EFFECT OF INCISING ON BENDING PROPERTIES OF REDWOOD DIMENSION LUMBER

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SUMMARY

Three incising patterns were evaluated for their effects on the important bending properties of dimension-size redwood lumber. Two of the patterns were open, not widely spaced, incisings; a third was a closely spaced diagonal pattern. Test material was above the fiber saturation point and included a range in specific gravity representative of redwood.

Incising effects on bending properties of redwood varied with pattern and depth of incisions. Values for energy absorbed were reduced most; for modulus of elasticity, least; and for modulus of rupture, to an intermediate degree. Two open patterns of incising, on the average, reduced modulus of rupture about 10 percent and modulus of elasticity about 5 percent. A closely spaced diagonal pattern of incising caused about twice as much loss in strength.

These results provide an estimate of the immediate effect of incising on the strength and the stiffness of structural-sized redwood as opposed to the longtime effect. However, the long-range combined effects of improved penetration and retention and reduced strength properties must be considered in applying this information.

EFFECT OF INCISING ON BENDING PROPERTIES OF REDWOOD DIMENSION LUMBER

By
A. J. KASS, Technologist
Forest Products Laboratory,[1]
Forest Service
U.S. Department of Agriculture

INTRODUCTION

To increase service life of wood structural members in situations that promote decay, incising increases the depth and the uniformity of penetration of preservative chemicals. This is of particular interest for wood that resists penetration, such as heartwood of Douglas-fir and redwood. Incising timber has an effect on wood strength, particularly bending in which stresses are greatest at the outer incised faces. Previous study of the effect of incising en strength has indicated that reductions due to incising depend on the particular strength property considered (1, 2, 4-7).[2] Modulus of rupture was generally reduced more than modulus of elasticity, although trends were obscured somewhat by the effects of seasoning.

Incising redwood timber for cooling towers has been of special interest. Projecting the results of previous studies to this material is questionable because the studies were based on large timbers of Douglas-fir, 4 by 8 to 8 by 16 inches in cross section, whereas much of the material in cooling towers is only 2 to 4 by 4 inches. The previous studies suggested that the incising effect was related to the net reduction in moment of inertia. Incising 2- or 4- by 4-inch members would be expected to produce relatively greater strength reductions than comparable incising of larger timbers wherein the reduction in moment of inertia is proportionately less.

This is a report of previous work by R.L. Youngs of the Forest Products Laboratory staff. A purpose of his study was to evaluate effects of three patterns of incising on bending properties of green or resoaked redwood lumber 2 by 4 and 4 by 4 inches in cross section. Youngs did not attempt to evaluate incising effects in their entirety, and analysis of the results was not amenable to statistical treatment. Trends in the results, however, were sufficiently consistent to allow drawing tentative conclusions.

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.
[2] Italicized numbers in parentheses refer to literature cited at the end of report.

MATERIAL AND TEST SPECIMENS

Forty nominal 2- by 4-inch redwood pieces 12 feet long, twenty 4- by 4-inch pieces 14 feet long, and twenty 4- by 4-inch pieces 20 feet long were used. Prior to incising and specimen preparation, the pieces were impregnated with water in a treating cylinder to provide material comparable to green wood for incising and strength characteristics.

The 2- by 4-inch pieces were cut into 36-inch specimens and the 4- by 4-inch pieces into 56-inch specimens as shown In figure 1. Three patterns, 1, A, and C, used to incise the test specimens are shown in figure 2. Pattern C is the standard incising pattern of the American Railway Engineering Association, whereas patterns 1 and A were developed and used by Koppers Company, Inc. The incising patterns were distributed among the test specimens by the arbitrary scheme shown in figure 1. The approximate depth of penetration For patterns 1 and A was 3/8 inch; for pattern C, 3/8, 5/8, and 3/4 inch. The incising teeth were of the "oyster-knife" type with the cutting edge oriented parallel to the grain direction as contrasted to the "chisel-point" tooth design with a cutting edge perpendicular to the grain direction of the wood *(3).* The oyster-knife tooth produces more lateral separation with less cutting of the wood fibers than does the chisel-point tooth.

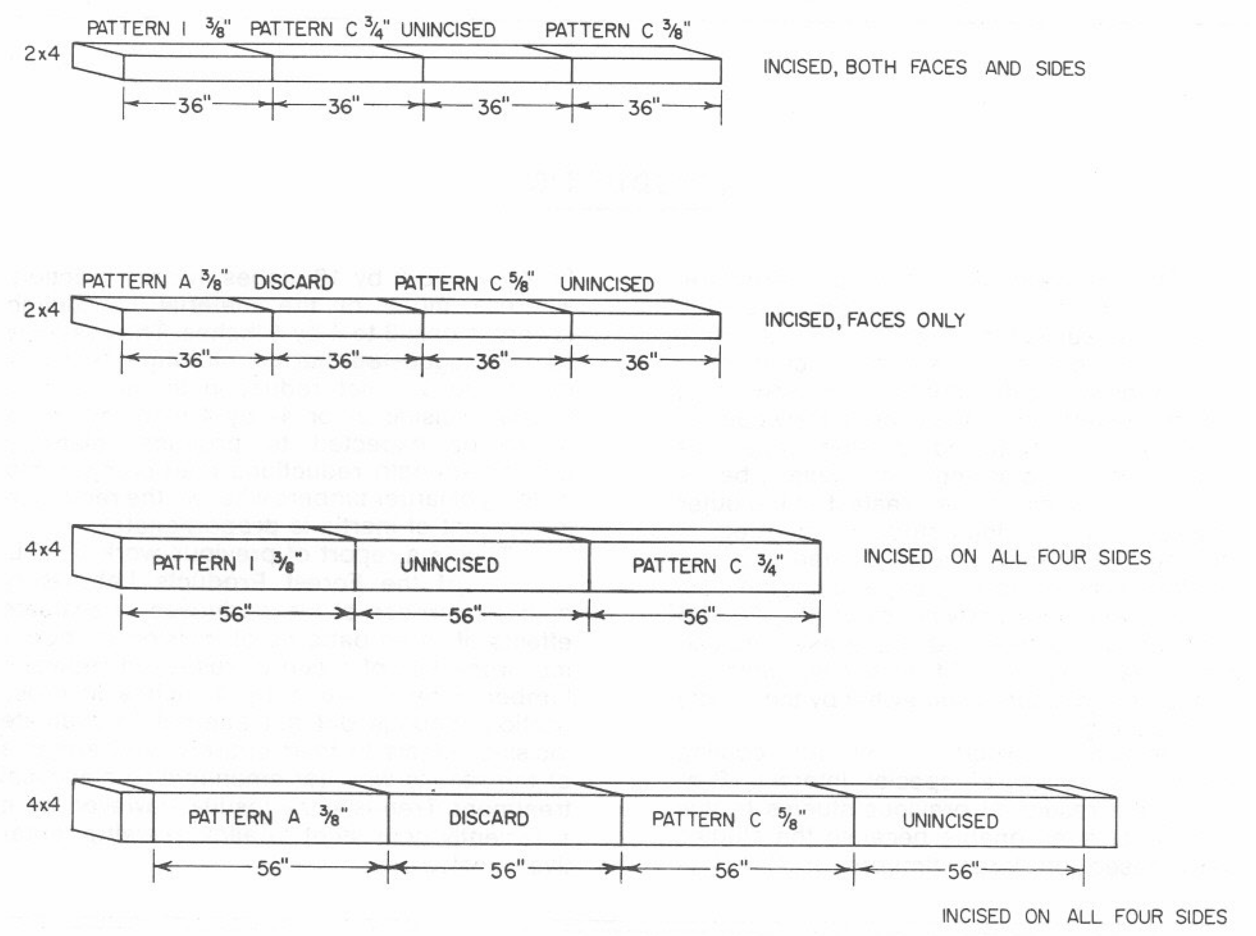

Figure 1.–Test lumber cutting diagrams. Twenty specimens were taken for each incising pattern and depth designation. A total of forty 2- by 4-inch and forty 4- by 4-inch specimens were not incised to serve as controls.

(M 142957)

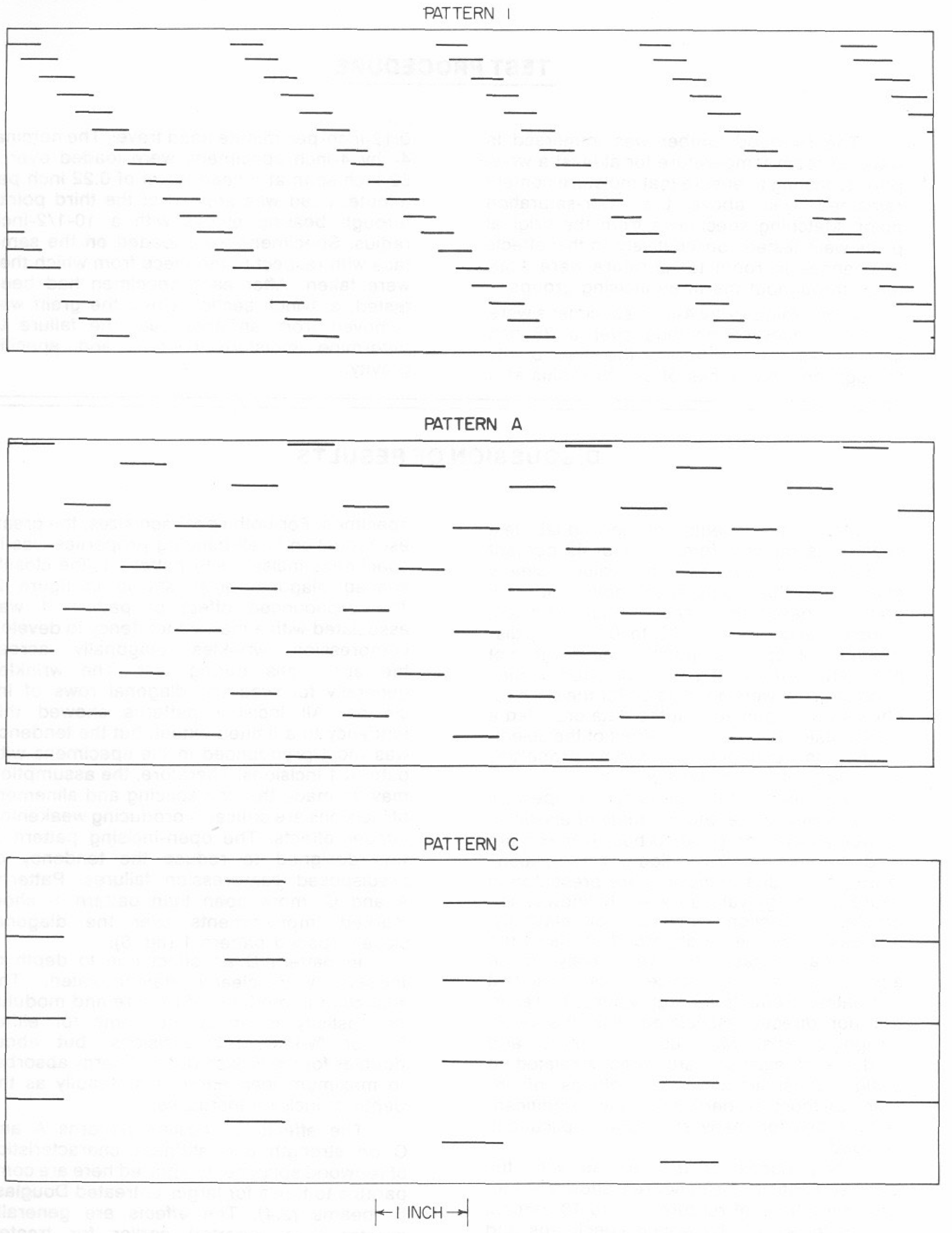

Figure 2.–Incising patterns: Pattern 1 is a closely spaced array of $^{3}/_{8}$-inch incisions arranged in sharply defined diagonal columns. In patterns A and C the incisions are more widely distributed. Pattern C is the standard pattern used by the American Railway Engineers Association. (M 142 956)

TEST PROCEDURE

The redwood lumber was immersed in water at room temperature for at least a week prior to testing to ensure that moisture content remained well above the fiber-saturation point. Matching specimens from the original piece were tested consecutively so that effects of changes in room temperature were scattered throughout the three incising groups.

The nominal 2- by 4-inch specimens were loaded in flatwise bending over a 28-inch span. Load was applied at the third points through bearing blocks of 5-inch radius at a 0.12-inch-per-minute head travel. The nominal 4- by 4-inch specimens were loaded over a 52-inch span at a head travel of 0.22 inch per minute. Load was applied at the third points through bearing blocks with a 10-1/2-inch radius. Specimens were loaded on the same face with respect to the piece from which they were taken. After each specimen had been tested, a 1-inch section along the grain was removed from an area near the failure to determine moisture content and specific gravity.

DISCUSSION OF RESULTS

Moisture contents of individual test specimens ranged from a low of 49 percent to more than 200 percent, values clearly above the fiber saturation point. Specific gravities, based on ovendry weight and test volume, ranged from 0.26 to 0.52. The distribution of specific gravities, although not precisely uniform (fig. 3), included values most of which were anticipated for the species. Thus it was assumed that the data provided a reasonable estimate of the effect of the selected incising treatments on bending properties of redwood in structural sizes.

The important bending properties, modulus of rupture and modulus of elasticity, as well as the energy absorbed to maximum load, are summarized in figure 4. Reductions in properties due to incising are presented in figure 5. Energy values generally showed the greatest reduction: modulus of elasticity, the least. The energy absorbed to maximum load is a characteristic very likely to be affected by incising; hence, a sensitive test of treatment effects. Energy values, however, are not directly associated with the usual design criteria. Modulus of rupture and modulus of elasticity are directly related to design considerations, and effects of incising on those properties may have significant implications for many structural applications of wood.

Comparisons of the incised with the unincised specimens in figure 5 show a reduction in modulus of rupture of 7 to 18 percent for the incised 2- by 4-inch specimens and 6 to 21 percent for the 4- by 4-inch specimens. Modulus of elasticity was not reduced more than 10 percent on the average for either size specimen. For both specimen sizes, the greatest reduction in all bending properties was in specimens incised with pattern 1, the closely spaced diagonal array shown in figure 2. The pronounced effect of pattern 1 was associated with a marked tendency to develop compression wrinkles diagonally across the specimens during test. The wrinkles generally followed the diagonal rows of incisions. All incising patterns showed this tendency to a limited extent, but the tendency was most pronounced in the specimens with pattern 1 incisions. Therefore, the assumption may be made that the spacing and alinement of incisions are critical in producing weakening lumber effects. The open-incising pattern A was designed to reduce the tendency of predisposed compression failures. Patterns A and C, more open than pattern 1, Show marked improvements over the diagonal closely spaced pattern 1 (fig. 5).

In pattern C an effect due to depth of incision was clearly demonstrated. The reduction in modulus of rupture and modulus of elasticity is about the same for either $^3/_8$– or $^5/_8$-inch-deep incisions, but about doubles for the $^3/_4$-inch depth. Energy absorbed to maximum load decreases steadily as the depth of incision increases.

The effects of incising patterns A and C on strength and stiffness characteristics of redwood specimens reported here are comparable to those for larger untreated Douglas-fir beams *(2, 4).* The effects are generally greater than reported earlier for treated Douglas-fir material *(2).* The effects of incising pattern 1 are comparable to those reported for 8- by 16-inch untreated Douglas-fir

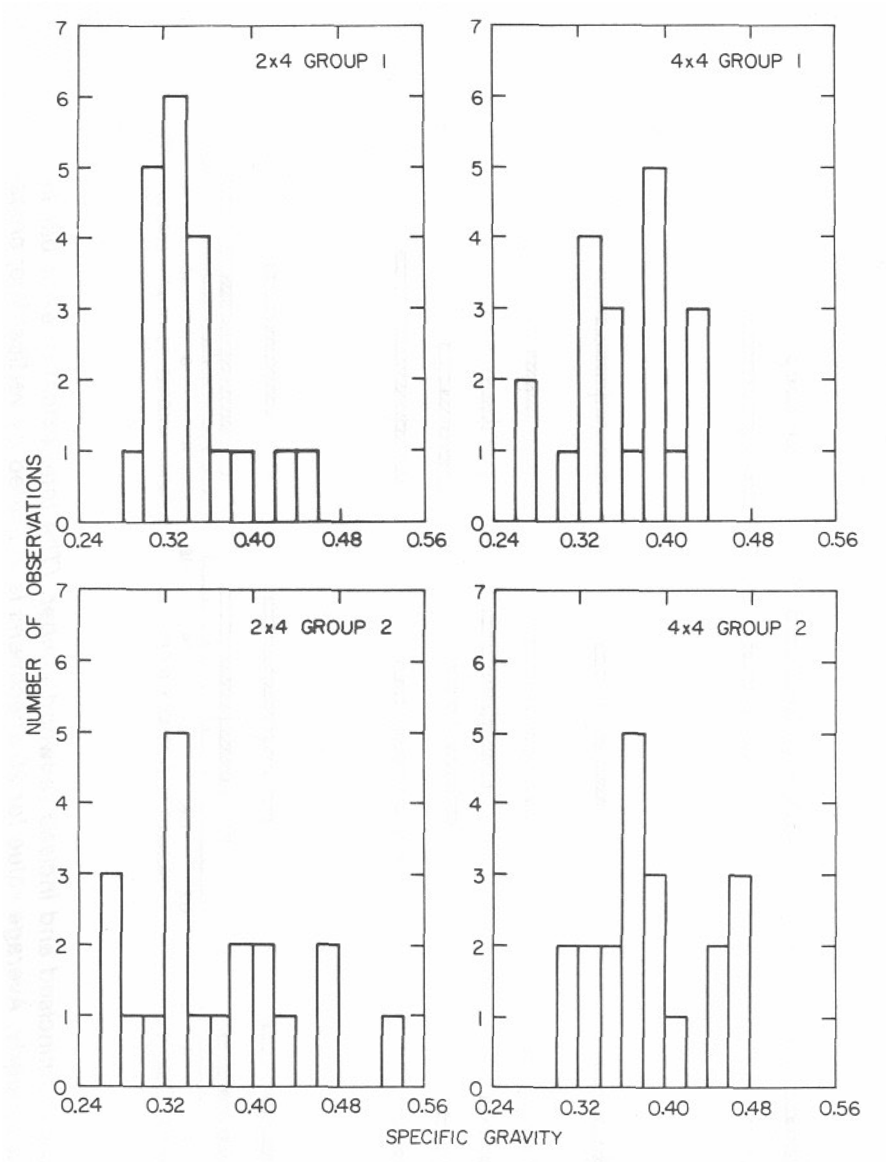

Figure 3.–Frequency histograms of specific gravity (weight ovendry and volume at test) specimens from unincised specimens after test. specimens included within each group are described in figure 1. The histograms offer no firm evidence that appreciable differences in material may exist among the four groups of test specimens.

(M 142 955)

beams incised after kiln drying *(7)*.

Incising provides a means to improve resistance to biological deterioration by increasing the uniformity and the depth of the preservative treatment. Presumably, the initial strength and stiffness of incised members are maintained over longer periods by improvement in decay inhibition. The results here yield an estimate of the immediate influence of incising on some important engineering properties.

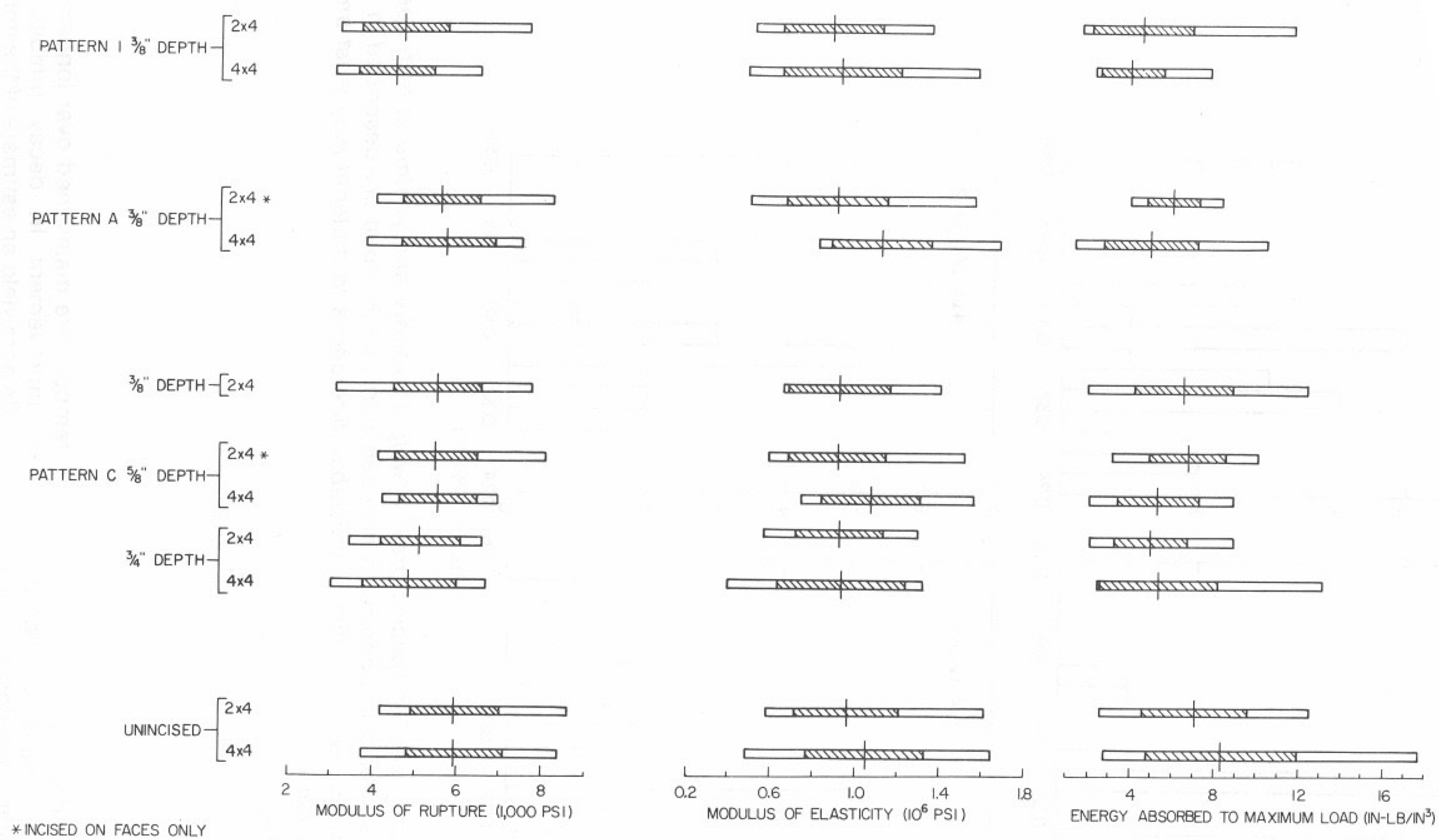

Figure 4.–Bending properties of unincised and incised redwood lumber. (The total extent of each bar indicates entire range of a property. Average value for 20 specimens is indicated by vertical line; cross-hatched section is ± 1 standard deviation from the average.)

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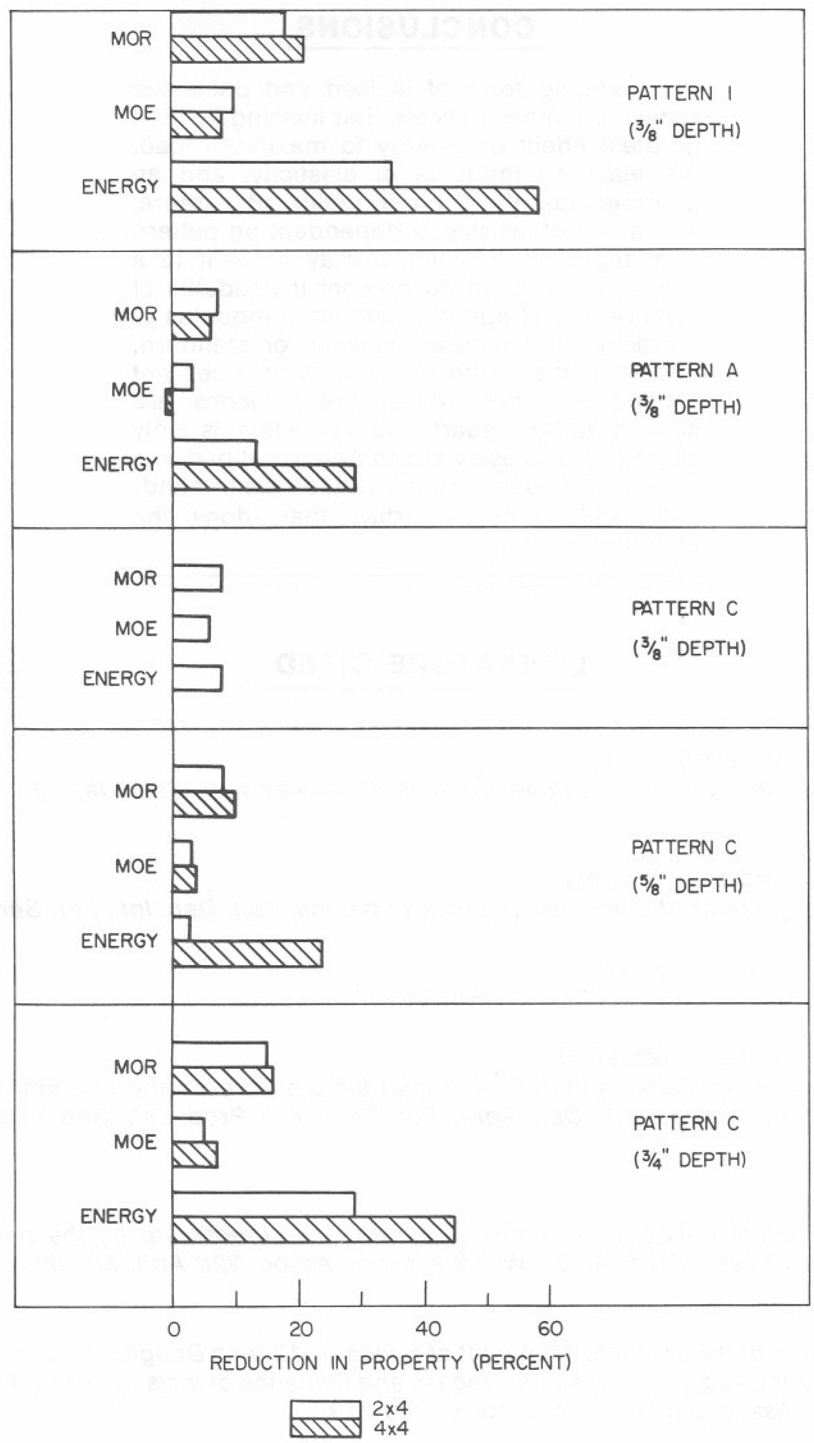

Figure 5.–Average percent reduction in bending properties of incised redwood lumber. Reduction values are based en average property values of matching unincised specimens. (See fig, 1 tor matching plan.) MOR equals modulus of rupture; MOE, modulus of elasticity; and energy, energy absorbed to maximum load.)

(M 142 954)

CONCLUSIONS

Bending tests of incised and unincised redwood lumber indicate that incising has the greatest effect on energy to maximum load, the least on modulus of elasticity, and an intermediate effect on modulus of rupture. The effect of incising is dependent on pattern and depth of incisions. It may amount to a reduction of about 10 percent in modulus of rupture and of about 5 percent in modulus of elasticity for the open incising, or standard, pattern if the depth of penetration does not exceed 5/8 inch. When the incisions are spaced farther apart, the reduction is only slightly less. Closely spaced diagonal patterns of incisions cause greater reductions in bending mechanical properties than does the standard pattern.

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