

INFORMATION REVIEWED
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The Problem: Does weighting of kiln loads reduce warping in kiln drying of hardwoods?

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It is safe to say that the annual loss of lumber due to warp is considerable and that, in some cases, it constitutes the major loss in the seasoning operation. Warping is caused mainly by the inherent shrinkage properties of the wood and cannot be avoided entirely. Some warping, however, can be prevented by taking precautionary measures.

In piling lumber, the following practices should provide proper support and protection and freedom from any external forces that might cause warping:

1. Place stickers in exact alignment over good foundation members.
2. Use close spacing between stickers, such as 16 inches.
3. Use stickers of uniform thickness.
4. Avoid big variations in board thickness in any one layer.
5. Use cover boards if protection from sun and rain is needed.
6. In drying random-length lumber, avoid unprotected and unsupported overhanging ends by sorting for length or by box piling.
7. Provide some weight on top of the pile to hold down top layers.

The results of some experimental work on weighting the top of the pile will be discussed in this article.

The possible effectiveness of measures for preventing warping can be understood best by knowing the inherent characteristics of wood that cause it.

Definition of Kinds of Warp

The several kinds of warp are defined as follows:

BOW.—Deviation flatwise from a straight line drawn from end to end of a piece of wood.

CROOK (sometimes called spring).—Deviation edgewise from a straight line drawn from end to end of a piece of wood.

CUP.—Deviation crosswise from a straight line drawn from edge to edge of a piece of wood.

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TWIST.—Distortion caused by the turning or winding of the edges of a piece of wood so that the four corners of any face are no longer on the same plane.

DIAMOND.—Distortion in which a piece of wood that was originally rectangular in cross section becomes diamond-shaped.

Examples of the different kinds of warp are given in figure 1.

Inherent Cause of Warp

Inherently, the warping of wood during drying is caused by the shrinkage that occurs with changes in moisture content. Shrinkage, however, is not the same in all directions of the grain. Shrinkage parallel to the annual rings (tangential shrinkage) is, for most species, nearly twice that across the rings (radial shrinkage). Shrinkage lengthwise of the fibers is very small as compared to transverse shrinkage. Because of these differences, wood with distorted or irregular grain tends to warp more than that with straight grain.

Figure 2 shows that, in a flat-sawed board, the annual rings are more tangential to the face nearest the outer portion of the tree than to the one nearest the pith. Cupping, therefore, is in the direction towards the bark, because of the greater shrinkage in the tangential direction than in the radial direction. The difference between the angle made by the annual rings with one face of a board and that made with the other face is greatest in lumber cut from small logs or from near the pith. This helps to explain why warping is usually greatest in lumber cut from small, second-growth trees.

As these inherent shrinkage differentials are the most direct cause of warping, irregular or cross-grain stock can be expected to warp considerably during seasoning. Where fibers are not parallel to the length of the board, the relatively great transverse shrinkage, acting in the longitudinal direction, is very apt to cause some bow, crook, or twist. This is why lumber from crooked logs has a tendency to warp.

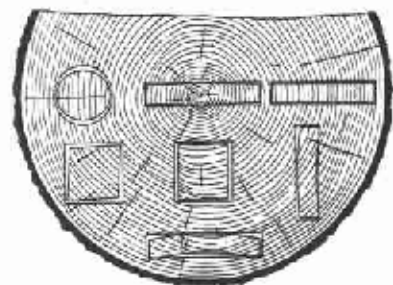


Fig. 1. Different kinds of warp.

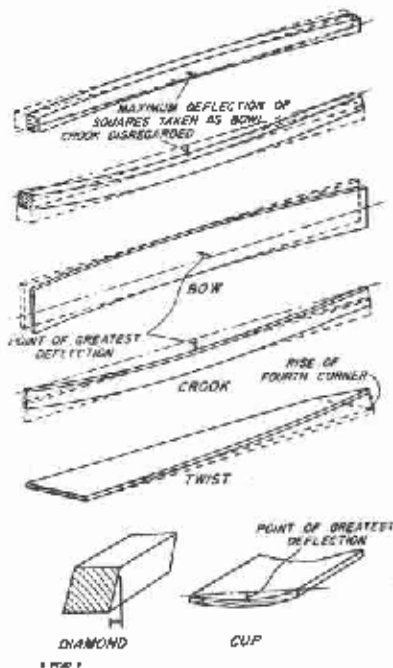


Fig. 2. Cupping in flat-sawed board.

Effect of Kiln Drying Schedule on Warping

As a warp-control measure, the particular kiln schedule used is not of great importance. Tests have indicated that the effect of the schedule on warping is not great within the range of temperature and relative humidity conditions usually used in kiln drying hardwoods. A low temperature and low relative humidity schedule is usu-

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ally best, since, by causing a steep moisture gradient, it sets the surface in such an expanded condition that final over-all shrinkage and therefore warping are reduced. Very low initial conditions of relative humidity, however may cause surface checks and should be used only when the stock being dried will take such conditions or can be inspected closely and frequently during drying.

Reduction of Warping in a Pile of Sugar Maple

It is commonly known that a certain amount of restraint is helpful in reducing warping, especially in the top layers. Where such warping is a problem, some operators use bolted or spring clamps, while others simply place some weight on the top of the pile.

The question has often arisen as to the amount of pressure that is needed. Warp measurement of 2¼-by 3-inch sugar maple in an unweighted, commercial kiln truck, after the maple was dried to about 6% percent moisture content, indicated that the weight of the stock reduced bow and twist down to the fifth layer. Below that layer, no further reduction was noticeable. The amount of crook (lateral deflection) did not differ significantly from the top to the bottom of the pile.

Warp Reduction in Some Experimental Kiln Runs on Blackgum

Some experimental warp data were also collected in kiln 1- by 10-inch blackgum, 3, 6, and 12 feet in length. The test material consisted of 3 groups of 10 plain-sawed and 10 quarter-sawed boards of each length. The 3 groups were weighted, respectively, with approximately 30, 90, and 150 pounds per square foot, so as to simulate the average pile weight on the top 20 layers, on the second 20 layers, and on the bottom 20 layers of a regular kiln truck of lumber 60 layers high. These weight values correspond to those of blackgum in the final stage of drying, when the lumber weighs about 3 pounds per board foot.

The kiln-drying conditions used are given in table 1. The original moisture content of the blackgum boards was about 95 percent and the final moisture content about 7 percent.

Table 1.—Kiln schedule used in drying 1- by 10-inch blackgum boards

Temperature °F.	Plain-sawed		Quarter-sawed	
	Relative humidity Percent	Time Hours	Relative humidity Percent	Time Hours
160	70	24	58	24
170	50	24	45	24
200	30	40	30	22
Warp measurements taken				
170 (Conditioning treatment)	77	17	77	17
Warp measurements taken				

Effect of Weight on Unit¹ Warp

Plain-sawed boards.—The effect of increases in weight above 30 pounds per square foot was most significant with respect to cupping. On the basis of the data from these tests, the average amount of cupping in the bottom 20 layers can be expected to be about one-half of that in the top 20 layers and that of the middle 20 layers about midway between the top and bottom averages. The effect on twisting, bowing and crooking was much less significant, but the average amounts for these also indicated the same general trend in the three groups of layers.

Quarter-sawed boards.—The effect of weight on the twisting, bowing, and crooking of quarter-sawed boards was slight and somewhat inconsistent and therefore of no practical significance.

Plain-sawed boards.—The conditioning treatment had little, if any, effect on bowing, crooking, and cupping, but was somewhat effective in reducing twisting.

Quarter-sawed boards.—The conditioning treatment did not reduce bowing and crooking of quarter-sawed boards, but a slight reduction in twisting was indicated. The effect on twisting, however was less than that shown for plain-sawed stock.

Effect of Length on Unit¹ Warp

Plain-sawed boards.—Twisting per unit length was very significantly affected by the length of the board during drying, particularly after the conditioning treatment. The average twist of a 1-foot segment from the 3-foot boards was approximately twice that of a 1-foot segment from the 12-foot boards. Average bow and crook were also greatest in the shortest-length boards, but, statistically, the results were much less significant than those for twist because of greater variability. The effect on cupping was

¹A board segment 1 foot long and 10 inches wide.

least significant, as might be expected. *Quarter-sawed boards.*—The twisting and crooking of the quarter-sawed boards were significantly affected by length and were greatest in the shortest-length boards. The effect on bowing and especially on cupping was too slight to be given consideration.

Warping of Plain-sawed Compared to Quarter-sawed Boards

Twisting was nearly two times greater and bowing was considerably greater in plain-sawed boards than in quarter-sawed boards, while the difference in crooking was less significant.

Importance of Proper Moisture Content and Storage Conditions

To reduce warping after seasoning, it is important to dry the lumber to a moisture content that is suitable for its use requirements. If the lumber is too wet, it will continue to warp upon any further drying. If too dry, it will not only have warped more than necessary during the drying process, but will very likely change shape during any subsequent moisture regain. Improper storage conditions for the dried lumber or fabricated articles may nullify, to some extent the care taken in drying.

¹A board segment 1 foot long and 10 inches wide.