CE201: Engineering Materials

TIMBER AND FRP

Reference Books:

1. Building Materials by Gurcharan Singh
2. A Text Book of Engineering Materials by Dr. M. A. Aziz

TIMBER

- denotes structural wood obtained from tree;
- a standing tree is called standing timber;
- when a tree has been cut and its stems and branches are roughly converted into pieces of suitable lengths, it is known as rough timber;
- When a roughly converted timber is further sawn and converted into commercial size, such as: plank, logs, batten, post, beam, etc., it is called converted timber.

Difference between wood and timber:

- Wood includes all types of wood which may be burning wood, structural wood, furniture wood, etc.
- But wood used as a structural material is called timber.

Advantages of using timber:

- Easily available everywhere;
- High salvage value;
- Can be transported easily by converting into small commercial sizes;
- Working with timber (i.e., repairing, alteration, addition, etc.) is easy;
- Can be easily jointed;
- Not corroded (so, it can be used in marine works);
- Light weight;
- Withstands shocks better than iron and concrete;
- Good insulator of heat and electricity;
- Good sound absorbing material.

- **Classification of trees:**
  - **Exogenous**
    - **Evergreen or conifers**
    - **deciduous**
  - **Endogenous**

- Exogenous trees:
- These trees increase in bulk by the formation of successive annual rings radially on the outside under the bark. Every year a new ring is added to the tree section. Age of tree can be determined from the number of annual rings. Used for engineering purposes. Two types:
- *Evergreen trees or conifers:* Having pointed needle-like or scale-like leaves bearing cone-shaped fruits. They are generally

- evergreen trees. Yield softwood. Examples, the pines, fur, kail, ceder, chir, deodar and cypress trees.

- *Deciduous trees*: Having flat broad leaves, which fall in autumn and new leaves appear in spring. Yield hardwood. Examples. Oak, Mehogany, Teak, Sal, Gorjon, Chambal, Telsu, Nageshwar, etc.

Endogenous trees:

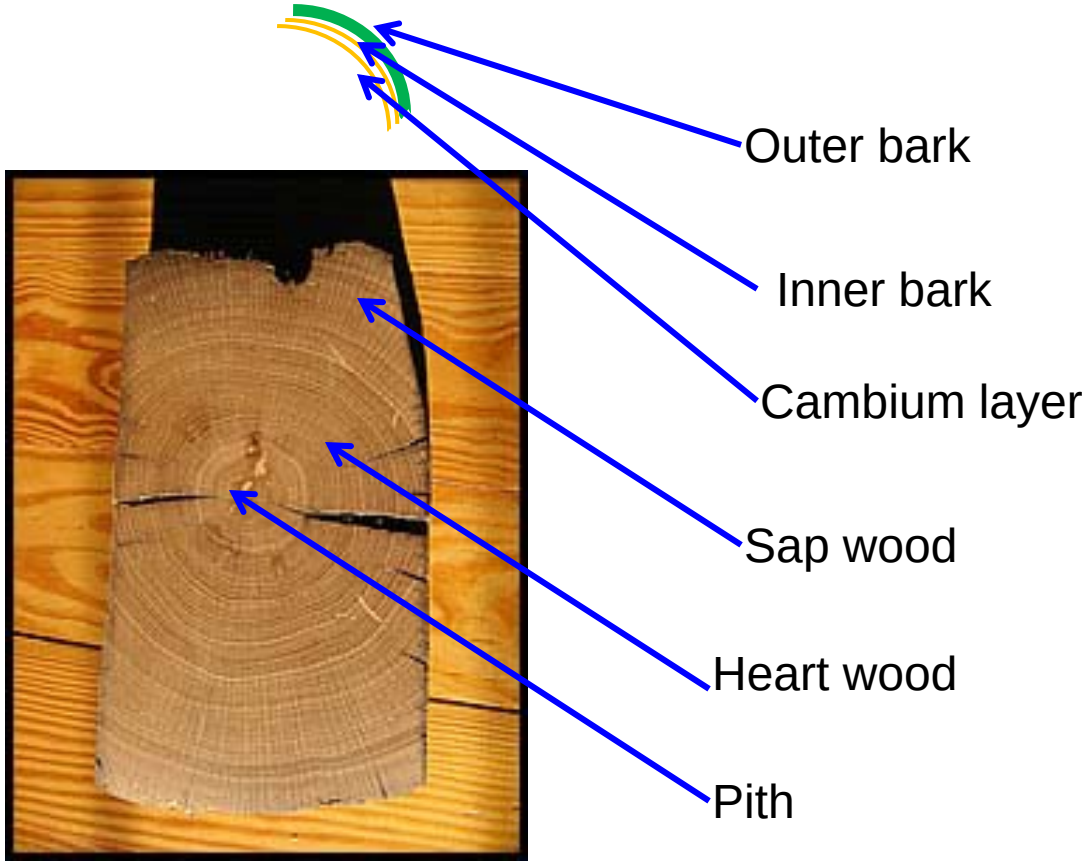
- These trees grow inward by depositing each fresh layer internally. Thus the older formations/layers of wood material are on the outside. They grow vertically in a fashion that the links (approx. annual growth) placed end-to-end with knot connecting two adjacent links. Example: Bamboo, palm, etc.

- **Hardwood/Softwood:**

- Characteristically, broad-leaved trees yield hardwood while conifers (needle-leafed trees) yield softwood;
- Hardwoods are dense with having narrow and well-defined annual rings. Softwoods comparatively less dense, lighter in color. They are not very strong but are soft with straight grains;
- Softwoods have more uniformity of structure than hardwoods.

Timber section:

- Consists of pith, heartwood, sapwood, cambium layer, inner bark, outer bark and medullar ray (Fig. 15.1, page no. 287, Aziz).



Pith:

- Central part, dark colored, consists of cellular tissues and nourishes the plant in its young age; in old age, the pith dries up and decays; Sap is transmitted by fibers deposited round the pith.

Cambium layer:

- A thin layer of sap lying between sapwood and the inner bark; it is full of sap which is yet to convert into sapwood; this is very sensitive layer; if it is exposed by removing the bark, cell stopped transmitting sap into the inner part and the tree dies.

Medullar ray:

- These are thin radial fibers, extending from cambium layer right up to pith. These rays help in holding together annual rings of both heartwood and sapwood. They may be continuous but mostly they are broken.

Heartwood:

- Dark colored portion of the tree surrounding the pith. Almost dead portion of tree and does not take active part in its growth. It provides strongest and durable timber for various engineering purposes.

Sapwood:

- Light colored wood lying between heartwood and cambium layer. Light in weight and is of recent growth containing a lot of sap. This is the active part of the wood and thus helps in growth in the tree.

Felling of trees:

- Cutting of trees in order to get timber from them is called felling of timber. The following facts should be carefully considered while felling trees:

- Season of felling: Trees should be cut only when sap is not active, i.e., in mid-summer and mid-winter. In autumn and spring sap is in vigorous motion, hence felling should be avoided. For hilly region, mid-summer and for plain areas, mid-winter are proper seasons for felling trees.

- Age of trees: Trees should be felled only when it has just attained maturity. Under-aged trees would yield more of sapwood, while over-aged trees develop certain defects in heartwood.

- Method of felling trees: Felling should be entrusted to an experienced person. Before felling, slope of the tree is assessed and cut is given to the stem on the side of the slope of the tree, as near to the ground as possible. Then cut is made on the opposite side of the slope to fell the tree.

- If tree is to be felled against the direction of the slope, ropes are tied to the tree and pulled to the direction of felling by giving suitable cut to the stem.

Conversion of timbers:

- The process by which timber is cut and sawn into suitable marketable sizes is known as conversion of timber. After felling, stems and branches of trees are cut into logs of suitable lengths. The logs are then transported to the saw mill and converted into marketable sections (i.e., planks, battens, beams, etc.).

- Sawing of Timbers:

- Ordinary sawing or cross sawing (Fig. 15.2, page no. 294, Aziz)
- Radial or Rift sawing (Fig. 15.3, page no. 294, Aziz)
- Tangential or slash sawing (Fig. 15.3, page no. 294, Aziz)
- Quarter sawing (Fig. 15.4, page no. 296, Aziz)
- Combination sawing (Fig. 15.5, page no. 297, Aziz)

Seasoning of timbers:

- The process of removing surplus moisture (in excess of equilibrium moisture content) from freshly converted timber is seasoning.

Advantage of seasoning:

- Seasoned timber is light.
- Improves strength properties.
- Easy to transport and handle.
- Timber less liable to be attacked by fungus and insects.
- Reduces the tendency to shrink and warp.
- Can easily be worked with.
- A seasoned timber maintains the shape of timber article unchanged.

Methods:

- Natural seasoning
- Artificial seasoning
- Water seasoning

Natural seasoning:

- After felling, timbers are sawn into commercial sizes;
- They are stacked under covered shed;
- Sufficient space is left around each sawn piece for free air-circulation;
- Also known as air seasoning; natural air remains circulating around each piece of the stack and in due course of time, seasoning is brought about.

Advantages:

- No skilled supervision is required;
- Simple and cheap method of seasoning;
- Thick section can be successfully seasoned.

Disadvantages:

- Since depends on natural air, no control can be exercised over it;
- Slow method; depends on climatic conditions, size and shape of the timber;
- Seasoning non uniform and uneven;
- Requires large space;
- Moisture cannot be brought to the desired level;
- Seasoned timber may have end split;
- Liable to be attacked by fungus and insects.

- Artificial seasoning:
- The drying of timber by exposure to high temperatures in a closed chamber or by applying chemicals, steam and smoke is termed as artificial seasoning.

- *Advantages of artificial seasoning:*
- Rate of drying can be regulated;
- No chance of timber being attacked by fungus and insects;
- Takes short time;
- Desired moisture content can be attained during seasoning;
- Better control of air, temperature and humidity;
- Seasoning more uniform;
- No end splits.

Methods of artificial seasoning:

- 1. Smoking;
- 2. Boiling;
- 3. Steaming;
- 4. Kiln seasoning;
- 5. Chemical seasoning;
- 6. Electrical seasoning;

Water seasoning:

- Timbers and logs are immersed and allowed to remain in water for a couple of days, then dried in natural air. In this process, the sap is diluted and is partly removed.

Decay or disease of timber:

- Occurs due to fungal action; the fungi feeds on softwood and converts it into powder; however, decay does not occur either due to any chemical action or due to fermentation of sap.

The main causes of timber decay are:

- Alternate dry and wet conditions;
- Defective seasoning of timber;

- Presence of fungi and insects such as marine borer, beetles, termite, etc.
- Lack of ventilation;
- Dark and damp condition;

- *Timber rots:*
- It is a sort of timber decay. During rot disintegration of timber takes place and gases like H_2S and CO_2 are generated.

- Two types: Dry rot and Wet rot.

- *Dry rot:*
- Disintegration of converted timber by the harmful effects of certain fungi, which feeds on timber and converts it into dry powder.
- Factors responsible are the same as those responsible for decay;
- If some timbers are affected by dry rot, the best way is to cut the affected portion;
- Dry rot may be preserved by using well-seasoned timber free from sap, and the timber should be adequately ventilated by fresh air;
- Detection: by tapping or scratching at one end and placing the ear at the other end of log.

- *Wet rot:*
- It is the decomposition of timber caused by moisture;
- It is caused if alternate dry and wet conditions prevail around the timber;
- Not caused by fungal attack;
- When unseasoned timbers are exposed to rain and wind, they are liable to be attacked by wet rot;
- In wet rot, the timbers get converted into grayish brown powder;
- Can be prevented by using well-seasoned timber; also using tarred or painted timbers exposing to rain or water.

- **Preservation of timber:**
- Preservation indicates an increase in life by developing resistance to insect attack, fungal infection and disease of timbers;
- A preservative acts like a disinfectant;
- A seasoned timber, since dried, is hygroscope and to prevent re-absorption of moisture and to impart immunity, the tissues of dry/seasoned wood have to be soaked with some type of a preservative;
- Seasoning, therefore, prepares a timber for preservative treatment by driving away moisture and sap.

Choice of preservative governed by:

- Their toxicity and poisonous effects;
- Permanency in their effect in treated wood;
- Should not be injurious to wood tissues;
- Cheaply available and safe to handle;
- Should allow a decorative treatment;
- Should not disfigure exposed surface of timber;
- Non-inflammable;
- Should have a good covering quality.

Methods of preservatives:

- *Charring:*
- Crude method; No special preservative is used;
- Timber kept wet for 0.5~1.0 hour and then burnt to a depth of 15-mm and cooled with water;
- A coal layer is formed on the surface which performs preservative functions;
- Layer is not affected by fungi, moisture or white ant;
- Used at lower ends of posts of timber.

Tarring:

- Application of a layer of hot tar on the surface;
- Generally applied to an embedded ends of posts.

Painting:

- Performs both aesthetic and preservative purposes.

Creosoting:

- Creosotes are obtained by the distillation of coal, petroleum or wood substances;

Three types: Coal-tar creosote, water gas-tar and wood-tar creosote;

- Creosote oil is applied under pressure on wood surface;
- Used on piles, poles and railway sleepers, etc.

Water soluble chemical salts:

- Used some chemical salts which are not toxic in nature and are also soluble in water;
- They are odorless and can be painted on drying;
- When appearance is important in wood, this type is most suitable;

- Wood treated with water soluble salts requires to be re-dried;
- The effects of these chemicals are lost gradually and so wood requires be painting or varnishing for surface treatment;
- Cheaper than creosote treatment;
- Example: Zinc chloride treatment; Creosote oil + NaF$\rightarrow$ known as Wolman's salt.

Ascu-Treatment:

- Mixture of 3 parts of $CuSO_4$.5H2O + 4 parts of $K_2Cr_2O_7$.$2H_2O$ + 1 part of As_2O_5.$2H_2O$
- The solution is prepared by mixing six parts of this powder to 100 parts of water by weight;
- The solution is then sprayed on the timber surface;
- After drying, the surface needs to be waxed, varnished, polished and painted;
- The solution is colorless.

Artificial wood:

Veneer:

- Thin sheets of timber of superior quality;
- Obtained by rotating wooden logs of the timber against a sharp knife of rotary cutter;
- Thickness 0.4 to 6.0 mm or even more;
- After removing from parent logs, they are dried in kiln to remove moisture;
- Used for manufacturing of plywood.

Plywood:

- Made from multiple veneers;
- Veneers are taken in odd numbers and are placed one above the other at right angles in successive veneers;
- All veneers held together with the help of adhesives;
- 3-ply, 5-ply, 7-ply, etc. are available; that is, veneers are used in odd numbers in a plywood;

Advantages of plywood:

- Suffers little expansion or shrinkage due to change in moisture content;
- Light and available in large sizes;

- Available in decorative designs;
- Not liable to split and cracks;
- Easy to work with;
- Make use of costly timber in most economical manner.

Impreg timber:

- Sunmica, formica, sungloss, etc.
- Veneers are partly or fully covered with resin;
- For this purpose, veneers are taken and immersed in resin. The resin fills in the wood cells and a consolidated mass is developed. The mass is then cured at a temperature of about 150 to 160^0C.

Characteristics of impreg timber:

- Strong, durable, good looking, weather resistant, electrically insulated and resists acidic effects.

Compreg timber:

- Same as impreg timber; except, they are cured under pressure;
- More durable and stronger than impreg timber.

Fiber-board:

- Manufactured from wood or other vegetable fibers; they are rigid boards of thickness varying from 6 mm to 25 mm; width 1.2m and length 3.5 m;
- The pieces of woods, cane or other vegetable fibers are heated in a hot water boiler; Due to boiling, the fibers get separated;
- These fibers are put in a vessel and steam is admitted in it under a pressure;
- The steam pressure is then suddenly increased to 70 kg/cm^2 and this pressure is maintained for a few seconds;

- The steam pressure is suddenly dropped down; in doing so, the natural adhesive contained in fibers is completely separated;
- Fibers are taken out of vessel and cleaned off all superfluous gums;
- They are spread on wire screen in form of loose sheets and pressed; the resulting material is called fiberboard;
- Depending on their form and composition, they are classified as insulating boards, medium hardboards, hardboards, super hardboards and laminated boards.

They may be used for following purposes:

- For the construction of walls panels and suspended ceilings;
- Construct partitions;
- Form-works;
- As insulating materials against heat and sound;
- As tabletops and for flush doors.

PLASTICS

- an organic material with high molecular weight;
- prepared out of resins, with or without the incorporation of fillers, plasticizers, solvents or pigments;
- Resins are the basic raw materials in plastic industry, and generally there is no shortage of the raw materials for the preparation of resins; it can be either of natural origin or synthetic;
- Synthetic resins are produced by the methods of polymerization and condensation;

Composition of plastic:

- basically an organic substance prepared from natural or synthetic resins;
- other materials like fillers, plasticizers, hardeners, pigments may be added or not;
- Generally it’s a compounds of carbon with other elements such as oxygen, hydrogen, nitrogen, etc.
- Carbon combines with itself and other elements and forms more complicated compounds.

Classification of plastics:

- basically two types of plastics:
- i. Thermo-setting plastics and ii. Thermo plastics.

Thermo-setting plastics:

- this variety requires great pressure and a momentarily heated condition during shaping for subsequent hardening;
- heat sets up cross-linkages between the molecules, the result of which is an infusible mass that is very hard and resistant to heat;
- It is non-fusible and insoluble;
- During this process, chemical reactions take place, which are not reversible;
- The scrap of a thermo-setting plastic article is not re-usable.

Thermo-plastics

- this variety hardens due to a physical change occurring in the materials;
- they could be softened by heat repeatedly, and the linkages between molecules are rather loose;
- material becomes more hard as it cools down;
- the process of softening by heat and hardening when cooled down could be repeated indefinitely;
- this property allows the scrap from the broken and rejected articles, and the trimmings from moulding machines to be re-used;
- they are required to be kept for sometimes in the mould until they cool down and harden;
- They are soluble in many solvents.

Fiberglass reinforced plastic (FRP):

- Glass fibers are used alone or in combination with cotton or jute fabric to prepare fiberglass reinforced plastic products with synthetic resins like phenol formaldehyde.
- The resins are dissolved in alcohol and the glass cloth/fiber is impregnated with the resin solution. They are then subjected to heat and pressure.
- The panels thus produced are strong, durable and make excellent heat insulating wall coverings.
- Glass-fibers and synthetic resins bonded together by a suitable synthetic adhesive and yield glass-veneers like wood-veneers, which can be used in place wood-veneers.

- In FRP, glass-fibers provide stiffness and strength, while resin provides a matrix to transfer load to the fibers.
- Aesthetic appearance, corrosion resistance, durability, dimensional stability, light transmission, lightweight, etc. are the favorable properties for FRP, which make it popular.

FRP and CRP

- **Fibre-reinforced plastic** (**FRP**) (also *fibre-reinforced polymer*) is a composite material made of a polymer matrix reinforced with fibres.
- The fibres are usually fibreglass, carbon, or aramid
- the polymer is usually an epoxy, vinylester or polyester thermosetting plastic.
- FRPs are commonly used in the aerospace, automotive, marine, and construction industries.

Structural Use of FRP/CRP

- FRP can be applied to strengthen the beams, columns and slabs in buildings. It is possible to increase strength of these structural members even after these have been severely damaged due to loading conditions.
- For strengthening beams, two techniques are adopted. First one is to paste FRP plates to the bottom (generally the tension face)of a beam. This increases the strength of beam, deflection capacity of beam and stiffness (load required to make unit deflection). Alternatively, FRP strips can be pasted in 'U' shape around the sides and bottom of a beam, resulting in higher shear resistance.

Structural Use of FRP/CRP

- Columns in building can be wrapped with FRP for achieving higher strength. This is called wrapping of columns. The technique works by restraining the lateral expansion of the column.
- Slabs may be strengthened by pasting FRP strips at their bottom (tension face). This will result in better performance, since the tensile resistance of slabs is supplemented by the tensile strength of FRP.

Advantages of FRP/CRP

- This has advantages over cast aluminium manifolds are:
  - Up to a 60% reduction in weight
  - Improved surface quality and aerodynamics
  - Reduction in components by combining parts and forms into simpler moulded shapes.