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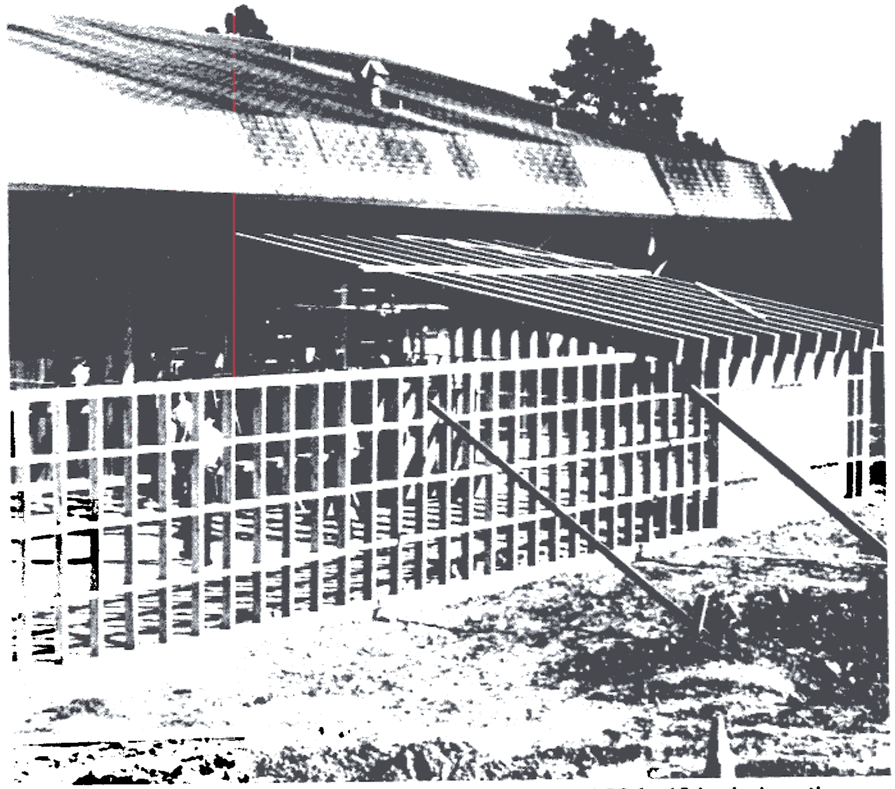
By laminating ¼-in. rotary-cut veneer into structural lumber, manufacturers can expand lumber output by at least 30% without increasing volume logged. The idea merits intensive study. Manufacturing plus raw material costs should total about $142/Mbf; sales price for desirable widths and lengths of the strong laminated product should approach or exceed $200/Mbf



Rafters 24 in. on centers, 3 in. thick, 12 in. deep and 32 ft. 10 in. in length were manufactured from ⅛-in. rotary-peeled Douglas-fir veneer. They were designed to take roof load of 39 lbs/ft² (live plus dead load) without exceeding 1.5 in. deflection over a 30-ft span.

Laminated lumber may be more profitable than sawn lumber

By PETER KOCH

PINEVILLE, LA—Reconstituted wood, in one form or another, will increasingly enter the marketplace in competition with solid wood and plywood. One of the promising reconstituted products is structural lumber laminated from rotary-cut veneer. Although several laboratories have published enthusiastic descriptions of such a product only one company in the United States is manufacturing it. Since 1970, TrusJoist Corp., Boise, ID, has produced lumber laminated from 1/8 and 1/10-in. rotary-peeled Douglas fir veneer. The lumber is 1.5 to 2.0 in. thick in widths to 24 in. and lengths to 80 ft. When loaded as a joist, its 12-in.-depth laminated material is rated by TrusJoist to have a modulus of elasticity of 2,200,000 psi and an allowable stress in bending of 2,800 psi.

Experimental data on southern pine also show that laminated lumber is surprisingly strong. When 17-ft southern pine stems were bucked into 8½-ft paired logs and one of each pair was sawn and the other peeled and laminated into 2 x 4s, the laminated 2 x 4s proved stronger than the sawn ones and also stronger than the Southern Pine Inspection Bureau values for kiln-dry select structural southern pine (SPIB 1970). See Table I.

Only dense grades of southern pine select structural and No 1 KD lumber (SPIB 1970) would have a modulus of elasticity (2,000,000 psi), slightly higher than that of the laminated log-run wood; allowable fiber stresses in bending for 2 x 4s of these grades (2,650 and 2,250 psi) would be slightly lower than that of the laminated wood.

Reasons for consideration

In addition to its superior strength, lumber laminated from veneer can be manufactured in desired lengths, widths, and thicknesses from short logs (8 ft) of small diameter (8 to 14 in.). This potential for utilizing small logs seems particularly useful in the southern pine region, where log size is likely to diminish with passing years.

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TABLE I
Strength of laminated lumber

Commodity	Allowable fiber stress in bending	Modulus of elasticity (not corrected for shear)
	psi	
Laminated 2x4 lumber (12% MC) made from ¼-in, rotary-peeled, log-run veneer	2,660	1,910,000 (1,950,000 if corrected for shear)
Sawn log-run, kiln-dry 2x4 lumber from matched logs	1,270	1,750,000
SPIB grades of sawn 2x4 lumber		
Select structural KD	2,250	1,900,000
No. 1 KD	1,900	1,900,000
No. 2 KD	1,350	1,500,000

TABLE II
Log diameter mix

Small-end diameter class	Percent of numbers of logs falling in class	Percent of volume in class (calculated as cylinders)
Inches	**Percent**	
5.0 - 6.9	72.1	36.2
7.0 - 8.9	13.8	20.2
9.0 - 10.9	7.2	16.0
11.0 - 12.9	3.8	12.0
13.0 - 14.9	2.5	10.9
15.0 and larger	.6	4.7
	100.0	**100.0**

TABLE III
Material balances

Product yield from 1 ton (ovendry) of barky saw logs	Process: Band-saw conversion to lumber	Process: Rotary peeling and laminating into lumber
	Tons, ovendry basis	
Dry, sized, double-end-trimmed lumber	0.35	0.53 (including 0.06 ton of studs from cores)
Pulp chips	.29	.29
Dry residue for particleboard	.15	.07
Sawdust	.11	.02
Bark	.10	.10
Total	**1.00**	**1.01** (including 0.01 ton of adhesive)

TABLE IV
Comparison of manufacturing requirements

Requirements to manufacture 1 ton of lumber (ovendry basis) and its residual fuel	Dry, planed lumber produced by sawing	Sized lumber laminated from rotary-peeled veneer
Man-hours expanded	3.1	4.5
Horsepower hours of mechanical energy		
Gross	179	30
Net[1]	(203)	(133)
Pounds of steam for heating or drying		
Gross	3,989	5,904
Net[1]	(2,251)	3,249
Plant depreciation, dollars	$3.91	$11.53
Tons of barky logs needed	2.86	2.13[2]

[1]Energy requirements after crediting recoverable energy from green bark and sawdust; values in parentheses are excess amounts over those needed for manufacture.

[2]These same 2.13 tons of barky logs will yield, in addition, 0.13 ton of planed, double-end-trimmed 2- by 4-inch studs from the veneer cores.

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One method of predicting future log size is to analyze diameters of logs extractable from existing stands. T.R. Dell, biometrician for the Southern Forest Experiment Station, made such an analysis for Alabama's entire pine resource. His study indicates that if all pines 6 in. dbh and larger were cut in 6 to 16-ft lengths to a minimum small-end diameter inside bark of 5 in., log diameter mix would be as shown in Table II.

Although these data are for Alabama, the proportions would probably be similar throughout the South. The high proportion of log volumes in diameter classes of 10.9 in. and smaller (72.4%) signals a potential problem: 14-ft and longer 2 x 10s and 2 x 12s of solid southern pine may be in short supply during the late decades of the century. Admittedly, the problem may not develop if future harvests can be controlled to yield substantially higher proportions of large logs; however, the very real possibility of such a large-log shortage gives impetus to studies of lumber laminated from veneer.

Moreover, the laminating process promises greater recovery of saleable product from each cu ft of log than is possible with sawing.

Material flow analysis

A ton (oven-dry basis) of barky logs can yield as much as 50% more lumber if rotary-peeled and laminated than if sawn. Material balances for the two processes are approximated in Table III.

Studies at western plywood mills show a smaller difference in yields from laminating and sawing. For example, data from a 1971 study, when adjusted to count lumber yield from cores and to eliminate spur trim from veneer (spur trimming is not necessary on veneer for laminated lumber), show only 23 to 36% greater lumber yield with the laminating process than with sawing. In practice, the yield advantage from peeling southern pine would probably be intermediate; at least a 30% gain seems reasonable.

By the end of the century, log scanning equipment coupled with computerized log positioning and sawing equipment may boost sawmill yields of lumber to 0.40 to 0.45 ton. However, during the same time span, improved veneer-bolt centering and peeling techniques will probably increase veneer yields slightly and hence potential yields of lumber laminated from veneer. Thus,

TABLE V
Requirements per 100 ft² floor

Requirements for joists only	Sawn joists	Laminated joists
Pounds of joists needed (ovendry weight)	278	224
Man-hours expended	1.4	1.2
Net energy, million BTU oil equivalent after deducting fuel value of bark and sawdust residues	.40	.65
Capital depreciation of plant and equipment	$1.42	$1.97
Pounds of logs needed (ovendry basis)	794	477[1]

[1]*The cores additionally would yield 29 pounds of 2 by 4 studs.*

TABLE VI
Estimated cost to produce ⅜-in plywood

Component of cost	Dollars per M sq. ft
Resin (phenolic)	$ 8 to $10
Power and fuel	2 to 3
Labor	17 to 20
Supplies	3 to 4
General administrative (except depreciation)	3.50 to 5
Depreciation	6 to 7
Wood	30 to 37
Total	**$69.50 to $86.00**

veneer yields will continue to substantially exceed sawn lumber yields.

Economics of manufacture

Because industry operating data are not available, a precise statement of manufacturing costs is impossible. However, estimates of economic viability of a plant manufacturing lumber laminated from southern pine veneer can be made by: (1) comparing lumber and plywood prices; (2) estimating requirements of man-hours, energy, and capital; and (3) equating costs specific to the plywood industry to those for manufacturing laminated lumber.

The points which follow assume manufacture of laminated lumber would not differ greatly in manpower, energy and capital costs from manufacture of conventional sheathing plywood. This assumption should be conservative because southern pine veneer for lumber would measure ¼-in. thick whereas veneer for plywood averages about ⅛-in. In comparison with ⅛-in. veneer, use of ¼-in. veneer increases lathe, dryer and layup productivity and decreases adhesive consumption. For example, a cu ft of ⅜-in. sheathing plywood requires about 0.74 lb of resin solids if mixed adhesive is spread at 90 lb/M sq ft of double glue line; a cu ft of 1.5-in.-thick lumber laminated from ¼-in. rotary-cut veneer requires only about 0.56 lb of resin solids at the same glue spread.

Lumber-plywood prices

As of October 1975, ½-in. sheathing plywood sold for $126/M sq ft FOB the mill. since 1,000 sq ft of ½-in. plywood contains only 42 cu ft of wood and 1,000 bd ft of dimension lumber contains about 59 cu ft, laminated lumber would have to sell for at least $177/Mbf (or 40% more than the price for 1,000 sq ft of ½-in. plywood) to equal the price per cu ft of plywood (i.e., $126/42 = $177/59 = $3.00/cu ft).

In fact, the market price per Mbf of favored sizes and grades of southern pine structural lumber is usually more than 40% higher than the price per M sq ft of plywood. Moreover, because of the extraordinary stiffness and strength of laminated lumber, it should command a premium over the same sizes of No. 2 KD lumber. For example, 2- by 12-in., 16-ft-long, No. 2 KD and better southern pine lumber was quoted at $190 net FOB mill per Mbf in the October 17, 1975, issue of RANDOM LENGTHS. No. 1 KD in the same width and length should sell at a $10 premium and select structural at a $25 premium. A net sales price FOB mill of $200/Mbf of 16-ft 2 x 12 lumber laminated from veneer would therefore appear likely; longer lengths, for example 24-ft, could be expected to sell at over $260/Mbf. These prices amount to $3.39 and $4.41 per cu ft. Because of these high prices, a plant making laminated structural lumber would naturally concentrate sales efforts on wide, long products—probably 16 ft and longer—and on specialty products requiring high stiffness and strength such as truss chords.

Another approach is to compare requirements needed to manufacture a ton (oven-dry basis) of sawn lumber and of laminated lumber, as shown in Table IV.

Such a tabulation is not the entire story, however, because the greater stiffness and strength of laminated lumber permit its use in sizes smaller than those for sawn lumber. For example, in floor systems calling for joists on 16-in. centers covered with ⅝-in. plywood underlayment and carpet, lumber joists might have a net dimension of 1.5 by 9.25 in., whereas joists laminated from veneer might measure only 1.5 by 7.5 in. for the same spacing and span.

A comparison of requirements for the joists required per 100 sq ft of such floors (including logging, manufacture, and transport to house site) would be as shown in Table V.

Thus during logging, manufacture and transport, the joists laminated from veneer require less raw material and fewer man-hours than sawn joists but are more capital and energy intensive.

A less complex analysis can be achieved by equating manufacturing costs of laminated lumber with those of sheathing plywood. In October 1975, Peter Vajda, president of Columbia Engineering, Vancouver, B.C., estimated the cost of producing ⅜-in. plywood. See Table VI. Vajda's costs assume a $15,000,000 investment in a plant capable of manufacturing 160 million sq ft (⅜-in. basis) of sheathing grade plywood annually.

By this computation, costs per 1,000 sq ft of ⅜-in. sheathing ranged from $69.50 to $86; Vajda believes that 25% of all sheathing plywood produced in 1975 was manufactured at a cost of $75 (or less) per thousand sq ft (⅜-in. basis). This amount corresponds to $2.40 per cu ft of sheathing plywood.

Assuming that it is technically possible to build a plant to make laminated lumber on the same scale and be operable at the same efficiency as the plywood plants described by Vajda, then the costs per thousand bd ft of lumber produced (i.e. , for 59 cu ft) would be only $142. Since the October 1975 sales price of 16-ft, 2 x 12, No. 2 KD and better, southern pine lumber was $190/Mbf, there would appear to be ample profit in such an operation.

Long lengths of wide structural lumber laminated from ¼-in. rotary-cut southern pine veneer should bring a better price per cu ft than plywood. ■