UNIT I
BASIC BUILDING MATERIALS:
BRICKS: Composition of good brick earth – Methods of manufacturing of bricks– comparison between clamp burning and kiln burning – Testing of bricks.
WOOD: Seasoning of timber – Defects in timber.
OTHER MATERIALS: Properties and uses of glass, plastics, steel, aluminum, bitumen.

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.

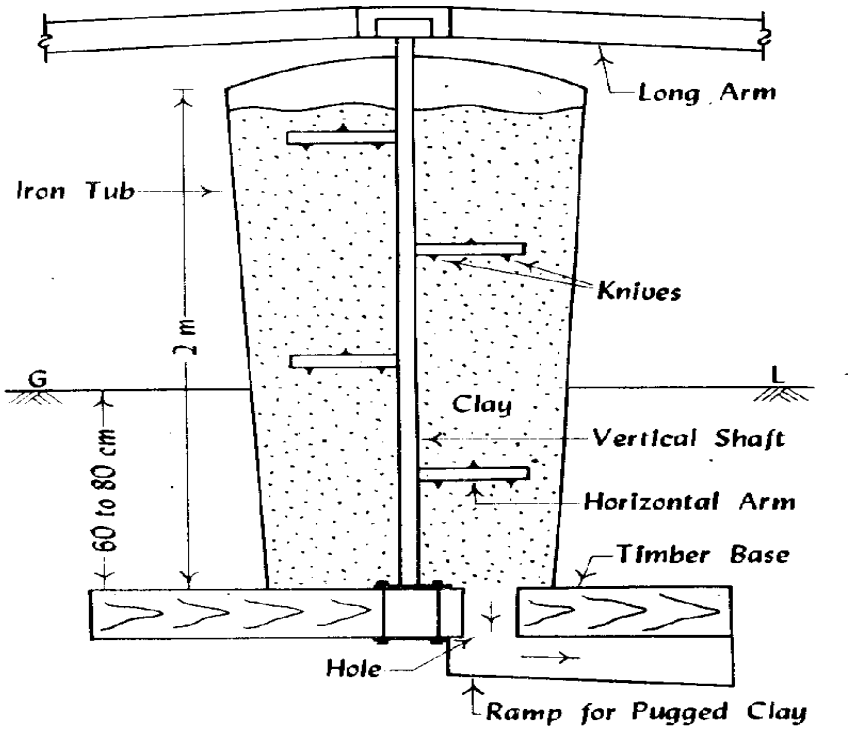
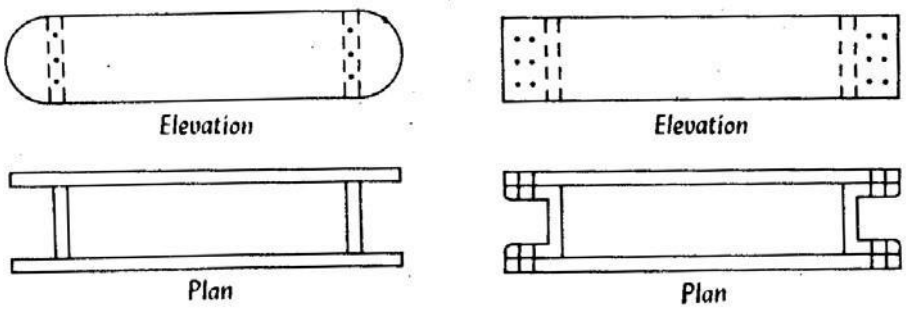


Fig.Pug Mill

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

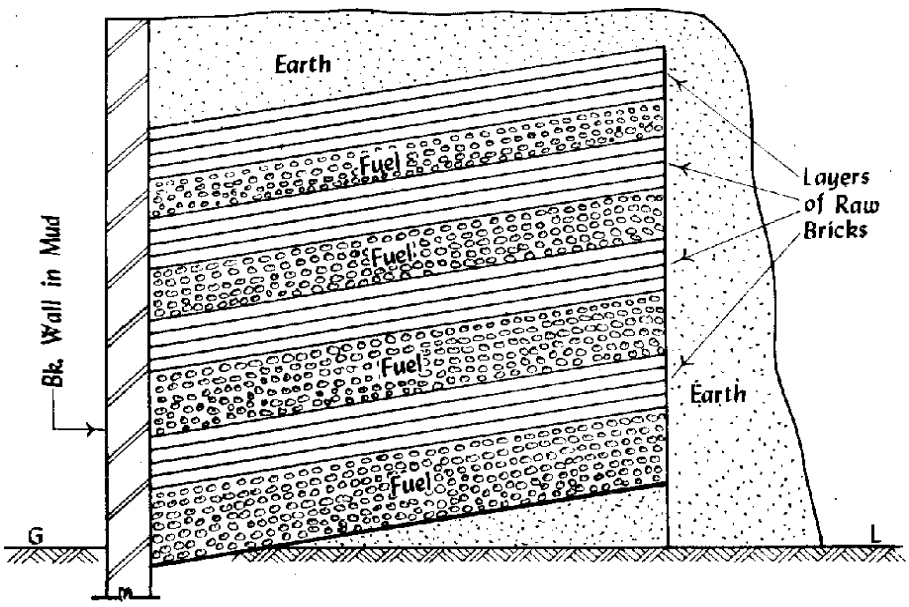


Fig. Typical diagram for Clamp burning

(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.

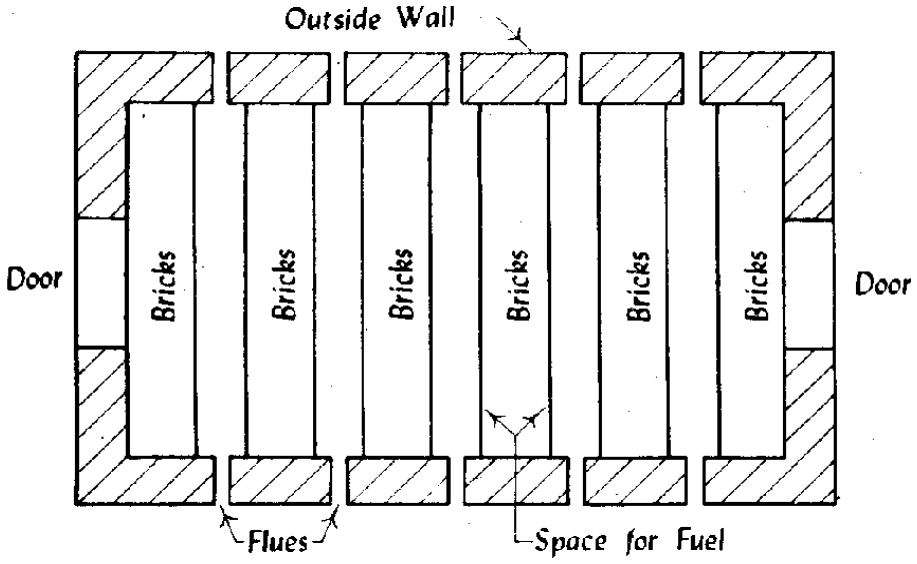


Fig. Intermittent kiln

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.

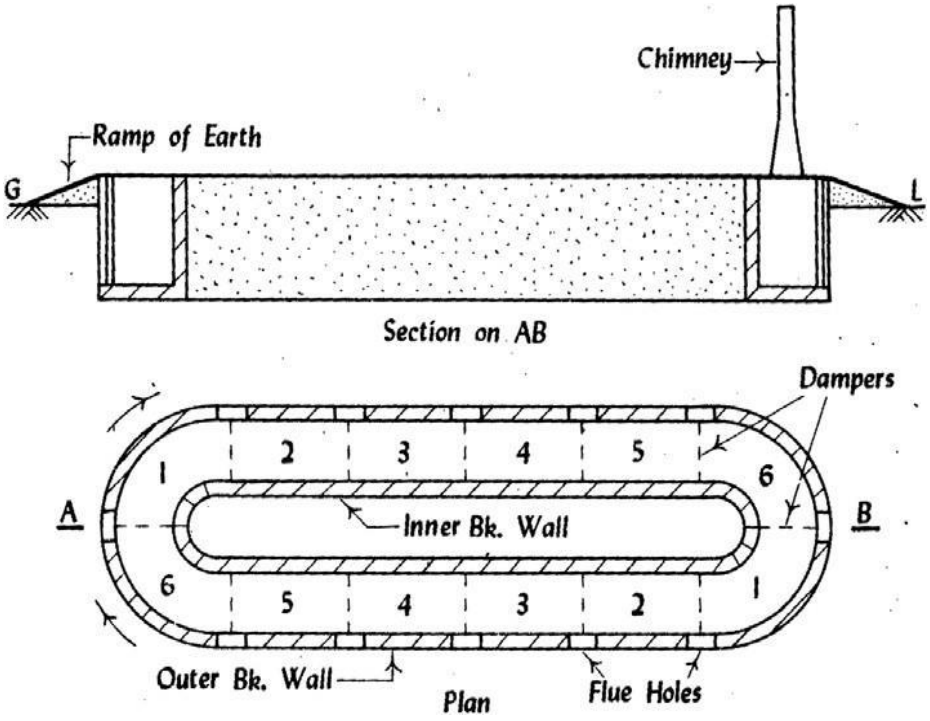


Fig . Bull's trench kiln

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

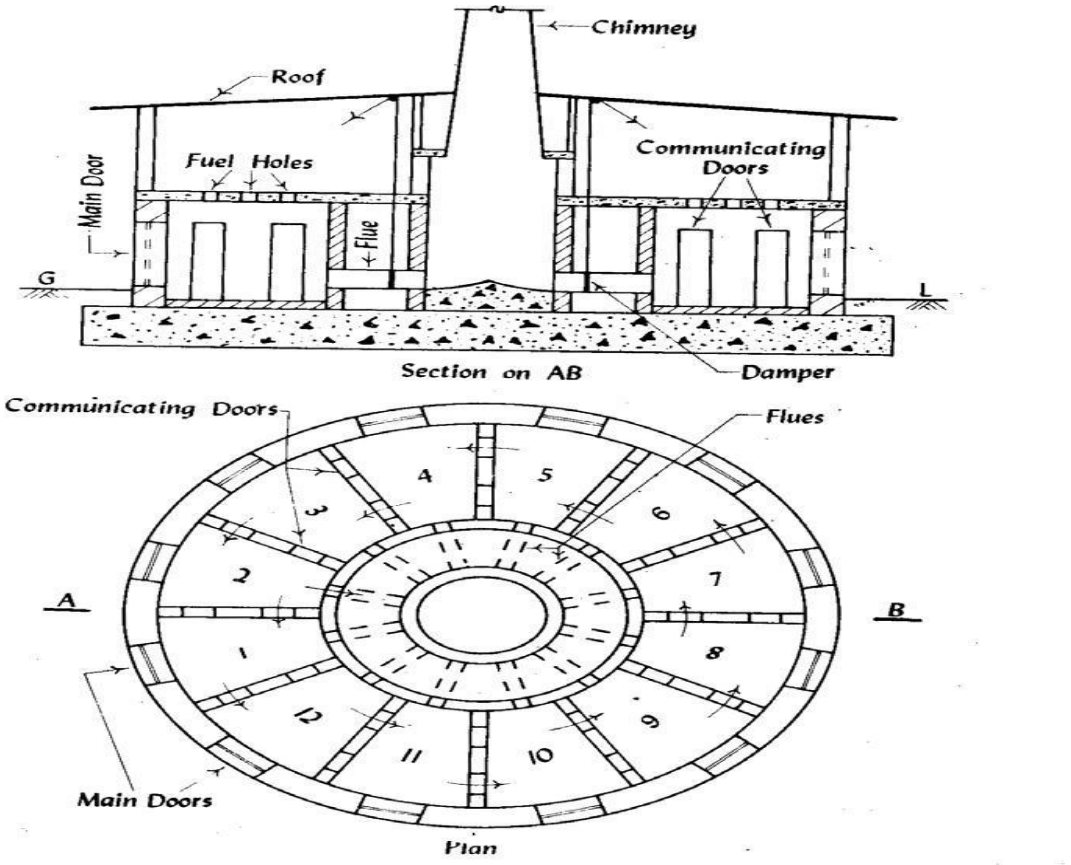


Fig. Hoffman's kiln

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 andwhen There iscontinuous demand of bricks.

9.	Time ofburn-ing andcool-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.

❖ CHARACTERISTICS OF GOOD BRICK

SIZE AND SHAPE

The bricks should have uniform size and plane, rectangular surfaces with parallel sides and sharp straight edges.

COLOUR

The brick should have a uniform deep red as indicative of uniformity in chemical composition and thoroughness in the burning of the brick.

TEXTURE AND COMPACTNESS

The surfaces should not be too smooth to cause slipping of mortar.

The brick should have precompact and uniform texture. A fractured surface should not show fissures, holes grits or lumps of lime.

HARDNESS AND SOUNDNESS

The brick should be so hard that when scratched by a finger nail no impression is made. When two bricks are struck together, a metallic sound should be produced.

WATER ABSORBTION should not exceed 20 per cent of its dry weight when kept immersed in water for 24 hours.

CRUSHING STRENGTH should not be less than 10 N/mm^2

TESTING OF BRICKS

- DIMENSION TEST
- WATER ABSORPTION TEST
- COMPRESSIVE STRENGTH TEST
- WARPAGE TEST
- EFFLORESCENCE TEST
- SOUND TEST
- STRUCTURE TEST
- TOUGHNESS TEST
- HARDNESS TEST

DIMENSION TEST

20 pieces out of selected pieces are taken and are laid flat

The tolerances on the sizes of bricks are fixed by giving maximum and minimum dimensions, not on individual bricks but on batches of 20 bricks chosen at random.

It follows from this method of measurement that batches are likely to contain, bricks outside the prescribed limit of tolerance.

Such lots should be rejected to avoid complaints about the variation of perpends.

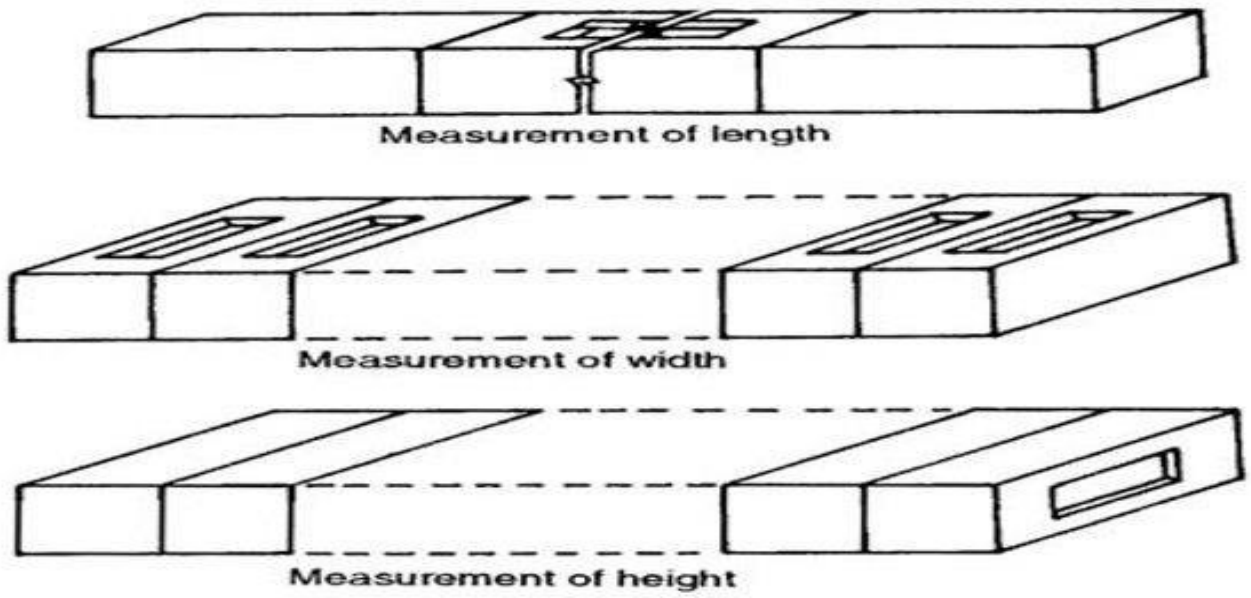


Fig.Dimension test

	Subclass-A		Subclass-B	
	Dimension (cm)	Tolerance (mm)	Dimension (cm)	Tolerance (mm)
Length	380	± 12	380	± 30
Width	180	± 6	180	± 15
Height				
(i) 9 cm	180	± 6	180	± 15
(ii) 4 cm	80	± 3	80	± 6

Fig.Tolerance limits in dimension test

WATER ABSORPTION TEST

24 HOURS IMMERTION COLD WATER TEST

- Dry bricks are put in an oven at a temperature of 105°to 115°C till these attain constant mass.
- The weight (W1) of the bricks is recorded after cooling them to room temperature.
- The bricks are then immersed in water at a temperature of 27° ± 2°C for 24 hours.
- The specimens are then taken out of water and wiped with a damp cloth. Three minutes, thereafter it is weighed again and recorded as W2.
- The water absorption in % = $\frac{W2-W1}{W1} X100$
- The average water absorption shall not be more than 20 per cent by weight upto class B and 15 per cent by weight for higher classes.

FIVE HOURS BOILING WATER TEST

- The weight of the oven dried bricks (W1) is recorded.
- Then the specimen is immersed in the water and boiled for five hours, followed by cooling down to 27° ± 2°C by natural loss of heat within 16–19 hours.
- The specimen is taken out of water and wiped with a damp cloth and the weight is recorded as W3.
- The water absorption in % $=\frac{W3-W1}{W1}X100$

COMPRESSIVE STRENGTH TEST

- For testing bricks for compressive strength from a sample the two bed faces of bricks are ground to provide smooth, even and parallel faces.
- The bricks are then immersed in water at room temperature for 24 hours. These are then taken out of water and surplus water on the surfaces is wiped off with cotton or a moist cloth.
- The frog of the brick is flushed level with cement mortar and the brick is stored under damp jute bags for 24 hours followed by its immersion in water at room temperature for three days.
- The specimen is placed in the compression testing machine with flat faces horizontal and mortar filled face being upwards.
- Load is applied at a uniform rate of 14 N/m2 per minute till failure. The maximum load at failure divided by the average area of bed face gives the compressive strength.

$$\text{Compressive strength (N/mm}^2\text{)} = \frac{\text{Maximum load at failure (N)}}{\text{Average area of bed faces (mm}^2\text{)}}$$

<u>WARPAGE TEST</u>

Warpage of the brick is measured with the help of a flat steel or glass surface and measuring ruler graduated in 0.5 mm divisions or wedge of steel 60 × 15 × 15 mm.For warpage test, the sample consists of 10 bricks from a lot.

- CONCAVE WARPAGE
- CONVEX WARPAGE

CONCAVE WARPAGE

- The flat surface of the brick is placed along the surface to be measured selecting the location that gives the greatest deviation from straightness.
- The greatest distance of brick surface from the edge of straightness is measured by a steel ruler or wedge..

CONVEX WARPAGE

- The brick is place on the plane surface with the convex surface in contact with the flat surface and the distances of four corners of brick are measured from the flat surface.
- The largest distance is reported as warpage.

The higher of the distance measured in concave and convex warpage tests is reported as warpage.

<u>EFFLORESCENCE TEST</u>

- When bricks come in contact with moisture , water is absorbed and the alkalis crystallise.
- After drying grey or white power patches appear on the brick surface
- The ends of the brick are kept in a 150 mm diameter porcelain or glass dish containing 25 mm depth of water at room temperature (20°–30°C) till the entire water is absorbed or evaporated.

- The water is again filled to 25 mm depth in the dish and allowed to be absorbed by the brick or evaporated.

The presence of efflorescence is classified as below

- Nil — When the deposit of efflorescence is imperceptible.
- Slight — When the deposit of efflorescence does not cover more than 10 per cent of the exposed area of the brick.
- Moderate — When the deposit of efflorescence is more than 10 per cent but less than 50% of the exposed area of the brick.
- Heavy — When the deposit of efflorescence is more than 50 per cent but the deposits do not powder or flake away the brick surface.
- Serious — When the deposits are heavy and powder or flake away the brick surface.

SOUND TEST

The bricks should produce clear mettalic sound when struct with each other

STRUCTURE TEST

The bricks should have uniform homogenous structure all the section

TOUGHNESS TEST

The bricks should not break into pieces when dropped on the level ground

HARDNESS TEST

The brick should possess sufficient hardness and does not show any sign of impression when scrached with fingernail.

WOOD

The hard fibrous material that forms the main substance of the trunk or branches of a tree or shrub, used for fuel or timber.

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.

❖ 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.

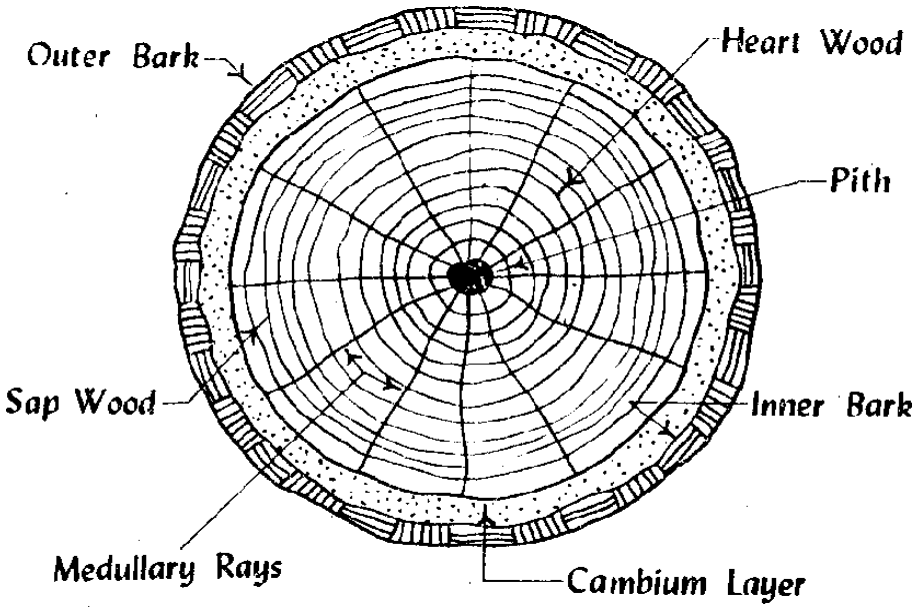


Fig .Micro structure of exogenous tree

- ✓ **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.

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.

❖ **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

- **Defects due to natural forces:**

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.

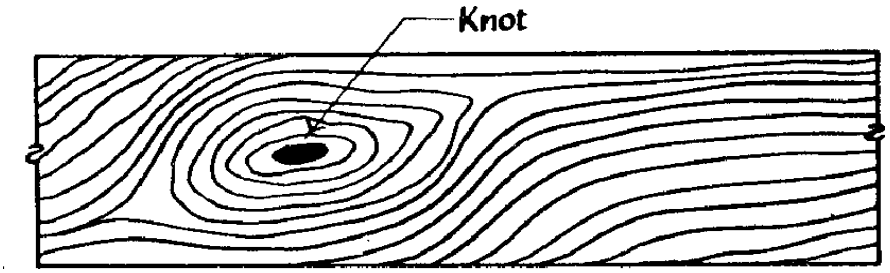


Fig.Knot

- **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.

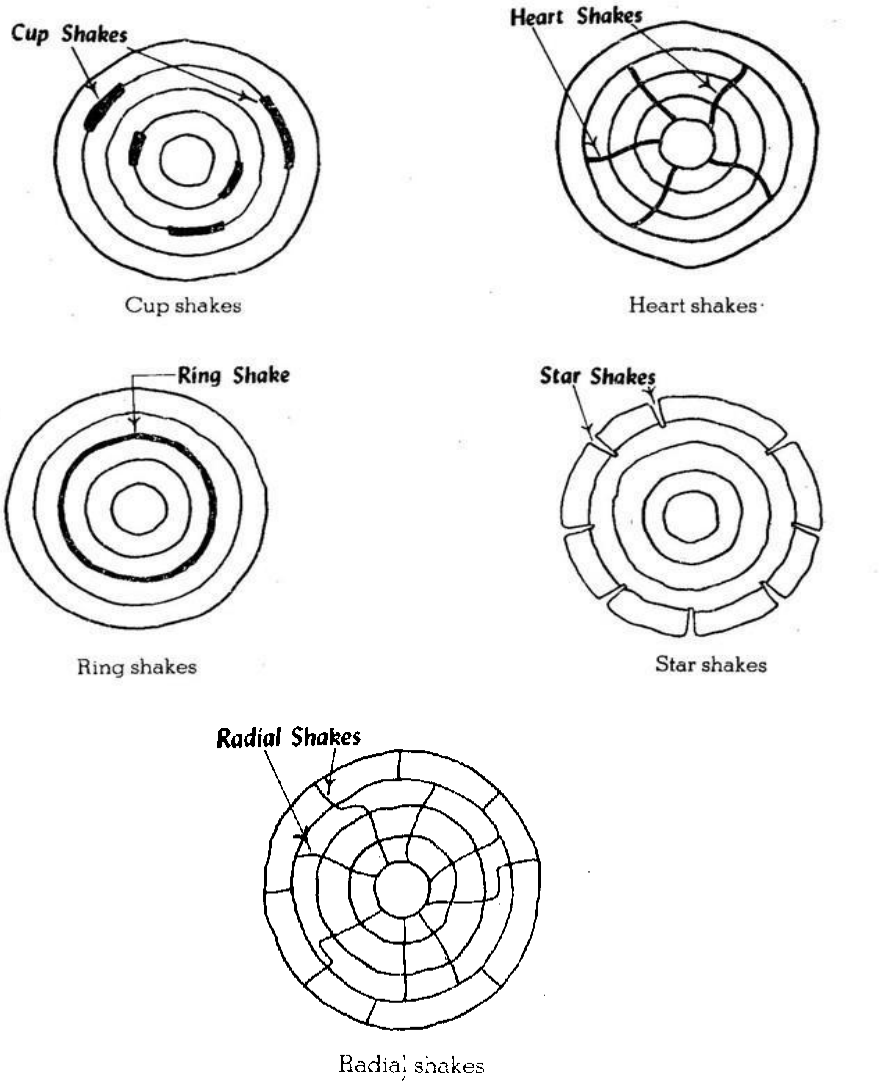


Fig. Different types of shakes

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

Fig. Twisted fibres

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

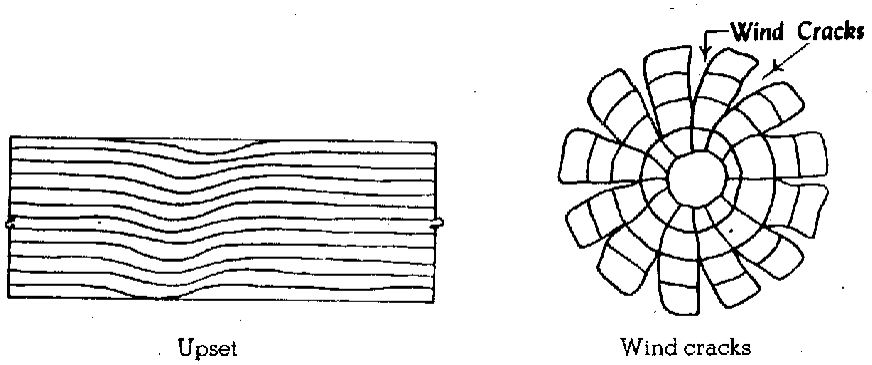


Fig.

❖ **Wood based products:**

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

- **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 veners is known as veneering. Veneers are used to produce plywoods batten boards and lamin boards.
- **Plywood**: 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.
- **Fibre board's**: 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.

❖ **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.

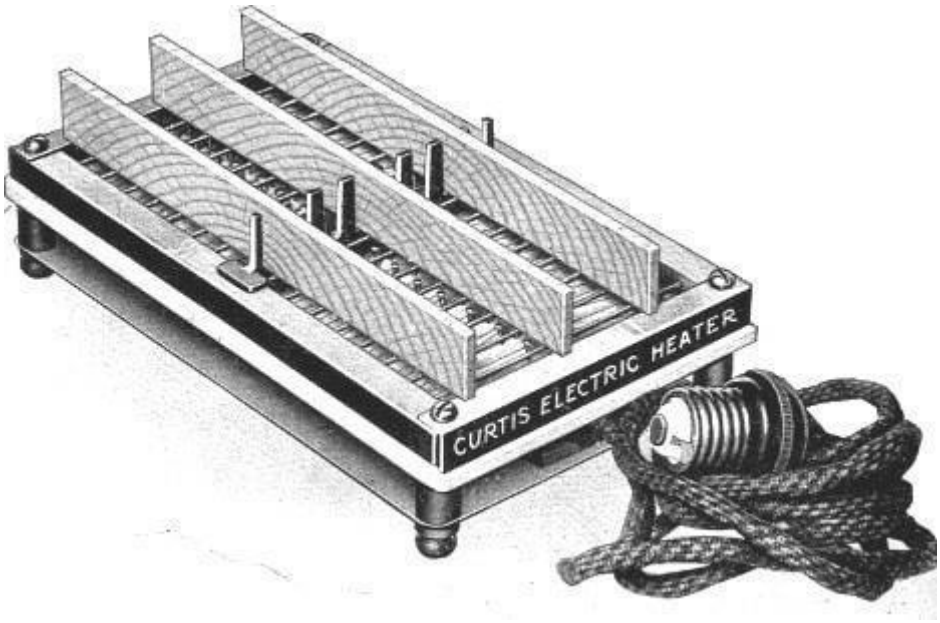


Fig. Electrical Seasoning

Glass:

Glass is an inorganic product of torsion which has been cooled to a soild state condition without crystalizing, slow cooling process leads to formation of crystal nuclei and crystallization takes place .

If the cooling rate is fast leaving no time to formation of crystal nuclei structure are super cooled liquid state turns to rigid and forms a glass.

Properties of glass :-

- Transparency.
- Strength
- Transmittance
- Workability
- U.value
- Recycling property.

Transparency:-

Transparency Is the main property of the glass which allows the vision of out side world through it.

The transparency of glass can be from both sides or side from one side only.

In one side transparency glass behaves like a mirror from the other side.

Strength:-

The strength of glass depends up on the modulus of rupture value of a glass in general is a brittle material but by adding admixtures and laminates to we can make it strong.

Transmittance:-

The visible fracture of light that passing through glass is property of visible transmittance .

Workability:-

A glass can be moulded in to any shape are it can be blown during melting.

Workability of a glass is superior property .

U value:-

Uvalue represents the amount of heat transfered to glass ,if a glass is said to be insulted unit then it should have lower heat value.

Recycling property:-

Any glass can be 100% recyclable it can be used as raw material in construction industry .

Uses of glass :-

Soda lime glass:-

It is used in the manufacturing of glass tubes ,laboratory apparatus , window glasses .

Potash lime glass:-

It is used in the manufacturing of glass obticals which have to with stand high temperatures.

Potash lead glass:-

It is used in the manufacturing of artificial gamps , electric bulbs ,lenses and prisms.

Common glass:-

It is mainly used in the manufacturing of medicine bottles.

Aluminium:-

Aluminium (Aluminum) has properties which makes it suitable as a building / construction material. Nowadays in advanced countries, aluminum became the important construction material for buildings especially for industrial buildings along with brick, cement and steel. The aluminum is one of the abundantly available non-ferrous metals on the surface of earth. But it is not available in direct form, generally it is extracted from bauxite. Aluminum also available in the form of oxides, sulphates, silicates and phosphates etc..

Properties of Aluminum as Building Material

Following are the properties of aluminum which makes aluminum as one of the important building materials.

- Air tightness
- High strength to weight ratio
- Ease in fabrication and assembly
- Low Handling and transportation cost
- Corrosion resistance
- Appearance
- High Scrap value
- Sound proof
- Low Maintenance cost

Air tightness

Doors and windows or its frames made form aluminum are perfectly air tight which cannot permit dust or air or water when they are closed. Now a days for fully air conditioned buildings like seminar rooms, theaters etc. aluminum doors and windows are using.

High strength to weight ratio

Aluminum as a construction material has a property of very high value of strength to weight ratio. It represents that small amount of aluminum can give more strength to structure. Because of less weight we can construct the structure in less time and load transferring to foundation also reduces.

Ease in fabrication and assembly

Compared to other metals aluminum alloys can be cast, forged, extruded, rolled or welded easily. During or after composition of aluminum alloy it cannot break because it is not having brittle nature. The assembly of aluminum structures can be easily dismantled or transported or assembled.

Low Handling and transportation cost

Handling of aluminum is very easy because of its less weight. So, we can transport it easily in large quantity to any place with low transportation cost.

Corrosion resistance

Corrosion resistance of aluminum is very high. It doesn't effected by weathering conditions. They can withstand against humid or hot dry conditions very well. Because of its good corrosion resistance, aluminum corrugated sheets are widely used for power plants, chemical plants, paper mills, petroleum refineries etc..

Appearance

Aluminum also gives beauty to the structure. Smooth and bright finishing is possible for aluminum structures. We can also provide various shades of colors on the aluminum sheets to enhance decorative style.

High Scrap value

Scrap value of aluminum is very high. So, it cannot be damaged easily and highly durable. Because of high scrap value, we can resale it for good value.

Sound proof

Aluminum sheets acts as sound proof materials. They are excellent reflectors of sound waves as well as electromagnetic waves. So, they do not allow external noise into the building and also interior sounds to outside.

Low Maintenance cost

Aluminum have high corrosive resistance and good properties against low temperature so, maintenance of aluminum is negligible. Even though it is expensive to buy, it will with stand for 25-30 years without any maintenance.

Uses of Aluminium in Building Construction

Aluminum is the second only to iron in annual consumption and it is the most important non-ferrous metal

Unless steel, scrap value of aluminum is very high and easy to transport because of its less weight(or) light weight.

Window frames

As wood with excellent properties is expensive, and other woods do not last long in many modern houses, we use aluminium for window frames. Many different slopes and colours can be made using aluminium alloys.

Built up curtain walls

Plain walls which do not support a roof are called curtain walls. In recent modern buildings, brick, mortar and cement have been replaced by aluminium and aluminium composite panels, curtain walls.

Built-up curtain walls can be made using aluminium frames to which glasses can be fitted in a conventional way.

Aluminium composite panels (ACP)

These aluminium laminates have started appearing as a much chosen material for facades, curtain walls. It is used in exteriors as well as interiors of building constructions.

The ACP sheet is lightweight and has high peeling strength, high durability and weather resistance. It is also resistant to fire and contains high anti-impact and anti-scratch properties. Also possesses excellent sound and thermal insulation properties.

These sheets are used for facades of buildings to add beauty or to provide attractive patterns. They can be easily bent to any shape to cover columns and pillars easily and also provide them with a very elegant look.

Aluminium roofing sheet

In olden days, roofing by rafters and clay tiles were very popular. It is becoming old-fashioned because it involves a lot of labour and tiles may also get broken after some days.Nowadays, roofing sheets are made from high-quality aluminium alloys, which does not rust, needs less maintenance and look good for a very long time.

These corrugated sheets are used for all classes of buildings, for industries, warehouses and for housing purposes. These aluminium sheets provide an attractive look to the building and also available in a variety of colours.

STEEL

Properties of steel are quite important for a civil engineer since steel is one of the most commonly used construction materials in the world. Steel is perhaps the most essential engineering and construction material in the world because of its material properties. Steel has excellent formability and durability, as well as high tensile and yield strength and heat conductivity. Aside from these significant properties, the greatest distinguishing property of stainless steel is its resistance to corrosion.

Properties of steel

1. **Ductility of steel**

One of the quite important properties of steel is its ductility. The capacity of a material to be drawn or plastically deformed without fracture is referred to as ductility. As a result, it indicates how soft or malleable the material is. Steel ductility varies according to the types and amounts of alloying elements present. Increase in carbon, for example, improves strength while decreasing ductility.

In other words, ductility is a measure of a metal's capacity to resist tensile stress, which is defined as any force that pulls the two ends of an object apart. The plastic deformation that occurs in metal as a result of such types of strain is known as ductility. The term "ductile" refers to the ability of a metal composition to be stretched into a thin wire without getting weaker or more brittle in the process.

2. **Tensile Strength of Steel**

Yield Strength of Steel

Yield strength is the highest amount of stress that may be applied before the material permanently changes its shape. This is an approximation to the elastic limit of steel. If the metal is stressed but does not reach the yield point, it will revert to its original shape once the tension is released. When the stresses exceed the yield point, the steel is unable to recover. Yield strength reflects the maximum load that can be safely applied to the metal, making it an important factor to understand when designing components.

Tensile (Ultimate) Strength of Steel

The amount of tensile stress that a material can resist before breaking or failing is referred to as its tensile (ultimate) strength. The ultimate tensile strength of a material is estimated by

dividing the area of the material tested by the stress applied to the material, which is commonly given in pounds or tons per square inch of material. Tensile strength is an essential measure of a material's capacity to function in an application, and it is commonly used to describe the properties of metals and alloys.

The most common method for determining an alloy's tensile strength is to place a test piece in the jaws of a tensile machine. By progressively separating the jaws, the tensile machine applies the tensile stress. The strain necessary to fracture the test piece is then measured and recorded. Metal yield strength can also be tested. The amount of stress that a material can resist without permanent deformation is referred to as its yield strength.

3. Corrosion Resistance

Corrosion resistance measures a material's ability to withstand damage caused by oxidation or other chemical processes. Materials have different levels of corrosion resistance. Metals that are exposed to rain, humidity, water or anything else that might cause the surface of a metal to oxidize are susceptible to corrosion damage. You can utilize stainless or galvanized steel, titanium, aluminum, weathering steel, or apply and maintain a sealant layer such as paint to prevent against corrosion.

While corrosion resistant materials such as stainless steel, weathering steel, titanium, galvanized steel or aluminum are available, they are not corrosion proof. In the presence of corrosive chemicals, stainless steel has a very thin oxide layer that stays passive. It is possible that the passive layer will deteriorate, exposing specific areas to corrosion. Galvanized steel resists corrosion by forming a thin layer of zinc coating that binds with the iron.

4. Weldability

The weldability of steel grades is mostly determined by their hardness. This, in turn, is determined by the chemical structure of the material, especially its carbon content. Manganese, chromium, molybdenum, vanadium, silicon and nickel are other alloying elements that have a little influence on steel hardness.

Steel weldability is difficult to describe, although it is commonly understood to indicate the ability of steel to be welded using standard techniques without cold cracking. Steel weldability is inversely related to hardenability. Because carbon content has a significant impact on steel hardenability, it also has an effect on weldability. As a result, as the carbon content increases, so does the weldability. Other alloying elements, such as manganese, nickel, and silicon, have an effect on the weldability of steel too. Their effect, however, is not as important as the existence of carbon content.

5. Hardenability

Steel is a composition of iron, carbon ranging from 0.0 to 1.2 percent and alloying elements. The hardness is provided by carbon, and the alloying elements determine how deep this hardness will occur. This is known as "hardenability." Hardenability is not the same as max hardness after quenching, which is solely determined by the quantity of carbon present and the proportion of martensite. Hardenability, on the other hand, refers to how deeply a steel alloy may be hardened. Steels that harden deeply are referred to as high hardenability steels, while steels that do not harden deeply are referred to as low hardenability steels. Carbon content, grain size, and alloying elements are the most important factors that are affecting hardenability and the rate of austenite transition.

When a piece of steel undergoes thermal treatment, it is referred to as quenching and tempering. Tempering is the process of fast heating the plate to a high temperature, whereas quenching is the process of fast cooling the hot plate through a liquid such as water, oil, or anything else. The outside of the plate is rapidly chilled when the steel is quenched. The interior depths of the material may not cool as rapidly depending on the thickness of the plate. If the

object cools too slowly, it may have a softer core and a tougher "shell." The capacity of a steel to be hardened by that method is referred to as hardenability.

6. Machinability

Three key elements affect the machinability of steel bars, which are thermal treatment, chemical composition and cold work.

Thermal treatment enhances steel machinability by lowering hardness and strength, decreasing stresses, and regulating microstructure. While this is often used in higher carbon steels, a spheroidize anneal is occasionally used in extremely low carbon steels to increase formability. Stress relief annealing, lamellar pearlitic annealing, and spheroidize annealing are machining techniques used to enhance machinability in bar steels.

The chemical composition of the steel is a crucial component that contributes to its machinability or lack thereof. Among the chemical elements that increase machinability are: carbon, lead, sulfur, phosphorus.

Low carbon steels are excessively ductile, resulting in sticky chips and workpiece material buildup on the tool edge (BUE). Machinability is optimum between 0.15 and 0.30 wt percent carbon. Machinability reduces as carbon content exceeds 0.30.

Lead is added to steel to provide an internal lubricant and minimize friction while cutting. Lead has no effect on the mechanical properties of steel.

Sulfur and manganese interact to generate manganese sulfides, which assist in chip breaking and enhance surface quality. Higher amounts of sulfur in non-desulfurized steels are preferable for machining.

Phosphorus strengthens the steel's softer ferrite phase, resulting in a harder and stronger chip having less ductility, which promotes breaking and improves finishing.

Cold work enhances the machinability of low-carbon steels by diminishing the hot-rolled product's high ductility. Coldworking the steel by drawing through a die or cold rolling produces harder, more brittle, and curled chips, resulting in a less built-up edge on the tool's cutting edge. Because of the enhanced yield-to-tensile-strength ratio, your tools and machines will have to perform less effort to separate the chip.

7. Durability of Steel

One of the very important properties of steel is its durability. To begin with, steel is quite durable. It can tolerate harsh environments. Steel, as a compound metal composed of iron and carbon, is very resistant to most elements, making it perfect for places with high winds, frequent storms, and harsh weather. Steel is very ideal for stormy places because it can withstand the area's severe winds and blowing sand. Steel is ideal for almost any application since it can sustain these harsh conditions without buckling or breaking.

Being able to rely on the safety of your steel structure is a huge benefit for you, no matter what you use your building for. A solid and dependable structure, such as steel, implies less risk and responsibility, which may result in cheaper costs and less uncertainty for you. When it comes to pre-engineered construction, we enjoy how building has evolved to assure better and stronger buildings.

8. Toughness of Steel

It is in the nature of all materials to have certain flaws. These flaws take the shape of extremely small cracks in steel. If the steel is not tough enough, the crack can propagate quickly without plastic deformation, resulting in a brittle fracture. Brittle fracture becomes more likely when thickness, stress raisers, tensile stress and colder temperatures increase. Steel toughness and resistance to brittle fracture are determined by a variety of parameters that should be addressed throughout the specification stages.The usage of steel in construction

Uses of steel

Metal Fabricators throughout the world choose using structural steel for construction. It is extensively used:

To Build High Rise Buildings

Structural steel is unaffected to external forces such as wind and earthquakes. This one is a flexible metal, so in the event of a storm or an earthquake, the steel component in the construction will not break but bend.

To Build Industrial Sheds

The added benefit of structural steel is that it budget-friendly. With the handiness of ready-made steel sections, structural frameworks can be raised in no time. Besides, a lot of work can be pre-done in the industrial site, thus saving time and money.

To Build Residential Buildings

As stated above, these structures have to stand the test of time. They should be able to endure external forces such as wind, earthquakes, and storms. The plasticity and flexibility of structural steel make it appropriate for the construction of housing buildings. A method called light gauge steel construction is followed to build residential buildings.

To Build Bridges

Steel has got a high strength to weight ratio, which depicts, steel is a tensile metal. It is tough and can withstand the weight of a fleet of cars and people. These abilities enable engineers, designers, and fabricators to construct large, colossal bridges that can stand the test of time.

To Build Parking Garages

Structural steel is suitable to build parking garages for the same reasons as cited above. But another quality that makes it noticeably suitable in construction is that it is lightweight. This enables it easier to construct structures.

Steel inclines to lose its strength when exposed to extreme heat, it is for this purpose that steel structures are now protected with materials to make them fire-resistant. There are additional materials which are coated on these erections which make them corrosion, Mould, and vermin resistant.

Properties of Plastics as a Construction Material

Each plastic material has its own peculiar properties to suit its particular uses. The success of plastic as an engineering material will depends up on the selection of variety of plastic. Following are the general properties of plastic.

1. Appearance
2. Chemical resistance
3. Dimensional stability
4. Ductility
5. Durability
6. Electric insulation
7. Finishing
8. Fire resistance
9. Fixing
10. Humidity
11. Maintenance
12. Melting point
13. Optical property
14. Recycling
15. Sound absorption

16. Strength
17. Thermal property
18. Weather resistance
19. Weight

1. Appearance of Plastics

In the market there are so many types of models of plastics are available such as transparent, colored etc. suitable pigments are added in the process of manufacturing of plastic material to get these different properties. So, these will give good appearance to the structure and makes it attractive.

2. Chemical Resistance of Plastics

Plastics offer great resistance against chemicals and solvents. Chemical composition of plastics during manufacturing will decide the degree of chemical resistance. Most of the plastics available in the market offer great corrosion resistance. So, corrosive metals are replaced by plastic in the case of water carrying pipes, etc.

3. Dimensional Stability

Thermo-plastic types of plastics can be easily reshaped and reused. But in the case of thermo-setting type plastics, it is not possible to reshape or remold the material.

4. Ductility of Plastics

Ductile nature of plastic is very low. When tensile stress are acting on plastic member they may fail without any prior indication.

5. Durability of Plastics

Plastics with sufficient surface hardness are having good durability. Sometimes, plastics may affected by termites and rodents especially in the case of thermo-plastic types, however it is not a serious problem because of no nutrition values in plastic.

6. Electric Insulation

Plastics are good electric insulators. So they are used as linings for electric cables and for electronics tools.

7. Finishing

Any type of finishing treatment van be given to the plastics. Mass production of plastic particles with uniformity of surface finish is done by having technical control during manufacturing.

8. Fire Resistance

The resistance to temperature or fire for varieties of plastics considerably varies depending upon the structure. Plastics made of cellulose acetate are burnt slowly. PVC made plastics do not catch fire easily. Plastics made of phenol formaldehyde and urea formaldehyde are fire proof materials.

9. Fixing

Fixing of plastic materials is so easy. We can bolt, drill or glued to fix plastic material position.

10. Humidity

The plastics made up of cellulosic materials are affected by the presence of moisture. The plastics made of poly vinyl chloride (PVC pipes) offers great resistance against moisture.

11. Maintenance

Maintaining of plastics are so simple. Because they do not need any surface finishing coats or paints etc.

12. Melting Point

Generally plastics have very low melting point. Some plastics may melt at just 50oC. So, they cannot be used in the positions of high temperature. Thermo setting type of plastics are having high melting point than thermo plastic type plastics. However, thermo setting types are cannot used for recycling. To improve the heat resistance of the plastics, glass fiber reinforcement is provided in its structure.

13. Optical Property

There are so many types of plastics. Some plastics are transparent which allows light in its original direction and some are translucent nothing but semi-transparent which allows light but changes light rays direction.

14. Recycling of Plastics

Disposal of plastics in the environment causes severe pollution. But it is not a serious problem because of its recycling property. We can use plastic waste disposal conveniently to produce drainage pipes, fencing, hand rails, carpets, benches etc.

15. Sound Absorption

By the saturation of phenolic resins we can produce acoustic boards. These acoustic boards are sound absorbents and provide sound insulation. Generally for theatres, seminar halls this type of acoustic ceilings are used.

16. Strength

Practically we can say that plastic is strong material but ideal section of plastic which is useful for structural component is not designed yet. Generally by reinforcing fibrous material into plastic improves its strength. If the strength to weight ratio of plastic is same as metals, then also we cannot give preference to plastics because of various reasons like, heavy cost, creep failure may occur, poor stiffness and sensitive against temperature.

17. Thermal Property

The thermal conductivity of plastics is very low and is similar to wood. So, foamed and expanded plastics are used as thermal insulators.

18. Weather Resistance

Most of the plastics except some limited varieties are capable of resistance against weathering. But, major problem is plastics when the plastics are exposed to sunlight, they are seriously affected by ultra violet rays and gets brittle. To prevent this, plastics are incorporated by fillers and pigments which helps to absorb or reflect the UV rays to surface.

19. Weight of Plastics

The Plastics have low specific gravity generally ranges from 1.3 to 1.4. So they are light in weight and easily transportable to any place in a large quantity.

Uses of plastics

Exterior covering

- Polyester coated concrete by Moulding from an existing plates.
- Sprayed polyurethane with sand and gravel agglomeration.
- Epoxy resins and polyesters on various supporting media
- PVC plasticized plates (spraying, coating or adhesive films)
- Polyester epidermis available as permanent shuttering

Weather Boarding

- Polyester
- PVC

- Polymethyl methacrylate

Windows

- PVC casing on metal Moulding
- Polyester laminated sheet on wooden Moulding
- PVC – chlorinated polyethylene compound
- Methyl polymethacrylate
- Polyester glass fiber and phenolic foam core
- PVC/ wood

Rolling Shutters

- Plasticized PVC extruded sections
- Rigid PVC extruded sections
- Polyamide winding gear
- Blinds and sunscreens
- Polyester, PVC

Interior Covering

a) Wall Lining

- Adhering films – vinyl coated fabrics or paper vinyl sheet doubling on fabric or paper etc.
- Sprayed lining polyurethane
- Laminate - Melamine and phenolic plastics – polyester
- Wall tiles – polystyrene, PVC – tiles or mosaic
- Coating – polyvinyl acetate

b) Floor Covering

- Asbestos plastic slabs (asphalt tile type)
- Vinyl asbestos slabs
- Homogeneous semi-flexible vinyl slabs
- Flexible, homogeneous or multi-layered vinyl slabs.
- Homogeneous vinyl carpets (a) stuck, (b) laid
- Vinyl carpets on felt (applied or coating)
- Multi-layered coating with cellular structure on fabrics
- Multilayered coating on cork structure
- Vinyl carpets on jute cloth.
- Thermosetting resin based covering
- Rubber covering
- Synthetic fiber tensile covering (polyamides, viscose etc.)

Ceilings and Counter Ceilings

- Translucent – polyester, PVC, polyamides, polyurethanes
- Opaque, extruded polystyrene or vinyl copolymers, impact type polystyrene
- Lighting – PVC, polymethylmethacrylate

Roof Covering

- Flat or corrugated sheets – polyester, PVC, polymethylmethacrylate
- Curved sheets – reinforced polymer
- Domes – polyester, polymethylmethacrylate
- Casements – polymethylmethacrylate, reinforced polyester
- Troughs – class / polyester
- Gutters – Rigid PVC polyester
- Downpipes – PVC

Roof Tightness

- Polybutylene with or without glass cloth armature
- Butyl rubber
- Multilayered bitumen with PVC film screens and armatures
- PVC sheets
- Welded polyester

Sanitary Equipment and Piping

- Appliances
- Sinks – polymethylmethacrylate, polyester, polyamides
- Basins – polyester, polymethylmethacrylate – polyester / glass fiber
- Baths – polyester, polymethylmethacrylate
- Showers – polymethylmethacrylate, polyester
- PipeWorks – PVC, phenolics, ABS – terpolymer
- Fittings – PVC and ABS – terpolymer – phenolic plastics
- Traps – polyamides
- Water – finishings – polystyrene and copolymers, polymer and copolymers, polyethylene

Insulation

Insulation materials and application of foams

- Polystyrene
- PVC
- Phenolic
- Formaldehyde urea
- Polyurethane

Properties of Bitumen and Bituminous Materials

Following are the properties of Bitumen

A. Adhesion
B. Resistance to Water
C. Hardness
D. Viscosity and Flow
E. Softening Point
F. Ductility
G. Specific Gravity

H. Durability
I. Versatility
J. Economical
K. Strength

1. Adhesion:

This property of bitumen cans bines all the components together without changing any properties of their road material. Bitumen has the ability to adhere to a solid surface in a fluid state depending on the nature of the surface. The water presence on the surface will prevent adhesion.

2. Resistance to Water:

We all know that bitumen is insoluble in water and can serve as effective sealant bitumen is water resistant capacity. Under some conditions water may be absorbed by minute quantities of inorganic salts in the bitumen or filler in it.

3. Hardness:

The hardness of bitumen can be measure by the penetration test which is measures the depth of penetration in tenths of m, the weighted needle is penetrate in bitumen after a given time, at a known temperature maintained in bitumen.

The bitumen grades measure by penetration, if penetrations greater than 40 than that type of bitumen mostly used in road construction and occasionally in industrial applications. If the penetrations less than 40 than that type of bitumen used exclusively in industrial applications. At hot climate lower grades bitumen is used.

4. Viscosity and Flow:

Bitumen are thermoplastic, viscoelastic materials, which behavior depends on temperature, speed and size of the load. Viscoelastic character means that by impact of external forces partially elastic deformation occurs (elastic component) and partially plastic strain occurs (viscosity component). At low temperatures, respectively, at high frequencies of load (fast passing cars), the bitumen behave as an elastic and solid material. The elastic unit is deformed under load and after reducing the load, it is returned to the original shape. This behavior, however, lasts continues as long as exceeding the limits of bearing capacity and materials damage, it means the bitumen binders crack. At high temperatures, respectively, during long-term loading (parking vehicles), the bitumen behaves as a viscous material. Resultantly, decrease in adhesive and flow properties and an increase in the softening point temperature and coefficient of thermal expansion.

5. Softening point:

Bitumen with lower softening point tends to melt on the road in summer and start flowing under the impact of temperature and traffic. Therefore it can be concluded that bitumen's with higher softening point melt at higher temperature and having better rutting resistance. This property make us to know whether given bitumen can be used at the particular place i.e. softening point value should be higher than pavement temperature otherwise bitumen present in the layer get soften and come out. These Properties of material can be tested in lab.

6. Ductility:

Bitumen is a highly ductile material, we can change the bitumen at solid and liquid state easily, Ductility test is conducted to determine the amount bitumen will stretch at temperature below its softening point. A briquette having a cross sectional area of 1 in2 is placed in a tester at 77 °F. Ductility values ranges from 0 to over 150 depending on the type of bitumen. If

bitumen is more ductile than it is very easy to form or formation of the film and coating would be proper.

7. Specific Gravity

Specific gravity of a binder does not influence its behavior . But all the same, its value is needed in mix design. The property is determined at 27º C.

8. Durability:

Bitumen durability refers to the long-term resistance to oxidative hardening of the Material in the field. Although, in-service, all bitumen harden with time through reaction. With oxygen in the air, excessive rates of hardening (poor durability) can lead to premature binder embrittlement and surfacing failure resulting in cracking and chip loss. Bitumen lives up to twenty years if maintained properly throughout the pavement life.

9. Versatility:

Bitumen have versatile properties due to versatility properties of Bitumen it is relatively easy to use it in many applications because of its thermoplastic property. It can be spread easily along the underlying pavement layers as it liquefies when heated making the job easier and hardens in a solid mass when cooled.

10. Economical:

At road construction bitumen is used as a main road construction material because it is available in cheaper rates as compare to another binder material almost all over the world which makes it feasible and affordable in many applications.

11. Strength:

Though the coarse aggregates are the main load bearing component in a pavement, bitumen or asphalt also play a vital role in distributing the traffic loads to the layers beneath.

USES OF BITUMEN

- Road and Highway Construction.
- Runway construction.
- Hydraulics & erosion control Catchment areas, basins.
- Dam grouting's.
- Dam linings.
- Embankment protection.
- Reservoir linings.
- Jetties, Dyke protection.
- Dyke protection.
- Swimming pools.
- Waste ponds.
- Water barriers.
- Mattresses for levee & bank protection.
- Membrane linings,
- Waterproofing.
- Revetments.
- Sand dune stabilization.
- Drainage gutters.
- Backed felts.

BUILDING TECHNOLOGY

UNIT – II
ADVANCED BUILDING MATERIALS

NANO MATERIALS: Introduction – Types and its applications.
SMART MATERIALS: Introduction – Types of smart materials and its applications.
MODERN BUILDING MATERIALS**:** Building products made of gypsum and their uses - GFRG

NANO MATERIALS

NANO TECHNOLOGY

Unlike the situation where conventional technologies are used to manipulate construction materials at the millimeter scale to achieve certain properties, similar properties can be achieved at the nanoscale by using nanotechnology. Nanotechnology has proved to be very useful in biological, physical, and chemical disciplines to solve real-world problems at the levels of the atomic and sub-micron scale.

Nanomaterials are described as materials that are extremely tiny in size and their size varies from 1 to 100 nm which is usually measured in the form of nanoscale. Due to their amazing work and technicalities, Nanomaterials have made their mark in the market and are now emerging as commodities because of their commercialization and authenticity. Their external and internal dimensions are present in the nanoscale and as explained above their length always ranges from 1 to 100nm. They are one of the most amazing materials because they provide great characteristics to any and everything they are a part of. Their work dimensions have drastically increased over time and now they are a huge part of almost all the industries and the market. Their size and shape do not define their characteristics and that's why they are now being commercialized at such a huge scale. Nanomaterials have a lot of uses in a lot of fields and it is all due to their remarkability and their authentic performances in all the fields as they not only prove their work but also provide measures that ensure the authenticity of the said products and materials.

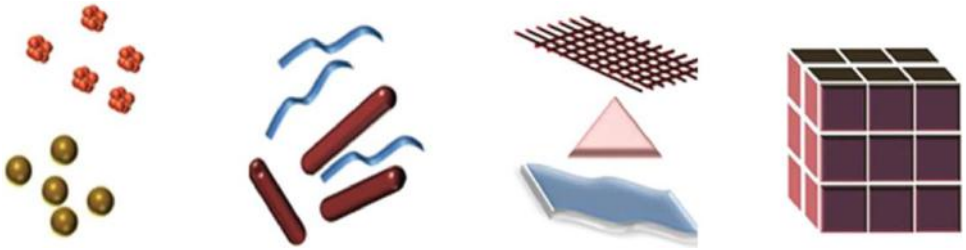
Nanomaterials form the bulk of new innovations and technologies that have fundamentally changed the quality of civil engineering materials and products. Nanomaterials usually have fundamental properties, such as the ability to measure the surface using the nanoscale. It means that the external or internal dimensions of the surface structures can be determined using the nanoscale.

The external surfaces of a nano object are used to determine the right category of nanomaterials to use to build the nano object. The internal measurements of the nanomaterial taper from small to large when they are taken along the principal axis that is not straight

Nanomaterials are cornerstones of nanoscience and nanotechnology. Nanostructure science and
technology is a broad and interdisciplinary area of research and development activity that has been growing explosively worldwide in the past few years. It has the potential for revolutionizing the ways in which materials and products are created and the range and nature of
functionalities that can be accessed. It is already having a significant commercial impact, which will assuredly increase in the future.

Nanoscale materials are defined as a set of substances where at least one dimension is less than approximately 100 nanometers. A nanometer is one millionth of a millimeter - approximately 100,000 times smaller than the diameter of a human hair. Nanomaterials are of interest because
at this scale unique optical, magnetic, electrical, and other properties emerge. These emergent properties have the potential for great impacts in electronics, medicine, and other fields.

Nanomaterials are already in commercial use, with some having been available for several years or decades. The range of commercial products available today is very broad, including stain resistant
and wrinkle-free textiles, cosmetics, sunscreens, electronics, paints and varnishes.
Nanocoating and nanocomposites are finding uses in diverse consumer products, such as windows, sports equipment, bicycles and automobiles. There are novel UV-blocking coatings on glass bottles which protect beverages from damage by sunlight, and longer-lasting tennis balls using butyl-rubber/nano-clay composites.



Classification of nanomaterials (a) 0D spheres and clusters; (b) 1D nanofibers, wires, and rods; (c) 2D films, plates, and networks; and (d) 3D nanomaterials

One way to classify nanomaterials is by the number of dimensions not confined to the nanoscale range. Zero-dimensional nanomaterials have all dimensions within the nanoscale zero dimensions (0D), but no dimensions are larger than 100 nm. They are the most common nanoparticles. One-dimensional nanomaterials have one dimension (1D) outside the nanoscale. They include nanotubes, nanorods, and nanowires. Two-dimensional nanomaterials have two dimensions (2D) not confined to the nanoscale. They include nanofilms, nanolayers, and nanocoating's. Three-dimensional nanomaterials, or bulk nanomaterials have all three dimensions (3D) outside the nanoscale.

Nano materials primary classified into **two** types

1. Natural nanomaterials
2. Artificial nano materials

Natural Nanomaterials

These include nano materials that exist in biological systems e.g. viruses, substances in our bone matrix, ribosome machinery etc.,

Artificial Nanomaterials

These are the ones that are fabricated by different experiments

- Carbon based
- Metal based
- Dendrimers
- Composites

Carbon Based Materials

These nanomaterials are composed mostly of carbon, most commonly taking the form of a hollow spheres, ellipsoids, or tubes. Spherical and ellipsoidal carbon nanomaterials are referred to as fullerenes, while cylindrical ones are called nanotubes. These particles have many potential applications, including improved films and coatings, stronger and lighter materials, and applications in electronics.

Metal Based Materials

These nanomaterials include quantum dots, nanogold, nano silver and metal oxides, such as titanium dioxide. A quantum dot is a closely packed semiconductor crystal comprised of hundreds or thousands of atoms, and whose size is on the order of a few nanometers to a few hundred nanometers. Changing the size of quantum dots changes their optical properties.

Dendrimers

These nanomaterials are nanosized polymers built from branched units. The surface of a dendrimer has numerous chain ends, which can be tailored to perform specific chemical functions. This property could also be useful for catalysis. Also, because three-dimensional dendrimers contain interior cavities into which other molecules could be placed, they may be useful for drug delivery.

Composites

Composites combine nanoparticles with other nanoparticles or with larger, bulk-type materials. Nanoparticles, such as nanosized clays, are already being added to products ranging from auto parts to packaging materials, to enhance mechanical, thermal, barrier, and flame-retardant properties.

Nanomaterials Applications in the Construction Industry

Nanomaterials have now paved their way in the construction industry and that is why this very revolution has brought an insane amount of changes in the products, services, and industries including the construction industry as well. It is very important to record an effect or impact that they cause on the environment and as well as on humans. There are a lot of benefits that nanomaterials have on the construction sector and the way that they protect the ecosystem is truly phenomenal. The nanomaterials are insanely small in size and due to their size, their performance is enhanced as the particles having a small size can exhibit advancements in the fields of catalysis, conductivity, magnetism, mechanical strength, and optical sensitivity as well. All these characteristics add up to a wide range of applications and are proving as a great material for the construction industry and all the processes that are involved in it.

Concrete

Nanomaterials have a wide range of applications in the field of construction and one of those is concrete. Concrete has the highest annual production as compared to all the other materials and this is due to the mixture of carbon nanotubes (CNTs) and the nanosized SiO_2 as well as these enhance the concrete mixture which includes the binding phase as well as the aggregates. Concrete has a huge amount of nanomaterials and that is what makes them more applicable in the construction field. Their weightage though is not too much but all the nanomaterials combined to make a huge difference in the whole criteria and the scenario itself.

Steel

Steel is used for building purposes and bridge constructions. These face challenges following strength, resistance, and formability as well. This is due to their introduction in the field of metal nanoparticles (NPS). Along with that, the copper particles are used to lessen the surface roughness to improve the anti-corrosion activities too.

Window glass

Along with concrete and steel, window glass is also one such thing that can be used to accomplish a lot of functions by the addition of TiO_2 and SiO_2 both in the form of nanoparticles. When the nanoparticles of TiO_2 are coated on the windows via a photochemical process then the reaction with sunlight and indoor light is productively used for the removal of both the dirt and the bacterial films as well if any of those are present. Whereas the silica layers or sheets which are present in the form of nanoparticles are used to fireproof the windows and are highly authentic. It is due to these properties and reasons that the usage of nanomaterials is being promoted at a huge level.

Minimizing the effects on the environment

As far as the advantages are concerned, there are some harmful effects too that might be caused due to the products and materials involved in the said field. However nanomaterials in the form of nano-electromechanical and micro-electromechanical systems (NEMS and MEMS). These are comprised of sensors that are either nano or micro in size as they have been a recent material of a lot of attention. They are highly being used for the protection of both the environment and the humans from any and every harmful effect that might be caused due to over-usage of the nanomaterials but the point is that nanomaterials themselves are used as a protective measure for eradicating the harmful effects on the environment.

Evaluation of hazards

Before jumping to the conclusion as to how we can minimize the harmful effects on the environment, we need to evaluate the hazards that are a source of causing harm to the environment. To evaluate those very hazards a certain targeted biota is set which helps the researchers and the case studies as to what led the chemicals to improvise the hazards for the environment itself. Evaluation is important as it gives a lead towards the main and root cause of the problem and a problem can only be solved if its root cause is known completely. Nanomaterials play a huge role in such identification and evaluation and that is why they are now being used more progressively in comparison to their past usage.

Waste management

The waste that is collected throughout the entire construction process has to be and needs to be managed properly because if that waste will be left open in the environment then it will cause a lot of potentially high health risks. Nanomaterials are very useful for such purposes and are effectively used for the management of wastes. These materials are a great source of protecting the environment and the humans from all the toxicity that the waste can bring along if it is left untreated and compiled in a single place in the form of garbage.

Construction wastes

There are a certain set of wastes that are generated while repairing, renovating, and any construction activities. To get rid of those very construction wastes it is important to dispose of them in the right places at the right time to avoid any hazardous harm in the form of health risks.

Manufacturing

A lot of products are released into the environment when the process of manufacturing is being carried out. It is important to get rid of all those hazardous materials that in one way or another are causing serious effects to the environment and humans both. To continue with this process, nanomaterials are used in bulk to make resources that will work as the protective agent for the environment and humans. Their harm can be so adverse that they can cause death-causing diseases too if left untreated. However, nanomaterials when adequately used can serve this purpose and act accordingly for the betterment of the environment.

SMART MATERIALS

Smart materials have different properties that can be changed according to the conditions in a controlled way by external factors, such as temperature, light, stress, moisture, electric or magnetic fields, pH or chemical compounds. These are also known as intelligent or responsive materials.

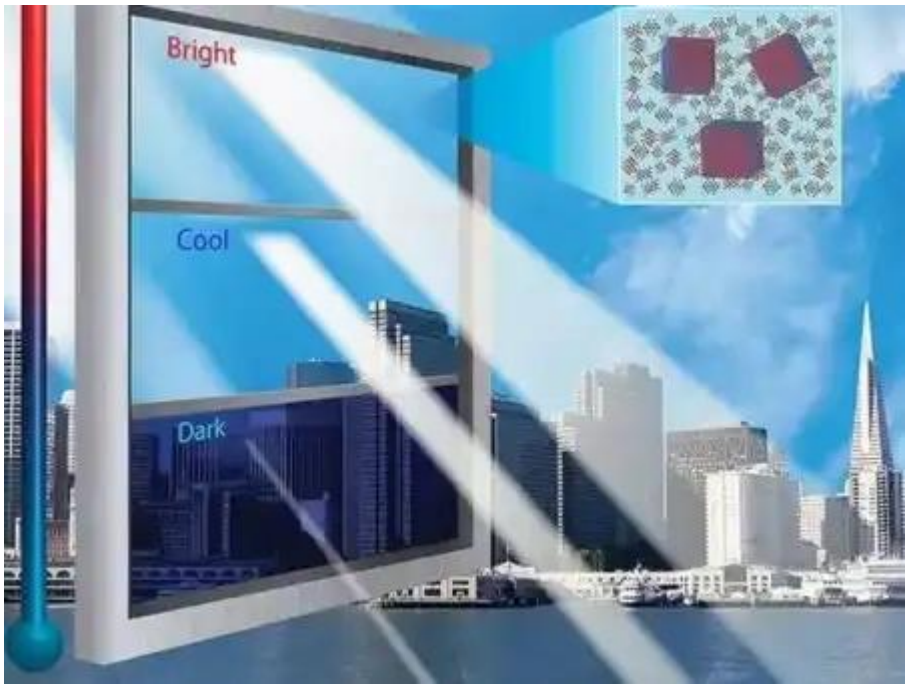
Their unique properties make them crucial materials in many fields of engineering. They are used in various civil engineering projects and contribute to increased performance and energy efficiency of a structure.

With the advancement of technology and the researches, new materials have been the developed and new types of smart materials have been introduced. Following are some of the varieties of materials which can be called as Smart materials.

TYPES OF SMART MATERIALS

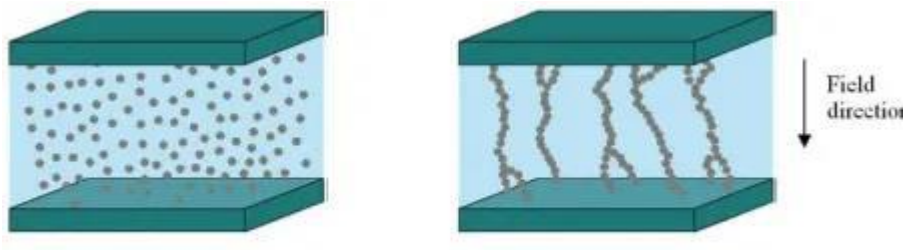
Electrochromic Materials

These are the materials which alter their light transmission properties when the voltage is applied to them. They affect the optical colour or opacity of a surface when a voltage is applied to them and also known as chromophores.



Electrorheological Fluids

These are the materials which are having colloidal suspension that undergoes changes in the viscosity when they are subjected to an electric field. These are Fluids which are highly sensitive and respond instantaneously to any change in the applied electric field. They are used in shock absorbers.

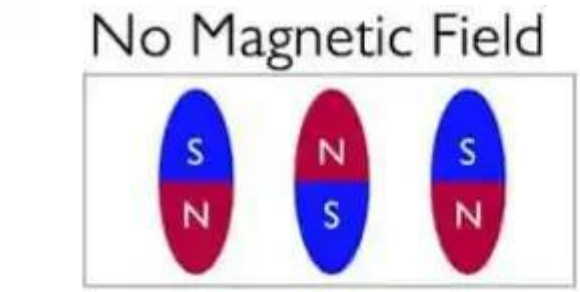


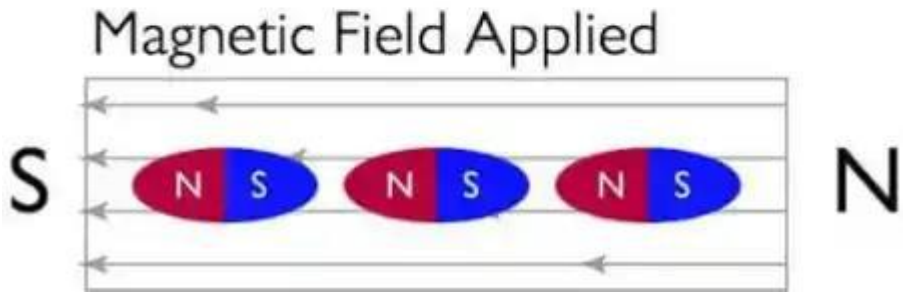
Piezoelectric Materials

These are the materials which possess capability to produce voltage when surface strain is introduced. These are the materials which undergo deformation when an electric field is applied across it. When it is integrated into a structural member, these materials generate an electric field in response to magnetic forces.

Magnetostrictive Materials

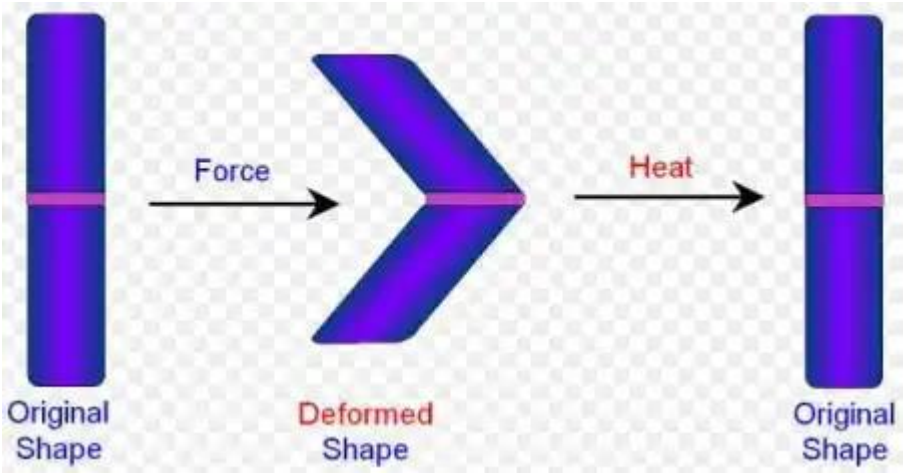
These are the materials which undergo mechanical deformation is proportional to the square of the electric field, which refers to the material quality of changing size in response to either magnetic field, and conversely, producing a voltage when they are stretched. These have been widely used in pumps, valves and aerospace wind tunnel.





Shape Memory Alloys

These are the materials which possess the ability to regain to some previously defined shape or size when they are subjected to the suitable thermal changes. Shape memory alloys have their applications in new civil engineering projects in the seismic protection of buildings. These are used in civil engineering projects for repeated absorption of strain energy without permanent deformation, for obtaining a wide range of the cyclic behaviour and to resist the fatigue resistance and they are used due to their great durability and reliability in the long run.



Electrostrictive Materials

This material has the same properties as piezoelectric material, but the mechanical change is proportional to the square of the electric field. This characteristic will always produce displacements in the same direction.

Thermoresponsive Materials

Thermoresponsive is the ability of a material to change properties in response to changes in temperature. They are useful in thermostats and In parts of automotive and air vehicles.

Applications of Smart materials

- Smart Materials are used in constructing smart structures and which are capable of sensing minute structural cracks and flaws.
- Smart Materials can be used for electromagnetic shielding and for enhancing electrical conductivity.
- Smart Materials plays a vital role in the construction of road pavements as a traffic-sensing recorder, and also melts ice on highway and airfields during snowfall in the winter season bypassing the low voltage current through it.
- Smart Materials are used in the designs of Smart buildings. They are used for vibration control, noise mitigation, safety and performance.
- Smart Materials are used in smart buildings for environmental control, structural health monitoring.

- Smart Materials are used to transform efficiency, comfort and safety for people and assets in smart buildings.
- Smart materials also reduce the effects of earthquakes.
- Smart Materials are used in marine and rail transport applications for strain monitoring using embedded fibre optic sensors.
- Smart Materials have used for the construction of Smart bridges especially cable-stayed bridges with a wider span to avoid the increases susceptibility to vibrations which are caused by wind, rain or traffic. These structures require less maintenance and the response of a structure can be monitored conveniently.
- Smart Materials are also used to monitor the civil engineering structures to evaluate their durability.
- Smart Materials are used to monitor the integrity of bridges, dams, where the fibre-optic sensors are embedded in the structures, are utilized to identify the trouble areas.
- Smart Materials can be used to rehabilitate the cracking and flaws of concrete when super elasticity smart material is used as the reinforcement bar.

GYPSUM

The gypsum is the hydrated sulphate of calcium and its chemical composition is $CaSO4\ 2H_2O$. It contains 79.1% calcium sulphate and 20.9% water. It is a white crystalline substance. Its density is 0.023 N/cm³. It is soft hardness being equal to 2. As a binding material, the gypsum quickly sets and hardens. Its initial setting time after addition of water is about 4 to 6 minutes and its final setting time is about 30 minutes. Its solubility in water is very poor, about 1% of gypsum in 495 parts of water. It is soluble in hydrochloric acid. But it is insoluble in sulphuric acid.

The gypsum very seldom occurs in nature in pure state. It contains impurities such as alumina. calcium carbonate, magnesium carbonate and silica. The gypsum containing upto 70% of $CaSO4\ 2H_2O$ can be used as a building material.

The physical forms of gypsum may be crystals as selenite. fibrous as stain spar and massive as alabaster. It is mainly used in the manufacturing of cement to increase its setting time. It is also used to prepare plaster of paris and gypsum boards. These boards are popularly known as the gypboards and they are formed by mixing gypsum with asphalt. The gypsum is also used as a filler in paint, paper and rubber industries.

GYPSUM PLASTER

Gypsum plasters gain one-half of their one-month strength in a day. Gypsum and sand mortars of 1:1 proportions may be expected to develop 80% of the neat strength at corresponding ages, while those of 1:2 proportions generally possess one-half to two third, of the neat strength. The gypsum to sand neat plaster in proportion of 1: 3 should set in 2 to 32 hours and in 1.5 to 8 hours when mixed with wood filers. The dry set density of gypsum wall plaster is 850 - 1040 kg/m³ and compressive strength of 1:2 gypsum wall plaster is 6 to 15 N/mm².

Gypsum wall plasters are divided into following four categories

Gypsum Neat Plaster

Gypsum neat plaster is 60.5% or more of calcined gypsum (plaster of paris) with material added to control workability, time of set and cohesiveness.

Gypsum Wood Fibre Plaster

Gypsum Wood Fibre Plaster is 60.5% or more of calcined gypsum. wood fibre 1.0% or more to

increase cohesiveness, and the remaining material to control workability and time of set.

Calcined Gypsum

Calcined Gypsum is used for finishing coat. It may or may not carry a retardant. Calcined gypsum may be white or grey.

Gypsum Ready Sanded Plaster

Gypsum ready sanded plaster consists of cementing material, predominantly calcined gypsum which has been mixed at the mill with the proper properties of sand and other desirable constituents. It is prepared for use simply by adding water. There are two grades of Gypsum Ready sanded plaster, the scratch or first coat, and the browning or second coat. The scratch coat contains 2 sand to 1 cementing material by weight. The browning coat contains 3 sand to 1 cementing material by weight. The cementing material carries at least 60.5% by weight of calcined gypsum and other ingredients to control set and workability.

USES AND PROPERTIES OF GYPSUM PLASTER

Following are the properties and uses of the gypsum plaster.

1. It is a fire-resistant material and it does not allow heat to pass easily. Hence it is used as an insulating material to protect wood or metal columns and beams from high temperature.

2. It is light in weight. To decrease the weight further, the fillers such as granulated cork, saw dust, wood, showings etc. may be added to it. Such fillers also improve heat and sound insulating quality of the gypsum plaster.

3. It is practically not affected by bacteria.

4. It is slightly soluble in water, about 2 gm/litre. Hence it cannot be adopted for damp conditions and external work. The bags containing gypsum plaster should therefore be stored in dry place.

5. It is used for ornamental plaster work and for preparation of boards and blocks. The gypsum plaster boards are used for ceiling, for internal lining of wall and for partition walls. They are cheap, easy to work, light in weight and fire proof.

6. It requires small proportion of sand and other aggregates. When used as base coat, the sand or light weight aggregate or wood fibre is added. When used as final coat, the lime putty is added.

7. It sets by natural process of crystallization. Hence it can be applied with case and without wastage.

8. It sets with little change in volume and with negligible shrinkage or drying

9. It shows good adhesion to the fibrous materials.

10. The plaster of paris is used in artwork, pottery, dentistry and in surgery for the shaping of fractured bones.

BUILDING PRODUCTS OF GYPSUM AND THEIR USES

A. Plaster Boards

They are made from a large sheet of gypsum plaster faced on both sides with stout paper as a reinforcement. They are available in thickness varying from 9.5 mm to 12.5 mm. There are two types of plaster boards depending upon the nature of facing plaster.

(i) Gypsum lath board (ii) Plaster wall board

In gypsum lath board, facing paper is rough to provide an adhesive grip for plaster, while in plaster wall board, the facing paper is of self-finish type to provide decorative finish such as a wood veneer. Because of good insulating properties, plaster boards are normally used for partition walls, internal lining of walls and for partition walls.

B. Pyrocell

When water is added to finally ground gypsum powder, gas is liberated and the mixture is expanded 3 to 4 times its volume. It hardens after some time. This mixture is known as pyrocell. It is light, cellular and fire-resistant. It is normally used for acoustical and insulating purposes in buildings.

C. Non-Load Bearing Gypsum Partition Blocks

These can be solid or hollow, rectangular with straight and squares edges and true surfaces. The compressive strength of these partition blocks should not be less than 50 N/m² on gross area. These boards are available in sizes as given in Table.

Length (mm)	Height (mm)	Breadth (mm)	Hollow Blocks	
			Circular Holes (mm)	Rectangular or Elliptical Holes (mm)
700 maximum in step of 100	300 maximum	75 100 125 150	15 20 25 15	20 20 30 20

GFRG PANEL

A GFRG panel is basically calcined gypsum plaster, reinforced with glass fibres which when filled with reinforced concrete in an appropriate proportion becomes strong enough to act as a load bearing and shear wall. GFRG panels can even resist the lateral loads due to earthquakes and wind. Not only the walls, but the roofs, floors, sunshades and the boundary walls can be also made using GFRG panels. Looking at its success and innumerable advantages, the technology spread like wildfire and is being adopted heavily throughout the construction industry.

GFRG houses are:

- Fire-resistant up to 1000°C
- Earthquake resistant
- Naturally cooler up to 4°C
- Eco-Friendly
- Water-resistant
- Economical

Advantages of GFRG Panel

a. Rapid Construction'
b. More carpet area for the same built-up area;
c. Less included the energy and carbon footprint, an essential reduction in the use of steel, sand, cement, and water;
d. Less construction cost;
e. Less building weight, hence reduction in design for seismic forces and savings in the foundation, especially in multi-storeyed buildings;
f. One can construct 8 to 10 storeyed buildings using GFRG Panels;
g. It gives a smooth finishing;
h. It releases less Co2 compared to other traditional building materials;
i. GFRG Panel made building gives better thermal comfort inside in winter season

GFRG Panel Disadvantages

- It requires more space for the movement of a crane during the construction time.
- It makes the construction method less cost-effective since the design of the GFRG Panel is complicated.
- For installing the GFRG panels, highly experienced and skilled labor is needed
- During the transportation and erection process, the GFRG Panel should be handled carefully.
- To cut the GFRG Panel at the site, it requires specific machinery.
- GFRG panels can't be used for the construction of walls in circular or in curve shape.

Applications of GFRG Panel in Building Construction

For Load Bearing Walls

For load-bearing walls: One of the most common applications of GFRG panels is observed as load-bearing structures in the buildings. When the cavities inside the GFRG panels are filled with

concrete, the compressive strength of the panels gets enhanced. Additionally, when the reinforcing bars are introduced, the ability of the panel to resist the lateral loads also gets enhanced. Henceforth, using such load-bearing structures in the construction is the most suitable option for multistoried buildings.

Partition Walls

GFRG panels can also be used as partition in-fill walls in single or multi-storied buildings. Such panels are used as partition walls, whereas these panels can also be used for cladding in industrial buildings or sports ground. Likewise, they can also be used as compound walls or security walls.

Horizontal Floor and Roof Slabs

GFRG panels for floor and slab are cut to the required size and it's marked with notations. Firstly, the wall joints, cavities, and the horizontal RCC tie beams are filled with concrete. Thereafter, a wooden plank of width 300 mm to 450 mm is provided to room span between the walls with support wherever the embedded microbeams are present. Finally, roof panels are to be lifted by the crane so that the panel can float perfectly horizontal. Each of the GFRG roof panels is placed over the wall in such a way that a minimum gap of 40 mm is provided.

Step-By-Step Construction Using GFRG Panels

Excavation and Foundation Work

Excavation of soil is executed in the same way to lay the foundation. Once the foundation is placed, the waterproofing of the foundation is fulfilled by spraying suitable chemicals.

Placing panels

The casting of reinforced concrete is laid down for the plinth beams. Then the starter bars are set inside the concrete casting so that the GFRG panels can be installed. They are put on the starter bars according to the dimensions and the areas allotted to them. Once they are set, waterproofing is given for protecting the joints.

Pouring concrete

After fixing the GFRG panels, they must be held in place until the concrete mixture is poured on them. The support bars provide support to these panels. After that, the concrete mix is filled into each of the holes of panels from the top.

Placing slabs

After finishing the walls, the panels are placed on the top as slabs. A reinforcement cage for the set beams is fitted and concrete screed is provided by pouring concrete mix on the slab.

UNIT – III

SURFACE FINISHES: Plastering – Pointing – White washing, distempering and Painting – Damp proofing - Form work and scaffolding.

PLASTERING AND POINITING

OBJECTIVE OF POINTING AND PLASTERING

The main objectives of providing point and plastering to the exposed surface are listed below:

- It is done for the improvement of the structure and to give it a smooth surface.
- It acts as a protective layer for the exposed surfaces from the effects of atmospheric actions.
- It is also a conductor, in case of inferior materials used or act as a rectifier to remove or rather hide defective workmanship.

PLASTERING

This is the process of covering rough walls, uneven surfaces in the construction houses and other structures with a plastic material, called plaster or mortar. Sometimes, the term 'rendering' is used instead of plastering when the plaster or cement is applied to the external surfaces of walls either to improve the appearance or to protect them from weather agencies, such as rain, heat, etc.

REQUIREMENT OF A GOOD PLASTER

To turn out to be a good plaster, the plastering material must possess or satisfy the following requirements:

1. It should adhere to the background and should remain adhered during all variations of the climate changes. Also, it should be possible to apply it during all weather conditions.

2. It should not contract in volume while drying and setting otherwise it will crack and give an unsightly appearance.

3. It should be cheap and economical.

4. It should be hard and durable, providing a smooth, non-absorbent and washable surface with required decorative effect and durability.

5. It should offer good insulation against sound and high resistance against fire.

6. It should effectively check the entry or penetration of moisture from the surface.

7. It should possess good workability.

TYPES OF PLASTER

There are various types of plasters used according to the requirements. To name some are as below:

- Lime plaster
- Mud plaster
- Cement plaster
- Water-proof plaster

1. Lime Plaster

Lime is used in plastering may be fat lime or hydraulic lime. Fat lime makes best plaster as they yield good putty after slaking. Hydraulic lime on the other hand yields harder and stronger plaster, but it may contain some unslaked particles which may slake slowly (may be in 8 to 12 months) on absorbing moisture from atmosphere and damage the plastering by forming blisters. As a precaution the hydraulic lime, if used, should be ground dry with sand: lift for about 2 or 3 weeks and then reground before use.

Mortar for lime plaster is usually prepared by mixing sand and lime in equal proportions. Cement in small quantity is sometimes added to the mixture to improve its strength. Gugal (a kind of fragrant gum) and chopped hemp are sometimes added at the rate of 4.5 kg and 2.7 kg respectively to every 2.85 cu.m. of plaster. This treatment prevents the formation of cracks in plaster on drying.

2. Mud Plaster

The mud plaster is prepared from equal volumes of well tempered clay or brick earth and of chopped straw, hay, loose soil or hemp and cow dung. All these ingredients are thoroughly mixed and lift for about 7 days with a large quantity of water. This is mixed again thoroughly till it comes to the desired consistency of plaster sometimes mud plaster made of clay and sand is also used.

3. Cement-Plaster

The cement plaster consists of one part of cement to four parts of clean, coarse and angular river sand by volume the materials are thoroughly mixed in dry condition before water is added to them. The mixing of materials is done or a water tight platform and plaster of one cement bag only is prepared at a time and this quantity of plaster is consumed within 30 minutes after adding water.

4. Water-Proof Plaster

The water proof plaster is prepared by mixing one part of cement, two parts of sand and pulverised alum at the rate of 120 N per m^2 of sand. In the water to be used. 0.75 N of soft soap is dissolved per one litre of water and this soap water is then added to the dry mix.

TOOLS FOR PLASTERING

The following tools are generally used in the plastering work:

1. Gauging Trowel

2. Floats

3. Floating Rule

4. Plumb bob

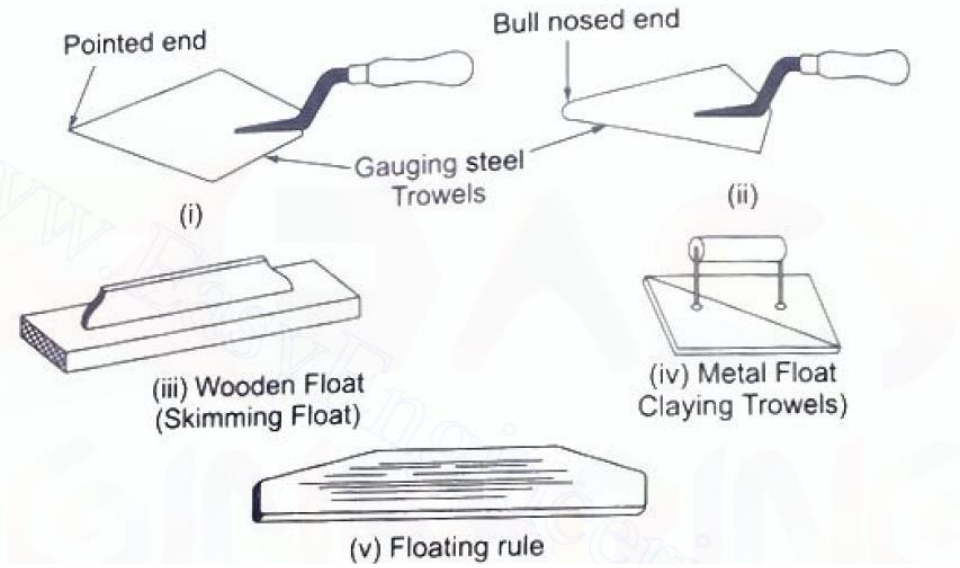
5. Miscellaneous tools

1. Gonging Trowel

This is ordinary trowel and is useful for applying plasters to mouldings, corners etc. The ends of the steel clades of trowels are either pointed or bull-nosed. This is available in sizes varying in length from 15 to 45 cm.

2. Floats

This tool is used to spread the plaster an the surface. It is made of thin tempered steel. It is also know as the laying trowel. The float is known as the skimming float and is used for final or finishing could plaster. A float provided with nails projecting by about 3 mm from the surface is known as the den float and it is used to make zigzag lines on the plastered surface so as to form a key for the subsequent coat.



3. Floating Rule

This tool is used to check the level of the plastered surface between the successive screeds.

4. Plumb Bob

This tool is very much useful in forming screeds (i.e., strips of mortor) in the same vertical place

5. Miscellaneous Tools

The other additional tools like straight edges, brushes, set square, spirit levels, scratches, plumb rule etc., are used in plaster-work at different stages of plastering.

POINITING

Pointing is defined as the finishing of masonry joints with a rich mortar and in a decorative manner. Poiniting is applied when it is desired to exhibit the material of the masonary, to exhibit the workmanship, to make the masonary cheap and when the material used in the masonry is capable of resisting the atmospheric action.

For pointing, the mortar from the joints is raked out to a depth of nearly 2 cm and the joints are properly cleaned and wetted with water. After cleaning and wetting the joints, they are filled with fresh mortar richer than already used in the masonry.

METHODS OF POINTING

masonry work involves the following operations.

The pointing

1. All the mortar joints are raked out by a special pointing tool to a depth of 15 to 20 mm. so as to provide an adequate key for the fresh mortar used for pointing.

2. The dust from the masonry joints is removed by the brushes.

3. The surface is then washed with clean water and it is kept wet for a few hours.

4. The joints so prepared are filled up with suitable mortar with a small trowel. The mortar is well pressed into the joints to form a close contact with the old interior mortar joints. The joints are rendered flush, sunk or raised according to the type of pointing required. All excess mortar striking to the sides is scraped away.

5. The finished pointing work is kept wet for about 3 days when lime mortar is used for pointing and 10 days when cement mortar is used for pointing.

TYPES OF POINTING

(a) Beaded Pointing - In this type, the raked joints are first filled up with mortar and finished flush with the face of the wall and then head is formed by a steel or iron rod with a concave edge in the middle of joint.

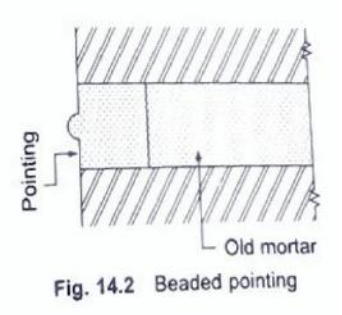


Fig. 14.2 Beaded pointing

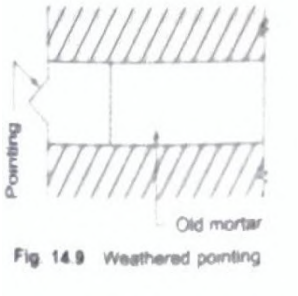


Fig. 14.9 Weathered pointing

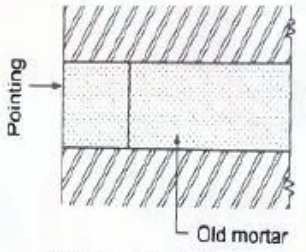


Fig. 14.3 Flush pointing

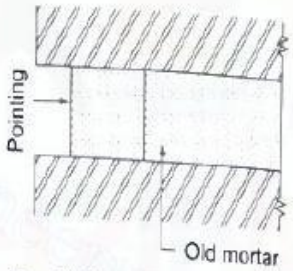


Fig. 14.4 Recessed pointing

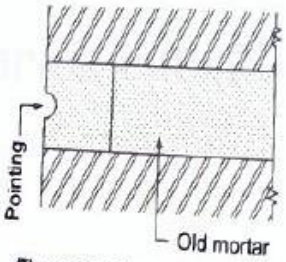


Fig. 14.5 Rubbed pointing

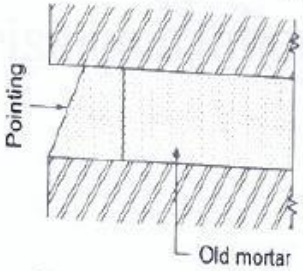


Fig. 14.6 Struck pointing

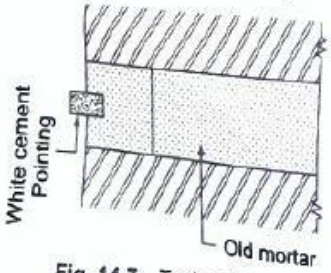


Fig. 14.7 Tuck pointing

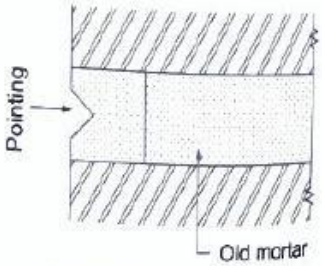


Fig. 14.8 Vee-Pointing

(b) Flush Pointing - In this type of pointing, it is formed by removing the excess mortar from the joint. The joint is made flush with the face. This type of joint does not give good appearance. But it is durable as it does not provide any space for accumulation of dust, water etc. and hence it is extensively used.

(c)Recessed Pointing - In this type, the face of the pointing is kept vertical and is pressed inside the plane of the wall by means of a suitable tool.

This type is not generally recommended but may be used for facing work of good texture bricks and good quality mortar.

(d) Rubbed or Keyed or Grooved Pointing - This pointing is a modification of flush pointing by forming a groove at its mid height, by a pointing tool. It gives better appearance.

(e) Struck Pointing - In this type of pointing, the face of pointing is kept inclined, The upper edge of joint is about 10 mm inside the face of masonry. This joint disposes water easily. If the lower edge of joint is kept inside the face of masonry, it is known as the overhand struck pointing. But it will not form a satisfactory joint as water will be collected in the joint.

(f) Tuck Pointing-In this type, the mortar is first pressed in the raked joints and is finished flush with the face of the wall. While the pressed mortar is still green, a narrow channel or groove is formed at the centre of joints. This groove is then filled in with white lime putty, containing small amount of silver sand, which is left to project beyond the face of the joint by 3 mm.

(g) Vee-Pointing - In this type of pointing, a vee-shaped groove is formed in the mortar joint

(h) Weathered Pointing-In this type, the face of the pointing instead of keeping vertical, is kept sloping outwards To achieve this, the mortar is first filled up into the raked your and then top horizontal joint is pressed inside by an amount of 3 to 6 mm with a special pointing tool.

This type is mostly used for brickwork, particularly for finishing horizontal joints as it immediately throws off the rain water. Sometimes, a struck pointing is formed by pressing inside the bottom of the point. This has the advantage of not allowing the rain water a collected in the recess.

WHITE-WASHING

The complete process of white-washing can be carried out under the following operations:

1. Preparation of white-wash

2. Preparation of surface, and

3. Application of white-wash

1. Preparation of White-Wash

The white-wash is prepared from fresh burnt shell lime or pure stone lime mixed with water. Shell lime is preferred to pure lime (white stone) as it is whiter and slakes more perfectly to a smoother paste.

To prepare white-wash, fresh lime is slaked at site of work and is dissolved in a tub with sufficient quantity of water. After slaking, it is allowed to remain in the tub of water for two days and then stirred up with a pole until it attains the consistency of thin cream. This mixture is then strained or screened through a clean coarse cloth. Clean, gum dissolved in hot water is then added at the rate of 2 kg per m^2 of lime (or 4 kg per m* of thin cream or white wash-

water) to the white-wash water. The solution so formed is called as 'white wash. Sometimes, a part or whole of the gum may be replaced by the rice.

To prevent the glare effect due to white-wash, sometimes, the copper sulphate at the rate of 4 kg/m^3 of thin cream is added. In order to have better adhesive properties, alum or common salt may be added in the same proportion as gum.

2. Preparation of Surface

Before applying white-wash to new wall surfaces, it is essential that surfaces should be cleaned. Brushed and made free from loose materials any other foreign matter. If the surface to be coated is entire smooth or over smooth, then coats will not stick to it. In such a case, the surface should be rubbed with sand paper to ensure proper adhesion of white-wash.

In case of re-white washing, all loose materials and scales should be scrapped off. The old loose white-wash is removed by rubbing with sand paper. All holes in wall, irregularities of surface, minor repairs, etc are corrected in advance by filling with lime putty.

All greasy spots should be given a coat of a mixture of rice water and sand so that the finishing wash may stick to the surface. If old white-wash is discoloured by smoke or other reasons as in kitchens. factories, restaurants, etc then in such cases, the surfaces should be given a wash of a mixture of wood ashes and water or yellow earth, before the application of white-wash. Cement plastered walls should be washed with a weak solution of soap and dried before applying white-wash.

3. Application of White-Wash

The white-wash is applied to a specified number of coats with a jute brush. Usually, three coats are required for new work and for scrapped surfaces, while one or two coats are considered sufficient for old work. For each coat, one stroke is given from the top downwards and the other from the bottom upwards over the first storke, and similarly one stroke from the right and another form the left over the first brush before it dries. Each coat should be allowed to dry before applying the next coat. The finished dry wash surface should not show any signs of cracking or peeling and should also not come off readily on fingers when rubbed.

DISTEMPERING

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 present a neat appearance. They are available in a variety of colours.

PROPERTIES OF DISTEMPERS

Following are the properties of distempers:

(i) On drying, the film of distemper shrinks. Hence it leads to cracking and flaking, if the surface to receive distemper is weak.
(ii) The coatings of distemper are usually thick and they are more brittle than other types of water paints.
(iii) 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.
(iv) They are generally light in colour and they provide a good reflective coating.
(v) They are less durable than oil paints..
(vi) They are treated as water paints and they are easy to apply.
(vii) They can be applied on brickwork, cement plastered surface, lime plastered surface, insulating boards, etc.
(viii) They exhibit poor workability.
(ix) They prove to be unsatisfactory in damp locations such as kitchen, bathroom, etc.

INGREDIENTS OF A DISTEMPER

A distemper is composed of base, carrier, colouring 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 white 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 ready made distempers supply complete 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:
(1) Preparation of surface: The surface to receive the distemper is thoroughly rubbed and cleaned. The important facts to be kept in mind are
(i) The new plastered surfaces should be kept exposed for a period of two months or so to dry out before distemper is applied on them. The presence of dampness on the surface results in failure of distemper coating.
(ii) The surface to receive distemper should be free from any efflorescence patches. These are to be wiped out by clean cloth.
(iii) The irregularities such as cracks, holes, etc. of the surface are to be filled by lime putty or gypsum and allowed to become hard before distemper is applied on the surface.
(iv) If distemper is to be applied on the existing distempered surfaces, the old distemper should be removed by profuse watering.
(2) Priming coat: After preparing the surface to receive the coats of distemper, a priming coat is

applied and it is allowed to become dry. For ready made distempers, the priming coat should be composed of materials as recommended by the makers of distempers. For local made distempers, the milk is used for priming coat. One litre of milk will cover about 10 m2 of the surface.
(3) Coats of distemper: The first coat of distemper is then applied on the surface. It should be of a light tint and applied with great care. The second coat of distemper is applied after the first coat has dried and become hard.

Following facts are to be remembered:
(i) The distempering should be done in dry weather to achieve better results.
(ii) The oil-bound distemper or washable distemper adheres well to oil-painted walls, wood, corrugated iron, etc. But a priming coat of pure milk should be applied before distempering is done on such surfaces.
(iii) The application of distemper by a spraying pistol is superior to that by brushes. The spraying affords smooth and durable film of distemper.

PAINTING

Following are the objects of painting a surface:
(1) It protects the surface from weathering effects of the atmosphere and actions by other liquids, fumes and gases.
(2) It prevents decay of wood and corrosion in metal.
(3) It is used to give good appearance to the surface. The decorative effects may be created by painting and the surface becomes hygienically good, clean, colourful and attractive.
(4) It provides a smooth surface for easy cleaning.

CHARACTERISTICS OF AN IDEAL PAINT

Following are the characteristics of an ideal paint:
(i) It should possess a good spreading power i.e. maximum area of the surface should be covered by minimum quantity of the paint.
(ii) The paint should be fairly cheap and economical.
(iii) The paint should be such that it can be easily and freely applied on the surface.
(iv) The paint should be such that it dries in reasonable time and not too rapidly.
(v) The paint should be such that its colour is maintained for a long time.
(vi) The paint should form a hard and durable surface.
(vii) The paint should not affect health of workers during its application.
(viii) The paint should not be affected by weathering actions of the atmosphere.
(ix) The paint should possess attractive and pleasing appearance.
(x) The surface coated with paint should not show cracks when the paint dries.
(xi) When applied on the surface, the paint should form a thin film of uniform nature.

INGREDIENTS OF AN OIL BORNE PAINT

An oil paint essentially consists of the following ingredients:

(1) a base,
(2) a vehicle or carrier,
(3) a drier,
(4) a coloring pigment, and
(5) a solvent.

(1) Bases: A base is a solid substance in a fine state of division and it forms the bulk of a paint. It determines the character of the paint and imparts durability to the surface which is painted. It reduces shrinkage cracks formed on drying and it also forms an opaque layer to obscure the surface of to be painted.

BASES FOR PAINTS

No.	Name	Description
1.	White lead	This is a carbonate of lead and it forms the base of lead paints. It possesses good bulk and is the most widely used base. It is dense, permanent and water-proof. It is not suitable for delicate work as lead becomes discoloured when exposed to the sulphur vapours. It is most suitable for wood surfaces and not used for iron surfaces as it does not afford protection against rusting.
2.	Red lead	This is an oxide of lead and it forms the base of lead paints. It is quite suitable for painting iron surfaces and for providing a priming coat to the wood surfaces. It solidifies in a short time with linseed oil and hence it is used as a drier also.
3.	Oxide of zinc or zinc white	This is an oxide of zinc and it forms the base of all zinc paints. It is smooth, transparent and non-poisonous. It is not discoloured when exposed to the sulphur vapours. It has less bulk and hence it is costly. It is less durable and it is difficult to work.
4.	Oxide of iron	This is an oxide of iron and it forms the base of all iron paints. The tint of paint varies from yellowish brown to black. It mixes easily with the vehicle. It is effective in preventing rusting of iron surfaces. It is cheap and durable. It is generally used for priming coat of the iron surfaces.
5.	Titanium white	This material possesses intense opacity. It is non-poisonous and provides a thin transparent film. It is used for receiving the coat of an enamel.
6.	Antimony white	This is nearly similar to the titanium white.
7.	Aluminium powder	This forms the bulk of aluminium paints. It keeps moisture content of wood surfaces practically the same. It also prevents cracking and warping of wood. It is generally used for a priming coat to new woodwork.
8.	Lithophone	This is a mixture of zinc sulphide and barytes. It is similar in appearance to oxide of zinc. It is cheap and it can easily be applied on the surface. However, when exposed to daylight, it changes colour. Hence, it is used for interior work of inferior nature.

(2) Vehicles: The vehicles are the liquid substances which hold the ingredients of a paint in liquid suspension. They are required mainly for two reasons:
(i) to make it possible to spread the paint evenly and uniformly on the surface in the form of a thin layer; and (ii)to provide a binder for the ingredients of a paint so that they may stick or adhere to the surface.

VEHICLES FOR PAINTS

No.	Name	Description
1.	Linseed oil	This is the most common material used as vehicle of a paint. It is extracted from flax seeds. The linseed oil prepared from fine full-grown ripe seeds is clear, transparent, pale, sweet to the taste and practically odourless. It is used in various grades.
	a Raw linseed oil	The raw linseed oil is thin and pale. It requires more time for drying and is used for interior work of delicate nature.
	b Boiled linseed oil	This oil is thicker and darkly coloured than raw oil. It dries quickly. It is prepared by adding some quantity of drier such as litharge or red lead to the raw oil. It cannot be used for interior delicate work. It is used for exterior surfaces.
	c Pale boiled linseed oil	This is similar to boiled linseed oil except that it does not possess a dark colour. It is more suitable for painting plastered surfaces.
	d Double boiled linseed oil	This oil dries very quickly and is suitable for external work. It however requires a thinning agent like turpentine.
	e Stand oil	Formerly this oil was prepared by exposing raw linseed oil to sun till it thickened like honey. At present, the heat treatment is used for this purpose. This oil dries slowly and provides a durable, clear and shining finish.
2.	Tung oil	This oil is far superior to linseed oil and is used for preparing paints of superior quality.
3.	Poppy oil	This oil is prepared from poppy seeds. It dries slowly. But its colours last long. It is used for making paints of very delicate colours.
4.	Nut oil	This oil is extracted from ordinary walnuts. It is nearly colourless and dries rapidly. It does not provide a durable finish and is used for ordinary work as it is cheap.

(3) Driers: These substances accelerate the process of drying. A drier absorbs oxygen from the air and transfers it to the linseed oil, which in turn, gets hardened. The various patented driers are available in the market. They may be either in the form of soluble driers or paste driers. The former driers are compounds of metals such as cobalt, lead, manganese, etc. dissolved in linseed oil or some other volatile liquid.

The latter driers are compounds of the same metal. But they are mixed with inert fillers such as barytes, whiting, etc. and then ground in linseed oil. The inert fillers serve as adulterants and the weight of inert filler in a paint should not exceed one- fourth the weight of base. They are used for the following purposes.

(i) to bring down the cost of paint;

(ii) to improve the durability of paint;

(iii) to modify the weight of paint; and

(iv) to prevent shrinkage and cracking

The litharge, red lead and sulphate of manganese can also be used as driers. The litharge is the most used drier, the proportion being 1.25 N to 5 litres of oil. The red lead is less effective than litharge and it is to be used when its addition does not interfere with the tint of the paint. Manganese sulphate is used with zinc paints to eliminate the risk of discolouration of a lead drier. It is required to take extreme care in mixing sulphate of manganese. Otherwise, the spots

will be formed on the painted surface.
Cobalt is the most reactive of drier metals and is generally regarded as a surface drier. It is widely used as the only additive in thin-film paint formulations. Lead is less reactive than cobalt has increasing restrictions in its applications because of ecological requirements. Numerous other metals, including cerium and vanadium, have been used occasionally and are effective driers. Certain organic compounds also catalyze the drying of oils and have been used for this purpose when freedom from all metallic contamination is required.
Following precautions should be taken while using the driers:
(i) A drier should not be added until the paint is about to be used.
(ii) More than one drier should not be used in a mixture.
(iii) The driers need not be used with pigments that dry well.
(iv) The driers should not be used unnecessarily nor in excess especially in the finishing coat as they have a tendency to injure the colour of a paint and to destroy the elasticity of a paint and to cause flaking of a paint.
(4) Colouring pigments: When it is desired to have a different colour than the base of a paint, a colouring pigment is to be added. The pigments are available in the form of fine powders in various colours and qualities. Following are five divisions of the colouring pigments:
(i) Natural earth colours such as ochres, umbers, iron oxides, etc.
(ii) Calcined colours such as lamp black, Indian red, carbon black, red lead, etc.
(iii) Precipitates such as prussian blue, chrome green, chrome yellow, etc.
(iv) Lakes prepared by discolouring barytes or china clay with the help of suitable dyes.
(v) Metal powders such as aluminium powder, bronze powder, copper powder, zinc powder etc.,

COLOURING PIGMENTS FOR PAINTS

Tint of paint	Pigments
Black	Graphite, lamp black, ivory black, vegetable black
Blue	Indigo, prussian blue
Brown	Burnt umber, raw umber
Green	Chrome green, copper sulphate
Red	Carmine, red lead, vermilion red
Yellow	Chrome yellow, raw sienna, yellow ochre, zinc chrome.

(5) Solvents: The function of a solvent is to make the paint thin so that it can be easily applied on the surface. It also helps the paint in penetrating through the porous surfaces. The most commonly used solvent is the spirit of turpentine. The turpentine is inflammable, evaporates rapidly and dries the oil consequently. The use of a thinner in paint reduces the protective value of the coating, flattens colours and lessens the gloss of the linseed oil as the spirits evaporate leaving an excess of colour not mixed with the oil.
The turpentine is a transparent volatile liquid and it is obtained by distilling the resinous

exudation of some varieties of pine trees. It has a pungent odour and is often adultered with mineral oils and some of them have higher penetrating values but are otherwise inferior. The benzine and naphtha are used as substitutes.

A solvent or thinner is not generally used in finishing coats on the exposed surfaces as it has a tendency to impair or damage or injure the firmness of the paint. But if the surface is to be exposed to the sun, the turpentine is added to reduce the possibility of the paint blistering.

Following are the simple tests for ascertaining the purity of turpentine:

(i) On evaporation, it should not leave any residue.

(ii) The paper coated with turpentine and left to dry should remain unstained and should then take ink freely.

(iii) When shaken vigorously, it should not froth i.e. form a m

(iv) When warmed gently, it should not smell of resin or coal tar.

TYPES OF PAINTS

The brief descriptions of different types of paints are given below:

(1) **Aluminium paint:** The very finely ground aluminium is suspended in either quick-drying spirit varnish or slow-drying oil varnish as per requirement. The spirit or oil evaporates and a thin metallic film of aluminium is formed on the surface. The advantages of an aluminium paint are as follows:

(I) It is visible in darkness.

(ii) It resists heat to a certain degree.

(iii) The surfaces of iron and steel are better protected from corrosion by this paint than any other paint.

(iv) It possesses a high covering capacity. A litre of paint can cover an area of about 200 m^2.

(v) It gives good appearance to the surface.

(vi) It is impervious to the moisture.

(vii) It possesses high electrical resistance.

The aluminium paint is widely used for painting gas tanks, hot water pipes, marine piers, oil storage tanks, radiators, etc.

(2) **Anticorrosive paint:** This paint essentially consists of oil and a strong drier. A pigment such as chromium oxide or lead or red lead or zinc chrome is taken and after mixing it with some quantity of very fine sand, it is added to the paint. The advantages of an anticorrosive paint are as follows:

(I) It is cheap.

(ii) It lasts for a long duration.

(iii) The appearance of the paint is black.

(3) **Asbestos paint:** This is a peculiar type of paint and it is applied on the surfaces which are exposed to the acidic gases and steam.

(4) **Bituminous paint:** This paint is prepared by dissolving asphalt or minera or vegetable bitumen in any type of oil or petroleum. A variety of bituminous paints is available. The paint presents a black appearance and it is used for painting ironwork under water.

(5) **Cellulose paint:** This paint is prepared from nitro-cotton, celluloid sheets, photographic films, etc. An ordinary paint hardens by oxidation. A cellulose paint hardens by evaporation of thinning agent. It thus hardens quickly. It is a little more costly, but it presents a flexible, hard and smooth surface. Also, the surface painted with cellulose paint can be washed and easily cleaned. The cellulose paint is not affected by contact with hot water and the surface can stand extreme degrees of cold and heat.

(6) **Cement paint:** This paint consists of white cement, pigment, accelerator and other additives. It is available in dry powder form. The cement paint is available in variety of shades and it exhibits excellent decorative appearance. It is water-proof and durable. It proves to be useful for surfaces which are damp at the time of painting or are likely to become damp after painting. For external finish, on cement-plastered walls, it is mixed with water immediately before its application. It is desirable to provide cement paint on rough surface rather than on smooth surface because its adhesion power is poor on smoothly finished surface. For painting surfaces like corrugated iron sheets, etc., the cement paint is mixed with boiled linseed oil. The mixture is constantly stirred during use.

The cement paint is applied two coats. Before the first coat is applied, the surfaces are wetted to even and control suction and to assist the hardening process of the cement paint. It should however be seen that there is no presence of liquid water on the surface when the paint is applied. The application of paint over a surface exposed directly to hot sunlight should be avoided. Otherwise the coating will dry before it is cured and will become chalky.

The second coat is applied not less than 24 hours after the first coat and it considerably helps in improving the appearance of the surface. For tropical countries, the rewetting of surface before the application of second coat is absolutely necessary. It is also essential to keep the surface wet after the final coat for about 2 days by frequent splashing of water to get the best performance. The application of cement paints during freezing weather should be avoided.

Following are the advantages of cement paints:

(i) It requires less skill and time for applying cement water paints and the applying implements can be cleaned with water only.

(ii) The preparation of surfaces is easier in a cement paint system as necessary to remove the previous coats of cement paints.

(iii) They are suitable for painting fresh plasters having high alkalinity because cement paints are not likely to be attacked by the alkalinity of masonry surfaces.

(iv) They become an integral part of the substrata and add to its strength.

(v) They can be applied over new and damp walls which cannot be painted over with oil paints until they are sufficiently dried.

(vi) They prove to be economical as compared to the oil paints and they dry more rapidly than the oil paints

Following precautions should be taken to avoid defects or complaints of the cement paints :

(I) The defect of cracking occurs when the film of paint has not adequate flexibility to move with thermal or moisture movements in the surface. The cement paints however become

integral part of the surface, if they are suitably cured and hence they do not move independently of the surface.
(ii) The efflorescence or crystalline deposits are sometimes seen on the finished surfaces. Such defects are mainly due to the nature of surface before application of paint or due to some external factor like highly saline atmosphere.
(iii) The flaking or lifting of the paint film due to loss of adhesion can be prevented by properly curing the surface after the application of paint.
(iv) The most common fungi or micro-organisms found in paints and coatings are moulds and they are attached to paint coatings by mycelial hairs which extend into and under the coatings. Such defects can be removed by scrubbing the surface with brush or by applying suitable fungicides or by adding the fungicides to the paint itself. A fungicidal wash may also be used effectively to retard fresh growth.
(v) The paint should be cured sufficiently after application. It will avoid the phenomena of chalking of surfaces which indicates the paint film losing adhesion with the surface and becoming powdery.
(vi) The term fleeting is used to indicate the bleaching or fading of colours caused mainly by the exposure to the weather actions. This defect can be considerably made less conspicuous by choosing lighter shades of paints for such surfaces.
(7) **Colloidal paint:** No inert material is mixed in this type of paint. It requires more time to settle and in the process of settlement, it penetrates through the surface. It may be used for interior as well as exterior walls.
(8) **Emulsion paint:** A variety of emulsion paints is available. It contains binding materials such as polyvinyl acetate, synthetic resins, etc. This paint is easy to apply and it dries quickly in about 12 to 2 hours. The colour of the paint is retained for a long period and the surface of paint is tough and it can be cleaned by washing with water. There is absence of odour and the paint possesses excellent alkali resistance.
The application of emulsion paint can be carried out either by brush or spray gun. For long service life, it is recommended to apply two coats of emulsion paint. For rough cement plastered surface, a thin coat of cement paint may first be applied to smoothen the surface. It is necessary to have a sound surface to receive the emulsion paint.
(9) **Enamel paint:** This paint is available in different colours. It contains white lead or zinc white, oil, petroleum spirit and resinous matter. It dries slowly and forms a hard and durable surface. The surface provided with this paint is not affected by acids, alkalies, fumes of gas, hot and cold water, steam, etc. It can be used for both internal and external walls. In order to improve the appearance, it is desirable to apply a coat of titanium white in pale linseed oil before the coat of enamel paint.
(10) **Graphite paint:** The paint presents a black colour and it is applied on iron surfaces which come in contact with ammonia, chlorine, sulphur gases, etc. It is also used in mines and underground railways.
(11) **Inodorous paint:** No turpentine is used in this paint, but white lead or zinc white is mixed with methylated spirit. The white lead or zinc white is well ground in oil. The shellac with some

quantity of linseed oil and castor oil is dissolved in methylated spirit. The paint is not durable, but it dries quickly. The methylated spirit evaporates and a film of shellac remains on the surface.

(12) **Luminous paint:** This paint contains calcium sulphide with varnish. The surface on which luminous paint is applied shines like radium dials of watches after the source of light has been cut off. The paint should be applied on surfaces which are free from corrosion or any other lead paint.

(13) **Oil paint:** This is the ordinary paint and it is generally applied in three coats of varying composition. They are respectively termed as primes, undercoats and finishing coats. This paint is cheap and easy to apply and it possesses good opacity and low gloss. It should be remembered that the oil paint should not be applied during humid and damp weather. The presence of dampness on wall surface also considerably affects the life of oil paint coating. It is advisable to redecorate the surfaces finished with oil paint with a coating of fresh oil paint only. The layer of old oil paint serves as a foundation for the fresh paint.

(14) **Plastic paint:** This paint contains the necessary variety of plastics and it is available in the market under different trade names. The application of plastic paint can be done either by brush painting or spray painting. This paint possesses pleasing appearance and it is attractive in colour. This paint is widely used for show rooms, auditoriums, etc.

The plastic emulsion paints were introduced in our country in 1955 or so and they are becoming more and more popular day by day. An emulsion is a liquid having fine suspended particles of a substance. For plastic emulsion paints, the emulsion is composed of plastic compounds such as vinyl acetate and acrylate which are held in water.

The typical composition of one litre of plastic emulsion paint is as follows:

2 N Binders
5 N Pigments
1 N Other solids
6 N Water
14 N Total weight

When the paint dries, the water evaporates and a film of binders, pigments and other solids is left behind. One litre of plastic emulsion paint covers about 15 m^2 of wall surface per coat. For interior jobs, the two coats of paint are sufficient, each coat having a thickness of about 0.04 mm.

Following are the important guidelines for the use of plastic emulsion paints:

(i) Application: It is observed that the plastic emulsion paints are widely used for interior jobs in our country because they cannot resist effectively the attack of enemies of paints such as salts, dust and gases carried by air, sunlight, fog, rain, rise and fall of temperature, etc.

(ii) Base surface: The success of paint will depend on the quality of plaster and characteristics of base surface. The surface to be painted should be cleaned of all dust particles and rubbed with sandpaper, if necessary. The levelling putty should be applied, if required.

(iii) Brushes: The application of these paints should be done with clean brushes or sponge

rollers. These paints possess good flow properties and hence the brush marks are automatically levelled off giving beautiful, uniform and washable surface in a short time.
(iv) Colour of paints: If dark colour plastic emulsion paints are required, they should be used as made by the manufacturers. For light colour paints, a white emulsion with certain other colours known as the tinters (available in tubes). may be added to the paints made by the manufacturers.
(v) Diluting the paint: These paints are usually supplied with thick consistency and for diluting the paints, the instructions given by the manufacturer should be strictly followed. In a general way, it can be stated that half litre extra water will be required for first coat and quarter litre extra water will be required for second coat.
(vi) Metallic surfaces: These paints are water based and hence they are not suitable for metallic surfaces. These paints are not water-repellent and it is likely that some fungus growth may develop in unfavourable circumstances.
(vii) Moisture resistance: These paints allow moisture to evaporate through minute pores. But even then, it is desirable to allow 4 months, preferably one year, for moisture to escape from fresh masonry and fresh plaster.
(viii) Nature of surface: The plastic binders need not require a rough surface for adhesion and they even stick to a smooth surface. However the initial roughening of surface before the application of first coat is necessary to remove dust, salts, etc. A good plastic emulsion paint would not colour a moist cloth when rubbed on the painted surface.
(ix) Thickness of coat: The thickness of coat should neither be too thin nor too thick. In fact, it must possess elasticity to match the stresses in the plaster and should not separate out from the surface. However the film of paint can be made durable by thickening in successive coats and not in one coat at a time.
(x) Washing: It is desirable to wash the painted surfaces with wet cloth lightly at least once in a month. If this precaution is not taken, the dust particles would adhere to the surface and the paint may lose its good appearance.
(15) **Silicate paint:** This paint is prepared by mixing calcined and finely ground silica with resinous substances. The paint when dried forms a hard surface and it is durable. It can stand extreme heat and it adheres firmly to brickwork also. It is not affected by alkalies. No chemical action takes place on metals by this paint. The drier used with this paint should be of a special silicate drier type.
The silicate paint can directly be applied on brick, plaster or concrete surfaces. These surfaces should be made wet before the paint is applied. The two or three coats of silicate paint are recommended and it is not necessary to have a priming coat. The tool which is used to apply silicate paint should be immediately cleaned with water after use. The surfaces should not be painted with silicate paint in hot weather.
(16) **Synthetic rubber paint:** This paint is prepared from resins. It has the following advantages.
(i) It offers good resistance to the water and is not affected by heavy rains.
(ii) It dries quickly.
(iii) A uniform colour is maintained when this paint is applied on the surface

(iv) It is little affected by weather and sunlight.
(v) It can be applied on surfaces which may not be completely dry e.g. fresh concrete.
(vi) It is moderate in cost and covers a sizeable area.
(vii) It is easy to apply on the surface.
(viii) It possesses excellent chemical resisting property

DAMP-PROOFING

Meaning of the term damp-proofing: One of the basic requirements in case of all the buildings is that the structure should remain dry as far as possible. If this condition is not satisfied, it is likely that the building may become unhabitable and unsafe from structural point of view. Hence, in order to prevent the entry of damp into a building. The courses, known as the damp-proofing courses, are provided at various levels of entry of damp into a building.
At present, practically all the buildings are given the treatment of damp proofing Thus the provision of damp-proofing courses prevents the entry of moisture from walls, floors and basement of a building. The treatment given to the roofs of a building for the same purpose is known as the water-proofing.

15-2-1. CAUSES OF DAMPNESS

The dampness in a building is a universal problem and the various causes which are responsible for the entry of dampness in a structure are as follows:
(1) Rising of moisture from the ground: The ground on which the building is constructed may be made of soils which easily allow the water to pass. Usually the building materials used for the foundations, absorb moisture by capillary action. Thus the dampness finds its way to the floors through the substructure.
(2) Action of rain: If the faces of wall, exposed to heavy showers of rain, are not suitably protected, they become the sources of entry of dampness in a structure. Similarly the leaking roofs also permit the rain water to enter a structure.
(3) Exposed tops of walls: The parapet walls and compound walls should be provided with a damp-proof course on their exposed tops. Otherwise the dampness entering through these exposed tops of such walls may lead to serious results.
(4) Condensation: The process of condensation takes place when warm humid air is cooled. This is due to the fact that cool air can contain less invisible water vapour than warm air. The moisture is deposited on the walls, floors and ceilings. This is the main source causing dampness in badly designed kitchens
(5) Miscellaneous causes of dampness: There are various miscellaneous causes of dampness as mentioned below:
(I) If the structure is located on a site which cannot be easily drained off, the dampness will enter the structure
(ii) The orientation of a building is also an important factor. The walls obtaining less sunshine and heavy showers of rain are liable to become damp.
(iii) The newly constructed walls remain damp for a short duration.
(iv) Very flat slope of a roof may also lead to the penetration of rain water which is temporarily

stored on the roof
(v) The dampness is also caused due to bad workmanship in construction such as defective rain water pipe connections, defective joints in the roofs, improper connections of walls, etc.

Thus the important sources of dampness can be summarised as follows:
(i) defective junctions between roof slab and parapet wall;
(ii) defective roof covering of the pitched roofs;
(iii) faulty eaves and valley gutters;
(iv) improper rain water pipe connections;
(v) inadequate roof slope;
(vi) moisture from wet ground below foundation;
(vii) splashing rain water;
(viii) unprotected tops of walls, parapets and compound walls; etc.

EFFECTS OF DAMPNESS

The building materials such as bricks, timber, concrete, etc., have a moisture content which is not harmful under normal circumstances. The rise in moisture content of these materials beyond a certain level from where it becomes visible or when it causes deterioration, leads to the real dampness. In absolute terms, the moisture content of different materials may be the same. But the acceptable limit differs from material to material. For instance, the presence of 10 per cent by weight of water in timber is not harmful. But the same level could saturate a brick or cause deterioration of plaster.

The structure is badly affected by dampness. The prominent effects of dampness are as follows:
(i) A damp building gives rise to breeding of mosquitoes and creates unhealthy conditions for those who occupy it.
(ii) The metals used in the construction of the building are corroded.
(iii) The unsighty patches are formed on the wall surfaces and ceilings.
(iv) The decay of timber takes place rapidly due to dry-rot in a damp atmosphere.
(v) The electrical fittings are deteriorated and it may lead to leakage of electricity and consequent danger of short circuiting.
(vi) The materials used as floor coverings are seriously damaged.
(vii) It promotes and accelerates the growth of termites.
(viii) It results in softening and crumbling of the plaster.
(ix) The materials used for wall decoration are damaged and it leads to difficult and costly repairs.
(x) The continuous presence of moisture in the walls may cause efflorescence which may result in disintegration of stones, bricks, tiles, etc. and the strength of wall is then reduced.
(xi) The floorings get loosened because of reduction in the adhesion when moisture enters through the floor.
(xii) The dampness combined with warmth and darkness breeds germs of dangerous diseases such as tuberculosis, rheumatism, etc. and the occupants may also become asthmatic.

FORMWORK

When concrete is placed, it is in a plastic state. It requires to be supported by temporary supports and casings of the desired shape till it becomes sufficiently strong to support its own weight. This temporary casing is known as the formwork or forms or shuttering. The term Moulds is sometimes used to indicate formwork of relatively small units such as lintels, cornices, etc. For circular work such as arch, dome, etc., the term centering is generally used. In the early days, the job of formwork was carried out by the carpenter with available timber and nails as best as possible with the approach of rule of thumb. The formwork techniques have also developed side by side along with the growth in the development of concrete construction. With the technological advancement and introduction of new materials of formwork, more rational approach is being made in the design of formwork.

REQUIREMENTS OF FORMWORK

Following are the requirements of a good formwork:

(1) Easy removal (2) Economy (3) Less leakage (4) Quality

(5) Rigidity (6) Smooth surface (7) Strength (8) Supports.

Each requirement of formwork will now be briefly discussed.

(1) **Easy removal:** The design of formwork should be such that it can be removed sily with least amount of hammering. This will also prevent the possible injury to e concrete which has not become sufficiently hard. Further, if the removal of formwork easy, it can be made fit for re-use with little expenditure.

The operation of removing the formwork is commonly known as the stripping and hen the stripping takes place, the components of the formwork are removed and then used for another part of the structure. Such forms whose components can be re-used times are known as the panel forms. Sometimes the forms are prepared for individual non-standard members and uctures. Such forms do not have repeatable elements. In some cases, the formwork cannot be stripped from the structure and it forms rt of the structure itself. All such forms are known as the stationary forms.

(2) Economy: It is to be noted that the formwork does not contribute anything to the stability of the finished structure and hence, it will be desirable to bring down its cost to a minimum consistent with safety. The various steps such as reduction in number of irregular shapes of forms, standardising the room dimensions, use of component parts of commercial sizes, putting the formwork in use again as early as possible, etc. may be taken to effect economy in the formwork. The formwork should be constructed of that material which is easily available at low cost and which can safely be re-used for severaltimes.

(3) Less leakage: The formwork should be so arranged that there is minimum of leakage through the joints. This is achieved by providing tight joints between adjacent sections of the formwork.

(4) Quality: The forms should be designed and built accurately so that the desired size, shape

and finish of the concrete is attained.

(5) Rigidity: The formwork should be rigid enough so as to retain the shape without any appreciable deformation. For visible surface in the completed work, the deflection is limited to 1/300 of span and that for hidden surface, it is limited to 1/150 of span. It should be noted that a rigid formwork will be robust and stiff enough to allow repeated use.

(6) Smooth surface: The inside surface of formwork shouldbe smooth so as to turn out a good concrete surface. This is achieved by applying crude oil or soft soap solution to the inside surface of formwork. This also makes the removal of formwork easy.

(7) Strength: The formwork should be sufficiently strong enough to bear the dead load of wet concrete as well as the weights of equipments, labour, etc. required for placing and compacting the concrete. This requires careful design of the formwork. The over-estimation of loads results in expensive formwork and the under-estimation of loads results in the failure of formwork. The loads on vertical forms are to be assessed from various considerations such as density of concrete, dimensions of section, concrete temperature, slump of concrete, reinforcement details, stiffness of forms, rate of pouring of concrete, etc.

(8) Supports: The formwork should rest on sound, hard and non-yielding supports.

COST OF FORMWORK

The cost of formwork plays a significant role in the cost of concrete. It varies from 30% to 40% of the cost of concrete for ordinary structures and may go as high as 50% to 60% for special structures such as dams, bridges, etc.

The four components contributing to the total cost of formwork are as follows

(i) cost of formwork material;

(ii) cost of erecting, placing and removal of formwork;

(iii) cost of joining material such as nails, wires, etc.; and

(iv) cost of labour for fabrication of formwork.

In general, it can be stated that careful watch should be kept on the cost of formwork and all attempts should be made to bring down the cost of formwork to a minimum so as to achieve overall economy in the concrete work.

MATERIALS USED FOR PREPARING FORMWORK

The usual materials which are employed in the preparation of formwork are steel and timber. The formwork is also sometimes prepared from aluminium, pre-cast concrete or fibre glass for cast-in-situ members involving curved surfaces.

(1) Steel formwork: The steel is used for formwork when it is desired to re-use the formwork several times. The initial cost of steel formwork is very high. But it proves to be economical for large works requiring many repetitions of the formwork. The erection and removal of steel formwork are simple and it presents a smooth surface on removal.

Following are the advantages of steel formwork over timber formwork:

(i) It can be re-used several times, nearly ten times more than timber formwork.
(ii) It does not absorb water from the concrete and hence, the chances of the formation of honey-combed surface are brought down to the minimum level.
(iii) It does not shrink or distort and hence, it is possible to achieve higher degree of accuracy and workmanship by its use as compared to the timber formwork.
(iv) It is easy to install and to dismantle and hence, there is saving in the labour cost.
(v) It gives excellent exposed concrete surfaces requiring no further finishing treatment. The surface obtained by the use of timber formwork invariably requires plastering for getting the desired finish of the concrete surface.
(vi) It possesses more strength and is more durable than the timber formwrok.
(vii) The design calculations for the steel formwork system can be made precisely because of the known characteristics of steel

(2) Timber formwork: When formwork is required for small works requiring less repetitions, the timber is preferred to steel. The timber formwork is cheap in initial cost and it can be easily adopted or altered for a new use. The timber to be used as formwork should be well-seasoned, free from loose knots, light in weight and easily workable with nails without splitting.
Following facts in connection with the timber formwork should be remembered:
(i) The timber is to receive wet concrete. Hence, the timber formwork should be neither too dry nor too wet. If it is too dry, the timber will swell and get distorted when wet concrete is placed on it. This will affect the workability of concrete and honeycomb surface will appear on removal of the formwork.
On the other hand, if it is too wet, the timber will shrink in hot weather resulting in gaps in the formwork through which concrete will flow out. Hence, the ridges will be formed on the concrete surface. It is found that a moisture content of about 20% is appropriate for the timber formwork.
(ii) The dimensions of components of the timber formwork will depend upon the loads to be carried and the availability of timber sections. But generally, the latter is the governing factor as the former can be adjusted by suitable spacing of the supports.
(iii) The minimum nails should be used in timber formwork and the nail heads should be kept projecting so as to facilitate easy removal.
(iv) The timber formwork proves to be economical for buildings with minimum number of variations in the dimensions of the rooms. Thus, the cutting of timber pieces is brought down to the minimum.
(v) It is the common practice to support formwork for slab in buildings with the timber ballies which are cut to approximate sizes with wedges below them for final adjustments. It leads to the formation of weak points which are seldom prevented from displacement. The timber ballies are generally not straight and they do not transmit the load axially.

The idea of using plywood as the formwork is becoming popular at present because it affords the following advantages over the timber formwork:
(i) The plywood formwork can be re-used several times as compared to ordinary timber formwork. Under normal conditions, the plywood formwork can be used for 20 times to 25 times and the timber formwork can be used for 10 times to 12 times.
(ii) The plywood formwork gives surfaces which are plain and smooth and hence, they may not require any further finishing treatment.
(iii) It is possible to cover up more area by using large size panel and hence, there is considerable reduction in the labour cost of fixing and dismantling of formwork

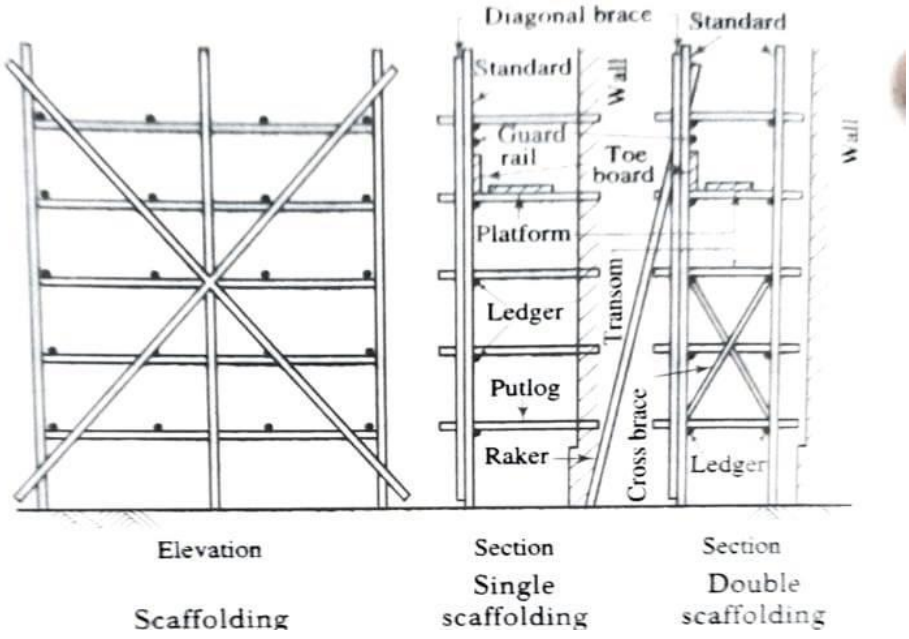
SCAFFOLDING

Definition: When the height above floor level exceeds about 1.50 m a temporary structure, usually of timber, is erected close to the work to provide a safe working platform for the workers and to provide a limited space for the storage of plant and building materials. The temporary framework is known as a scaffolding or simply a scaffold and it is useful in construction, demolition, maintenance or repair works.

COMPONENT PARTS OF A SCAFFOLDING
An ordinary scaffolding consists of the following parts:
(1) Standards: These are the vertical members of the framework and they are either supported on the ground or drums or embedded into the ground.
(2) Ledgers: These are the horizontal members parallel to the wall.
(3) Putlogs: These are the transverse pieces which are placed on the ledgers and which are supported on the wall at one end. They are at right angles to the wall.
(4) Transoms: These are putlogs, but their both ends are supported on the ledgers.
(5) Braces: These are the diagonal or cross pieces fixed on the standards.
(6) Bridle: This is a piece which is used to bridge an opening in a wall and it supports one end of the putlog at the opening.
(7) Guard rail: This is a rail provided like a ledger at the working level.
(8) Toe board: This is a board placed parallel to the ledgers and supported between the putlogs. It is provided to work as a protective measure on the working platform.
(9) Raker: This is an inclined support.
The various members of a scaffold are secured by means of devices such as nails, bolts, rope, etc.

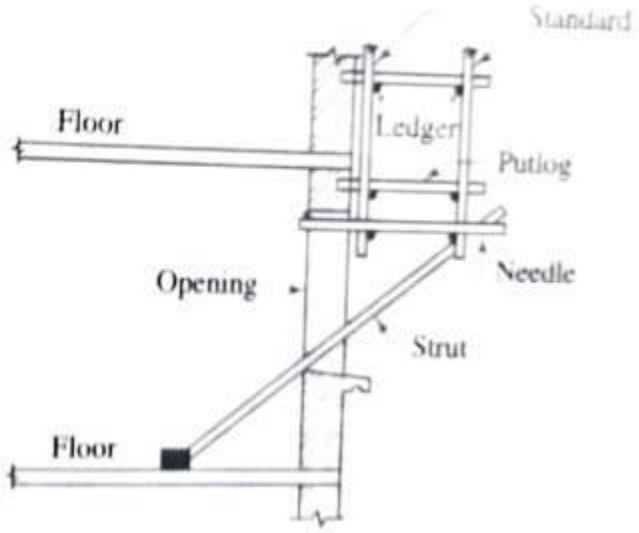
TYPES OF SCAFFOLDING
Following are the types of scaffolding:
(1) Single scaffolding or bricklayer's scaffolding

(2) Double scaffolding or mason's scaffolding
(3) Cantilever or needle scaffolding
(4) Suspended scaffolding
(5) Trestle scaffolding
(6) Steel scaffolding
(7) Patented scaffolding.
Building Construction
(1) **Single scaffolding or bricklayer's scaffolding :**
This is the most common type of scaffolding scaffolding and is widely used in the construction of brickwork. It consists of a single row of standards placed at a distance of about 1.20 m from the wall. The distance between the successive standards is about 2 m to 2.50 m. The ledgers are then fixed to the standards at a vertical distance of about 1.20 m to 1.80 m.
The putlogs, with one end on the ledger and the other end on the wall, are then placed at a horizontal distance of about 1.20 m to 1.80 m. The braces, guard rail and toe board are fixed This type is also sometimes known as the putlog scaffolding.



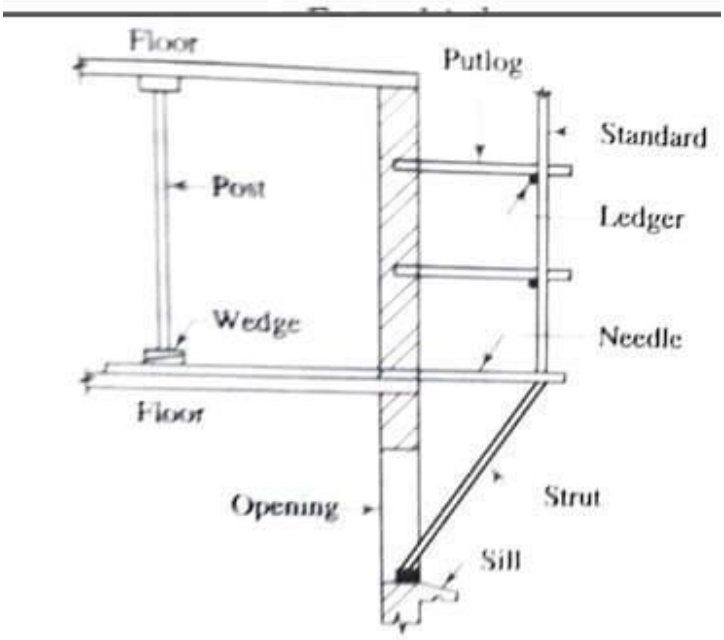
(2) **Double scaffolding or mason's scaffolding:** This scaffolding is stronger than the single scaffolding and it is used in the construction of stonework The framework is similar to the single scaffolding except that two rows of standards are provided. The distance between the face of the wall and the first row of standard is about 200 mm to 300 mm and the distance between the two rows is about one metre The rakers and cross braces may be provided to make the scaffolding more strong. This type is also sometimes known as an independent scaffolding.
(3) **Cantilever or needle scaffolding :** This type of scaffolding is useful under the following circumstances:
(I)The proper hard ground is not available for the standards to rest.

(ii) It is desired to keep the road or pavement near the face of wall, clear of obstruction caused by the scaffolding.
(iii) The construction work is to be carried out for upper parts of a multi- storeyed building.
In this type of scaffolding, the general framework may be of single scaffolding type or of double scaffolding type. But the standards are supported by a series of needles or ties which are taken out at floor levels or through openings or through holes kept in the masonry.
A cantilever scaffolding of putlog type. The needles are supported at the floor levels and strutted through projections such as sills, cornices, string courses, etc. The inner end of the needle projects sufficiently inside and is well strutted between the floors.



Cantilever scaffolding

A cantilever scaffolding of independent type. The needles are passing through the openings and are strutted on the floors through the openings. The suitable timber blocks should be interposed at the ends of struts on the floor levels.



Cantilever scaffolding

(4) **Suspended scaffolding:** This is a very light type of scaffolding and can be used only for the maintenance works such as painting, pointing, whitewashing, distempering, etc. The working platform is suspended from the roofs by means of ropes, wires or chains and arrangements are made such that the platform can be raised or lowered. This type of scaffolding does not create any obstruction on the ground and it is the most effective as it always provides the optimum level for working.

(5) **Trestle scaffolding:** In this type scaffolding, the working platform is supported on movable contrivances such as ladders, tripods, etc., mounted on wheels. This type of scaffolding is useful for minor repairs or painting work inside the rooms and the maximum height upto which this type of scaffolding can be adopted is about 5 m from the supporting surface.

(6) **Steel scaffolding:** In place of timber, the steel tubes can be effectively used for the scaffolding work. The diameter of the tubes is about 40 mm to 50 mm and the thickness is about 5 mm. The tubes are available in standard lengths with special couplings and set-screws. The advantages of steel scaffolding are manifold. The scaffolding can be used upto any height; it is strong and more durable; it can be easily erected and dismantled; it possesses high scrap value and it is resistant to fire. However the disadvantages are that the initial cost is high, it requires skilled labour and it also requires periodical painting.rowoman)

(7) **Patented scaffolding:** Now-a-days, the various patented scaffoldings made of steel, with special types of couplings and frames, are available. Usually the working platform is supported on a bracket which can be adjusted to any suitable height.

UNIT -4

PLUMBING SERVICES: Different types of pipes –Pipe fitting.

Types of pipes
1. Cast iron pipes
2 Steel pipes
3. Reinforced cement concrete (RCC) pipes
4.Pre-stressed concrete (PSC) pipes
5.Asbestos cement (AC) pipes
6.Wrought iron pipes
7. Copper, brass and lead pipes
8.Plastic pipes
9.Glass reinforced plastic (GRP) pipes.

1. Cast Iron Pipes: These are pipes widely used in water supply and sewage systems for trunk as well as distributary mains, due to their durability, strength, resistance to corrosion case of laying, simplicity for repairs and maintenance.

Their disadvantages are as follows:
a) Procurement of sizes larger than 1200 mm (about 3.94 ft) in diameter is a problem.
(b) It is difficult to get the specials required for connections, cross-connections and appurtenances. Inner coating with coal tar or cement mortar is required for carrying corrosive water.
2. Steel Pipes: These pipes are manufactured for various purposes in water supply systems, such as rising mains, conveying mains, distribution systems, inverted siphons and on bridges and other structures where strength and low weight are required. They are used in size ranging from 900 mm (about 2.95 ft) to 3000 mm (about 9.84 ft) in diameter.
Disadvantages:
(a) If a partial vacuum is formed while emptying the pipeline, it is likely to collapse easily or get deformed permanently.
(b) The life of a steel main is generally half that of a cast iron main.
(c) They are not suitable as underground distributary main, due to the inconvenience involved in tapping them for service connections and the extra cost incurred in providing protective coating to prevent rusting. Hence, an internal coating of coal tar or cement mortar to prevent rusting and external coating of fiber glass with bitumen or cement mortar or cathodic protection, is required for underground steel mains. In the case of pipelines laid above ground level periodic painting of external surfaces is necessary. for every four to seven years, depending on atmospheric conditions.
Three types of steel pipes are available namely
(a) Electricity welded steel pipes,
(b) Seamless pipes, and

(c) Spirally welded pipes.
The details can be obtained from the code of specification for electrically welded steel pipes for water, gas, and sewage.
3. Reinforced Cement Concrete Pipes: Reinforced cement concrete pipes may be precast or cast in situ. Plain concrete pipes are used in sizes up to 600 mm (about 1.97 ft) diameter beyond that, it is necessary to go in for reinforced concrete pipes. The specifications of concrete pipes are given in the codes IS ; 458 – 1971 and SP: 35 (S and T) 1987.
Advantages:
(i) The life of pipes is more than 65 years.
(II) They can be constructed easily at site or at factories according to international standards.
(III) Concrete pipes are not easily biodegradable.
(iv) The properties of concrete are well understood.
(v) They can be manufactured with indigenous equipment.
Disadvantages:
(I) Because of heavy weight, handling and laying is difficult.
(ii) They are affected by acids, alkalies and bactericial action.
(iii) Unless they are well executed at site, there is a possibility of seepage in large diameter pipes.
4. Pre-Stressed Concrete (PSC) Pipes: Pre-stressed concrete pipes consist of a core, coat and circumferential winding. Two types are generally in use :
(i) PSC cylinder pipes
(ii) PSC non-cylinder pipes.
RCC pipes can be used up to a pressure of 3.0 kg/cm² and CI and steel pipes up to 24 kg/cm². Between these two extremes, PSC can be used, since they are cheaper than metal pipes. In these pipes, permanent internal stresses are introduced by tension steel to counter act the stresses caused in the pipe under service. These stresses are entirely independent of the stresses caused by the external load or internal pressure. The sizes of these pipes vary from 80 to 1800 mm and lengths from 2 m to 25 m. The details can be obtained from the code of practice of pre-stressed concrete pipes, IS: 784 - 1978.
5. Asbestos Cement (AC) Pipes: The asbestos cement pipe is made of a mixture of asbestos and portland cement compressed by steel rollers to form a laminated material great strength and density. These are very lightweight and can be handled and transported easily. They are not affected by acids, salts and other corrosive materials. Asbestos cement pipes can meet the requirements of water supply rising mains and distribution pipes. The diameter of these pipes range from 80 to 600 mm and the lengths are in 3 m, 4 m and 5 m. The details can be obtained from the code of specifications of asbestos cement pipe, IS: 1592-1980. Asbestos cement pipes are however banned in USA, Europe and other developed countries.
6. Wrought Iron Pipes: Wrought iron pipes are manufactured by rolling flat plates of the metal to the required diameter, welding the edges and galvanizing with zinc. They can be easily cut and threaded. They are costlier than CI pipes. These are used only in buildings.

7.Copper, Brass, and Lead Pipes: These are used generally as a part of the plumbing work of a building, such as gooseneck, hot water piping, chlorination and alum dosing piping of water supply system. The details can be obtained from IS: 1545 1969, IS: 407 1966 and IS 404- 1962 respectively.

8. Plastic Pipes: Three kinds of plastic pipes are used for potable water supplies

(1) Low density polyethylene (LDPE) pipes.

(ii) High density polyethylene (HDPE) pipes.

(iii) Unplasticised poly vinyl chloride (UPVC) pipes.

Plastic pipes are becoming increasing popular due to their resistance to corrosion, light weight and low cost. Polyethylene pipes are made by an extrusion process from a compound consisting of virgin polyethylene in which carbon black and a suitable non-toxic anti-oxidant is evenly dispersed. The low density polyethylene should have a density, not greater than 0.93 g/ml band high density. Polyethylene should have a density, greater than 0.94 g/ml at 27° C. These are

Low Density Polyethylene (LDPE) Pipes :

flexible and made up to 60 mm diameter coils of lengths of 25, 50, 100, 150 and 200 m. The code of LDPE is IS: 3076 - 1968.

High Density Polyethylene (HDPE) Pipes: The code of HDPE is IS: 4984 - 1978. High density polyethylene pipes are harder than low density polyethylene pipes. HDPE pipes of sizes ranging from 300 to 3000 mm internal diameter are manufactured by a helical winding process and are known as spiral pipes. They can be used for carrying sewage and industrial effluents as underground conduits. The spiral HDPE pipes have a few advantages over conventional pipes.

(i) Free from rust and incrustrain.

(ii) Light in weight, thus making transport, loading and unloading easier.

(iii) High resistance to impact.

(iv) Easy to join.

(v) Resistant to a broad spectrum of chemicals and corrosive materials.

Disadvantages

(I) At present there is a shortage of raw material.

(ii) High cost of raw material

Rigid (Unplasticised) Polyvinyl Chloride (PVC) Pipes: The pipes are composed of polyvinyl chloride plus necessary additives for getting good surface finish and mechanical strength. They do no cause toxicity and have no detrimental effect on the composition of water passing through them. Rigid PVC pipes and high density polyethylene pipes been used for water distribution systems, in sizes ranging from 15 to 150 mm in diameter and occasionally up to 350 mm

Advantages:

(i) Lighter than CI or AC pipes, hence easier to handle and transport.

(i) Resistant to a wide range of chemicals, fungi, bacteria and corrosive agents.

(1) Due to their elastic property, they can withstand deformation resulting from earth shock movements

9. Glass Reinforced Plastic (GRP) Pipes: Fibre glass reinforced plastic pipes are manufactured

using glass fibre, polyester resin and fillers to form a homogeneous structure. Such a homogeneous structure gives better strength and durability. The matrix is of a low density and gives high tensile strength. Further details can be obtained from IS: 12709 - 1989
Advantages:
(i) They are light in weight (1/5th of steel and 1/10th of concrete) hence easy to load and handle.
(ii) Resistant to corrosion and rust.
(iii) Good durability, because of resistance to high temperature and UV-radiation resistant.
Disadvantages :
(i) Initial cost is more.
(i) The AWWA (American Water Works Association) has recommended them for water supply systems (AWWA 950-81)

Various types of pipe fittings are available in plumbing systems for different purposes and functions. A pipe fitting is used in plumbing system to join multiple pipes of same size or different sizes, to regulate the flow or to measure the flow. They are made up of different materials like copper, iron, brass, PVC etc.

Types of Pipe Fittings in Plumbing System

Different pipe fittings and their functions are explained below.

- Elbow
- Reducer
- Tee type
- Cross type
- Coupling
- Unions
- Adaptors
- Bushings
- Plug
- Cap
- Wyes
- Valve

Elbow Pipe Fittings

Elbows are used to change the direction of flow between two pipes. Elbows are generally available with an angle of 22.5o, 45o and 90o. If pipes are of same diameter then normal elbows are used otherwise Reducer elbows are used. Elbows are made of different materials.

These are generally coming with female threads and we can fix them by butt or socket welding also.

Reducer Pipe Fittings

Reducer is a pipe fitting component which reduces the flow size from larger to smaller by reducing size of pipe. Usually there are two types of reducers are available. One is concentric reducer which is like cone shaped with gradual decreasing around the pipe but in this case accumulation of air may possible and it results in cavitation. Other one is eccentric reducer which is having one edge parallel to connecting pipe due to which air accumulation is not possible.

Tee type Pipe Fitting

Tee type fitting is a component of plumbing system which is in T-shape. It is having one inlet and two outlets, outlets are arranged at 90o to the main line connection (inlet). It can also be used to combine the flow from two inlets to one outlet. They are also available in different materials and different sizes. If the 3 sides of T-fitting are similar in size then it is called as Equal tee otherwise it is called as Unequal tee.

Cross type

Cross type fittings contains 4 opening in 4 directions. These are connected when there are 4 pipes are meeting at a point. These fittings generate more amount of stress on pipe as the temperature changes, because they are located at the center of four connection points. Cross fittings are generally used for fire sprinkler systems.

Coupling

A coupling is used to connect the pipes of same diameter. Coupling are also useful if the pipe is broken or leakage occurs. Generally there are two types of couplings are available. Compression coupling and slip coupling. Compression coupling is regular coupling which is connected between two pipes and it prevents leakage by the arrangement of gaskets or rubber seals on both sides, otherwise glue is provided. Slip coupling is easier to install and it contains two pipes which are arranged as one into other, inner pipe can slide up to some length. So, we can fix long length damaged pipe by slip coupling.

Unions

Union is a type of fitting, which functions as similar to coupling. But coupling cannot be removed after fixing but in this case we can remove the union whenever we needed. Unions consists nut, male and female ended threads. So, this is also useful for maintaining purpose of pipe.

Adaptors

If the pipes are not having special ends or plain ends then adaptors make them threaded either male or female whichever is needed. Adopters are generally used for copper and PVC pipes. Male adapters contain male threads and female adapters contains female threads. One end of adapter is plain which is glued or welded or soldered to the plain pipe end.

Bushings
Used to make the diameter of a pipe fitting smaller. They differ from reducers in that they make abrupt changes in diameter and take very little space. Two examples of galvanized steel bushings are face bushings, which take the least amount of space, and hex bushings which can be tightened with an adjustable wrench.

Plug
Plug is a component of plumbing component which is generally used to close pipe opening during inspections and repairs. Plug are generally contains male threads.

Cap
Cap is a type of pipe fitting which function is same as plug but the only difference is plug contain male threads and cap contain female threads which is screws on the male thread of pipe. These are available in different materials like rubber, copper, steel, plastic etc.

Wyes
Used primarily to gain inside access to DMV (drain-waste-vent) systems.

Valves in Pipe Fittings
Valves are components of plumbing system which are used to stop or regulate flow of fluid in its path. Different types of valves are available depending up on their applications.Some important types of valves and its applications are listed below.

- Gate valve, plug valve and Ball valve - used for isolation only
- Globe valve - used for throttling
- Check valve - used for preventing reverse flow (non-return)
- Butterfly valve - used for isolation as well as throttling
- Diaphragm valve - used for isolation as well as throttling