# AN OVERVIEW OF SILVICULTURAL INFLUENCES ON LOBLOLY PINE VENEER-BASED PANEL PROPERTIES


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( **ABSTRACT** )Loblolly pine (*Pinus taeda* L.) harvested from five silviculturally different stands was used to manufacture 13-ply laminated veneer lumber (LVL) and 3-ply plywood. LVL panels were assembled as either all A-grade or all C-grade veneer. Plywood panels were produced according to four different veneer grade layups (AAA, ACA, ACC, and CCC). Many significant differences in modulus of elasticity (MOE) and modulus of rupture (MOR) were found to exist between the stands for both panel products. MOR significantly varied according to stand for both LVL but not plywood, and MOE varied significantly according to stand for plywood but not LVL.


## INTRODUCTION

Loblolly pine (*Pinus taeda* L.) is the principal timber species in the southern United States for a variety of wood-based products. Consequently, numerous investigations have been conducted to assess its properties. Southern yellow pine plantations presently make up one-third of the acreage in pine forests but are projected to account for 56 percent of all pine stands by the year 2000. By 2030, plantations are expected to make up two-thirds of the South's pine forests [4].

## MATERIALS AND METHODS

For this study, five representative trees each from five silviculturally different loblolly pine stands growing near Crossett, AR were harvested and bucked into peeler bolts (Table 1). All stands are described in detail by Baker and Bishop [3] and Shupe et al. [6].

All bolts were rotary-peeled by Hunt Plywood at Pollock, LA, USA to a target thickness of 1/8-in. Laminated veneer lumber (LVL) panel fabrication was accomplished at a Riverwood International plywood mill at Joyce, LA, USA. A commercial extended phenolic resin (52 % solids) was applied to veneers with a curtain coater at a rate of 92 pounds per 1,000 ft.$^2$ of double glue-line. The four replicate billets of each specific assembly type were cut into beams of approximately 1.5 in. x 3.75 in. x 8 ft. Edgewise bending specimens were tested in accordance with ASTM D-198 [1].

Three-ply plywood panels were produced from veneer from each stand with four different layups. The layups were (1) all A-grade veneer (AAA), (2) all C-grade veneer (CCC), (3) A-grade veneer on one face only and C-grade veneer on the other face and core (ACC), and (4) A-grade veneer on each face and C-grade veneer in the core (ACA). Four panels (21 in. x 21 in.) were manufactured for each specific veneer layup from each of the five stands. A commercial phenol formaldehyde resin (43% solids) was mixed according to the manufacturers recommendations and spread at 75 lbs. per 1,000 ft.$^2$ of double glueline. Plywood bending specimens were tested in accordance with ASTM D-4761 [2].

Table 1. Basic stand information mean values of the five harvested loblolly pine trees from each of the five stands growing near Crossett, Ark, USA.

| Stand | Age (Yrs.) | Height (ft.) | DBH[1] (in.) | Basal area (ft. ²/acre) | Site index | Live crown ratio (%)[2] |
|---|---|---|---|---|---|---|
| 1 - Sudden sawlog | 48 | 94.2 | 21.1 | 90 | 95 | 56 |
| 2 – Conventional | 48 | 93.8 | 15.3 | 118 | 95 | 39 |
| 3 – Natural | 48 | 98.6 | 16.4 | 76 | 100 | 39 |
| 4 - Single tree | 49 | 88.6 | 16.4 | 72 | 89 | 55 |
| 5 - Crop tree | 79 | 110.2 | 24.7 | 42 | 97 | 56 |

[1]Diameter at breast height.

[2]Live crown ratio = {length of live crown / total length of tree} x 100

## RESULTS AND DISCUSSION

The effect of silvicultural practice and veneer grade on LVL modulus of rupture (MOR) and modulus of elasticity (MOE) is shown in Table 2. Results from unpaired t-tests indicate that the MOR of the A-grade panels from stand 1 (1-A) (12,045 psi) is significantly higher than 2-A (10,268 psi), 3-A (9,584 psi), and 4-A (10,631 psi) by 17, 26, and 13 percent, respectively (Table 3). The high strength of LVL made from stand 1 (sudden sawlog) can be partially attributed to the higher specific gravity of these panels (Table 2). A similar trend was observed for the MOR of the C-grade specimens. The MOR of group 1-C (9,307 psi) was significantly greater than 2-C (8,156 psi) and 4-C (7,595 psi) by 14 and 23 percent, respectively. However, 3-C (9,454 psi) yielded a slighter higher edgewise MOR than 1-C, although not significantly greater.

It is interesting to note from data in an earlier study on these same stands by Groom and Mullins [5] that all of the A-grade veneer from stand 1 (sudden sawlog) came from the bottom 20 ft. of the trees. All of the C-grade veneers were obtained from the area 20-30 ft. above the stumps. None of the stand 1 (sudden sawlog) veneer came from the live crown area, which is the upper area of the crown that is still alive. The live crown ratio (percentage of total tree height comprised of living braches) for harvested trees from this stand was fifty-six percent (Table 1).

The factorial analyses of the plywood bending strength found that the stand effect was a significant source of variation for MOE. The mean latewood percentage from the five stands ranged from 53 - 61 percent and appeared not to be influential for mechanical properties (Table 3).

Table 2. Effect of silvicultural practice and veneer grade on edgewise mechanical and physical properties of loblolly pine laminated veneer lumber [6].

| Stand-Veneer grade[1] | Moisture content (%) | Specific gravity[2] | MOR (psi) | MOE (x $10^6$ psi) |
|---|---|---|---|---|
| 1-A | 11.45[3] (5.04)[4] | 0.73 (3.31) | 12,045 (5.52) A[5] | 2.09 (1.25) A |
| 1-C | 11.49 (4.12) | 0.68 (2.98) | 9,307 (1.13) a | 2.01 (4.97) a |
| 2-A | 10.43 (3.19) | 0.70 (3.33) | 10,268 (3.74) B | 2.11 (5.26) A |
| 2-C | 10.23 (4.00) | 0.65 (3.98) | 8,156 (1.34) c | 1.95 (1.66) a |
| 3-A | 11.48 (2.95) | 0.66 (4.09) | 9,584 (3.67) B | 1.68 (6.48) A |
| 3-C | 11.23 (1.09) | 0.64 (4.10) | 9,454 (3.56) a | 1.65 (3.98) a |
| 4-A | 10.86 (3.06) | 0.68 (4.65) | 10,631 (1.39) B | 2.19 (3.40) A |
| 4-C | 10.79 (4.95) | 0.64 (3.93) | 7,595 (2.50) c | 1.76 (2.22) a |

[1]The number to the left of the dash represents the stand and the letter to the right corresponds to panel fabrication wit either all A-grade veneer (A) or all C- grade veneers.

[2]Specific gravity based on volume at 11% equilibrium moisture content and ovendry weight.

[3]Represents the mean of 11 samples.

[4]Values in parenthesis are coefficients of variation (%).

[5]Unpaired t-tests were made within each column. Capitol letters denote all A-grade specimens and lower

Table 3. Effect of silvicultural practice on physical and mechanical properties of 3-ply loblolly pine plywood [7].

| Stand | Latewood (%) | MC[3] (%) | SG[4] | MOR (psi) | MOE (x $10^6$ psi) |
|---|---|---|---|---|---|
| 1 | 57.15[1] (2.15)[2] | 7.2[5] | 0.67 | 13,202 AB[6] (0.53) | 2.13 B (0.40) |
| 2 | 53.14 (2.54) | 7.3 | 0.68 | 14,008 A (0.41) | 2.39 A (0.26) |
| 3 | 60.72 (0.70) | 7.3 | 0.65 | 12,632 B (0.56) | 2.10 B (0.35) |
| 4 | 60.81 (1.76) | 7.4 | 0.69 | 12,120 A (0.61) | 2.10 B (0.38) |
| 5 | 56.86 (1.19) | 7.7 | 0.63 | 11,827 B (0.68) | 1.86 C (0.56) |

[1]Each mean value represents the mean of 12 samples.
[2]Coefficient of variation (%).
[3]Moisture content (%) ovendry basis.
[4]Specific gravity based on volume and weight at 40% RH and 110°F.
[5]Each mean value represents the average of 96 samples.
[6]Tukey grouping.

Stand 2 gave the highest MOR (14,008 psi) and was significantly superior for MOE. This finding is important in that a conventional Southern yellow pine (SYP) stand, which was managed for lumber production, yielded plywood MOR that was 6 and 10 percent higher, respectively, than stand 1 and stand 3. The sudden sawlog silvicultural method is considered advantageous for rapidly producing sawlogs, but appears less favorable for plywood. Therefore, our finding suggests that foresters will not need to segregate stands for either end-product (lumber or plywood), but simply continue to manage in a traditional manner and produce whatever product that is most economically advantageous at harvest. In short, no special silvicultural method appears necessary to produce Southern pine plywood with favorable mechanical properties.

The stands displayed a similar pattern for MOE as was shown for MOR (Table 3). Stand 2 (2.39 x $10^6$ psi) was significantly superior to stands 1, 3, 4, and 5 by 11, 12, 12, and 22 percent, respectively. It was our intention to randomly select veneer from various trees, peeler bolts and locations within the bolts for each stand for panel fabrication. This would allow the panels from each stand to be more representative of a particular stand and differences between stands to be attributable to the stands rather than bias sampling from specific peeler bolts or zones within a bolt.

It is interesting to compare the LVL and plywood results to previous studies on these same stands on veneer mechanical properties [8] and wettability [9]. The veneer study found that Stand 4 had the highest airdry, mean tensile strength, tensile MOE, and bending MOR and was nearly the highest for bending MOE. However, differences between the stands were only significant for tensile strength [8]. The wettability results indicate very minimal differences on tight and loose sides and on earlywood and latewood in mean contact angles between the stands.

## CONCLUSIONS

Most LVL and plywood properties were significantly affected by silvicultural practice. MOR significantly varied according to stand for both LVL but not plywood. However, MOE varied significantly according to stand for plywood but not LVL. With regards to LVL, maximum flexural strength and stiffness values were obtained from stand 1, which was managed to produce sawlogs as rapidly as possible stand 1. All A-grade veneer panels from stand 1 (1-A) gave significantly higher values for edgewise and flatwise MOR, but no significant differences were observed for either edgewise or flatwise MOE. Stands 1-4 can be considered statistically similar for MOE. For plywood properties, stand 2 gave the highest, but not significantly, mean MOR and significantly highest mean MOE.

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