Wood Strength Definitions

Collected From: http://www.woodbin.com/ref/wood/strength_defs.htm

Strength may be defined as the ability to resist applied stress: the greater the resistance, the stronger the material. Resistance may be measured in several ways. One is the maximum stress that the material can endure before "failure" occurs. Another approach is to measure the deformation or strain that results from a given level of stress before the point of total failure. Strength of wood is often thought of in terms of bending strength. This is certainly a useful yardstick of strength but is by no means the only one. A number of other strength criteria are described below.

Stress is the amount of force for a given unit of area. It is typically measured in pounds per square inch (psi). Example: if a 1000 pound load was applied on the edge of a block of wood measuring 2-inches by 2-inches in cross-section by 10 inches in length, the applied stress would be 1000 pounds divided by 4 square inches = 250 lb./sq. inch.

Strain is defined as unit deformation or movement per unit of original length. It is typically expressed in inches per inch. Example: if the 10-inch long block of wood in the stress example above was compressed by 0.002 inches, the strain would be 0.002 inches/10 inches = 0.0002 inches per inch.

Elasticity is a property of wood in which strains or deformations are recoverable after an applied stress is removed, up to a certain level of stress known as the **proportional limit.** Below this point, each increment of stress will produce a proportional increment of strain (the stress/strain ratio is constant) and the wood will return to its original position once the stress is removed. Beyond the proportional limit, each increment of stress will cause increasingly larger increments of strain (as failure is approached) and removal of the stress will only result in a partial recovery of the strain.

Modulus of elasticity or Young's modulus is the ratio of stress to strain. Within the elastic range below the proportional limit, this ratio is a constant for a given piece of wood, making it useful in static bending tests for determining the relative stiffness of a board. The modulus of elasticity is normally measured in pounds per square inch (psi) and is abbreviated as MOE or E. Values for E relating to wood properties are commonly in terms of million psi; for simplicity, a board with a modulus of elasticity of 2,100,000 psi. (2.1 x 106) may be reported as 2.1E.

Modulus of rupture is the maximum load carrying capacity of a member. It is generally used in tests of bending strength to quantify the stress required to cause failure. It is reported in units of psi.

Fiber stress at proportional limit represents the maximum stress a board can be subjected to without exceeding the elastic range of the wood. Permanent set will result if an applied stress exceeds the proportional limit. This property is typically reported in units of psi.

Maximum crushing strength is the maximum stress sustained by a board when pressure is applied parallel to the grain.

Impact bending involves dropping a hammer of a given weight upon a board from successively greater heights until complete rupture occurs. The height of the drop that causes failure provides a comparative measure of how well the wood absorbs shock. It is reported in units of inches or centimeters.

Stiffness may be quantified using the modulus of elasticity, E. The higher the E value, the stiffer the wood and the lower the deformation under a given load. A board rated at 2.0E is twice as stiff as one rated at 1.0E.

Compression stress shortens or compresses the material. For the woodworker, the primary types of compression to consider are parallel to the grain and perpendicular to the grain. Compression parallel to the grain shortens the fibers in the wood lengthwise. An example would be chair or table legs which are primarily subjected to downward, rather than lateral pressure. Wood is very strong in compression parallel to the grain and this is seldom a limiting factor in furniture design. It is considerably weaker in compression perpendicular to the grain. An example of this type of compression would be the pressure that chair legs exert on a wooden floor. If the applied pressure (weight) exceeds the fiber stress at proportional limit for the wood, permanent indentations will result in the floor. Compression stress is measured in psi.

Tensile stress elongates or expands an object. Measurements of tensile stress perpendicular to the grain are useful for quantifying resistance to splitting. Examples of such stress include splitting firewood, driving nails, and forcing cupped boards to be flat. Wood is relatively weak in tension perpendicular to the grain but it is very strong in tension parallel to the grain (visualize a board being pulled from both ends). Due to difficulties in testing and the limited use for such data, tension parallel to the grain has not been extensively measured and/or reported to date. Tensile stress is measured in psi.

Shear stress involves the application of stress from two opposite directions causing portions of an object to move in parallel but opposite directions. Wood is very resistant to shearing perpendicular to the grain and this property is not measured via a standard test. Wood shears much easier in a direction parallel to the grain - consider a screw running perpendicular to the grain: it will shear out to the nearest end-grain if a sufficiently large force is applied to the board parallel to the grain. Shear stress is measured in psi.

Density is weight per unit volume. For wood, density is expressed as pounds per cubic foot, kilograms per cubic meter, or grams per cubic centimeter - at a specified moisture content. Density is the single most important indicator of strength in wood: a wood that is heavier (i.e., more wood substance per unit volume) will generally tend to be stronger than a lighter one.

Specific gravity as applied to wood, is the ratio of an ovendry weight of a wood sample to the weight of water (whose volume is equal to the volume of the wood sample at a specified moisture content). Specific gravity is often used in place of density to standardize comparisons of wood species - as with density, the higher the specific gravity, the heavier the wood, and the stronger it tends to be. At a moisture content of 12 percent, most woods have a specific gravity between 0.3 to 0.8 (water has a specific gravity of 1.0).