

USE AND PRODUCTION OF SOLID SAWN TIMBERS IN THE UNITED STATES

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ABSTRACT

Although timber production has grown steadily over the last decade, information about the use of timbers and the corresponding resource remains in short supply. This study adds to the available literature on solid sawn timbers by compiling data on timber production and uses. The major categories of solid sawn timbers researched were railroad ties, timber bridges, and other transportation structures. The outlook seems relatively bright for railroad ties. The demand for wood railroad ties has grown with the railroad industry, and there is no reason to think that this demand will not continue to grow for many decades to come. Of all uses of solid sawn timbers, timber bridges have the least promising outlook. Steel and concrete are the major materials used by the bridge industry. Other markets for solid sawn timbers are smaller than that for railroad ties, and timbers in these markets will also face competition from other materials. The research reported here helps quantify an important segment of the wood products industry in the U.S. economy.

Timber production has grown steadily over the last 15 to 20 years. The greatest increases have occurred in the Northeast and the South (12). In this paper, solid sawn timber refers to lumber 2 4 inches (≥ 102 mm) in width and thickness, as defined by the Western Wood Products Association (31) and the Southern Forest Products Association (23). The large size of solid sawn timbers adds to the cost of kiln-drying; therefore, some solid sawn timbers are surfaced and sold green. On the other hand, the large size improves the tire resistance of solid sawn timbers compared to that of dimension lumber.

Solid sawn timbers are available in three structural grades (Select Structural, No. 1, and No. 2) and two nonstructural

grades (Standard and Utility) (24). The grades are determined by natural wood characteristics, such as location of knots, slope of grain, checks, wane, warp, and manufacturing defects.

Information is available on the production of southern pine solid sawn timbers, but there is little information on the production of hardwood and other softwood solid sawn timbers in the United States. The results of a survey of hardwood solid sawn timbers in the eastern

United States conducted by West Virginia University suggest growth in production and marketing options for hardwood manufacturers (11).

At present, solid sawn timbers are primarily used for railroad ties and various transportation structures: bridges, sound barriers, guardrails, and signposts. Wood crossties have had a distinguished history and face a productive future (14). The Railway Tie Association is planning surveys of the industry, which promise to add information about the future production and use of crossties. Little information was found on transportation structures other than bridges and railroad ties, but the continued construction of highways suggests that products made from solid sawn timbers may have a place in the market. For example, the growing demand for highway sound barriers indicates a potential growth area.

The information presented here is critical to efforts by the forest products industry to improve the use of solid sawn timbers and to identify markets for this resource.

OBJECTIVES

The objectives of this research were as follows:

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1. To provide information on major uses of solid sawn timbers, wood species used, and competing products;

2. To describe the volume production of hardwood and softwood solid sawn timbers in the United States;

3. To provide an outlook for major markets for solid sawn timbers.

We examined the total amount of solid sawn timbers being used in the United States. Data were collected on the uses of solid sawn timber and total volume of timber being used for the production of railroad ties, timber bridges, and other transportation structures.

METHODOLOGY

This study was conducted in three stages: 1) determination of differences between lumber and timber products; 2) collection of data on different types of timber products; and 3) organization of data by major type of timber product, application, and production rate.

Information on timber product manufacture and use, specifically for railroad ties, bridges, and other transportation structures, was collected through a literature search. Information was also gathered through interviews of Forest Service employees, forest products industry employees, university professors, independent researchers, and government agencies. These specialists were interviewed in person or by telephone. Data were also sought from such sources as the Internet, technical journals, and other publications.

RAILROAD TIES

Wood is still considered the material of choice for railroad ties. Of the millions of railroad ties currently being used in U.S. railroad systems, 94 percent are made of wood (22). The average number of wood railroad ties in each section of track has increased by 20 or more ties since 1924. Wood railroad ties are used for 171,098 miles (275,468 km) of railroad track (17). The railroad industry replaces approximately 2 percent of all ties in a given year (16).

WOOD SPECIES

The wood species most commonly used for railroad ties are ash, beech, oak, pine, Douglas-fir, and maple. The most commonly used hardwood and softwood species are oak and pine, respectively. The species used to make railroad ties depends on the geographical location of the railroad track, which in turn depends on climate. For example, pine is commonly used in the southern United States because it is readily available there. The species used for railroad ties are listed in **Table 1**.

SERVICE LIFE

The average life of hardwood railroad ties in the United States was 35 years during the first half of the 20th century and has increased to 40 to 50 years (1). Service life ranges from 30 to 50 years, depending on region. Climate has much to do with the length of service life. The hot, wet climate in the South leads to a shorter service life (30 yr.) compared to that of ties in the North. Railroad ties in the hot, dry climate in the West have a service life of 50 years and ties in the East, a service life of roughly 46 years (14).

PRODUCTION

Historically, the production of wood railroad ties has varied depending upon demand. Demand dropped under 50

million ties per year during the mid-1930s before surging during World War II (14). Demand dropped again in 1961, reaching a low point of 12 million ties. The average annual demand for wood railroad ties has recently increased. Estimates indicate that less than 6 percent of all ties used in the United States and less than 15 percent used worldwide are made of material other than wood. According to the Association of American Railroads, average annual use is 3,039 ties per mile (1.61 km), or a total of 10,725,938 ties (17).

The largest proportion of solid sawn timbers in the United States is used for railroad ties. The production of railroad ties is expected to increase at an average of approximately 3 percent per year. **Table 2** shows railroad tie production by year and region from 1995 through 1998.

Railroad ties are grouped in four categories: replaced treated crossties, replaced switch and bridge ties, added crossties, and added switch and bridge ties. Replaced and added crossties are further subdivided into new and used ties. These categories are defined as follows:

Replaced crossties. – New ties: new crossties used to replace damaged crossties on a railroad track; Used ties: used

TABLE 1. – Species used for railroad ties.

Species	Species
Ash (<i>Fraxinus</i> spp.)	Western hemlock (<i>Suga heferophylla</i>)
Beech (<i>Fagus grandifolia</i>)	Western larch (<i>Larix occidentalis</i>)
Birch (<i>Betula</i> spp.)	Locust (<i>Robinia pseudoacacia</i>)
Catalpa (<i>Catalpa</i> spp.)	Maple (<i>Acer</i> spp.)
Western red cedar (<i>Thuja plicata</i>)	Red mulberry (<i>Morus rubra</i>)
Cherry (<i>Prunus serotina</i>)	Oak (<i>Quercus</i> spp.)
Bald cypress (<i>Taxodium distichum</i>)	Pine (<i>Pinus</i> spp.)
Douglas-fir (<i>Pseudotsuga menziesii</i>)	Poplar (<i>Liriodendron tulipifera</i>)
Elm (<i>Ulmus</i> spp.)	Redwood (<i>Sequoia sempervirens</i>)
Fir (<i>Abies</i> spp.)	Sassafras (<i>Sassafras albidum</i>)
Gum (<i>Liquidambar styraciflua</i>)	Spruce (<i>Picea</i> spp.)
Hackberry (<i>Celtis</i> spp.)	Sycamore (<i>Platanus occidentalis</i>)
Hickory (<i>Carya</i> spp.)	Walnut (<i>Juglans nigra</i>)

TABLE 2. – U.S. wood railroad tie production by year and region (15).

Year	No. of ties			Board feet of ties		
	East	West	Total	East	West	Total
1995	5,164,873	5,388,706	10,553,579	206,594,920	215,548,240	422,143,160
1996	5,044,760	6,886,564	11,931,324	201,790,400	275,462,560	477,252,960
1997	4,814,283	6,024,918	10,839,201	192,571,320	240,996,720	433,568,040
1998	4,964,360	4,437,504	9,401,864	198,574,400	177,500,160	376,074,560

cross-ties removed from one part of a track to replace damaged cross-ties on another part of the track.

Added cross-ties. – New ties: new cross-ties used for new railroad tracks added to a railroad system; Used ties: used ties removed from a railroad track and used for a new railroad track.

Approximately 94 percent of the ties used as replacements or additions are new ties.

COMPETITIVE STANDING

Wood railroad ties will continue to be used because other materials are cost prohibitive or have not performed as well as wood. Concrete ties are more expensive than wood ties and their fastening systems need to be improved (30). Steel ties lack good ballast support, which shortens their lifespan compared to that of wood ties.

Engineered wood products are being tested to determine whether they can perform as well as products from solid sawn wood. Research is also being conducted on increasing the lifespan of wood railroad ties. Most ties are replaced because of abrasion and cutting from metal plates. To reduce this type of wear and tear, tests are being conducted on wood railroad ties wrapped in fiber-reinforced fiberglass.

TIMBER BRIDGES

The major species groups used for timber bridges are Douglas-fir and southern pine. Solid sawn timbers were the first raw materials used for bridges. Bridges represent an important market for timber products. Timber bridges have evolved from log stringers to bridges constructed from treated and prestressed solid sawn timbers, glulam stringers, and bolted connections (19).

Timber bridges are located throughout the United States; 87 percent are located in 19 states (19) and approximately 66 percent in 9 states (8). Twenty percent of all timber bridges are located in rural areas of the South and South-Central United States (19). The lower traffic rates in these areas mean less wear and tear on bridge material. According to National Bridge Inventory reports (9), more timber bridges are located in Louisiana than in any other state as of 1992. Alabama, Mississippi, Iowa, and Arkansas also have a high percentage of timber bridges; Maine has the smallest number (35 bridges) (8).

Timber bridges represent 7 percent of the 570,000 bridges listed on the National Bridge Inventory and less than 6 percent of replacement structures built since 1982 (10). The number of timber bridges in the U.S. roadway system is shown in **Table 3**. The National Highway System inventory, which includes all interstate bridges, lists 128,508 bridges (9). Of these, only 401 are timber bridges, which is less than 1 percent of the total. More than half (55%) of all U.S. bridges are located on county highways and almost one-quarter (23%) on state highways. Concrete bridges are evenly distributed between county and state highways (26).

In 1992, an average of 15,000 board feet of solid sawn timber was used for bridge superstructures (20). In recent years, the construction of timber bridges has dropped to less than 8 percent of total bridge construction. According to the Federal Highway Administration (FHWA) (21), this decline may be the result of several factors, which include the past performance and current lifespan of timber bridges and the maintenance required by timber bridges. Since wood is a biological material, it is vulnerable to attack by fungi and insects as well as damage from fire and accidents (19).

Steel and concrete are the main competitors to solid sawn timbers for bridge construction (**Table 4**), but glued-laminated lumber (glulam) is also a competitor. The steel and concrete industries hold more than a 90 percent share of the bridge market (20). As the data in **Table 4** indicate, solid sawn timbers were the least-used material for bridges from 1960 to 1994. Their use has continued to decrease (9). Steel dominates the market, followed by concrete and prestressed concrete. The rural South and South-Central United States promise the best market opportunities for the timber bridge industry.

TIMBERS FOR OTHER TRANSPORTATION STRUCTURES

In addition to railroad ties and bridges, solid sawn timbers are used to make posts for signs, guardrails, and sound barriers. Information on these products is scanty, and more research is needed in this area. Most timber transportation structures other than railroad ties and bridges utilize sawn timber posts. Solid sawn timbers are used in these products for various reasons. Compared with posts made from other materials, wood posts are less expensive, are easier to replace and install, are more attractive, and do not rust. They are also resistant to wind, snow, and ice. Solid sawn timbers also have some disadvantages. They are

TABLE 3. – Timber bridges listed on National Bridge Inventory, February 1998 (18).^a

Bridge system	Total bridges	Timber bridges	Timber bridges
		(no.)	(%)
National Highway System	128,508	401	< 1
Federal Aid roadway	171,390	4,625	3
Off-road system	282,852	33,272	12
Total	582,750	38,292	7

^a National Highway System: all interstate highways; Federal Aid roadway system: old U.S. highways; off-road system: all state roads. In addition to timber bridges, the National Bridge Inventory includes 39,503 steel bridges with timber decks.

TABLE 4. – Number of bridges built per 5-year interval by material (9).

Period	Prestressed concrete	Steel	Concrete	Solid sawn timbers
1960 to 1964	16,591	21,078	8,682	5,080
1965 to 1969	14,708	19,039	11,496	4,162
1970 to 1974	10,104	15,045	12,515	3,351
1975 to 1979	7,776	10,112	11,937	2,906
1980 to 1984	6,507	7,824	12,133	1,714
1985 to 1989	6,724	7,974	14,111	1,819
1990 to 1994 ^a	2,209	2,562	4,501	582

^a Data are still being updated.

TABLE 5. – Materials used for sound barrier construction by year (28).

Year	Block	Concrete	Wood	Metal	Berm
------(ft. ²) ^a -----					
1986	1,238,000	1,335,000	570,000	140,000	65,000
1987	980,000	1,798,000	280,000	140,000	0
1988	3,035,000	2,196,000	280,000	54,000	22,000
1989	3,154,000	1,432,000	1,485,000	269,000	140,000
1990	2,303,000	1,733,000	947,000	0	43,000
1991	3,509,000	2,217,000	657,000	43,000	11,000
1992	5,630,000	2,960,000	764,000	151,000	43,000
1993	3,444,000	1,873,000	355,000	11,000	86,000
1994	2,411,000	1,292,000	667,000	22,000	86,000
1995	4,198,000	1,841,000	205,000	258,000	108,000
Total	29,902,000	18,667,000	6,210,000	1,088,000	608,000

^a 1 ft.² = 0.093 m².

not as strong as steel or concrete and they retain moisture, which can cause warping and shrinkage.

SOUND BARRIERS

Solid sawn timbers are also used to make sound barriers for roads and highways to reduce noise from traffic (25). Other materials for sound barriers include concrete, metal, earth berm, and block (Table 5). Three types of designs are used for wood sound barriers: timber planks, plywood, and glulam panels (3). In a typical barrier, the panel section is made from timber planks or glulam and attached to a post. The posts can be made from large solid sawn timbers, glulam timbers, steel, or concrete.

Although there is no specification for the use of solid sawn timbers in sound barriers, the decision to use solid sawn timbers depends on the height and wind load of the sound barrier (8). Approximately 17 percent of sound barriers are constructed of wood or a combination of earth berm and wood (5). No data are available on the production of solid sawn timbers solely for use in sound barriers. Concrete and block are the only materials used more than wood.

The market for sound barriers rose in the 1980s. By the end of 1980, more than 189 miles (304 km) of sound barriers had been constructed in a total of 31 states and Puerto Rico (25); 85 percent of these barriers are in 9 states: California, Minnesota, Colorado, Virginia, Oregon, Arizona, Washington, Massachu-

setts, and Connecticut (4). By the end of 1996, more than 450 miles (725 km) of sound barriers had been built in the United States, at a cost of more than \$300 million (29).

The use of sound barriers has gained popularity in the United States as real estate developments along highways continue to grow (2). Barriers range in height from 5 feet to more than 20 feet (1.5 m to more than 6 m); their length is governed by the length of the area for which they are constructed (25). The longer the span of residential or commercial space, the longer the sound barrier (29).

Some competitors to wood such as concrete and block maintain a larger share of the market for the construction of sound barriers. One reason that wood is used less than concrete and block is that wood sound barriers are treated with creosote; in certain parts of the United States, these sound barriers are being removed because of environmental concerns.

HIGHWAY GUARDRAILS

Another market for solid sawn timbers is wood guardrails, i.e., protective structures on highways and roads used to prevent vehicles from going off the road. Guardrails are driven into the ground at 10- to 15-foot (3- to 4.6-m) centers and a railing is connected to the top of the guardrail with W-shaped or triple V-shaped cross sections (25).

The high incidence of accidents on roadways makes guardrails mandatory for safety. Since 1974, highway guardrails have been responsible for saving 50,000 lives and preventing 850,000

nonfatal injuries (27). These numbers suggest a steady market for wood guardrails for highways and other roads. (No production data were found on the amount of wood guardrails used for marine applications.) Wood guardrails are more attractive than steel guardrails, and they can be driven more easily into loose clay fill (13). Wood also has a cost advantage over other materials. Bowlby estimated the cost of a guardrail system as \$20/unit for steel and \$11/unit for wood.¹

The main competitors to wood for guardrail posts are concrete and steel. Research has found that all of these materials perform well, but wood is superior to steel in resisting damage below the ground surface (25). Many guardrails are currently being made with steel rails and sawn wood posts. Guardrails are also being made with steel rails and steel-wood posts.

SIGNPOSTS

The use of posts for roadway signs in the United States dates to as early as 1905, when the Buffalo Automobile Club of New York erected signposts to direct horseless carriages (25). Typical signs are composed of a sign blank, face, and post.

Little literature has focused on production and use estimates for signposts in the United States. According to the U.S. Department of Agriculture, the United States has more than 58 million roadside signs (25). No information is available on how many signs are supported by wood posts, although information has been published on common types and sizes of posts. The predominant wood post is square, has nominal dimensions of 4 by 4, 4 by 6, and 6 by 6 inches (standard 89 by 89, 89 by 140, and 140 by 140 mm), and varies in length from 12 to 18 feet (4 to 6 m) (6).

The most widely used materials for signposts are wood and aluminum (6). Aluminum is considered to be the major competitor to wood. The paucity of data makes analysis of the post market difficult. It is likely that the market for wood posts will continue, however small.

WOOD SPECIES

The wood species used for signs, guardrails, and sound barriers are not specified by national standards. The species used to make transportation structures depend on geographical loca-

¹ Bowlby, R. 1992. President of Burke-Parsons Bowlby Corp., Spencer, WV. Personal communication.

tion. For example, pine is commonly used in the southern states.

OUTLOOK FOR SOLID SAWN TIMBERS

Wood railroad ties have a proven track record of durability when exposed to even the heaviest loads, like the Cooper E-120 locomotive, and the toughest environmental conditions (7). With these advantages, wood has continued to take the larger market share of railroad ties, although substitute products continually arise to challenge the place of wood. Therefore, the outlook for solid sawn timbers for railroad ties is excellent.

Wood will continue to be used for bridges in the future, although not as much as in the past. Timber bridges have only a few advantages over steel or concrete, such as quicker installation and ease of replacement. The lifespans of bridges made from timber and other materials are similar. The future for wood lies in short- to medium-span bridges and bridges for rural areas. Although concrete and steel have replaced wood as the major bridge construction material in the United States in this century, particularly on interstate and state roads, highway officials feel that wood could still be used extensively in short- to medium-span bridges in rural areas (19). These bridges require less maintenance than longer bridges, can be installed very easily, and are economical and long lasting.

The future for wood guardrails, sound barriers, and signposts is potentially large but difficult to predict. Available information is limited to the decade between 1980 and 1990. More information is needed on these products before detailed predictions can be made. Nevertheless, the continuing need for highways indicates a concomitant need for guardrails, sound barriers, and signposts. Research has addressed some areas of concern, such as a grading system for solid sawn timbers used in the transportation industry (12). More research is needed in areas such as the effects of timber products on the environment, timber production rates, and the effects of moisture on solid sawn timbers.

The use of wood for guardrail posts has potential. At present, most states use either wood blocks on wood posts or steel blocks on steel posts (25). Wood blocks are less expensive than steel blocks, although the difficulty and cost

of installation is about the same for both materials. Moreover, wood is superior to steel in resisting damage below the groundline.

As communities continue to grow alongside highways, the market for sound barriers will grow accordingly. In 1985, 189 miles (304 km) of sound barriers were built. From 1981 to 1986, an additional 450 miles (720 km) of sound barriers were constructed, an average of 91 miles (147 km) per year. The length of sound barriers is expected to span 10 miles (16 km) (29). Since the average cost of wood is \$12 per linear foot (3.048 m), the sound barrier market is valued at \$3.8 million per year (29). Wood has held a nice share of the sound barrier market. However, for wood to capture a greater portion of this market, some changes must take place.

For a typical sound barrier, posts range from nominal 8 inches wide by 12 inches deep (standard 184 by 286 mm) to nominal 12 inches wide by 20 inches deep (standard 286 by 495 mm). Large solid sawn timbers must be used to prevent shrinkage and warp, which increases the need for maintenance. However, the larger the solid sawn timbers, the higher the cost. Other wood materials, such as glulam timber, glulam panels, and timber planks, are just as strong as are solid sawn timbers and cost less. As the size of members increases, engineered wood products such as glulam will be more cost effective than sawn timber and have a higher design value. Furthermore, glulam gives manufacturers the flexibility of producing any size, length, and shape of a member. Thus, solid sawn timbers will need to compete with these kinds of products as well as steel and concrete. Better designs such as tongue-and-groove fitted solid sawn timbers may help to eliminate cracks caused by shrinkage and warp (25). Environmental concerns must be addressed as well.

There will always be a need for new signposts for roads as well as replacements for deteriorated posts. According to the 1988 Annual Report on Highway Safety Improvement Programs, improvement to road signs reaps the highest benefit-to-cost ratio of any highway safety improvement program (6). Replacement times are not predictable because little information is kept on wood signposts. If better records on

wood signposts were kept, the market for this product could be estimated more accurately.

EMERGING MARKETS AND COMPETITORS

Several competitive products can influence how well solid sawn timbers will do in the future. For example, the use of engineered wood products has soared in the past 5 to 10 years, and these products are replacing solid sawn timbers in residential and nonresidential construction. Whether or not engineered wood products could replace solid sawn timbers in the exterior markets described in this paper has not been determined.

The following wood products are important to the wood industry, although information on them is scarce:

- Timber frame structures
- Blocking material
- Mining solid sawn timbers
- Landscape solid sawn timbers
- Cross arms
- Engineered wood products
- Parallam®
- Glulam

CONCLUSIONS

Railroad ties, timber bridges, and other transportation structures (e.g., signposts) represent the major categories of solid sawn timbers. Other timber products will no doubt emerge in the wood industry in the future. An accurate picture of the production and use of solid sawn timbers in transportation structures has been compromised by the lack of available information and data. This situation also prevents an accurate estimation of the future for timber. Nevertheless, the future looks promising for some products.

A steady demand and the need to replace decayed and/or worn ties promise a relatively bright outlook for railroad ties. Substitute products, like engineered wood products, steel, and plastic, are serious competitors to the use of wood. Timber bridges have the least promising outlook. Materials such as steel and concrete are replacing solid sawn timbers; these materials can handle the stresses of various climates, are very durable, and have long lifespans. For timber bridges to maintain their place in the market, the industry must concentrate on a smaller market, specifically rural areas in the South and South-Central states.

Sound barriers, guardrails, and signposts have a potential for success in their respective markets. Most of these markets are not large compared to that for railroad ties, and solid sawn timbers will face competition from other materials. Effort must be made to keep cost and maintenance of wood transportation structures as low as possible.

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