

THE CAUSES OF WARP IN LUMBER SEASONING

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Lumber degrade due to warp has long been a matter of much concern among lumbermen. Warp is complex. It seems as if each one of us choses to view it in a different way, and unless we investigate carefully all of the factors involved, we are likely to know too small a part of the problem when trying to apply corrective measures.

Definition of Warp

Let us define the forms of warp in order to all use the same terms. Warp in lumber can be defined as any deviation from flatness or straightness. One form is cupping, the deviation from flatness transversely across the face of a board. Bow is the same type of deviation but in a lengthwise direction from end to end of the piece. Crook is an edgewise deviation and twist is a variation of cup in which the board takes on a spiral propeller like form from end to end. One of the worst types of warp from a standpoint of degrade is kink, the sharp, short bend in the piece.

Causes of Warp

Many of the causes of warp are inherent in the wood and are not controllable. Others are induced by external forces which can and should be controlled. Still others seem to be a combination of causes and effect of which a partial control is possible if we know the basic causes and learn how to apply this knowledge. The fact that it is possible to exert some measure of control over warp is good reason to make every effort to do so, and to stop looking for short cuts to quality. There are so few of them in the lumber business.

INHERENT WARP

Differential Shrinkage

Inherent warp is entirely a matter of differential shrinkage. If wood shrank equally in all directions of the grain as it dries, inherent warp would be no problem. The fact is, tangential shrinkage is about twice that of radial shrinkage in the hardwoods. We are more fortunate in the softwoods. Ponderosa Pine, for instance shrinks from fiber saturation point to zero about 6% across the grain (tangentially) to 4% V.G. (radially). Shrinkage lengthwise of the board is negligible, only about 1/10 of 1%, except for the abnormal shrinkage in the wood adjacent to the pith of the tree. In rare cases, another form of abnormal longitudinal shrinkage is seen in the bands of compression wood that form in some trees when subjected to abnormal loads, such as snow or constant high winds. When lumber is sawn to include abnormal wood, every effort should be made to keep the stresses that occur as well balanced as possible. Otherwise, this abnormal lengthwise shrinkage causes degrade.

Most softwood lumber is sawn by turning the log to produce flat sawn lumber in the boards. Differential shrinkage becomes a major problem in flat sawn lumber. The fact that tangential shrinkage exceeds radial shrinkage accounts for the cupping that occurs. Because more of the grain is tangentially disposed on the sap side of a board than on the heart side the board always cups toward the outside, or the sap side. Moreover, since the shrinkage differential increases progressively with every board cut more nearly toward the heart of the log, the cupping also becomes increasingly severe. There is so little difference between the shrinkage of heartwood and sapwood that this does not significantly affect the warping of the board. The main cause is this differential shrinkage as related to the position each board is sawn from the log (See Figure 1).

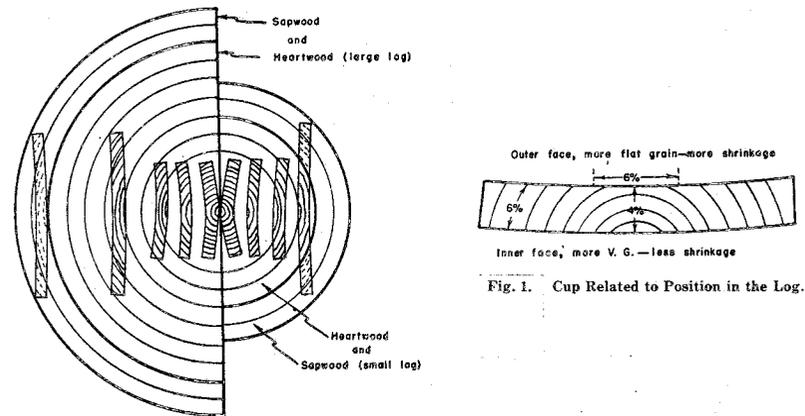


Fig. 1. Cup Related to Position in the Log.

Logs that produce boards of a width greater than desired for the knot size and type for the grade should be turned down to the proper cut size rather than sawing alive. Otherwise, when these wider pieces are ripped they will be unbalanced in the grade; the heart pith will often be placed along one edge of the board. This results in crooked lumber. (Refer to Fig. 2) When the heart is boxed within the piece it often season checks severely on both faces. This is a severe defect in grades of thick decking which require at least one face of high appearance. While this is aside from the problem of warp it is truly allied to the problems of producing high grade lumber from this zone of the log.



Fig. 2 Board Ripped Down the Pith Dries Crooked

Twist

Boards cut from spiral grained trees will shrink more lengthwise as they dry than is normal to straight grained ones. This is not abnormal shrinkage as compared to the shrinkage of the pith zone or compression wood. It is due to the fact that the tangential shrinkage of spirally arranged wood fibers is partly transposed in a longitudinal direction, hence the greater than normal lengthwise shrinkage.

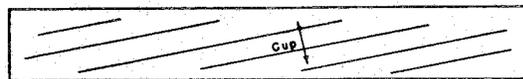


Fig. 3. Twist from Spiral Grain

Moisture Content

The degree of inherent warp in lumber is also related to the moisture content of the wood from the fiber saturation point to zero. This means that the lower the moisture content to which the lumber is dried the greater the shrinkage and the greater the amount of warping that develops due to the differential shrinkage stresses.

CORRECTIVE MEASURES

Sawing

The sawmill is the first place to use corrective measures for the prevention of inherent warp. Crooked logs may be cross-cut to avoid the cross grain that otherwise develops when the grain in a curved sweep is cut through in straight lines of the boards. The two short logs that develop are relatively straight by comparison, and the lumber that is produced dries consistently straighter.



Fig. 4. Warp From Crooked Log

Turn those coarse knotted logs in sawing to avoid the production of boards with branch knots extending to the edges of the pieces. Otherwise many of the boards will not only be low in grade because of the knot structure and placement but will contain excessive warp as well where the grain of the wood deviates around the knots. Next time you find boards with this type of knot

placement, sight along their edge and note how they are kinked around each of these knots that are not placed in the exact center of the edge.



Fig. 5 Warp Around Branch Knot

Taper sawing of those logs with swelled butts will to some degree reduce the amount of cross grain and subsequent warp that would otherwise occur when these cross grained boards are dried.



Fig. 6 Bow in Board Sawn Parallel to Pith

Small sized logs are often sawn into narrow dimension grades. The problem of warping is often severe unless the cants cut from this size log balance the pith zone so that when gang ripped, the pith is centrally placed on a face of a 2 x 4 or 2 x 6. When on the edge it generally causes excessive crooking due to the large amount of longitudinal shrinkage of the wood along this zone. In this item, crook is more degrading than bow. Consider the production of 4/4 paneling, rather than dimension from species suitable for this type of item. Warping can be largely avoided by this type of utilization because the 4/4 boards can be held to widths that permit a proper balance of the sawing without canting to 4 and 6 inch sizes.

Specified Moisture Content

In these days of drying to specified moisture content it may be necessary to dry to a final moisture level that is lower than commonly used for commercial lumber. Keep in mind that after every precaution has been followed to avoid warp, some warp will still be present in some of the flat sawn boards. I know of no magic schedule that can be used to prevent the warp inherent at these low moisture content levels.

The Blanker

The use of a split roll blanker will be very helpful to decrease the amount of roller split at the planer. Keep in mind that the boards must be fed into the blanker so that their edges are in contact with the bed. In other words the boards must be belly up or they will be roller split by blanker before they go through the planer. If the lumber cannot be turned correct side up because of high planer feed rates, blanking is of doubtful value.

Fast drying rates lead to severe casehardening stresses and steep moisture gradients. These factors are not necessarily undesirable, for both of them can be relieved by proper treatment. They can both be classed as a normal part of the drying procedure. But these stresses and gradients must be properly relieved in lumber that is to be put to critical end use needs.

Temperature

Experiments at the Western Pine Laboratory found no difference in the warping of lumber seasoned at different temperature levels, from air drying to very high temperature schedules. Shrinkage is reported to be less, but this may not affect the total warp. Some reports have indicated a slight drooping of the lumber between stickers at very high temperatures with lumber of high initial moisture content. This is not normal to conventional seasoning practices.

Casehardening

Casehardened lumber does not warp if it is left full size, and not remanufactured except by trimming. In theory, a casehardened board could be planed equally from all sides and still remain straight. In practice, a slight difference in the amount taken from the two sides of a board is enough to cause it to warp. If "Surfaced One Side", the result is generally disastrous. The board will generally cup so badly that the lumber may be worthless.

Final conditioning to relieve casehardening stresses does not reduce the amount of warp due to the inherent shrinkage differential of wood. In fact our tests have shown that the longer charges of lumber were given a final conditioning treatment, the greater the total amount of cupping and the more the degrade from roller split whenever the stock was allowed to thoroughly cool before machining. We found that bulk piling immediately after conditioning would be beneficial in reducing the amount of degrade from roller split. But this lasts only a few days. As soon as the stock had lost the surplus moisture in storage, the degree of cupping (and roller split degrade) was as much as or worse than before. In other words, any treatment that tends to reduce the total final moisture content level of a charge will increase the warp.

Warp Relief

A thorough steaming will reduce the cupping of resawn lumber warped from this cause. But this requires extra handling and seasoning expense. The preferred method is to prevent the damage, by drying to the proper final moisture content prior to adequate final reconditioning to relieve drying stresses prior to resawing. If the final gradient is not sufficiently low, bulk piling for a period will equalize the moisture content. It does not necessarily relieve casehardening stresses. In fact, we have held bulk piled lumber for a three year period without any significant change in casehardening stresses measured at intervals during this period.

A board may be cupped severely and be fully free of casehardening stresses. Prove this by a prong test of a cupped cross section. If no longer casehardened, the curve in the cup will remain curved and the saw cut straight.

INDUCED WARP

Stacking Practices

Wood is quite plastic when green, particularly at the temperatures used in kiln drying. If mispiling or variations in thickness or the stickers induce deformations in the green lumber, they tend to keep this shape when dry. Develop stacking practices which perfectly align all crossers with each other and their base supports to avoid piling kinks into the lumber.

It has been suggested that extra weight be applied to a pile of lumber will keep it flat throughout the drying process. This is only a partial aid. Our research has shown that if a piece of flat sawn lumber has sufficiently sharp ring curvature no amount of weighting will prevent cupping in flat sawn boards dried to low moisture content levels. The lumber between the stickers will be definitely cupped, the amount depending upon the differential shrinkage involved. The drier the wood the greater the cupping, because the amount of shrinkage is directly proportional to the moisture content between the fiber saturation point and zero. The area held flat under the stickers instead of cupping will often split due to the severe forces involved. The lumber loses its plasticity as it dries and at very low moisture content becomes so brittle it breaks under the strain.

Avoid induced warp by making use of good piling and sawing practices. Avoid overdrying.

Moisture Gradient

The moisture gradient left in the lumber also affects the inherent warp when it is remanufactured before the moisture has had a chance to equalize. For instance, if a board is resawn when the core is still several per cent wetter than the shell; it may be perfectly flat at the time of resawing, but later as the resawn piece comes to equilibrium with the surrounding air conditions, the inner face being high in moisture content continues to lose moisture and to warp as it shrinks.

This type of warp is often confused with casehardening. In a casehardened board, the warping occurs immediately as it goes through the resaw. In the piece with the excessive moisture gradient it does not occur until later. This often dismays the shipper because the resawn product was flat when shipped before further drying occurred.

Drying Rate

It has been said that fast drying rates should reduce the amount of warp caused by differential shrinkage. The explanation given is that greater set caused by the faster drying rate will tend to prevent cupping at the later stages of the drying. This may be true, but other types of degrade would probably offset it. The faster the rate, the greater the variation in final moisture content and the greater the number of excessively low moisture content pieces. Since warp is directly related to the final moisture content, a more moderate drying rate is more likely to reduce the total over all percentage of warp in a charge. How economical this is would depend upon the grade of lumber, the final moisture content requirements and the amount of warping that can be tolerated.

Storage

Unless lumber is properly protected after seasoning, it will lose the high quality achieved through careful drying practices. One of the things that happen to improperly stored lumber is the development of warp. Unprotected top courses are most subject to this damage from exposure to sun, rain and drying winds that in some regions may come at any time. The weathering may be so severe that top courses of unprotected piles must be discarded, unfit for sale at any grade.

The direction of the warp depends whether the boards are taking on (absorbing) or giving off (desorbing) moisture. Turn them over on a bulk stacked pile and the warp generally reverses itself in a short time. After the boards have reached equilibrium the warping direction follows the pattern normal to differential shrinkage.

Sheds

Covered sheds help, but even under sheds the E.M.C. of the air may be unsuited to the end use needs of the product. Lumber should not be stored for long periods on stickers. This practice tends toward excessive induced warp. Every piling error, large or small, is dried into the lumber. After a sufficient period on stickers, the warps and kinks become permanent features of the boards.

Bulk Storage

If the lumber cannot be shipped soon after it has been seasoned, bulk piling for a period will be of great benefit toward reducing the induced warp piled into lumber. Although many operations avoid bulk storage because of the extra cost involved, this extra cost is offset to a considerable degree by the benefits of bulk storage. The lumber will be flatter; it will machine better and hold its grade much better than when left in storage on stickers. The improvement is only in the warp due to induced causes.

Bulk storage does not reduce casehardening stresses. Casehardened lumber stored for several years has shown virtually no change in the stresses. There will, however, be a beneficial improvement in moisture content uniformity by proper bulk storage.

Lumber Covers

Excellent protection can be secured by storing dry lumber under covers of sisal kraft or plastic. This reduces the change in moisture content both indoor and out even in rainy areas. Benefits far outweigh the costs for long storage periods.

Conclusions

Not all warp can be eliminated. That caused by differential shrinkage is inherent in the wood and will develop as drying progresses regardless of the type of seasoning method. Warp induced through errors in sawing, piling, handling, machining and storage is preventable. The causes of induced warp are many, but they can all be eliminated with diligent effort.