

MSR'S PROMISE FOR THE WOOD PRODUCTS INDUSTRY

by

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INTRODUCTION

Lumber has long been an important material for construction, primarily because it is economical, easily used, and readily available. In the last 100 years, other construction materials such as aluminum, steel, concrete and plastics have displaced lumber in many applications.

A major difference between lumber and alternative construction materials involves the method used to produce the various categories for each of these materials. Whereas wood is taken in its natural form, machined into lumber and sorted into grade categories, the alternative materials are produced for specific categories by control of the constituent materials and manufacturing processes. The constituent materials and manufacturing processes for lumber such as soil moisture and nutrients, sunlight, temperature, and wind are controlled mostly by nature and not by man. Recent work with intensive agricultural practices are modifying this condition, but we are a long way from eliminating the sorting process for lumber in favor of manufacturing process control.

The existing state of affairs is that better definition and less variability of material properties exist for lumber alternatives than for lumber. Applications that demand tight definition of material properties will not provide good marketing opportunities for lumber unless very special sorting techniques are used*.

Fortunately for lumber sales, most of the usual applications demand only that the material meet certain minimum requirements. It is possible to sort lumber into grade categories that meet these minimum requirements. Until recently the sorting has been done by visual characteristics only. Even though minimum requirements are usually met, lumber sorted visually has a broad distribution of material property values; and therein lies the opportunity. If the minimum requirements are met, and if the distribution is broad, then most of the material is much better than required. If by some means, the better material can be identified, then it can be put into a new category with higher minimum values. Because engineering design is usually based on minimum values, a category with higher minimums is worth more.

*These statements are intended to apply to solid sawn lumber only. Laminated veneer lumber, for example, can have more tightly defined mechanical properties by reason of its manufacturing process.

Starting in 1962, when the first high speed machine began producing Machine Stress Rated (MSR) lumber, a means has been available for identifying the better material. Growing out of the research efforts of Potlatch Forests Inc. and others, the MSR concept has expanded until today it is generally recognized among the truss industry that MSR lumber is the material of choice for use in critical members of trusses.

Wood has a number of advantages over alternative materials. It is a renewable resource, it requires far less energy to manufacture it into desirable structural shapes, for its weight it is very strong, under repeated loading it does not lose its strength, and in many applications it has greater fire safety than alternative materials. For these reasons, lumber will successfully continue to compete in the marketplace. Better sorting to reduce the variability of its mechanical properties will make it even more competitive.

With Machine Stress Rating, there is something for everyone. Society as a whole benefits from the more optimal use of the available forest resource. The lumber producer benefits by increased profit from sales of the same but better sorted lumber. The truss manufacturer can be more competitive because with MSR a higher design value with the same amount of lumber or the same design value with less lumber is possible. And finally the consumer ends up with a more reliable structure.

The following paragraphs discuss the production, use, and advantages of MSR lumber. The discussion is weighted toward the sawmill which is faced with the decision of whether or not to produce MSR lumber. Methods for estimating yields and profitability are included.

WHAT IS MSR LUMBER AND HOW IS IT PRODUCED?

MSR lumber is sorted according to a different set of rules than for visual grading. The major difference from the visual grade rules is that each piece of lumber is first machine measured and spray-marked according to its bending modulus of elasticity or E value. For constant cross-section dimensions, bending E is a measure of the lumber's stiffness. The spray mark identifies the E category and hence the highest MSR grade for which the lumber potentially qualifies. Following machine identification of E category, the visual grader determines the grade according to both E category and visual characteristics of the lumber such as the size of edge knots, the amount of wane and other defects. The grader may reduce the grade from the machine determined value because of overriding visual defects, but he may not raise it. There are numerous acceptable material flow arrangements, but the more successful ones feed the entire planer output into the machine so that it can do the first sort. Downstream of the machine, the visual grader applies the appropriate grade stamp to the piece.

In addition to in-line E measurement of every piece of lumber, an off-line quality control check is periodically made on samples of production. Typically, 5 pieces from each size-grade combination are checked each shift. The edgewise bending E is measured, and an edgewise bending proof load is applied. Not only does this process give some assurance

that the grade requirements are being met, the data accumulated over a period of time can be used to adjust the in-line machine thresholds for maximum grade recovery.

WHERE IS MSR LUMBER USED?

MSR lumber is used primarily in trusses. Light frame roof construction is dominated by roof trusses, and parallel chord floor trusses are now making major inroads into construction of floor systems. Ease of handling, uniformity, possibility of much longer free spans, and the ready made holes for plumbing, ductwork and wiring are among the reasons for the change from floor joists to floor trusses. Also, the lumber supply can come from small logs, and this reduces the pressure on the available supply of wide width lumber. Figure 1 illustrates some of the uses for MSR lumber.

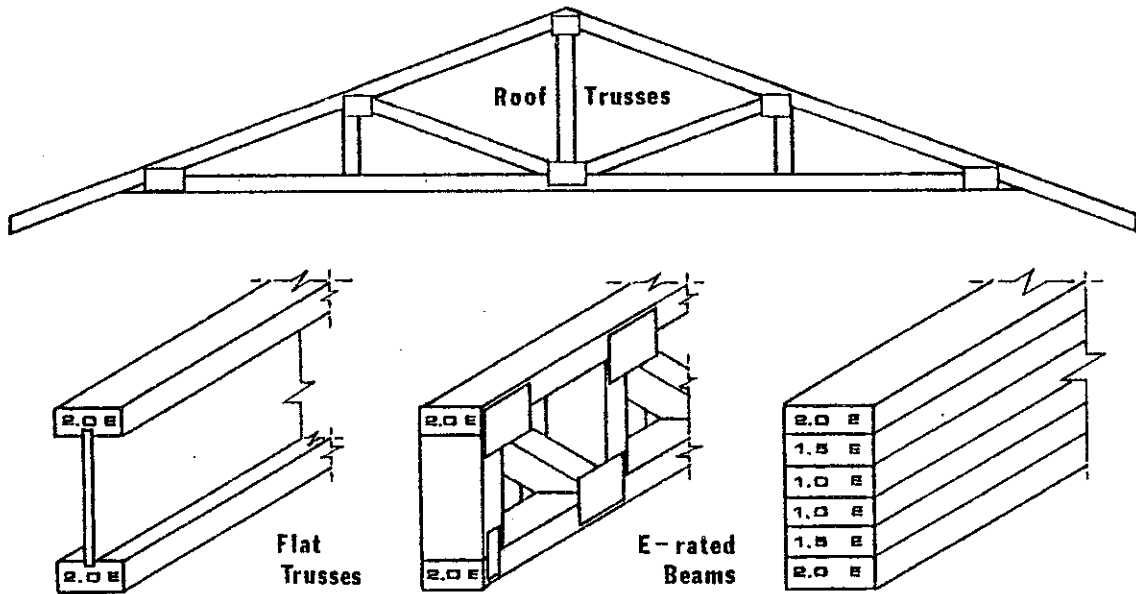


Figure 1
Some Uses for MSR Lumber.

TECHNICAL ADVANTAGES OF MSR LUMBER

Because of the machine E measurement, MSR lumber has better consistency of mechanical properties than visually graded lumber. This is recognized, by the National Design Specification [1] which for E, assigns a coefficient of variation* (COV) of .11 to MSR lumber and .25 to visually graded lumber. The difference is illustrated in Figure 2 which shows two normal (Gaussian) probability density functions having the same mean value but different coefficients of variation, .11 and .25. For applications such as column loading where E is critical, the design load is determined by the low end of the E distribution. The National Design Specification formulas document this advantage of MSR lumber. Figure 2 shows the fifth percentile locations for the two distributions. The fifth percentile as a percentage of the mean value is 81.9% for the narrow distribution and 58.9% for the broad one. If the design value is determined as a fraction of the fifth percentile, then the broad distribution design value will be only 71.9% of the narrow one. Figure 3 shows the cumulative distribution functions corresponding to the probability density functions of Figure 2. From a cumulative distribution function, one can easily find the proportion of the material between any two E values.

In reality the distributions are not normal, and the distribution width is controlled not only by sorting accuracy but also by practical considerations such as how many grades are pulled. But, it has been observed that the E distributions for MSR lumber are truncated at the low end while visual grade distributions have a lower tail of E values. Figure 4 is an estimated** cumulative distribution function (CDF) for #2 & Better, 2x4-16', KD SPF at one particular mill. The data for this curve consists of E measurements of 150 pieces of lumber. The lower tail extends downward considerably from the bulk of the distribution, a common feature of E distributions for visually graded lumber. Figure 5 illustrates estimated CDF's for both #1 and Standard & Better grades. The data for these curves consists of E measurements of 100 pieces of lumber for each grade and was obtained the same day at one mill. The lack of clear separation in E distribution is unusual for these two grades; but clearly it can happen, and it would seem reasonable that comparisons at different mills or at different times would show even larger anomalies.

Figure 6 shows estimated cumulative distribution functions of E for four MSR grades from the same machine. Note that machine testing has caused the lower tail of E values to be removed from each curve. Because the set-up, calibration and quality control procedures are similar for different mills that produce MSR lumber, the distribution of E meets the same standards for the different mills. This has resulted in a trend toward more interchangeability in the use of different species for the same application.

*The coefficient of variation of a distribution is defined as the distribution's standard deviation divided by its mean value.

**The estimated CDF is a French-curve-smoothed version of the empirical CDF defined in statistics (see e.g. [2,3]).

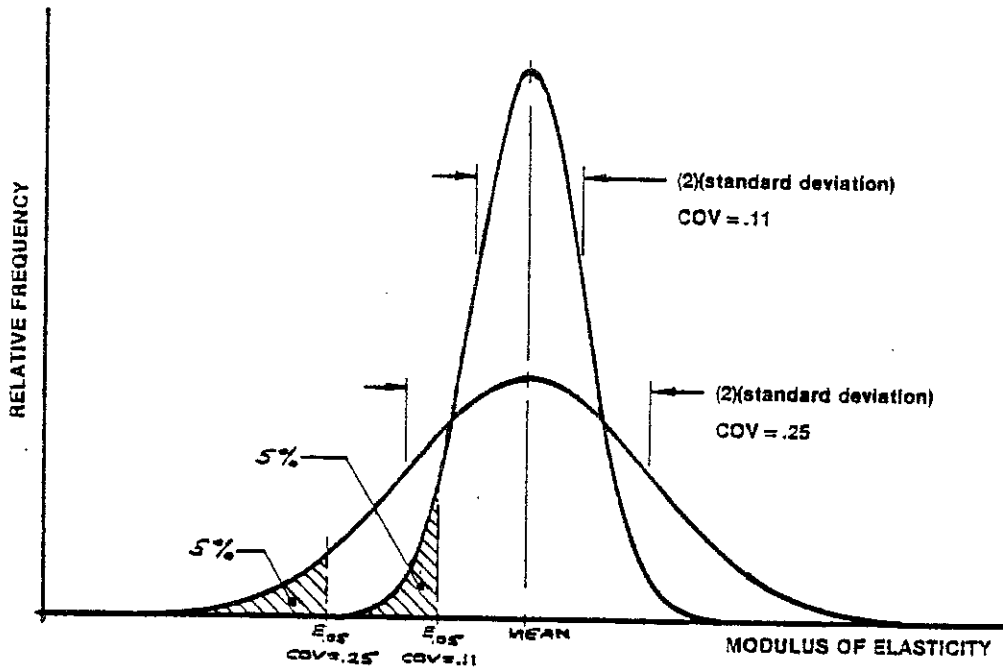


Figure 2

Normal Probability Density Function: COV = .11 and .25. Shaded Areas Denote Positions of the Lower 5% of Material in Each Group.

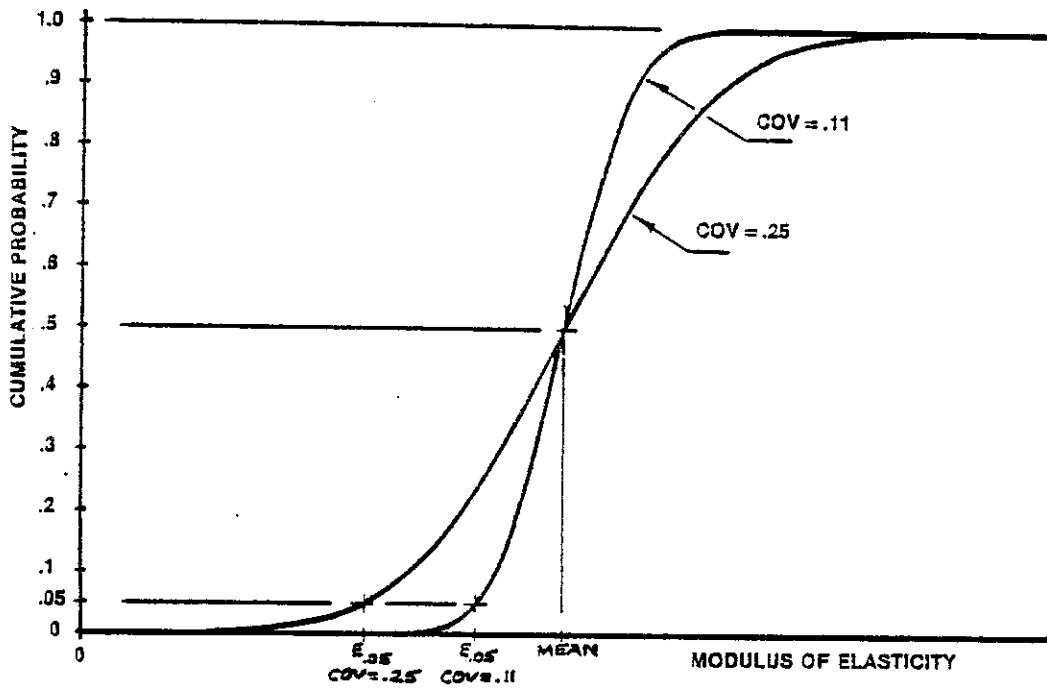


Figure 3

Normal Cumulative Distribution Functions: COV = .11 and .25.
Fifth Percentile $E_{.05}$ is Easily Found from Intersection with Ordinate Value .05.

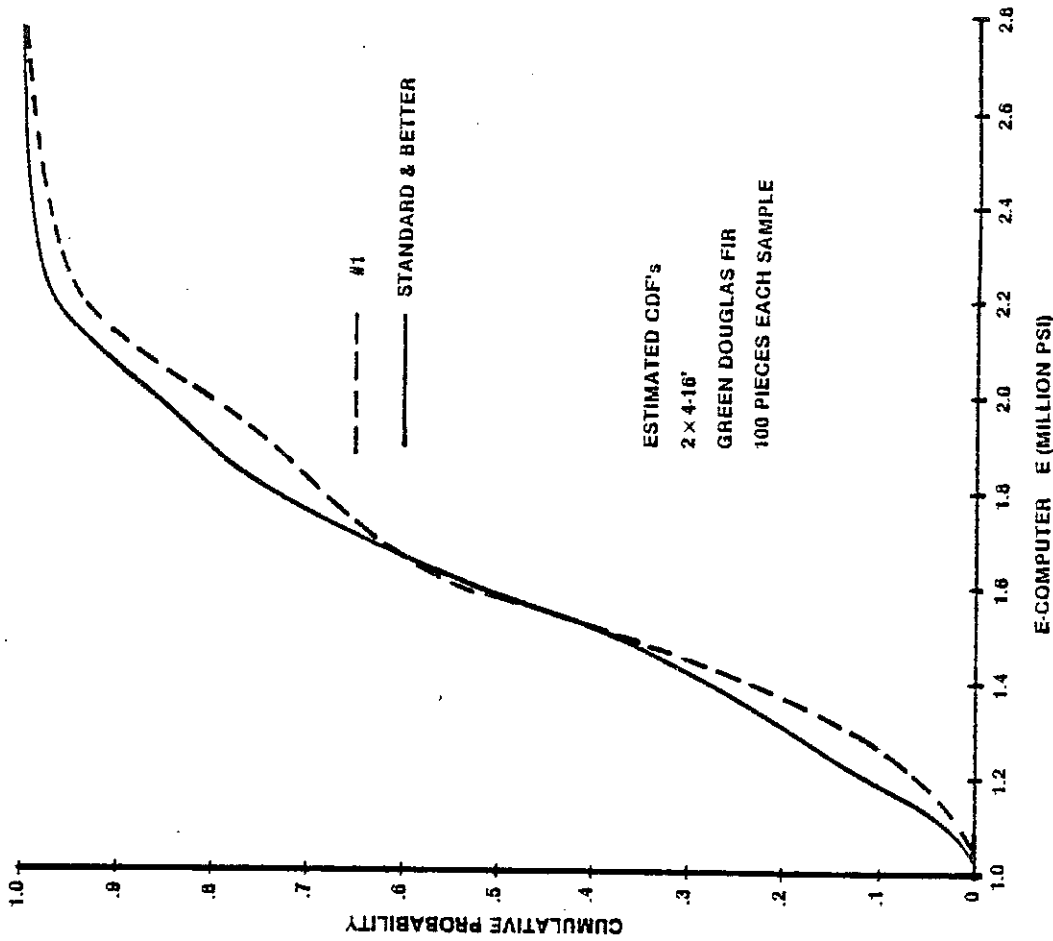


Figure 4

Estimated CDF: A Typical Curve for Visually Graded Lumber. Illustrates the Usual Lower Tail of Low E Material & the Potential of Much of the Material for MSR Grades.

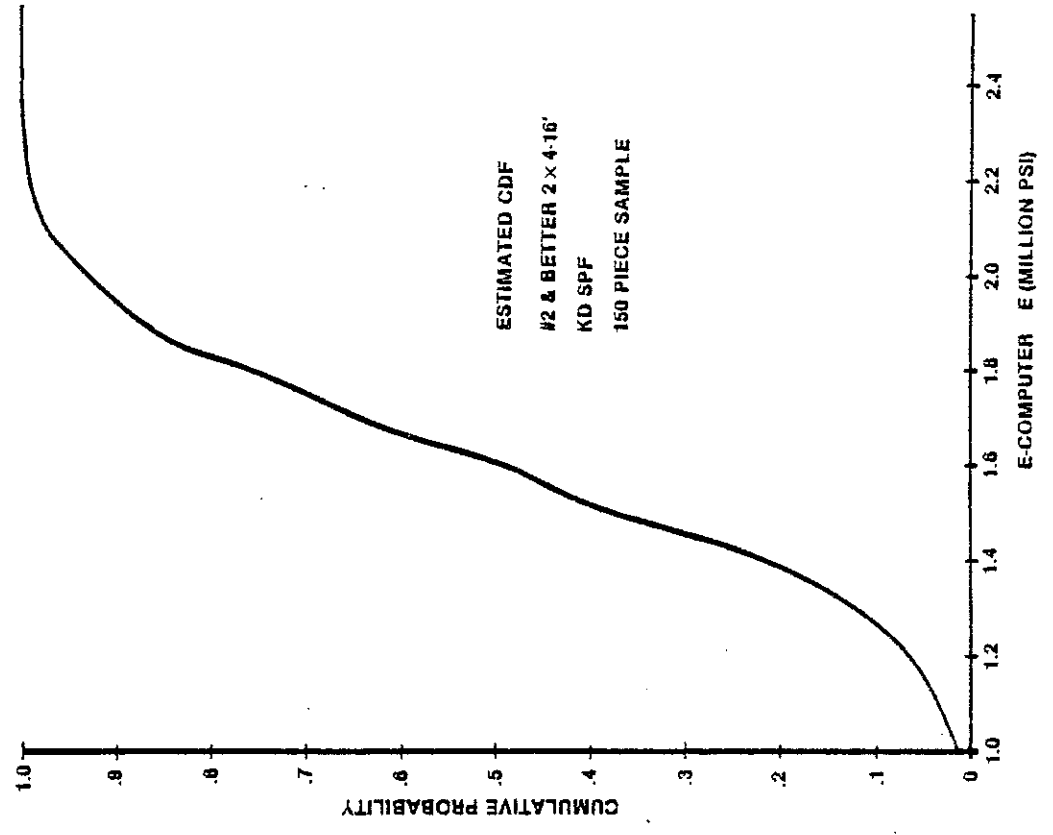


Figure 5

Estimated CDF's: Illustrates Unusual Lack of Clear Separation in Distribution of E Between Two Important Visual Grades at Same Mill on Same Day.

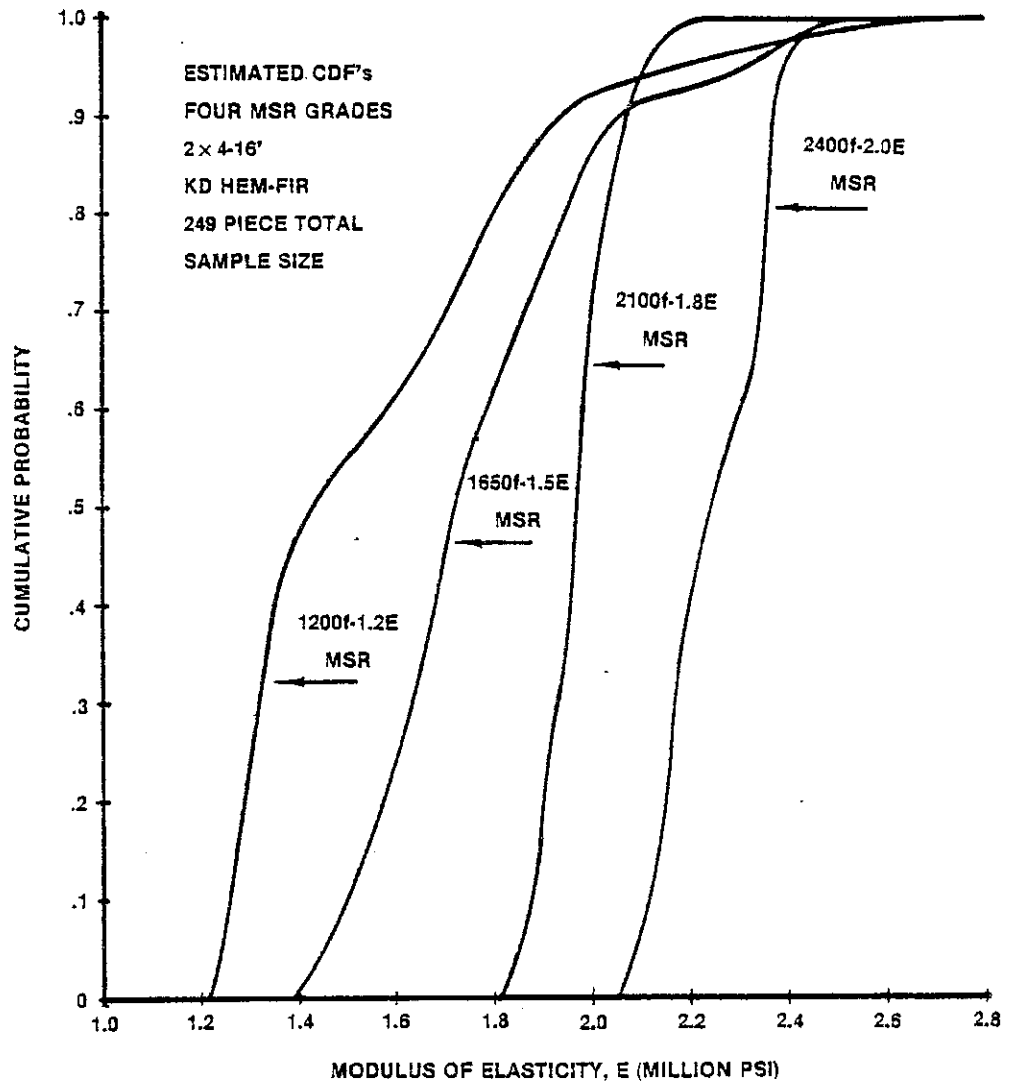


Figure 6

Estimated CDF's: Data, Courtesy of the Frank Lumber Company
Illustrates Truncation of Low E Material from Each Distribution,
a Primary Feature of the MSR Process.

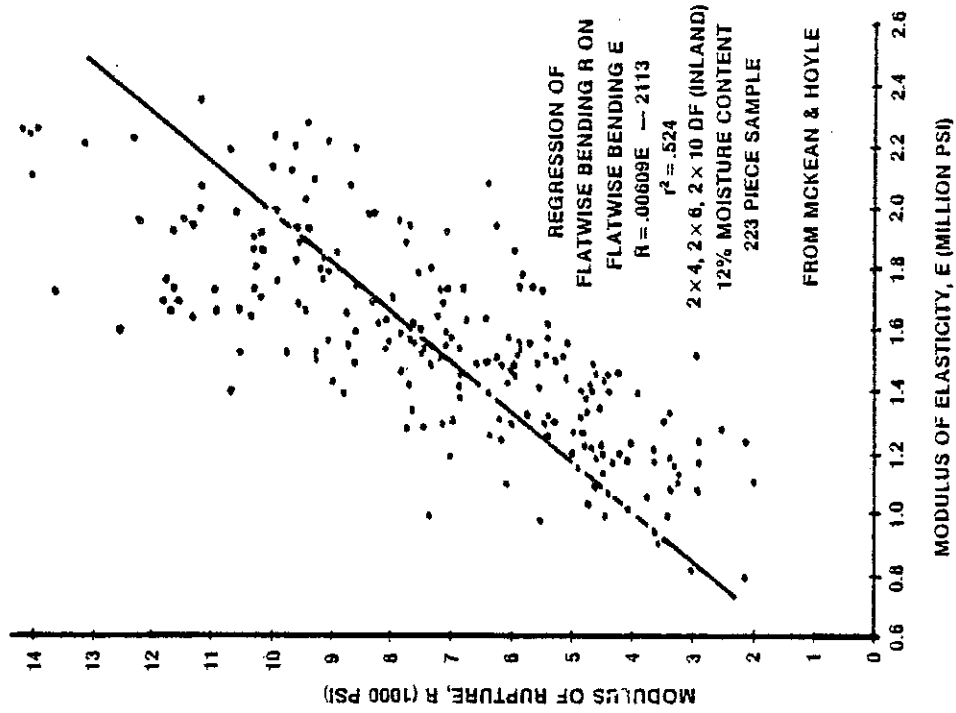


Figure 7

Scatter Plot, Flatwise Bending R versus Flatwise Bending E: Illustrates Basis for Estimating Bending Strength from Modulus of Elasticity.

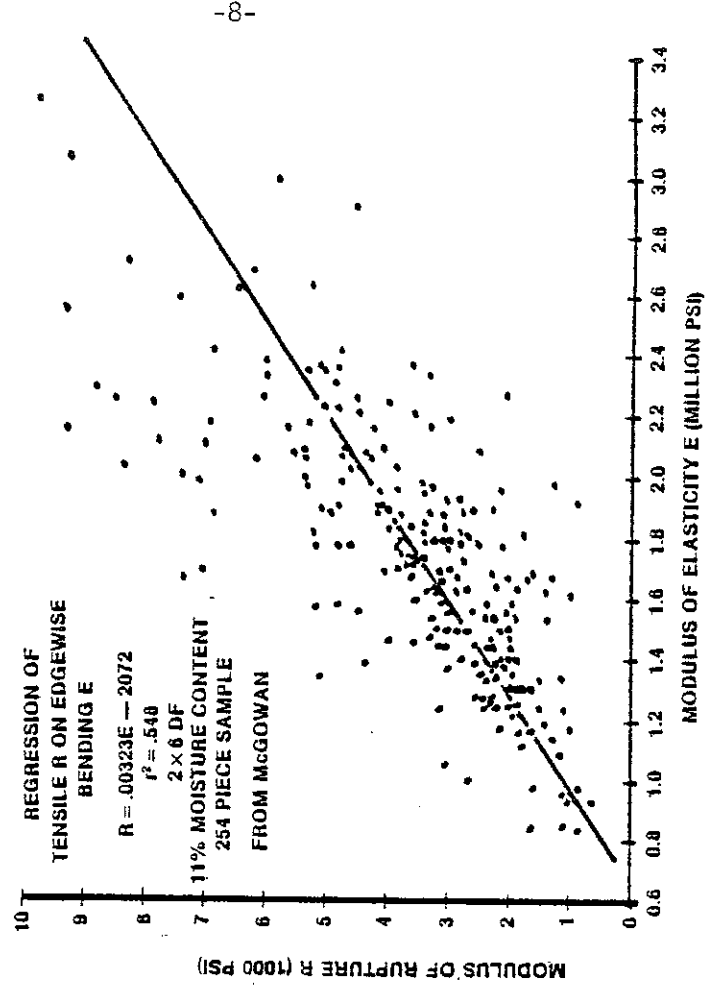


Figure 8

Scatter Plot, Tensile R Versus Edgewise Bending E: Illustrates That Tensile Strength May Be Estimated from E Measurement.

Bending strength of MSR lumber is inferred from its E value. The correlation of bending strength to E is not perfect, but it is good enough so that approximately 50% of the strength estimate's variability can be removed if it is based on E. Figure 7 taken from McKean & Hoyle [4] is a typical scatter diagram showing the flatwise bending strength versus flatwise bending E of 223 pieces of 2x4, 2x6, and 2x10, Douglas Fir lumber. Note that the strength values trend higher for higher E values. Note also that the spread of strength values for a given narrow band of E values is less than the total spread; this fact allows bending strength inferences to be made from the measurement of E. Both edgewise bending E and edgewise bending strength for the MSR grades are verified by off-line quality control checks on samples of production. In contrast there are no in-plant quality control tests on visually graded lumber.

Tensile strength also has a positive correlation with E. Figure 8 taken from McGowan [5] is a scatter plot showing tensile strength versus edgewise bending E for 254 pieces of 2x6 Douglas Fir lumber. The grade rules have recognized the contribution of E measurements for predicting tensile strength by allowing a higher tension design load to be applied to MSR lumber. Figure 9 is a plot of the total allowed tension design load versus width for several visual and MSR grades of Hem-Fir. Under current rules the MSR grades do not suffer the decrease in design stress with width as do the visual grades.

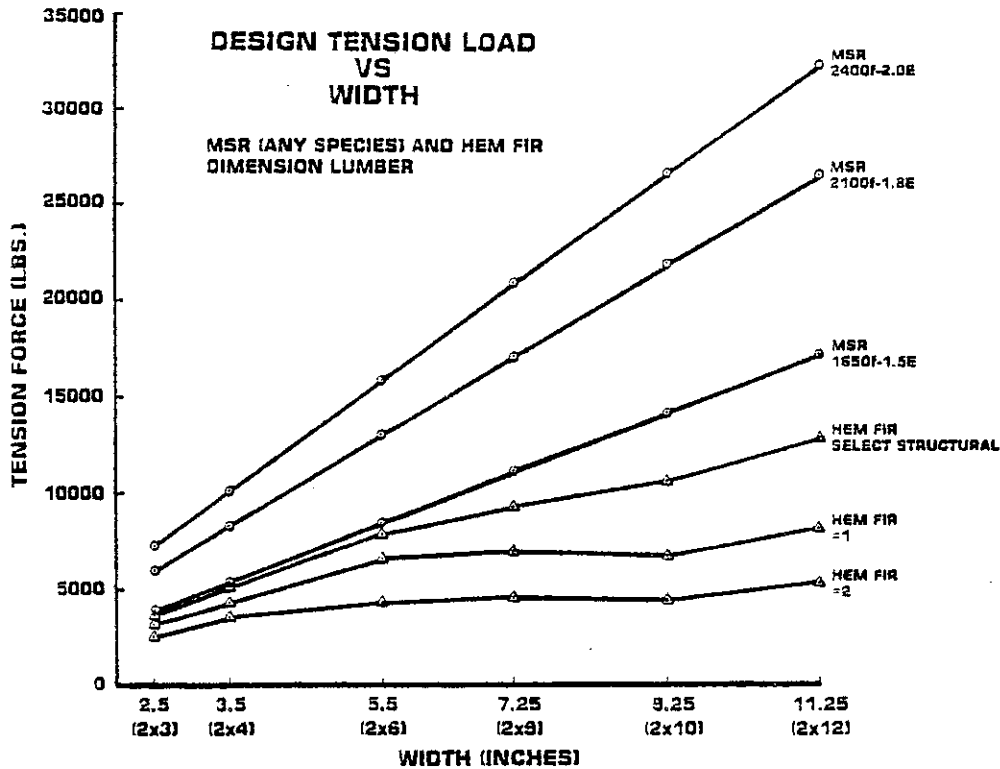


Figure 9
Present Rules Governing Allowed Design Tension Load Illustrate an Important Advantage of MSR Lumber.

Other advantages are being considered. For example, there is a positive correlation between density and E. Thus, one can expect higher E material to have better nail plate holding capability and also higher strength in compression perpendicular to grain.

ADVANTAGES TO THE TRUSS MANUFACTURER

It is important to consider why a truss manufacturer would ask for MSR lumber and be willing to pay a premium for it.

With the cost of lumber being about 56% of the cost of a truss [6], a manufacturer's competitive position is improved if he can build a roof or floor system stronger or more rigid with the same amount of lumber or an equal design with less lumber. In one example [7], the cost per truss for an agricultural building was reduced from \$117.16 to \$92.22 by converting from #1 and #2 Douglas Fir to 1950f-1.5E MSR material. The trusses are identical with respect to their loading and use.

Truss manufacturers have said they trust the "reliability and exactness" of MSR lumber. Reliability advantages follow from the reduced variability of mechanical properties. Procedures for investigating this advantage of MSR lumber have been studied and reported in the literature [8,9].

Experience indicates that waste can be reduced to 1 or 2% with MSR from as high as 10% with the visually graded alternative [10]. Considering the speed and efficiency of today's truss production, there is simply no place for a lumber resorting operation at the truss manufacturing site. In a 1975 survey [6], a list of comments by truss producers indicates the trend toward MSR in trusses. Table 1 contains comments regarding lumber procurement that have been selected from this list.

Table 1
Selected Individual Comments on Procurement of Lumber.
(From Galligan & Kallio 1975 Survey)

- | |
|---|
| <ol style="list-style-type: none">1. We buy only from mills which MSR their production.2. Variances in quality of identical grades.3. Higher grades are becoming a problem, re: floor trusses.4. Have had a problem obtaining MSR lumber in quantities required.5. Lack of consistency in quality of lumber causes extreme in lumber waste.6. Multiple standards in grading--(one mill's quality vs. another's quality, yet both of same grade).7. More sources of supply for special grades.8. Stress grade lumber is not easy to locate at times.9. Lack of control at mill on grading.10. Too much variation in same grades.11. Hard to buy better grades at times.12. Grades don't reflect engineering requirements. |
|---|

Because of the uniformity of MSR grades across different species, there is an opportunity for the truss producer to reduce the number of grades held in inventory and hence the cost of inventory.

The greatest disadvantage of MSR lumber has been its lack of availability. With the recent introduction of MSR capabilities into a number of sawmills, this disadvantage has been reduced. Truss producers are now putting MSR designs into their books because they have dependable MSR sources of supply.

CONTRIBUTION OF MSR TO SAWMILL PROFIT

The decision to produce MSR lumber can have a very positive influence on sawmill profit. The concept is straightforward: simply sort the lumber in a way that makes it more valuable to the user for structural purposes. The object here is to identify which items are affected by the decision to produce MSR lumber and then to determine how this affects sawmill profit.

Effect of MSR on Product Mix and on Product Value

We consider only that part of the product mix that is most affected by MSR today, dimension lumber in sizes 2x3 through 2x12. For the moment let us further restrict attention to one size and one species combination, say 2x4 DF&L.

Table 2 lists four grades that might be produced, representative prices (1979), fraction of product mix, and contribution to value. Adding numbers in the last column gives \$206.60 as the average price/MBF of the 2x4 DF&L product mix. Selling price and fraction of production for each visual grade are numbers to which mills have ready access.

Table 2.
Value of Visually Graded Product Mix.

GRADE	PRICE PER MBF	FRACTION OF MIX	Contr. To Value
#1	250	.25	\$ 62.50
STD & BTR	205	.60	123.00
UTILITY	150	.13	19.50
ECONOMY	80	.02	1.50

VALUE OF VISUAL MIX \$206.60

Table 3.
Value of Machine Stress Rated Product Mix.

GRADE	PRICE PER MBF	FRACTION OF MIX	Contr. to VALUE
2400f-2.0E	290	.136	\$ 39.44
2100f-1.8E	270	.143	38.61
1650f-1.5E	250	.352	68.00
#1	250	0	0
STD & BTR	205	.243	49.82
UTILITY	150	.107	16.05
ECONOMY	80	.020	1.50

VALUE OF MSR MIX \$233.52

Table 3 lists a set of grades that might be sold if MSR lumber were being produced. Price, fraction of product mix, and contribution to value are also listed. The average value of the MSR mix for this example is \$233.52/MBF or \$26.92/MBF more than the visual mix. The fraction of production in each grade is necessarily an estimate, and we investigate further how these estimates can be obtained. Additional details are available [11,12].

The best method for estimating MSR yield is to transport a representative sample of rough sawn lumber to a location that is producing MSR lumber. Having the lumber planed and graded at such a location brings all the accuracy and acquired expertise of the facility to bear in producing realistic MSR yield estimates for the material. Care should be taken to ensure that the sample is representative of production at the mill under study, and that the sample is large enough for meaningful results. It is desirable that the MSR grades being produced at the test facility match those contemplated for production.

Where it is impractical to test a sample of material at a MSR facility, off-line equipment can be used to measure E which is the primary determinant of MSR grade. For example, the Transverse Vibration E-Computer can be used to provide E measurements that are very well correlated with Average E measured by in-line equipment. Figure 10 shows a scatter plot of E-Computer E versus CLT* Average E for 249 pieces of 2x4 Hem-Fir.

Percival [13] has demonstrated the very close correlation between E-Computer E measurement and dead load static bending E obtained from a simple portable E-tester. Details of Percival's E-tester design are included in [13].

Even though low point E for each piece is not measured by either the E-Computer or Percival's E-tester as it is in the CLT, these simpler techniques are very useful for estimating MSR yield. Typically, these yield estimates would include a downgrading factor which is a guess of the amount of low point downgrading that would occur. A visual override downgrading factor is either guessed from the general appearance of the lumber or is more carefully obtained with help from an experienced lumber grader who checks each piece.

In most cases strength testing is not included in the MSR yield estimation procedure because its contribution to yield estimation accuracy is not felt to be worth the extra cost. If strength testing is desired, a procedure is suggested in [14].

If the material tested is representative of mill run for the DF&L 2x4 lumber in the example, then the MSR yield estimates are complete.

*CLT (Continuous Lumber Tester)-- The high speed production machine responsible for most MSR lumber production in North America.

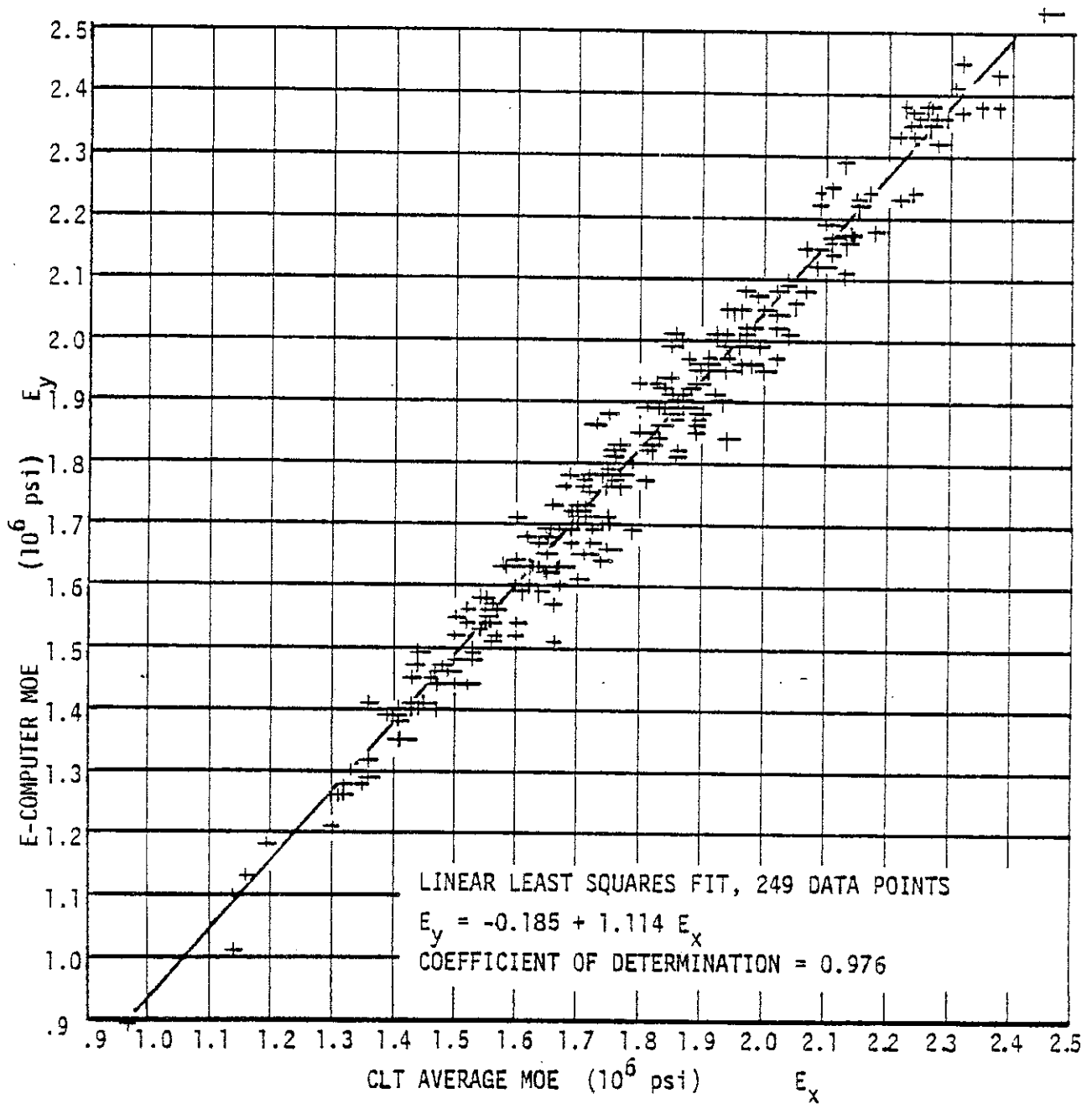


Figure 10. Flatwise long-span bending MOE as measured using a Metriguard Model 3300 E-Computer is shown correlated with CLT-measured average MOE for 249 pieces of 2 x 4 Hem-fir. The data, courtesy of Frank Lumber Co., illustrates the tight correlation between CLT measurements of MOE and off-line measurements.

Where the CLT is not used for yield estimation, the process is repeated for each visual grade, and Table 4 is the result. For example, in the first column the fractions of #1 visual grade material contributing to the three MSR grades 2400f-2.0E, 2100f-1.8E and 1650f-1.5E are .30, .20, and .25 respectively. Note that the 25% residual #1 material not satisfying requirements for the 1650f-1.5E MSR Grade has been reduced to Standard and Better. This is in accordance with the American Lumber Standards Committee requirement that does not allow lumber to be placed in a visual grade carrying a bending stress value equal to or greater than any MSR grade from which it has been rejected [15]. Figure 11 shows how the value .136 for 2400f-2.0E yield is obtained from the values in Table 4 and the visual mix fractions. The value of the 2x4, DF&L, MSR product mix from Table 3 is computed to be \$233.52/MBF or \$26.92/MBF increase in value from the visual only product mix.

Table 4.

Example; MSR Yield Estimates from Four Visual Grades.

Grade	# 1	S&B	U	E
2400f-2.0E	0.30	0.10	0.01	0
2100f-1.8E	0.20	0.15	0.02	0
1650f-1.5E	0.25	0.45	0.15	0
#1	0	0	0	0
Standard & Better	0.25	0.30	0	0
Utility	0	0	0.82	0
Economy	0	0	0	1

$$.136 = (.30)(.25) + (.10)(.80) + (.01)(.13) + (0)(.02)$$

2400f-2.0E Fraction
2400f-2.0E Yield from #1
#1 Fraction
2400f-2.0E Yield from Std. & Btr.
Std. & Btr. Fraction
2400f-2.0E Yield from Utility
Utility Fraction
2400f-2.0E Yield from Economy
Economy Fraction

Figure 11.

Example: Fraction 2400f-2.0E MSR from Yield Estimates and Visual Mix Fractions.

This example considers only the DF&L 2x4 fraction of dimension lumber. Other sizes and species can be considered in an identical manner. The overall average value per MBF for dimension lumber can be computed by summing the weighted contribution to value for each component.

The likelihood of the MSR mix being worth more is due to two factors; first, higher prices for MSR lumber and second, higher yields in the upper grades. Both factors work together to give a value increase that is usually between \$10 and \$30 per MBF. Any value increase must exceed additional costs for the proposition to be profitable.

Effect of MSR on Production Costs

The extra costs incurred by producing MSR lumber can be broken roughly into the categories: capital investment, labor, maintenance and overhead.

Capital investment includes all costs associated with acquiring the MSR machinery, facility to put it in, installation costs, and related equipment such as conveyors. Some mills have found that additional sorting capacity is required to handle the MSR mix if several MSR grades are pulled. Depending on the individual mill, the capital investment could range from about \$200,000 to \$800,000. Assuming a 7 year amortization schedule at 18% interest, this translates to a yearly cost range of from \$52,472 to \$209,890 for capital investment. Initial cash outlay for capital equipment can be minimized by a suitable leasing arrangement.

The next most expensive cost item is labor. The additional requirement here can vary considerably depending on the type of people available and their present workload. Most important is that someone be responsible for quality control of the MSR lumber product. This involves off-line quality control, record keeping, and general attention to the overall MSR process. Routine maintenance and calibration of the MSR machinery can be performed by someone already working in the vicinity, perhaps the planerman. The total estimated additional labor cost is taken as \$25,000/year.

Maintenance and repair is not a large item provided standard routine maintenance of bearings and machinery is employed, and \$10,000/year should cover any conceivable contingency. Overhead cost, primarily electric power, is estimated at \$3000/year.

The total extra cost for MSR is thus between \$90,472 and \$247,890 per year.

Ince [16] performed a more detailed study of MSR production costs. His study based on 1978 figures also includes a 15% internal rate of return on investment as a production cost. Cost estimates in \$/MBF are listed in Table 5. Low and high range costs from the above estimates are listed as well as the estimates from Ince's work. Figure 12 taken from [16] shows Ince's cost estimates versus annual throughput volume.

Table 5. Cost of Producing MSR Lumber.

Annual Production Level (MMBF)	Low Range Cost (\$/MBF)	High Range Cost (\$/MBF)	Ince Cost (\$/MBF)
10	9.05	24.79	12.62
20	4.53	12.40	—
30	3.02	8.26	4.42
50	1.81	4.96	2.66
70	1.29	3.54	2.13
90	1.01	2.75	1.66
120	.75	2.07	1.25

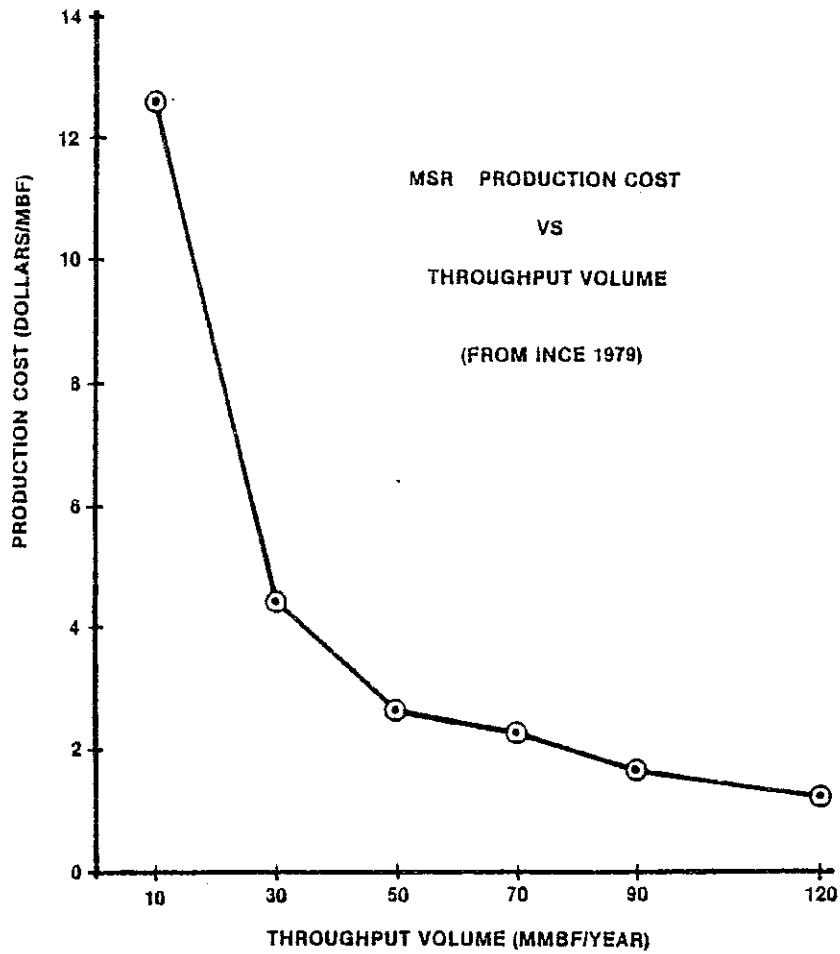


Figure 12.
Estimated Cost of MSR Production Versus Throughput Volume.

Liability Implications

Let us consider further the estimated 25% of #1 material that was reduced to Standard & Better in the example of Table 4. This is material that according to the MSR process and the American Lumber Standards Committee [15] does not meet the design values assigned to the #1 grade; yet, by the visual rules, it would be sold as #1. It is not easy to document the value of reduced liability exposure attributable to removing these low end pieces from structural use. However, concerning the truss manufacturer, Meeks [17] has stated: "His first line of defense against a product complaint is a well established quality control system, high quality suppliers, and a reputation for high quality products. In my opinion, the established use of MSR lumber, purchased from a responsible supplier, would help to establish this position."

Annual Contribution to Profit

Annual production level and value increase/MBF realized for MSR material are the most important factors in determining the profitability of MSR. This can be seen from Figure 13 which shows the annual contribution of MSR to profit versus production level for the three amounts of value increase: \$10/MBF, \$20/MBF and \$30/MBF. The band of profit in each case accounts for the range of costs shown in Table 5. For \$10/MBF value increase, breakeven production level varies from 9.1 to 24.8 MMBF/year as the cost varies from low to high extreme. At \$20/MBF, the breakeven production range is 4.5 to 12.4 MMBF/year. If \$30/MBF value increase is achieved, then the breakeven production level range is 3.0 to 8.3 MMBF/year. At higher production levels, the effect of MSR production costs on profit is not nearly so significant as the MSR value increase achieved. Similarly, when, the value increase is high, the production level is much more important than cost. The added cost for MSR production becomes important at low production levels and/or when there are only low MSR value increases.

Sales of MSR Lumber

During 1975, wood used in trusses in the United States was estimated at 2 billion board feet [6]. This was 6% of the 36 billion board feet U.S. softwood consumption in 1975. By 1977, the estimated yearly use of wood in trusses increased to 4.7 billion board feet [18] or 10% of the 47 billion board feet consumption. The percentage of wood used in trusses can be expected to continue rising as parallel chord floor trusses replace conventional wood joists in floor systems.

For the year 1977, 3% of lumber used in U.S. truss construction was MSR [19], and in 1977, 7 CLT's were operating. By the end of 1981 there were 27 CLT's, and it is estimated that about 12% of truss lumber was MSR. Figure 14 is a plot of the number of operating CLT's versus year. The 15 year birthing and growing-up period from 1962 to 1977 is evident from the curve. This curve and recent literature [20,21] show the tremendous increase in production of MSR lumber during just the last few years.

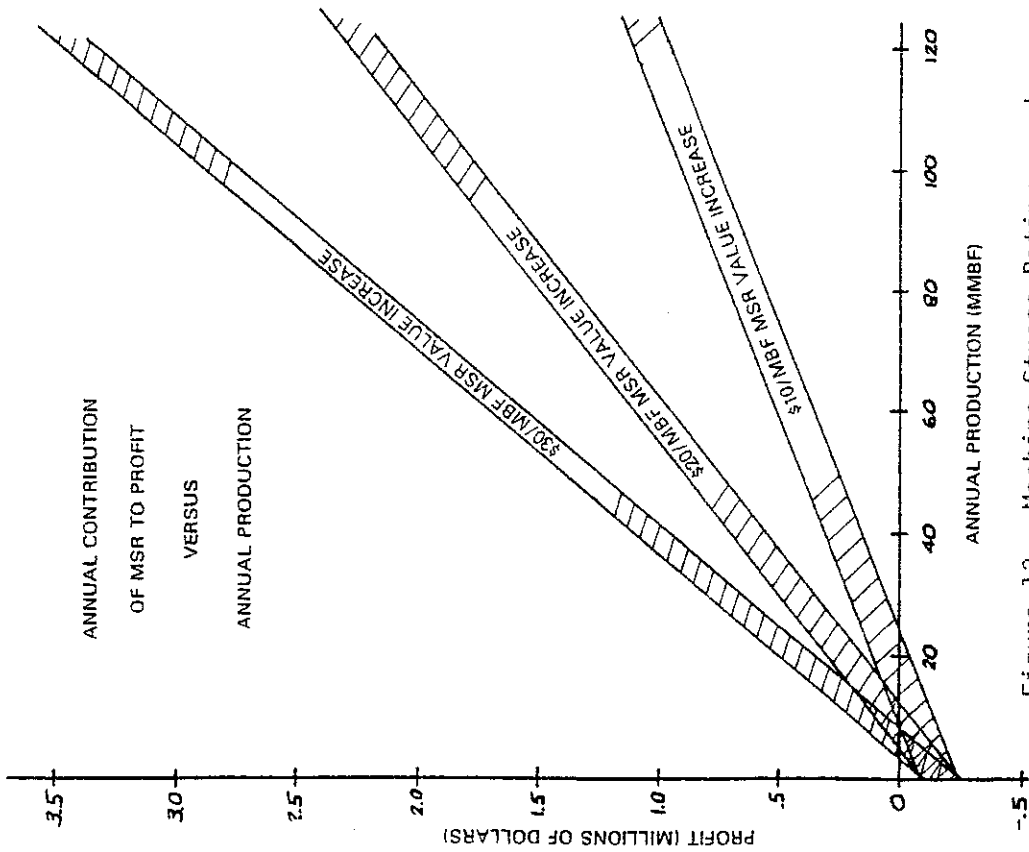


Figure 13. Machine Stress Rating can be very profitable. The bands illustrate the profit spread between high and low cost installations.

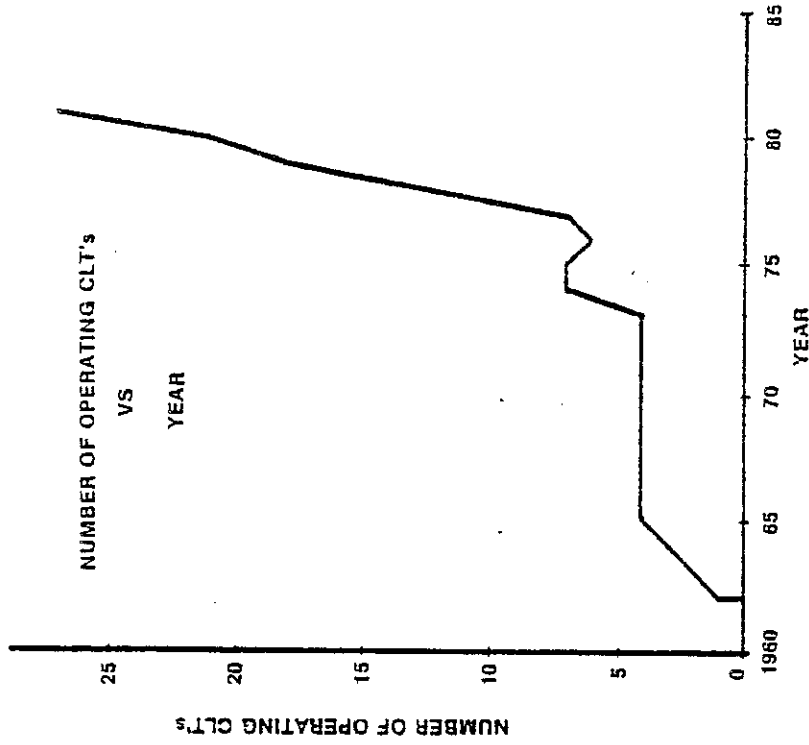


Figure 14. Illustrates the 15 year birthing and growing-up period for MSR.

MSR lumber has usually been sold as a specialty item directly to the truss manufacturer. This situation may change as more truss manufacturers change to MSR. Wholesalers will not want to pass up that much business. Any successful sales campaign for MSR lumber will require knowledge of its end use. The salesman must have a firm understanding of engineering terms such as modulus of elasticity and extreme fiber stress in bending. He must also be aware of the engineering requirements for lumber that will be used in given specific applications. Then he can zero in on those grades of specific interest to the customer and direct production accordingly. Gaining this knowledge is not an impossible task. The truss plate manufacturers are geared to assist, both with special schooling and with computer programs. Computer programs are accessible via the phone lines that allow a salesman to explore various options with his customer in the customer's office. Plotter sketches of the truss design in question and cost analyses for the lumber grades being considered can be made on the spot. The opportunity is great, but an aggressive sales effort will be required to capitalize on it.

CONCLUSION:

Increased sorting accuracy of dimension lumber by using the MSR process allows more efficient utilization of the available wood fiber. This advantage is felt at all levels including the consumer who obtains a more reliable structure, the truss manufacturer who can market a more competitive truss, the lumber producer who can sell his lumber with increased profits, and society at large which has a vested interest in the forest resource.

Profitability of MSR to the lumber producer depends on his annual production volume, value increase due to MSR, and MSR production costs. Breakeven volume can range from 3 MMBF/year for a low-cost, high-value-increase operation to 25 MMBF/year for a high-cost, low-value-increase operation. These production volumes are based on the full planer throughput and not just on the fraction that qualifies for MSR. Annual profitability in excess of one million dollars per year for a high volume operation that achieves a \$20/MBF value increase attributable to MSR is not an unreasonable figure. For a specific location a MSR yield study can provide estimates of yields to be expected in MSR grades of interest. These yield estimates are useful in predicting the value increase/MBF and hence profit that MSR would contribute.

To complete the program an aggressive sales effort directed toward the truss producer will open new lumber marketing opportunities for the producer of MSR lumber.

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