LAMINATED VENEER LUMBER

A high-quality structural lumber substitute

by

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SYNOPSIS

Laminated veneer lumber (LVL) represents a design alternative for structural lumber users. Depending upon the process and species used in manufacture, a wide range of performance characteristics and product costs are possible. This paper reviews processing options, discusses research completed, and covers existing product uses. Comments are also included on the future outlook for this technology.

INTRODUCTION

The objective of this paper is to provide an overview of the various processes by which laminated veneer lumber (LVL) can be produced, and then to discuss application experiences and prospective uses for this material. The future outlook for this new industry is also discussed.

Strong incentives presently exist for the commercial development of processes aimed at producing new, high-yield structural products from wood. These incentives include: 1) overcoming the problem created by the diminishing supply of large logs suitable for lumber of large dimensions, and 2) optimizing the economic picture by using an increasing percentage of the forest biomass previously considered forest residue.

Much has been written about materials made by laminating veneer. It began in 1944 with the production of aircraft parts manufactured by glue-laminating 1/7-inch (3.63 mm) Sitka spruce veneer. At that time, Luxford[1] showed that clear laminated and clear solid wood material possessed equal strength properties.

Because future demand for wood structural products is expected to increase, the U.S. Forest Products Laboratory (FPL) has concentrated a significant portion of its research program on improving processes for manufacturing structural materials suitable for both exterior and interior use. In this regard, parallel-laminating veneer sheets from either hardwoods or softwoods, using a staggered or overlapping jointing system (i.e. one with no preformed end joint), has proved to be an effective method of producing structural products with more predictable and uniform properties, when compared to solid members.

Lumber-like products generally can be produced by parallel-laminating rotary-peeled veneer into thick, wide, and long panels that can be sawed into desired widths and lengths.

PROCESSING OF LVL

LVL has been used for many years by the furniture industry to produce curved furniture parts. In the last 15 years, however, much larger volumes of LVL have appeared in the marketplace as the amount and availability of high-quality solid-sawn lumber for use in demanding structural applications has become more scarce and thus more expensive. Uses for this material include chords of truss joists and flanges of I-section joists and beams, and as tension laminations in glued-laminated beams. This demand Las spurred the development of new production technologies.

Nearly all schemes to produce LVL for structural use somewhat resemble those of established plywood operations.[2] Veneer is rotary peeled, dried, spread with adhesive, assembled in the desired configuration, pressed either in conventional plywood presses or on a continuous or step basis, then ripped to width. Innovations to the conventional process have been developed largely to accommodate the performance requirements of specific end products.

Continuous pressing LVL is currently used in commercial manufacture of MICRO=LAM®[3] and by Metsäliiton Teollisuus Oy, Finland, for producing Kertowood®[4] Descriptions of these processes are unpublished, except for the use of phenol-formaldehyde resin and 1/8- to 1/10-inch (3.18 to 2.54 mm) veneers.

Composite studs and planks have been prepared utilizing structural particleboard cores and veneers to produce lumber substitutes.[5] Again, the basic components are derived from structural panel plants and have the advantages of consistent strength and stiffness in unlimited lengths and sizes. Arrowood Technologies, Ltd., of Roxboro, North Carolina, is building a plant to produce COM-PLY® structural framing material, primarily 2 inch (50.8 mm) by 8 inch (20.32 cm), by 10 inch (25.4 cm) and by 12 inch (30.48 cm) up to 36 feet (10.97 m) long for use as floor joists.

Another more recent proposal has been to produce structural lumber substitutes using parallel-strand lumber (PSL). Such schemes would develop cross sections in a continuous process using long strands (up to 1 to 2 feet (30.48 to 60.96 cm) developed either from veneer or other processes utilizing roundwood as the basic raw material source. Again, the perceived advantages are unlimited sizes and lengths, consistent properties, and very high mechanical properties.

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To produce its Press-Lam®, the FPL rotary-peeled veneer, press-dried it, spread the sheets with adhesive, hot-laminated them with staggered butt joints, and step-pressed them in a cold end-loading press?" One major drawback of this process was its reliance on residual drying heat in order to cure the adhesive; this necessitated short assembly times, but resulted in short press cycles. Two pieces of new equipment were required to make Press-Lam's manufacture feasible: a continuous press dryer for veneer and a continuous cold-press.

In other early research, continuous hot-pressing[8] was used by Canadian researchers to press 1/4-inch (6.35-mm) cold veneer into a 1-1/2-inch- (38.1-mm) thick panel; veneers were laminated sequentially to form 1/2-inch- (12.7-mm) , 1-inch- (25.4-mm), and finally 1-1/2-inch- (38.1-mm) thick products. An end-loading hot-press and an intermittent press sequence were also used for producing continuous LVL panels.

Continuous processes for the manufacture of LVL require substantial capital investments, thus limiting production of LVL. If existing plywood facilities were adapted to processing of 5/8-inch- (15.88-mm) to 1-1/2-inch- (38.1-mm) thick panels, subsequent panel ripping and end jointing of the resultant structural components could conceivably compete both in price and performance with the highest structural grades of lumber. Completed research[9] has indicated that unjointed 8-foot (2.44-m) LVL made from mill-run C-grade 1/8- or 1/10-inch (3.18- to 2.54-mm) veneers can be made, with adequate processing quality control, and provides an adequate substitute for high grades of structural lumber. Preliminary conclusions from this limited testing also show no width effect for different grades or thicknesses of veneer. End jointing of 3/4-inch (19.05-mm) LVL with scarf joints with a slope of 1:8.3 resulted in a retention of 95% of the material tensile strength. Vertical finger joints retained 83% of the material tensile strength, and horizontal finger joints yielded 71%. End-jointed 3/4-inch (19.05-mm) LVL provided tensile strengths that exceed the American Institute of Timber Construction 301B grade[10] of laminating lumber and the Select Structural grades of structural lumber." While end jointing of LV is feasible, it should be noted that there are practical problems involved in end jointing high-strength material which must be solved, and extra quality control steps are required to assure satisfactory results. Offset scarf joints or 3 stage-folded scarf joints can be used to join nominal 2-inch (50.8-mm) LVL cut from B-foot (2.44-m) lengths, to provide tensile strengths with sufficiently low variance to justify preliminary calculated design levels from 2,000 pounds per square inch (psi) to 2,400 psi (140.6 to 168.7 kg/cm^2).

This research[9] opens the door to a number of product and process options. For example, although additional quality control would be required, structural grades of LVL could be produced in plywood facilities with visually graded veneer. These 8-foot (2.44-m) lengths, ripped to lumber widths, could then be end jointed in a laminating plant, under proper quality control guidelines, to produce lengths of high-grade structural lumber.

MARKETS FOR LVL

A marketing research study by Youngquist and Bryant[12] identified 21 potential market areas for products of LVL. by end-use requirements, essential product properties, price, and potential U.S. market volume. Even though this work was published over 5 years ago, the markets identified then and the market volumes reported are still probably on target.

Table 1 presents a summary of essential product properties, initial judgments as to the technical feasibility of the product, and comments relating to what characteristics each of the seven selected products should possess. An analysis of this table indicates that, from a technical standpoint, relatively large existing markets are available for longer, wider material with uniform strength properties.

Table 2 summarizes economic information for the markets discussed in Table 1, and provides an estimate of the total market volume for each of the products. The low and high cost figures for the laminated veneer "substitute" product were calculated from the various LVL cost estimates plus a cost factor depending upon the particular requirements of the end product. From these data, it appears that LVL truck decking provides the greatest cost differential and thus potential for the greatest profits. In studying Table 2, it should be remembered that veneer prices and lumber prices do not maintain the same ratio over time. Therefore, differences between the LVL and lumber values shown can be expected to vary in either direction as conditions affecting veneer and lumber values vary.

Additional markets considered potentially promising are summarized in Table 3, which provides a comparative judgment as to price and performance of LV products for the markets considered. From this analysis, it appears that purlins, joists, tension laminations for glulam beams, and mobile home truss chords are promising markets for LVL.

FUTURE OUTLOOK

There has been considerable activity in the United States recently aimed at development of standards, approval of codes, the marketing of a continuous process for producing LVL, and startup of new plants.

To meet the need of production expected soon to approach commodity levels, two standards for LVL have been developed. The first is by the American Institute of Timber Construction (AITC) based in Englewood, Colorado, which provides for LVL as a substitute for tension laminates. This standard, AITC 402,[15] is contained in the AITC Inspection Manual. Another approach to LVL standardization is a draft standard under development by the American Plywood Association APA). The APA standard uses performance ratings and will provide for trademarking based on the mechanical capabilities of the product. This standard will be available after review by the industry standards committee.

A natural development stemming from the manufacture of new structural panel products and structural lumber substitutes is the combination of these products into various components.

A noteworthy composite product is the I-shaped beam using structural lumber substitutes in the flanges and structural panel products in the webs. The Trus-Joist Corporation has had significant production of these beams for many years, and other manufacturers are now producing them. Their apparent advantages are light weight, unlimited length, better dimensional stability, and economical viability as an alternative to solid-sawn products.

In view of increasing production, a group of the panel-webbed I-beam producers has been meeting to develop an industry standard which will allow for the rational development and marketing of a variety of cross-sectional shapes and sizes. These structural components should find their way into many flooring and roofing systems.

At this writing there are four LVL producers that have obtained code-approved stress values for their products.

1. Trus-Joist Corporation, Boise, Idaho. This firm's MICRO=LAM®, which is manufactured by laminating Douglas fir (Pseudotsuga menziesii) 1/8- or 1/10-inch (3.18- to 2.54-mm) veneers in a continuous press using a crushed lap joint, has received a Council of American Building Officials National Research Board Approval.[16]

2. McCausey Lumber Company, Detroit, Michigan. This firm markets a product trade-named Basterplank® for U.S. markets, and Kertopuu® when marketed in other parts of the world. The product is manufactured by Metsäliiton Teollisuus Oy in Lohja, Finland. This product has received a Southern Building Code Congress International approval for framing systems.[17] The material is made using 0.110-inch- (2.79-mm) thick veneers of either Scotch pine (Pinus sylvestris) or Norway spruce (Picea abies), which are individually scarf jointed together before lamination into the panel configuration in a continuous press operation.

3. Weyerhaeuser Company, Tacoma, Washington. This firm's Lamineer®, made from Douglas fir veneer up to 1/8 inch (3.18 mm) thick, on conventional plywood manufacturing equipment, has received approval is for use as one grade of tension ply lumber.

4. MacMillan Bloedel, Ltd., Vancouver, B.C., Canada. This company's Parallam®, made using long lengths of thin veneer edgings and trim waste which are glued together using a crushed lap joint, has received approval[18] for use as structural beams or joists.

The Raute Company, headquartered in Lahiti, Finland, has developed and is now selling a complete line of equipment for the manufacture of LVL. The Metsäliiton products, Kertopuu® and Masterplank®, are produced using the Raute system; and Gang-Nail Systems, Inc., Wilmington, NC, has recently announced that they intend to purchase a Raute LVL line. Gang-Nail plans to produce LVL continuously in 48-inch (1.22-m) widths and in thicknesses ranging from 3/4 inch to 3-1/2 inches (19-90 mm), for use in I-beams and joists.

The Trus-Joist Corporation has stated their interest in selling their equipment and licensing their technology worldwide. Presently, they are actively seeking customers in the Pacific basin through their subsidiary, Trus-Joist Japan, Inc.

SUMMARY

Structural lumber substitutes and combinations of panels with these substitutes are being made into components and are seen as a growing business which could reach major commodity proportions in the next 5 to 10 years. These products include laminated veneer lumber, composite lumber, and parallel-strand lumber. As these new products begin to find their way into structural uses, sound research and an expanded data base are necessary for their successful utilization.

NOTICE

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TABLE 1

Promising laminated veneer markets property requirements and judgments as to success probability[1]

Product	Important property requirements	Judgment as to technical feasibility	Optimum product
Headers	High flexural strength High resistance to deflection Good dimensional stability	Excellent	Deep, long lengths Thicknesses ranging from 4 to 6 inches
Horizontal truss chords	Strength values of 2,000 psi tension-minimum MOE range 1.6-1.8 x million psi Deflections down to a range of 1/180 to 1/480 Good dimensional stability	Excellent	Consistent and relatively high strength-to-weight ratio needed Straightness and low warp essential
Manufactured housing	Good dimensional stability Good nail-holding ability High deflection resistance Good structural properties	Excellent	Long lengths Wide choice of depths and thicknesses Prefabricated pieces ready for Installation
Mobile home truss chords	Good strength-to-weight ratio High flexural and tension properties Good dimensional stability	Excellent	Material 7 to 14 feet long Prefabricated pieces ready for installation
Truck deck Container deck	High flexural strength High resistance to deflection High impact resistance High resistance to rolling shear forces Good abrasion resistance Good fastening capabilities	Excellent	Presized, predrilled panels ready for installation
Scaffold planking	High flexural strength High resistance to deflection Weather resistance Good nail-holding Resistance to warping Nonslip/skid resistance High reliability-uniformity	Excellent	Prefabricated to required size Pretested due to high product liability potential
Electrical distribution crossarms	High flexural strength about both axes Resistance to torsional forces High penetration sad retention of preservatives Good dimensional stability Low conductivity	Good-excellent[2]	Prefabricated Combinations of low-grade solid-sawed and parallel-laminated outer faces possible

[1]All values except for manufactured housing are from University of Washington.[13] Value for manufactured housing is from U.S. Department of Commerce."

[2]Market penetration is highly dependent on prevailing price and availability of solid sawed crossarms.

TABLE 2

Promising markets for parallel laminated veneer (PLV) products[1]

Potential market	Finished product prices, Existing product	PLV product Low	PLV product High	Estimated total market,
	- $/Mfbm, or $/unit - ($/m^3)			MMfbm/yr (m^3/yr)
Truck decking	580-1,000 (245-424)	345 (146)	604 (256)	42/1976 (99,057/1976) 104/1980 (245,283/1980)
Scaffold planking	600 (254)	490 (208)	575 (244)	16/1975 (37,736/1975)
Garage headers	25-75 (ea.) (11-32)	17 (ea.) (7)	46 (ea.) (20)	
Manufactured housing	150-800 (64-339)	350*	575	883/1972 (2,082,547/1972)
Mobile home truss chords, ridge beams	400-600 (170-243)	403 (171)	575 (244)	5/-- (11,792/--)
R.E.A. crossarms	9-11* (ea.)	10* (ea.)	14* (ea.)	12/1976 (28,302/1976)
Horizontal truss chords and tension lam stock	500-600 (212-254)	489 (207)	575 (244)	500/-- (1,179,245/--)
Ladder rails	500 (212)	380* (161)	430* (182)	0.8/1976 (1,887/1976)

[1]All values except for manufactured housing are from University of Washington.[13] (Updated to Nov. 1977 where indicated)*. Value for manufactured housing is from U.S. Department of Commerce.[14]

TABLE 3

Laminated veneer marketing study of potentially promising markets

Market	PLV price compared to existing product price[1]	Judgment as to performance suitability[1]	Estimated market volume
Roof decking	=to(-)	(-)	--
Ladder rails	=to(+)	(+)	1.7 MMfbm ($4,009\ m^3$)
Mobile home ridge beams	=to(+)	(+)	32 Mfbm ($76\ m^3$)
Purlins/timbers	=to(+)	(+)	100 MMfbm ($235,849\ m^3$)
Small glulam beams, PLV face lams (including crossarms)	=to(+)	(+)	840 Mfbm ($1,981\ m^3$)
Joists	=to(+)	(+)	--
Garage door headers	=to(-)	(+)	42 MMfbm ($99,057\ m^3$)
Tension lams for glulam beams	=to(+)	(+)	8.4 MMfbm ($19,811\ m^3$)
Mobile home truss chords	=to(+)	(+)	5 MMfbm ($11,793\ m^3$)

[1](+), (-) indicates laminated veneer most likely will (+) or will not (-) be able to compete on a price and/or performance basis with existing products.

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