SOME REASONS FOR VARIABILITY IN THE SHRINKAGE OF GREEN LUMBER

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The amount of shrinkage which develops when green lumber is placed directly into use varies a great deal. The purpose of this note is to discuss some of the factors which relate to this variability, and to point out that the average moisture content is not always a good criterion for predicting shrinkage.

The factors which are related to the shrinkage and swelling of a small (one quarter inch or so) cube of wood should be reviewed. When such a cube is green, water is found both in the cell cavity and within the cell wall structure. Changing the amount of water in the cell cavity has no effect on the size of the cube. When the cube is dried, the water in the cell cavity is the first to be removed. After the cell cavity is empty, water begins to move out of the cell wall structure. As this water is removed, the cube shrinks. The moisture content of the wood when all of the water in the cell cavity has been removed, but all the water in the wall remains, is called the fiber saturation point (FSP). It is below this point that a small sample of wood will shrink or swell with change in moisture content. This relationship between size and moisture content is represented in Figure 1 (3). Notice that when one-half of the cell wall water has been removed from the Douglas fir cube, the flat sawn face will be about 96% of its green size and the edge grain face will be about 97% of its green size. Shrinkage in the longitudinal direction is negligible. The coefficient of moisture shrinkage is greater in the tangential direction than in the radial direction. These coefficients also vary with species.

The assumption is often made that a fiber saturation point of 28-30% is common for all species. In fact, however, various species may exhibit marked differences in the fiber saturation point. Work by N. C. Higgins (2) pointed out some sizeable differences in the FSP. On the basis of these findings, it appears that at a moisture content at which a small cube of western redcedar just begins to shrink, sitka spruce has exhibited 1/3 of its total possible shrinkage.

The relationship between shrinkage and moisture content in the small cube of wood is defined, therefore, by the fiber saturation point and the coefficient of shrinkage. The coefficient depends upon both the species and the direction of cut, i.e., flat sawn or edge grain.

The shrinkage and swelling in the small cube cannot be directly related to a corresponding situation in a drying board. In the cube, the moisture content is essentially uniform throughout and the shrinkage is practically unrestrained. In a board being dried, the moisture content of the surface is much lower than the moisture content of the core. As a result,
there is internal restraint to the tendency of the surface to shrink. Internal restraint in turn produces internal forces in the board. There is a natural tendency for the board to take on a size that minimizes these internal forces. To accomplish this minimizing of forces, the board shrinks.

The limitations of using average moisture content to estimate shrinkage in a board are illustrated in Figure 2. Shown are the moisture gradients in three hypothetical boards. In the first example the moisture gradients is uniform and therefore shrinkage could be properly estimated by using information of the type shown in Figure 1. In the second example, a portion of the board is above the FSP. This board exhibits some shrinkage because the surface layers have a tendency to shrink. As a result of this tendency, the core of the board is compressed slightly. In the third example, the moisture gradient is still more severe. However, the portion of this board below the FSP is the same as in example two, and therefore the tendency to shrink is the same. In an investigation of shrinkage in beech it was found that the boards began to shrink at an average moisture content of above 70%. (1). From these examples it should be clear that average moisture content may not always be a good basis for estimating board shrinkage.

In the above examples the wide variation in average moisture content, at a given condition of shrinkage, results in part from the fact that a portion of the board is above the FSP. Average moisture content is a more reliable factor upon which to estimate shrinkage if the entire moisture gradient is below the FSP. Even in this case, however, an error is introduced due to the effects of set.

Set is the amount of permanent deformation which is produced in a board as it dries. Surface set is a stretching of wood layers on the surface of a board to such an extent that the normal size is increased. Set results from drying stresses and is the cause of casehardening, internal honeycomb, and some other drying defects. Generally speaking, the faster the wood is dried the greater the amount of surface set which will be produced. The greater the amount of set the less will be the total shrinkage of the board.

There are four factors which determine the amount of shrinkage which develops when drying a green board to any given average moisture content. These factors are: 1) the coefficient of shrinkage, 2) the fiber saturation point, 3) the moisture gradient, 4) the amount of set. The coefficient of shrinkage depends upon the species in question and the direction of the cut (flat or edge-grain). The fiber saturation point varies with species and is not necessarily 28-30% moisture content. The moisture gradient and the amount of set are both dependent upon the method of drying. A board will begin to shrink when the average moisture content is considerably above the fiber saturation point. When the entire moisture gradient is below the FSP, the shrinkage may be less than would be estimated from Figure 1 due to the effect of set.

There does not appear to be a precise relationship between average moisture content and shrinkage which can be used to accurately predict the amount of shrinkage which will occur when a green board dries. Further research on actual lumber shrinkage is needed to establish the relationship between the moisture gradient and shrinkage. A green board or piece of dimension will generally shrink less than would be expected from the information of the type given in Figure 1.

**Literature Cited**


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