Chapter 8
Properties of Red Maple Laminated Veneer Lumber

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Past research has shown that red maple has excellent potential as a structural material. Research studies have demonstrated, for example, that solid-sawn red maple can perform well in commonly used engineered components such as trusses and prefabricated I-joists. In addition, red maple lumber can be used in glued-laminated (glulam) timber. These efforts are based upon earlier research that showed the good to excellent mechanical properties of red maple wood (Green and McDonald 1993).

Engineered composite materials represent one of the fastest growing segments of the wood products industry. Wood composite I-joists are used in more than 40 percent of new residential construction in North America, and laminated veneer lumber (LVL) is the primary material in I-joist manufacture. LVL is made in large billets from veneer sheets that are bonded together with an adhesive system. The billets can be produced to a specified thickness and cut to a desired width. One of the most significant technical advantages of LVL is that specific performance characteristics can be incorporated into its design. By strategically placing selected veneer sheets within the composite, it is possible to manufacture a wood-based product that has well-controlled physical and mechanical properties. This enables LVL to be used in a variety of products, such as commodity structural components, wind turbine blades, and other specialty products. Although southern pine and Douglas-fir are the dominant raw materials currently used in LVL production, LVL can be manufactured from a wide range of wood species.

The purpose of the work reported in this chapter was to examine the flexural properties of LVL manufactured from ultrasonically rated red maple veneer sheets. The specific objectives were:

1. to determine the flatwise and edgewise bending properties of 1/2-inch- (1.3-cm-) thick red maple LVL billets, and
2. to examine the relationship between nondestructive parameters of red maple veneer and flexural properties of LVL billets.

Materials and Methods

The flatwise and edgewise bending properties of LVL billets were determined and the predictability of their structural performance explored. The experimental procedure is shown in **Figure 8.1.** Twelve red maple veneer sheets that had been ultrasonically rated were manufactured into 12 LVL billets in the laboratory. The sheets were selected on the basis of their corresponding dynamic modulus of elasticity (MOE_d) values. The MOE_d of red maple veneer was calculated from wave propagation time *(T),* gauge length *(L),* and veneer density (ρ) using the equation:

$$MOE_d = \left(\frac{L}{T}\right)^2 \rho$$

The moisture content of the veneer ranged from 5 to 8 percent at the time of ultrasonic testing.

Each 50- by 101- by 0.125-inch (127- by 257- by 0.3-cm) veneer sheet was first cut into four 25- by 50- by 0.125-inch (64- by 257- by 0.3-cm) sheets. The four sheets were then pressed into a 0.5-inch- (1.3-cm-) thick LVL billet. A phenol-formaldehyde resin was applied at a rate of 34 lb/10^3 ft^2 (166 g/m^2) in

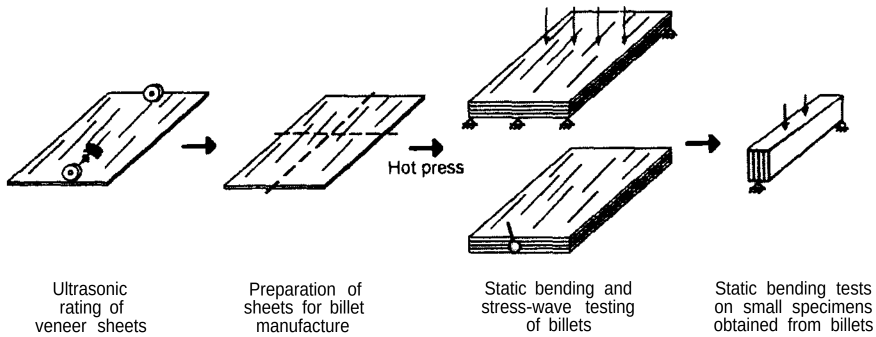

Figure 8.1. – Flow chart for this study.

LVL fabrication. Each billet was hot pressed at 175 lb/in^2 (1.21 MPa) for approximately 3 minutes at a platen temperature of 300°F (149°C). After hot pressing, billets were allowed to cool for 24 hours. They were then trimmed and tested nondestructively using stress wave and static bending (center-line loading) test methods to obtain estimates of modulus of elasticity (MOE).

Six 1- by 20- by 0.5-inch (2.5- by 51- by 1.3-cm) specimens were cut from each billet, parallel to grain. These specimens were conditioned at 74°F (23°C) and 65 percent relative humidity (12% equilibrium moisture content) for several weeks. Specimens were then tested to failure in edgewise bending using third-point loading. Both edgewise bending MOE (MOE_{ew}) and modulus of rupture (MOR) values were then determined.

Results and Discussion

Test results for the (0.5-in.- [1.3-cm-] thick) billets and corresponding small specimens are summarized in **Table 8.1.** The average values for billet MOE and small specimen MOE are similar to bending MOE values reported in the Wood Handbook for clear red maple (USDA 1999). The observed MOR values for the small specimens are slightly lower than corresponding clear wood values. These results are encouraging as they indicate that the stiffness and strength of LVL manufactured from red maple would be comparable to that of clear wood. While these results are notable, caution should be exercised because the sample size was small.

To explore the predictability of structural performance of LVL billets manufactured from ultrasonically rated red maple veneer, linear regression analysis was conducted to examine the relationship between nondestructive parameters of red maple veneer and static bending properties of corresponding LVL billets. The results of regression analysis are summarized in **Table 8.2.**

Table 8.1. – Results of tests on LVL billets[a] and corresponding small specimens.[b]

Billet	Veneer MOE_d	Billet MOE_{fw}	Small specimen MOE_{ew}	Small specimen MOR
	- - - - - - - - - - - (×10~ lb/in²)	- - - - - - - - - - -		(lb/in^2)
1	1.51	1.09	1.44	9,930
2	1.80	1.91	1.67	12,034
3	2.32	2.06	1.82	13,605
4	1.67	1.68	1.43	12,210
5	1.75	1.69	1.50	13,637
6	2.10	1.87	1.72	14,414
7	1.37	1.40	1.41	8,265
8	1.34	1.09	1.20	8,600
9	2.04	1.81	1.81	14,218
10	1.44	1.47	1.28	11,296
11	1.64	1.75	1.64	11,204
12	2.13	1.82	1.78	15,564
Average	1.76	1.64	1.56	12,081
SD	0.311	0.299	0.202	2,228.5

a 0.5 inch (1.3 cm) thick.

b MOE, is dynamic modulus of elasticity; MOE_{fw} is flatwise bending modulus of elasticity; MOE_{ew} is edgewise bending modulus of elasticity; MOR is modulus of rupture; SD is standard deviation.

Table 8.2. – Results of linear regression analysis of relationship between nondestructive parameters of red maple veneer and flexural properties of LVL billets.[a]

Nondestructive parameter of veneer *(x)*	Flexural properties of LVL *(y)*	$y = a + bx$ a	b	r	Syx
T	MOE_{fw} of billet	4.810	-0.0478	0.78	0.203
	MOE_{ew} of small specimen	3.897	−0.0352	0.86	0.114
	MOR of small specimen	36,480.6	−367.4	0.81	1,435.47
MOE_d	MOE_{fw} of billet	0.217	0.8068	0.84	0.177
	MOE_{ew} of small specimen	0.517	0.5918	0.91	0.090
	MOR of small specimen	956.3	6,324.1	0.88	1,145.36

a *T* is ultrasonic wave propagation time: MOE_d, is dynamic modulus of elasticity; MOE_{fw} is flatwise bending modulus of elasticity; MOE_{ew} is edgewise bending modulus of elasticity; *r* is correlation coefficient; S_{yx} is standard error of estimate.

Figures 8.2 and 8.3 illustrate typical relationships between nondestructive parameters of red maple veneer and static bending properties of LVL billets and small specimens. Both wave propagation time and dynamic MOE of veneer are significantly correlated to the static bending properties of the LVL billets. The correlation coefficients for the relationships range from 0.78 to 0.86 for *T* versus $MOE_{fw/ew}$/MOR and 0.84 to 0.91 for MOE_d versus $MOE_{fw/ew}$MOR. Dynamic MOE of red maple veneer, as calculated from wave propagation time, gauge length, and veneer density, is apparently a better predictor of the structural properties of LVL billets than is wave propagation time. This indicates that both ultrasonic wave propagation time and veneer density should be taken into account when using ultrasonic propagation to sort red maple veneer for LVL manufacture.

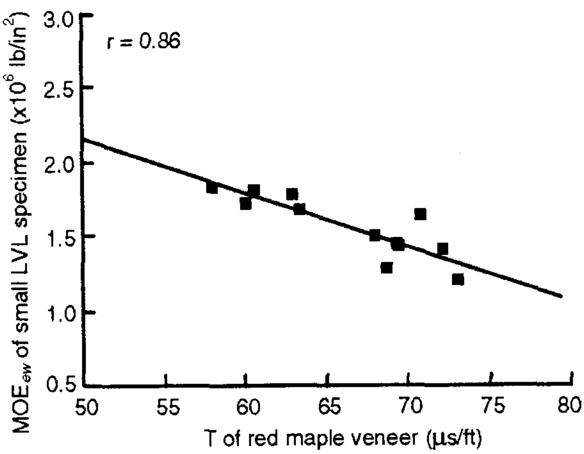

Figure 8.2. – Relationship between ultrasonic wave propagation time *(T)* of red maple veneer and edge-wise bending MOE (MOE_{ew}) of small LVL specimens.

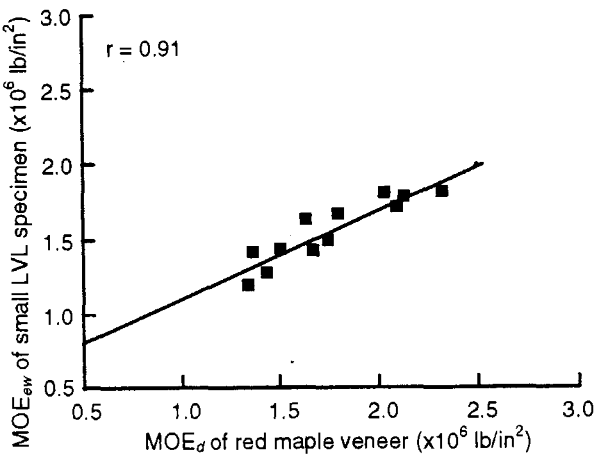

Figure 8.3. – Relationship between stress wave MOE (MOE_{sw}) of red maple veneer and edgewise bending MOE of small LVL specimens.

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