
بسم الله الرحمن الرحيم

Wood
An Ancient building Material

By

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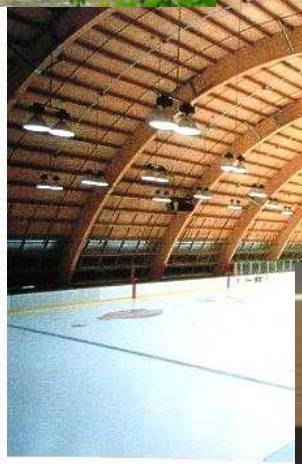


Wood and Timber

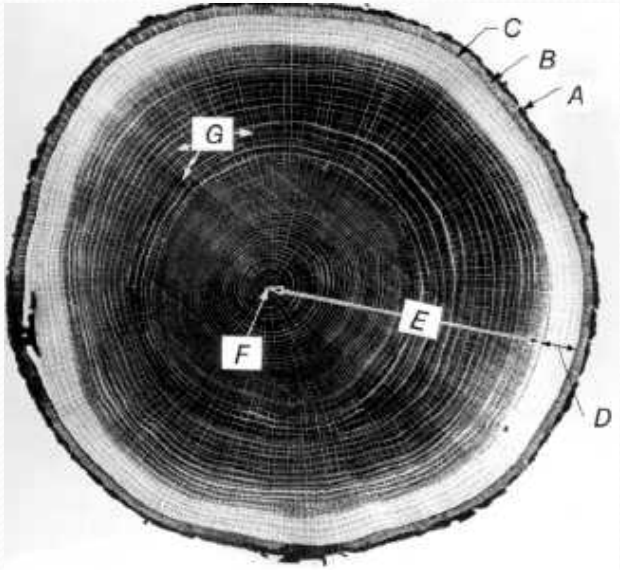
- Wood is a hard, fibrous tissue found in many plants. It has been used for centuries for both fuel and as a construction material for several types of living areas such as houses, known as carpentry.
- In the United Kingdom and Australia, *timber* is a term also used for sawn wood products (that is, boards), whereas generally in the United States and Canada, the product of timber cut into boards is referred to as *lumber*.
- Throughout history, the unique characteristics and comparative abundance of wood have made it a natural material for homes and other structures, furniture, tools, vehicles, and decorative objects.
- Today, for the same reasons, wood is prized for a multitude of uses.
- Types:
  - Wood suitable for buildings: Timber
  - Woof of fallen tree: Rough Timber
  - Sawed and finished wood: Converted Timber / Lumber
- All wood is composed of cellulose, lignin, hemicelluloses, and minor amounts (5% to 10%) of extraneous materials contained in a cellular structure.

Types of Trees:

- Exogenous Trees/ Endogenous
  - Exogenous Trees
    - Grow in girth and material contained in the bark.
    - Most of the building wood
    - In the form of concentric rings called '"Annual rings"
    - Normally one rings represents one year growth
- Endogenous Trees:
    - Grows inwards by adding every year a fresh layer of internally
    - The older formation are outside
    - Flexible and slender and not fit for buildings
- Deciduous/Evergreen Trees:
    - Shed their leaves each winter –Building wood mostly
- Evergreen:
    - Don't shed leaves every winter

X-section of tree: Bark, Wood, Branches, and Cambium

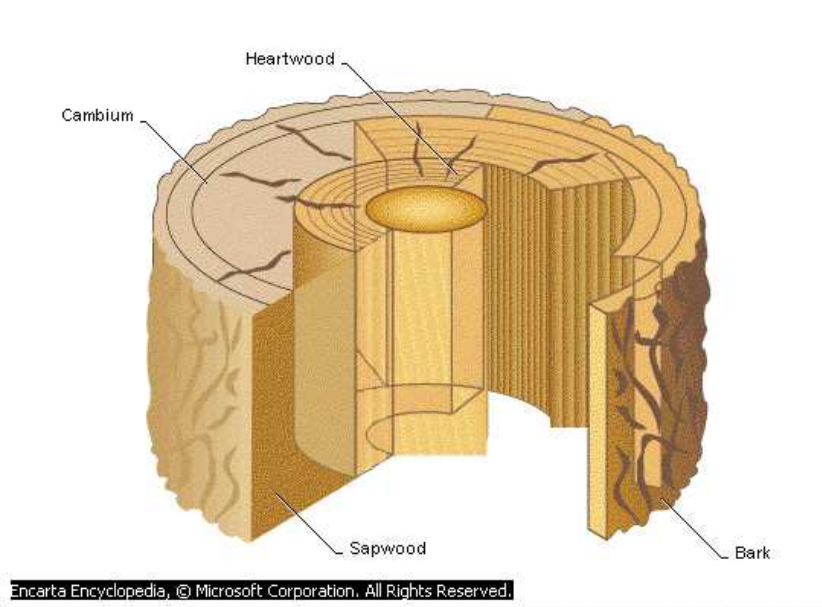
- Cross section of white oak tree trunk:
- (A) outer bark (dry dead tissue):
  - outer corky dead part (A), whose thickness varies greatly with species and age of trees
- (B) inner bark (living tissue):
  - which carries food from the leaves to growing parts of the tree;
- (C) cambium:
  - Outer ring between the sapwood and bark
  - Lighter, weaker and vulnerable to decay.
- (D) sapwood:
  - Transmits the sap from roots to branches
- (E) heartwood, (F) pith, and (G) wood rays.



Sapwood and Heartwood:

- Sapwood is located between the cambium and heartwood
- Sapwood contains both living and dead cells and functions primarily in the storage of food;
- In the outer layers near the cambium, sapwood handles the transport of water or sap. The sapwood may vary in thickness and number of growth rings.
- Sapwood commonly ranges from 4 to 6 cm (1-1/2 to 2 in.) in radial thickness.
- In certain species, the sapwood contains few growth rings and usually does not exceed 1 cm (1/2 in.).
- As a rule, the more vigorously growing trees have wider sapwood. Many second-growth trees of merchantable size consist mostly of sapwood.
- .

- In general, heartwood consists of inactive cells that function in either water conduction or food storage.
- The transition from sapwood to heartwood is accompanied by an increase in extractive content.
- Frequently, these extractives darken the heartwood and give species such as black walnut and cherry their characteristic color



Growth Rings

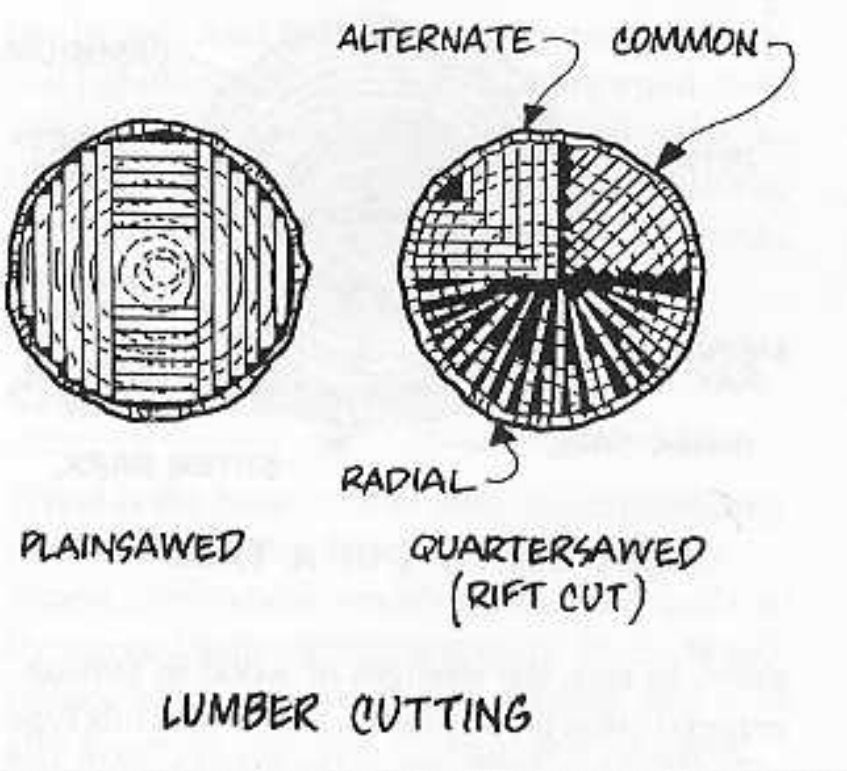
- In most species in temperate climates, the difference between wood that is formed early in a growing season and that formed later is sufficient to produce well-marked annual growth rings.

- The age of a tree at the stump or the age at any cross section of the trunk may be determined by counting these rings.
- However, if the growth in diameter is interrupted, by drought or defoliation by insects for example, more than one ring may be formed in the same season.
- In such an event, the inner rings usually do not have sharply defined boundaries and are termed false rings.
- Trees that have only very small crowns or that have accidentally lost most of their foliage may form an incomplete growth layer, some times called a discontinuous ring.

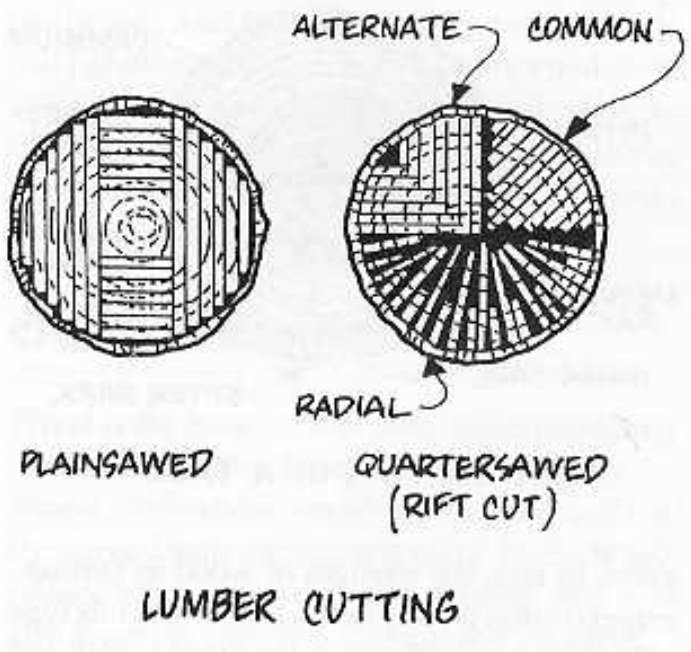
Cross section of pine log showing growth rings. Light bands are early wood , dark bands latewood.
An annual (growth) ring is composed of an inner early wood zone and outer latewood zone.

Cutting and Sawing Lumber

Shrinkage, distortion, and warpage of lumber depends partially on the way lumber is cut from a tree. Wood shrinks most in the direction of the annual growth rings (tangentially); less across these rings (radially); and very little parallel to the grain (longitudinally).



Cutting and Sawing Lumber

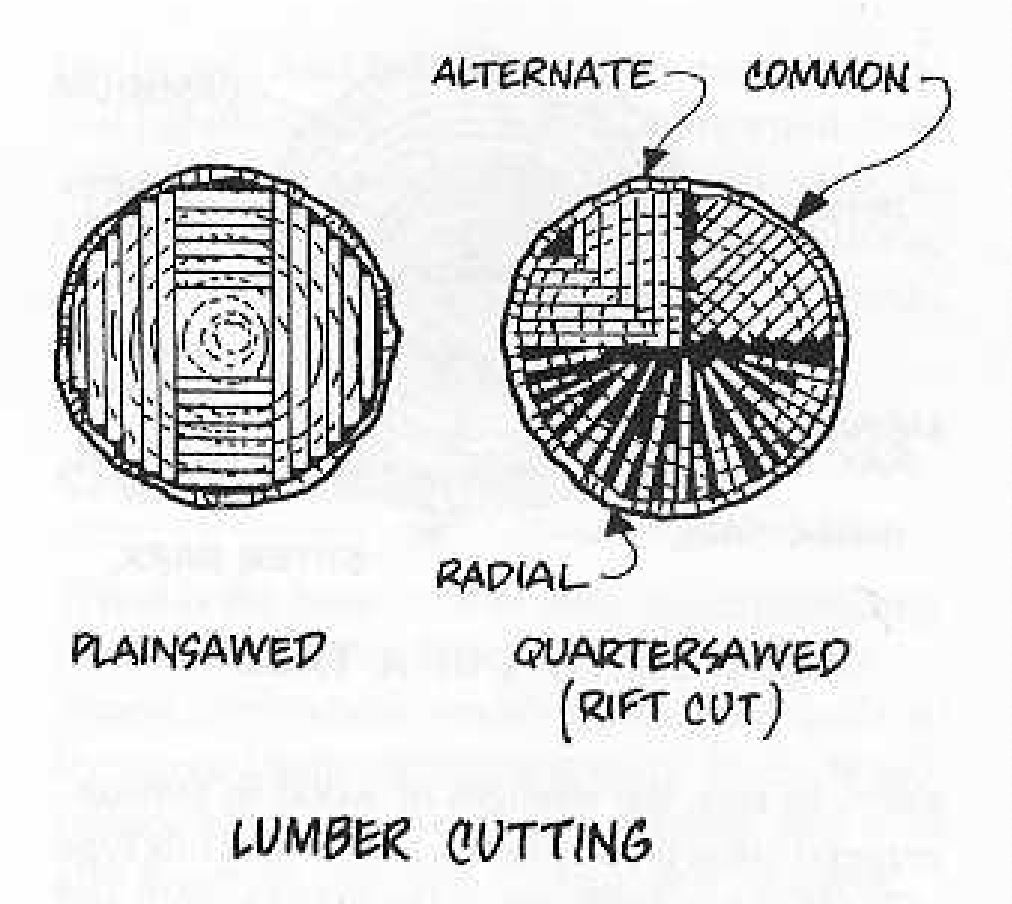


Lumber can be cut from a log in two different ways: tangent to the annual rings, called *plain-sawed* in hardwoods and *flat-grained* or *slain-grained* in softwoods.

Lumber cut radially to the annual rings is called *quarter-sawed* in hardwoods, and *edge-grained* or *vertical-grained* in softwoods.

Cutting and Sawing Lumber

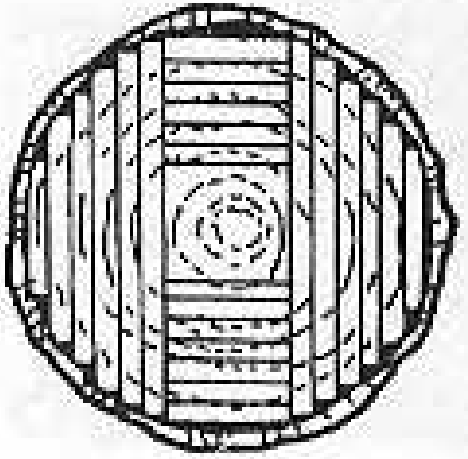
Lumber is classified as *quarter-sawed* if the grain is 45 degrees to 90 degrees to the wide face and *plain-sawed* if the grain is 0 degrees to 45 degrees to the wide face.



Cutting and Sawing Lumber

Characteristics of plain-sawed lumber include:

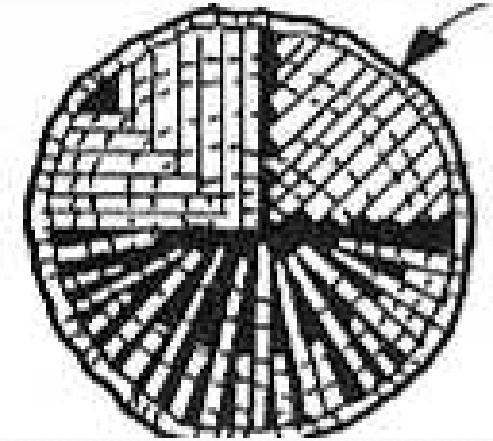
1. Distinct grain pattern,
2. May twist, cup, or wear unevenly,
3. Tends to have a raised grain,
4. Shrinks and swells more in width, less in thickness,
5. Less waste in cutting, and therefore less expensive.



Cutting and Sawing Lumber

Characteristics of Quarter-sawed lumber include:

1. Relatively even grain pattern,
2. Wears evenly with less warpage,
3. Shrinks and swells more in thickness, less in width,
4. More waste in cutting and therefore more costly.

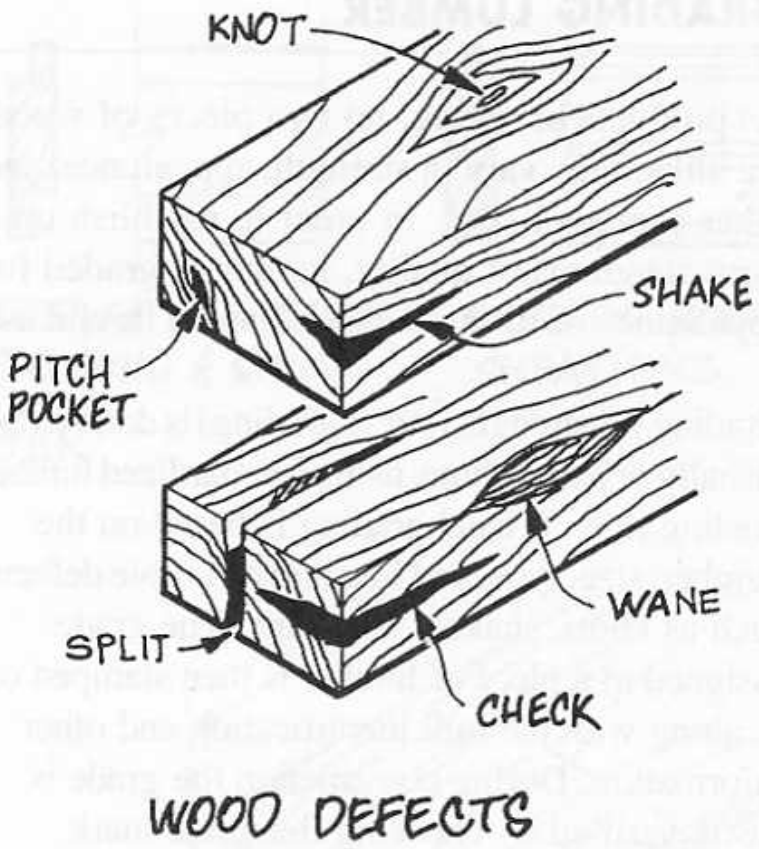


Wood Defects

- Variety of defects that affect the strength, appearance, use, and grading of lumber. Defects may be natural or caused by manufacturing.
- Wood can be damaged by insects, decayed by fungus, and of course, destroyed by fire.

Wood Defects

NATURAL DEFECTS:



Knot: branch embedded in a tree and cut through manufacturing.

Shake: pitted area sometimes found in cedar and cypress.

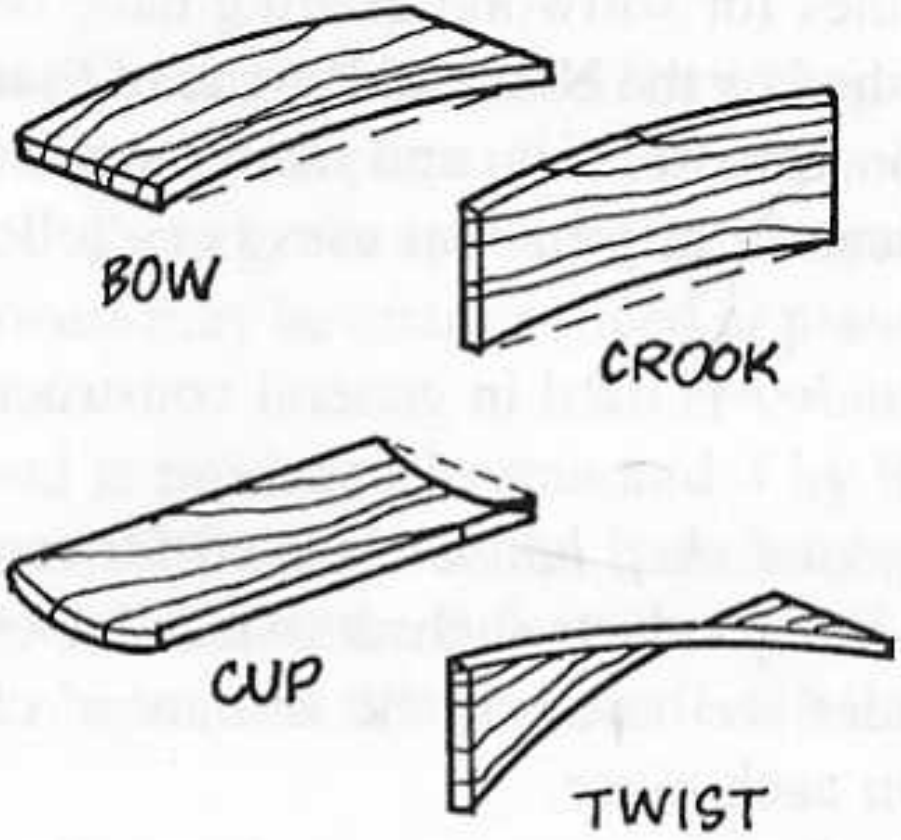
Pitched Pocket: opening between growth rings and containing resin.

Check: lengthwise grain separation caused by seasoning.

Split: lengthwise separation of wood extending from one face to another.

Wane: lack of wood on the edge or corner.

Warp: shrinkage distortion of a plane surface, includes---bow, crook, cup and twist.



TYPES OF WARPAGE

Seasoning of wood

- seasoning is process of drying out timber after conversion. (Conversion felled trees are converted in sawmills into thick plank sizes).

- Freshly cut wood contains considerable water, which amounts to from one-third to more than one-half of the total weight.

- The drying of wood before it is processed into timber is called seasoning, and is done for a number of reasons. Seasoned wood is far more resistant to decay than fresh wood;

- it is much lighter and therefore less expensive to ship; it has much higher heating value, which is important if it is to be used as fuel; and, most important, wood changes in shape during drying, and this change in shape should be completed before the wood is worked or used.

- Wood may be seasoned either by air-drying or kiln-drying. Air-drying takes several months, whereas kiln-drying takes a few days. In both cases, the wood must be carefully stacked to prevent warping, and the rate of drying must be carefully controlled.

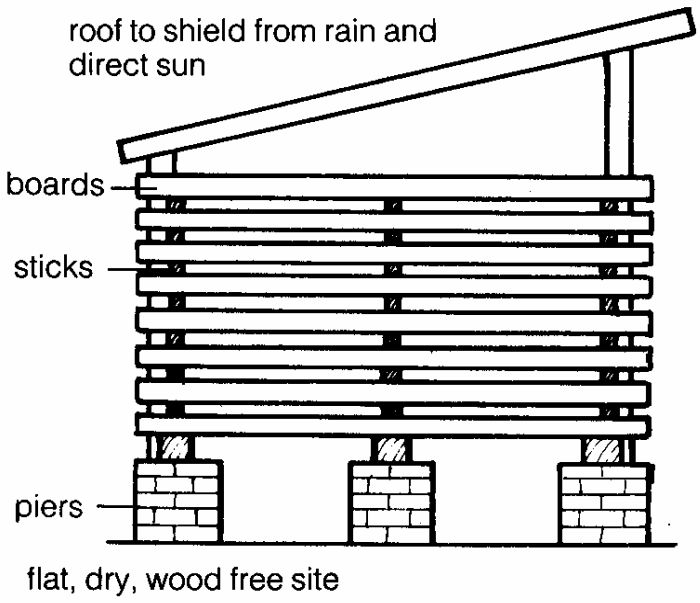
Wood Seasoning Methods

Air Seasoning – the natural method. Boards are stacked in the open air with sticks (thin strips of wood) between them to allow air to circulate. The stack is raised clear of the ground on piers and has a roof to protect it from the weather.

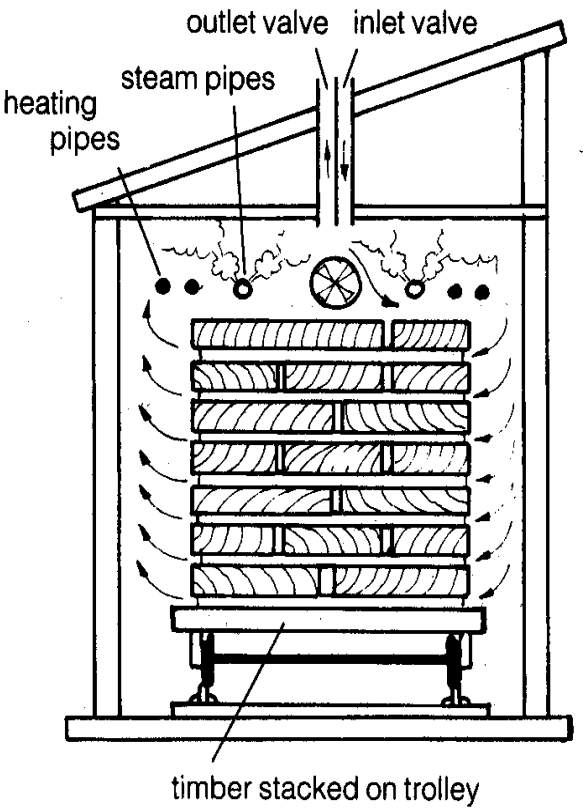
The ends of the boards are painted, or have cleats (wood or metal strips) nailed across them to prevent the end grain drying more quickly than the rest of the board, as this causes splitting (checking).

Advantages. It is cheap and needs little skilled attention.

Disadvantages. It takes 3 to 6 years to dry. The moisture content can only be reduced to 15 –18% by air seasoning.



- Kiln Seasoning – the artificial method. Boards are stacked on trolleys with sticks between them, and pushed into a kiln. The kiln is sealed and seasoning proceeds in three stages.
  - Stage 1. Steam is injected at low temperature to force free moisture out of the wood cells.
  - Stage 2. Steam is reduced and the temperature is increased to dry the wood
  - Stage 3. Finally there is a flow of hot, almost dry, air.



Advantages. It takes only a few days or weeks and kills insect eggs in the wood (e.g. woodworm). It is possible to reduce moisture content to below 12%, making the wood suitable for use in centrally heated and air-conditioned buildings

Disadvantages. Kilns are expensive to build and to run.
It needs a more attention and a lot of skill as incorrect drying will ruin he wood.

- Water seasoning:
  - Large logs are immersed in water for 15 days.
  - Later dried in the open air.
  - Suitable for wood containing more sap.
  - Not suitable where strength is required like structural uses.
  - Most of the fermentable matters removed and wood less vulnerable to attacks of worms.
- Chemical seasoning or salt seasoning:
  - Timber soaked in the solution of urea.
  - Later dried in kiln.
- Electric seasoning:
  - Quick but expensive.
  - High frequency AC currents passed in the wood.

Characteristics of good Timber

- Quality of timber depends on:
  - Species used, the soil where tree is grown, time of felling and methods of seasoning and treatment.
- Free of defects like knots, wanes, etc.
- Obtained from hearth of sound treed and sap removed.
- Uniform structure and color.
- Narrow annual rings.
- Heavier in weight
- Firm adhesion of fibers.

Causes of wood decay and preservation

- Wood is naturally a very durable substance. If not attacked by living organisms, it will last for hundreds or even thousands of years.
- Samples of wood used by the ancient Romans have been found virtually in their original condition when a combination of circumstances protected them against attack.
- The most important of the organisms attacking wood are the fungi that cause so-called dry rot, which actually occurs only when the wood is damp.
- The sapwood of all trees is susceptible to this type of decay, but the heartwood of a few species is naturally resistant to these fungi. Walnut, redwood, cedar, mahogany, and teak are among the well-known woods that are extremely durable
- Other woods are resistant to various types of attack. Greenheart and teak are particularly resistant to the attack of marine borers, and so are often used for underwater construction for wharves.
- A number of woods are comparatively resistant to termites, including redwood, black walnut, mahogany, and several types of cedar.
- In most of these cases, the woods are aromatic, and the resistance is probably due to the resins and similar chemicals they contain.

- Wood may be preserved by protecting it chemically against deterioration. The most important method of treatment has long been impregnation with creosote or zinc chloride.
- This method is still one of the best, although a number of newer chemicals, notably several containing copper compounds, have been introduced for the same purpose. Wood can be protected against weathering by suitable surface coatings, applied by brushing, spraying, or dipping. Surface applications yield little penetration, however, and therefore do not prevent deterioration under attack by insects, fungi, or borers.
- By applying a finish to wood we not only protect it but tend to improve its appearance. A highly polished dining table or floor is not only safe from attack by organisms and chemicals they become more attractive or aesthetically pleasing. New paints and coatings are constantly being developed to improve and enhance the appearance and properties of both natural and processed wood

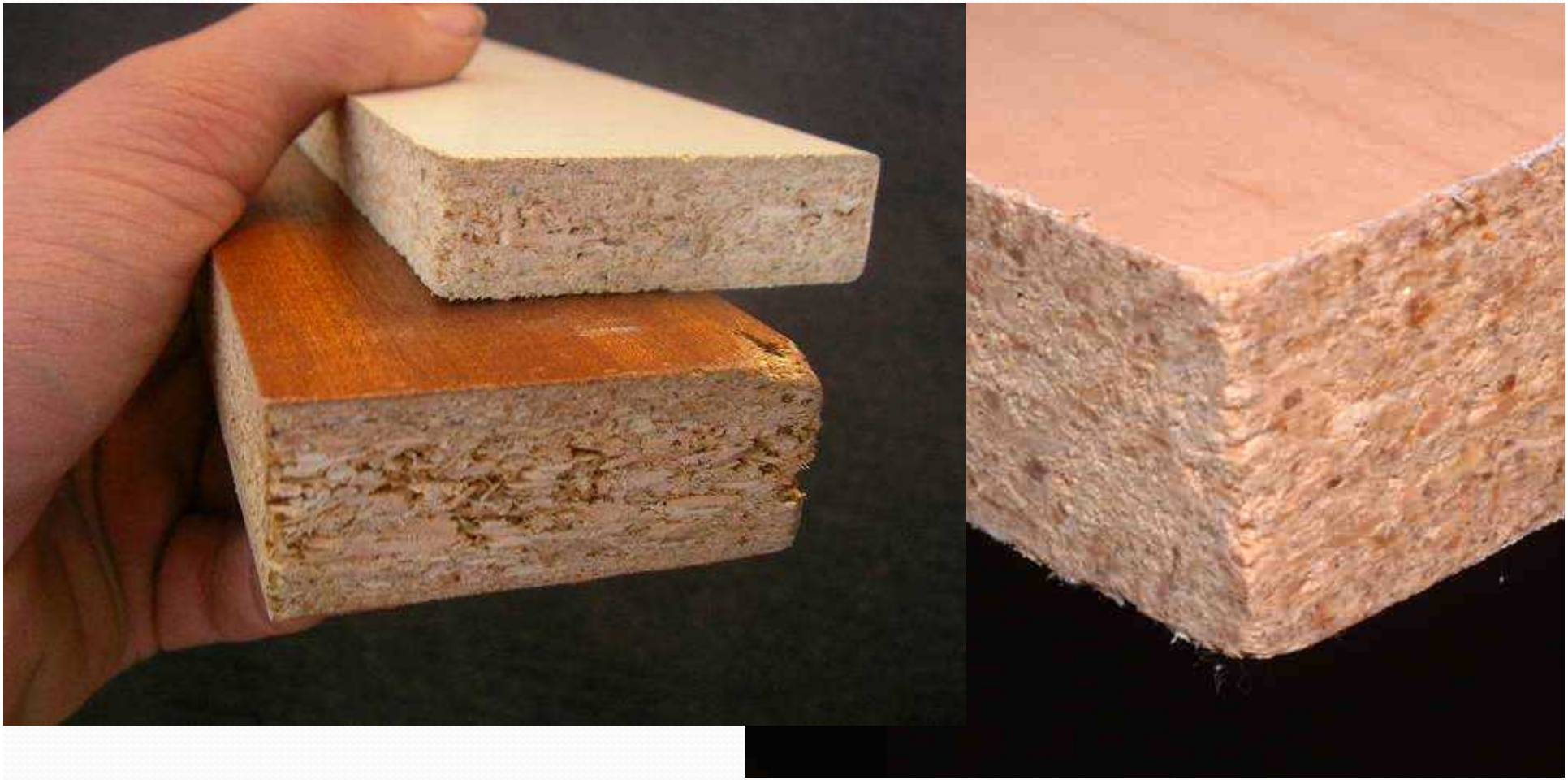
- Commonly used wood preservation techniques:
  - A good preservative must be:
    - Cheap - Easy to use and handle - Non injurious to the tissues of trees- Should preserve permanently and must not wash.
    - Should not affect the color of the wood.
- Methods of Preservation
  - Brush treatment and painting
    - 2-4 coats of oil, paint or creosote
  - Charring of timber:
    - Charring the outer fibers of timber by fire
    - Envelop of charcoal is devoid of food and restricts fungi.
    - Reduces the strength as burns the outer fibers.
  - Dipping:
    - Dipped in preservative and soaked for few minutes.
    - Used for lower ends of poles and wooden piles.
  - Creosoting;
    - Moisture extracted and the vacuum filled with creosote
    - Creosote is by-product coal tar produced in manufacture of coal gas

Engineered Wood Products

- OSB
- LVL
- Plywood
- Particle Board
- Glulam
- MDF
- I-Beams
- Trusses

Particle Board

manufactured from wood particles, such as wood chips, sawmill shavings, or even saw dust. Made with larger pieces of wood than used to make MDF

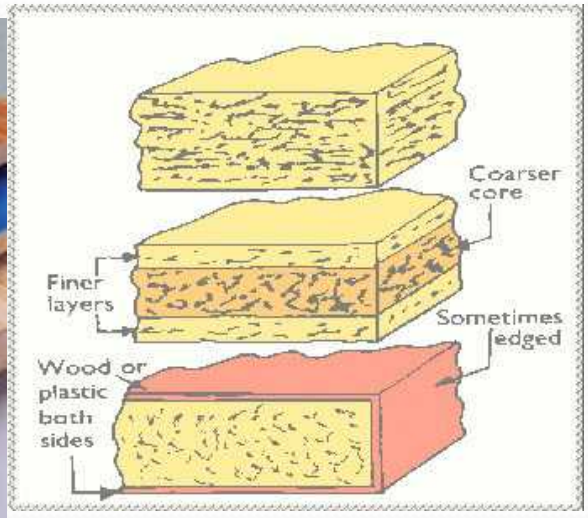


Chipboard or Particleboard

Most chipboard is of graded density, having smaller chips packed tightly together on the outside to give a smoother and stronger face. Chipboard is made by gluing wooden chips together under heat and pressure.

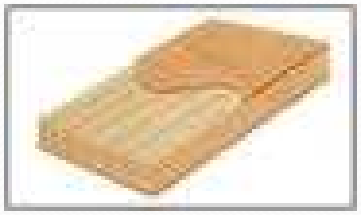
It is suitable only for interior use. Veneered and melamine-faced chipboard is widely used for worktops, shelves and furniture making.

Usual sheet size is 2240 x 1220mm. Common thicknesses are



Blockboard and Laminboard

These are made by sandwiching strips of softwood between two plies. The strips are narrower in laminboard than in blockboard.



They are usually made in interior grade only. The grain of the face plies runs at right angles to the core strips. The core strips are arranged with the heartside alternately on top and underneath (as when edge jointing boards) to avoid warping.

Both block and laminboard can be faced with veneers of decorative hardwood.

It is usually cheaper to make blockboard than to make multiply over 12 mm thick.

Usual sheet size is 2440 x 1220mm. Common thickness is 18mm.

Hardboard

Hardboard is made by mixing wood fibres with water and synthetic resin glue, hot-pressing it into sheets and leaving it to dry.

It is not very strong and is usually fixed onto a wooden frame. Standard grade is for interior use. Tempered grade is impregnated with oil for exterior use and for bending to make curved shapes. Can be melamine-faced or ready painted.

Medium Density Fibreboard (MDF)

A fairly new material (1979) but extensively used that is like a very smooth chipboard.

Fibreboard is made from a pulp of wood or other vegetable fibres which is dried under heat and pressure.
For adhesion it relies principally on the natural resin contained in the pulp.
It is used for model-making, light structural items such as speaker cabinets and extensively for furniture – wardrobes kitchen units etc.

Usual sheet size is 2240 x 1220mm but may be supplied in half or quarter sheets. MDF is available in a large range off thickness from 5mm to over 50mm.




Oriented Strand Board (OSB)

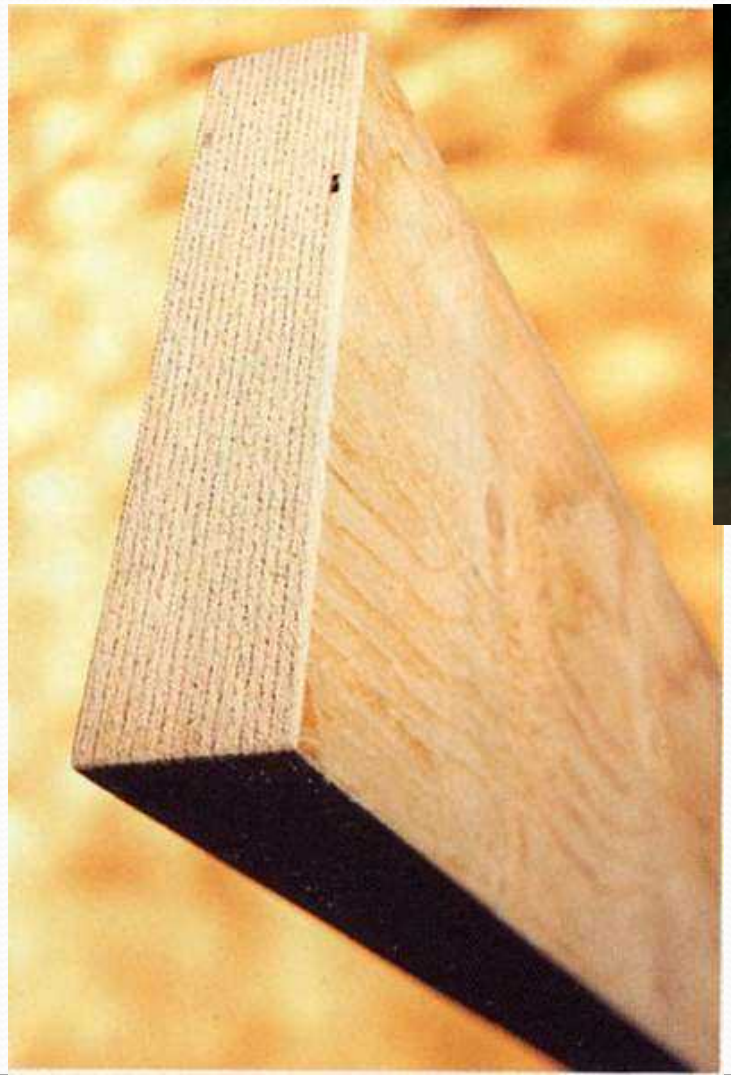
Oriented Strand Board (OSB)

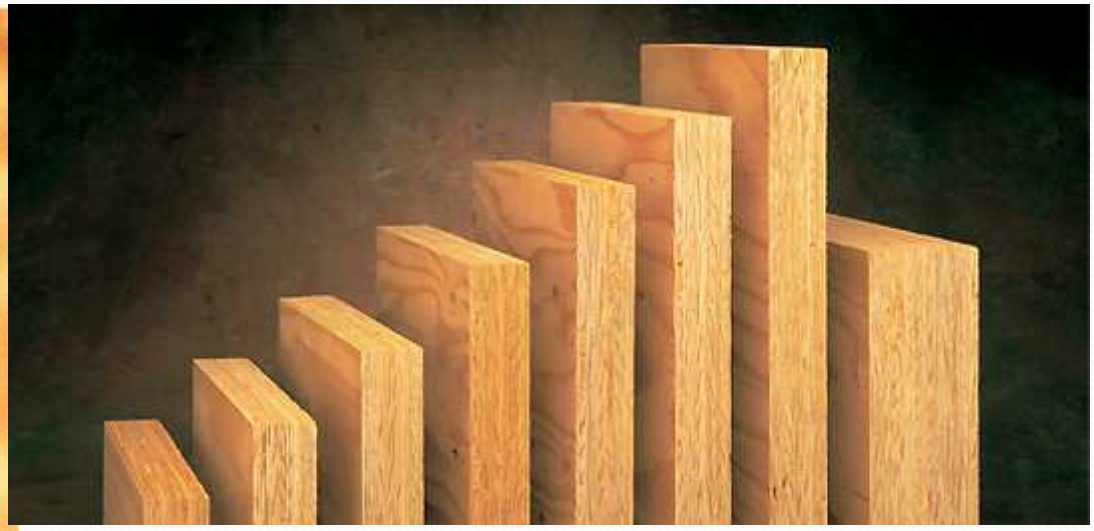
Laminate Strand Lumber (LSL)

Made up of strands of lumber instead of veneers

Laminated Veneer Lumber (LVL)

LVL is made by gluing sheets of veneer together. Unlike plywood, here all veneer layers are going in the same direction. Wide panels are manufactured to the thickness of the desired lumber. The panels are ripped into lumber of nominal width.



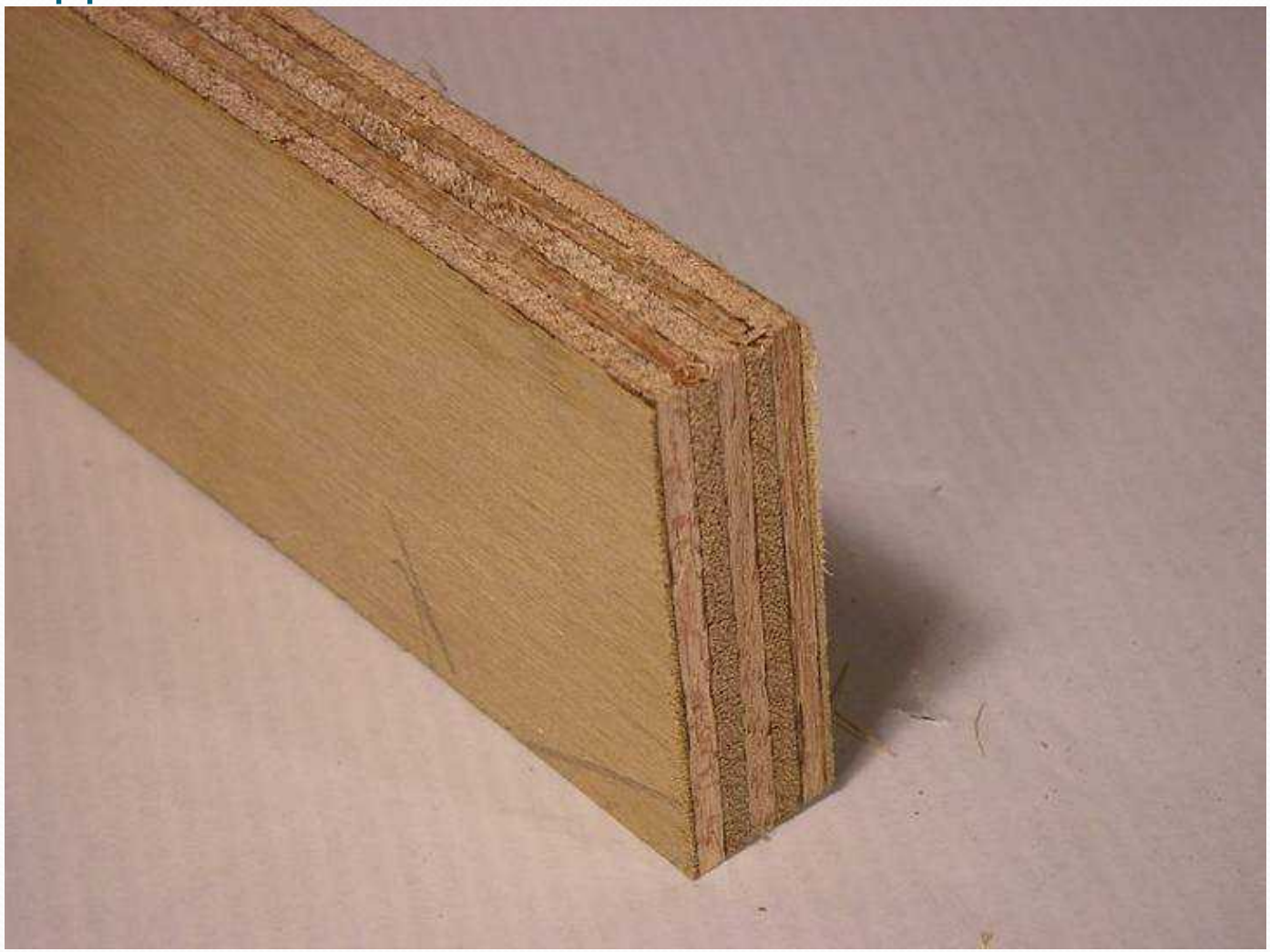


Masonite

Type of hardboard invented by William H. Mason. It is formed using the Mason method, using wooden chips and blasting them into long fibers with steam and then forming them into boards. The boards are then pressed and heated to form the finished boards. No glue or other material is added.

Plywood

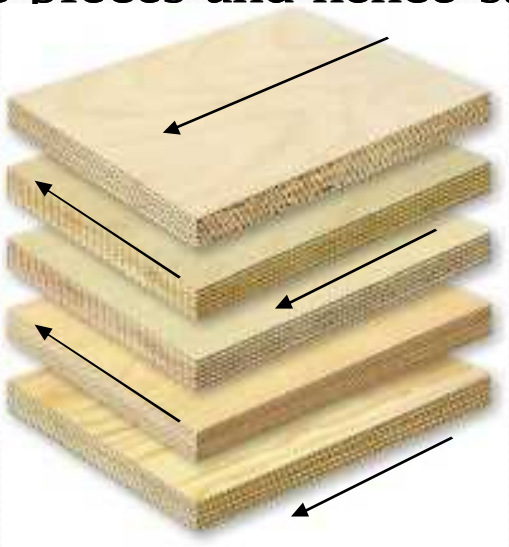
made from thin sheets of wood veneer, called plies or veneers, layered in opposite directions



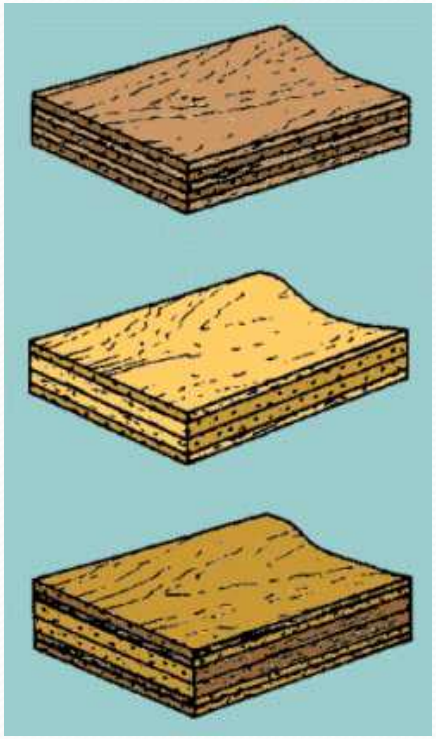
WOOD MATERIAL THEORY

Plywood

This is made from layers or plies of wood glued together so that the grain of each ply is at right angles to the next. There is always an odd number of plies so that the grain runs the same way on both outside pieces and hence stresses are balanced.



Direction of layers at 90 degrees to each other



Traditional 5- ply plywood

WOOD MATERIAL THEORY

Plywood can be faced with a veneer of decorative hardwood to improve its appearance, or with melamine to give a harder wearing surface.

Plywood is graded for interior or exterior use depending on the water resistance of the glue used, and this is shown by code letters on each sheet.

WBP – Weather and boil proof.

BR – Boil resistant

MR – Moisture resistant

Int. – Interior use only

Plywood is also graded by the smoothness of the surface and number of defects in it.

Plywood can be nailed near the edge without splitting. Thin plywood is flexible and can be formed into curved shapes.

Usual sheet sizes are 2440 x 1220mm and 1525 x 1525mm.

Common thicknesses are 4, 6, 9 and 12 mm.

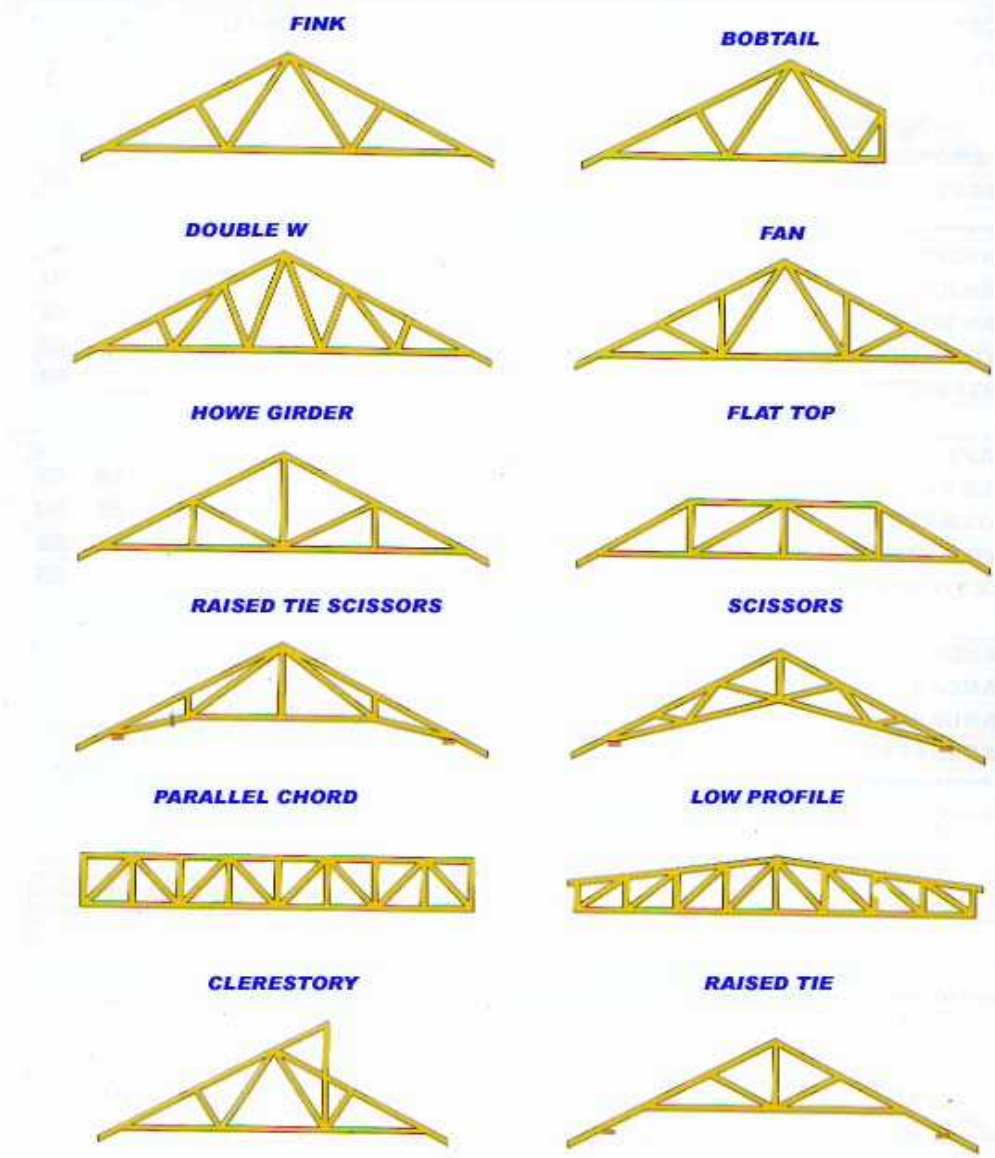
Wood I-Beams

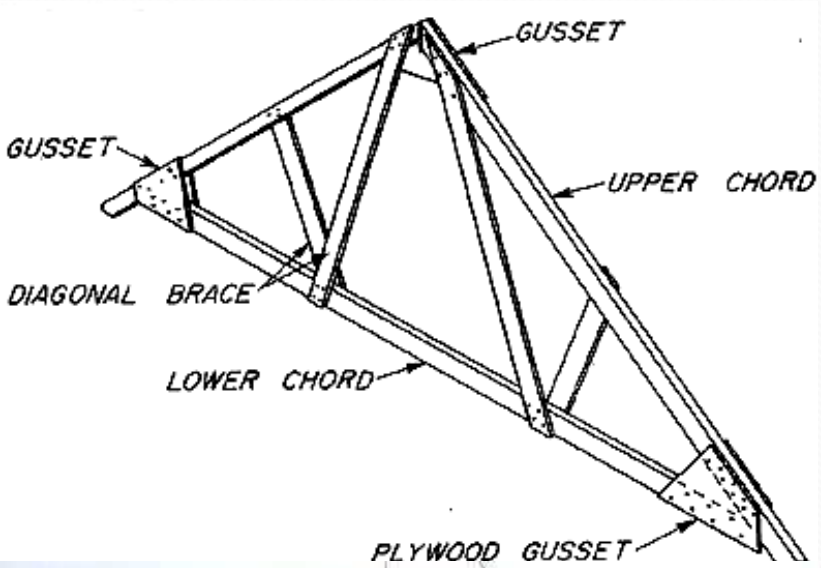
Veneer lumber is used for the flanges and plywood or OSB is used for the web to resist shear.

Glued Laminated Lumber (Glulam)

These beams are made by gluing many boards together to form a structural member bigger than the trees from which the board were sawn. Since the load is carried by the material in the top and bottom faces and the middle only has to resist shear, high quality lumber is used in the top and bottom while medium grade lumber is used in the center. (gluelam or glulam) Joints between boards are typically scarf of finger joints.

Wood Trusses





Important Wood types

- Deodar (Cedrus Deodara)
- Kail (Biar) or Blue Pine (Pinus excelsa)
- Chir (Pine) (Pinus Longifolia)
- Bamboo or Bans (Bambusa).
- Jaman
- Mango
- Neem
- Olive
- Phulai
- Shishum (Tali)
- Teak or Sagwan.

Assignment

- Write the names of most commonly used two softwoods and two hardwoods. Explain their properties and uses in Civil Engineering.