CHAPTER-1

STONES

1. Introduction:

All the building structures are composed of different types of materials. These materials are either called building materials or materials of construction. The materials of construction can be classified as :

i) Cement materials such as lime, cement, mortar etc.
ii) Protective materials such as paints, varnishes, plaster etc
iii) Solid materials such as stones, bricks, iron, timber etc

2. Classification of Rocks:

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

1. Geological classification
2. Physical classification
3. Chemical classification

I. Geological Classification:

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

a. **Igneous rocks:** Rocks that are formed by cooling of Magma (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.

II. 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.

III. 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.

3. Uses of stones:

1. **Structure**: Stones are used for foundations, walls, columns, lintels, arches, roofs, floors, damp proof course etc.

2.**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.

3. **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.

4. **Basic material**: Stones are disintegrated and converted to form a basic material for cement concrete, murum of roads, calcareous cements, artificial stones, hallow blocks etc. 5.**Miscellaneous**: 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.

4. Qualities of a good building stone:

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

1. **Crushing strength:** For a good building stone, the crushing strength should be greater than l00 N/ mm2.
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 for longtime. It is desirable to prefer light coloured stones as compared to dark coloured stones because the dark coloured stones easily gets attacked by weathering agents.
3. **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.
4. **Fracture**: For good building stone its fracture should be sharp, even and clear.
5. **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.
6. **Percentage wear**: For a good building stone, the percentage wear should be equal to or less then 3 percent.
7. **Resistance to fire**: A good building stone be fire proof. Sandstone, Argillaceous stone resists fire quitewell
8. **Specific gravity**: For a good building stone the specific gravity should be greater then 2.7 or so.
9. **Texture**: A good building stone should have compact fine crystalline structure should be free from cavities, cracks or patches of stuff or loose material.
10. **Water absorption:** For a good building stone, the percentage absorption by weight after 24 hours should not exceed 0.60.
11. **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.

12. **Toughness Index**: Impact test, the value of toughness less than 13 – Not tough, between 13 and 19 – Moderate, greater than 19- high

5. Properties of natural stone materials:

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

1. Granite

1. Igneous rock
2. Composed of quart, felspar and mica and minerals
3. Available in grey, green, brown and pink and red
4. Hard and durable
5. High resistance to weathering
6. The texture varies with its quality
7. Specify gravity 2.7 and compressive strength 700 to 1300 kg/cm^2
8. Used for ornamental, road metal, railway ballast, aggregate for concrete; for construction of bridges, piers and marine works etc.

2. Ballast

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

3. Sand Stone:

1. Sedimentary rock
2. It is available in variety of formations fine grained, coarse grained compact or porous

3. Available in white, green, blue, black, red and yellow.
4. Specific gravity 2.65 to 2.95
5. Compressive strength is 650kgs / cm2
6. Used for ashlar works

4. Lime Stone:

1. Sedimentary rock: It is available in a variety of forms which differ from one another in colour Compaction, texture, hardness and durable

a. Compact lime stone

b. Granular limestone

c. Magnesia lime stone

d. Kankar lime stone

f. Used for paving, road metal, etc

5. Marble

1. Metamorphic rock

2. Available in white, blue, green, yellow black and red colour

3. High compactness,

4. Suitable for decorative works, wall lining columns, pile, table slabs, hearths, tiled floors, steps of stair case etc.

6. Slate:

1. Metamorphic rock
1. Non absorbent, compact fine grained and produce metallic ringing sound when struck
2. Available in black, dark blue, grey, reddish brown etc.
3. Used for providing damp proof course, paving dados etc

Selection of stones for different purposes:

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

a. 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.

b. 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.

c. For ornamental works such as moulding and carvings, fine- grained sand stone, fine grained marble and fine grained granite are used.

d. 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

e. For road metal, stones should be hard, tough, resistant to abrasion and durable. Basalt and course-grained granite are generally recommended for this purpose.

f. For railway ballast, the stone should be hard, dense, durable, tough and easily workable sandstone, compact lime stone, trap and quartzite are commonly used

g. 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.

h. 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

a. 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.

b. 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.

c. Terrazo : This is a mixture of marble chips and cement. It is used for bathrooms residential buildings, temples etc.

Advantages of artificial stones:

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

Dressing of a stone: The stones, after being quarried, are to be cut into suitable sizes and this process is known as the dressing of stones. The dressing of stones is carried out for the following purposes:

- To obtain a definite and regular shape.
- To make the transport from quarry easy and economical.
- Provides pleasing appearance
- To suite to the requirements of stone masonry.
- At quarry site, it is possible to get cheap labour for the process of dressing of stones.
- It is possible to sort out stones for different works
- The irregular and rough portions of the stones are removed which decrease the weight of stones.

Tests on stones:

Following are different tests on building stones:

1. **Acid test:** This test is carried out to understand the presence of calcium carbonate in building stone. A sample of stone weighing about 50 to 100 gm is taken. It is placed in a solution of hydrophobic acid having strength of one percent and is kept there for seven days. Solution is agitated at intervals.

   A good building stone maintains its sharp edges and keeps its surface free from powder at the end of this period. If the edges are broken and powder is formed on the surface, it indicates the presence of calcium carbonate and such a stone will have poor weathering quality.

2. **Attrition test:** This test is done to find out the rate of wear of stones, which are used in road construction. The results of the test indicates the resisting power of stones against the grinding action under traffic.

   The following procedure is adopted:

i. Samples of stones is broken into pieces about 60mm size.
ii. Such pieces, weighing 5 kg are put in both the cylinders of Devil's attrition test machine. Diameter and length of cylinder are respectively 20 cm and 34 cm.
iii. Cylinders are closed. Their axes make an angle of 30 degree with the horizontal.
iv. Cylinders are rotated about the horizontal axis for 5 hours at the rate of 30 rpm.
v. After this period, the contents are taken out from the cylinders and they are passed through a sieve of 1.5mm mesh.
vi. Quality of material which is retained on the sieve is weighed.
vii. Percentage wear worked out as follows:

Percentage wear = (Loss in Weight/Initial Weight) x 100

3. **Crushing test:** Samples of stone is cut into cubes of size 40 x 40 x 40 mm sizes of cubes are finely dressed and finished. Maximum number of specimen to be tested is three. Such specimen should be placed in water for about 72 hours prior to test and therefore tested in saturated condition.

   Load bearing surface is then covered with plaster of paris of about 5mm thick plywood. Load is applied axially on the cube in a crushing test machine. Rate of loading is 140 kg/sq.cm per minute. Crushing strength of the stone per unit area is the maximum load at which the sample crushes or fails divided by the area of the bearing face of the specimen.

4. **Crystalline test:** At least four cubes of stone with side as 40mm are taken. They are dried for 72 hrs and weighed. They are then immersed in 14% solution of Na2SO4 for 2 hours. They are dried at 100ºC and weighed. Difference in weight is noted.

   This procedure of drying, weighing, immersion and reweighing is repeated at least 5 times. Each time, change in weight is noted and it is expressed as a percentage of original weight.

   Crystallization of CaSO4 in pores of stone causes decay of stone due to weathering. But as CaSO4 has low solubility in water, it is not adopted in this test.

5. **Freezing and thawing test:** Stone specimen is kept immersed in water for 24 hours. It is then placed in a freezing machine at -12 degC for 24 hours. Then it is thawed or warmed at atmospheric temperature. This should be done in shade to prevent any effect due to wind, sun rays, rain etc. this procedure is repeated several times and the behaviour of stone is carefully observed.

6. **Hardness Test:** For determining the hardness of a stone, the test is carried out as follows:

i) A cylinder of diameter 25mm and height 25mm is taken out from the sample of stone.
ii) It is weighed.
iii) The sample is placed in Dorry's testing machine and it is subjected to a pressure of 1250 gm.
iv) Annular steel disc machine is then rotated at a speed of 28 rpm.
v) During the rotation of the disc, coarse sand of standard specification is sprinkled on the top of disc.
vi) After 1000 revolutions, specimen is taken out and weighed.
vii) The coefficient of hardness is found out from the following equation:

Coefficient of hardness = 20 – (Loss of weight in gm/3)

7. **Impact test:** For determining the toughness of stone, it is subjected to impact test in a Page Impact Test Machine as followed:

i) A cylinder of diameter 25mm and height 25mm is taken out from the sample of stones.
ii) It is then placed on cast iron anvil of machine.
iii) A steel hammer of weight 2 kg is allowed to fall axially in a vertical direction over the specimen.
iv) Height of first blow is 1 cm, that of second blow is 2 cm, that of third blow is 3 cm and so on.
v) Blow at which specimen breaks is noted. If it is nth blow, 'n' represents the toughness index of stone.

8. **Water absorption test:** The test is carried out as follows:

i) From the sample of stone, a cube weighing about 50gm is prepared. Its actual weight is recorded as W1 gm.

ii) Cube is then immersed in distilled water for a period of 24 hrs.

iii) Cube is taken out of water and surface water is wiped off with a damp cloth.

iv) It is weighed again. Let the weight be W2 gm.

v) Cube is suspended freely in water and its weight is recorded. Let this be W3 gm.

vi) Water is boiled and cube is kept in boiling water for 5 hours.

vii) Cube is removed and surface water is wiped off with a damp cloth. Its weight is recorded. Let it be W4 gm.

From the above observations, values of the following properties of stones are obtained.

Percentage absorption by weight after 24 hours =(W2 – W1) x 100 / W1

Percentage absorption by volume after 24 hours = (W2 – W1) x 100 / (W2 – W3)

8. **Microscopic Test:** The sample of the test is subjected to microscopic examination. The sections of stones are taken and placed under the microscope to study the various properties such as

i. Average grain size

ii. Existence of pores, fissures, veins and shakes

iii. Mineral constituents

iv. Nature of cementing material

v. Presence of any harmful substance

vi. Texture of stones etc.

9. **Smith's Test :** This test is performed to find out the presence of soluble matter in a sample of stone. Few chips or pieces of stone are taken and they are placed in a glass tube. The tube is then filled with clear water. After about an hour, the tube is vigorously stirred or shaken.

   Presence of earthy matter will convert the clear water into dirty water. If water remains clear, stone will be durable and free from any soluble matter.

Preservation of stones:

Preservation of stone is essential to prevent its decay. Different types of stones require different treatments. But in general stones should be made dry with the help of blow lamp and then a coating of paraffin, linseed oil, light paint, etc. is applied over the surface. This makes a protective coating over the stone. When treatment is done with the linseed oil, it is boiled and applied in three coats over the stone. Thereafter, a coat of dilute ammonia in warm water is applied.

The structure to be preserved should be maintained by washing stones frequently with water and steam so that dirt and salts deposited are removed from time to time. However, the best way is to apply preservatives. Stones are washed with thin solution of silicate of soda or potash. Then, on drying a solution of $CaCl_2$ is applied over it. These two solutions called Szerelmy's liquid, combine to form silicate of lime which fills the pores in stones. The common salt formed in this process is washed afterwards. The silicate of lime forms an insoluble film which helps to protect the stones.

BRICKS

The common brick is one of the oldest building material and it is extensively used at present as a leading material in construction because of its durability, strength, reliability, low cost, easy availability, easy to handle etc.. Bricks are used for building up exterior and interior walls, partitions, footings and other load bearing structures. A brick is rectangular in shape and of size that can be conveniently handled with one hand. Bricks may be made of burnt clay or mixture of sand and lime.

Size of a standard brick (modular brick) should be 19 x 9 x 9 cm.

Comparision of brick and stonework: The brickwork is superior to the stonework in the following respects:

- The cost of construction works out to be less in case of brickwork than stonework as less skilled labour is required in the construction of brickwork.
- No lifting devices are necessary to carry bricks as they can be easily moved by manual labour.
- The bricks resist various atmospheric effects better than stones.
- In case of brickwork, the mortar joints are thin and hence the structure becomes more durable.
- It is easy to construct connections and openings in case of brickwork than stonework.
- At places where stones are not available and plenty of clay is available, there the brick work is cheaper

Classification of bricks:

Bricks can broadly be divided into two categories.

(i) Unburnt or sundried bricks

(ii) Burnt bricks

(i) Un burnt or Sun dried bricks- Unburn 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 some what 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 some times found stronger than even first class bricks.

Qualities of Good Brick:

(i) Bricks should be table moulded, well burnt in kilns, copper coloured, free from cracks and with sharp and square edges.

(ii) Bricks should be uniform shape and should be of standard size.

(iii) Bricks should give clear ringing sound when struck each other.

(iv) Bricks when broken should show a bright homogeneous and compact structure free from voids.

(v) 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 cold water for a period of 24 hours.

(vi) Bricks should be sufficiently hard no impression, should be left on brick surface, when it is scratched with finger nail.

(vii) Bricks should be low thermal conductivity and they should be sound proof.

(viii) Bricks should not break when dropped flat on hard ground from a height of about one meter.

(ix) Bricks, when soaked in water for 24hours, should not show deposits of white salts when allowed to dry in shade.

(x) No brick should have crushing strength below 5.5N/mm2

Composition of a brick:

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 prevents 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 imparts 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

Manufacturing of bricks:

The manufacturing of brick, the following operations are involved

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

i) **Preparation of clay:** The preparation of clay involves following operations

a) **Unsoiling** :- 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 ingradient 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

ii) **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:** 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. Bricks prepared by hand moulding are of two types.

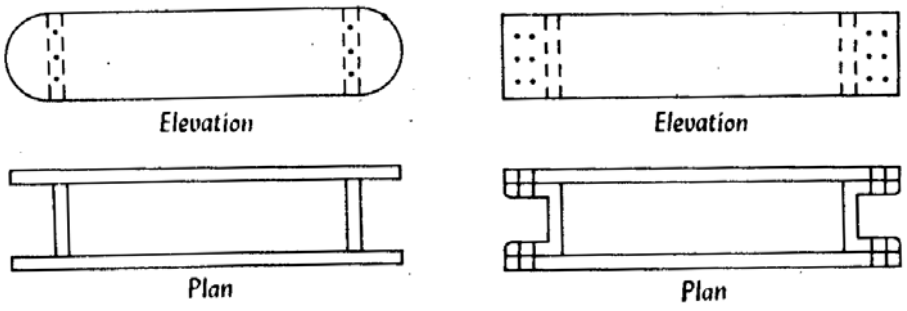


Fig. Wooden mould & Steel mould

a) Ground moulded bricks

b) Table moulded bricks

(a) **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

(b) **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

(a) Plastic clay machines

(b) 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.

iii) **Drying**: The damp bricks, if burnt, are likely to be cracked and distored. Hence moulded bricks are dried before thay 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

(i) **Artificial drying** – drying by tunnels usually 120^0C about 1 to 3 days

(ii) **Circulation of air**- Stacks are arranged in such a way that sufficient air space is left between them free circulation of air.

(iii)**Drying yard**- special yards should be prepared slightly higher level prevent the accumulation of rain water

(iv)**Period for frying** – usually about 3 to 10 days to bricks to become dry

(v) **Screens** – screens are necessary, may be provided to avoid direct exposure to wind or sun.

iv) **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 below fig.

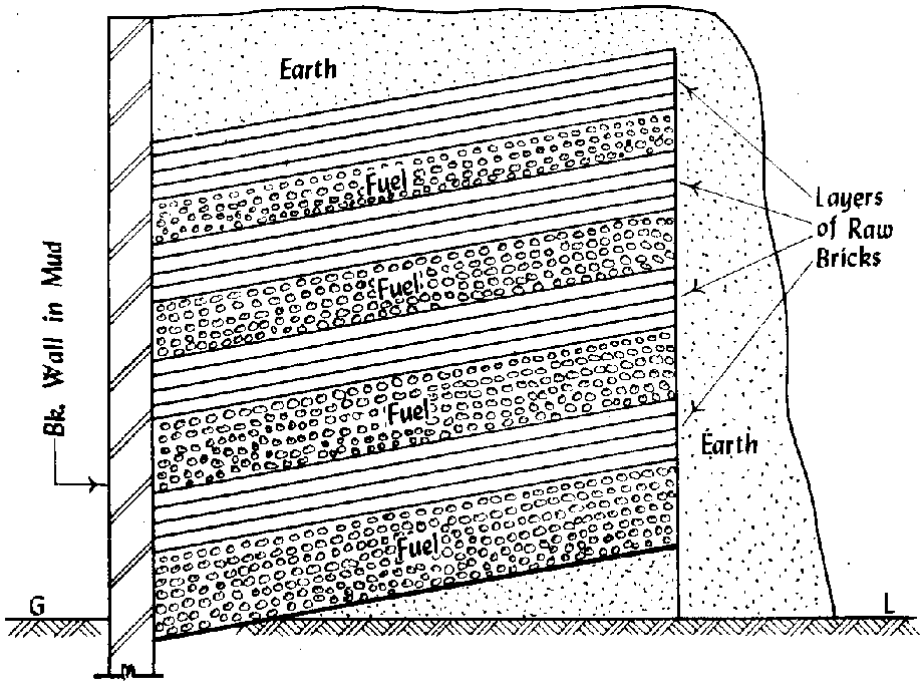


Fig. Clamp

(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 putap. 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 andtop 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:

(i) The bricks produced are tough and strong because burning and cooling are gradual

(ii) Burning in clamps proves to be cheap and economical

(iii) No skilled labour and supervision are required for the construction of clamps

(iv) There is considerable saving of clamps fuel

Disadvantages:

(i) Bricks are not of required shape

(ii) It is very slow process

(iii) It is not possible to regulate fire in a clamp

(iv) Quality of brick is not uniform

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

1) Intermittent kilns

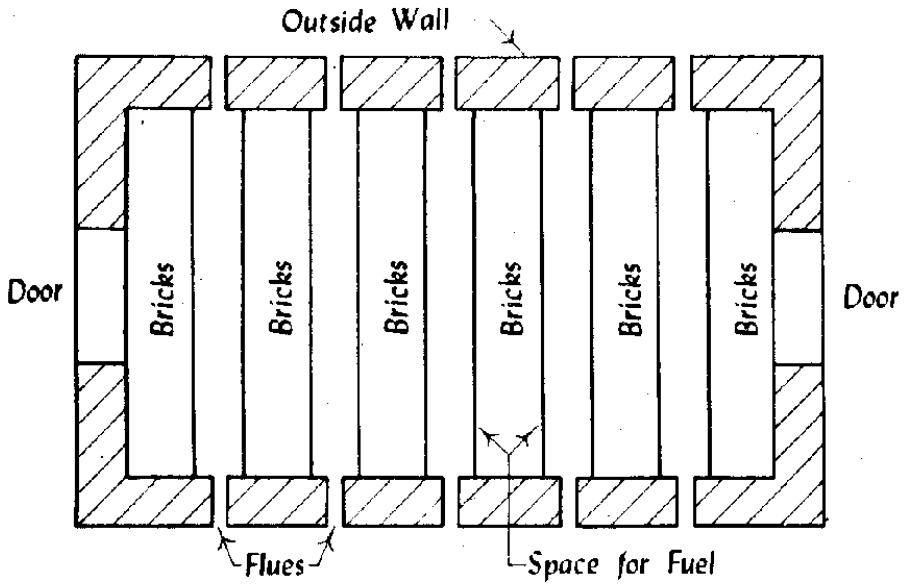
2) Continuous kilns

1) Intermittent kilns: These intermittent in operation, which means that they are loaded, fired, cooled and unloaded.

a) Intermittent up-draught kilns

b) Intermittent down-draught kilns

a) **Intermittent up-draught kiln**: This is in the form of rectangular with thick outside walls as shown in the fig . 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.



(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

(vii) 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.

(b) 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.

2. Continuous kilns:

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 under ground 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.

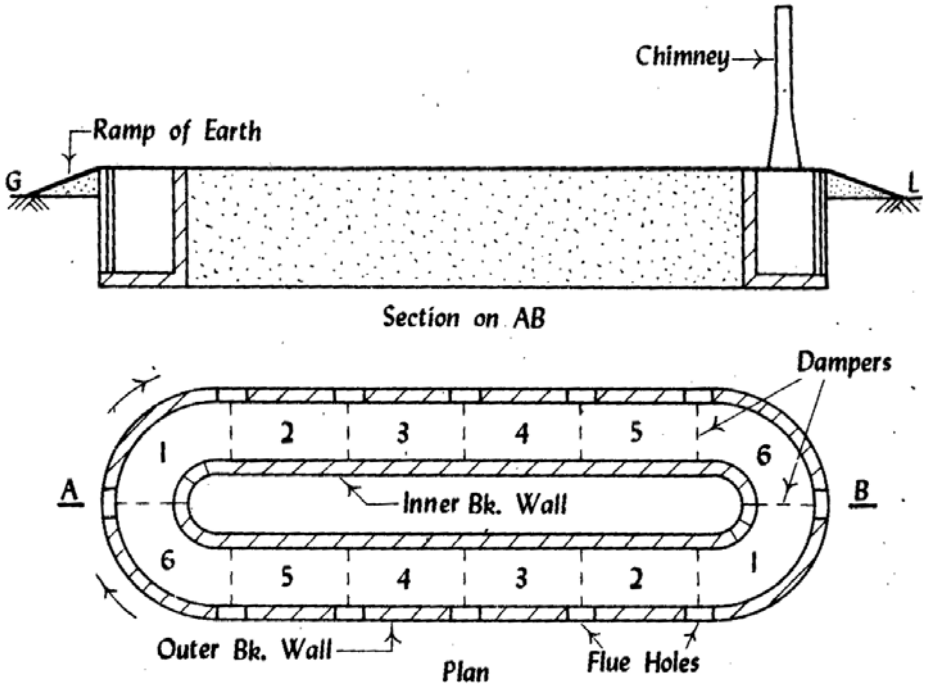


Fig. Bull's trench kiln

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) Hoffman'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. Below shows plan and section of Hoffman's kiln with 12 chambers

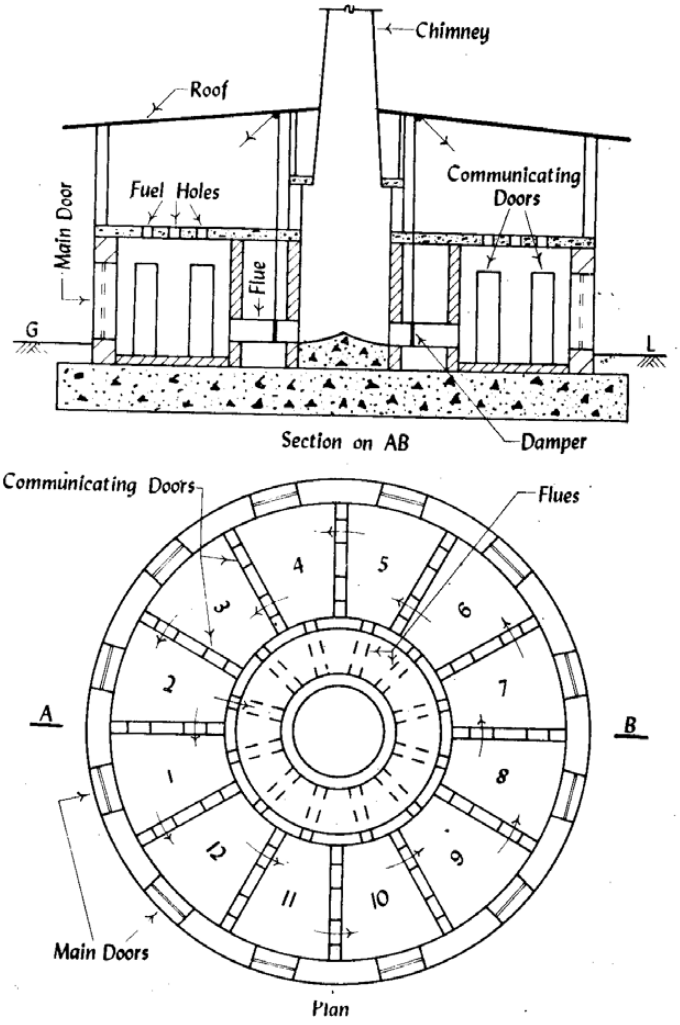


Fig. Hoffman's kiln

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

(i) Good quality of bricks are produced

(ii) It is possible to regulate heat inside the chambers through fuel holes

(iii) Supply of bricks is continuous and regular

(iv) 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 too 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 deque 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 of burn- 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 utilised.	Hot flue gas is used to dry and pre-heat raw bricks. Hence wastage of heat is the least.

Tests for bricks :

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

ii. Absorption

iii. Crushing strength or compression strength

iv. Hardness

v. Presence soluble salts

vi. Shape and size

vii. Soundness

viii. 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

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:

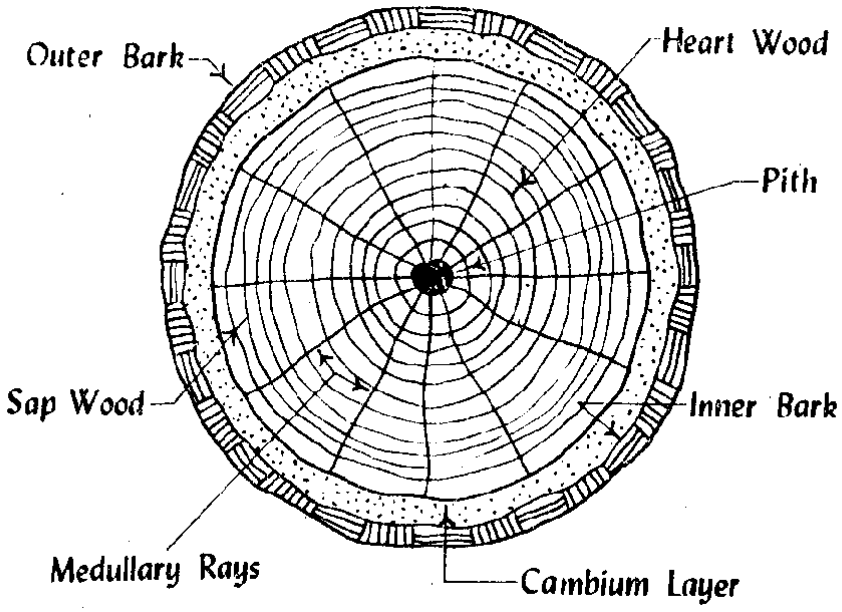
(i) Used in the form of piles, posts, beams, lintels, door/window frames and leaves, roof members etc

(ii) Used for flooring, ceiling, paneling and construction of partition walls

(iii) Used for form work for concrete, for the timbering of trenches, centring for arch work, scaffolding, transmission poles and fencing

(iv) Used in wagon and coach building, marine installations and bridges

(v) Used in making furniture of agriculture implements, sports goods, musical instruments, well curbs, mortar bodies, carts and carriages, railway sleeps, packing cases etc



Defects in Timber:

Defects occurring in timber are grouped into the following divisions.

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

(i) **Chip mark:** mark or sign placed by chip on finished surface of timber

(ii) **Diagonal grain:** Due to improper sawing of timber

(iii) **Torn grain:** Due to falling of tool small impression is formed

(iv) **Wane:** Presence of original rounded surface on the manufactured piece of timber

b) **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

(i) **Blue stain:** Sap of wood is stained to bluesh colour

(ii) **Brown rot:** Decay or disease of timber by removal of cellulose compounds from wood and wood assumes the brown colour

(iii) **Dry rot:** Convert the wood into dry powder form

(iv) **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

(v) **Sap stain:** The sap wood looses its colour because of feed on cell contents of sap wood.

(vi) **Wet rot:** Caused chemical decomposition of wood of the timber and timber converts to grayish brown powder known as wet rot.

(vii) **White rot:** Attack lignin of wood and wood assumes the appearance of white mass

c) Defects due to insects:

(i) **Beetles**: Small insects form holes of size about 2mm diameter and attack sap wood of all spacies 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.

(ii) **Marine borers**: These make holes or bore tunnels in wood for taking shelter. The wood attacked by marine borers loses colour and strength

(ii) **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 do not disturb the outer shell or cover

d) Defects due to natural forces:

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

(i) **Burls**: Irregular projections appear on the body of timber because of shock at younger age

(ii) **Callus**: Soft tissue or skin which covers the wound of tree.

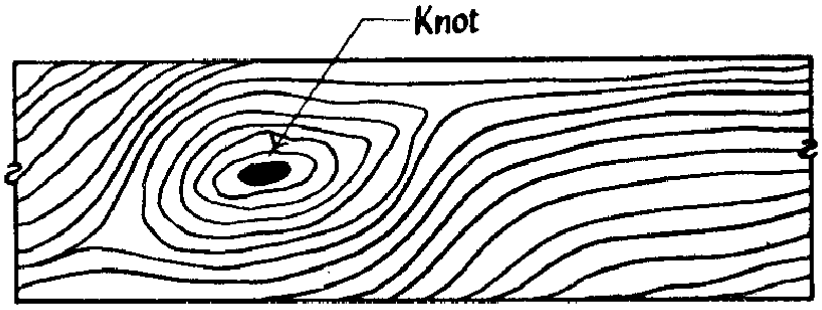
(iii) **Chemical stain**: Discoloured due to the chemical action caused

(iv) **Coarse grain**: Annual rings are widened, tree grows rapidly hence timber possesses less strength**Dead wood**: Timber obtained from dead standing tree

(v) **Druxiness**: White decayed spots by fungi

(vi) **Foxiness**: Due to poor ventilation during storage or by commencement of decay due to over maturity indicated by red or yellow tinge in wood

(vii) **Knots**: Bases of branches or limbs which are broken or cut off from the tree as shown in the fig



(viii) **Rind galls**: Rind means bark and gall indicates abnormal growth and peculiar curved swellings found on the body of a tree.

Preservation of wood

Preservation of timber is carried out to:

- Increase in life of timber structures
- Protect the timber structures from fungi, insects etc.

Requirements of a good preservative:

i. Cover large area with small quantity
ii. Cheap and easily available
iii. Free from unpleasant smell
iv. Efficient in killing fungi, insects etc.
v. Pleasant appearance

Types of preservatives:

i. **Ascu treatment** - ASCU is a special preservative which is available in powder form. It is dissolved in water to get preservative solution.It should be added 6 parts by weight of ASCU in 100 parts by weight of water. The final solution is applied on timber by spraying. This solution does not contain any odor. It is useful mainly to get rid of from white ants. ASCU contains hydrated arsenic pent oxide, copper sulphate or blue vitriol and sodium dichromate or potassium dichromate in it. After applying ASCU, the timber can be coated with paint, varnished etc.

ii. Chemical salts - Chemical salts like copper sulphate, mercury chloride and zinc chloride are used as preservative which can be dissolved in water to get liquid solution. They are odourless and do not generate flames when contact with fire.

iii. Coal tar - Coal tar is heated and obtained liquid hot tar is applied on timber surface using brush. Coal tar contains unpleasant smell and does not allow paint on it. So, it is used for door frames, window frames etc. It is very cheap and has good fire resistance.

iv. **Creosote oil -** Creosote oil is prepared by the distillation of tar. It is black or brown in colour. It contains unpleasant smell. It is applied in a special manner.

Firstly, the timber is well seasoned and dried. Then, it is placed in airtight chamber and inside air is pumped out. Finally creosote oil is pumped into the chamber with high pressure about 0.7 to 1 N/mm2 at a temperature of 50ºC.

After allowing it for 2 hours, the timber absorbs creosote oil sufficiently and taken out from the chamber. Creosote oil is flammable so, it is not used for timber works in fireplaces. It is generally used for wood piles, poles, railway sleepers etc.

v. **Oil paints -** Oil paints are suitable for well-seasoned wood. They are generally applied in 2 or 3 coats. Oil paints prevents timber from moisture. If timber is not seasoned, then oil paints may lead to decay of timber by confining sap.

vi. **Solignum paints -** Solignum paints are applied in hot condition using brush. They are well suitable for preserving timber from white ants. Solignum paints can be used by adding colour pigments so, the timber has good appearance.

Methods of preservation:

1. Brushing -
2. Charring
3. Dipping
4. Hot and cold tank treatment
5. Injecting under pressure
6. Spraying

Characteristics of good timber:

1. **Appearance**: A freshly cut surface of timber should exhibit hard and of shining appearance.
2. **Colour**: A colour should preferably be dark
3. **Defects**: A good timber should be free from series defects such as knots, flaws, shakes etc
4. **Durability**: A good timber should be durable and capable of resisting the action of fungi, insects, chemicals, physical agencies, and mechanical agencies.
5. **Elasticity:** The timber returns to its original shape when load causing its deformation is removed
6. **Fibres**: The timber should have straight fibres
7. **Fire resistance**: A dense wood offers good resistance to fire
8. **Hardness**: A good timber should be hard
9. **Mechanical wear**: A good timber should not deteriorate easily due to mechanical wear or abrasion
10. **Shape**: A good timber should be capable of retaining its shape during conversion or seasoning
11. **Smell**: A good timber should have sweet smell. Unpleasant smell indicates decayed timber
12. **Sound** : A good timber should give a clear ringing sound when struck
13. **Strength**: A good timber should be sufficiently strong for working as structural member such as joist, beam, rafter etc.
14. **Structure**: The structure should be uniform
15. **Toughness**: A good timber should be tough (i.e.) capable of offering resistance to shocks due to vibration
16. **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.

17. **Weathering effects**: A good timber should be able to stand reasonably the weathering effects (dry & wet)
18. **Weight**: The timber with heavy weight is considered to be sound and strong.
19. **Working conditions**: Timber should be easily workable. It should not clog the teeth of saw.

Commercial forms of timber:

1. ***Batten -*** Breadth & thickness do not exceed 50mm
2. ***Baulk -*** square timber piece obtained by removing bark & sap. Cross sectional dimension exceeds 50mm & 200mm on both sides
3. ***Board -*** Thickness less than 50mm & width exceeds 150mm
4. ***Deal -*** Thickness 50mm to 100mm & width less than 230mm
5. ***Plank -*** Thickness less than 50mm & width exceeds 50mm
6. ***Quartering -*** Square piece of timber. Length 50mm to 150mm
7. ***Scantling -*** Breadth & thickness exceed 50mm & length not more than 200mm

Industrial forms of Timber:

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

1. **Veneers**: 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 veneers is known as veneering. Veneers are used to produce plywoods batten boards and jamin boards.
2. **Plywoods**: Plywoods 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, panelling walls, packing cases, railway coaches, formwork for concrete etc. Thickness may vary from 6 to 25mm.
3. **Fibre boards**: 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) For internal finish of rooms such as wall panelling; 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.

4. **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, sunglass, sunmica etc and it is used for moulds, furniture, decorative articles etc.
5. **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.

STEEL

It is an alloy of iron and carbon, with carbon content up to a maximum of 1.5%. The carbon occurs in the form of iron carbide, because of its ability to increase the hardness and strength of the steel. Most of the steel produced now-a-days is plain carbon steel or simply carbon steel.

A carbon steel is defined as a steel which has its properties mainly due to its carbon content and does not contain more than 0.5% of silicon and 1.5% of manganese. The plain carbon steels varying from 0.06% carbon to 1.5% carbon are divided into the following types depending upon the carbon content.

1. **Dead steel or very low carbon steel** - < 0.10% of carbon
2. **Mild steel** - 0.10% to 0.25% of carbon
3. **Medium carbon steel** - 0.25% to 0.60% of carbon
4. **High carbon steel or hard steel** - 0.60% to 1.10% of carbon

Uses of steel:

Name of steel	Carbon content	Uses
Mild steel	Upto 0.10%	Motor body, sheet metal, tin plate etc.
Medium carbon steel	Upto 0.25%	Boiler plates, structural steel etc.
	Upto 0.45%	Rails, tyres etc.
	Upto 0.60%	Hammers, large stamping and pressing dies etc.
High Carbon steel or hard steel	Upto 0.75%	Sledge hammers, springs, stamping dies etc.
	Upto 0.90%	Miner's drills, smith's tools, stone mason's tools etc.
	Upto 1.00%	Chisels, hammers, saws, wood working tools etc.
	Upto 1.10%	Axes, cutlery, drills, Knives, picks, punches etc.

Advantages of steel:

1. High strength - This means that the weight of structure that made of steel will be small
2. Uniformity - Properties of steel do not change as oppose to concrete
3. Elasticity - Steel follows Hooke's law very accurately
4. Ductility - can withstand extensive deformation without failure under high tensile stresses
5. Toughness - steel has both strength and ductility
6. Maintain is strength indefinitely - does not deteriorate its age like timber and concrete
7. can be recycled
8. Very strong and flexible - steel framed houses are ideal in cyclone/hurricane prone regions
9. Steel has also high strength to weight ratio as compared to concrete
10. Structures can be prefabricated in large sections

Properties of mild steel:

1. It can be magnetised permanently
2. It can be readily forged and welded
3. It cannot be easily hardened and tempered
4. It has fibrous structure
5. It is malleable and ductile
6. It is not easily attacked by salt water
7. It is tougher and more elastic than wrought iron
8. It is used for all types of structural work
9. It rusts easily and rapidly
10. Its melting point is about 1400ºc
11. Its specific gravity is 7.80
12. Its ultimate compressive strength is about 80 to 120 kN per cm2
13. Its ultimate tensile and shear strengths are about 60 to 80 kN per cm2

Properties of Hard steel:

1. It can be easily hardened and tempered
2. It can be magnetised permanently
3. It cannot be readily forged and welded
4. It has granular structure

5. It is not easily attacked by salt water
6. It is tougher and more elastic than mild steel
7. It is used for finest cutlery, edge tools and for parts which are to be subjected to shocks and vibrations
8. It rusts easily and rapidly
9. Its melting point is about 1300ºc
10. Its specific gravity is 7.90
11. Its ultimate compressive strength is about 140 to 200 kN per cm2
12. Its ultimate shear strength is about 110 kN per cm2
13. Its ultimate tensile strength is about 80 to 110 kN per cm2