

FLEXURAL PROPERTIES OF LUMBER FROM A 50-YEAR-OLD LOBLOLLY PINE PLANTATION¹

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ABSTRACT

Flexural properties of dimension lumber from a 50-year-old loblolly pine plantation stand were evaluated. The results indicate very impressive visual grade recovery, particularly No. 1, which amounted to about 44% yield. The results also indicate that the overall degrees of compliance of visually graded lumber to standard SPIB requirements of strength and stiffness are 99 and 94%, respectively.

Keywords: Southern pine, dimension lumber, grade recovery, plantation stand, flexural properties, design requirements, visual grade compliance.

INTRODUCTION

The quality and properties of dimension lumber from southern pine plantations, particularly from loblolly pine (*Pinus taeda* L.) (Bendtsen 1978; Pearson and Gilmore 1971, 1980; Biblis et al. 1993, 1995, 1997) and slash pine (*Pinus elliotti* Engelm.) (MacPeak et al. 1990; Biblis 1990) have been evaluated. MacPeak et al. (1990) reported that all tested dimension lumber obtained from a 50-year-old planted slash pine stand met the flexural strength and stiffness values required by the Southern Pine Inspection Bureau (SPIB) for the corresponding visual grades. The loblolly pine studies by Biblis et al. (1993, 1995, 1997) involved two different stand densities and four stand ages (25-, 30-, 35- and 40-year-old). The results indicate that the structural quality of

loblolly pine dimension lumber increases with stand age and stand density. Moreover, there is conclusive evidence that dimension lumber obtained from loblolly plantation stands aged 40 years or less does not meet the SPIB's required flexural design properties, particularly the stiffness values for the assigned visual grades. In loblolly plantations, even at age 35, the percentage compliances of lumber to flexural design strength (F_b) and stiffness (E) requirements are only 89 and 52%, respectively. At age 40, the average flexural stiffness (MOE) of lumber meets the required average design (E) value for the corresponding grade. However, when individual pieces of lumber are considered, the results indicate that the percentage of pieces of lumber complying to required stiffness "E" is alarmingly low. On average, considering all grades and lumber sizes of an unthinned 40-year-old loblolly plantation stand, only 66% of the lumber meets the required "E" value.

This study was undertaken to determine

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whether dimension lumber from a 50-year-old loblolly plantation stand meets the required SPIB flexural strength and stiffness values for the assigned visual grades.

MATERIALS AND METHODS

The investigated loblolly pine plantation is located on a Piedmont site in West Georgia. The 50-year-old stand was established with 1.83- by 2.44-m (8-ft \times 8-ft) spacing on a site index of 27.4 m/50 yr (90 ft/50 yr). At age 18, the stand was lightly thinned at the rate of 19.6 m³/ha (3 cords/acre). In addition, the stand at age 40 was subjected to a severe storm that caused the untimely felling of a significant number of trees and consequent salvaging of sawtimber with an estimated scaled volume of 20.4 m³/ha (3,500 bf-Doyle/acre). Later at age 48, the stand was subjected to another storm that again caused the untimely felling of additional trees and consequent salvaging of sawtimber with an estimated scaled volume of 11.7 m³/ha (2,000 bf-Doyle/acre). Finally, at age 50 the stand had 271 standing trees/ha (110 trees/acre) with an average diameter at breast height (DBH) of 37.3 cm (14.7 in.), basal area of 12.0 m², (130 sq. ft) and volume of approximately 81 m³/ha (13,900 bf-Doyle/acre).

Prior to the selection of sample trees, the timber size distribution for the stand was established by measuring DBH of all trees in four 0.1-hectare (1/4-acre) plots in the stand. Twelve trees representing the DBH distribution for the stand were then selected as samples for the study. These were properly identified, harvested, and measured for size.

Each sample tree was bucked into 3.66 m-long (12-ft) sawlog segments in the field. The large end of each sawlog was spray-painted with a different color to identify the location of the sawlog within a tree (i.e., first, second, third, or fourth log). Afterwards, the large- and small-end diameters outside bark were measured and recorded. All sawlogs from the sample trees were transported to the cooperating sawmill and sawn into lumber. All green

lumber was sorted by width and length and then stacked and kiln-dried to approximately 15% moisture content (MC). Thereafter, all the lumber pieces were dressed to the mill's specifications and subsequently graded to SPIB visual grades by qualified lumber graders. The lumber, prior and during testing, was stored in the Auburn University Forest Products Laboratory at drier conditions; that resulted in MC during testing between 8 and 9%, as indicated in Table 1.

All sawn lumber was transported and stored inside the laboratory for a minimum of 3 weeks prior to testing. Based on actual sizes, the 3.81- by 19.1-cm (2- \times 8-in.) and 3.81- by 14.0-cm (2- \times 6-in.) test pieces were trimmed to 3.5 m (138 in.) long, while all 3.81- by 8.9-cm (2- \times 4-in.) pieces were trimmed to 2.44 m (96 in.) long. All test samples that were trimmed to the desired size were regraded by a qualified lumber grader. A total of 356 pieces of lumber were destructively tested edgewise in flexure to failure with third-point loading according to ASTM D 198-84 (1994). The 3.81- by 19.1-cm (2- \times 8-in.) and 3.81- by 14.0-cm (2- \times 6-in.) pieces were tested over a span of 3.35 m (132 in.), and the 3.81- by 8.9-cm (2- \times 4-in.) pieces were tested over a 2.29-m (90-in.) span. A Tinius-Olsen hydraulic testing machine with a capacity of 54,480 kg (120,000 lbs) was used to test the lumber. For flexure tests, the distances between the load points were 76.2 cm (30 in.) for the 3.81- by 8.9-cm (2- \times 4-in.) and 1.12 m (44 in.) for the 3.81- by 14.0-cm (2- \times 6-in. and 2- \times 8-in.) lumber. Load and corresponding deflection-to-failure data were obtained with a data acquisition system. The modulus of rupture (MOR), modulus of elasticity (MOE), MC, and specific gravity (SG, based on oven-dry weight and volume) for each tested piece of lumber were subsequently calculated.

Flexural test results were used for making comparisons with the required bending strength value for each visually graded piece; that is, the obtained MOR value of every piece was compared to the required bending strength

TABLE 1. Flexural properties and compliance to visual grade requirements of lumber obtained from a 50-year-old thinned loblolly pine plantation tested edgewise according to ASTM D 198 with third-point loading over the spans of 228.6 cm for 3.81- × 8.9-cm (2 × 4s) and 335.3 cm for 3.81- × 8.9-cm (2 × 6s), and 3.81- × 19.1-cm (2 × 8s).

SPIB visual grade	Pieces tested	MC %	SG ^a	MOE ^b Gpa	MOR ^b Mpa	SPIB required		Meet standards	
						BSV ^c Mpa	MOE Gpa	"F _b " %	"E" %
Lumber size (2" × 4") 3.81- × 8.9-cm									
No. 1	35	8.4	0.58	16.5 (0.2)	71.7 (4.8)	26.8	11.7	100	100
No. 2	34	7.5	0.50	13.7 (0.7)	44.8 (5.5)	21.7	11.0	100	100
No. 3	5	8.1	0.51	10.4 (1.3)	29.6 (2.1)	12.3	9.7	100	60
All grades	74							100	97
Lumber size (2" × 6") 3.81- × 14.0-cm									
No. 1	105	8.5	0.55	15.5 (0.4)	58.6 (2.1)	23.9	11.7	100	95
No. 2	105	8.0	0.43	12.6 (3.4)	37.2 (2.1)	18.1	11.0	98	93
No. 3	25	8.7	0.51	12.0 (1.2)	32.4 (5.5)	10.8	9.7	96	88
ECON	23	8.5	0.53	8.3 (0.5)	26.9 (3.4)			100	100
All grades	258							99	94
Lumber size (2" × 8") 3.81- × 19.1-cm									
No. 1	18	8.6	0.57	14.7 (1.0)	51.0 (4.1)	10.1	9.7	100	89
No. 2	4	8.4	0.49	12.4 (1.0)	44.1 (4.8)	17.4	11.0	100	75
No. 3	2	8.3	0.52	9.2	46.9	10.1	9.7	100	50
All grades	24							100	83
All lumber	356							99	94

^a Oven-dry basis.

^b Numbers in parentheses are standard deviations.

^c BSV is the required bending strength value obtained by multiplying the "F_b" by 2.1.

value (BSV) of the corresponding visual grade. The BSV was calculated by multiplying the SPIB required bending design value F_b for each grade by the combined adjustment factor 2.1 for safety and duration of load. This comparison is shown in Table 1 and is reflected by the percentage of the number of pieces meeting or exceeding the requirements to the total number of pieces tested. The percentages of the tested pieces with E values above those recommended by SPIB grading rules for the corresponding visual grade are also listed therein.

RESULTS AND DISCUSSION

Table 1 summarizes the results of the flexural tests conducted on lumber produced from

the 50-year-old plantation stand of loblolly pine investigated. Table 1 shows the flexural properties of lumber by size class and visual grade category of all logs obtained from the stand. Also shown in these tables are the number of lumber pieces tested and the average specific gravity (SG) and moisture content (MC) of lumber in the aforementioned classifications. Although the moisture content of the tested lumber was 8.5%, it is not expected to significantly influence the results since any positive effect from the lower MC% on the strength and stiffness of the lumber is negated by the additional negative influence from the defects (Green et al. 1986). In addition, the table shows the bending strength value (BSV) required by SPIB grading rules (1994) for

each visually graded piece and the stiffness design value, E, recommended by SPIB grading rules as the average value for each visual grade. Table 1 shows that the distribution of visual grades of all tested lumber is 44% for No. 1, 40% for No. 2, and 15% for No. 3 and below. The No. 1 grade lumber recovery in this case is exceptionally good compared to that of younger loblolly stands.

Table 1 also presents what is considered to be the most important results of the study, i.e., a measure of the degree of compliance of visually graded lumber to standard requirements of strength and stiffness set for a given visual grade classification. In terms of strength, lumber obtained from the 50-year-old loblolly stand exhibited a very high level of compliance; on average (i.e., regardless of grade), 99% compliance. In terms of stiffness, which is considered a more sensitive parameter for lumber of younger loblolly pine plantation stands, on average 94% of the lumber produced from the 50-year-old stand had E-values that exceeded the published "E" for the corresponding grade.

The results of this study reinforce the view that loblolly pine plantations managed for sawtimber production should have a 50-year harvest rotation. Such a management option is also more economically desirable than managing the same stand for pulpwood production based on a 20-year rotation (Biblis et al. 1998).

CONCLUSION

It can be concluded from the results of this limited study that dimension lumber produced from a 50-year-old loblolly pine plantation meets the flexural strength and stiffness requirements for the corresponding visual grades.

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REFERENCES

- AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM). 1994. Standard methods of static tests of timbers in standard sizes. D 198-84. Standard method for establishing structural grades and related allowable properties for visually graded lumber. D 245-81. Annual Book of ASTM Standards, section 4, vol. 04.09. Philadelphia, PA.
- BENDTSEN, B. A. 1978. Properties of wood from improved and intensively managed trees. *Forest Prod. J.* 28(10): 61-72.
- BIBLIS, E. J. 1990. Properties and grade yield of lumber from a 27-year-old slash pine plantation. *Forest Prod. J.* 40(3):21-24.
- , R. BRINKER, H. F. CARINO, AND W. C. MCKEE. 1993. Effect of stand age on structural properties and grade compliance of lumber from loblolly pine plantation timber. *Forest Prod. J.* 43(2):23-28.
- , H. CARINO, R. BRINKER, AND W. C. MCKEE. 1995. Effect of stand density on flexural properties of lumber from two 35-year-old loblolly pine plantations. *Wood Fiber Sci.* 27(1):25-33.
- , ———, AND ———. 1997. Flexural properties of lumber from two 40-year-old loblolly pine plantations with different stand densities. *Wood Fiber Sci.* 29(4):375-380.
- , ———, AND L. TEETER. 1998. Comparative economic analysis of two management options for loblolly pine timber plantations. *Forest Prod. J.* 48(4):29-33.
- GREEN, D. W., C. L. LINK, A. L. DEBONIS, AND T. E. MCLAIN. 1986. Predicting the effect of moisture content on the flexural properties of southern pine dimension lumber. *Wood Fiber Sci.* 18(1):134-156.
- MACPEAK, M. D., L. F. BURKART, AND D. WELDON. 1990. Comparison of grade, yield, and mechanical properties of lumber produced from young fast-grown and older slow-grown planted slash pine. *Forest Prod. J.* 40(1): 11-14.
- PEARSON, R. G., AND R. C. GILMORE. 1971. Characterization of the strength of juvenile wood of loblolly pine (*Pinus taeda* L.) *Forest Prod. J.* 21(1):23-30.
- , AND ———. 1980. Effect of fast growth rate on the mechanical properties of loblolly pine. *Forest Prod. J.* 30(5):47-54.
- SOUTHERN PINE INSPECTION BUREAU. 1994. Grading rules. SPIB, Pensacola, FL.