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Steam-Pressed Scrim Lumber (SPSL)

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Abstract

Scrim is formed by forming fiber bundles of small-diameter trees into 7.5 foot long (up to 10 feet) into mats and converted into steam pressed scrim lumber (SPSL) for beams, headers, and large timbers. Research has shown that SPSL produced from southern pine is fully engineered to compete with other EWP products presently on the market. Strength properties for the SPSL are presented. Design values ranged from 15.4-16.9 GPa for MOE and 19.3-28.4 MPa for MOR depending on beam size. Depending on gauge length, tension design values ranged from 18.2-20.9 MPa. Flatwise and edgewise compression values ranged from 4.6-10.2 MPa. Other furnishes are discussed.

Keywords steam-pressed scrim lumber; structural composite lumber; southern pine, mechanical properties; design values

Introduction

Scrimber is a process developed and patented in 1975 by CSIRO in Australia and whose USA World-wide rights were granted to Timtek™. Timtek™ contracted with the Department of Forest Products, Mississippi State University, to conduct research to determine the physical properties attained by using the process on southern yellow pine and to improve its physical properties to meet the requirements of US markets. The definition of steam pressed scrim lumber (SPSL) is as follows: a composite of wood scrims (mats of wood strands) obtained through crushing small-diameter logs and glued together in steam-injection press so that wood fibers are primarily oriented along the length of the member. The least dimension of the strands in the scrim shall not exceed 3/4 inch (19 mm). The average length of the strands shall be greater than

20 times their least dimension. SPSL is considered to be an structural composite lumber (SCL) product.

Scrim is formed by forming fiber bundles of small-diameter trees into 7.5 foot long (up to 10 feet) into mats and converted into steam pressed scrim lumber (SPSL) for beams, headers, and large timbers. This paper is a synopsis of our results in developing SPSL. Scrimming trials have been conducted with a large number of furnishes to date. Table 1 gives a listing of these materials. Of the materials scrimmed, only fire-killed western pines, sweetgum, and hybrid poplar heartwood did not produce acceptable scrim.

Table 1: Lignocellulosics for which scrimming trials have been conducted.

Species	Scrim Quality (1=superior, 5=will not scrim)
Southern pine (*Pinus* spp.)	2
Lodgepole pine (*Pinus contorta*)	4
Ponderosa pine (*Pinus ponderosa*)	3
Fire-killed lodgepole pine	5
Fire-killed ponderosa pine	5
Hybrid poplar (*Populus* spp.), heartwood	5
Hybrid poplar (*Populus* spp.), sapwood	3
Sweetgum (*Liquidambar styraciflua*)	5
Yellow-poplar (*Liriodendron tulipifera*)	3
Aspen (*Populus tremuloides*)	1
Bamboo (species unknown)	3
Corn stover (*Zea mays*)	
Kenaf (*Hibiscus cannabinus*)	3
Spruce (*Picea* spp.)	1
Paper birch (*Betula papyrifera*)	2
Basswood (*Tilia americana*)	1

The mechanical properties of SPSL produced from three pine species have been evaluated. The majority of the work has been conducted with southern pine. The purpose of this research was to characterize the mechanical properties and design stress values for SPSL produced from southern pine. The paper summarizes our results for the basic flexure properties for SPSL produced from these species. Additional studies have been conducted with fire-killed ponderosa and lodgepole pines and small-diameter green stock of the same species (Linton *et al*. 2008). Other properties have been discussed at a recent conference (Kitchens *et al*. 2010)

Methods and Materials

Materials

Juvenile southern yellow pine trees from young plantations were harvested from east central Mississippi and west central Alabama. Logs measuring 79-178 mm in diameter were harvested and sent through a debarker. Debarked logs were soaked in a hot water bath at 54-60°C for six hours. The hot logs were passed through a set of rollers to break the logs into large fiber bundle sections along the grain. They were then sent through a scrimming mill where they were passed down the scrim line to a series of scrimming heads of successively smaller size. These scrim mills produced scrim that was approximately 6-7 mm thick and 2.1-2.4-m long (for a demonstration of the technique see http://www.cfr.msstate.edu/timtek/index.asp). Beam production and the scrimming process have been described previously (Barnes *et al*. 2006, Linton *et al*. 2008, Seale *et al.* (2006). The scrim was kiln-dried to a nominal moisture content of 20% at 80 °C with no wet bulb control followed by spraying with a stage B resole phenol formaldehyde resin to yield 12% solids. The scrim was re-dried in a commercial conveyor drier at 115 °C to 6% moisture content or less. Following hand forming, the beams were consolidated in a proprietary steam press. The rough beams (Fig. 1) were trimmed to a final size of 44.5- x 298-mm x 5.5-m.

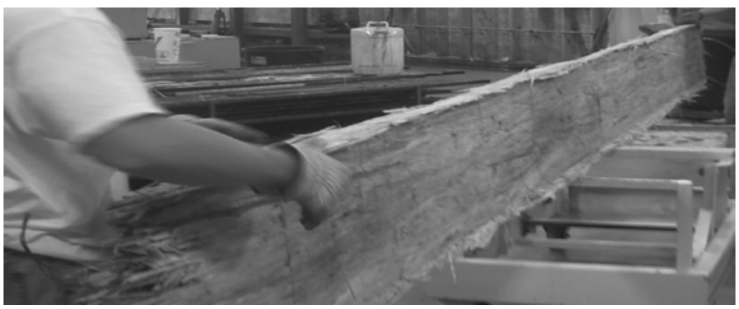

Figure 1. Typical rough beam shown immediately after pressing.

Sampling and Testing

Two groups of southern pine samples were tested. The first set contained full-sized beams measuring 44- x 286-mm x 5.3-m samples. The finished beams were non-destructively graded using an Inspex™ x-ray inspection system to determine if there were any low density areas (LDAs) in them. This technique was previously described at the 2006 SmallWood conference (Leng *et al*. 2006). These LDAs are formed when a piece of scrim is larger than the others causing parts of the scrim to not bond well with the other pieces that surround it. This can cause a decrease in the mechanical properties of the beam. The use of x-ray technology allowed us to determine how the samples needed to be cut to allow us to achieve the maximum property values out of each piece. Figure 3 shows the x-ray images taken from a set of samples. The light areas in each piece indicate LDA locations. Number 1 shows a sample that does not contain any LDAs. This is an example of a sample that was tested. Numbers 2, 3, and 4 show typical samples rejected because of LDAs in each piece. After the initial x-ray scans are done, the beams were cut into selected sample sizes.

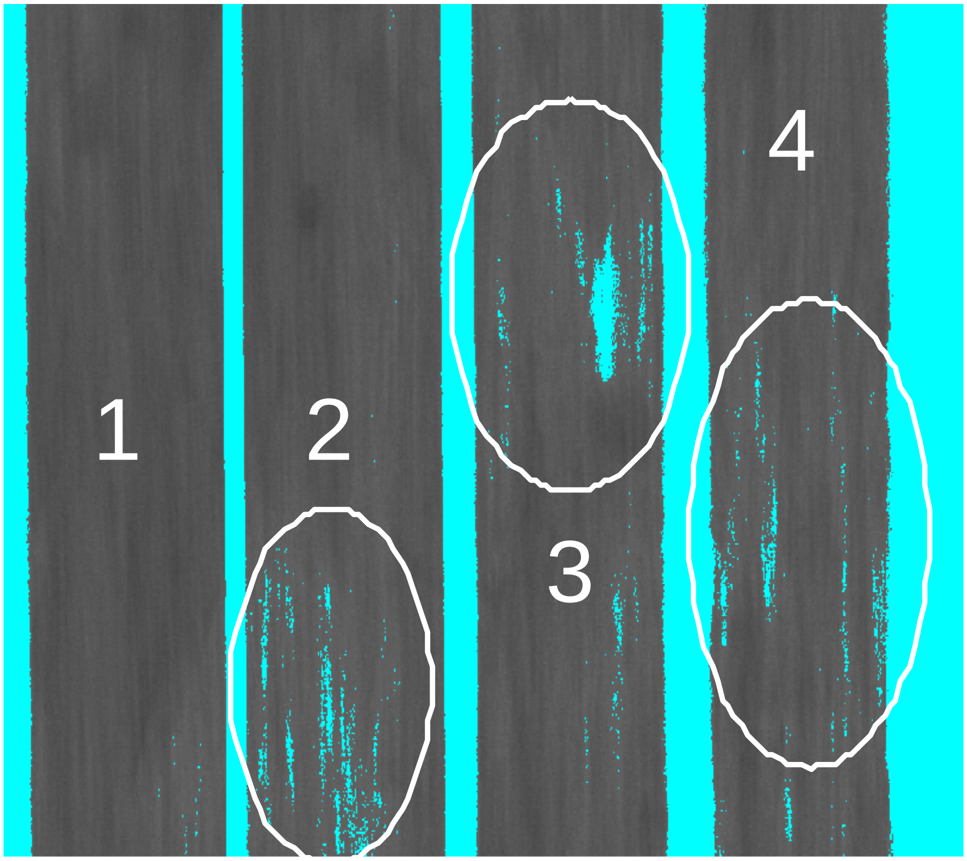

Figure 3. X-ray images of SPSL beams showing areas of low density (denote by circles).

The second set contained smaller samples of different depths cut from the larger parent beams. All samples were nominally 44 mm in width. Samples were tested using ASTM standard D 4761 (2007) using third point loading in bending to determine modulus of rupture (MOR) and modulus of elasticity (MOE). All bending samples were tested on an 18:1 span: depth ratio. Both depth and volume effects were determined. Tension tests were also conducted in the fiber direction using ASTM D 4761 (2007). Compression testing was conducted in both along and across the fiber direction using ASTM D 4761 (2007). The compression tests had sample sizes of 1.5-in x 6-in, 2-in x 6-in, and 2-in x 8-in. The spans for these tests were the same as the lengths for each sample. Design values were calculated for the various mechanical properties using ASTM D5456 (2004).

Results and Discussion

Bending

The MOE and MOR values from the static bending tests are shown in Table 2. Depth effects are illustrated in Figure3. ASTM standard D 5456 contains a table with adjustment factors for different mechanical properties of wood which were applied to obtain the design values. Using these adjustment factors we are able to calculate our design stress values by dividing each value by the associated adjustment factor. Table 3 contains the design stress values for static bending tests conducted on SPSL.

Table 2. Average values for mechanical properties by beam depth.

Depth	MOE (GPa)	MOR (MPa)
63.5 mm depth		
Number of Samples	78	78
Mean	16.8	59.7
Maximum	19.2	79.7
Minimum	13.7	44.0
COV %	7.6	11.7
89.9 mm depth		
Number of Samples	36	36
Mean	16.9	53.1
Maximum	19.9	68.1
Minimum	13.4	41.1
COV %	9.2	13.4
184.2 mm depth		
Number of Samples	20	20
Mean	17.7	51.6
Maximum	19.4	60.2
Minimum	15.7	40.8
COV %	6.1	12.3
285.8 mm depth		
Number of Samples	20	20
Mean	15.3	40.5
Maximum	17.0	48.1
Minimum	13.2	35.2
COV %	6.6	8.8

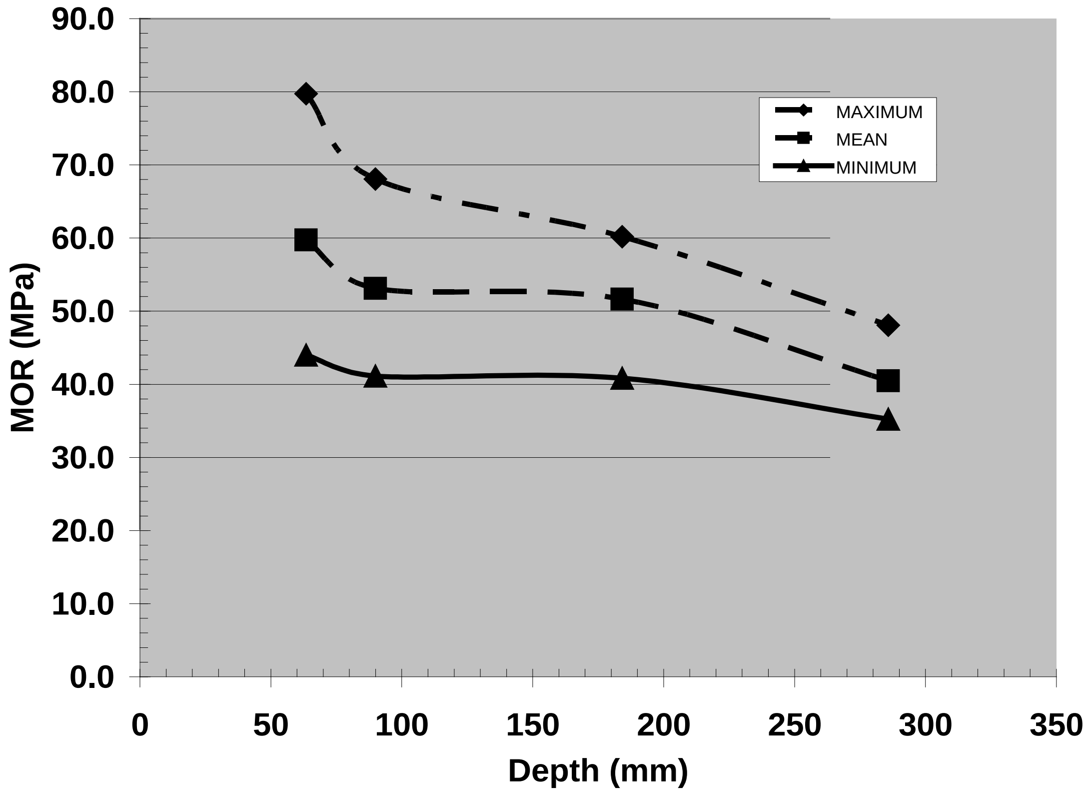

Figure 3: MOR depth effects for beams tested in static bending.

Table 3. Design bending stress values for SPSL.

Sample Size (depth x span, cm)	MOE (GPa)	MOR (MPa)
6.4 x 129.5	16.8	28.4
8.9 x 175.3	16.9	25.3
18.4 x 346.7	17.7	24.6
28.6 x 529.6	15.4	19.3

Tension

Tension tests were conducted on four different gauge lengths. Table 4 shows the mean, maximum, and minimum values along with the coefficient of variation (COV). Like the static bending tests, an adjustment factor (2.1) was applied to each of these properties to obtain the design value shown in Table 4.

Table 4. Tensile strength for SPSL

Gauge length (m)	0.61	1.22	2.44	3.35
Number of tests	30	78	36	31
Mean (MPa)	43.8	40.3	38.2	38.6
Maximum (MPa)	52.8	53.8	46.8	45.5
Minimum (MPa)	34.4	27.5	29.5	31.4
COV %	10.7	13.8	12.2	8.5
Design Stress Value (MPa)	20.9	19.2	18.2	18.4

Compression
Both edgewise and flatwise compression perpendicular tests were conducted to develop compression design values for SPSL. Values were recorded for each test at 0.5 and 1.0 mm of compression. Results for each test can be seen in Table 5. An adjustment factor of 1.67 was applied to each test so that a weighted design stress value could be determined.

Table 5: Design stress values for compression properties of SPSL

	Edgewise		Flatwise	
Compression level (mm)	0.5	1.0	0.5	1.0
Number of tests	30	30	30	30
Mean (MPa)	10.1	17.0	7.7	13.9
Maximum (MPa)	13.4	21.1	11.5	20.5
Minimum (MPa)	6.9	12.3	5.2	9.7
COV %	15.9	13.4	21.6	20.4
Design Stress Value (MPa)	6.1	10.2	4.6	8.3

Summary and Conclusions

SPSL was shown to be a product that can compete in today's market. Trees from first plantation thinnings typically have little value in today's market, but with forest products available such as, SPSL, landowners will be able to get more out of their investments in a shorter period of time. With increased value of small-diameter timber, landowners will be more apt to practice proper silvicultural practices on plantations which will promote increased growth, size, and value for the remaining trees.

The purpose of this research was to obtain the mechanical and physical properties of a new engineered wood product, SPSL, and determine the design stress values for beams made from southern pine. In this study, a new process using juvenile wood from first plantation thinnings was used to make structural beams. After data analysis, it was determined that each sample passed APA guidelines and certification tests. MOR and MOE samples were determined to be comparable, and in many cases exceeding, values for products already commercially available. Tensile stress values and compression perpendicular to the grain values also met expectations and are comparable to commercially available products.

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