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THE STRENGTH OF ASPEN STUDS

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Recently considerable interest has developed in the possibility of manufacturing 2 by 4 inch by 8 foot dimension lumber (studs) from aspen boltwood. Research at the School of Forestry has considered the effects of sawing procedures, drying schedules, and pre- and post-treatments on the quality of aspen studs produced. A conference to discuss these topics was held (1). This research is continuing with the goal of providing information on boltwood yields in terms of board footage and grade. When such information is available the economic feasibility of production can be better assessed. One important question is: "How strong are aspen studs as compared to those species customarily used for studs?". This note answers that question.

The strength values for dimension lumber used by engineers and code agencies are derived using procedures detailed in American Society of Testing and Materials standards D2555-69 and D245-69. These values are recognized, however, only when the lumber has been graded under rules approved by the American Lumber Standards Committee (ALSC) as described in Voluntary Product Standard PS20-70. The strength values computed in this paper were determined using procedures and softwood lumber rules which have been approved by ALSC. However, to date no grading rules for aspen dimension lumber have been approved or considered by ALSC.

The general procedure for determining the strength of dimension lumber is as follows. Clear, green, straight-grained specimens have been tested to determine five basic strength properties. The results of these tests, the mean and standard deviation of each property, are listed in ASTM D2555-69. In many cases, as with aspen, more than one species is sold under a single commercial name. The strength values used for the group of species are weighted averages of the individual species values. The weighting is on the basis of relative volumes of standing timber. Table 1 shows the clear, green, wood strength values for the two species of aspen in the group and the relative standing volumes. For three of the strength properties, i.e., bending stress, compression parallel to the grain and shear, the working stresses are derived from the weighted 5% exclusion limits. The other strength values, i.e., compression perpendicular to the grain and modulus of elasticity, are determined from the weighted means. Table 2 outlines the computation of the

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[illegible] Minnesota [illegible] cooperating with the Division of Forestry, Minnesota [illegible] and Forest Industries of Minnesota

exclusion limits. The allowable stresses for clear, green, straight-grain material is next computed. See Table 3. The reduction factors are used to compensate for duration of load and provide a safety factor. A size factor is required for the bending stress, and in these calculations a factor for 2 x 4's was used. The exclusion limit is divided by the reduction factor to obtain the green working stress value. This green value is increased by prescribed percentages to obtain the values for 19% maximum moisture content material.

The last step in the calculations involves reducing the strength of clear material according to the severity of the strength reducing defects allowed in each grade. The strength reductions used here for each strength property and grade combination are those currently used by the major lumber grading agencies under the new National Grading Rule.

Table 4 shows the various strength properties which could be used in the engineering of wood structures with aspen 2 x 4's. Note that since no grade rules presently have been written or approved for aspen dimension these values will not be recognized by any agency or code group.

Table 5 is a comparison of the strength of "stud" grade 2 x 4's of aspen and four other species commonly used for studs. The strength of aspen studs is about the same as Engelmann spruce or balsam fir. It has about 3/4 the strength of West Coast Hemlock-Fir and about 2/3 the strength of Douglas Fir-Larch. When used in conventional stud walls the strength of aspen far surpasses the actual loads encountered.

Literature Cited

1. Thompson, R. D. 1969. (Editor) Proceedings of Aspen Stud Seminar. School of Forestry, University of Minnesota.

Table 1

Basic Properties of Aspen as Listed in ASTM D2555-69[1]

			Clear Green Wood Strength Values Unadjusted for End Use											
Species	Standing[2] Timber Volume (million cu. ft.)	Relative Standing Volume (%)	Modulus of Rupture (psi) Mean	Std. Dev.	Modulus of Elasticity (1000 psi) Mean	Std. Dev.	Compression Parallel to Grain (psi) Mean	Std. Dev.	Horizontal Shear (psi) Mean	Std. Dev.	Compression Perpendicular to Grain (psi) Mean	Std. Dev.	Specific Gravity Mean	Std. Dev.
Bigtooth Aspen	2970	21.12	5400	846	1120	246	2500	450	732	102	206	58	.36	.036
Quaking Aspen	11093	78.88	5130	821	860	189	2140	385	656	92	181	51	.35	.035

[1] These values are for aspen grown in the United States. Somewhat higher values for most strength properties should be used for aspen grown in Canada - see D2555, Table 3.

[2] Per letter from Chief of Forest Survey, USDA, Forest Service, Dated April 3, 1970.

Six study areas, each 2.5 acres in size, were established to sample before and after thinning conditions. One-half of each of the six areas was used as a control with no thinning. A total of 600 mil-acre plots, 100 per area, were systematically located. Stem counts and height measurements were taken before and after thinning. The number of "desirable trees" left after thinning was also tallied. A "desirable tree" was defined as being over four feet in height with good stem form, good general crown characteristics and free of disease or mechanical injury.

Jack pine stems averaged 18,500 and ranged from 6,400 to 44,300 per acre before thinning (Table 1). Some of the individual mil-acre plots had a stem count prior to thinning equivalent to over 100,000 stems per acre. Thinning reduced the number of stems about 80 percent leaving a final average density of 3,330 stems per acre. Less than 50 percent of the residual trees were classified as desirable. Many of them were injured by the equipment. Some of the injured trees were bent over and others had the top portion of the crown cut off. Many of the stems that are undesirable may persist and cause future management problems.

There was also a reduction in average height from 6.9 to 5.5 feet, which may be an indication of an adverse selection process. During the operation, stems on the edge of the reserve strip were often pushed forward and down by the outside frame of the cutter. The smaller stems usually angled outside of the frame and returned upright but the larger stems often became entwined in a position where they were cut off or bent over and damaged (Figure 3).

Table 1. Jack pine reproduction before and after thinning operation.

Area No.	Stems/Acre Before	Stems/Acre After	Height[1/] Before	Height After	Desirable Trees/Acre
1	12,700	3,000	6.6	5.6	1,320
2	44,300	8,800	7.1	5.3	2,880
3	8,600	1,700	7.2	5.8	960
4	6,400	1,580	6.1	4.5	700
5	27,900	2,740	6.9	5.2	1,480
6	11,200	2,160	7.4	6.6	1,400
$\bar{x}$	18,500	3,330	6.9	5.5	1,460

[1/]Height is in feet, based on average of three tallest trees on the plot.

Stocking and tree distribution are also important parameters of stand density. The thinning operation reduced the number of overstocked mil-acre plots (more than one tree) from 87 to 49 percent. The number of plots with a single tree was increased from 4 to 23 percent. Seventeen percent of the plots had a single desirable tree. However, the number of non-stocked plots was increased from 9 to 28 percent. The increase in non-stocked plots was primarily due to an overlapping of cut strips caused by the cutter bouncing sideways over the surface debris which resulted in open patches in the stand.

Figure 3. Large jack pine bent over by equipment.

Conclusions

Stands such as the one resulting from the Badoura burn present the forest manager with a dilemma. He must consider at least three alternatives in his decision-making process:

1. Leave the stand as it is and depend on natural selection and thinning processes. This usually results in a longer rotation with smaller trees.
2. Thin the stand at an early age at lowest cost possible to produce the maximum amount of merchantable volume in as short a time period as possible.
3. Thin the stand at an older age and do it in a selective manner. This may be the most expensive alternative but may also yield some return from thinned material.

The thinning operation described appeared to be a good economic alternative in terms of treatment costs. The operation increased growing space, and will likely meet the specified objectives. Observations immediately after thinning indicate that there may be an overabundance of poorly-formed, problem-type trees and less than an optimum distribution pattern. However, final judgment of the results of the operation cannot be made until the stand develops and recovers from thinning. It will take a period of at least five years to assess the success of the thinning.

Note: Trade names of equipment mentioned in this study serve to aid in description and imply neither endorsement nor criticism.

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