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THE FIBER-SATURATION POINT OF WOOD

Water is held in wood under a variable force ranging from a high molecular attraction for that closest to the wood molecules both on and within the cell walls to the comparatively small force of capillary attraction exerted by the cell cavities. Water held in the cell cavities is usually referred to as free water or absorbed water. Strictly speaking, it is not entirely free, but it is free in contrast to the water held in the cell wall which is usually referred to as bound water, hygroscopic water, or, more technically, "adsorbed" water. The moisture content (expressed as a percentage of the weight of the oven-dry wood) at which the cell walls are saturated and the cell cavities are free from water is known as the fiber-saturation point. This point was first recognized by H. D. Tiemann and described by him in Forest Service Bull. 70, issued in 1906.

The fiber-saturation point has significance in that it is a point at which there is an abrupt change in certain physical properties that vary with the moisture content. When dry wood takes up water a measurable amount of heat is evolved up to the fiber-saturation point as a result of the strong attraction of the wood for water. A measurable compression also occurs in the water taken up to the fiber-saturation point for the same reason. When wood is dried the energy needed to remove the virtually free water or absorbed water is practically the same as that required to evaporate an equal amount of water from an open pan. Below the fiber-saturation point, the force of attraction of the wood for the water is so great that it appreciably increases the amount of heat required to cause evaporation, and also reduces the vapor pressure or relative humidity of the vapor in contact with the wood. Conversely, the relative humidity of the surrounding air has to be reduced definitely below 100 percent to cause moisture loss from wood whose moisture content is at the fiber-saturation point. Expansion of gas or vapor when wet wood is heated, however, may force out considerable free-water even at 100 percent relative humidity. The relative humidity has to be lowered more and more to remove progressively smaller remaining amounts of water, the last of the water being virtually removable only when the immediately surrounding relative humidity is 0 percent.

When a piece of wood is dried, shrinkage occurs only when the moisture in some part of it falls below the fiber-saturation point value, although an apparent shrinkage produced by collapse frequently occurs above this point as a result of the removal of free water from completely filled cells. When bound water is removed from the cell walls, however, such a large contractive force is exerted that the space originally occupied by the water disappears. Conversely, this force is equivalent to swelling pressure when wood is confined. The shrinkage of the cell walls is thus equal to the volume of the water removed (corrected for the small amount of compression of the water). The fiber-saturation point may thus be defined as the moisture content at which true shrinkage begins.

When green wood is dried a moisture gradient forms from its center to the surface. Part of the wood thus falls below the fiber-saturation point and tends to shrink before all of it is down to the fiber-saturation point. As a result, there is some shrinkage of the piece as a whole before the average moisture content has reached the fiber-saturation point.

In general it can be assumed that the volumetric shrinkage of a block as a whole is equal to the volume of the water removed below the fiber-saturation point, in other words that the cell cavities do not change in size. This assumption affords a means of determining the fiber-saturation point from the volumetric shrinkage that occurs between the soaked (green) and the oven-dry condition together with the specific gravity.

The strength of wood is practically unaffected by the loss of the virtually free water. Most of the strength properties, however, increase with a loss of bound water. The fiber-saturation point may thus also be defined as the moisture content below which the strength properties are affected.

The electrical conductivity of wood above the fiber-saturation point is practically a direct function of the bulk of the virtually free water. As the moisture content is reduced below the fiber-saturation point electrical conductivity decreases at a vastly greater rate. This may presumably be due to the fact that the water in the cell wall structure is no longer in continuous fluid films.

Each of these various moisture content-property relationships affords a means for determining the fiber-saturation point. They all give values in the range of 20 to 35 percent. Most softwoods (conifers) have values between 27 and 31 percent and most hardwoods (broad-leafed trees) have values between 28 and 32 percent. These differences may be due to differences in chemical composition.

For general calculating purposes, such as for air space, shrinkage and swelling, specific gravity values between the green and oven-dry condition, and effect of moisture on the thermal conductivity of wood, it is recommended that a value of 30 percent moisture content be used for the fiber-saturation point of all species of woods except in strength calculations or in other special cases where actual reliable data for the particular species are available.