been crash-tested and are now available for general use

Some of the obstacles cited to expanded use of engineered wood for guide rails, posts, and poles include:
- A lack of consistent design guides and design details (such as steel rail to wood rail transitions)
- The large size of wood posts requires larger equipment to drive posts than is required for competing materials
- A history of widely fluctuating prices for wood posts and poles

Workshop 3 & 6- Noise/Sight Barriers and Formwork/Falsework

Potentially large markets exist for wood visual and acoustic highway screens. Recycled materials, combined with wood products, could be used for many of the components which form noise and sight barriers. The formwork/falsework field is currently the largest application area of engineered wood in the transportation market. The newly adopted LRFD code for formwork and falsework will bring the design process to modem standards and could increase the use of engineered wood products for this application.

Other opportunities for noise/sight barriers and formwork/falsework include:
- New wood-based composite materials like cement bonded wood
- "Permanently" marked form materials that can be re-used more often than current products
- Recently completed FHWA publications for construction and design of bridge temporary works

Some of the obstacles cited to expanded use of noise/sight barriers and formwork/falsework include:
- A history of poorly designed noise and sight barriers has reduced engineers confidence in wood
- Proprietary forming and falsework systems which have inconsistent design methods

Workshop 4 Retaining Walls, Piles, Culverts, and Drop Inlets

The need for improved preservative methods and consistent quality products were cited as the major obstacles to expanded use of engineered wood for retaining walls, piles, culverts, and drop inlets (or other wood-based geotechnical structures). Opportunities of which the industry could take advantage are in the areas where the properties of wood, such as its non-corrosive nature, exceed those of competing materials. An engineered wood culvert used in highly acidic streams is one example.

Other opportunities for the expanded use of engineered wood for geotechnical structures include:
- Innovative prefabrication techniques resulting from the Timber Bridge Initiative which could decease first costs and reduce construction time
- New wood-based composites are becoming available which may increase the durability of geotechnical wood structures which must survive in very harsh environment

Some of the obstacles cited which limit the use of geotechnical structures include:
- The lack of standard plans
- The difficulty of constructing durable connections and the cost of durable connections
- The perception that wood products cannot be made to be durable in harsh environments

Workshop 5 Repair and Rehabilitation

The basic challenge facing engineers whose responsibility includes repair and rehabilitation of highway structures is to convert the connotation of repair and rehabilitation from the negative to the positive.

Opportunities for repair and rehabilitation using engineered wood include:

- Hardwood structural glued-laminated wood panels have been tested for bridge deck applications and design guides are now available.
- Repair of transportation structures using wood and plastic composites

Some of the obstacles cited which have limited the expanded use of engineered wood for repair and rehabilitation include:

- Connecting wood or wood-based composites to other materials for repair is often difficult
- Very little design information or standard planning is available

Workshop A- Material Characterization

An accurate and consistent characterization of wood and wood-based composites and the components made of wood or wood based-composites is essential to the expansion of wood markets. The combination of engineered wood with other materials such as fiber reinforced plastics (FRP's) may produce a material possessing exceptionally useful properties. The low cost, light weight, and availability of wood combined with high strength and reliable properties of FRP could be applied to numerous highway structural applications.

Opportunities for expanded use of engineered wood based on advances made in material characterization include:

- In-grade testing of various species and sizes of wood may add material choices for engineers
- Recent advances made to machine stress-rating and stress wave grading techniques should provide more efficient use of wood resources
- More accurate design values for many hardwood species are now available
- Developments made in engineered wood for larger markets (such as housing) can often be converted to applications in transportation

Some of the obstacles which limit the use of engineered wood include:

- The continued difficulty of defining long-term durability and structural performance of wood products
- Inherent properties of wood such as dimensional instability related to moisture changes

Workshop B- Evaluation, Analysis, and Design

Although timber design has kept pace with the advances made by other materials, the need for continued design and evaluation improvements was seen by the workshop group as essential to expanded use of engineered wood. Specifically, the group noted the need for "proof loading" methods to evaluate wood structures, new non-destructive inspection methods, expanded education of engineers, and development of standardized plans for engineered wood products.

Opportunities for expanded use of engineered wood based on advances made in evaluation, analysis and design include:

- Recently completed standard plans for stress-laminated bridges and hardwood glued laminated bridges
- New design specifications in the American Association of State Highway and Transportation Officials *Standard Specifications for Highway Bridges* for stress-laminated wood bridges
- The recent completion of several FHWA crash-tests for wood rail systems

Some of the obstacles related to evaluation, analysis and design which have limited the expanded use of engineered wood for transportation include:

- The lack of standard plans for pedestrian bridges
- The need for more empirical data on the energy adsorbing characteristics of wood so that this feature can be used more advantageously
- The need for more accurate inspection methods which will allow more precise evaluation of in-service wood structures

Workshop C- Construction

Because wood is a light-weight and relatively inexpensive material and most construction crews are familiar with it, the use of wood as a highway structures material is generally accepted. The major obstacle facing the expanded use of engineered wood is the lack of industry-wide quality control standards. The inherent variability of wood quality makes the need for quality control even more necessary for wood products than for other materials.

Opportunities for expanded use of engineered wood based on advances made in construction include:

- Recent innovations in the prefabrication of wood structures as a result of the Timber Bridge Initiative and the ISTEA of 1991
- Many new engineered wood products are now available which reduce construction time and which are of higher quality than traditional sawn lumber

Some of the construction-related obstacles which limit the use of engineered wood include:

- The lack of contractors with experience in heavy timber construction
- The lack of training aids for constructors specifically for wood transportation structures

Workshop D and E- Economics, Marketing and Technology Transfer

Marketing efforts for engineered wood products exist for many applications. Engineered wood products such as bridges, noise/sight barriers and formwork are already commonplace but could be expanded. A marketing strategy for these and other engineered wood products should be based on a unified approach. Achieving a unified marketing strategy will require a unification of the industry-something that has been impossible to accomplish thus far.

Opportunities for expanded use of engineered wood based on advances made in marketing and technology transfer include:

- Establishment of the USDA Forest Service's National Timber Bridge Information Resource Center
- Studies of current market conditions for wood bridges are now available
- Large increase in the amount of technical support information available

Some of the obstacles which limit the use of engineered wood include:

- The lack of consistent wood terminology hampers clear communication of technical information
- The belief on the part of many engineers in the "second-class" nature of wood for structural applications

Workshop F-Environmental

Like the repair and rehabilitation group, the environmental group found that the most pressing challenge was to change the perception that preservative treated wood products are an environmental liability. Providing preservative treated wood products users as well as the general public with the facts about wood preservatives should be the highest priority for the engineered wood products industry.

Opportunities for expanded use of engineered wood based on advances made environmental include:

- The perception of wood as an "environmentally friendly" material can be used advantageously to promote wood
- Wood has the potential to be re-used or recycled after its original service life

Some of the environmental and recycling obstacles which limit the use of engineered wood include:

- Poor quality designs and specifications for wood structures have frequently led to environmental problems and diminished engineer's confidence
- Composites manufactured of wood and other materials may be more difficult to recycle than conventional wood products

The Next Step

Either explicitly or implicitly, each of the groups recognized the need for actions to be taken to take advantage of opportunities available or to eliminate obstacles. The need for actions requires another step in the process begun by this meeting. At the nearly-unanimous suggestion of the experts, a strategic planning committee comprised of 15 to 20 key persons in the engineered wood community was formed. The strategic planning committee will has as its mission the task of developing an action plan to implement the resolutions of the expert group.

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