Timber

Timber has been one of the primary materials of engineering construction; it is widely used for structural purpose.

The engineering should have some knowledge of the classification of trees and of their growth and structure in orders to understand the fundamentals of the physical and mechanical properties of timbers.

Classification of trees:

For the engineering purposes, trees are classified according to their mode of growth:

a. Endogenous.

b. Exogenous: consist of two types: 1- Soft woods. 2- Hard woods.

a. Endogenous trees:

This group is confined largely to tropical semitropical regions. Timber from these trees has very limited engineering applications. Example of endogenous tress is:

- Palms: because of their long, straight stems are sometimes locally used as piles.
- Bamboo: Is used structurally to a considerable extent.

b. Exogenous trees:

These trees increase in bulk growing outer bark and annual rings are formed in the horizontal section of such a tree. Timber which is mostly used for engineering purpose belongs to this category. This timber can be divided into two groups:

a. Soft woods: Such as deodar

b. Hard woods: such as oak and teak.

Structural axes of wood:

1. Longitudinal axis: Parallel to the length of the fiber
2. Tangential axis: Perpendicular to the fibers and tangential growth rings.
3. Radial axis: Perpendicular to the fibers and to the growth rings. I.e. parallel to the wood rays that radiate from the center of a tree.

Moisture of timber:

Freshly cut wood from live trees is said to be in green condition. Green wood contains moisture in two general forms:

a. Free moisture: contained in the cell cavities of the walls.

b. Hygroscopic moisture: held in submicroscopic capillaries of the cell walls.

In the green condition, the cell walls of wood are almost saturated but the amount of free water varies widely between the species and even between sapwood and heartwood of the same species. Moisture content is expressed as a percentage of the oven dry weight of wood.

Fiber Saturation point:

The moisture content at which all free water is removed (i.e. cell cavities empty) while the cell walls are fully saturated. Changes in moisture content below the fiber saturation point are associated with shrinkage and swelling, as well as variation in strength and elastic properties and other properties. Fiber saturation point in range general between 20 to 32%.

Seasoning of wood:

As a result of daily and seasonal fluctuations in relative humidity and temperature, most wood in service continually gaining or losing moisture. The most practical means of minimizing troublesome variations in moisture content is by seasoning timber prior to its fabrication finished products or used structurally so the object of seasoning is to lower the moisture content of the wood a point at which the swelling and shrinkage is reduced a minimum for given conditions.

a. The temperature of the process.

b. The moisture.

c. The circulation.

Proper kiln can control the rate and degree of drying, that the tendency during drying to warp and split is reduced minimum. Uneven shrinkage may occur when the loss of moisture from the surface is greater than that from the interior. This shrinkage can be controlled by supplying moisture inside the kiln which assists in keeping the surface soft until the heat has penetrated to the interior, so that warping and cracking are prevented.

In artificial drying, temperatures of 70 to 82°C are useful employed for a period depending on the type of wood.

Shrinkage, warping and checking in drying:

The shrinkage of woods in drying is due to the loss of moisture from the walls of the cells. Shrinkage from green to oven dry condition in different species ranges as following:

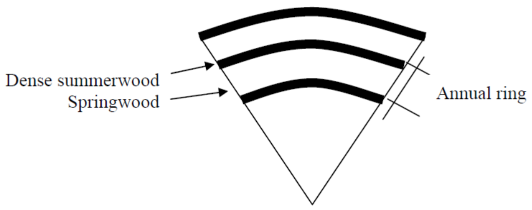
Volumetric 7 to 21%

Longitudinal 0.1 to 0.3%

Radial 2 to 8%

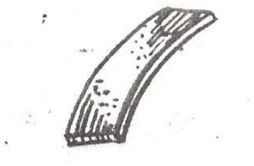
Tangential 4 to 14%

The amount of shrinkage varies in different direction being small longitudinal in the direction of the fibers, contractively large radial, and greatest tangentially. The different between tangential and radial shrinkage is explained by the fact that bands of dense summerwood are continuous in tangential direction and shrink a great deal forcing the loc of springwood along with them. However, in a radial direction summerwood bands alternate with bands of less dense springwood, and the total shrinkage is the summation of shrinks of summerwood and springwood which is smaller than for all summerwood.

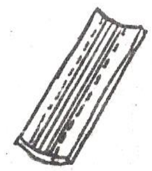


The warping of lumber is due either to unequal drying different portions or to unequal shrinkage of both radial and tangential direction. The warping can be classified into:

a. Bow: This defect is indicating by the curvature formed in the direction of length of timber as shown in Fig.:



b. Cup: This defect is indicating by the curvature formed in the transverse direction of timber as shown in Fig.:



c. Cup: When a piece of timber has spirally distorted along its length, it is known as twist:

Checking of timber in drying is a result of the inability of the timber to accommodate strains consequent upon unequal shrinkage.

<u>Types of checking:</u>

1-Temporary checking:

A great many small checks occur particularly in the ends of timbers, owing to the more rapid drying from the cross section and the consequent extent of shrinkage of the end portion. These checking are considered temporary, because they close up and become impressible as the inner portion of the timber dries and shrink.

2-Permanent checking:

Large checking, caused by the shrinkage of timber in a longitudinal direction along the rings which is greater than that along the radius.

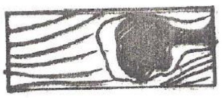
3-Case hardened checking:

Some woods, mostly hardwoods, become case hardened when rapidly dried in the kiln that is the outer port dries and shrinks, and commonly checks, while the interior is still in its original conditions. The drying of the interior is thus retarded, but when it does occur great internal strains are set up, resulting in the formation of large or numerous radial checks follow the rays. When these checks are comparatively small, but numerous, the wood is said to be honeycombed. Case hardening of timber may be avoided by air seasoning before placing in the kiln or by admitted steam to the kiln.

Natural defects in timber:

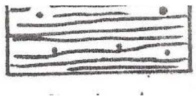
1. Knots: one of the most common defects, they originate in the timber cut from the stem or branches of a tree because of the encasement by the successive annual layers of wood. Knots can be classified as:

- Pin knots – does not exceed 6.5mm.
- Small knots – between 6.5-20mm.
- Medium knots – between 20-40mm
- Large knots – greater than 40mm.



Large knot

Small or medium knot



Pin knots

Effect of knots:

In structural beams the effect of knots on the bending strength largely depends upon their location. Knots in the tension side of a beam near point of maximum stress will have a significant effect on the maximum load a beam will sustain, whereas knots on the compression side are somewhat less serious. Knots in any position have little effect on shear. Stiffness of beams is not greatly affected by knots. In long columns, in which stiffness is the controlling factor, knots are not of importance. In short or intermediate columns, the reduction in strength caused by knots is approximately proportional to the size of the knot, although large knots have a somewhat greater affect than small ones. Knots increases hardness and strength in compression perpendicular to grain. Knots are harder to work and machine than the surrounding wood, may project from the surface when shrinkage occurs, and are a cause of twisting.

Shakes: These are cracks which partly or completely separate the fibers of wood. Shakes can be classified into:

1- Cup shakes: These are caused by the rupture of tissue in a perpendicular direction as shown in Fig.

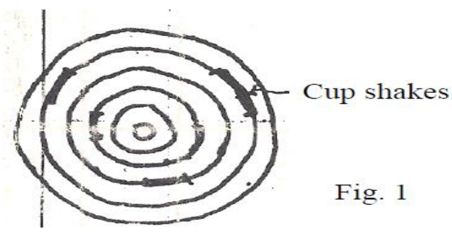


Fig. 1

2- Heart shakes: These cracks occur in the center of cross- sectional of tree and they extend from pith to sap wood in the direction of modularly rays as shown in Fig. 2. These cracks occur due to shrinkage of interior part of tree. Heart shakes divide the tree cross sectional into two to four parts.

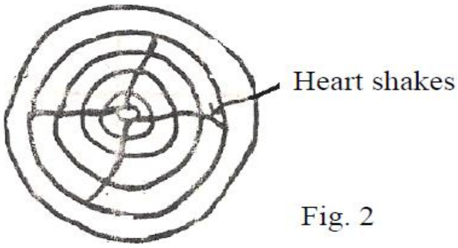


Fig. 2

3- Ring shakes: When cup shakes cover the entire ring, they are known as radial shakes, Fig. 3.

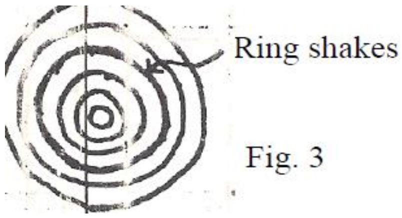


Fig. 3

4- Star shakes: These are cracks which extend from bark towards the sap wood. They are usually confined up to the place of sap wood. They are usually formed due to extreme heat or frost, Fig. 4.

Fig. 4

5- Radial shakes: These are similar to star shakes, but they are fine, irregular and numerous. They usually occur when tree exposed to sun for seasoning after being felled down. They run for a short distance from bark towards the center, Fig. 5.

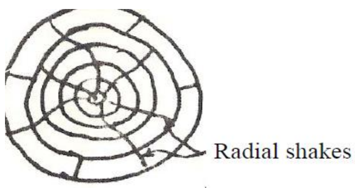


Fig. 5

6- Wind shakes: If wood is exposed to atmospheric agencies, its exterior surface shrinks. Such a shrinkage results into cracks as shown in Fig. 6.

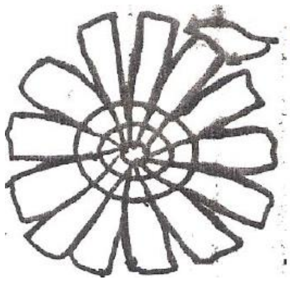


Fig. 6

Mechanical properties of woods:

The intelligent use of wood for any structural purpose requires a general knowledge of the mechanical properties of different woods, in order that one selected may conform in its structure qualities to the requirements imposed, and in order that a given purpose may be served at a minimum expense.

1. Tensile strength: Timber in construction is practically never subjected to pure tensile stresses for the simple reason that the end connections cannot be so devised that they do not involve either shear along the grain or compression across the grain Failure in tension across the grain involves principally the resistance offered by the thinner – walled wood elements to being tern apart longitudinal.
2. Compressive strength: The compressive strength of wood in a direction normal to the grain is simply a matter of the resistance offered by the wood elements to being crushed or flattened. The cells with thinnest walls collapse first, end the action proceeds gradually.

The compressive strength of wood in a direction // to the grain depends upon the internal structure and the moisture content of the wood and the manner of failure is fixed by these same factors. The individual fibers of wood act as so many hallow columns bound firmly together, and failure involves either buckling or bending of the individual fibers or bundles of elements.

3. Flexural strength: The flexural strength of timber is determined by the following formula:

$$S_b = 3/2 \left(PL / bh^2 \right)$$

Where:- L= specimen length, P= load, b=width, h= height.

The tensile strength of all timber is greatly an excess of its compressive strength (about 3 times as much the average), and the latter will usually be the determining factor in limiting the cross- breaking strength. (Compressive strength will always be the determining factor, assuming there exist no defects such as knots or uneven grain on the tension side of the beam).

4. Stiffness: Stiffness of timber largely upon the same factors as strength. Dense woods are always stiffer than open, porous woods, and heavy woods are stiffer than light woods.

Moisture and strength:

All woods gain in strength and in stiffness when thoroughly air seasoning or kiln dried. The extent of this effect depend upon the size and type of the timbers dried only by air seasoning, even though the process is prolonged for several months or even years, seldom lose sufficient moisture to benefit their strength to more than a slight degree. Such timbers, therefore, cannot be safely depended upon to show any greater strength than if they were in the original green condition. The explanation of this fact is that a great part of the moisture which is first evaporated from wood is water which exists only as “ free water “ in the cell cavities, whereas only variation in the moisture content of the walls of the wood element affects strength in any way.

The relationship between strength and moisture content can be seen in Fig. below: