EFFECTS OF TENSION WOOD IN HARDWOOD LUMBER AND VENEER

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EFFECTS OF TENSION WOOD IN HARDWOOD LUMBER AND VENEER

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Causes of unusual behavior always are sought when hardwood lumber and veneer have tendencies to behave out of the ordinary. Research at the Forest Products Laboratory has shown that a particular type of wood fibers with peculiar inner layers often is associated with longitudinal warping, sometimes with collapse, and also with rough machining of hardwood lumber. Veneer that includes such abnormal fibers also tends to buckle and to have fibrous surfaces rather than to be smoothly cut. These fibers in many hardwood species are typical of unusual wood structure known as tension wood.

The purpose of this report is to present information on the occurrence and effects of tension wood in hardwood lumber and veneer. It is believed that such information will assist manufacturers to recognize an important cause of certain kinds of unusual behavior in hardwood lumber, veneer, and products from these materials. Such recognition of intrinsic characteristics of wood always is the first step towards improvement in the use of lumber or veneer by savings of material and labor in the final products.

What is Tension Wood

Tension wood is a type of wood found in hardwood species that includes few to many of the peculiar fibers technically known as "gelatinous" or commonly as "tension wood" fibers. These have inner layers that differ in microscopic appearance and in swelling and coloring with certain biological reagents.

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and dyes from the outer layers of the abnormal fibers and also entire walls of normal fibers. The characteristics make possible laboratory identification of tension wood fibers that are shown as swollen and darkly stained inner layers in figure 1.

The name of tension wood seems to have come from observations that the greatest numbers of its particular kind of fibers occurred on the upper or tension side of leaning trees and of branches. This seems to be essentially the case in some species; in a leaning white oak, for example, tension wood fibers were found only on the upper side, and Clarke working on English beech also reported tension wood on the upper side of leaning trees. On the other hand, tension wood fibers were found on all sides of some leaning aspen trees; however, the greatest concentration of these fibers was on the upper side of the trees.

Certain growth conditions in a leaning tree trunk seem to stimulate formation of abnormal fibers, and the resulting abnormal wood appears to be related to the response of tree trunks to change from leaning toward vertical positions. It is reasonable that such a response would be most effective in slender tree trunks and less so in thicker ones; nevertheless, that the stimulation to form tension wood fibers appears to be present whether or not these fibers actually are effective in restoring vertical growth of a tree trunk.

In the cross section of a log, the tension wood fibers are found in greatest numbers in one sector of each growth ring. Tension wood sometimes is formed in consecutive growth rings, but it also is found in intermittent zones consisting of a few to several rings that are separated by other rings with essentially normal fibers. Tension wood tends to be darker colored than normal wood in such species as mahogany, and the abnormal wood appears denser with an almost glasslike sheen on a smoothly cut surface when many of its peculiar fibers are present (fig. 2). Tension wood also may have a silvery or lustrous appearance in light-colored aspen and cottonwood lumber and in English beech.

The most serious characteristic of tension wood is its greater shrinkage along the grain than normal wood. Most hardwood species have nominal longitudinal shrinkage between green and ovendry conditions of less than 0.3 percent, but

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some longitudinal shrinkage of tension wood has been found to be as great as 0.9 percent of the original length of test specimens. Research on mahogany showed that longitudinal shrinkage of tension wood was directly related to increases in numbers of the abnormal specimens. Additional work also showed longitudinal shrinkage tended to increase with the combined effects of increasing numbers of the peculiar fibers and with increase in specific gravity of the wood. The increase in specific gravity was associated with greater thickness in the inner layer of the tension wood fiber walls.

Effects on Lumber

Warping. -- A frequent defect in hardwood lumber that includes tension wood is warping, that is, bowing, crooking, and twisting resulting from unequal changes in the length of the pieces. This defect has been seen to be so serious that pieces of mahogany, for example, containing even small amounts of tension wood were not usable as door stiles and drawer separators for cabinets and furniture which required exact fitting. The warping was the result of the excessively large shrinkage along the grain in tension wood as compared with normal wood. Differences in intrinsic shrinkage along the grain of tension wood and normal wood cause internal stresses in pieces which include both types of wood. Although some rough boards were practically straight after kiln drying, warping occurred frequently when relatively short pieces were ripped from boards that included tension wood. Even after straightening by carefully jointing adjacent edges of such pieces, longitudinal warping continued to be a serious defect because of the internal stresses that remained in the pieces having both tension wood and normal wood. Such internal stresses also have been seen to be great enough to cause splits extending 1 to 3 feet from ends of oak railway ties in which tension wood was concentrated in one part.

Surface effects. -- The tension wood fibers frequently cause unusual behavior of surfaces of lumber. Projecting fibers were common on sawed surfaces of lumber in which tension wood was detected by microscopical examination. Figure 3 shows a sawed surface of mahogany lumber with the groups of projecting fibers of tension wood. Some planed or shaped surfaces also had zones of torn grain in the parts that included tension wood (fig. 4). Examinations of surfaces with projecting fibers and torn grain showed that tension wood fibers tended to be torn partly loose instead of being cut clean by saw teeth or

knives of cutting heads. Groups of these fibers held together tenaciously in lengths of 1/4 inch to as much as 3/4 inch, with these groups of fibers remaining attached at one end to the piece. When aspen and cottonwood lumber was planed green, or even air dried, severe tearing of surface fibers was relatively common.

These defects are more serious than chipped grain such as may occur when normal lumber with cross grain is planed against the direction of the grain. Planing tension wood against the grain usually causes tearing, while planing with the grain tends to raise the grain in zones of tension wood. Turning pieces to circular cross section, as for furniture parts, also has resulted in fuzzy surfaces of the parts that were made up of tension wood fibers. The seriousness of the machining defects of tension wood lies mainly in greater depth of tearing of surface fibers and larger extent of projecting fibers on turned surfaces than is encountered usually in normal wood.

**Collapse.** The presence of tension wood fibers, together with large amounts of moisture in green lumber, frequently is associated with collapse. With these conditions, surfaces and edges of boards have longitudinal zones which appear sunken and the cells of the wood as seen through a microscope are extremely distorted. Heartwood, particularly, in such species as aspen, cottonwood, oak, and willow, shows considerable tendency to collapse in areas of lumber that include tension wood. Such behavior also is accompanied by splitting that appears to be the result of the extremely large transverse shrinkage of tension wood. Sapwood, however, also has been seen to collapse when large numbers of tension wood fibers were present in poplar lumber (fig. 5).

**Effects on Veneer**

The intrinsic characteristics of tension wood affect the behavior of veneer in much the same ways as in lumber (fig. 6). Buckling of cottonwood veneer that includes the peculiar tension wood fibers is common, and in thin veneer, less than 1/16 inch, buckling is accompanied sometimes by numerous small splits. Pieces of thicker veneer, 1/8 inch, for example, frequently are warped so as to be unusable for baskets and crates for fruits and vegetables. When such containers are made up of green material, warping often will distort the slats of containers so as to be unusable when at ordinary dryness (fig. 7).

Rotary-cut veneer from parts of the bolts including numerous tension wood fibers, usually is fuzzy because of the partly torn groups of these fibers. Fuzziness, in general, is most severe in the part of a complete revolution of a veneer bolt that includes the greatest number of tension wood fibers. In
sliced veneer, tension wood areas also tend to be more fuzzy than normal areas and expensive cabinet veneers frequently have serious buckling. Thus, tension wood generally impairs the usefulness of veneer by distortion of the sheets, poorly cut surfaces, or both these characteristics.

**What to do About Tension Wood**

Tension wood has been shown to be responsible for some unsatisfactory behaviors of hardwood lumber and veneer. Sometimes the material that includes tension wood is expensive furniture wood, at other times it is low-cost basket and crating material, but, in any case the cost of material plus labor is included in processing lumber or veneer from logs to the final products. It is desirable, therefore, to keep as small as possible losses caused by unsatisfactory behavior of tension wood by means of practical selections of lumber and veneer.

Any practical selection of lumber or veneer that is intended to exclude tension wood should be based on the requirements of the end product. A practical selection also should include reasonable knowledge of intrinsic characteristics of tension wood by the operator in order to detect and separate highly undesirable pieces from those that will have acceptable behavior. Skillful workmen usually recognize some pieces of material as being better than others for particular purposes as the result of their experience and after some attention to behavior of certain pieces during processing. Thus, a practical selection of lumber or veneer with respect to tension wood deals mainly with general characteristics and only to slight extents with technicalities that have been determined in the laboratory or other testing procedures.

Detection in lumber and veneer. --Projecting fibers on sawed surfaces always are a reason to suspect that tension wood is present, particularly when the fuzzy areas are in streaks or mainly confined to part of the surface as in figure 8. It seems reasonable to reject such boards for pieces that must be finished precisely and remain straight without secure fastening to other parts, for example, door stiles of cabinets. Warping in rough, dry lumber also may indicate that tension wood is present, although all boards containing tension wood are not always bowed or crooked. If pieces being ripped from lumber spring out of shape this often indicates internal stresses which are caused by the differences in longitudinal shrinkage of normal wood and tension wood. Tearing of the grain (fig. 4) during the first planing of cabinet lumber also indicates tension wood in the same way as projecting fiber on sawed surfaces. Streaks of tension wood sometimes can be detected in simple visual examinations, even without damage to surface fibers, by the differences in texture and color between tension wood and normal wood (fig. 2).
Fuzziness caused by groups of fibers partly torn loose from the surfaces on undried veneer indicates tension wood. Sometimes its presence also is indicated by projecting fibers on sawed surfaces of flitches such as mahogany and other cabinet woods, as has been seen on sawed lumber. Buckling, either in the green condition or the dry, is reason to suspect tension wood in veneer.

Material to reject. -- Tension wood should be rejected only for purposes in which effects of its undesirable behavior are serious, and pieces including tension wood should be used where its effects are of small consequences. These factors are extremely variable with respect to the many products made from hardwood lumber and veneer. Relationship of length of pieces of lumber to their width and thickness is an important factor, since relatively short and thick pieces are affected less by warping than long, slender pieces. However, there is no rule-of-thumb by which material with tension wood can be classed as acceptable or not. Nevertheless, it appears valuable material, and some labor can be saved by discreet use of practical selections of lumber and veneer with respect to tension wood. Whether or not material is to be rejected depends on the kind of end products, amounts of labor required in their processing, and possible salvage of material rejected for certain uses.

It is frequently possible to detect tension wood in rotary veneer when freshly cut by its fuzziness and tendency to be buckled. The parts with tension wood in each revolution of the veneer bolt can be clipped out; or, if the veneer is clipped automatically in regular and narrow widths, as for some container staves and tops, the defective pieces can be readily sorted out even in the green condition. Detection of tension wood in expensive cabinet woods for sliced veneer should begin with the flitches so that those containing tension wood can be segregated for relatively thicker veneer and, thereby, minimize splitting which is common in thin veneer that is even slightly buckled.

The research on tension wood has shown many of its intrinsic characteristics that cause unsatisfactory behavior of hardwood lumber and veneer. This kind of technical information is presented in order to assist manufacturers in alleviating some of the problems associated with tension wood through a better recognition of its significance. By greater knowledge of the intrinsic structure and properties of tension wood, the Forest Products Laboratory hopes to contribute to improved use of hardwoods as valuable industrial materials.
Figure 1. -- Cross section of aspen wood showing solid grouping of tension wood fibers with typical swelling and buckling of the dark-colored inner layers. Highly magnified.

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Figure 2. --Smooth end-grain (top) and side surfaces of a mahogany board showing areas of tension wood detected by the darker color and apparently denser structure than normal wood in the same piece.

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Figure 3. --Projecting groups of tension wood fibers on a sawed surface of a mahogany board.
Figure 4. Torn grain in zones of tension wood in mahogany lumber.
Figure 5. --Collapse that caused a sunken appearance in tension wood of poplar sapwood.
Figure 6. --Cottonwood veneer; left, sliced normal wood, middle, sliced tension wood and, right, rotary-cut tension wood. Note serious warping and fuzzy surfaces of tension wood as compared to normal wood.
Figure 7. --Top of a berry crate made up of green veneer. Note warping, splitting, and fuzziness in the outer slats of tension wood in comparison with flatness and smoothness of the middle slat.
Figure 8. --Aspen boards with projecting groups of fibers that indicate areas of tension wood.