BEHAVIOR OF PREDRILLED ASPEN STUDS DURING DRYING AND SUBSEQUENT TREATING

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INTRODUCTION

Straightness and dimensional stability in structural dimension lumber are qualities increasingly demanded by customers. Producing straight and stable lumber is a much studied problem and several techniques have been proposed to solve this dilemma(1,3,4,5,8,9,10,11,12). The most notable methods include saw-dry-rip and top load restraint to reduce warp. Neither of these methods are too applicable for studs, however. The practice of producing studs from veneer peeler cores precludes the use of S-D-R and the use of small diameter trees greatly restricts the ability of S-D-R to reduce warp. The stacking of lumber flatwise for kiln drying maximizes the ability of top load restraint to prevent bow and twist but it translates into a lesser ability to prevent crook.

Lumber should not only be restrained from warping, but it should also be dried to a moisture content (MC) close to the equilibrium moisture content it will attain while in use. For exterior wall framing members, a moisture content of 12 percent is suggested for much of the United States(14). Research performed by two other organizations found that framing members on interior walls reach a MC as low as 8 percent(6,7). Eight percent is much lower than the upper limit of 19 percent set by the American Softwood Lumber Standard and the 15 percent maximum for KD material(13). Moisture content should be uniform as well as low to assure dimensional stability. Obstacles to these goals include increased drying cost due to longer kiln residence times and the increase of warp associated with kiln drying to a low moisture content such as 8 percent.

OBJECTIVES

The research reported here is a continuation of the research presented at the 1989 Western Dry Kiln Association Meeting(5). In that paper, it was reported that holes drilled perpendicular to the narrow edge reduced drying time by approximately 20% and greatly improved moisture content uniformity. However, a reduction of crook was not realized even though the predrilled studs were vertically stacked for the kiln drying. This was due to some mechanical problems with the weight restraint system.

The specific objective of the research described in this paper was to dry aspen studs from dead green to a low and uniform moisture content while preventing crook. The predrilled holes were sized and positioned such that grade rule limitations were not exceeded. Since the holes were drilled perpendicular to the wide face, it is believed they could facilitate the installation of electrical wires. This might also be the case for some of the plumbing.

In addition, the dimensional stability of these studs was studied over time under seasonal cyclic humidity and temperature conditions. The studs were also examined after treatment to rejection with CCA - Type III preservative and the redrying.

EXPERIMENTAL DESIGN AND PROCEDURES

Ninety-one green 2 x 8's were obtained from the Rajala Sawmill in Deer River, MN. Pieces as near quartersawn as possible were selected in order to increase the potential for crook development. The 2 x 8's were surfaced to a thickness of 1-3/4" and ripped to form a side-matched pair of studs 3-7/8" wide and eight feet long. Each member of the pair was then randomly allocated to the control group or to the group to be predrilled.

Each stud of the predrilled group contained 29 holes of 3/4" diameter arranged along two parallel lines (Figure 1). The holes were 3/4" in from each edge and spaced 6" apart along each line and were offset so that the holes of one line fell midway between the holes of the other line. This pattern of drilling removed the same amount of material from the 4" face as that allowed in the grading rules, i.e. a "1-1/2 inch hole or equivalent smaller per one linear foot."(11)

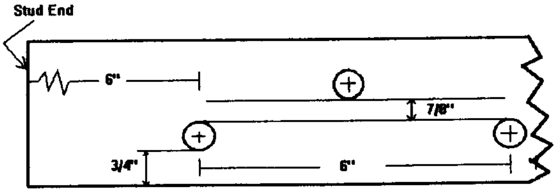

Figure 1.--Drilling pattern for predrilled studs.

The green studs were measured for weight and crook and the direction of crook was marked in order to retain it for comparative purposes in subsequent measurements.

The predrilled studs were stacked in racks designed to hold the studs with their wide faces oriented vertically (Figure 2). The racks were constructed of 3/4" diameter rods welded at their bottom ends to a 1/4" thick iron plate and the rods were spaced 1-3/4" apart to accommodate the thickness of a green stud. A 1/4" thick iron plate, with 7/8" diameter holes drilled in a row and 1-3/4" on center, was slipped over the upper ends of the vertical rods in order to maintain their uniform spacing. Three of these racks were clamped to the cross beams of the kiln car; one at either end and one midspan.

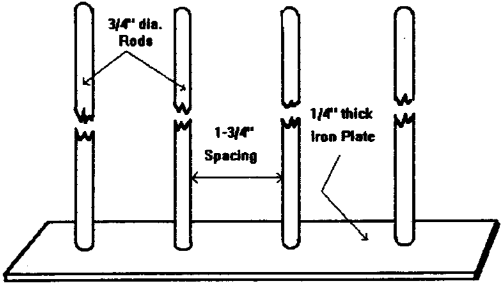

Figure 2.--Schematic of restraint system.

Dry, paper birch stickers 7/8" thick were placed two feet apart to separate the studs vertically. The middle slot was reserved for six 48" long sample boards. After stacking, four 500 lb concrete blocks were placed atop the charge to provide a load of approximately 63 lbs per square foot of the top area.

The control group was stacked in the conventional manner with the wide faces of each stud horizontal. Dry, paper birch stickers 7/8" thick were placed two feet apart and the same top-load restraint of 2000 lbs. was applied.

The same kiln schedule was followed for both groups (Table 1). Schedule T12-E7 from Dry Kiln Schedules for Commercial Woods, FPL-GTR-57 was employed from the green condition to approximately 30% moisture content oven dry basis(2). At 30% MC, the schedule was changed to a high-temperature drying at 240°F DBT and 190°F WBT. The conventional schedule was used above the fiber saturation point in order to minimize collapse and the high-temperature drying was used from the fiber saturation point to the final MC of 9% so as to take advantage of possible plastic flow of lignin to relax the stresses that cause warp.

Table 1.--Kiln schedule used for drying the green studs.

Step	Moisture Content	Temperature (Deg. Fahreneit) DBT	WBT
1	>60%	160	140
2	60 to 50	160	130
3	50 to 40	160	120
4	40 to 30	160	110
5	30 to 9	240	190
	OR		
5	30 to 9	210	160

After drying, the studs from each group were evaluated for crook magnitude and direction, weighed, and then metered for moisture content. The readings were taken at four locations on each stud using an electrical resistance moisture meter.

The studs were then stored indoors on 1" stickers for 16 months, starting in the summer and continuing through the fall of the following year. This sequence of seasons, summer/fall/winter/spring/summer/fall, combined with indoor storage, subjected the studs to sequential periods of high, moderate, low, moderate, high, and moderate relative humidities. For the summer the indoor air temperature generally ranged between 80 and 95°F while for the other seasons the range was about 65 to 70°F. After this storage, each stud was again measured for crook, it was weighed and its MC determined by meter.

The studs were treated to refusal with CCA - Type III preservative at Quality Wood Treating in White Bear Lake, Minnesota. Immediately after treating they were weighed and measured for crook. They were then dried by about the same schedule as in Table I. The redrying differed from that used for initial drying because of steam problems that prevented attainment of the 240 F DBT. After redrying to about 9% MC, the studs were again measured for crook magnitude and direction, weighed, and metered for MC.

RESULTS AND DISCUSSION

Drying Rates for the Initial Drying

Figure 3 compares the drying rates for the predrilled and undrilled studs. The curves were created with MC calculations that were based on the intermediate MC sections.

The predrilled studs dried to 9% average MC in about 60% of the time required for the control group. The predrilled group had a lower initial MC due to the loss of moisture during the drilling but the effect of this on total drying time is probably offset by the fact that the high-temperature drying started at a lower MC for the predrilled group.

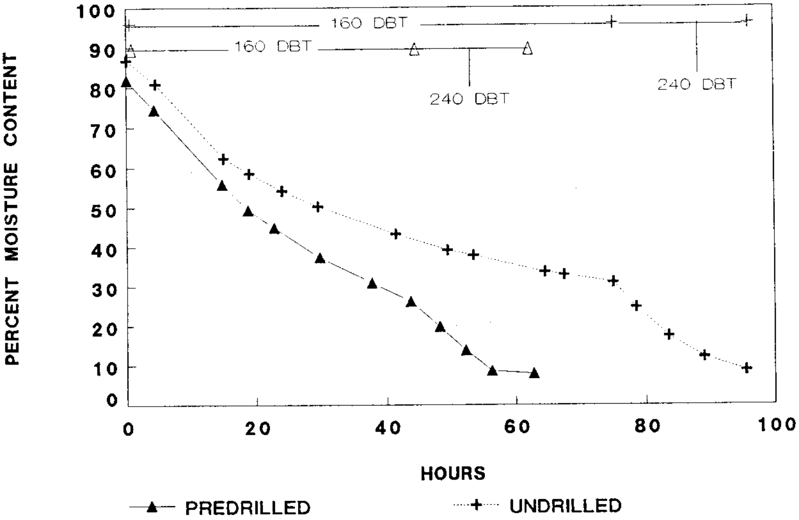

Figure 3.--Kiln drying rates for predrilled and controls.

Preservative Treatment and Redrying

Table 2 compares the solution uptake for the two groups based on average stud weights before and after treating. The figures show that the solution uptake calculated as a percentage of the stored weight was about 35% greater for the predrilled studs (8÷23x100). No formal tests were performed to compare the relative effectiveness of treating for the drilled and control groups, but casual observations made during the cutting of MC cross-sections indicated that penetration was superior for the drilled studs.

Table 2.--Calculation of preservative retention.

TREATMENT		GREEN	DRIED	STORED	TREATED	REDRIED
DRILLED	*AVE.*	7059	4283	4223	5534	4249
	STD.	641	348	328	564	330
UNDRILLED	*AVE.*	7367	4519	4369	5380	4424
	STD.	606	354	344	550	337

SOLUTION
UPTAKE(%)

DRILLED: *(5534−4223)/4223=31*
UNDRILLED: *(5380−4369)/4369=23*

The increased end grain in the predrilled studs also aided drying after treating (Figure 4). They dried to a 9% final average MC in approximately 29 hours compared to 46 hours for the controls, even though they started at an average treated MC of 38% compared to 33% for the controls. In summary, the predrilled studs took up 30% more weight of treating solution than did the controls but they required only 63% as much drying time to reach 9% MC.

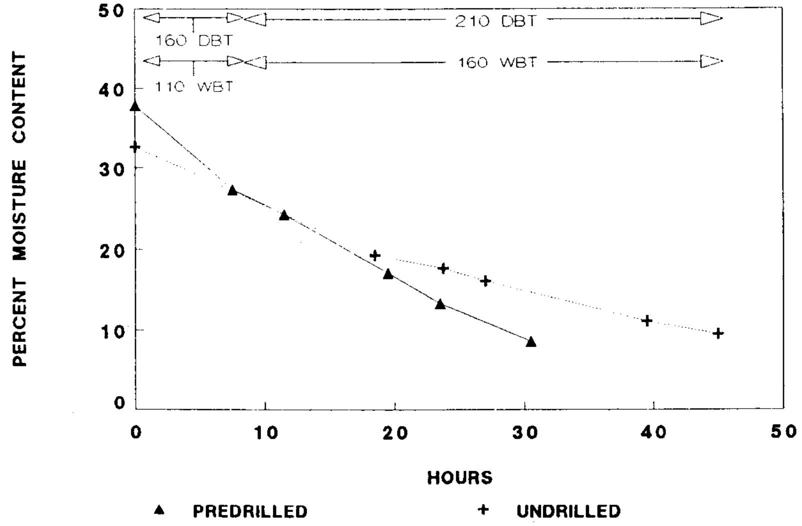

Figure 4.--Kiln drying rates for the treated studs.

Moisture Content and Crook Data

The summary of crook data for each stage of the processing is shown in Table 3. For each stage, the predrilled group exhibits less crook than the undrilled group. This was somewhat surprising for the green stage. This is believed due to the fact that the control group was measured five days after crook was measured for the predrilled group. Even though the studs were stored in a cold room while wrapped in plastic, additional crook may have developed for the control group during the 5-day storage due to the relaxation of growth stresses.

Table 3.--Summary of crook results.

		GREEN	DRIED	STORED	TREATED	REDRIED
N	DRILLED	91	85	85	85	79
	UNDRILLED	91	85	85	85	79
AVERAGE	DRILLED	6.04/32"	5.28/32"	6.22/32"	8.36/32"	5.09/32"
	UNDRILLED	7.45/32"	10.6/32"	9.71/32"	10.9/32"	10.5/32"
# OF STUDS MAKING GRADE	DRILLED	71	70	61	54	67
	UNDRILLED	60	42	47	42	41
% MAKING GRADE	DRILLED	78	82	72	64	85
	UNDRILLED	66	49	55	49	52
# OF STUDS > 1/4"	DRILLED	20	15	24	31	12
	UNDRILLED	31	43	38	43	38

For the drilled studs, it is of interest that the initial drying reduced the amount of crook by comparison to the green studs and that the redrying after treatment also reduced crook by comparison to the stored studs. This was not the case for the controls, however. Both the initial drying and the redrying caused an increase in crook for the same two comparisons. The vertical stacking plus top load weighting was able to remove some of the existing crook while conventional stacking plus top load weighting was incapable of preventing the development of additional crook.

For each of the five stages there was a higher percentage of stud grade for the predrilled, especially for the stages other than green. The percentage on grade for the predrilled studs was about the same after initial drying and redrying. The same pattern held for the controls which suggests that the level of ability of each restraining method to prevent crook remained constant. This was the case even though many studs from both groups displayed crook after redrying that was opposite in direction to what they had after drying.

After the initial drying there were 28 more of the undrilled studs with crook greater than 1/4" than was the case for the drilled studs. After redrying, the differential was 26 studs.

Both groups remained relatively stable during the long term storage following drying. Crook for the control group decreased 0.89/32" while for the drilled group there was a gain of 0.94/32". A possible explanation for this behavior is that the predrilled studs were dried to an estimated average MC of 7.9% while for the control group it was 8.8%. For the controls the equalization during storage may have caused some crook opposite in direction to that present immediately after drying, thus slightly reducing their average crook during storage. On the other hand, small changes such as these might be simply due in large part to experimental error and chance occurrence.

The drilled studs had a more uniform MC after drying than did the undrilled studs as shown in Figure 5. There are several control studs in the 17.5-18.4% MC range but no predrilled. For the comparisons at 9.5% MC and above, there is only one for which there is a greater number of predrilled studs while for the comparisons at less than 9.5% the total number of predrilled studs is much greater.

Moisture content readings were taken by an electrical resistance-type moisture meter after the storage period and after the redrying period. The meter failed to register a reading for the majority of the studs. This suggests a comparatively shallow penetration of solution during the treating since the readings were made at a depth of less than 1/2".

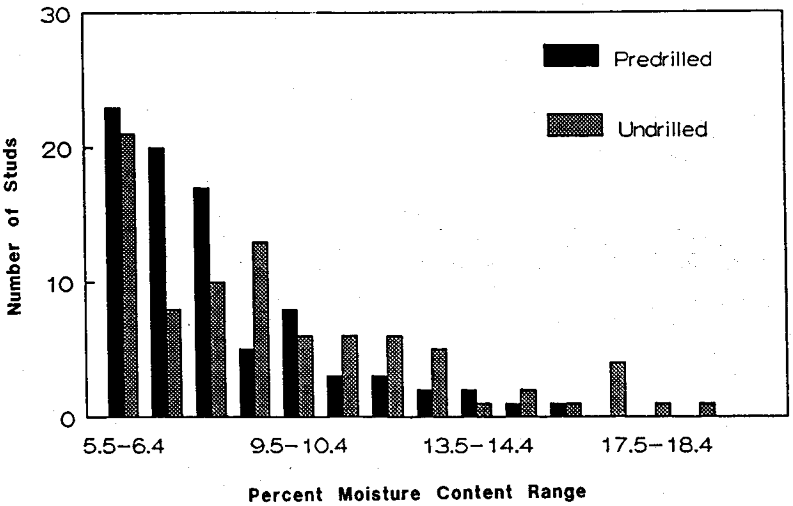

Figure 5.--Distribution of stud moisture contents after initial drying.

SUMMARY AND CONCLUSIONS

Quartersawn, green aspen 2 by 8's were ripped into side-matched 2 by 4's and randomly allocated to a predrilled or undrilled group. The predrilled group was processed with 3/4" holes perpendicular to the wide face such that the material removed was equivalent to the grading rule limitation of a 1-1/2" hole, or equivalent smaller, per linear foot.

The drilled group was stacked for kiln drying with the wide edges oriented vertically and concrete slabs were placed on top of the charge. The undrilled studs were stacked in the conventional manner and with top load restraint equal to the drilled group. Both groups were dried by the same schedule and then evaluated. The dried studs were stored on stickers indoors for 16 months and thus experienced the cyclical conditions of such storage. After storage, they were evaluated again. Finally, the studs were treated with a waterborne preservative, redried and reevaluated.

Predrilling and vertical stacking reduced the drying time from dead green to 9% MC by approximately 40%. Crook was consistently lower and stud grade recovery was consistently higher for the predrilled group. Moisture content distribution after drying was tighter for the predrilled group.

The drilled studs accepted more preservative and gave indications of better preservative penetration than the control studs. The drilled studs accepted solution equal to 31% of their pretreatment weight while for the undrilled studs it was 23%.

Predrilling and vertical stacking of light framing studs seems to be a viable option for producers who want to produce a stable and straight stud, experience higher grade recovery, and reduce kiln residence time. The benefits of predrilling in this research were obtained without exceeding the hole allowance for studs given in the grading rules. An effective restraining system in the context of conventional stacking would greatly enhance the possibility of utilizing this processing technique. Acceptance of the predrilled stud should be achievable by educating both the producer and the consumer with respect to its inherent advantages. Without such an effort this commodity market may be lost to non-wood materials.

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