Timber

The word timber refers to the wood used for construction. This word derives from old English word 'timbrian' which means 'to build'.

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

Living tree yielding good timber is called standing timber. After felling and separating branches, it is known as rough timber. when bark its removed and stem is roughly converted into pieces of suitable length for transportation is known as log. After the log is seasoned and converted into commercial sizes like planks, battens, posts and beams, it is known as converted timber.

Learning Objectives: After studying this chapter, the student will be able to:

- know the properties of timber, and
- select suitable timber for building works.

Engineering Aspect of Timber:

Even primitive man used timber as a building material. Many ancient temples, palaces and bridges of can be seen even today. Wide use of timber for engineering aspects is due to its special properties as given below:

- It is a naturally available, ready to use material. The rough timber used for temporary works like scaffolding, centring shoring and strutting
- It can be converted to any size and shape easily and hence used for doors, windows, flooring and roofing.
- Timber has good strength and hence used for making load bearing members like beams, columns, trusses and piles.

Outer bark: It is the outermost skin of the tree. It consists of wood fibres. Fissures and cracks may be present in this layer.

Medullary rays: These are thin radial fibres, extending from the pith to the cambium layer. They hold the annual rings together.

Table 1 shows the difference between soft wood (coniferous) and hard wood (deciduous) trees.

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

1. **Endogenous tress:** These trees grow inwards. In these trees fresh fibrous mass is in the innermost portion. These trees do not yield good timber for structural works. Example: Bomboo, cane , 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.

2. 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.

Table 1 shows the difference between soft wood (coniferous) and hard wood (deciduous) trees.

Table 1 Comparison between soft wood and hard wood:

Soft wood	Hard wood
Annual rings are distinct, medular rays are not distinct	Annual rings are not distinct medular rays are distinct
Light in colour	Dark in colour
Light in weight	Heavy
Close grained structure	grained structure
Strong in resisting direct tension but weak in resisting compression or shear	Equally strong in resisting tension, compression and shear

Classification based on durability:

The Forest Research Institute of India conducts durability tests on specimens of size 600 × 50 × 50 mm by burying them in the ground up to half their length and observing them over several years. On the basis of durability it classifies trees into the following three classes:

a. High durability: If the average life is more than 10 years.

b. Moderate durability: If the average life is 5-10 years.

c. Low durability: If the average life is less than 5 years.

Classification Based on Grading :

Based on permissible stresses, defects and so on, IS:12326-1976 classifies timber into three grades:

Special Grade, Grade-I and Grade-II.

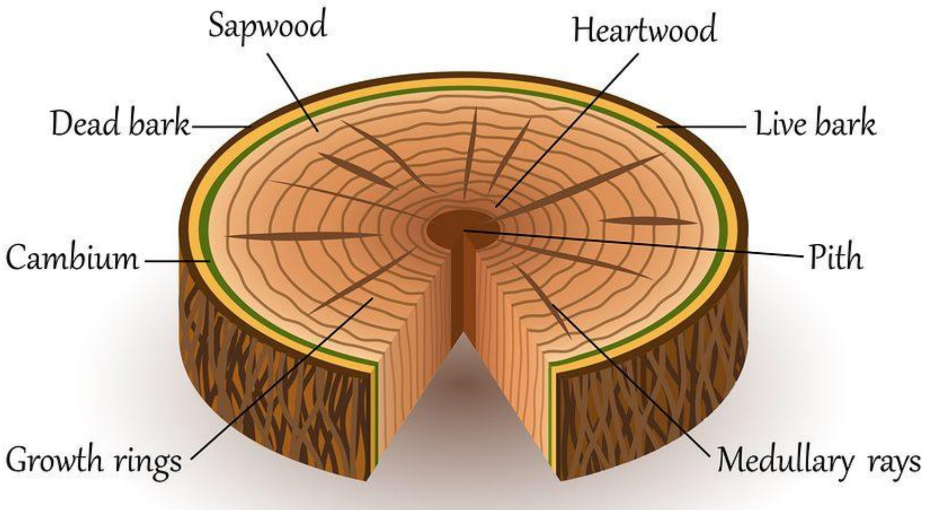
Classification Based on Availability Based on availability, IS: 339-1963 classifies timber as:

X – Most common, 1415 m^3 or more per year.

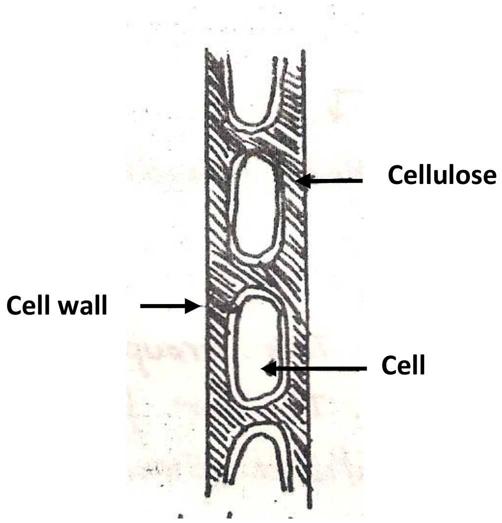
Y – Common, 335 m3 to 1415 m^3 per years.

Z – Less common, less than 335 m^3 per year.

Structure of wood:



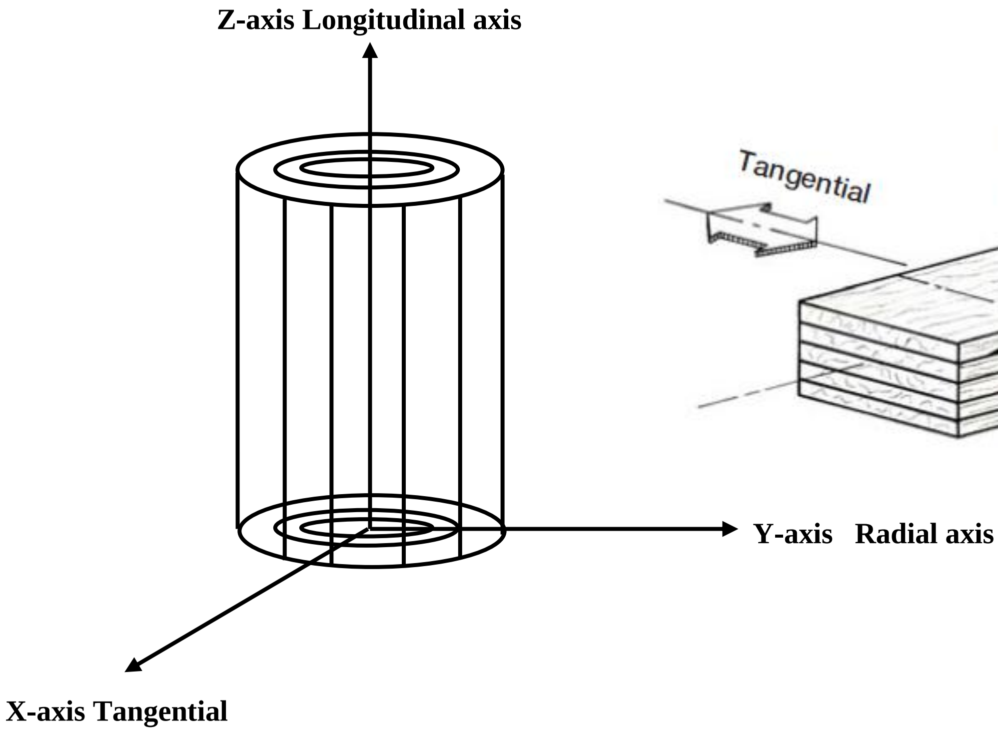
Cross section of an exogenous tree

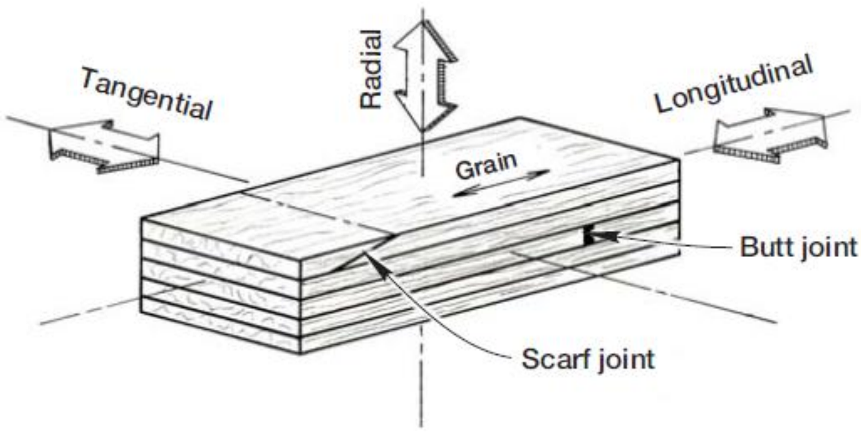


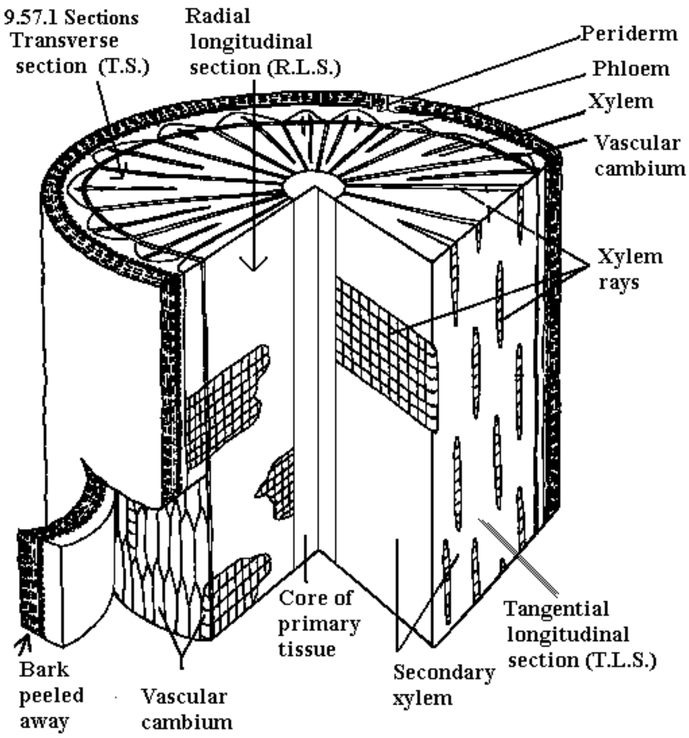
Longitudinal section of an exogenous tree

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 as seen in cross section.







Moisture of timber:

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

1. Free moisture: contained in the cell cavities of the walls.
2. 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 point in drying wood at which all free moisture has been removed from the cell itself while the cell wall remains saturated with absorbed moisture.

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%.

Density and specific gravity:

The specific gravity of wood is its density (weight per unit volume) relative to that of water. By convention, the specific gravity of wood is based on weight of oven dry only per unit volume. Because of shrinkage the oven dry in a given piece occupies different volumes, depending on moisture content of the piece. Average specific gravities of woods based on oven dry weight and volume range between 0.13 to 1.20 while the specific gravity of wood substance itself, is about 1.5, regardless of species. Consequently the specific gravity of any particular species of wood is a measure of the relative amount of solid substance per unit volume, e.g. wood with a specific gravity of a contains ⅓ solid wood substance, the remainder of its volume being occupied by cell cavities, intercellular species and cell wall capillaries.

Seasoning of Timber:

Seasoning is the process of reducing moisture content in a freshly cut tree to the desired level. Objects of seasoning The objects of seasoning are to:
1. increase the durability by protecting it from fungi, insects and other causes related to moisture content;

2. Impart hardness, stiffness, strength and resistance to electric shocks;

3. Maintain shape and size;

4. Make it workable;

5. Make it fit to receive painting;

6. Make it suitable for gluing;

7. Reduce the tendency of cracking and warping;

8. Decrease weight and save transportation cost and

9. Allow to burn easily, if used as fuel.

Methods of seasoning Methods of seasoning may be broadly grouped into: (a) Natural seasoning (b) Artificial seasoning

(a) Natural Seasoning:

This type of seasoning may be in the form of:

(i) Air seasoning (ii) Water seasoning

(i) Air Seasoning:

In a shed with a platform of height, 300 cm timber is stacked as shown in Fig 2. Care is taken to see that air can circulate around each timber balk. Moisture content decreases over a period of time. Well seasoned timber contains only 15 percent moisture. This process is slow but it is the best method of seasoning.

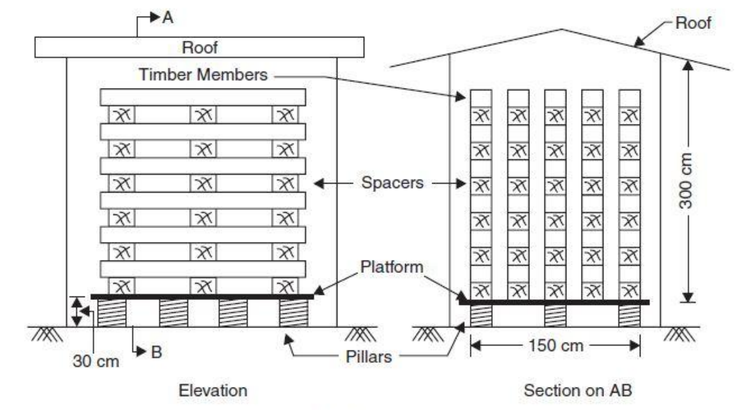


Fig. 1.8. Air seasoning

Figure (2): Air seasoning

(ii) Water seasoning:

In this method logs are placed in a river with thicker ends pointing upstream. A number of logs are tied together and the group is anchored to a standing tree or to rock to see that it is not carried away by the river. The sap contained in the timber is washed out over a period of 2-4 weeks. The timber is then stacked in a dry place. Compared to air seasoning this method takes less times.

Advantages of Natural Seasoning

• It requires low investment.

• It does not require skilled labour.

• It is ideally suited, to low and non-uniform market demand.

Disadvantages of Natural Seasoning:

• It needs larger space for seasoning.

• The process is very slow, usually takes 2-4 years.

• As the process depends on natural air, there is no control on it.

• Ends may dry fast and split. Interiors may remain moist while exteriors dry fast.

• The moisture content may not be brought down to the desired level.

• Chances of fungi and insect attack cannot be ruled out during the seasoning period.

(b) Artificial Seasoning:

The various methods of artificial seasoning are: (i) Boiling (ii) Kiln seasoning (iii) Chemical seasoning (iv) Electrical seasoning

(i) Boiling: In this method timber is immersed in water and then water is boiled for 3-4 hours. Instead of boiling hot steam may be passed over the timber. Them it is dried slowly. This process of seasoning is fast but costly. It reduces the strength of timber to some extent.

(ii) Kiln seasoning: A kiln is an airtight chamber. In this timber to be seasoned is placed and hot air is pumped in. After moisture content is brought down, the temperature is reduced and the chamber is allowed to cool.

The kiln used may be progressive type also. In such a kiln, carriages carrying timber moves from one to the other end slowly. Hot air is pumped from discharging end so that temperature is higher at that end compared to at the charging end. As timber comes out at discharging end sufficient moisture is removed. This method is suitable if seasoning is required on large scale, since in this case investment is high.

(iii) Chemical seasoning: It is also known as salt seasoning. In this method, the timber is dipped in a solution of sodium chloride or sodium nitrate. The surface salt draws out inner moisture. This preliminary treatment by chemicals ensures uniform seasoning across the section. It is then taken out and seasoned in the ordinary way.

(iv) Electrical seasoning: In this method, high frequency alternating current is passed through the timber. Heat is introduced internally and the timber starts drying. As the moisture content reduces resistance to electricity increases. The measure of resistance may be used to stop seasoning at appropriate level. This method is fast and uniform. Many plywood companies adopt this method. It is a costly technique.

Advantages of artificial seasoning:

- Drying is uniform, hence defect such as shrinkage, cracks and wrapping are minimum.
- Drying process is fast, hence economical.
- Moisture content can be reduced to the desired level.
- Chances of fungi and insects attack are low.
- Wood becomes more suitable for painting.

Disadvantages of artificial seasoning:

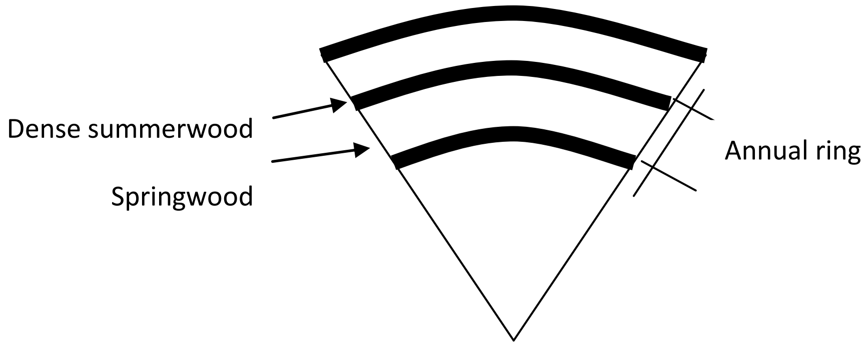
- It needs high investment.
- Skilled supervision is required.
- If demand is low and intermittent, it is uneconomical.

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%

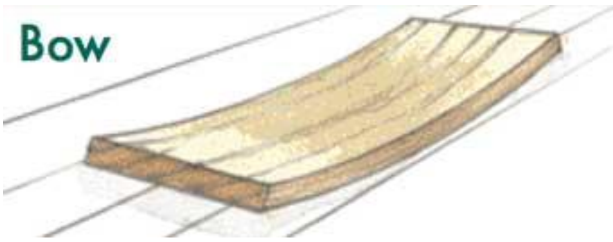
The amount of shrinkage varies in different direction being small longitudinal in the direction of the fibers, contractively large radial, and greatest tangentially. The different between tangential and radial shrinkage is explained by the fact that bands of dense summerwood are continuous in tangential 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.:

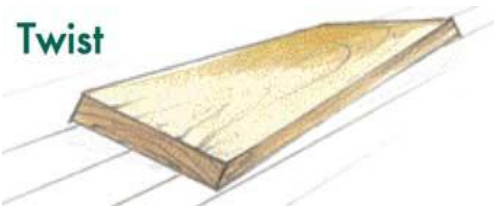


B. Cup:

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

C. **Twist:**

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.

Types of checking:

- **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 becomes impressible as the inner portion of the timber dries and shrink.

- **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.

Case hardened checking:

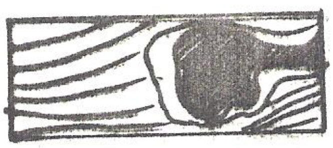
Some woods, mostly hardwoods, become case hardened when rapidly dried in the kiln, that is the outer port dries and shrinks, and commonly checks, while the interior is still in its original conditions. The drying of the interior is thus retarded, but when it does occur great internal strains are set 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.

<u>Natural defects in timber:</u>

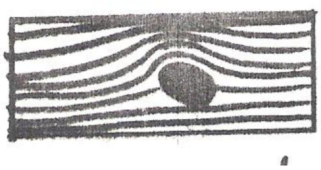
1. Knots: one of the most common defects, they originate in the timber cut from the stem or branches of a tree because of the encasement by the successive annual layers of wood.

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

<u>Effect of knots:</u>

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.

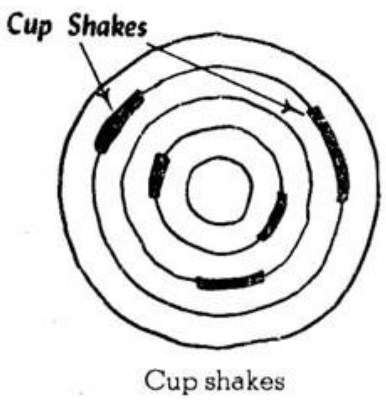
In long columns, in which stiffness is the controlling factor, knots are not of importance. In short or intermediate columns, the reduction in strength caused by knots is approximately proportional to the size of the knot, although large knots have a somewhat greater affect than small ones.

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: Shakes are cracks in timber due to excessive heat, wind or frost during the growth of the tree. Depending upon their shapes and positions, shakes are classified as cup shakes, heart shakes, ring shakes, star shake,

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

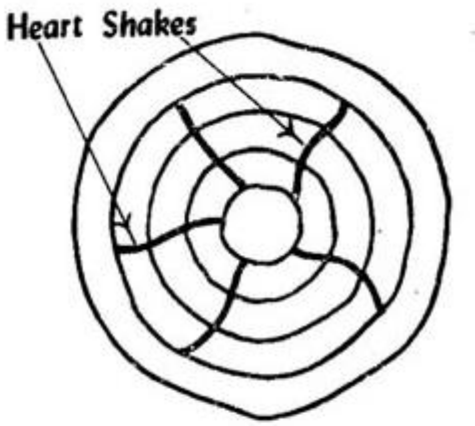
Cup shakes – These are caused by the rupture of tissue in a perpendicular direction as shown in Fig. 1:



Cup shakes

Fig. 1

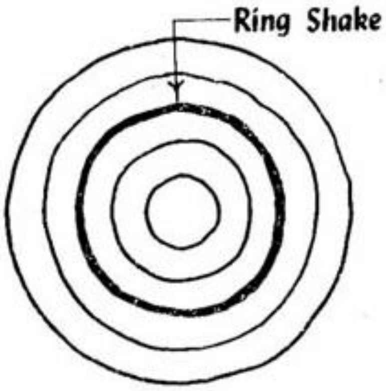
- Heart shakes – These cracks occur in the center of cross- sectional of tree and they extend from pith to sap wood in the direction of modularly rays as shown in Fig. 2. These cracks occur due to shrinkage of interior part of tree. Heart shakes divide the tree cross sectional into two to four parts.



Heart shakes

Fig. 2 Heart shakes

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



Ring shakes

Fig. 3: Ring shakes

- 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. 3

Fig. 4 : Star shakes

- 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.

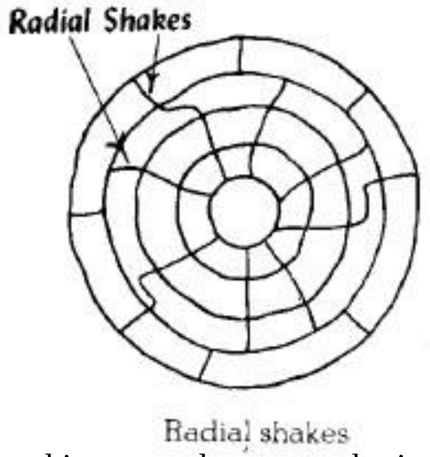


Fig. 5 : Radial shakes

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

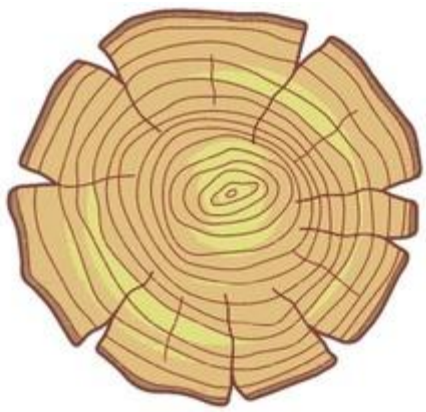


Fig. 6: Wind shakes

Preservation of Timber:

Except teak all other timber need treatment with preservation to protect it from attacks of fungi, insects and the weather. Requirements of wood preservative

• It should effectively resist fungi, insects and the action of weather.

• It should possess good penetration and spreadability.

• It should be durable.

• It should give good appearance.

• It should should not affect the strength of timber.

• It should be free from unpleasant smell.

• It should be non-inflammable.

• It should be cheap and easily available.

• It should cover large area with small quanitiy.

Widely used preservatives:

The following are widely used preservatives:

Coal tar, Solignum paints , Chemical salt , Creosote and ASCU

1. Coal tar: By applying hot coal tar with a brush, timber can be protected from attack by fungi and insects. Since it spoils the appearance, this treatment is mainly restricted to unimportant structures likes fence posts, electric pole, etc.

2. Soligmum paint: It is a special paint which protects timber from termite attack. After thorough cleaning two to three coats of paint are applied on the wood. Painting is necessary time to time.

3. Chemical salt: Copper sulphate, zinc chloride and sodium fluoride are dissolved and are used as preservative. After treatment with these chemicals, paints are applied on timber to improve appearance.

4. Creosote: Creosote is oil obtained by the distillation of coal tar. Timber is kept in a chamber and creosote is pumped in at higher temperature. A temperature of 50°C is maintained for 2-3 hours. It gives good protection to timber.

5. ASCU: This is a special preservative developed by the Forest Research. Institute, Dehradun. It consists of 1 part of hydrated arsenic pentoxide, 3 parts of copper sulphate and 4 parts of potassium dichromate or sodium dichromate. This is also available in powder form. By mixing 6 parts of its with 100 parts of water, the solution is prepared and sprayed on the surface of timber. Then the surface is painted.

Mechanical properties of woods:

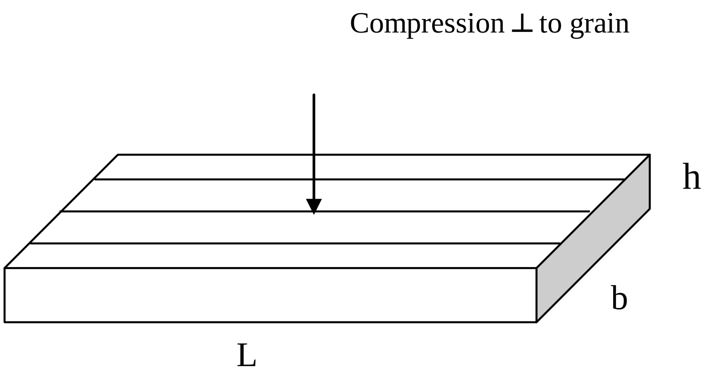
The intelligent use of wood for any structural purpose requires a general knowledge of the mechanical properties of different woods, in order that one selected may conform in its structure qualities to the requirements imposed, and in order that a given purpose may be served at a minimum expense.

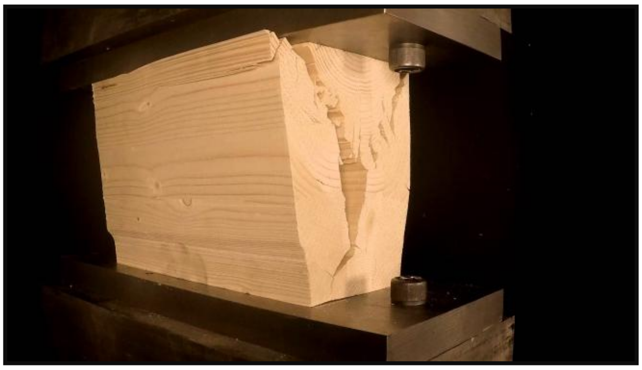
1. Tensile strength: Timber in construction is practically never subjected to pure tensile stresses for the simple reason that the end connections cannot be so devised that they do not involve either shear along the grain or compression across the grain.

Tensile strength of timber

Failure in tension across the grain involves principally the resistance offered by the thinner – walled wood elements to being tern apart longitudinal.

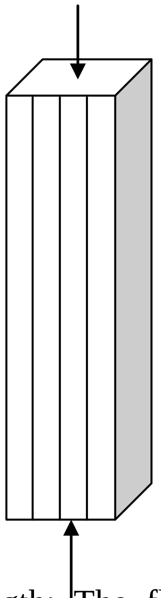
2. Compressive strength: The compressive strength of wood in a direction normal to the grain is simply a matter of the resistance offered by the wood elements to being crushed or flattened. The cells with thinnest walls collapse first, end the action proceeds gradually.



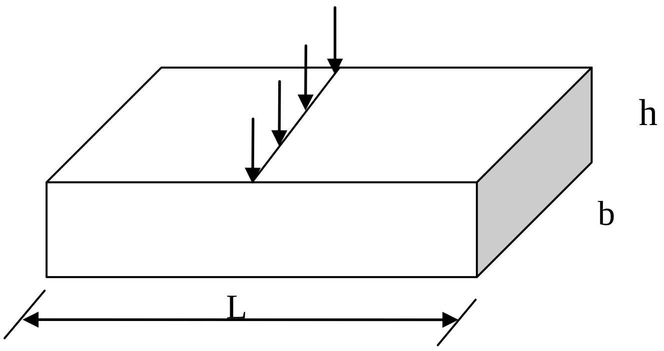


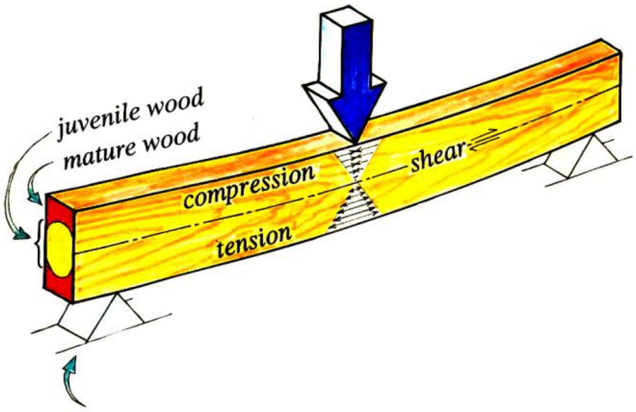
The compressive strength of wood in a direction // to the grain depends upon the internal structure and the moisture content of the wood and the manner of failure is fixed by these same factors. The individual fibers of wood act as so many hallow columns bound firmly together, and failure involves either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

Compression // to grain



3. Flexural strength: The flexural strength of timber is determined by the following formula: $\sigma_b = \frac{3}{2}\left(\frac{pl}{bh^2}\right)$





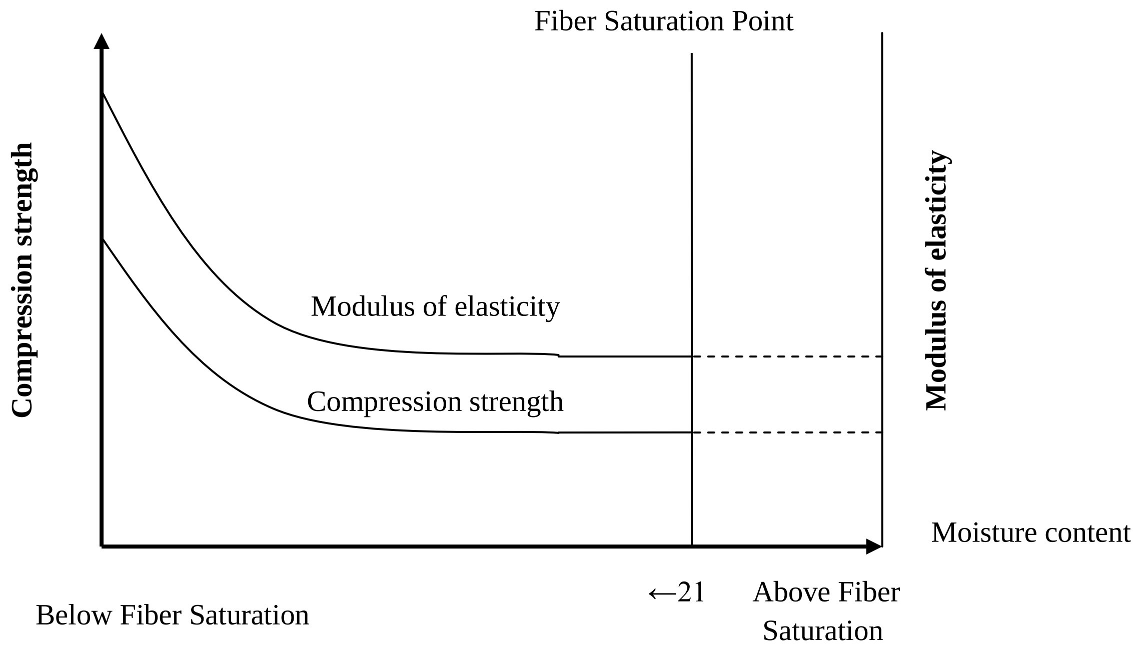
The tensile strength of all timber is greatly an excess of its compressive strength (about 3 times as much the average), and the latter will usually be the determining factor in limiting the cross- breaking strength. (Compressive strength will always be the determining factor, assuming there exist no 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 through 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 where 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:



PROPERTIES OF GOOD TIMBER:

A good timber has the following properties:

• It is free from serious defects like knots, shakes and cracks.

• It has uniform colour.

• Its texture is fine and even.

• It has close grains.

• It has pleasant odour when freshly cut.

• It has higher density.

• It is hard.

• It has higher strength.

• It has higher modulus of elasticity.

• Its fire resistance is high.

Plywood of the following types are manufactured:

• Ordinary grade, used as packing material.

• Exterior grade, made of good quality wood and bonded with waterproof glue.

• Marine grade, in which core and exterior are of superior quality.

The thicknesses of plywood boards are as given below:

• 3 ply – 3, 4, 5, 6 mm

• 5 ply – 5, 6, 8, 9 mm

• 7 ply – 9, 12, 15, 16 mm

• 9 ply – 12, 15, 16, 19 mm

• 11 ply – 19, 22, 25 mm

• More than 11 ply – as per order

1. Fibre board: Wooden chips and vegetable fibres are placed in boiling water till fibres separate. These fibres are blended with resin and steam under pressure. After releasing pressure, fibres are allowed to flow out and cleaned. Then fibres are spread in the form of sheets and pressed under controlled heat and pressure. Thus fibre boards are manufactured. The thickness of these boards varies from 25 to 32 mm and in size 1.8 × 1.2 m, 2.4 × 1.2 m, 2.4 × 1.8 m. These boards are suitable for wall panelling, ceilings and flush doors.

2. Particle boards: These boards are manufactured from chips of wood, rice husk and bagasses obtained after crushing sugar cane. First moisture content in these materia is reduced to 15 percent by drying. Then gluing material like formaldehyde is sprayed and spread in three layers along with a resin mix. The outer layers consist of fine particles and richer resin content. The mat is pressed with hydraulic presses. Particle boards are heavier. They have reasonable strength. They are used as partitions and for making furniture. Figure 2.11 shows a typical board. The dimensions of boards available are as given below:

Thickness: 6, 9, 12, 15, 18, 22, 25, 27, 30, 35, 40 mm

Width: 450, 600, 900, 1000, 1200, 1500, 1800 mm

Length: 900, 1000, 1200, 1500, 1800, 2100, 2400, 2750, 3000, 3600, 4800 mm

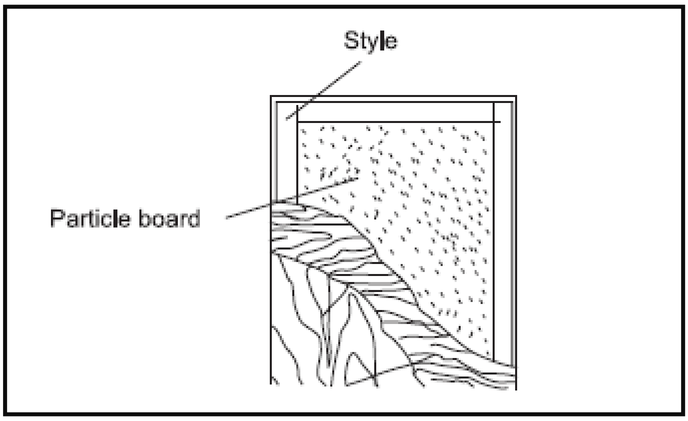


Fig. 3: Particle board

3. Block boards: Block boards are known as batten boards also. The core of these boards consists of strips of wood of width 25-80 mm, glued together. Veneers are glued on either side of the above mat. Thickness of the veneer used is 0.5-1.5 mm while total thickness is 18 mm and above. These boards are used for making bodies of buses, railway coaches, partitions and furniture.

4. Hard board: Hard board is made from wood and wood waste, which is pulped and mixed with paraffin wax and formaldehyde.

5. Bamboo: It is a woody grass. It is flexible, strong and durable. Bamboo is used for scaffolding. *Location:* AP, TN, and Karnataka.

6. Casurina: It is reddish brown in colour and its density is about 7.65 kN/m3. It has strong straight fibres. It is used for scaffolding. *Location:* AP, TN, and Karnataka.

7. Deodar: It is yellowish brown in colour and its density is 5.60 kN/m3. It is moderately strong, can be worked easily and possesses distinct annual rings. It is used for making packing material, cheap furniture and railway sleepers. *Location:* UP, Punjab, Himalayan range.

8. Jack: Its colour is yellow and darkens with age. Density is 5.95 kN/m3. It is even grained, moderately strong, easy to work, maintains shape and is used for making furniture, door panels, musical intrumemts and boats *Location:* Karnataka, TN, Kerala and Maharashtra.

9. Mahogany: It is reddish brown and its density is about 7.20 kN/m3. It takes good polish, is easy to work and durable under water. It is commonly used for making furniture and cabinets *Location:* Karanataka, TN, Kerala and Maharashtra.

10. Mongo: Its colour is deep grey and the specified gravity is 5.6–7.20 kN/m3. It maintains shape. It is moderately strong and easy to work. It is used for making cheap furniture, packing boxes and cabinets.

11. Sissoo: It is dark brown and its density is 7.7 kN/m3. It is strong, tough, durable, takes good polish and has good appearance. It is used for making quality furniture, bridge piles, railway sleepers and for carvings. *Location:* Karanataka, Maharasthtra, Orissa, UP, West Bengal
and Assam.

12. Teak: Its color varies from deep yellow to dark brown and density is 6.39 KN/m^3. It is moderately hard, durable, fire resistant, Takes good polish and is not attacked by white ants and rot. It is used for all superior works. *Location:* Central and South India.