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FACT SHEET

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Understanding Dimensional Changes In Wood Products

Eric McConnell, Ph.D.
Extension Specialist, Forest Operations & Products
School of Environment and Natural Resources
Ohio State University Extension

Our forefathers built America using timber harvested from virgin forests. Giant Douglas-firs and old growth southern pines provided straight-grained boards with many annual rings per inch for home construction, and slow grown hardwoods provided wide boards with excellent grain patterns for furniture. Warp and seasoning checks were minimized by the nature of this old-growth wood.

Today's lumber comes from smaller trees that have grown during our lifetime. The wood properties of these faster-grown trees are different. Warp and seasoning checks are prevalent because of juvenile wood, reaction wood, cross-grain, and fewer annual rings per inch. Discriminating buyers who understand these dimensional changes in wood will be able to choose boards and timbers that are more likely to provide many years of satisfactory service.

A Closer Look at Wood Structure

Pinch both ends of a soda straw and you will have some idea of what a single wood cell looks like. Millions of these hollow tubes are glued together with lignin to form the woody parts of a tree. The cells of a tree trunk are aligned nearly vertically, with their tapered ends overlapping. Trees grow annual layers of new wood around the perimeter of the trunk and limbs, just under the bark. These new wood cells are formed throughout the growing season but not during the dormant season. Thin-walled cells, called earlywood, are created early in the growing season, and thick-walled cells, called latewood, are formed during the summer. The alternating light (earlywood) and dark (latewood) colored bands of wood make up the annual ring of one growing season.

Conifers, or softwoods, are simpler in structure than the more complex hardwood tree species. Between 90 and 95% of the wood in conifers is made up of one type of cell, the longitudinal tracheid. Ray cells running from the heart center to the bark and food storage cells, called parenchyma, make up the remaining fraction. Hardwood species contain a variety of cell types in differing proportions compared to the more simple pines and spruces. The terms "softwood" and "hardwood" are not true indicators of wood hardness. Wood cells are often called fibers by the paper and fiberboard industries.

How Wood Dries and Shrinks

The cells in a living tree contain two forms of water. Cell walls are saturated with bound water, and the hollow center cavities contain varying amounts of free water. Water begins to evaporate from the surface of a freshly sawn board. At the same time, free water migrates slowly from the center of the board as this surface drying takes place. When the cell cavity is empty, further evaporation removes the bound water from the cell wall. Shrinkage results as the cell wall becomes thinner.

The process of removing water during drying does not occur evenly throughout a board. The ends of boards dry faster than the middle. The outer shell of a board may dry much faster than the center core, causing serious stresses and defects. Boards exposed to the sun will dry faster on the warm side. Individual wood cells shrink more tangentially, around the annual rings, and less in the radial direction, which runs across the annual rings. Normal wood cells shrink very little along their length in the longitudinal direction. Certain abnormal cells, however, can shrink spectacularly in length.

Moisture Content Is Important

Moisture content is a ratio of the amount of water in wood relative to the weight of oven-dried wood. It is expressed as "percent Moisture Content (% MC)" by multiplying the ratio times 100. Wood acclimates to its surroundings. Therefore, an initial conditioning period for the wood to equilibrate to its new environment and intended application is a must. Equilibrium moisture content (EMC) is the point at which the moisture content of the wood and its environment are equal. Generally, the EMC in a heated house during winter is fairly low but can become relatively high during wet and warm weather. A rule of thumb that provides a good estimate of EMC in the home is to divide the indoor relative humidity (RH) by five (EMC = RH ÷ 5).

Problems of dimensional change in wood products are directly related to changes in moisture content. Lumber often appears to be drier than it really is. Home users often find that further drying has undone their best workmanship. Flooring gaps are an example of wood continuing to dry, and shrink, after it has been put into service. Occasionally the problem is caused by dry lumber taking on moisture and swelling, causing the flooring to buckle. Making the moisture content of the wood fit the application is vital.

Cross Grain Causes Twist

When the long axis of the wood cells is nearly parallel to the long axis or center line of a board, the lumber is straight grained. Wood cells in a tree trunk can also be oriented in a spiral. Some trees, such as elm, do this naturally. The lumber of most other species only exhibits this characteristic when sawn from the central portion of the tree. Boards and timbers sawn from spiral-grained trees will be cross grained. Drying produces unequal shrinking and causes the piece to twist. This effect is most often seen in 4x4s and other square timbers.

Seasoning Checks

Seasoning checks are almost always present in square timbers that contain the boxed heart. The outer shell of this 6x6 shrinks much more than the inner core due to the greater degree of shrinkage around the annual rings. Wood fibers are pulled apart to relieve this stress. The result is a series of openings along the grain, which are called seasoning checks. Round timbers such as fence posts and utility poles develop the same kind of seasoning checks along their length because they contain the heart center. Other types of sawn lumber will develop checking, especially at the ends of boards where drying is accelerated.

Figure 1. End checking of a pine timber.

Reaction Wood: Compression Wood and Tension Wood

Trees form reaction wood in response to the stimulus of leaning. Various natural happenings place a tree in a leaning position. When this occurs, the tree forms reaction wood annual rings to correct the situation. These rings are larger and look different than the normal wood. The cell walls are thicker and have a different chemical make-up. Reaction wood is termed "compression" wood in conifers and forms on the underside of the stem. "Tension" wood forms on the upper side of leaning hardwood trees. The important result is reaction wood exhibits exaggerated longitudinal shrinkage. This

Figure 2. Compression wood as viewed in pine lumber (left) and tension wood inside a hardwood tree (right).

can be upwards of 2% whereas normal wood shrinks no more than 0.1% along its length. Reaction wood annual rings can be anywhere in a log and can end up in any sawn piece of lumber.

Reaction wood shrinkage shows up as soon as drying begins. The part of a board with reaction wood present will change dimensions unevenly compared to the other portion, which has essentially no longitudinal shrinkage. This causes boards and timbers to warp and twist as they are dried. Reaction wood is sensitive to changes in weather, even though it may have been kiln dried. For example, the seat on a picnic table can bow as much as 4 inches in dry weather but be straight in winter. Laminated street lighting poles can suffer from this reaction wood problem, often with broken glue joints. Some poles end up bowing towards the street and others away from the street.

Juvenile Wood Causes Bowing

The first dozen annual rings at the center of a southern pine log are usually juvenile wood. This fast-grown wood with the pith at the center is chemically different than the older mature wood. The cells in juvenile wood shrink more in length than the cells of normal annual rings. Sawing patterns often result in 2x4s and 2x6s with one face containing juvenile wood. If this face shrinks more in length than the other face, the lumber will become bowed. A surprising amount of force—capable of pulling nails—may develop during this dimensional change. However, not all 2x6s with the pith exhibited on one side will misbehave in this manner.

Figure 3. Notice how this stack of southern pine lumber is leaning due to the bowing of several boards. The central core, or pith, is readily identifiable in many of the boards, indicating the presence of juvenile wood.

Wide Boards Cup

Wide boards are usually side cut. That is, they are sawn from the outer portion of the log and have the annual rings running from edge to edge. Shrinking is greatest across the face nearest the bark and less across the face nearest the pith or heart center. The result is a board that slightly resembles a trough. Changes in moisture content, usually further drying, heighten this cupping problem. One way to minimize the cupping is to use narrow boards whenever possible. Another method is to edge glue several narrow pieces to achieve the desired width, alternating the annual rings so they first cup "up" and then "down" in alternate boards.

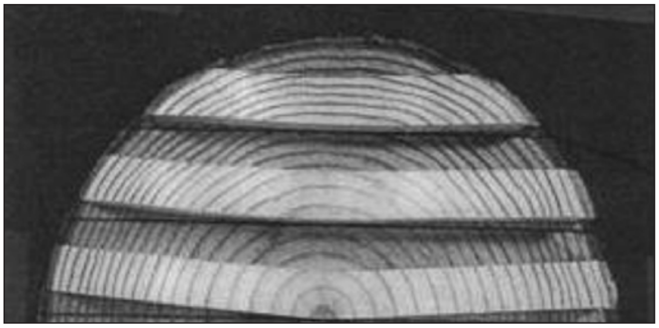

Figure 4. Flatsawn lumber cups away from the pith due to greater tangential shrinkage (photo is of red pine from the United States Forest Service Forest Products Laboratory).

Wood Composites

Wood composite products are manufactured from logs broken down into various sized pieces, called furnish, which are then arranged into a panel, lumber, or timber. Plywood is a panel product made by gluing sheets of wood veneer in such a manner that the grain of alternating layers are at right angles. Oriented strand board (OSB) is a panel product produced from small flakes of wood glued together with alternating grain direction in three layers. Structural composite lumber is a group of lumber-sized products manufactured using veneers or strands of varying lengths, but the wood pieces are all oriented in the same direction. Structural composite lumber products include laminated veneer lumber, parallel strand lumber, and laminated strand lumber. All of these products are hot-pressed with an applied adhesive at high temperatures and pressures.

Wood I-joists resemble steel I-beams and are often constructed using laminated veneer lumber and OSB. Laminated timbers, called Glulam, are made by gluing several pieces of lumber wide face to wide face, with the grain of all in a longitudinal direction. The lumber is selected and dried to a low moisture content, followed by cold-pressing with an adhesive. Good glue joints are always stronger than the wood being glued. Dimensional stability is improved in all of these glued products as any shrinkage effect that can cause bowing or twisting is greatly minimized.

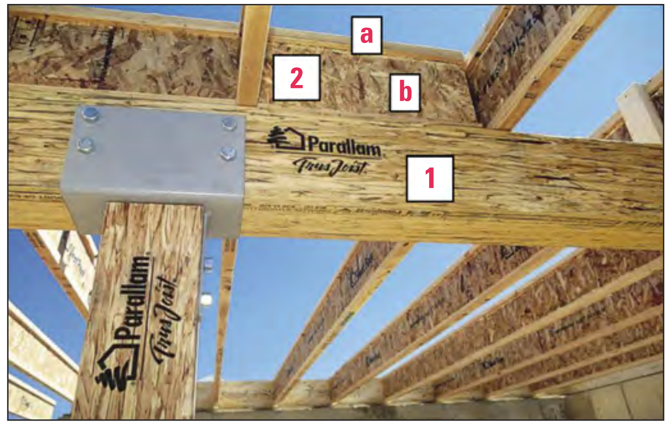

Figure 5. A construction site using wood composite products. (1) Parallel strand lumber. (2) A wood I-joist consisting of (a) laminated veneer lumber and (b) oriented strand board.

More Information

Detailed information regarding the dimensional stability of wood can be found in the Wood Handbook published by the U.S. Forest Service Forest Products Laboratory. Your local OSU Extension educator can assist you in obtaining this information. You may also search the Forest Operations & Products website at **www.ohiowood.osu.edu** or contact the School of Environment and Natural Resources.

Acknowledgment

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