UNIT -1

STONES

Introduction:

All the building structures are composed of different types of materials. These materials are either called building materials or materials of construction. It is very essential for a builder, may be an architecture or engineer or contractor, to become conversant thoroughly with these building materials. The knowledge of different types of material, their properties and uses for different purposes provides an important tool in the hands of the builders in achieving economy in material cost. The material cost in a building ranges 30 to 50 percent cost of total cost construction. In addition to material economy, the correct use of material results in better structural strength, functional efficiency and esthetic appearance.

Classification of Rocks:

Building stones are obtained from rocks occurring in nature and classified in three ways.

- Geological classification
- Physical classification
- Chemical classification

- **Geological Classification:**

According to this classification, the rocks are of the following types.

a) **Igneous rocks:** Rocks that are formed by cooling of Magana (molten or pasty rocky material) are known as igneous rocks. Eg: Granite, Basalt and Dolerite etc.

b) **Sedimentary rocks:** these rocks are formed by the deposition of production of weathering on the pre-existing rocks. Examples: gravel, sandstone, limestone, gypsum, lignite etc.

c) **Metamorphic rocks.** These rocks are formed by the change in character of the pre-existing rocks. Igneous as well as sedimentary rocks are changed in character when they are subject to great heat and pressure. Known as metamorphism. Examples: Quartzite, Schist, Slate, Marble and Gneisses.

- **Physical Classification:**

This classification based on general structure of rocks. According to this, the rocks are classified into three types

a) **Stratified Rocks:** These rocks posses planes of stratification or cleavage and such rocks can be easily split along these planes

Ex: sedimentary rocks

b) **An stratified rocks:** The structure may be crystalline granular or compact granular. Examples: Igneous rocks and Sedimentary rocks affected by movements of the earth.
c) **Foliated Rocks:** These rocks have a tendency to split up in a definite direction only. Ex: Metamorphic rocks.

➢ **Chemical Classification:**

According to this classification rocks are classified into three types.

a) **Siliceous rocks:** In these rocks, silica is predominates. The rocks are hard; durable and not easily effected by weathering agencies. Ex: Granite, Quartzite, etc.
b) **Argillaceous Rocks:** In these rocks, clay predominates. The rocks may be dense and compact or may be soft. Ex: slates, Laterites etc.
c) **Calcareous rocks:** In these rocks, calcium carbonate predominates. The durability to these rocks will depend upon the constituents present in surrounding atmosphere. Ex: Lime Stone, marble etc.

❖ **<u>Uses of stones:</u>**

✓ **Structure**: Stones are used for foundations, walls, columns, lintels, arches, roofs, floors, damp proof course etc.
✓ **Face works.** Stones are adopted to give massive appearance to the structure. Wall are of bricks and facing is done in stones of desired shades. This is known as composite masonry.
✓ **Paving stones:** These are used to cover floor of building of various types such as residential, commercial, industrial etc. They are also adopted to form paving of roads, foot paths etc.
✓ **Basic material**: Stones are disintegrated and converted to form a basic material for cement concrete, morum of roads, calcareous cements, artificial stones, hallow blocks etc.
✓ **Misalliances**: Stones are also used for (i) ballast for railways (ii) flux in blast furnace (iii) Blocks in the construction of bridges, piers, abutments, retaining walls, light houses, dams etc.

❖ **<u>Properties of stones in structural requirements:</u>**

The following are the Characteristics or requirements of a good building stone.

✓ **Crushing strength:** For a good building stone, the crushing strength should be greater than l000kg per cm^2.

- ✓ **Appearance**: Good building stone should be a uniform colour, and free from clay holes, spots of other colour bands etc capable of preserving the colour forlongtime.
- ✓ **Durability**: A good building stone should be durable. The factors like heat and cold alternative wet and dry, dissolved gases in rain, high wind velocity etc affect the durability.
- ✓ **Fracture**: For good building stone its fracture should be sharp, even and clear.
- ✓ **Hardness**: The hardness greater than 17, treated as hard used in road works. It is between 14 to 17, medium hardness, less 14 said be poor hardness.
- ✓ **Percentage wear**: For a good building stone, the percentage wear should be equal to or less then 3 percent.
- ✓ **Resistance to fire**: A good building stone be fire proof. Sandstone, Argillaceous stone resists fire quite well
- ✓ **Specific gravity**: For a good building stone the specific gravity should be greater then 8.7 or so.
- ✓ **Texture**: A good building stone should have compact fine crystalline structure should be free from cavities, cracks or patches of stuff or loose material.
- ✓ **Water absorption:** For a good building stone, the percentage absorption by weight after 24 hours should not exceed 0.60.
- ✓ **Seasoning**: Stones should be well seasoned before putting into use. A period of about 6 to 12 months is considered to be sufficient for proper seasoning.
- ✓ **Toughness Index**: Impact test, the value of toughness less than 13 – Not tough, between 13 and 19 – Moderate, greater than 19- high

❖ **<u>Characteristics of stones</u>**

In order to ensure suitable selection of stone of particular work, one must be conversant with its composition, characteristics, uses and place of availability.

❖ **Granite**

Igneous rock
Composed of quart, felspar and mica and minerals
Available in grey, green, brown and pink and red
Hard and durable
High resistance to weathering
The texture varies with its quality
Specify gravity 2.7 and compressive strength 700 to 1300 kg/cm^2

Used for ornamental, road metal, railway ballast, aggregate for concrete; for construction of bridges, piers and marine works etc.

- **Balast**

  Igneous rock
  It is compact, hard and heavy
  Available in red, yellow grey, blue and greenish black colour
  Specific gravity is 3 and compressive strength varies 1530 to 1890 kg/cm2.
  Used for ornamental, rail road ballast, aggregates for concrete etc.

- **Sand Stone:**

  Sedimentary rock
  It is available in variety of formations fine grained, coarse grained compact or porous
  Available in white, green, blue, black, red and yellow.
  Specific gravity 2.65 to 2.95
  Compressive strength is 650kgs / cm2
  Used for ashlar works.

- **Lime Stone:**

  Sedimentary rock: It is available in a variety of forms which differ from one another in colour Compaction, texture, hardness and durable
  Compact lime stone
  Granular lime stone
  Magnesia lime stone
  Kanker lime stone
  Used for paving, road metal, etc.

- **Marble**

  Metamorphic rock
  Available in white, blue, green, yellow black and red colour
  High compactness,
  Suitable for decorative works, wall lining columns, pile, table slabs, hearths, tiled floors, steps of stair case etc.

- **Slate:**

  Metamorphic rock
  Non absorbent, compact fine grained and produce metallic ringing sound

when struck
Available in black, dark blue, grey, reddish brown etc.
Used for providing damp proof course, paving dados etc

❖ **Selection of stones:**

In contemplating the use of stone for various engineering works, the selection of the nature and quality of stone is governed by the purpose in view, cost of stone, its ornamental value and durability Suitability various types of stones for different purposes and situation is briefly discussed below

- For face work, in general marble, granite and close-grained sand stone are used in the form of thin slabs (veneers) where the structure subjected to adverse weather effects.
- For pillars, balustrade, pedestals, columns statues and door and window sill and paving stone, granite marble and compact lime stone can be recommend because they can take good polish.
- For ornamental works such as moulding and carvings, fine- grained sand stone, fine grained marble and fine grained granite are used.
- For bridges, piers, docks, break-waters and other marine structures the stone should be very hard, heavy, strong and durable granite and gneiss are recommended for this purpose
- For road metal, stones should be hard, tough, resistant to abrasion and durable. Basalt and course-grained granite are generally recommended for this purpose.
- For railway ballast, the stone should be hard, dense, durable, tough and easily workable sandstone, compact lime stone, trap and quartzite are commonly used
- In situation like steps, doors sills, pavings etc where there is a regular flow of traffic, stone should be hard, dense, easily workable and durable. Marble, slates and sand stones are commonly use in such places.
- In fire proof construction, compact sand stone should always be preferred.

❖ **Artificial stones**: These are also known as cast stones or reconstructed stones. Artificial stones may take up various forms such as

❖ **Cement concrete:** This is the mixture of cement, fine aggregates, coarse aggregates and water. It may be cast in site or pre-cast if steel is used with cement concrete, it is known as reinforced cement concrete.

- **Mosaic tiles:** Pre-Cast concrete tiles with marble chips at top surface are known as tiles. They are available in different shades and widely adopted at present.
- **Terrazo :** This is a mixture of marble chips and cement. It is used for bathrooms residential buildings, temples etc.

Advantages of artificial stones:

- ✓ Cavities may be kept in artificial stones to convey pipes, electric wires etc.
- ✓ Grooves can be kept in artificial stone while it is being cast which are useful for fixing various fittings.
- ✓ It can cast in desired shape.
- ✓ It can be made in a single piece and hence trouble of getting large blocks of stone for lintels, beams etc is avoided.
- ✓ It can be made stronger than natural stone.
- ✓ It is cheap and economical.
- ✓ It is more durable than natural stone.
- ✓ sNatural bed is absent in artificial stones and hence, the question of taking precautions with respect to the natural bed of stones does not arise.

BRICKS

Bricks are obtained by moulding clay in rectangular blocks of uniform size and then by drying and burning these blocks. As bricks are of uniform size, they can be properly arranged, light in weight and hence bricks replace stones.

- **Composition - Manufacture Process.**

Composition – Following are the constituents of good brick earth.

- **Alumina**: - It is the chief constituent of every kind of clay. A good brick earth should contain 20 to 30 percent of alumina. This constituent imparts plasticity to earth so that it can be moulded. If alumina is present in excess, raw bricks shrink and warp during drying and burning.
- **Silica**-A good brick earth should contain about 50 to 60 percent of silica. Silica exists in clay either as free or combined form. As free sand, it is mechanically mixed with clay and in combined form; it exists in chemical composition with alumina. Presence of silica prevents crackers shrinking and warping of raw

bricks. It thus imparts uniform shape to the bricks. Durability of bricks depends on the proper proportion of silica in brick earth. Excess of silica destroys the cohesion between particles and bricks become brittle.

- **Lime** – A small quantity of lime is desirable in finely powdered state to prevent shrinkage of raw bricks. Excess of lime causes the brick to melt and hence, its shape is last due to the splitting of bricks.
- **Oxide of iron**- A small quantity of oxide of Iron to the extent of 5 to 6 percent is desirable in good brick to impart red colour to bricks. Excess of oxide of iron makes the bricks dark blue or blackish.
- **Magnesia**- A small quantity of magnesia in brick earth imparts yellow tint to bricks, and decreases shrinkage. But excess of magnesia decreases shrink leads to the decay of bricks.

The ingredients like, lime, iron pyrites, alkalies, pebbles, organic matter should not present in good brick earth

Manufacture of bricks:

The manufacturing of brick, the following operations are involved

1. Preparation of clay
2. Moulding
3. Drying
4. Burning

1. **Preparation of clay :-**

The preparation of clay involves following operations.

a. **Un soiling:** - Top layer of 20cm depth is removed as it contain impurities.
b. **Digging: -** Clay dug out from ground is spread on level ground about 60cm to 120cm heaps.
c. **Cleaning:-** Stones, pebbles, vegetable matter etc removed and converted into powder form.
d. **Weathering:-** Clay is exposed to atmosphere from few weeks to full season.
e. **Blending:-** Clay is made loose and any ingredient to be added to it is spread out at top and turning it up and down in vertical direction.
f. **Tempering**:- Clay is brought to a proper degree of hardness, then water is added to clay and whole mass is kneaded or pressed under the feet of men or cattle for large scale, tempering is usually done in pug mill.

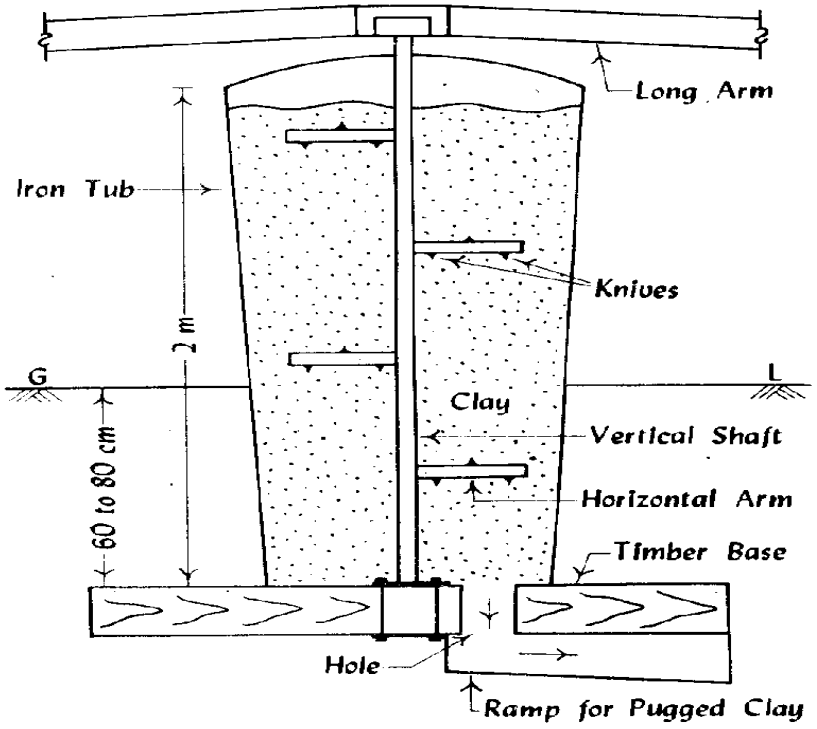
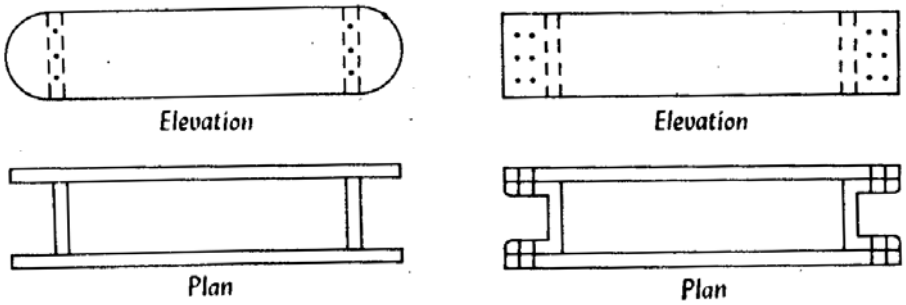


Fig.Pug Mill

Process done in pug mill:- Clay with water is placed in pug mill from the top. When the vertical staff is rotated by using electric pair, steam or diesel or turned by pair of bullocks. Clay is thoroughly mixed up by the actions of horizontal arms and knives when clay has been sufficiently pugged, hole at the bottom of tub, is opened cut and the pugged earth is taken out from ramp for the next operation of moulding.

2. **Moulding**: Clay, which is prepared form pug mill, is sent for the next operation of moulding. Following are the two ways of moulding.
   a) Hand Moulding
   b) Machine Moulding

a) Hand Moulding: Moulds are rectangular boxes of wood or steel, which are open at top and bottom. Steel moulds are more durable and used for manufacturing bricks on large scale as shown in fig Bricks prepared by hand moulding are of two types.



Wooden mould Steel mould

i. Ground moulded bricks
ii. Table moulded bricks

i. **Ground moulded bricks:** ground is first made level and fine sand is sprinkled over it. Mould is dipped in water and placed over the ground to fill the clay. Extra clay is removed by wooden or metal strike after the mould is filled forced mould is then lifted up and raw brick is left on the ground. Mould is then dipped in water every time lower faces of ground moulded bricks are rough and it is not possible to place frog on such bricks.

   Ground moulded bricks of better quality and with frogs on their surface are made by using a pair of pallet boards and a wooden block

ii. **Table-moulded bricks**: Process of moulding these bricks is just similar to ground bricks on a table of size about 2m x 1m.

b. Machine moulding: This method proves to be economical when bricks in huge quantity are to be manufactured at the same spot. It is also helpful for moulding hard and string clay. These machines are broadly classified in two categories

i. Plastic clay machines
ii. Dry clay machines

a. **Plastic clay machines:** This machine containing rectangular opening of size equal to length and width of a brick. Pugged clay is placed in the machine and as it comes out through the opening, it is cut into strips by wires fixed in frames, so there bricks are called wire cut bricks.
b. **Dry clay machines:** In these machines, strong clay is first converted into powder

form and then water is added to form a stiff plastic paste. Such paste is placed in mould and pressed by machine to form hard and well shaped bricks. These bricks are behavior than ordinary hand moulded bricks. They carry distinct frogs and exhibit uniform texture.

3. **Drying**: The damp bricks, if burnt, are likely to be cracked and distored. Hence moulded bricks are dried before they are taken for the next operation of burning. Bricks are laid along and across the stock in alternate layers. The drying of brick is by the following means

- **Artificial drying** – drying by tunnels usually 120^0C about 1 to 3 days
- **Circulation of air**- Stacks are arranged in such a way that sufficient air space is left between them free circulation of air.
- **Drying yard**- special yards should be prepared slightly higher level prevent the accumulation of rain water
- **Period for drying** – usually about 3 to 10 days to bricks to become dry
- **Screens** – screens are necessary, may be provided to avoid direct exposure to wind or sun.

4. **Burning:** This is very important operation in the manufacturing of bricks to impart hardness, strength and makes them dense and durable. Burning of bricks is done either in clamps or in kilns. Clamps are temporary structures and they are adopted to manufacture bricks on small scale. Kilns are permanent structures and they are adopted to manufacture bricks on a large scale. A typical clamp is as shown in fig

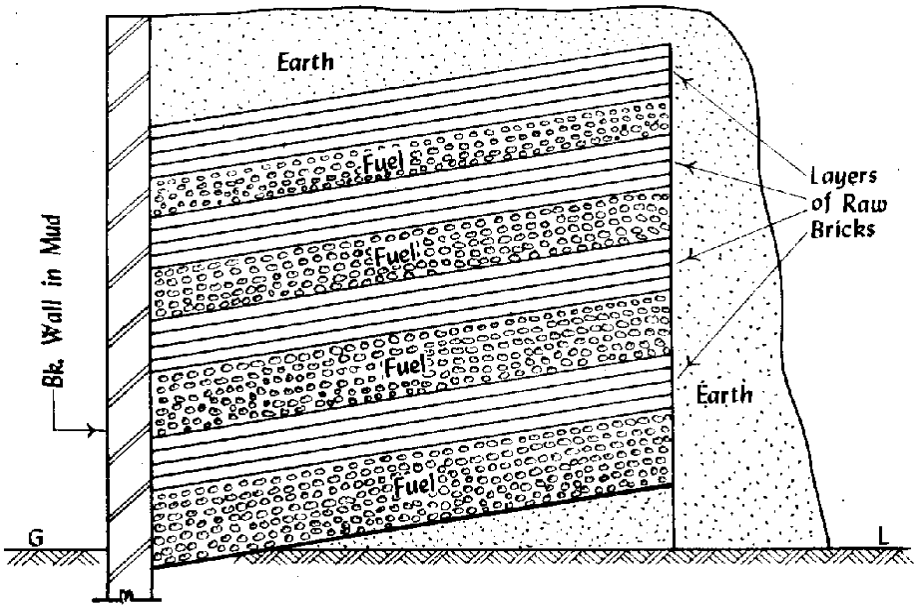


Fig. Typical diagram for Clamp burning

(1) A trapezoidal shape in plan with shorter is slightly in excavation and wider end raised at an angle of 15^0 from ground level

(2) A brick wall with mud is constructed on the short end and a layer of 70cm to 80cm thick fuel (grass, cow dung, ground nuts, wood or coal) laid on the floor.

(3) A layer consists of 4 or 5 courses of raw bricks laid on edges with small spaces between them for circulation of air

(4) A second layer of fuel is then placed, and over it another layer of raw bricks is put up. The total height of clamp in alternate layers of brick is about 3 to 4 m

(5) When clamp is completely constructed, it is plastered with mud on sides and top and filled with earth to prevent the escape of heat

(6) The period of burning is about one to two months and allow the same time for coding

(7) Burnt bricks are taken out from the clamp

Advantages:

1. The bricks produced are tough and strong because burning and cooling are gradual
2. Burning in clamps proves to be cheap and economical.

3. No skilled labor and supervision are required for the construction of clamps
4. There is considerable saving of clamps fuel.

Disadvantages:

1. Bricks are not of required shape
2. It is very slow process
3. It is not possible to regulate fire in a clamp
4. Quality of brick is not uniform.

Kilns: A kiln is a large oven, which is used to burnt bricks by

a) Intermittent kilns
b) Continuous kilns

a. **Intermittent kilns:** These intermittent in operation, which means that they are loaded, fired, cooled and unloaded.
   i. Intermittent up-draught kilns
   ii. Intermittent down-draught kilns.

i. **Intermittent up-draught kiln**: This is in the form of rectangular with thick outside walls as shown in the fig 2.4. wide doors are provided at each end for loading and unloading of kilns. A temporary roof may be installed to protect from rain and it is removed after kiln is fired. Flues are provided to carry flames or hot gases through the body of kiln.

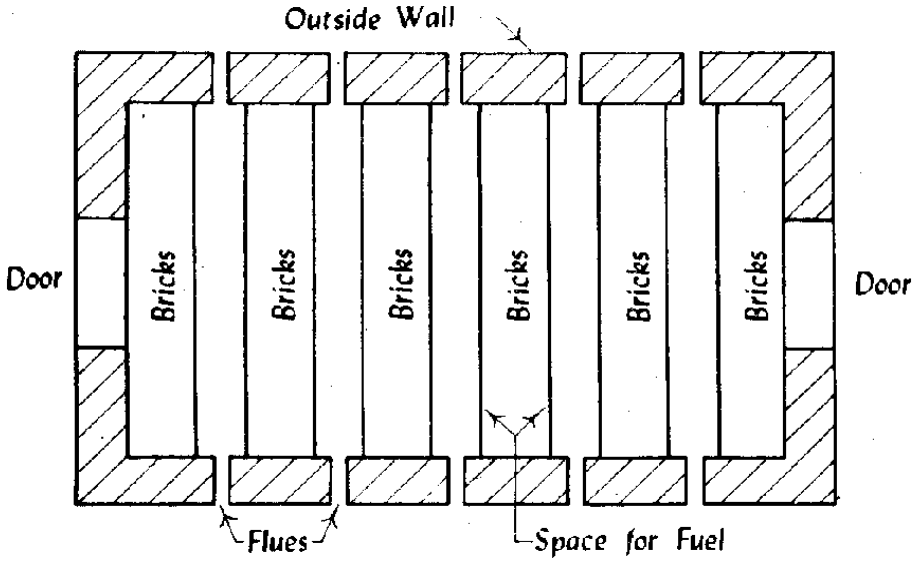


Fig. Intermittent kiln

i. Raw bricks are laid in row of thickness equal to 2 to 3 bricks and height 6 to 8 bricks with 2 bricks spacing between rows.
ii. Fuels are filled with brush wood which takes up a free easily.
iii. Loading of kiln with raw bricks with top course is finished with flat bricks and other courses are formed by placing bricks on edges.
iv. Each door is built up with dry bricks and are covered with mud or clay.

v. The kiln is then fired for a period of 48 to 60 hours draught rises in the upward direction from bottom of kiln and brings about the burning of bricks.
vi. Kiln is allowed to cool down and bricks are then token out Same procedure is repeated for the next burning.

Bricks manufactured by intermittent up drought kilns are better than those prepared by clamps but bricks burnt by this process is not uniform, supply of bricks is not continuous and wastage of fuel heat.

ii. Intermittent down-draught kilns:

These kilns are rectangular or circular in shape. They are provided with permanent walls and closed tight roof. Floor of the kiln has opening which are connected to a common chimney stack through flues. Working is same as up-draught kiln. But it is so arranged in this kiln that hot gases are carried through vertical flues upto the level of roof and they are then released. These hot gases move down ward by the chimney draught and in doing so, they burn the bricks.

Advantages:

i. Bricks are evenly burnt.
ii. Performance of this kiln is better than that of up-draught kiln.
iii. This kiln is suitable for burning of structural clay tiles, terra cota because of close control of heat.

b. <u>Continuous kilns:</u>

These kilns are continuous in operations. This means that loading, firing, cooling and unloading are carried out simultaneously in these kilns. There are three types of continuous kilns.

a. Bull's trench kiln
b. Hoffman's kiln
c. Tunnel kiln

a) Bull's trench kiln: This kiln may be of rectangular, circular or oval shape in the plan as shown in fig. It is constructed in a trench excavated in ground either fully underground partially projecting above ground openings is provided in the outer walls to act as flue holes. Dampers are in the form of iron plates and they are used to divide the kilns in suitable sections and most widely used kiln in India.

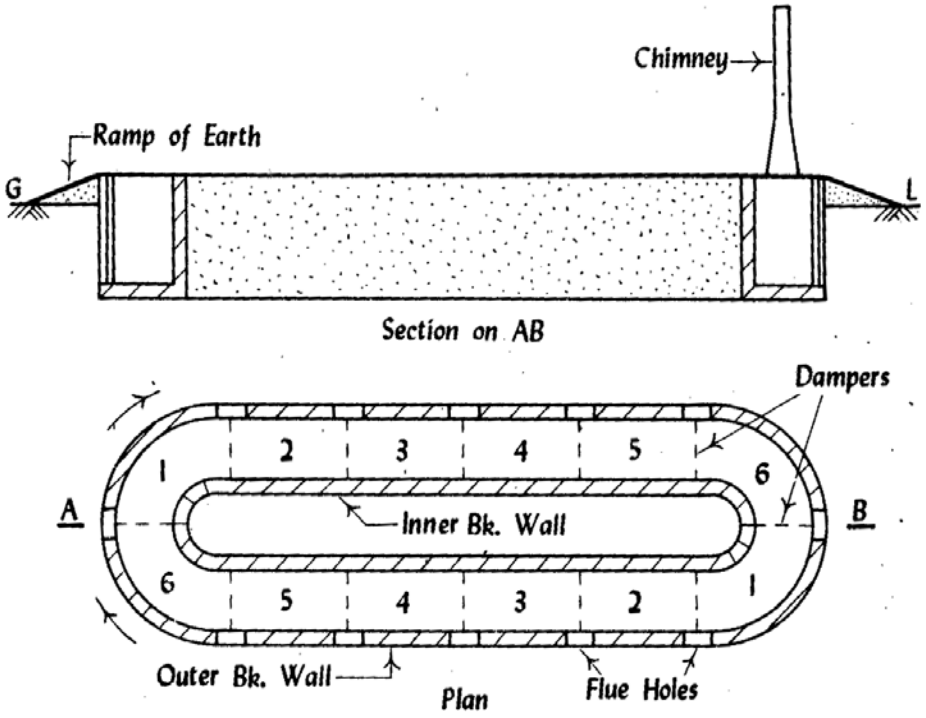


Fig . Bull's trench kiln

The bricks are arranged in such a way that flues are formed. Fuel is placed in flues and it is ignited through flue holes after covering top surface with earth and ashes to prevent the escape of heat usually two movable iron chimneys are employed to form draught. These chimneys are placed in advance of section being fired. Hence, hot gases leaving the chimney warm up the bricks in next section. Each section requires about one day to burn. The tentative arrangement for different sections may be as follows

Section 1 – loading Section 2 – empty Section 3 – unloading Section 4 – cooling Section 5 – Burning Section 6 – Heating

b). Haffman's kiln: this kiln is constructed over ground and hence, it is sometimes known as flame kiln. Its shape is circular to plan and it is divided into a number of compartments or chambers. A permanent roof is provided; the kiln can even function during rainy season. Fig shows plan and section of Hoffman's kiln with 12 chambers

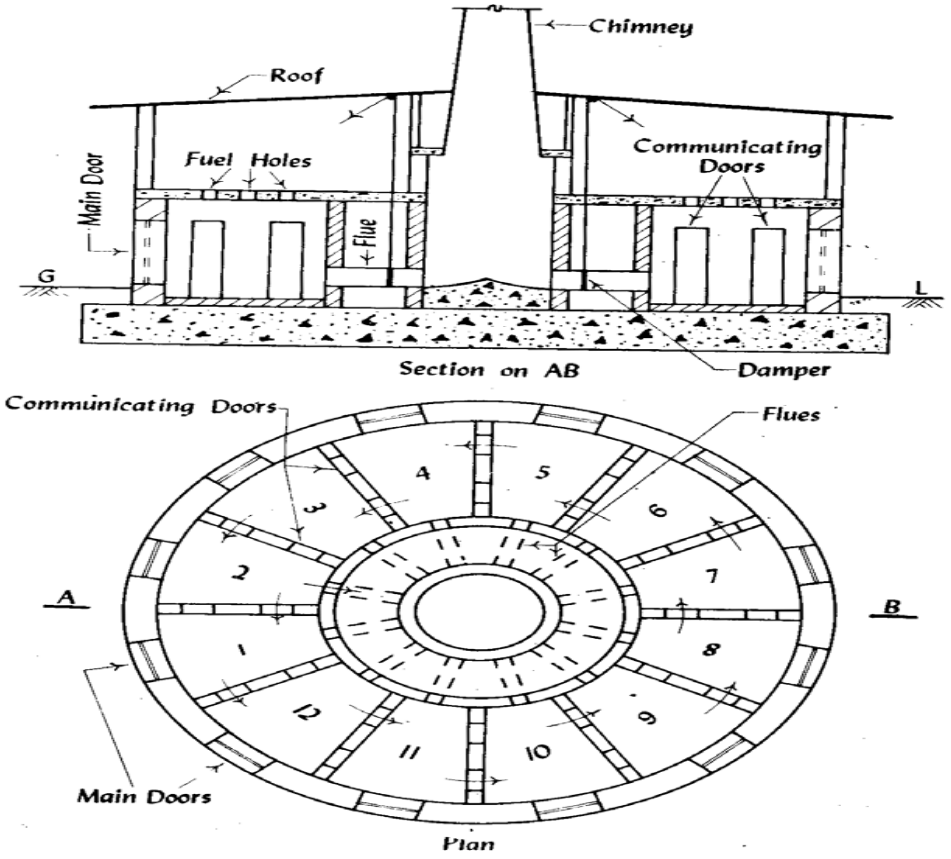


Fig. Hoffman's kiln

Chamber 1 - loading
Chamber 2 to 5 – drying and pre-heating
Chambers 6 and 7 - burning
Chambers 8 to 11 - cooling Chamber 12 – unloading.

The initial cost in stalling this kiln is high, the following advantages

- Good quality of bricks is produced.
- It is possible to regulate heat inside the chambers through fuel holes.
- Supply of bricks is continuous and regular.
- There is considerable saving in fuel due to pre heating of raw bricks by flue gases.

c). Tunnel kiln: This type of kiln is in the form of tunnel, which may be straight, circular or oval in the plan. Raw bricks are placed in trolleys which are then moved from one end to the other end of tunnel. Raw bricks get dried and pre-heated as they approach zone of fire. In zone of fire, bricks are burnt to the required defuel and they are then pushed forward for cooling. When bricks are sufficiently cooled, they are unloaded. The kiln proves to be economical when the bricks are manufactures on a large scale. As temperature is under control, uniform bricks of better quality are produced.

COMPARISON BETWEEN CLAMP-BURNING AND KILN-BURNING

No.	Item	Clamp-burning	Kiln-burning
1.	Capacity	About 20000 to 100000 bricks can be prepared at a time.	Average 25000 bricks can be prepared per day.
2.	Cost of fuel	Low as grass, cow dung, litter, etc. may be used.	Generally high as coal dust is to be used.
3.	Initial cost	Very low as no structures are to be built.	More as permanent structures are to be Constructed.
4.	Quality of bricks	Percentage of good quality bricks is small about 60% or so.	Percentage of good quality bricks is more about 90% or so.
5.	Regulation of fire	It is not possible to control or regulate fire during the process of burning	Fire is under control Throughout the process of burning.
6.	Skilled supervision	Not necessary through-out the process of burn-ing.	Continuous skilled super Vision is necessary.
7.	Structure	Temporary structure.	Permanent structure.
8.	Suitability	Suitable when bricks are to be manufactured on a small scale and when the demand of bricks is not continuous.	Suitable when bricks are to be manufactured on a large scale and when There is continuous demand of bricks.

9.	Time ofburn-ing and cool-ing.	It requires about 2 to 6 months for burning and cooling of bricks.	Actual time for burning of one chamber is about 24 hours and only about 12 days are required for Cooling of bricks.
10.	Wastage of heat.	There is considerable wastage of heat from top and sides and hot flue gas is not properly Utilized.	Hot flue gas is used to dry and pre-heat raw bricks. Hence wastage of heat is the least.

❖ **Classification of bricks:**

Bricks can broadly be divided into two categories.

(i) Un burnt or sundried bricks

(ii) Burnt bricks

i. **Un burnt or Sun dried bricks-** UN burn or sun dried with the help of heat received from sun after the process of moulding. These bricks can only be used in the constructions of temporary and cheap structures. Such bricks should not be used at places exposed to heavy rains.

ii. **Burnt Bricks:** The bricks used in construction works are burnt bricks and they are classified into the following four categories.

a) **First Class bricks:** These bricks are table moulded and of standard shape. The surface and edges of the bricks are sharp, square, smooth and straight. The comply all the qualities of good bricks and used for superior work of permanent nature.

b) **Second class bricks:** These bricks are ground moulded and they are burnt in kilns. The surface of bricks is somewhat rough and shape is also slightly irregular. These bricks are commonly used at places where brick work is to be provided with a coat of plaster.

c) **Third class bricks:** These bricks are ground moulded and they burnt in clamps. These bricks are not hard and they have rough surfaces with irregular and distorted edges. These bricks give dull sound when struck together. They are used for unimportant and temporary structures and at places where rainfall is not heavy.

d) **Fourth class bricks:** These are over burnt bricks with irregular shape and

dark colour. These bricks are used as aggregate for concrete in foundation, floors, roads, etc because of the fact that the over burnt bricks have compacted structure and hence, they are sometimes found stronger than even first class bricks.

❖ **Qualities of Good Brick:**

a) Bricks should be table moulded, well burnt in kilns, copper coloured, free from cracks and with sharp and square edges.
b) Bricks should be uniform shape and should be of standard size.
c) Bricks should give clear ringing sound when struck each other.
d) Bricks when broken should show a bright homogeneous and compact structure free from voids.
e) Bricks should not absorb water more than 20 percent by weight for first class bricks and 22 percent by weight for second class bricks, when soaked in coldwater for a period of 24 hours.
f) Bricks should be sufficiently hard no impression, should be left on brick surface, when it is scratched with finger nail.
g) Bricks should be low thermal conductivity and they should be sound proof.
h) Bricks should not break when dropped flat on hard ground from a height of about one meter.
i) Bricks, when soaked in water for 24hours, should not show deposits of white salts when allowed to dry in shade.
j) No brick should have crushing strength below 55kg/cm2

❖ **Tests for bricks:**

A brick is generally subjected to following tests to find out its suitability of the construction work.

1. Absorption.
2. Crushing strength or compression strength.
3. Hardness.
4. Presence soluble salts.
5. Shape and size.
6. Soundness.
7. Structure.

1. **Absorption:** A good should not absorb not more than 20 percent of weight of dry brick
2. **Compressive strength:** crushing or compressive strength of brick is found out by placing it in compression testing machine. It is pressed till it breaks. Minimum crushing strength of brick is 35kg/cm^2 and for superior bricks, it may vary from 70 to 140 kg/cm^2.
3. **Hardness:** No impression is left on the surface the brick is treated to be sufficiently hard
4. **Presence of soluble salts**: The bricks should not show any grey or white deposits after immersed in water for 24 hours
5. **Shape and size:** It should be standard size and shape with sharp edges
6. **Soundness**: The brick should give clear ringing sound struck each other
7. **Structure**: The structure should be homogeneous, compact and free from any defects

❖ **Grading of Bricks**

As per IS-10719557 and 1970 code specifications,

a) Bricks with compressive strength not less than 140kg/cm2 – Grade A-A class.
b) Bricks with compressive strength not less than 105kg/cm2 – First class bricks - Grade A.
c) Bricks with compressive strength not less than 70kg/cm2 – Second class bricks – Grade B.
d) Bricks with compressive strength not less than the average value 35kg/cm2 – class III bricks – Grade C.

TIMBER

Timber denotes wood, which is suitable for building or carpentry or Various other engineering purposes like for construction of doors, Windows, roofs, partitions, beams, posts, cupboards, shelves etc.

Uses of timber:

- Used in the form of piles, posts, beams, lintels, door/window frames and leaves, roof members etc.
- Used for flooring, ceiling, paneling and construction of Partition walls.
- Used for form work for concrete, for the timbering of Trenches, centering for arch work, scaffolding, transmission poles and fencing.

- Used in wagon and coach building, marine installations and bridges.
- Used in making furniture of agriculture implements, sports goods, musical instruments, well curbs, mortar bodies, carts and carriages, railway sleeps, packing cases etc.

❖ **Classification of trees**

Depending upon their mode of growth trees may be divided in the following two categories

a. **Endogenous trees:** These trees grow inwards and fibrous mass is seen in their longitudinal sections. Timber from these trees has very limited engineering applications Ex: bamboo, cane , palm etc.
b. **Exogenous trees:** These increases in bulk by growing outwards and used for engineering purposes.

Exogenous trees are further sub divided into two groups

a. conifers
b. deciduous

a) Conifers or evergreen trees: These trees having pointed, needle like or scale like leaves and yield soft wood.

b) Deciduous trees: The trees having flat broad leaves and leaves of those trees fall in autumn and new ones appear in spring season. Timber for engineering purpose is mostly derived from deciduous trees. These trees yield hard wood. Ex: ash, beach, oak, sal, teak, shishum and walnut.

Comparison of softwood and hard wood

S.No.	Item	Soft wood	Hard wood
1	Annual rings	Distinct	Indistinct
2	color	light	dark
3	fire resistance	poor more	poor more
4	modullarly rays	Indistinct	distinct
5	Structure	resinous and split easily	non-resinous & close grained
6	weight	light	heavy
7	strength	strong for direct Pull & weak for Resisting thrust or shear	Equally strong for resisting tension, compression & shear

❖ **Structure of tree:** From the visibility aspect, the structure of a tree can be divided into two categories

1. Macro structure
2. Micro structure

1. **Macro structure:** The structure of wood visible to the naked eye or at a small magnification is called macro structure. Fig shows the macro structure of exogenous tree.

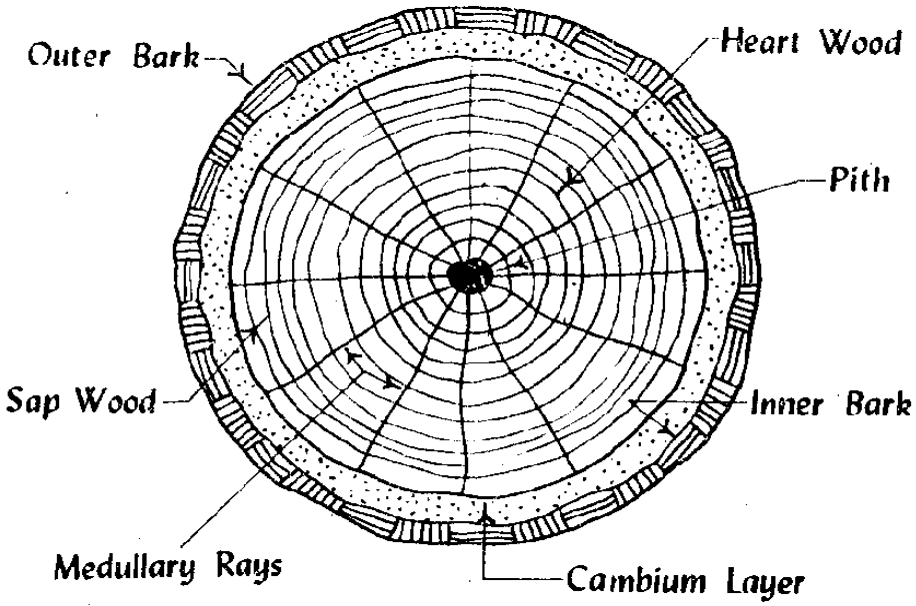


Fig .Micro structure of exogenous tree

- ✓ **Pith**: The innermost central portion or core of the tree is called pith or medulla
- ✓ **Heart wood:** The inner annual rings surrounding the pith is known as heart wood. It imparts rigidity to tree
- ✓ **Sap wood:** The cuter annual rings between heart wood and cambium layer is known as sap wood
- ✓ **Cambium layer:** Thin layer of sap between sap wood and inner bark is known as cambium layer
- ✓ **Inner bark:** The inner skin or layer covering the cambium layer is known as inner bark
- ✓ **Outer Bark:** The outer skin or cover of the tree is known as outer bark

- ✓ **Medullary rays:** The thin radial fibres extending from pith to cambium layer are known as medullary rays

2. **Micro structure:** The structure of wood apparent only at great magnifications is called micro structure under micro scope, it becomes evident that the wood consists of living and lead cells of various sizes and shapes.

❖ **Defects in Timber:**

Defects occurring in timber are grouped into the following divisions.

➢ **Defects due to conversion:** During the process of converting timber to commercial form, the following defects may occur.

- **Chip mark:** mark or sign placed by chip on finished surface of timber.
- **Diagonal grain:** Due to improper sawing of timber.
- **Torn grain:** Due to falling of tool small impression is formed
- **Wane:** Presence of original rounded surface on the manufactured piece of timber

➢ **Defects due to fungi:** The attack of timber by fungi when moisture content of timber is above 20% and presence of air and warmth for the growth of fungi the following defects are caused

- **Blue stain:** Sap of wood is stained to bluesh colour
- **Brown rot:** Decay or disease of timber by removal of cellulose compounds from wood and wood assumes the brown colour
- **Dry rot:** Convert the wood into dry powder form
- **Heart rot:** This is formed when branch has come out of a tree and the tree becomes weak and gives out hallow sound when struck with a hammer
- **Sap stain:** The sap wood looses its colour because of feed on cell contents of sap wood.
- **Wet rot:** Caused chemical decomposition of wood of the timber and timber converts to grayish brown powder known as wet rot.
- **White rot:** Attack lignin of wood and wood assumes the appearance of white mass

➢ **Defects due to insects:**

- **Beetles**: Small insects form holes of size about 2mm diameter and attack sap wood of all species of hard woods. Tunnels are formed in all directions in sapwood by the larvae of these beetles and converted into fine flour like powder. They do not disturb outer cover and looks sound.
- **Marine borers**: These make holes or bore tunnels in wood for taking shelter. The

wood attacked by marine borers loses colour and strength

- **Termites**: White ants are very fast in eating away the wood from the core of the cross section. They make tunnels inside in different directions and usually donot disturb the outer shell or cover

➢ **<u>Defects due to natural forces:</u>**

The main natural forces responsible for causing defects in timber are abnormal growth and rapture of tissues

- **Burls**: Irregular projections appear on the body of timber because of shock at younger age
- **Callus**: Soft tissue or skin which covers the wound of tree.
- **Chemical stain**: Discolored due to the chemical action caused
- **Coarse grain**: Annual rings are widened, tree grows rapidly hence timber possesses less strength
- **Dead wood**: Timber obtained from dead standing tree
- **Druxiness**: White decayed spots by fungi
- **Foxiness**: Due to poor ventilation during storage or by commencement of decay due to over maturity indicated by red or yellow tinge in wood
- **Knots**: Bases of branches or limbs which are broken or cut off from the tree as shown in the fig.

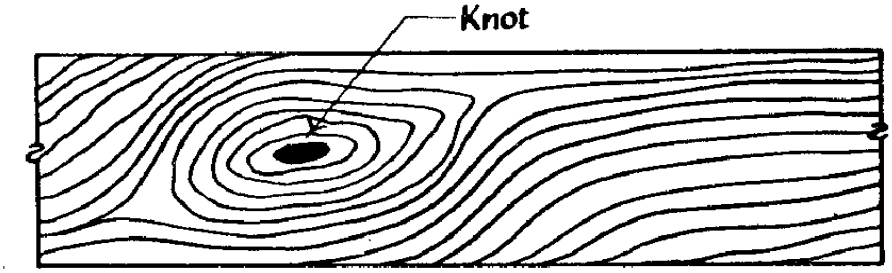


Fig.Knot

- **Rind galls**: Rind means bark and gall indicates abnormal growth and pecullar curved swellings found on the body of a tree.
- **Shakes**: These are cracks which partly or completely separate the fibres of wood as shown in fig.

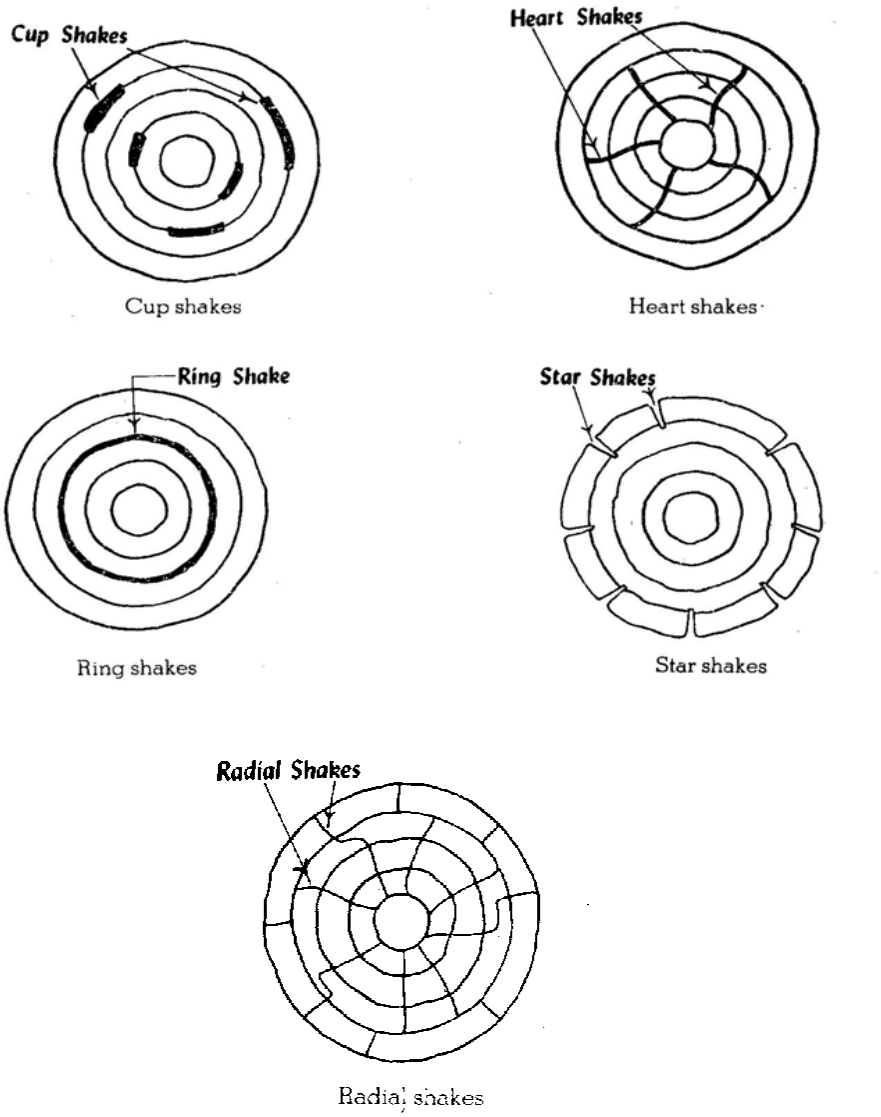


Fig. Different types of shakes

- **Twisted fibers**: or wandering hearts: caused by twisting of young trees by fast blowing wind as shown in fig.

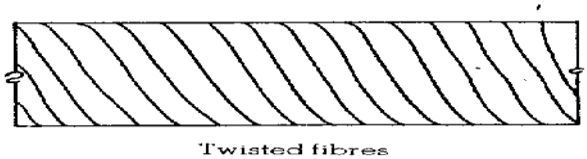


Fig.

- **Upsets or ruptures**: Indicate wood fibers which are injured by crushing or compression as shown in fig .

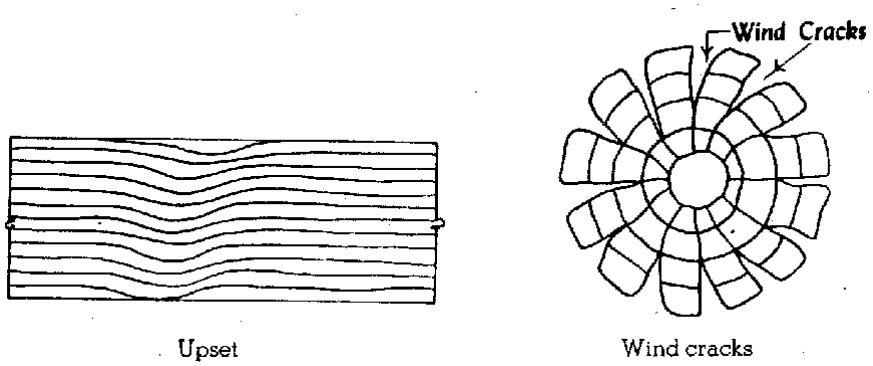


Fig.

❖ **<u>Wood based products:</u>**

Timber which is prepared scientifically in a factory is termed as industrial timber and such timber possesses desired shape, appearance strength

- **<u>Veneers</u>**: These are thin sheets or slices of 0.40 to 6mm wood of superior quality. Indian timbers, which are suitable for veneers, are mahagony, oak, rosewood, sissoo, teak etc. The process of preparing a sheet of veners is known as veneering. Veneers are used to produce plywoods batten boards and lamin boards.
- **<u>Plywood</u>**: Plywood's are boards, which are prepared from thin layers of wood or veneers. Three or more veneers in odd number are pressed using adhesives. The plywoods are used for various purposes such as ceilings, doors, furniture, partitions, paneling walls, packing cases, railway coaches, formwork for concrete etc. Thickness may vary from 6 to 25mm.
- **<u>Fibre board's</u>**: These are rigid boards and they are also known as pressed wood or reconstructed wood. The thickness varies from 3mm to 12mm. These are available in lengths from 3 to 4.5m and width varying from 12 to 18m.

  These are used for

  i. Internal finish of rooms such as wall paneling; suspended ceilings.
  ii. To construct form work for cement concrete.
  iii. To construct partitions.
  iv. To prepare flush doors, tops of tables etc.
  v. To provide an insulating material of heat and sound.
  vi. To work as paving or flooring material.

- **Impreg timbers**: Timber which is fully or partially covered with resin is known as impreg timber. The usual resin employed is phenol formaldehyde which is soluble in water. Impreg timber is available under trade names such as formica, sungloss, sunmica etc and it is used for moulds, furniture, decorative artuicles etc.
- **Compeg timbers**: The process of preparing compreg timbers is same as that of impreg timbers except that curing is carried out under pressure. The strength and durability of compreg timbers is more as compared to the impreg timbers.

❖ **Properties of good timbers:**

i. **Appearance**: A freshly cut surface of timber should exhibit hard and of shining appearance.
ii. **Colour**: A colour should preferably be dark
iii. **Defects**: A good timber should be free from series defects such as knots, flaws, shakes etc
iv. **Durability**: A good timber should be durable and capable of resisting the action of fungi, insects, chemicals, physical agencies, and mechanical agencies.
v. **Elasticity:** The timber returns to its original shape when load causing its deformation is removed
vi. **Fibres**: The timber should have straight fibres.
vii. **Fire resistance**: A dense wood offers good resistance to fire
viii. **Hardness**: A good timber should be hard
ix. **Mechanical wear**: A good timber should not deteriorate easily due to mechanical wear or abrasion
x. **Shape**: A good timber should be capable of retaining its shape during conversion or seasoning
xi. **Smell**: A good timber should have sweet smell. Unpleasant smell indicates decayed timber
xii. **Sound** : A good timber should give a clear ringing sound when struck
xiii. **Strength**: A good timber should be sufficiently strong for working as structural member such as joist, beam, rafter etc.
xiv. **Structure**: The structure should be uniform
xv. **Toughness**: A good timber should be tough (i.e.) capable of offering resistance to shocks due to vibration
xvi. **Water permeability**: A good timber should have low water permeability, which is measured by the quantity of water filtered through unit surface area of specimen of wood.

xvii. **Weathering effects**: A good timber should be able to stand reasonably the weathering effects (dry & wet)

xviii. **Weight**: The timber with heavy weight is considered to be sound and strong.

xix. **Working conditions**: Timber should be easily workable. It should not clog the teeth of saw.

❖ **Seasoning of timber**

Seasoning of timber is the process by which moisture content in the timber is reduced to required level. By reducing moisture content, the strength, elasticity and durability properties are developed. A well-seasoned timber has 15% moisture content in it.

❖ **Methods of Seasoning of Timber**

There are two methods of Seasoning of timber which are explained below.

1. Natural seasoning
2. Artificial seasoning

1.Natural Seasoning of Timber

Natural seasoning is the process in which timber is seasoned by subjecting it to the natural elements such as air or water. Natural seasoning may be water seasoning or air seasoning.

a. Water Seasoning

Water seasoning is the process in which timber is immersed in water flow which helps to remove the sap present in the timber. It will take 2 to 4 weeks of time and after that the timber is allowed to dry. Well-seasoned timber is ready to use.

Fig.Water Seasoning

b. Air seasoning

In the process of air seasoning timber logs are arranged in layers in a shed. The arrangement is done by maintaining some gap with the ground. So, platform is built on ground at 300mm height from ground. The logs are arranged in such a way that air is circulated freely between logs. By the movement of air, the moisture content in timber slowly reduces and seasoning occurs. Even though it is a slow process it will produce well-seasoned timber.

Fig. Air Seasoning

2. Artificial Seasoning of Timber

Natural seasoning gives good results but takes more time. So, artificial seasoning of timber is developed nowadays. By artificial seasoning, timber is seasoned with in 4-5 days. Here also different methods of artificial seasoning are there and they are as follows.

- Seasoning by Boiling
- Chemical seasoning
- Kiln seasoning
- Electrical seasoning

Seasoning by Boiling

Seasoning of timber is also achieved by boiling it in water for 3 to 4 hours. After boiling timber is allowed to drying. For large quantity of timber boiling is difficult so, sometimes hot steam is passed through timber logs in enclosed room. It also gives good results. The boiling or steaming process develops the strength and elasticity of timber but economically it is of heavier cost.

Chemical Seasoning

In case of chemical seasoning, timber is stored in suitable salt solution for some time. The salt solution used has the tendency to absorb water from the timber. So, the moisture content is removed and then timber is allowed to drying. It affects the strength of the timber.

Fig Chemical Seasoning

Kiln Seasoning

In this method timber is subjected to hot air in air tight chamber. The hot air circulates in between the timber logs and reduces the moisture content. The temperature inside the chamber is raised with the help of heating coils. When the required temperature is obtained moisture content and relative humidity gets reduced and timber gets seasoned. Even though it is costly process it will give good results strength wise.

Fig Kiln Seasoning

Electrical Seasoning

In the method of electrical seasoning timber is subjected to high frequency alternating currents. The resistance of timber against electricity is measured at every interval of time. When the required resistance is reached seasoning, process is stopped because resistance of timber increases by reducing moisture content in it. It is also called as rapid seasoning and it is uneconomical.

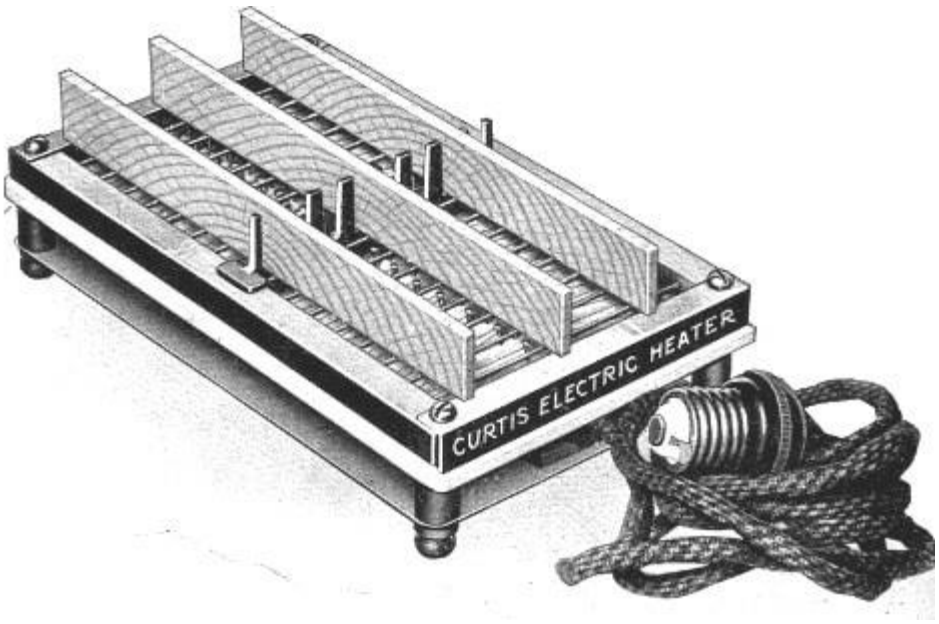


Fig. Electrical Seasoning

TILES

Manufacture of Common Tiles:

Following four distinct operations are involved in the general process of manufacturing the common tiles:

(i) Preparation of clay

(ii) Moulding

(iii) Drying

(iv) Burning.

i) Preparation of Clay:

The selected clay is taken and it is made free from any impurity such as grit, pebbles, etc. Such clay is then pressed and converted into fine powder in pug mills.

For tiles of superior quality, a large quantity of pure water is added to the powdered clay and it is well mixed in a tank. The mixture is then allowed to stand quietly. The coarse heavy particles settle at the bottom of tank. The fine particles are taken into other tanks and the water is then allowed to dry off. The fine clay left after such process is used for the manufacture of tiles.To make the tiles hard and impervious, a mixture of ground glass and pottery-ware may be added in required quantity to the clay of tiles.

(ii) Moulding:

The clay is placed in moulds which represent the pattern or shape in which the tile is to be formed. The moulding may be done either with the help of wooden moulds or mechanical means or potter's wheel. The wooden moulds should be prepared from well-seasoned timber. The clay is pressed into such moulds and tiles are ready for drying when clay is taken out of moulds.

The care should be taken to preserve the shape of tiles during the removal of moulds. The tiles which do not have a uniform section throughout their length are moulded with the help of wooden moulds. The moulding with the help of mechanical means includes the provision of machines and the clay is pressed into such machines to get tiles of desired section and shape.

This method of moulding is adopted for tiles having a uniform section throughout their length. The cutting of tiles in desired length is carried out with the help of a fine wire. The method of moulding by potter's wheel is similar to one that is adopted by a potter in the manufacture of earthenware vessels. This method is adopted when tile is of perfectly circular shape when on the wheel. It may however have diameter varying along its length.

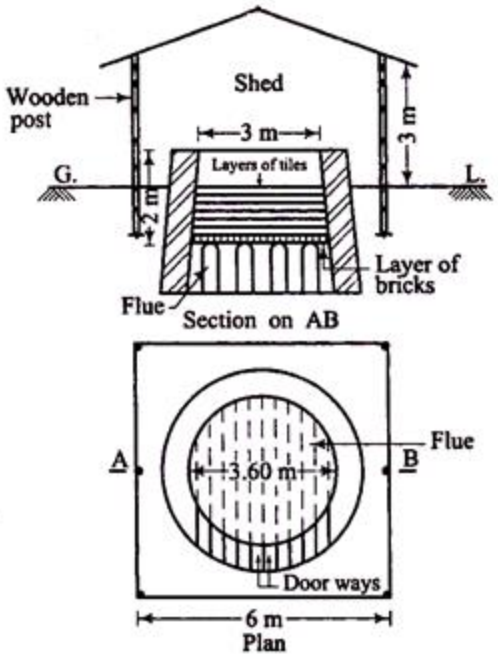
(iii) Drying:

The tiles, as they come out of moulds, are placed flat one above the other in suitable number. The different heaps are thus formed. After about 2 days, the irregularity of tiles due to warping is corrected with a flat wooden mallet. The tiles are then lifted as they have by now become hand-hard. The edges and under surfaces are cleaned. They are stacked on edge under a shade to dry for about two days or so. The drying under a shade prevents warping and cracking of tiles due to rain and sun.

(iv) burning:

The tiles are then burnt in kilns. A typical kiln, known as the Sialkote kiln, for accommodating about 30000 to 40000 tiles is shown in fig. It is circular in shape and is protected by a shed. A layer of bricks is laid flat on the rows of long narrow flues. The burning is effected by firing wood placed in these flues. The bricks are arranged in such a way that open spaces are left in between them.

Above the layer of bricks, the dried tiles are placed on edge layer by layer. The closing of doorways is affected by brickwork in mud. The top of kiln is covered with a layer of old tiles placed in a loose condition.



Circular kiln for burning tiles

FIG. 3-1

The regulation of heat is important to achieve better results. The fire is gentle in the beginning. It removes moisture. It is then raised to about 800°C. It is slackened for a period

of about 6 hours and again raised to white heat, temperature being 1300°C. This temperature is maintained steady for a period of 3 hours.

The process of slackening the fire for 6 hours and then raising the temperature to white heat is repeated. The white heat is maintained for 4 hours. Finally, the flues are filled with the fuel and the doorways are closed by brickwork in mud. The kiln is then gradually allowed to cool down. It requires about 72 hours completing the process of burning the tiles.

The tiles are taken out of the kiln. The under burnt tiles are sorted out and they are placed on the top of kiln in the subsequent burning of tiles. It is thus seen that this kiln is an intermittent kiln.

A new automatic process known as the single firing technology has been found out and it has resulted in the drastic reduction of the firing cycle from 72 hours in the old double firing conventional method to a stunning average of just one hour.

This new technology has reduced the fuel consumption and lowered the total cost of production. The new technology has increased the quality, design and versality of tiles and thus a new chapter of discovery has opened for the ceramic industry.

Characteristics of a Good Tile:

Following are the characteristics of a good tile:

1. It should be free from any cracks, flaws or bends.
2. It should be regular in shape and size.
3. It should be sound, hard and durable.
4. It should be well burnt.
5. It should give a clear ringing sound when struck with hand or with one another or with light hammer.
6. It should fit in properly, when placed in position.
7. It should give an even and compact structure when seen on its broken surface.
8. It should possess uniform colour.

Types of Common Tiles:

Depending upon the use to which the tiles are put, the following are their different types:

i. Drain tiles
ii. Floor or paving tiles
iii. Roof tiles.

(i) Drain Tiles:

These tiles are prepared in such a way that they retain porous texture after burning. Hence, when such tiles are laid in the water-logged areas, they allow subsoil water to pass through

their skeleton. These drains may be circular, semi-circular or segmental. They are also used to convey irrigation water. Such drain tiles are rarely adopted in modern times.

(ii) Floor or Paving Tiles:

The floor or paving tiles may be square or hexagonal in shape. These are flat tiles and their thickness varies from 12 mm to 50 mm. The size of square tiles varies from 150 mm to 300 mm. The floor tiles should be hard and compact so that they can resist wear and tear in a better way. The floor tiles of thin section can be adopted for ceiling also.

To prepare coloured floor tiles, the colouring substance is added in the clay at the time of its preparation. The floor tiles of comparatively less strength can be adopted for fixing on walls.

- **<u>The ceramics floor or paving tiles have the following distinct advantages despite their high cost:</u>**
  i. They are available in an endless range of colours and designs.
  ii. They are easier to lay as they are small in size.
  iii. They are much lighter than either mosaics or marbles.
  iv. They are scratch, stain and damp-proof as well as anti-slip.
  v. They do not require polishing and the floor is ready for use the very next day.

(iii) Roof Tiles:

These tiles are used to serve as covering for pitched roof. The various types of roof tiles are available in the market.

Their important varieties are as follows:

(a) Allahabad Tiles:

These tiles are made from selected clay. The moulding of clay is done under pressure in machines. The burning of these tiles is done in such a way that they attain more strength. These tiles are provided with projections so that they interlock with each other, when placed in position. The tiles of special shapes are made for hip, ridge and valley portions of the roof. These tiles are extensively used in North-Western India.

(b) Corrugated Tiles:

These tiles have corrugations and when they are placed in position, a side lap of one or two corrugations is formed. The placing of such tiles on a roof gives an appearance of corrugated galvanized iron sheets. These tiles are handsome in appearance, but they can easily be blown away by a violent wind.

(c) Flat Tiles:

These are ordinary floor tiles. To fix them on battens, two or more holes are provided on their surface. The suitable laps are provided at sides and edges.

(d) Flemish Tiles:

These tiles have got the shape of letter 's' with dimensions as 350 mm X 225 mm x 12 mm and they are prepared with the help of a mould. These tiles do not form a good covering as the plain tiles and they are used only for sheds.

(e) Guna Tiles:

These are hollow tapered burnt clay tiles. They are conical in shape with a base of 100 mm diameter at the broader end and 75 mm at the narrower end. The thickness of the annular ring is 6 mm. These tiles can be manufactured on the potter's wheel and on account of their conical shape, they can be inserted one into another so as to form a ring of guna tiles. The ring may be made of suitable shape such as circular, elliptical, parabolic, etc.

(f) Manglore Tiles:

These tiles are of flat pattern and they are provided with suitable projections so that they interlock with each other, when placed in position. These tiles are red in colour and made of double channeled Basel Mission Manglore pattern. The special Manglore tiles are available for hip, ridge and valley portions of the roof. It is found that about fifteen Manglore tiles are required for covering one square metre of roof area.

These tiles are manufactured on large scale in South India especially at Manglore, Cochin and Calicut. This industry was established in the early 19th Century by German Missionaries. The first unit manufacturing Manglore pattern tiles was started at Morvi, Saurashtra in 1951 and at present, more than 200 units are working in this area.

Thus, Morvi has become the Bangaluru of Gujarat State and some other units, about 30 or more, are also located in Bulsar and Surat districts of the Gujarat State.

The Manglore pattern roofing tiles are becoming popular in rural and semi-urban areas and they are used by middle and low income group people because of various reasons such as architectural effect, scarcity and rising prices of other substitutes, growth of population, etc. The life of these roofing tiles is estimated at about 25 years with replacement of about 5% per year.

According to the Bureau of Indian Standards (BIS): 654-1962, the Manglore pattern tiles are divided into two classes, namely, Class AA and Class A.

The characteristics of both these classes are mentioned in table 3-1.

The dimensions of Manglore tiles are given in table 3-2.

TABLE 3-1
CLASSIFICATION OF MANGLORE TILES

No.	Item	Class AA	Class A
1.	Maximum water absorption percentage	19	24
2.	Minimum average breaking load	1.00 kN (102 kg)	0.80 kN (82 kg)
3.	Minimum individual breaking load	0.89 kN (91 kg)	0.67 kN (68 kg)

TABLE 3-2
DIMENSIONS OF MANGLORE TILES

Effective length	Effective width
320 mm	210 mm
340 mm	215 mm
350 mm	220 mm

(g) Pan Tiles:

These tiles are short and heavy. They are less curved in section than pot tiles. Such tiles are moulded flat first and then they are given the required curvature by moulding in suitable forms. The drying and burning of tiles are done carefully to get better quality of tiles. These tiles are of length 330 mm to 380 mm and of width 230 mm to 280 mm.

(h) Pot Tiles:

These are ordinary half round country tiles and they are also known as the locking tiles. They are prepared on potter's wheel and shape is given to such tiles by a potter with his wet hands. The polishing of inner and outer surfaces is done either with a wet cloth or a wetted strip of leather.

These tiles are semi-circular in section and taper along the length of 300 mm with diameter of about 230 mm at larger end and of about 200 mm at smaller end. They are placed on the roof with their concave and convex sides uppermost alternatively so that they can become self-locked. An overlap of at least 80 mm is provided at edges, when these tiles are used.

These tiles are liable to break easily and hence they require frequent replacement and repair which may prove to be extremely difficult.

Following are the advantages of these tiles:

i. These tiles are less liable to be displaced by the birds.
ii. These tiles may be used as a sole covering to the roof.
iii. The pitched roof may be made completely leak proof because of the fact that good drainage is ensured by these tiles even when the slope of roof is less.

PAINTS

Paints are applied on the surfaces of timber, metals and plastered surfaces as a protective layer and at the same time to get pleasant appearance. Paints are applied in liquid form and after sometime the volatile constituent evaporate and hardened coating acts as a protective layer.

Constituents of Paint

The essential constituents of paints are:

1. Base
2. Vehicle
3. Pigment
4. Drier
5. Thinner

1. Bases: It is a principal constituent of paint. It also possesses the binding properties. It forms an opaque coating. Commonly used bases for paints are white lead, red lead, zinc oxide, iron oxide, titanium white, aluminum powder and lithopone. A lead paint is suitable for painting iron and steel works, as it sticks to them well. However it is affected by atmosphere action and hence should not be used as final coat. While zinc forms good base but is costly. Lithopone, which is a mixture of zinc sulphate and barytes, is cheap. It gives good appearance but is affected by day light. Hence it is used for interior works only.

2. Vehicles: The vehicles are the liquid substances which hold the ingredients of a paint in liquid suspension and allow them to be applied on the surface to be painted. Linseed oil, Tung oil and Nut oil are used as vehicles in paints. Of the above four oils, linseed oil is very commonly used vehicles. Boiling makes the oil thicker and darker. Linseed oil reacts with oxygen and hardens by forming a thin film.

3. Pigment: Pigments give required color for paints. They are fine particles and have a reinforcing effect on thin film of the paint.
The common pigments for different colours are:
Black—Lamp black, suit and charcoal black.
Red—venedion red, red lead and Indian red.
Brown—burned timber, raw and burned sienna
Green—chrome green, copper sulphate.
Blue—Prussian blue and ultra marine
Yellow—ochre and chrome yellow.

4. The Drier: These are the compounds of metal like lead, manganese, cobalt. The function of a drier is to absorb oxygen from the air and supply it to the vehicle for hardening. The drier should not be added until the paint is about to be used. The excess drier is harmful because it destroys elasticity and causes flaking.

5. The Thinner: It is known as solvent also. It makes paint thinner and hence increases the coverage. It helps in spreading paint uniformly over the surface Turpentine and neptha are commonly used thinners. After paint applied, thinner evaporates and paint dries.

- **Properties of an Ideal Paint**

1. It should be possible to apply easily and freely.
2. It should dry in reasonable time.
3. It should form hard and durable surface.
4. It should not be harmful to the health of workers.
5. It should not be easily affected by atmosphere.
6. It should possess attractive and pleasing appearance.
7. It should form a thin film of uniform nature i.e., it should not crack.
8. It should possess good spreading power.
9. It should be cheap.

Types of Paints

Depending upon their constituents there are various types of paints. Brief descriptions of some of them which are commonly used are given below:

Oil Paint: These paints are applied in three coats-primer, undercoat and finishing coat. The presence of dampness while applying the primer adversely affects the life of oil paint. This paint is cheap and easy to apply.

Enamel Paint: It contains white lead, oil, petroleum spirit and resinous material. The surface provided by it resists acids, alkali and water very well. It is desirable to apply a coat of titanium white before the coat of enamel is applied. It can be used both for external and internal walls.

Emulsion Paint: It contains binding materials such as polyvinyl acetate, synthetic resins etc. It dries in 1,5 to 2 hours and it is easy to apply. It is more durable and can be cleaned

with water. For plastered surfaces, first a coat of cement paint should be applied and then the emulsion point. Emulsion paint needs sound surfaces.

Cement Paint: It is available in powder form. It consists of white cement, pigment and other additives. It is durable and exhibits excellent decorative appearance. It should be applied on rough surfaces rather than on smooth surfaces. It is applied in two coats. First coat is applied on wet surface but free from excess water and allowed to dry for 24 hours. The second coat is then applied which gives good appearance.

Bituminous Paints: This type of paint is manufactured by dissolving asphalt or vegetable bitumen in oil or petroleum. It is black in color. It is used for painting iron works under water.

Synthetic Rubber Paint: This paint is prepared from resins. It dries quickly and is little affected by weather and sunlight. It resists chemical attack well. This paint may be applied even on fresh concrete. Its cost is moderate and it can be applied easily.

Aluminum Paint: It contains finely ground aluminum in spirit or oil varnish. It is visible in darkness also. The surfaces of iron and steel are protected well with this paint. It is widely used for painting gas tanks, water pipes and oil tanks.

Anti-corrosive Paint: It consists essentially of oil, a strong dire, lead or zinc chrome and finely ground sand. It is cheap and resists corrosion well. It is black in color.

- **Application of Paint**

Preparation of surface for application of paint is the most important part in painting. The surface to be painted should not be oily and it should be from flakes of the old paint. Cracks in the surface should be filled with putty and then with sand paper. Then primer is applied. Painting work should be carried out in dry weather. The under coats and first coats must be allowed to dry before final coat is applied.

- **Distemper**

The main object of applying distemper to the plastered surfaces is to create a smooth surface. The distempers are available in the market under different trade names. They are cheaper than paints and varnishes and they a present a neat appearance. They are available in a variety of colors.

- **Properties of distempers:**

Following are the properties of distempers:

1. On drying, the film of distemper shrinks. Hence it leads to cracking and flaking, if the surface to receive distemper is weak.
2. The coatings of distemper are usually thick and they are more brittle than other types of water paints.
3. The film developed by distemper is porous in character and it allows water vapour to pass through it. Hence it permits new walls to dry out without damaging the distemper film.
4. They are generally light I colour and they provide a good reflective coating.
5. They are less durable than oil paints.
6. They are treated as water paints and they are easy to apply.
7. They can be applied on brickwork, cement plastered surface, lime plastered surface, insulating boards, etc.
8. They exhibit poor workability.
9. They prove to be unsatisfactory n damp locations such as kitchen, bathroom, etc.

Ingredients of distemper: Distemper is composed of base, carrier, coloring pigments and size. For base, the whiting or chalk is used and for carrier, the water is used. Thus it is more or less a paint in which whiting or chalk is used as base instead of whit lead and the water is used as carrier instead of linseed oil.
The distempers are available in powder form or paste form. They are to be mixed with hot water before use. The oil-bound distempers are a variety of an oil paint in which the drying oil is so treated that it mixes with water. The emulsifying agent which is commonly used is glue or casein. As the water dries, the oil makes a hard surface which is washable.

It should be remembered that most of the manufacturers of readymade distempers supply completely directions for use of their products. These directions are to be strictly followed to achieve good results.

- **Process of distempering:** The application of distemper is carried out in the following way:

Preparation of surface:

The surface to receive the distemper is thoroughly rubbed and clean.

Whitewashing:

The fresh lime is slaked at site of work and mixed thoroughly with sufficient quantity of water in a tub. It is then screened through a clean cloth. The clan gum dissolved in hot water is then added at the rate of 20 N per m3 of lime. The rice may be used in place of gum.

The surface to be whitewashed should be cleaned before the work is started. For whitewashing walls which are whitewashed before, the old loose whitewash is to be first removed and repairing to the plaster is carried out, if necessary.

The lime is toxic for germs. It reflects light and thus it increases the brightness of the surface. The whitewashing therefore is extensively used for interior wall surfaces and ceilings of houses.

The process of whitewashing is sometimes used for exterior wall surfaces also. A satisfactory work gives an opaque smooth surface with uniform white color and does not readily come off on the hand, when rubbed.

Color washing:

This is prepared by adding the coloring pigment to the screened whitewash. It should be seen that the coloring pigment is not affected by the presence of lime. Ordinarily, the yellow earth is popular of color washing. Generally, the walls are color washed and ceilings are whitewashed. The mixture is to be kept constantly stirred during use.

The color wash is applied in the same fashion as the whitewash. A satisfactory work does not give out powder when the finished surface is rubbed with the fingers.

The process of color washing imparts cleanliness and pleasant appearance of the surfaces which are treated.

- **Varnish**

Varnish is the solution of resins or resinous substances like amber, copal, shellac, gum resin etc. in solvents like oil, turpentine, alcohol etc. Depending upon the solvents used varnishes are classified as, oil varnishes, turpentine varnishes, spirit varnishes and water varnishes.

The desirable characteristics of an ideal varnish are

- It should give glossy surface.
- Should be durable.
- It should dry rapidly after application.
- It should not develop cracks after drying.
- It is commonly used on wooden surfaces.

❖ **Types of varnishes:**

Based on the different solvents used, varnishes are classified under the following categories:

Water Varnish

- They consists of lac dissolved in hot water with borax, ammonia, potash or soda just enough to dissolve the lac.
- Varnish so made withstands washing. It is used for painting wall paper and for delicate work.
- They are used for varnishing wall paper, maps, pictures, book jackets for delicate work.

Polyurethane Varnish

- These varnishes are typically hard, Absorption resistant and durable coating.
- They are popular for hardwood floors but are considered by some wood finishers to be difficult or unsuitable for finishing furniture or other detailed pieces.

Oil Varnish

- These are made by dissolving hard resins like amber or copal in oil.
- They are slow to dry but are hardest and most durable of all varnishes.
- There are suited for being used on exposed surfaces requiring polishing or frequent cleaning and for superior works.

Turpentine Varnish

- These are made from soft resins like mastic, common resin is dissolved in turpentine oil.
- These varnishes used as solvent in which soft resign such as Gun dammar, mastic and Rosin are dissolved.
- They dry quickly but not so **durable**.
- These are cheaper than oil varnishes .

Spirit Varnish

Varnishes in which spirit is used as a solvent as known as spirited varnish or French polish. Shellac is dissolved in spirit and the product is applied in a thin layer.

This varnish gives a transparent finish thus showing the grains of the timber. These however, do not weather well and as such are used for polishing wood work not exposed to weather.

Acrylic varnish or Gloss Varnish

Acrylic Varnishes, made from 100% acrylic polymer emulsions, form durable films when dry. They have excellent flexibility and resistance to chemicals, water, abrasion and ultraviolet radiation. Use them to provide lasting protection for artwork.