Warp reduction in young-growth ponderosa pine studs

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Conventional kiln-drying under restraint with an initial plasticization treatment reduced fall-down from 51.0 percent to 34.4 percent.

Increasing amounts of lumber are being cut each year from young, small-diameter ponderosa pine trees. Unfortunately, this material tends to warp severely when it is dried. Downgrading as a result of warp for commercial operations has been as high as 60 percent.

Investigations aimed at finding practical methods for reducing warp in softwood construction lumber fall into three general areas: alternate drying schedules, altered sawing patterns, and drying under restraint.

Except for the first, each of these techniques has led to significant reductions in warp. Drying under top-load restraint appears more practical than other methods because it is either less expensive or easier to integrate into a production system.

The most promising of these techniques is high-temperature drying under restraint. Unfortunately, it has never been tried on ponderosa pine. High-temperature drying without restraint is frequently said to lead to less warp, but there is little data to confirm this. There is, on the other hand, considerable data for radiata pine showing the effectiveness of top-load restraint.

This study was initiated on the premise that top-load restraint was the simplest, most practical method for reducing warp in ponderosa pine. The study: (1) established which form of warp is most prevalent; and (2) compared the effectiveness of a 200 lb/ft² top-load restraint when studs are air dried, kiln dried at conventional temperatures, or high temperature dried.

Materials and preparation

Each test unit was 3 feet wide by 8 feet long by 38 inches high. This resulted in approximately 150 boards or about 800 board...
feet per test run. Approximately 10,000 board feet of material was obtained from a cooperating mill in northern California. Care was taken at the mill in selecting the material to insure that as much distortion-prone material was included as possible. All material was shipped to the U.C. Forest Products Laboratory in Richmond, California, where each board was numbered and alternately placed into one of 12 drying units.

Due to limited kiln capacity, a portion of the test material remained solid-piled until a kiln was available. To avoid mold and stain development, this portion of the material was hand-dipped with a commercial anti-stain solution, completely sealed in plastic and stored out-of-doors.

Four reinforced-concrete blocks—16 inches thick by 8 feet long by 3 feet wide—were formed to provide the desired top load (200 lb/ft²).

Procedures
A total of 12 test runs was made. For comparative purposes a control or unrestrained test was made for each of the different drying methods. There was one replication for each drying method.

The air-drying tests with restraint were used because of the simplicity of the method and its ease of incorporation into many mill situations. Conventional and high-temperature drying with restraint were used because of their reported potential.

All test units were stuck flush at both ends and on center with 1½-inch-wide stickers (spacers) and placed on an asphalt work area. The humidity of the air was relatively high due to the laboratory’s close proximity to the ocean. Therefore, drying was slow for these units.

The kiln runs were made using two 1000-board-feet experimental dry kilns, one operating at conventional temperatures and the second capable of reaching 240°F.

Both conventional and high-temperature kiln schedules used in the restrained loads were subjected to a four-hour pre-plastici-zation period before starting the schedule.

Each charge was dried to the same final moisture content of 15 percent, so that the majority of the pieces would be below the 19 percent moisture content required by American Lumber Standards. Twenty boards on the outside edges of the units were periodically metered with an electrical resistance meter to determine when the test unit had reached the desired moisture content. The units were allowed to cool for 24 hours after drying before the concrete block was removed.

After drying and at the time when warp was assessed the moisture content of each piece was again measured with an electrical resistance meter. All boards were examined by Western Wood Products Association grading standards for warp. Those exceeding the limits in any one type of warp were classed as “out-of-grade” and the actual amount of warp in each of these was then remeasured.

Results
Kiln drying at conventional temperatures, with restraint, produced the best results: 65.6 percent of the boards met grade (see table 1). Conventional kiln drying without restraint led to the greatest fall-down, with only 49.0 percent of the two charges making grade.

Restraint seemed to have little beneficial effect when the material was air dried. The percent of boards making grades was 58.1 when no restraint was used and 55.6 when restraint was used. Comparisons of the air-drying tests with the other two methods should be made in light of the fact that the average final moisture contents of these runs was higher than the kiln-drying runs. It is felt that the level of degrade for the air-drying runs would have been much higher had their moisture content been reduced, as would often be the case in summer/fall air drying.

High-temperature drying at first glance
appears to have been the least successful of the three methods. One should note, however, that these runs had on the average the lowest final moisture content. The percentage of boards in grade would probably have been significantly higher if the units had been dried to a higher final moisture content. As with air drying, the use of restraint appeared to have no effect. High temperature drying both with and without restraint were better than conventional kiln drying without restraint.

Crook was the single most serious type of defect, and the major cause of down-grading, with twist and bow of less importance, though still serious.

Top load restraint was most effective in reducing twist. In conventional kiln drying there was only a 1.0 percent loss with restraint as compared with 17.0 percent for twist, probably because of uneven lumber of defect, and the major cause of down-grading, with twist and bow it was much less than for boards to distort between the 4-foot sticker space reduction.

Another possible and yet relatively simple means for reducing the amount of crook would be the use of recently-developed serrated kiln sticks.

It has been observed by kiln operators and others that warp is usually less at the bottom of a charge than the top. It was expected in these tests that degrade would decrease the lower one goes into a unit since the restraint is greater due to the added weight of the tiers above. This was not confirmed. This may be due to the 38-inch height of the units and the difference in weight between the top course and bottom course. At the start of drying it was calculated that the top tier had 188 lb/ft² of restraint, while the bottom tier had 272 lb/ft².

Any increase in recovery would be offset by the loss of volume or throughput in the kiln as a result of the space taken up by the concrete slab. The 16-inch slab used in this study would reduce kiln throughput for an 8-foot-high charge by 16.7 percent. No attempt was made to determine the economic tradeoff between lower production and higher quality. It may be possible to reduce the weight/ft² needed which would decrease the throughput loss from the space reduction.

It is felt that the amount of degrade due to warp is directly related to final moisture content. This was verified by a separate test made on 50 boards selected from those air-dried boards that did not meet grade (table 2). All three forms of warp increased with decreasing moisture content. Bow and crook appear to be more strongly dependent upon moisture content than twist, the former exhibiting roughly a 50-percent increase when moisture content was reduced from 13 to 8 percent. The increase was even greater for the change from 8 to 5.6 percent. Based on this data it seems that some control over fall-down is possible by keeping final moisture content as high as possible, consistent with shipping weight and customer constraints.

Conclusions

The results of this study show that top-load restraint can reduce warp losses in young-growth ponderosa pine studs. In the best case, conventional kiln-drying under restraint with an initial plasticization treatment, fall-down was reduced from 51.0 percent to 34.4 percent, although this would probably be less when adjusted for the height of a commercial-size unit.

Greater improvements could probably be obtained with increased sawing accuracy and the use of five stickers in a course rather than three. The use of more stickers would help reduce the large losses due to bow and perhaps crook.

Drying to the highest possible final moisture content would also give greater recoveries, because warp was found to increase significantly as final moisture content decreased.

The use of restraint with air-drying or high-temperature drying did not appear to be effective. High-temperature drying, while somewhat better than conventional kiln drying without restraint, was not as effective as conventional kiln drying with restraint or air drying.

The 16-inch thick concrete slab used reduced kiln throughput roughly 17 percent. It is likely that a thinner block would work just as effectively, which would help minimize the problem of kiln capacity lost to the presence of the concrete slab.

The major cause of fall-down was found to be crook, with bow and twist being less important. Top-load restraint reduced losses due to twist, but had little or no effect on bow and crook.

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