DEPARTMENT OF CIVIL ENGINEERING

LECTURE NOTE

BUILDING MATERIALS

AND

CONSRUCTION TECHNOLOGY

3RD SEMESTER

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1.STONE

STONE:
Stone is a naturally available building materials which has been used from the early age of civilization.It is available in the form of rocks,which is cut to required size and shape and used as building blocks.

Classification of rock:
Stones used for civil engineering works may be classified in the following three ways:

- Geological
- Physical
- Chemical

Geological Classification

Based on their origin of formation stones are classified into three main groups—Igneous, sedimentary and metamorphic rocks.

(*i*) **Igneous Rocks:** These rocks are formed by cooling and solidifying of the rock masses from their molten magmatic condition of the material of the earth. Generally igneous rocks are strong and durable. Granite, trap and basalt are the rocks belonging to this category, Granites are formed by slow cooling of the lava under thick cover on the top. Hence they have crystalline surface. The cooling of lava at the top surface of earth results into non-crystalline and glassy texture. Trap and basalt belong to this category.

ii) **Sedimentary Rocks:** Due to weathering action of water, wind and frost existing rocks disintegrates. The disintegrated material is carried by wind and water; the water being most powerful medium. Flowing water deposits its suspended materials at some points of obstacles to its flow. These deposited layers of materials get consolidated under pressure and by heat. Chemical agents also contribute to the cementing of the deposits. The rocks thus formed are more uniform, fine grained and compact in their nature. They represent a bedded or stratified structure in general. Sand stones, lime stones, mud stones etc. belong to this class of rock.

(*iii*) **Metamorphic Rocks:** Previously formed igneous and sedimentary rocks undergo changes due to metamorphic action of pressure and internal heat. For example due to metamorphic action granite becomes greisses, trap and basalt change to schist and laterite, lime stone changes to marble, sand stone becomes quartzite and mud stone becomes slate.

Physical Classification

Based on the structure, the rocks may be classified as:

- Stratified rocks
- Unstratified rocks

(*i*) **Stratified Rocks:** These rocks are having layered structure. They possess planes of Stratification or cleavage. They can be easily split along these planes. Sand stones, lime stones, slate etc. are the examples of this class of stones.

(*ii*) **Unstratified Rocks:** These rocks are not stratified. They possess crystalline and compact grains. They cannot be split in to thin slab. Granite, trap, marble etc. are the examples of this type of rocks.

(*iii*) **Foliated Rocks:** These rocks have a tendency to split along a definite direction only. The direction need not be parallel to each other as in case of stratified rocks. This type of structure is very common in case of metamorphic rocks.

Chemical Classification

On the basis of their chemical composition engineers prefer to classify rocks as:

- Silicious rocks
- Argillaceous rocks and
- Calcareous rocks

(*i*) ***Silicious rocks:*** The main content of these rocks is silica. They are hard and durable. Examples of such rocks are granite, trap, sand stones etc.

(*ii*) ***Argillaceous rocks:*** The main constituent of these rocks is argil *i.e.*, clay. These stones are hard and durable but they are brittle. They cannot withstand shock. Slates and laterites are examples of this type of rocks.

(*iii*) ***Calcareous rocks:*** The main constituent of these rocks is calcium carbonate. Limestone is a calcareous rock of sedimentary origin while marble is a calcareous rock of metamorphic origin.

Properties of Stones

The following properties of the stones should be looked into before selecting them for engineering works:

(*i*) **Structure:** The structure of the stone may be stratified (layered) or unstratified. Structured stones should be easily dressed and suitable for super structure. Unstratified stones are hard and difficult to dress. They are preferred for the foundation works.

(*ii*) **Texture:** Fine grained stones with homogeneous distribution look attractive and hence they are used for carving. Such stones are usually strong and durable.

(*iii*) **Density:** Denser stones are stronger. Light weight stones are weak. Hence stones with specific gravity less than 2.4 are considered unsuitable for buildings.

(*iv*) **Appearance:** A stone with uniform and attractive colour is durable, if grains are compact.Marble and granite get very good appearance, when polished. Hence they are used for face works in (*v*) **Strength:** Strength is an important property to be looked into before selecting stone as building block. Indian standard code recommends, a minimum crushing strength of 3.5 N/mm2 for any building block. Table 1.1 shows the crushing strength of various stones. Due to non-uniformity of the material, usually a factor of safety of 10 is used to find the permissible stress in a stone. Hence even laterite can be used safely for a single storey building, because in such structures expected load can hardly give a stress of 0.15 N/mm2. However in stone masonry buildings care should be taken to check the stresses when the beams (Concentrated Loads) are placed on laterite wall.

(*vi*) **Hardness:** It is an important property to be considered when stone is used for flooring and pavement. Coefficient of hardness is to be found by conducting test on standard specimen in Dory's

testing machine. For road works coefficient of hardness should be at least 17. For building works stones

(*vii*) **Percentage wear:** It is measured by attrition test. It is an important property to be considered

in selecting aggregate for road works and railway ballast. A good stone should not show wear of more

than 2%.

(*viii*) **Porosity and Absorption:** All stones have pores and hence absorb water. The reaction of water with material of stone causes disintegration. Absorption test is specified as percentage of water absorbed by the stone when it is immersed under water for 24 hours. For a good stone it should be as small as possible and in no case more than 5.

(*ix*) **Weathering:** Rain and wind cause loss of good appearance of stones. Hence stones with good weather resistance should be used for face works.

(*x*) **Toughness:** The resistance to impact is called toughness. It is determined by impact test.Stones with toughness index more than 19 are preferred for road works. Toughness indexes 13 to 19 are considered as medium tough and stones with toughness index less than 13 are poor stones.

(*xi*) **Resistance to Fire:** Sand stones resist fire better. Argillaceous materials, though poor in strength, are good in resisting fire.

(*xii*) **Ease in Dressing:** Cost of dressing contributes to cost of stone masonry to a great extent.Dressing is easy in stones with lesser strength. Hence an engineer should look into sufficient strength rather than high strength while selecting stones for building works.

(*xiii*) **Seasoning:** The stones obtained from quarry contain moisture in the pores. The strength of the stone improves if this moisture is removed before using the stone. The process of removing moisture from pores is called seasoning. The best way of seasoning is to allow it to the action of nature for 6 to 12 months. This is very much required in the case of laterite stones.

Requirements of Good Building Stones

The following are the requirements of good building stones:

(*i*) **Strength:** The stone should be able to resist the load coming on it. Ordinarilly this is not of primary concern since all stones are having good strength. However in case of large structure, it may be necessary to check the strength.

(*ii*) **Durability:** Stones selected should be capable of resisting adverse effects of natural forces like wind, rain and heat.

(*iii*) **Hardness:** The stone used in floors and pavements should be able to resist abrasive forces caused by movement of men and materials over them.

(*iv*) **Toughness:** Building stones should be tough enough to sustain stresses developed due to vibrations. The vibrations may be due to the machinery mounted over them or due to the loads moving

over them. The stone aggregates used in the road constructions should be tough.

(*v*) **Specific Gravity:** Heavier variety of stones should be used for the construction of dams,retaining walls, docks and harbours. The specific gravity of good building stone is between 2.4 and 2.8.

(*vi*) **Porosity and Absorption:** Building stone should not be porous. If it is porous rain water enters into the pour and reacts with stone and crumbles it. In higher altitudes, the freezing of water in pores takes place and it results into the disintegration of the stone.

(*vii*) **Dressing:** Giving required shape to the stone is called dressing. It should be easy to dress so that the cost of dressing is reduced. However the care should be taken so that, this is not be at the cost of the required strength and the durability.

(*viii*) **Appearance:** In case of the stones to be used for face works, where appearance is a primary requirement, its colour and ability to receive polish is an important factor.

(*ix*) **Seasoning:** Good stones should be free from the quarry sap. Laterite stones should not be used for 6 to 12 months after quarrying. They are allowed to get rid of quarry sap by the action of nature. This process of removing quarry sap is called seasoning.

(*x*) **Cost:** Cost is an important consideration in selecting a building material. Proximity of the quarry to building site brings down the cost of transportation and hence the cost of stones comes down. However it may be noted that not a single stone can satisfy all the requirements of a good building stones, since one requirement may contradict another. For example, strength and durability requirement contradicts ease of dressing requirement. Hence it is necessary that site engineer looks into the properties required for the inteded work and selects the stone.

Tests on Stones

To acertain the required properties of stones, the following tests can be conducted:

(*i*) crushing strength test

(*ii*) water absorption test

(*iii*) abrasion test

(*iv*) impact test

(*v*) acid test.

(*i*) **Crushing Strength Test:** For conducting this test, specimens of size 40 × 40 × 40 mm are prepared from parent stone. Then the sides are finely dressed and placed in water for 3 days. The saturated specimen is provided with a layer of plaster of paris on its top and bottom surfaces to get even surface so that load applied is distributed uniformly. Uniform load distribution can be obtained satisfactorily by providing a pair of 5 mm thick playwood instead of using plaster of paris layer also. The specimen so placed in the compression testing machine is loaded at the rate of 14 N/mm2 per minute. The crushing load is noted. Then crushing strength is equal to the crushing load divided by the area over which the load is applied. At least three specimen should be tested and the average should be taken as crushing strength.

(*ii*) **Water Absorption Test:** For this test cube specimen weighing about 50 grams are prepared and the test is carried out in the steps given below:

(*a*) Note the weight of dry specimen as W1.

(*b*) Place the specimen in water for 24 hours.

(*c*) Take out the specimen, wipe out the surface with a piece of cloth and weigh the specimen. Let its weight be W2.

(*d*) Suspend the specimen freely in water and weight it. Let its weight be W3.

(*e*) Place the specimen in boiling water for 5 hours. Then take it out, wipe the surface with

cloth and weigh it. Let this weight be W4. Then,

(*ii*) water absorption test

(*iii*) abrasion test

(*iv*) impact test

(*v*) acid test.

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(*e*) Place the specimen in boiling water for 5 hours. Then take it out, wipe the surface with

cloth and weigh it. Let this weight be W4. Then,

$$\text{Percentage absorption by weight} = \frac{W_2 - W_1}{W_1} \times 100 \qquad \ldots(1)$$

$$\text{Percentage absorption by volume} = \frac{W_2 - W_1}{W_2 - W_3} \times 100 \qquad \ldots(2)$$

$$\text{Percentage porosity by volume} = \frac{W_4 - W_1}{W_2 - W_3} \times 100 \qquad \ldots(3)$$

$$\text{Density} = \frac{W_1}{W_2 - W_1} \qquad \ldots(4)$$

$$\text{Specific gravity} = \frac{W_1}{W_2 - W_3} \qquad \ldots(5)$$

$$\therefore \quad \text{Saturation coefficient} = \frac{\text{Water absorption}}{\text{Total porosity}}$$

$$= \frac{W_2 - W_1}{W_? - W_?}.$$

(*iii*) **Abrasion Test:** This test is carried out on stones which are used as aggregates for road construction. The test result indicate the suitability of stones against the grinding action under traffic. Any one of the following test may be conducted to find out the suitability of aggregates:

(*i*) Los Angeles abrasion test

(*ii*) Deval abrasion test

(*iii*) Dorry's abrasion test.

However Los Angeles abrasion test is preferred since these test results are having good correlation with the performance of the pavements.

The Los Angeles apparatus [Fig. 1.1] consists of a hollow cylinder 0.7 m inside diameter and 0.5 m long with both ends closed. It is mounted on a frame so that it can be rotated about horizontal axis. IS code has standardised the test procedure for different gradation of specimen. Along with specified weight of specimen a specified number of cast iron balls of 48 mm diameter are placed in the cylinder.

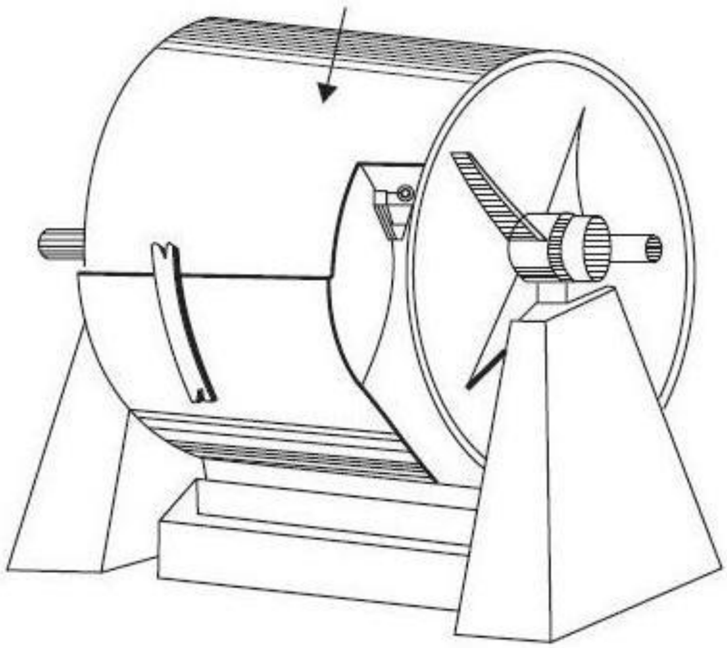


Fig. 1.1. Los Angeles testing machine

Then the cylinder is rotated at a speed of 30 to 33 rpm for specified number of times (500 to 1000). Then the aggregate is removed and sieved on 1.7 mm. IS sieve. The weight of aggregate passing is found.

Then Los Angeles value is found as,

$$= \frac{\text{Weight of aggregate passing through sieve}}{\text{Original weight}} \times 100.$$

The following values are recommended for road works:

For bituminous mixes – 30%

For base course – 50%

(*iv*) **Impact Test:** The resistance of stones to impact is found by conducting tests in impacting testing machine (Fig. 1.2). It consists of a frame with guides in which a metal hammer weighing 13.5 to 15 kg can freely fall from a height of 380 mm.

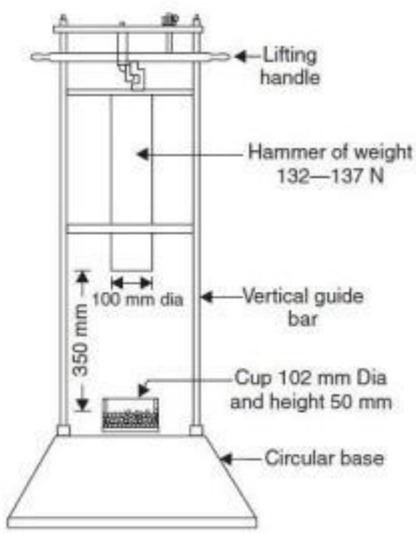


Fig. 1.2. Aggregate impact testing machine

Aggregates of size 10 mm to 12.5 mm are filled in cylinder in 3 equal layers; each layer being tamped 25 times. The same is then transferred to the cup and again tamped 25 times. The hammer is then allowed to fall freely on the specimen 15 times. The specimen is then sieved through 2.36 mm sieve. Then,

Where

W2 = weight of fines

W1 = original weight.

(*v*) **Acid Test:** This test is normally carried out on sand stones to check the presence of calcium carbonate, which weakens the weather resisting quality. In this test, a sample of stone weighing about 50 to 100 gm is taken and kept in a solution of one per cent hydrochloric acid for seven days. The solution is agitated at intervals. A good building stone maintains its sharp edges and keeps its surface intact. If edges are broken and powder is formed on the surface, it indicates the presence of calcium

carbonate. Such stones will have poor weather resistance.

Uses of Stones

Stones are used in the following civil engineering constructions:

(*i*) Stone masonry is used for the construction of foundations, walls, columns and arches.

(*ii*) Stones are used for flooring.

(*iii*) Stone slabs are used as damp proof courses, lintels and even as roofing materials.

(*iv*) Stones with good appearance are used for the face works of buildings. Polished marbles and granite are commonly used for face works.

(*v*) Stones are used for paving of roads, footpaths and open spaces round the buildings.

(*vi*) Stones are also used in the constructions of piers and abutments of bridges, dams and retaining

(*vii*) Crushed stones with graved are used to provide base course for roads. When mixed with tar they form finishing coat.

(*viii*) Crushed stones are used in the following works also:

(*a*) As a basic inert material in concrete

(*b*) For making artificial stones and building blocks

(*c*) As railway ballast.

Common Building Stones

The following are the some of commonly used stones:

(*i*) Basalt and trap

(*ii*) Granite

(*iii*) Sand stone

(*iv*) Slate

(*v*) Laterite

(*vi*) Marble

(*vii*) Gneiss

(*viii*) Quartzite.

Their qualities and uses are explained below:

(*i*) **Basalt and Trap:** The structure is medium to fine grained and compact. Their colour varies from dark gray to black. Fractures and joints are common. Their weight varies from 18 kN/m3 to 29 kN/m3.

The compressive strength varies from 200 to 350 N/mm2. These are igneous rocks. They are used as road metals, aggregates for concrete. They are also used for rubble masonry works for bridge piers, river walls and dams. They are used as pavement.

(*ii*) **Granite:** Granites are also igneous rocks. The colour varies from light gray to pink. The structure is crystalline, fine to coarse grained. They take polish well. They are hard durable. Specific gravity is from 2.6 to 2.7 and compressive strength is 100 to 250 N/mm2. They are used primarily for bridge piers, river walls, and for dams. They are used as kerbs and pedestals. The use of granite for monumental and institutional buildings is common. Polished granites are used as table tops, cladding for columns and wall. They are used as coarse aggregates in concrete.

(*iii*) **Sand stone:** These are sedimentary rocks, and hence stratified. They consist of quartz and feldspar. They are found in various colours like white, grey, red, buff, brown, yellow and even dark gray. The specific gravity varies from 1.85 to 2.7 and compressive strength varies from 20 to 170 N/mm2. Its porosity varies from 5 to 25 per cent. Weathering of rocks renders it unsuitable as building stone. It is desirable to use sand stones with silica cement for heavy structures, if necessary. They are used for masonry work, for dams, bridge piers and river walls.

(*iv*) **Slate:** These are metamorphic rocks. They are composed of quartz, mica and clay minerals. The structure is fine grained. They split along the planes of original bedding easily. The colour varies from dark gray, greenish gray, purple gray to black. The specific gravity is 2.6 to 2.7. Compressive strength varies from 100 to 200 N/mm2. They are used as roofing tiles, slabs, pavements etc.

(*v*) **Laterite:** It is a metamorphic rock. It is having porous and sponges structure. It contains high percentage of iron oxide. Its colour may be brownish, red, yellow, brown and grey. Its specific gravity is 1.85 and compressive strength varies from 1.9 to 2.3 N/mm2. It can be easily quarried in blocks. With

(*vi*) **Marble:** This is a metamorphic rock. It can take good polish. It is available in different pleasing colours like white and pink. Its specific gravity is 2.65 and compressive strength is 70–75 N/ mm2. It is used for facing and ornamental works. It is used for columns, flooring, steps etc.

(*vii*) **Gneiss:** It is a metamorphic rock. It is having fine to coarse grains. Alternative dark and white bands are common. Light grey, pink, purple, greenish gray and dark grey coloured varieties are available. These stones are not preferred because of deleterious constituents present in it. They may be used in minor constructions. However hard varieties may be used for buildings. The specific gravity varies from 2.5 to 3.0 and crushing strength varies from 50 to 200 N/mm2.

(*viii*) **Quartzite:** Quartzites are metamorphic rocks. The structure is fine to coarse grained and often granular and branded. They are available in different colours like white, gray, yellowish. Quartz is the chief constituent with feldspar and mica in small quantities. The specific gravity varies from 2.55 to 2.65. Crushing strength varies from 50 to 300 N/mm2. They are used as building blocks and slabs. They are also used as aggregates for concre

2.BRICK

Constituents of good brick earth:

Bricks are the most commonly used construction material. Bricks are prepared by moulding clay in rectangular blocks of uniform size and then drying and burning these blocks. In order to get a good quality brick, the brick earth should contain the following constituents.

- Silica
- Alumina
- Lime
- Iron oxide
- Magnesia

Silica

- Brick earth should contain about 50 to % of silica.
- It is responsible for preventing cracking, shrinking and warping of raw bricks.
- It also affects the durability of bricks.
- If present in excess, then it destroys the cohesion between particles and the brick becomes brittle.

Alumina

- Good brick earth should contain about 20% to 30% of alumina.
- It is responsible for plasticity characteristic of earth, which is important in moulding operation.
- If present in excess, then the raw brick shrink and warp during drying.

Lime

- The percentage of lime should be in the range of 5% to 10% in a good brick earth.
- It prevents shrinkage of bricks on drying.
- It causes silica in clay to melt on burning and thus helps to bind it.
- Excess of lime causes the brick to melt and brick looses its shape.

Iron oxide

- A good brick earth should contain about 5% to 7% of iron oxide.
- It gives red colour to the bricks.
- It improves impermeability and durability.
- It gives strength and hardness.
- If present in excess, then the colour of brick becomes dark blue or blakish.
- If the quantity of iron oxide is comparatively less, the brick becomes yellowish in colour.

Magnesia

- Good brick earth should contain less a small quantity of magnesia about1%)
- Magnesium in brick earth imparts yellow tint to the brick.
- It is responsible for reducing shrinkage
- Excess of magnesia leads to the decay of bricks.

Harmful Ingredients in Brick:

Below mentioned are some of the ingredients which are undesired in brick earth.

Lime

- A small quantity of lime is required in brick earth. But if present in excess, it causes the brick to melt and hence brick looses its shape.
- If lime is present in the form of lumps, then it is converted into quick lime after burning. This quick lime slakes and expands in presence of moisture, causing splitting of bricks into pieces.

Iron pyrites

- The presence of iron pyrites in brick earth causes the brick to get crystallized and disintegrated during burning, because of the oxidation of the iron pyrits.

- Pyrites discolourise the bricks.

Alkalis

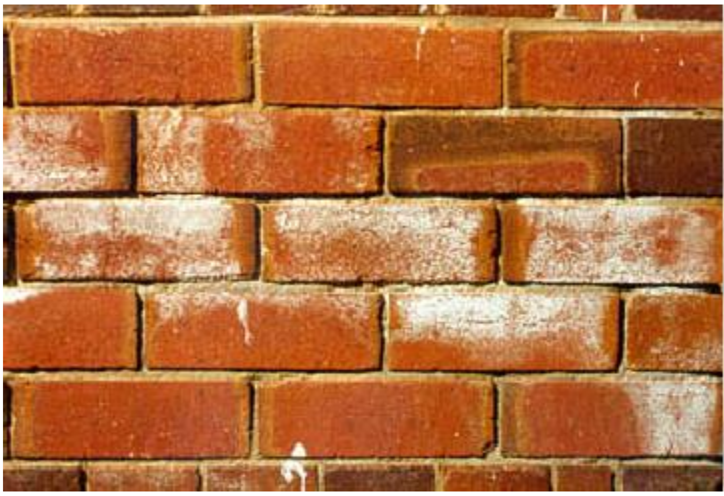
- These are exist in the brick earth in the form of soda and potash. It acts as a flux in the kiln during burning and it causes bricks to fuse, twist and warp. Because of this, bricks are melted and they loose their shape.
- The alkalis remaining in bricks will absorb moisture from the atmosphere, when bricks are used in masonry. With the passage of time, the moisture gets evaporated leaving grey or white deposits on the wall surface (known as**efflorescence**). This white patch affects the appearance of the building structure.

Pebbles

- Pebbles in brick earth create problem during mixing operation of earth. It prevents uniform and through mixing of clay, which results in weak and porous bricks
- Bricks containing pebbles will not break into shapes as per requirements.

Vegetation and Organic Matter

- The presence of vegetation and organic matter in brick earth assists in burning. But if such matter is not completely burnt, the bricks become porous. This is due to the fact that the gasses will be evolved during the burning of the carbonaceous matter and it will result in the formation of small pores.

Efflorescence in BrickStone in Brick

Manufacturing of bricks

In the process of manufacturing bricks, the following distinct operations are involved.

- Preparation of clay
- Moulding
- Drying
- Burning

Each of the above operation of the manufacturing bricks will now be studied at length.

Preparation of clay

The clay for brick is prepared in the following order.

- Unsoiling
- Digging
- Cleaning
- Weathering
- Blending
- Tempering

Unsoiling: The top layer of the soil, about 200mm in depth, is taken out and thrown away. The clay in top soil is full of impurities and hence it is to be rejected for the purpose of preparing bricks.

Digging: The clay is then dug out from the ground. It is spread on the levelled ground, just a little deeper than the general level. The height of heaps of clay is about 600mm to 1200mm.

Cleaning: The clay as obtained in the process of digging should be cleaned of stones, pebbles, vegetable matters. If these particles are in excess, the clay is to be washed and screened. Such a process naturally will prove to be troublesome and expensive.

Weathering: The clay is then exposed to atmosphere for softening and mellowing. The period varies from few weeks to full season.

Blending: The clay is made loose and any ingredient to be added to it , is spread out at its top. The blending indicates intimate or harmonious mixing. It is carried out by taking a small amount of clay every time and turning it up and down in vertical direction. The blending makes clay fit for the next stage of tempering.

Tempering: In the process of tempering, the clay is brought to a proper degree of hardness and it is made fit for the next operation of moulding .Kneaded or pressed under the feet of man or cattle .The tempering should be done exhaustively to obtain homogeneous mass of clay of uniform character.For manufacturing good bricks on a large scale, tempering is done in pug mill.A typical pug mill capable of tempering sufficient earth for a daily output of about 15000 to20000 bricks.

A pug mill consists of a conical iron tub with cover at its top .It is fixed on a timber base which is made by fixing two wooden planks at right angle to each other. The bottom of tub is covered except for the hole to take out pugged earth. The diameter of pug mill at bottom is about 800mm and that at top is about 1 m.The provision is made in top cover to place clay inside pug mill .A vertical shaft with horizontal arms is provided at center of iron tub.The small wedge-shaped knives of steel are fixed at arms.The long arms are fixed at vertical shaft to attach a pair of bullocks .The ramp is provided to collect the pugged clay .The height of pug mill is about 2m. Its depth below ground is 600m to800mm lessen the rise of the barrow run and to throw out the tempered clay conveniently.In the beginning, the hole for pugged clay is closed and clay with water is placed in pug mill from the top. When vertical shaft is rotated by a pair of bullock, the clay is thoroughly mixed up by the action of horizontal arms and knives and homogeneous mass is formed.

The rotation of vertical shaft can also be achieved by using steam, diesel or electrical power.When clay has been sufficiently pugged, the hole at the bottom of the tub, is opened out and pugged earth is taken out from the ramp by barrow i.e. a small cart with wheels for next operation of moulding.The pug mill is then kept moving and feeding of clay from top and taking out of pugged clay from bottom are done simultaneously.If tempering is properly carried out, the good brick earth can then be rolled without breaking in small threads of 3mm diameter.

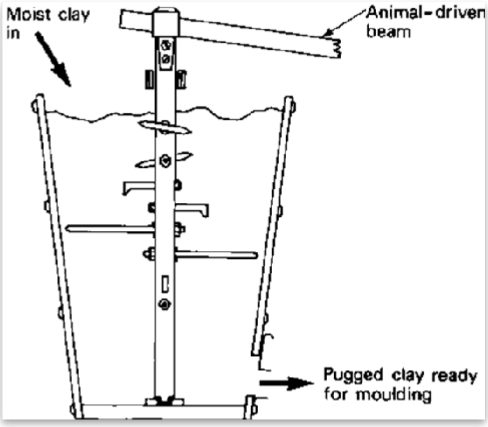


Fig of a Pug mill

Moulding:

The clay which is prepared as above is then sent for the text operation of moulding.Following are two types of moulding:

i. Hand Moulding

ii. Machine Moulding

Hand moulding:

In hand moulding , the bricks are moulded by hand *i.e.;* manually. It is adopted where manpower is cheap and is readily available for the manufacturing process of bricks ona small scale.The moulds are rectangular boxes which are open at top and bottom.They may be of wood or steel.It should be beprepared from well-seasonedwood. The longer sides are kept slightly projecting to serve as handles. The strips of brass or steel are sometimes fixed on the edges of wooden moulds to make them more durable.It is prepared from the combination of steel plate and channel. It may even be prepared from steel angles and plates. Thethickness of steel mould is 6mm.They is used for manufacturing bricks on alarge scale. The steel moulds are more durable than wooden one and turn out bricks of uniform size.The bricks shrink during drying and burning .Hence the mouldsare therefore made larger than burnt bricks (8-12%).

The bricks prepared by hand moulding are of two types: Ground mouldedand Tablemoulded

Ground mouldedbricks: The ground is first made level and fine sand is sprinkled over it.The mould is dipped in water and placed over the ground. The lump of tempered clay is taken and is dashed is the mould.The clay is pressed in the mould in such a way that it fills all the corners of mould.The surplus clay is removed by wooden strike or framed with wire. A strike is a piece of wood or metal with a sharp edge.It is to be dipped in water every time.The mould is then lifted up and raw brick ids left on the ground.The mould is dipped in water and it is placed just near the previous brick to prepare another brick.The process is repeated till the ground is covered with raw bricks.The lower faces of ground moulded bricks are rough and it is not possible to place frog on such bricks.A frog is mark of depth about 10mm to 20mm which is placed on raw brick during moulding.It serves two purposes.

1.It indicates the trade name of the manufacturer

2.In brick work, the bricks are laid with frog uppermost. It thus affords a key for mortar when the next brick is placed over it.

The 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. A pallet is a piece of thin wood.The block is bigger than the mould and it has projection of about 6mm height on its surface.The dimensions of projection correspond to internal dimensions of mould.The design of impression or frog is made on this block.The wooden block is also known as the moulding block or stock board.

The mould is placed to fit in the projection of wooden block and clay is then dashed inside the mould.A pallet is placed on the top and the whole thing is then turn upside down.The mould is taken out and placed over the raw brick and it is conveyed to the drying sheds.The bricks are placed to stand on their longer sides in drying sheds and pallet boards are brought back for using them again.As the bricks are laid on edge, they occupyless space and they dry quicker and better.

Table Moulded Bricks:

i) The process of moulding of bricks is just similar as above.But in this case, the mould stands near a table size 2m x 1m. The bricks are moulded on the table and send for further process of drying.
ii) However the efficiency of the moulder gradually decreases because of standing at some place for a longer duration.The cost of brick is also increases when table moulding is adopted.

Machine Moulding:

This type of moulding is carried out by two processes:

i) Plastic clay machine
ii) Dry clay machine

Plastic Clay Moulding

i) Such machine consists of a rectangular opening having length and width is equal to an ordinary bricks. The pugged clay is placed in the machine and it comes out through the rectangular opening.

ii) These are cut into strips by the wire fixed at the frame. The arrangement is made in such a way that the strips thickness is equal to that of the bricks are obtained. So it is also called as WIRE CUT BRICKS.

Dry Clay Machinemoulding:

In these machines, the strong clay is finally converted in to powered form.A small quantity of water is then added to form a stiff plastic paste.

ii) Such paste is placed in mould and pressed by machine to form dry and well-shaped bricks. They do not require the process of drying.

Drying

The damp bricks, if brunt,are likely to be cracked and distorted.Hence the moulded bricks are dried before they are taken for the next operation of burning. For the drying the bricks are laid longitudinally in the stacks of width equal to two bricks,A stack consists of ten or eight tiers.The bricks are laid along and across the stock in alternate layers. All the bricks are placed on edges. The bricks are allowed to dry until the bricks are become leather hard of moisture content about 2%.

Burning

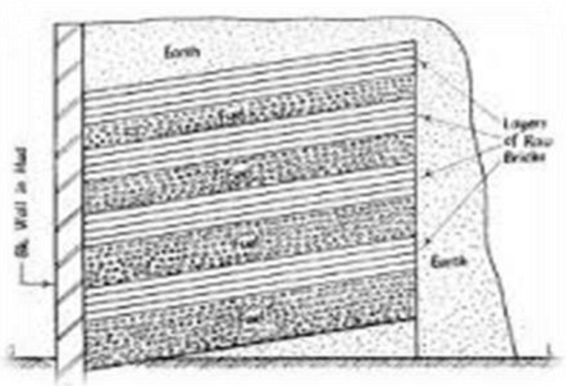
Bricks are burned at high temperature to gain the strength, durability, density and red color appearance.All the water is removed at the temperature of 650 degrees but they are burnt at an temperature of about 1100 degrees because the fusing of sand and lime takes place at this temperature and chemical bonding takes between these materials after the temperature is cooled down resulting in the hard and dense mass.

Bricks are not burnt above this temperature because it will result in the melting of the bricks and will result in a distorted shape and a very hard mass when cooled which will not be workable while brickwork. Bricks can be burnt using the following methods:

(a) Clamp Burning
(b) Kiln Burning

Clamp Burning:

Clamp is a temporary structure generally constructed over the ground with a height of about 4 to 6 m. It is employed when the demand of the bricks is lower scale and when it is not a monsoon season. This is generally trapezoidal in plan whose shorter edge among the parallel sides is below the ground and then the surface raising constantly at about 15 degrees to reach the other parallel edge over the ground.A vertical brick and mud wall is constructed at the lower edge to support the stack of the brick. First layer of fuel is laid as the bottom most layer with the coal, wood and other locally available material like cow dung and husk.Another layer of about 4 to 5 rows of bricks is laid and then again a fuel layer is laid over it. The thickness of the fuel layer goes on with the height of the clamp.



After these alternate layers of the bricks and fuel the top surface is covered with the mud so as to preserve the heat.Fire is ignited at the bottom, once fire is started it is kept under fire by itself for one or two months and same time period is needed for the cooling of the bricks.

Disadvantages of Clamp burning:

1. Bricks at the bottom are over-burnt while at the top are under-burnt.
2. Bricks loose their shape, and reason may be their descending downward once the fuel layer is burnt.
3. This method cannotemploy for the manufacturing of large number of bricks and it is costly in terms of fuel because large amount of heat is wasted.
4. It cannot be employed in monsoon season.

Kiln Burning:

Kiln is a large oven used for the burning of bricks. Generally coal and other locally available materials like wood, cow dung etc can be used as fuel. They are of two types:

- Intermittent Kilns.
- Continuous Kilns.

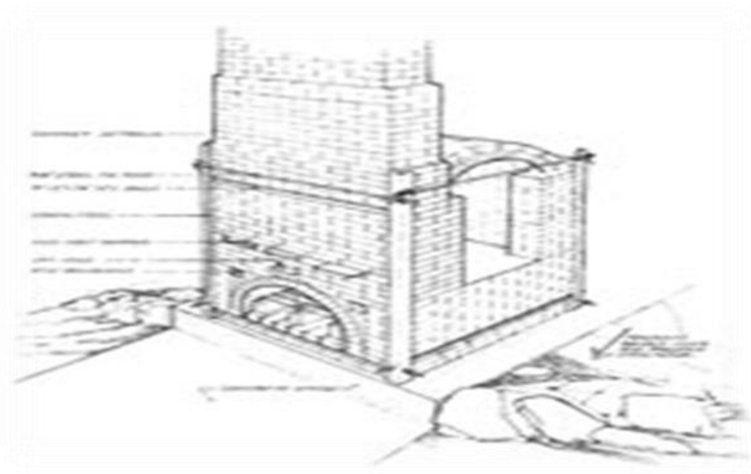


Fig of a typical kiln

Intermittent Kilns: these are also the periodic kind of kilns, because in such kilns only one process can take place at one time. Various major processes which takes place in the kilns are:*Loading, unloading, Cooling, and Burning of bricks.*

There are two kind of intermittent kilns:

(i) Up-draught Intermittent Kilns
(ii) Down draught Intermittent Kilns

Down draught kilns are more efficient because the heat is utilized more by moving the hot gases in the larger area of the kiln. In up draught kilns the hot gases are released after they rise up to chimney entrance.

Continuous Kilns:

These kilns are called continuous because all the processes of loading, unloading, cooling, heating, pre-heating take place simultaneously. They are used when the bricks are demanded in larger scale and in short time. Bricks burning are completed in one day, so it is a fast method of burning.There are two well-known continuous kilns:

*Bull's Trench Kiln:*Bull's trench kiln consists of a rectangular, circular or oval plan shape. They are constructed below the ground level by excavating a trench of the required width for the given capacity of brick manufacturing.This Trench is divided generally in 12 chambers so that 2 numbers of cycles of brick burning can take place at the same time for the larger production of the bricks. Or it may happen that one cycle is carried out at one time in all the 12 chambers by using a single process in the 2-3 chambers at the same time.The structure is under-ground so the heat is conserved to a large extent so it is more efficient. Once fire is started it constantly travels from one chamber to the other chamber, while other operations like loading, unloading, cooling, burning and preheating taking place simultaneously.

Such kilns are generally constructed to have a manufacturing capacity of about 20,000 bricks per day. The drawback of this kiln is that there is not a permanent roof, so it is not easy to manufacture the bricks in the monsoon seasons.

*Hoffman's Kiln:*The main difference between the Bull's trench kiln and the Hoffman kilns are:

1. Hoffman's kiln is an over the ground structure while Bull's Trench Kiln is an underground structure.
2. Hoffman's kiln have a permanent roof while Bull's trench Kiln do not have so it former can be used in 12 months a year to manufacture bricks but later is stopped in the monsoon season.

Hoffman's kiln is generally circular in plan, and is constructed over the ground. The whole structure is divided into the 12 chambers and the entire processes takes place simultaneously like in Bull's trench Kiln.

Classification of Bricks as per common practice:

Bricks, which are used in construction works, are burnt bricks. They are classified into four categories on the basis of its manufacturing and preparation, as given below.

1. First class bricks
2. Second class bricks
3. Third class bricks
4. Fourth class bricks

First Class Bricks:

These bricks are table moulded and of standard shape and they are burnt in kilns. The surface and edges of the bricks are sharp, square, smooth and straight. They comply with all the qualities of good bricks. These bricks are used for superior work of permanent nature.

Second Class Bricks:

These bricks are ground moulded and they are burnt in kilns. The surface of these bricks is somewhat rough and shape is also slightly irregular. These bricks may have hair cracks and their edges may not be sharp and uniform. These bricks are commonly used at places where brick work is to be provided with a coat of plaster.

Third Class Bricks:

These bricks are ground moulded and they are 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.

Fourth Class Bricks:

These are over burnt bricks with irregular shape and dark colour. These bricks are used as aggregate for concrete in foundations, floors, roads etc, because of the fact that the over burnt bricks have a compact structure and hence they are sometimes found to be stronger than even the first class bricks.

Classification of Bricks as per constituent materials

There are various types of bricks used in masonry.

- Common Burnt Clay Bricks
- Sand Lime Bricks (Calcium Silicate Bricks)
- Engineering Bricks
- Concrete Bricks
- Fly ash Clay Bricks

Common Burnt Clay Bricks

Common burnt clay bricks are formed by pressing in moulds. Then these bricks are dried and fired in a kiln. Common burnt clay bricks are used in general work with no special attractive appearances. When these bricks are used in walls, they require plastering or rendering.

Sand Lime Bricks

Sand lime bricks are made by mixing sand, fly ash and lime followed by a chemical process during wet mixing. The mix is then moulded under pressure forming the brick. These bricks can offer advantages over clay bricks such as: their colour appearance is grey instead of the regular reddish colour.Their shape is uniform and presents a smoother finish that doesn't require plastering.These bricks offer excellent strength as a load-bearing member.

Engineering Bricks

Engineering bricks are bricks manufactured at extremely high temperatures, forming a dense and strong brick, allowing the brick to limit strength and water absorption.Engineering bricks offer excellent load bearing capacity damp-proof characteristics and chemical resisting properties.

Concrete Bricks

Concrete bricks are made from solid concrete. Concrete bricks are usually placed in facades, fences, and provide an excellent aesthetic presence. These bricks can be manufactured to provide different colours as pigmented during its production.

Fly Ash Clay Bricks

Fly ash clay bricks are manufactured with clay and fly ash, at about 1,000 degrees C. Some studies have shown that these bricks tend to fail poor produce pop-outs, when bricks come into contact with moisture and water, causing the bricks to expand.

Tests on Bricks

To know the quality of bricks following 7 tests can be performed. In these tests some are performed in laboratory and the rest are on field.

- Compressive strength test
- Water Absorption test
- Efflorescence test
- Hardness test
- Size, Shape and Colour test
- Soundness test
- Structure test

Compressive strength test: This test is done to know the compressive strength of brick. It is also called crushing strength of brick. Generally 5 specimens of bricks are taken to laboratory for testing and tested one by one. In this test a brick specimen is put on crushing machine and applied pressure till it breaks. The ultimate pressure at which brick is crushed is taken into account. All five brick specimens are tested one by one and average result is taken as brick's compressive/crushing strength.

Water Absorption test: In this test bricks are weighed in dry condition and let them immersed in fresh water for 24 hours. After 24 hours of immersion those are taken out from water and wipe out with cloth. Then brick is weighed in wet condition. The difference between weights is the water absorbed by brick. The percentage of water absorption is then calculated.The less water absorbed by brick the greater its quality. Good quality brickdoesn't absorb more than 20% water of its own weight.

Efflorescence test: The presence of alkalies in bricks is harmful and they form a grey or white layer on brick surface by absorbing moisture. To find out the presence of alkalis in bricks this test is performed. In this test a brick is immersed in fresh water for 24 hours and then it's taken out from water and allowed to dry in shade.If the whitish layer is not visible on surface it proofs that absence of alkalis in brick. If the whitish layer visible about 10% of brick surface then the presence of alkalis is in acceptable range. If that is about 50% of surface then it is moderate. If the alkalies' presence is over 50% then the brick is severely affected by alkalies.

Hardness test: In this test a scratch is made on brick surface with a hard thing. If that doesn't left any impression on brick then that is good quality brick.

Size, shape and colour test: In this test randomly collected 20 bricks are staked along lengthwise, width wise and height wise and then those are measured to know the variation of sizes as per standard. Bricks are closely viewed to check if its edges are sharp and straight and uniform in shape. A good quality brick should have bright and uniform colour throughout.

Soundness test: In this test two bricks are held by both hands and struck with one another. If the bricks give clear metallic ringing sound and don’t break then those are good quality bricks.

Structure test: In this test a brick is broken or a broken brick is collected and closely observed. If there are any flows, cracks or holes present on that broken face then that isn’t good .

3. CEMENT,MORTAR AND CONCRETE

Cement is a binder, a substance that sets and hardens and can bind other materials together. Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to be used in the presence of water.Non-hydraulic cement will not set in wet conditions or underwater, rather it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting.Hydraulic cement is made by replacing some of the cement in a mix with activated aluminium silicates, pozzolanas, such as fly ash. The chemical reaction results in hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack (e.g., Portland cement).

Use

- Cement mortar for Masonry work, plaster and pointing etc.
- Concrete for laying floors, roofs and constructing lintels,beams,weather-shed,stairs,pillars etc.
- Construction for important engineering structures such asbridge,culverts,dams,tunnels,light house,clocks,etc.
- Construction of water,wells, tennis courts,septic tanks, lamp posts, telephone cabins etc.
- Making joint for joints,pipes,etc.
- Manufacturing of precast pipes,garden seats, artistically designed wens, flower posts, etc.
- Preparation of foundation, water tight floors, footpaths, etc.

Types of Cements

Many types of cements are available in markets with different compositions and for use in different environmental conditions and specialized applications. A list of some commonly used cement is described in this section:

Ordinary Portland cement

Ordinary Portland cement is the most common type of cement in general use around the world. This cement is made by heating limestone (calcium carbonate) with small quantities of other materials (such as clay) to 1450°C in a kiln, in a process known as calcination, whereby a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which is then blended with the other materials that have been included in the mix. The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum into a powder to make 'Ordinary Portland Cement'(often referred to as OPC). Portland cement is a basic ingredient of concrete, mortar and most non-specialty grout. The most common use for Portland cement is in the production of concrete. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water. As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Portland cement may be grey or white.

- This type of cement use in construction when there is no exposure to sulphates in the soil or ground water.
- Lime saturation Factor is limited between i.e. 0.66 to 1.02.
- Free lime-cause the Cement to be unsound.
- Percentage of (AL_2O_3/Fe_2O_3) is not less than 0.66.
- Insoluble residue not more than 1.5%.
- Percentage of SO_3 limited by 2.5% when C_3A < 7% and not more than 3% when C_3A >7%.
- Loss of ignition -4%(max)
- Percentage of Mg0-5% (max.)
- Fineness -not less than 2250 cm^2/g.

Rapid hardening Portland cement

- It is firmer than Ordinary Portland Cement
- It contains more C_3S are less C_2S than the ordinary Portland cement.
- Its 3 days strength is same as 7 days strength of ordinary Portland cement.

Low heat Portland cement

- Heat generated in ordinary Portland cement at the end of 3days 80 cal/gm. While in low heat cement it is about 50cal/gm of cement.
- It has low percentage of C3A and relatively more C_2S and less C_3S than O.P. Cement.
- Reduce and delay the heat of hydration. British standard (B S. 1370 : 1974) limit the heat of hydration of this cement.

Sulphate resisting Portland cement

- Maximum C3A content by 3.5% and minimum fineness by 2500 cm'/g.

- Firmer than ordinary pot land cement.
- Sulphate forms the sulpha-aluminates which have expensive properties and so causes disintegration of concrete.

Sulphate resisting Portland cement

- For this cement, the silage as obtained from blast furnace is used
- The clinkers of cement are ground with about 60 to 65 percent of slag.
- Its strength in early days is less and hence it required longer curing period. It proves to be economical as slag, which is a Waste product, is used in its manufactures.

Pozzolanic cement

- As per Indian standard, the proportions of Pozzolana may be 10 to 25 % by weight. e.2. Burnt clay, shale, Fly ash.
- This Cement has higher resistance to chemical agencies and to sea water because of absence of lime.
- It evolves less heat and initial strength is less but final strength is 28 days onward equal to ordinary Portland cement.
- It possesses less resistance to the erosion and weathering action.
- It imparts higher degree of water tightness and it is cheap.

White Portland cement

- Grey colour of O.P. cement is due to presence of Iron Oxide. Hence in White Cement Fe,,O, is limited to 1 %. Sodium Alumina Ferrite (Crinoline) NavAlF6 is added to act as flux in the absence of Iron-Oxide. •:
- It is quick drying, possesses high strength and has superior aesthetic values and it also cost lee than ordinary Cement because of specific requirements imposed upon the raw materials and the manufacturing process.
- White Cement are used in Swimming pools, for painting garden furniture, moulding sculptures and statues etc.

Coloured Portland

- The Cement of desired colour may be obtained by mixing mineral pigments with ordinary Cement.
- The amount of colouring material may vary from 5 to 10 percent. If this percentage exceeds 10percent, the strength of cements is affected.
- The iron Oxide in different proportions gives brown, red or yellow colour. The coloured Cement are widely used for finishing of floors, window sill slabs, stair treads etc.

Expansive cement

- This type of cement is produced by adding an expanding medium like sulphoaluminate and a stabilising agent to the ordinary cement.
- The expanding cement is used for the construction of water retaining structures and for repairing the damaged concrete surfaces.

High alumina cement

- This cement is produced by grilling clinkers formed by calcining bauxite and lime. It can stand high temper lures.
- If evolves great heat during setting. It is therefore not affected by frost.

Composition of Cement clinker

The various constituents combine in burning and form cement clinker. The compounds formedin the burning process have the properties of setting and hardening in the presence ofwater.They are known as Bogue compounds after the name of Bogue who identified them. These compounds are as follows: Alite (Tricalcium silicate or C_3S), Belite (Dicalcium silicate or C_2S), Celite (Tricalciumalluminate or C_3A) andFelite (Tetracalciumalumino ferrite or C_4AF).

Tricalcium silicate

It is supposed to be the best cementing material and is well burnt cement.It is about 25-50% (normally about 40 per cent) of cement. It renders the clinker easier to grind,increases resistance to freezing and thawing, hydrates rapidly generating high heat and developsan early hardness and strength. However, raising of C_3S content beyond the specified limitsincreases the heat of hydration and solubility of cement in water. The hydrolysis of C_3S is mainly responsible for 7 day strength and hardness. The rate of hydrolysis of C_3S and the character of gel developed are the main causes of the hardness and early strength of cement paste. The heat of hydration is 500 J/g.

Dicalcium silicate

It constitutes about 25-40% (normally about 32 per cent) of cement. It hydrates andhardens slowly and takes long time to add to the strength (after a year or more). It impartsresistance to chemical attack. Rising of C_2S content renders clinker harder to grind, reducesearly strength, decreases resistance to freezing and thawing at early ages and decreases heat ofhydration. The hydrolysis of C_2S proceeds slowly. At early ages, less than a month, C_2S has little influence on strength and hardness. While after one year, its contribution to the strength and hardness is proportionately almost equal to C_3S. The heat of hydration is 260 J/g.

Tricalcium alluminate

It is about 5-11% (normally about 10.5 per cent) of cement. It rapidlyreacts with water and is responsible for flash set of finely grounded clinker. The rapidity ofaction is regulated by the addition of 2-3% of gypsum at the time of grinding cement. Tricalciumaluminate is responsible for the initial set, high heat of hydration and has greater tendency tovolume changes causing cracking. Raising the C3A content reduces the setting time, weakens resistance to sulphate attack and lowers the ultimate strength, heat of hydration and contractionduring air hardening. The heat of hydration of 865 J/g.

Tetra calcium alumino ferrite

It constitutes about 8–14% (normally about 9 per cent) of cement. It isresponsible for flash set but generates less heat. It has poorest cementing value. Raising theC4AF content reduces the strength slightly. The heat of hydration is 420 J/g.

Hydration of Cement

In the anhydrous state, four main types of minerals are normally present: alite, belite, celiteand felite. Also present are small amounts of clinker sulfate (sulfates of sodium, potassium and calcium) and gypsum, which was added when the clinker was ground up to produce the familiar grey powder.

When water is added, the reactions which occur are mostly exothermic, that is, the reactions generate heat. We can get an indication of the rate at which the minerals are reacting by monitoring the rate at which heat is evolved using a technique called conduction calorimetry.Almost immediately on adding water some of the clinker sulphates and gypsum dissolve producing an alkaline, sulfate-rich, solution.Soon after mixing, the (C_3A) phase (the most reactive of the four main clinker minerals) reacts with the water to form an aluminate-rich gel (Stage I on the heat evolution curve above). The gel reacts with sulfate in solution to form small rod-like crystals of ettringite. (C_3A) reaction is with water is strongly exothermic but does not last long, typically only a few minutes, and is followed by a period of a few hours of relatively low heat evolution. This is called the dormant, or induction period (Stage II).The first part of the dormant period, up to perhaps half-way through, corresponds to when concrete can be placed. As the dormant period progresses, the paste becomes too stiff to be workable.At the end of the dormant period, the alite and belite in the cement start to react, with the formation of calcium silicate hydrate and calcium hydroxide. This corresponds to the main period of hydration (Stage III), during which time concrete strengths increase. The individual grains react from the surface inwards, and the anhydrous particles become smaller. (C_3A) hydration also continues, as fresh crystals become accessible to water.The period of maximum heat evolution occurs typically between about 10 and 20 hours after mixing and then gradually tails off. In a mix containing OPC only, most of the strength gain has occurred within about a month. Where OPC has been partly-replaced by other materials, such as fly ash, strength growth may occur more slowly and continue for several months or even a year.Ferrite reaction also starts quickly as water is added, but then slows down, probably because a layer of iron hydroxide gel forms, coating the ferrite and acting as a barrier, preventing further reaction.

Products of Hydration

During Hydration process several hydrated compounds are formed most important of which are, Calcium silicate hydrate, calcium hydroxide and calcium aluminium hydrates which is important for strength gain.

Calcium silicate hydrate:

This is not only the most abundant reaction product, occupying about 50% of the paste volume, but it is also responsible for most of the engineering properties of cement paste. It is often abbreviated, using cement chemists' notation, to "C-S-H," the dashes indicating that no strict ratio of SiO_2 to CaO is inferred. C-S-H forms a continuous layer that binds together the original cement particles into a cohesive whole which results in its strong bonding capacity. The Si/Ca ratio is somewhat variable but typically approximately 0.45-0.50 in hydrated Portland cement but up to perhaps about 0.6 if slag or fly ash or microsilica is present, depending on the proportions.

Calcium hydroxide:

The other products of hydration of C3S and C2S are calcium hydroxide. In contrast to theC-S-H, the calcium hydroxide is a compound with distinctive hexagonal prism morphology. It constitutes 20 to 25 per cent of the volume of solids in the hydrated paste. The lack ofdurability of concrete is on account of the presence of calcium hydroxide. The calcium hydroxide also reacts with sulphates present in soils or water to form calcium sulphate which further reacts with C3A and cause deterioration of concrete. This is known as sulphate attack. To reduce the quantity of $Ca(OH)_2$ in concrete and to overcome its bad effects by converting it into cementitious product is an advancement in concrete technology.The use of blendingmaterials such as fly ash, silica fume and such other pozzolanic materials are the steps toovercome bad effect of Ca(OH)2 in concrete. However, $Ca(OH)_2$ is alkaline in nature due to which it resists corrosion in steel.

Calcium aluminium hydrates:

These are formed due to hydration of C_3A compounds. The hydrated aluminates do notcontribute anything to the strengthof concrete. On the other hand, theirpresence is harmful to the durabilityof concrete particularly where theconcrete is likely to be attacked bysulphates. As it hydrates very fast itmay contribute a little to the earlystrength.

Various tests on cement:

Basically two types of tests are under taken for assessing the quality of cement. These are either field test or lab tests. The current section describes these tests in details.

Field test:

There are four field tests may be carried out to as certain roughly the quality of cement.There are four types of field tests to access the colour, physical property, and strength of the cement as described below.

Colour

- The colour of cement should be uniform.
- It should be typical cement colour i.e. grey colour with a light greenish shade.

Physical properties

- Cement should feel smooth when touched between fingers.
- If hand is inserted in a bag or heap of cement,it should feel cool.

Presence of lumps

- Cement should be free from lumps.
- For a moisture content of about 5 to 8%,this increase of volume may be much as 20 to 40 %,depending upon the grading of sand.

Strength

- A thick paste of cement with water is made on a piece of thick glass and it is kept under water for 24 hours.It should set and not crack.

Laboratory tests:

Six laboratory tests are conducted mainly for assessing the quality of cement. These are: fineness, compressive strength, consistency, setting time, soundness and tensile strength.

Fineness

- This test is carried out to check proper grinding of cement.
- The fineness of cement particles may be determined either by sieve test or permeability apparatus test.
- In sieve test ,the cement weighing 100 gm is taken and it is continuously passed for 15 minutes through standard BIS sieve no. 9.The residue is then weighed and this weight should not be more than 10% of original weight.
- In permeability apparatus test,specific area of cement particles is calculated.This test is better than sieve test.The specific surface acts as a measure of the frequency of particles of average size.

Compressive strength

- This test is carried out to determine the compressive strength of cement.
- The mortar of cement and sand is prepared in ratio 1:3.
- Water is added to mortar in water cement ratio 0.4.
- The mortar is placed in moulds.The test specimens are in the form of cubes and the moulds are of metals.For 70.6 mm and 76 mm cubes ,the cement required is 185gm and 235 gm respectively.
- Then the mortar is compacted in vibrating machine for 2 minutes and the moulds are placed in a damp cabin for 24 hours.
- The specimens are removed from the moulds and they are submerged in clean water for curing.
- The cubes are then tested in compression testing machine at the end of 3days and 7 days. Thus compressive strength was found out.

Consistency

- The purpose of this test is to determine the percentage of water required for preparing cement pastes for other tests.
- Take 300 gm of cement and add 30 percent by weight or 90 gm of water to it.
- Mix water and cement thoroughly.
- Fill the mould of Vicat apparatus and the gauging time should be 3.75 to 4.25 minutes.
- Vicat apparatus consists of aneedle is attached a movable rod with an indicator attached to it.
- There are three attachments: square needle,plungerand needle with annular collar.
- The plunger is attached to the movable rod.the plunger is gently lowered on the paste in the mould.
- The settlement of plunger is noted.If the penetration is between 5 mm to 7 mm from the bottom of mould,the water added is correct.If not process is repeated with different percentages of water till the desired penetration is obtained.

Setting time

- This test is used to detect the deterioration of cement due to storage.The test is performed to find out initial setting time and final setting time.
- Cement mixed with water and cement paste is filled in the Vicat mould.
- Square needle is attached to moving rod of vicat apparatus.
- The needle is quickly released and it is allowed to penetrate the cement paste.In the beginningthe needle penetrates completely.The procedure is repeated at regular intervals till the needle does not penetrate completely.(upto 5mm from bottom)
- Initial setting time =<30min for ordinary Portland cement and 60 min for low heat cement.
- The cement paste is prepared as above and it is filled in the Vicat mould.
- The needle with annular collar is attached to the moving rod of the Vicat apparatus.
- The needle is gently released. The time at which the needle makes an impression on test block and the collar fails to do so is noted.
- Final setting time is the difference between the time at which water was added to cement and time as recorded in previous step,and it is =<10hours.

Soundness

- The purpose of this test is to detect the presence of uncombined lime in the cement.
- The cement paste is prepared.
- The mould is placed and it is filled by cement paste.
- It is covered at top by another glass plate.A small weight is placed at top and the whole assembly is submerged in water for 24 hours.
- The distance between the points of indicator is noted.The mould is again placed in water and heat is applied in such a way that boiling point of water is reached in about 30 minutes. The boiling of water is continued for one hour.
- The mould is removed from water and it is allowed to cool down.

- The distance between the points of indicator is again measured.The difference between the two readings indicates the expansion of cement and it should not exceed 10 mm.

Tensile strength

- This test was formerly used to have an indirect indication of compressive strength of cement.
- The mortar of sand and cement is prepared.
- The water is added to the mortar.
- The mortar is placed in briquette moulds.The mould is filled with mortar and then a small heap of mortar is formed at its top.It is beaten down by a standard spatula till water appears on the surface.Same procedure is repeated for the other face of briquette.
- The briquettes are kept in a damp for 24 hours and carefully removed from the moulds.
- The briquettes are tested in a testing machine at the end of 3 and 7 days and average is found out.

CONCRETE

Concrete is a composite material composed mainly of water, aggregate, and cement. Often, additives and reinforcements are included in the mixture to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses.

The aim is to mix these materials in measured amounts to make concrete that is easy to: Transport, place, compact, finish and which will set, and harden, to give a strong and durable product. The amount of each material (ie cement, water and aggregates) affects the properties of hardened concrete.

Production of concrete

A good quality concrete is essentially a homogeneous mixture of cement, coarse and fineaggregates and water which consolidates into a hard mass due to chemical action between the cement and water. Each of the four constituents has a specific function. The coarser aggregate acts as a filler. The fine aggregate fills up the voids between the paste and the coarse aggregate. The cement in conjunction with water acts as a binder. The mobility of the mixture is aided by the cement paste, fines and nowadays, increasingly by the use of admixtures.The stages of concrete productionare:Batching or measurement of materials, Mixing, Transporting, Placing, Compacting, Curing andFinishing.

Batching

It i s the process of measuring concrete mix ingredients either by volume or by mass and introducing them into the mixture. Traditionally batching is done by volume but most specifications require that batching be done by mass rather than volume.The proportions of various ingredients are determined by proper mix design.

A concrete mix is designed to produce concrete that can be easily placed at the lowest cost. The concrete must be workable and cohesive when plastic, then set and harden to give strong and durable concrete. The mix design must consider the environment that the concrete will be in; ie exposure to sea water, trucks, cars, forklifts, foot traffic or extremes of hot and cold. Proportioning concrete is a mixture of cement, water, coarse and fine aggregates and admixtures. The proportions of each material in the mixture affects the properties of the final hardened concrete. These proportions are best measured by weight. Measurement by volume is not as accurate, but is suitable for minor projects.

Cement content as the cement content increases, so does strength and durability. Therefore to increase the strength, increase the cement content of a mix. WaterContent adding more water to a mix gives a weaker hardened concrete. Always use as little water as possible, only enough to make the mix workable.Water to cement ratio as the water to cement ratio increases, the strength and durability of hardened concrete decreases. To increase the strength and durability of concrete, decrease the water-cement ratio.Aggregates too much fine aggregate gives a sticky mix. Too much coarse aggregate gives a harsh or boney mix.Mixing concrete must be mixed so the cement, water, aggregates and admixtures blend into an even mix. Concrete is normally mixed by machine. Machine mixing can be done on-site or be a pre-mixed concrete company. Pre-mixed concrete is batched (proportioned) at the plant to the job requirements. Truck mixing the materials are normally added to the trucks at batching plants and mixed for required time and speed at the plant. The trucks drum continues to rotate to agitate the concrete as it is delivered to the site. Site mixing when site mixing begin by loading a measured amount of coarse aggregate into the mixer drum. Add the sand before the cement, both in measured amounts.

Mixing

The mixing operation consists of rotation or stirring, the objective being to coat the surface the all aggregate particles with cement paste, and to blind all the ingredients of the concrete into a uniform mass; this uniformity must not be disturbed by the process of discharging from the mixer. The mixing may done by manually or by mechanical means like, Batch mixer, Tilting drum mixer, Non tilting drum mixer, Pan type mixer, Dual drum mixer or Continuous mixers.

There are no general rules on the order of feeding the ingredients into the mixer as this depend on the properties of the mixer and mix. Usually a small quantity of water is fed first, followed by all the solids materials. If possible greater part of the water should also be fed during the same time, the remainder being added after the solids. However, when using very dry mixes in drum mixers it is necessary to feed the coarse aggregate just after the small initial water feed in order to ensure that the aggregate surface is sufficiently wetted.

Compaction

The operation of placing and compaction are interdependent and are carried out simultaneously. They are most important for the purpose of ensuring the requirements of strength, impermeability and durability of hardened concrete in the actual structure. As for as placing is concerned, the main objective is to deposit the concrete as close as possible to its final position so that segregation is avoided and the concrete can be fully compacted. The aim of good concrete placing can be stated quite simply.

It is to get the concrete into position at a speed, and in a condition, that allow it to be compacted properly. To achieve proper placing following rules should be kept in mind:The concrete should be placed in uniform layers, not in large heaps or sloping layers.The thickness of the layer should be compatible with the method of vibration so that entrapped air can be removed from the bottom of each layer.The rate of placing and of compaction should be equal. If you proceed too slowly, the mix could stiffen so that it is no longer sufficiently workable. On no account should water ever be added to concrete that is setting. On the other hand, if you go too quickly, you might race ahead of the compacting gang, making it impossible for them to do their job properly. Each layer should be fully compacted before placing the next one, and each subsequent layer should be placed whilst the underlying layer is still plastic so that monolithic construction is achieved. Collision between concrete and formwork or reinforcement should be avoided.For deep sections, a long down pipe ensures accuracy of location of concrete and minimum segregation.You must be able to see that the placing is proceeding correctly, so lighting should be available for large, deep sections, and thin walls and columns.Once the concrete has been placed, it is ready to be compacted. The purpose of compaction is to get rid of the air voids that are trapped in loose concrete.

It is important to compact the concrete fully because:Air voids reduce the strength of the concrete. For every 1% of entrapped air, the strength falls by somewhere between 5 and 7%. This means that concrete containing a mere 5% air voids due to incomplete compaction can lose as much as one third of its strength.Air voids increase concrete's permeability. That in turn reduces its durability. If the concrete is not dense and impermeable, it will not be watertight. It will be less able to withstand aggressive iquids and its exposed surfaces will weather badly.Moisture and air are more likely to penetrate to the reinforcement causing it to rust. Air voids impair contact between the mix and reinforcement (and, indeed, any other embedded metals). The required bond will not be achieved and the reinforced member will not be as strong as it should be.Air voids produce blemishes on struck surfaces. For instance, blowholes and honeycombing might occur. There are two methods for compaction which includes: vibration by vibrators or by tamping using tamping rods.

Curing

Curing is the process of making the concrete surfaces wet for a certain time period after placing the concrete so as to promote the hardening of cement. This process consists of controlling the temperature and the movement of moisture from and into the concrete.

Curing of concrete is done for the following purposes. Curing is the process of controlling the rate of moisture loss from concrete to ensure an uninterrupted hydration of Portland cement after concrete has been placed and finished in its final position.Curing also helps maintain an adequate temperature of concrete in its early stages, as this directly affects the rate of hydration of cement and eventually the strength gain of concrete or mortars.

Curing of concrete must be done as soon as possible after placement and finishing and must continue for a reasonable period of time, for the concrete to achieve its desired strength and durability.Uniform temperature should be maintained throughout the concrete depth to avoid thermal shrinkage cracks.

Material properties are directly related to micro-structure. Curing assists the cement hydration reaction to progress steadily and develops calcium silicate hydrate gel, which binds aggregates leading to a rock solid mass,makes concrete denser, decreases the porosity and enhances the physical and mechanical properties of concrete.

Some other purposes of curing can be summed up as: curing protects the concrete surfaces from sun and wind, the process of curing increase the strength of the structure, the presence of water is essential to cause the chemical action which accompanies the setting of concrete. Generally there is adequate quantity of water at the time of mixing to cause the hardening of concrete,but it is necessary to retain water until the concrete is fully hardened.

If curing is efficient, the strength of concrete gradually increases with age. This increase in strength is sudden and rapid in early stages and it continues slowly for an indefinite period.By proper curing, the durability and impermeability of concrete are increased and shrinkage is reduced.The resistance of concrete to abrasion is considerably increased by proper curing.

Curing period:

For ordinary Portland cement, the curing period is about 7 days to 14 days.If rapid hardening cement is used the curing period can be considerably reduced.

Disadvantages of improper curing:

Following are the disadvantages of improper curing of concrete:

The chances of ingress of chlorides and atmospheric chemicals are very high.The compressive and flexural strengths are lowered.The cracks are developed due to plastic shrinkage, drying shrinkage and thermal effects.The durability decreases due to higher permeability.The frost and weathering resistances are decreased.The rate of carbonation increases.The surfaces are coated with sand and dust and it leads to lower the abrasion resistance.The disadvantages are more prominent in those parts of surfaces which are directly exposed or which have large surfaces compared to depth such as roads, canal, bridges, cooling towers, chimneys etc.

Factors affecting evaporation of water from concrete:

The evaporation of water depends upon the following 4 factors: Air temperature, Fresh concrete temperature, Relative humidity and Wind velocity.

From the above mentioned factors it can be concluded environment directly influences the process of evaporation, hence only the fresh concrete temperature can be monitored or supervised by the concrete technologists.The evaporation of water in the first few hours can leave very low amount of water in the concrete hydration, this leads to various shrinkage cracks.Under normal condition the average loss of water varies from 2.5 to 10 N per m2 per hour.The major loss occurs in the top 50 mm layer over a period of 3 hours, the loss could be about 5% of the total volume of that layer.

Methods of curing:

While selecting any mode of curing the following two factors are considered:

- The loss of water should be prevented.
- The temperature should be kept minimum for dissipation of heat of hydration.

Methods of curing can be categorised into the following categories:

Water curing-preventing the moisture loss from the concrete surface by continuously wetting the exposed surface of concrete.

Membrane curing-minimizing moisture loss from concrete surface by covering it with an impermeable membrane.

Steam curing-keeping the surface moist and raising the temperature of concrete to accelerate the rate of strength gain.

Water curing is of the following types:

Ponding: most inexpensive and common method of curing flat slabs, roofs, pavements etc. A dike around the edge of the slab, is erected and water is filled to create a shallow pond. Care must be taken to ensure that the water in the pond does not dry up, as it may lead to an alternate drying and wetting condition.

Sprinkling: fogging and mist curing- using a fine spray or fog or moist of water to the concrete can be efficient method of supplying water to concrete during hot weather, which helps to reduce the temperature of concrete.

Wet coverings: water absorbent fabrics may be used to maintain water on concrete surfaces. They must be continuously kept moist so as to prevent the fabrics from absorbing water from the body of concrete,due to capillary action.

Impermeable membrane curing is of following types:-

Formwork: leaving the form work in place during the early age of concrete is an efficient method of curing.

Plastic sheeting: plastic sheets form an effective barrier to control the moisture losses from the surface of concrete, provided they are secured properly and protected from damage. The efficiency of this system can be enhanced by flooding the concrete surface with water, under the plastic sheet.

Membrane curing compounds: Curing compounds are wax, acrylic and water based liquids are spread over the freshly finished concrete to form an impermeable membrane that minimises the loss of moisture from the concrete surfaces.These are cost effective methods of curing where standard curing procedures are difficult to adopt.When applied to cure concrete the time of the application is critical for maximum effectiveness.Too early application dilutes the membrane, whereas too late application results in being absorbed into the concrete.They must be applied when the free water on the surface has evaporated.For concrete with low w/c ratio, this is not a suitable process.

Steam curing: Steam curing is the process of accelerating the early hardening of concrete and mortars by exposing it to steam and humidity. These types of curing systems are adopted for railway sleepers, concrete blocks, pipes, manhole covers, poles etc.Precast iron is cured by this method under pressure.Curing in hot and cold weather requires additional attention.

Hot weather: During hot weather, concrete must be protected from excessive drying and from direct wind and sun. Curing materials which reflect sunlight to reduce concrete temperature must be used.

Cold weather: Some problems associated with temperature below 40^0C are:

- Freezing of concrete before strength is developed.
- Slow development of concrete strength.
- Thermal stresses induced by the cooling of warm concrete to cooler ambient temperatures

Chemical curing: In this method water is sprinkled over the surface, after adding certain amount of some hygroscopic material (e.g. sodium chloride or calcium chloride). The hygroscopic materials absorb moisture from the atmosphere and thus keep the surface damp.

Alternating current curing: Concrete can be cured by passing alternating current through freshly laid concrete.

Water cement ratio and compressive strength

A cement of average composition requires about 25% of water by mass for chemical reaction. In addition, an amount of water is needed to fill the gel pores. Nearly 100 years ago, Duff Abrams discovered the direct relationship between water-to-cement ratio and strength, i.e.,lesser the water used higher the strength of the concrete,since too much water leaves lots of poresin the cement past. According toAbram's law, *the strength of fully compacted concrete at a given age and normal temperature is inversely proportional to the water – cement ratio.* Here the water-cement ratio is the relative weight of water to the cement in the mixture. For most applications, water-to-cement ratio should be between 0.4 and 0.5 lower for lower permeability and higher strength. In concrete, the trade off, of course,is with workability, since very low water content result in very stiff mixtures that are difficult to place. The water-to-cement ratio is a factor selected by the civil engineer.

Workability

Workability is one of the physical parameters of concrete which affects the strength and durability as well as the cost of labor and appearance of the finished product. Concrete is said to be workable when it is easily placed and compacted homogeneously i.e without bleeding or Segregation. Unworkable concrete needs more work or effort to be compacted in place, also honeycombs &/or pockets may also be visible in finished concrete.Definition of Workability "The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product."

Factors affecting workability:

- Water content in the concrete mix
- Amount of cement & its Properties
- Aggregate Grading (Size Distribution)
- Nature of Aggregate Particles (Shape, Surface Texture, Porosity etc.)
- Temperature of the concrete mix
- Humidity of the environment
- Mode of compaction
- Method of placement of concrete
- Method of transmission of concrete

How to improve the workability of concrete

- Increase water/cement ratio
- Increase size of aggregate
- Use well-rounded and smooth aggregate instead of irregular shape
- Increase the mixing time
- Increase the mixing temperature
- Use non-porous and saturated aggregate
- With addition of air-entraining mixtures

Workability tests:

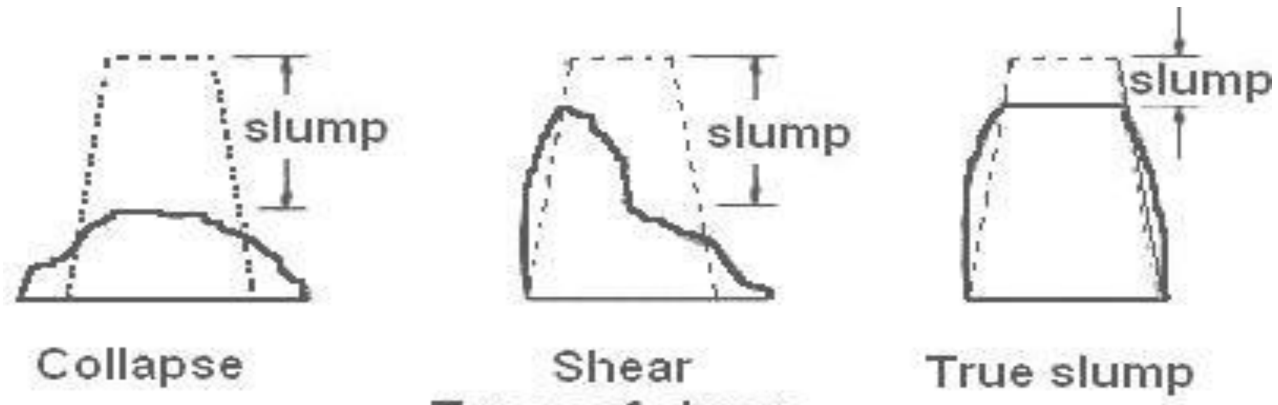
There are 4 types of tests for workability.They are slump test, compacting factor test, flow test, and vee bee test

Slump test

The slump test result is a slump of the behavior of a compacted inverted cone of concrete under the action of gravity. It measures the consistency or the wetness of concrete.Metal mould, in the shape of the frustum of a cone, open at both ends, and provided with the handle, top internal diameter 4 in (102 mm), and bottom internal diameter 8 in (203 mm) with a height of 1 ft (305 mm). A 2 ft (610 mm) long bullet nosed metal rod, (16 mm) in diameter.Apparatus Required: Compacting Factor apparatus, Trowels, Graduated cylinder, Balance and Tamping rod and iron bucket

The test is carried out using a mould known as a slump cone or Abrams **cone**. The cone is placed on a hard non-absorbent surface. This cone is filled with fresh concrete in three stages, each time it is tamped using a rod of standard dimensions. At the end of the third stage, concrete is struck off flush to the top of the mould. The mouldis carefully lifted vertically upwards, so as not to disturb the concrete cone. Concrete subsides. This subsidence is termed as slump, and is measured in to the nearest 5 mm if the slump is <100 mm and measured to the nearest 10 mm if the slump is >100 mm.

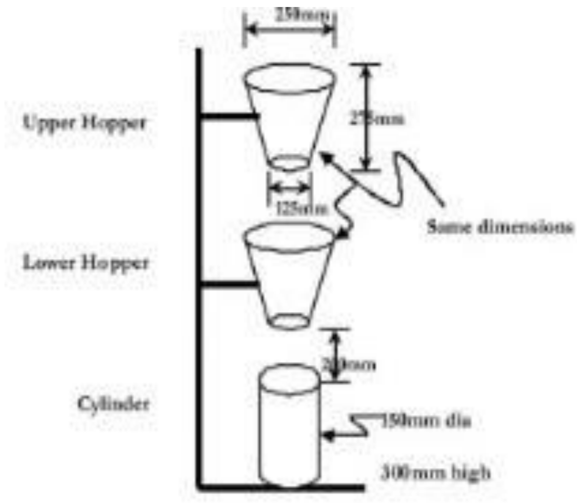
The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as true slump, shear slump or collapse slump. If a shear or collapse slump is achieved, a fresh sample should be taken and the test repeated. A collapse slump is an indication of too wet a mix. Only a true slump is of any use in the test. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which slump test is not appropriate. Very dry mixes; having slump 0 – 25 mm are used in road making, low workability mixes; having slump 10 – 40 mm are used for foundations with light reinforcement, medium workability mixes; 50 - 90 for normal reinforced concrete placed with vibration, high workability concrete; > 100 mm.



Types of slump

This test is usually used in laboratory and determines the workability of fresh concrete when size is about 40 mm maximum. The test is carried out as per specification of IS: 1199-1959.

Compacting factor test:



Steps for performing the experiment:

- keep the apparatus on the ground and apply grease on the inner surface of the cylinders.
- Measure the mass as w1 kg by weighing the cylinder accurately and fix the cylinder on the base in such a way that the central points of hoppers and cylinder lie on one vertical line and cover the cylinder with a plate.
- For each 5 kg of aggregate mixes are to be prepared with water-cement ratio by weight with 2.5 kg sand and 1.25 kg of cement and then add required amount of water thoroughly until and unless concrete appears to be homogeneous.

- With the help of hand scoop without compacting fill the freshly mixed concrete in upper hopper part gently and carefully and within two minutes release the trap door so that the concrete may fall into the lower hopper such that it bring the concrete into standard compaction.
- Fall the concrete to into the cylinder by bringing the concrete into standard Compaction immediately after the concrete has come to rest and open the trap door of lower hopper and then remove the excess concrete above the top of the cylinder by a pair of trowels, one in each hand will blades horizontal slide them from the opposite edges of the mould inward to the center with a sawing motion.
- Clean the cylinder from all sides properly. Find the mass of partially compacted concrete thus filled in the cylinder and say it W2 kg. After this refill the cylinder with the same sample of concrete in approximately 50 mm layers, by vibrating each layer heavily so as to expel all the air and obtain full compaction of the Concrete.
- Struck off level the concrete and weigh and cylinder filled with fully compacted concrete. Let the mass be W3 kg.
- Calculate compaction factor by using the formula: C.F = W2 – W1 / W3 – W1

Flow Table Test:

The flow table test or flow test is a method to determine the consistence of fresh concrete.

Flow table with a grip and a hinge, 70 centimetres (28 in) square.Abrams cone, open at the top and at the bottom - 30 centimetres (12 in) high, 17 centimetres (6.7 in) top diameter, 25 centimetres (9.8 in) base diameter.Water bucket and broom for wetting the flow table.Tamping rod, 60 centimetres (24 in) longConducting the testTheflowtable is wetted.The cone is placed in the center of the flowtable and filled with fresh concrete in two equal layers layers. Each layer is tamped 10 times with tamping rod.Wait 30 seconds before lifting the coneThe cone is lifted, allowing the concrete to flow.The flowtable is then lifted up 40mm and then dropped 15 times, causing the concrete to flowAfter this the diameter of the concrete is measured.

Vee-Bee Test:

This test is useful for concrete having low and very low workability. In this test the concrete is moulded into a cone in a cylinder container and the entire set up is mounted on a vibrating table. When vibrator starts, concrete placed on the cone starts to occupy the cylindrical

Container by the way of getting remoulded. Remoulding is complete when the concrete surface becomes horizontal. The time required for completion of remoulding since start of vibrator is measured and denoted as vee-bee seconds. This provides a measure for work.

4 OTHER CONSTRUCTION MATERIAL

A tree basically consists of three parts namely,trunk,crown and roots.the function of the trunk is to support the crown and to supply water and nutrients from the roots to the leaves through branches and from the leaves back to the roots.the roots are meant to implant the trees in the soil ,to absorb moisture and the mineral substancesit contains and to supply them to the trunk.

Details of structure:

From the visibility aspect,the structure of tree can be divided into two categories :-

(1). Macrostructure

(2). Microstructure

Macrostructure:-

The structure of wood visible to the naked eye or at a small magnification is called the macrostructure.Following are its different components:

(1) Pith: the innermost central portion of the core of the tree is called the pith or medulla. It varies in size and shape and for different types of trees.It consist entirely of cellular tissues and it nourishes its plant at its young age.when the plant becomes old,the pith dies up and decays and the sap is then transmitted by the woody fibres deposited round the pith.the pith of the branches is nothing but merely a prolongation of the stem.
(2) Heartwood: The inner annular rings surrounding the pith constitute the heart wood.It is usually dark in colour .as a matter of fact ,it indicates the dead portion of tree and as such,it does not take active part in the growth of the tree.But it imparts rigidity to the tree hence it provides strong and durable timber for various engineering purposes.
(3) Sapwood: The outer annular rings between heartwood and cambium layer is known as sapwood.It is usually light in colour in light and weight.It indicates recent growth and it contains sap.The annual rings of sap wood are less sharply defined than those of heartwood.It takes active part in the growth of the tree and the sap moves in upward direction through it. The sapwood is also known as the alburnum.
(4) Cambium layer The thin layer of sap between sapwood and inner bark is known as the cambium layer.It indicates sap which has not yet been converted into sap wood. If the bark is removed for any reason,the cambium layer gets exposed and the cells cease to be active resulting in the death of the fibre.
(5) Inner bark: The inner skin or layer covering the cambium layer is known as the inner bark.it gives protection to the cambium layer from any injury.
(6) Outer bark The outer skin or cover of the tree is known as the outer bark.it is the outermost protective layer and it sometimes contain cracks and fissures.it consists of cells and wood fibre and is also known as the cortex.

(7) Medullary rays The thin radial fibres extending from pith to cambium layer are known as the medullary rays.the function of these rays is to hold together the annular rings of heartwood and sapwood.these rays are sometimes broken and in some varieties of trees,they are not very prominent. Microstructure: The structure of wood apparent only at great magnifications is called the microstructure. A living cell consists of four parts namely membrane ,protoplasm,sap and core.The cell membrane consists mainly of cellular tissues and cellulose.The protoplasm is a granular,transparent ,viscous vegetable protein composed of carbon,hydrogen,oxygen,nitrogen and sulphur.The core of cell differs from protoplasm merely by the presence of phosphorus and it is generally oval. The cells ,according to the function they perform,are classified into the following three categories: - Conductive cells

- Mechanical cells

-Storage cells

(1).conductive cells: These cells serve mainly to transmit nutrient from root to the branches and leaves.

(2).mechanical cells These cells are elongated ,thickwalledand have tightly interconnected narrow interior cavities.these cells impart strength to the wood.

(3).storage cells: These cells serve to store and transmit nutrients to the living cells in the horizontal direction and they are usually located in the medullary rays. Defects in timber: Various defects occurring in timber are grouped into following five categories:

(1)defects due to conversion
(2)defects due to fungi
(3)defect due to insects
(4)defects due to natural forces
(5)defects due to seasoning

Defects due to conversion: During converting timber to commercial form the following defects may occur:

(i) chip mark: this defect is indicated by marks placed by chips on the finished surface of timber .they may also be formed by parts of a planning machine.

(ii) Diagonal grain: this defect is formed due to improper sawing of timber.it is indicated by diagonal mark on straight grained surface of timber.

(iii) Torn grain:this defect is caused when a small depression is formed on the finished surface of timber by falling of a tool or so.

(iv) Wane:this defects is denoted by the presence of original rounded surface on the manufactured piece of timber.

Defects due to fungi:

Fungi attack timber only when

(1)The moisture content of timber is above 20%.

(2)If there is a presence of air and warmth for the growth of fungi.

Due to attack of fungi following defects occur:

(i)Bluestain:the sap of the wood is stained to bluish colour by the action of certain type of fungi.

(ii) Brown rot:the fungi of certain types remove cellulose compound from wood and hence the wood assumes the brown colour.this is known as the brown rot.

(iii) Dry rot:the fungi of certain types feed on wood and during feeding ,they attack on wood and convert it into powder form.This is known as dry rot. This type of defect occur in place where there is dampness and no free circulation of air.The dry rot may be prevented by using well seasoned timber free from sap.

(iv) Heart rot: this is formed when a branch has come out of a tree.It occurs when heart woodis exposed to atmospheric agent.

(iv) Sap stain:certain types of fungi feed on cell contents of sap wood.In doing so ,the sap wood loses its colour.this is known as sap stain.It generally occurs when moisture content goes beyond 25 % or so.

(v) Wet rot:some varietiesof fungi cause chemical decomposition of wood of timber in doing so timber is converted into a greyish brown powder.This is known as wet rot.

(vi) White rot:this defect is opposite of brown rot.In this defect the wood assumes the appearance of a white mass consisting of cellulose compounds. Defect due to insects: Defects in timber occur dueto various types of insects. Such as:

(1)beetles

(2)marine borers
(3)termites

Decay of timber occurs due to the above insects. Defect due to natural force: The main natural forces responsible for causing defects in timber two,namely,abnormal growth and rupture of tissues.

(i) Burls:these are also known as the excrescences and they are particularly formed when a tree has received shock or injury in is young age. Due to such injury, the growth of tree is completely upset and irregular projections appear on the body of timber.
(ii) Callus:it indicates soft tissues or skin which covers the wound of a tree.
(iii) Chemical stain: the wood is sometimes discoloured by the chemical action caused with it by some external agency.
(iv) Coarse grain: if a tree grows rapidly, the annual rings are widened. Such timber possesses less strength.
(v) Dead wood: the timber which is obtained from dead standing trees contains dead wood.
(vi) Druxiness: this defect is indicated by white decayed spots which are concealed by healthy wood.
(vii) Foxiness: this defect is indicated by red or yellow tinge in wood or reddish brown stains or spots round the pith of tree discolouring the timber. It is caused due too poor ventilation.
(viii) Knots: these are the bases of branches or limbs which are broken or cut off from the tree. The portion from which the branch is removed receives nourishment from the stem for a pretty long time and it ultimately results in the formation of dark hard rings which are known as the knots.
(ix) Rind galls: the rind means bark and gall indicates abnormal growth. Hence peculiar curved swelling found on the body of a tree known as the rind gall.
(x) Shakes: these are cracks which partly or completely separate the fibres of wood. Following are the different types of shakes: cup shake, heart shake, ring shake, star shake, radial shake.
(xi) Twisted fibres: these are also known as the wandering hearts and they are caused by twisting of young trees by fast blowing wind.
(xii) Upset: these are also known as the ruptures and they indicate the wood fibres which are injured by crushing or compression.
(xiii) water stain: the wood is sometimes discoloured when it comes into contact with water. Thi defect is usually found in converted timber
(xiv) Wind cracks:if wood is exposed to atmospheric agencies, its exterior surface shrinks. These are known as the wind cracks.

Defects due to seasoning: Following defects occur in the seasoning process of wood.

(i) Bow: the defect is indicated by the curvature formed in the direction of length of timber.
(ii) case-hardening: the exposed surface of timber dries very rapidly. It therefore shrinks and is under compression. The interior surface which has not completely dried under tension. This defect is known as the case-hardening.
(iii) Check: a check is a crack which separates fibres of wood. It does not extend from one end to the other.
(iv) Collapse: due to uneven shrinkage, the wood sometime flattens during drying. This is known as collapse.
(v) Cup: this defect is indicated by the curvature formed in the transverse direction of timber.
(vi) Honey-combing: due to stresses developed during drying, the various radial and circular cracks in the interior portion of timber. This defect is known as honey-combing.
(vii) Radial shake: these are radial cracks.
(viii) Split: when a check extends from one end to the other, it is known as a split.
(ix) Twist: when a piece of timber has spirally distorted along its length, it is known as a twist.
(x) Warp:when a piece of timber has twisted out of shape, it is said to have warped.

TIMBER

TIMBER is the oldest material used by humans for construction after stone. Despite its complex chemical nature, wood has excellent properties which lend themselves to human use. It is readily and economically available; easily machinable; amenable to fabrication into an infinite variety of sizes and shapes using simple on-site building techniques;

- Exceptionally strong relative to its weight
- A good heat and electrical insulator
- It is a renewable and biodegradable resource.

However, it also has some drawbacks of which the user must be aware. It is a “natural” material and is available in limited amount.

Preservation:

Preservation of timber means protecting timber from fungi and insects attack so that its life is increased. Timber is to be seasoned well before application of preservatives. The following are the widely used preservatives:

1.Tar 2.Paints 3.Chemicalsalt 4.Creosote 5. ASCO

1.Tar

Hot coal tar is applied to timber with brush. The coating of tar protects the timber from the attack of fungi and insects. It is a cheapest way of protecting timber. Main disadvantage of this method of preservation is that appearance is not good after tar is applied it is not possible to apply other attractive paints. Hence tarring is made only for the unimportant structures like fence poles.

2.Paints

Two to three coats of oil paints are applied on clean surface of wood. The paint protects the timber from moisture. The paint is to be applied from time to time. Paint improves the appearance of the timber. Solignum paint is a special paint which protects the timber from the attack of termites.

3. Chemical salt

These are the preservatives made by dissolving salts in water. The salts used are coppersulphate, masonry chloride, zinc chloride and sodium fluoride. After treating the timber with these chemical salt paints and varnishes can be applied to get good appearance

4. Creosote

Creosote oil is obtained by distillation of coal tar. The seasoned timber is kept in an air tight chamber and air is exhausted. Then creosote oil is pumped into the chamber at a pressure of 0.8 to 1.0 N/mm^2 at a temperature of 50°C. After 1 to 2 hours timber is taken out of the chamber.

5.ASCO

This preservative is developed by the Forest Research Institute, Dehradun. It consists of 1 part by weight of hydrated arsenic pentoxide (As_2O_5, 2 H_2O), 3 parts by weight of copper sulphate. ($CuSO_4 \cdot 5\ H_2O$) and 4 parts by weight of potassium dichromate ($K_2Cr_2O_7$) or sodium dichromate ($Na_2Cr_2O_7 \cdot 2\ H_2O$). This preservative is available in powder form. By mixing six parts of this powder with 100 parts of water, the solution is prepared. The solution is then sprayed over the surface of timber. This treatment prevents attack from termites. The surface may be painted to get desired appearance.

Physical Properties:

Specific Gravity (SG):

Generally, specific gravity (SG) and the major strength properties of wood are directly related. SG for the major , usually used structural species ranges from roughly 0.30 to 0.90. Higher allowable design values are assigned to those pieces having narrower growth rings (more rings per inch) or more dense latewood per growth ring and, hence, higher SG.

Thermal Properties/Temperature Effects:

Although wood is an excellent heat insulator, its strength and other properties are affected adversely by exposure for extended periods to temperatures above about 100°F. The combination of high relative humidity or MC and high temperatures, as in unventilated attic areas, can have serious effects on roof sheathing materials and structural elements over and above the potential for attack by decay organisms. Simple remedies and caution usually prevent any problems.

At temperatures above 220°F, wood takes on a thermoplastic behavior. This characteristic, which is rarely encountered in normal construction, is an advantage in the manufacture of some reconstituted board products, where high temperatures and pressures are utilized.

Environmentally friendly

Timber is the most environmentally responsible building material. Timber has low production energy requirements and is a net carbon absorber. Timber is a renewable resource. Wellmanaged forests produce timber on a sustained continuous basis, with minimal adverse effects on soil and water values.

In plentiful and growing supply

Timber is readily available. Australia has significant forest resources including a plantation estate covering more than 1.6 million hectares, and the area is growing rapidly.

Strong and lightweight

Timber is strong, light and reliable making timber construction simpler and safer than steel or concrete construction. A comparison with steel and concrete shows that radiata pine structural timber, for example, has a strength for weight ratio 20 percent higher than structural steel and four to five times better than unreinforced concrete in compression. The lightweight structures possible in wood confer flow-on advantages in terms of reduced foundation costs, reduced earthquake loading and easier transport. Building components and complete constructions are simple and safe to erect, and cheaper to deconstruct or reuse at the end of a buildingís useful life.

Chemical Properties

Though, would is chemically inert as compared to other materials but is affected by some acids and bases. Some species have proven very useful for food containers (berry boxes and crates) because they are nontoxic and impart no taste to the foods contained therein. Wood structures have also found widespread use as storage facilities for salt and fertilizer chemicals

DRY ROT

The turning of timber tissues to almost dry powder by fungi is called dry rot.The fungus feed upon the wood and eats the wood tissue, thus penetrating the wood fibres from all direction.

Prevention:

1.well seasoned timber should be used. 2.timber should be used where there is free circulation and access of air.

Remedy:

1. the timber should be painted with a solution of copper sulphate

2.the high temperature of seasoning of kiln helps in killing the Fungi.

WET ROT

The disintegration of tissue of timber due to alternate wetting and drying is called wet rot. The attacks take place through the wounds in bark by the access of water.

Prevention:

All timber for exterior or underground work should be first properly seasoned and then coated with tar to keep out the dampness

Remedy:

The best remedy for treating wet rot is by using a suitable preservative

Seasoning of Timber

From day to day, most people have some contactwith "seasoned" timber. From childhood days woodencots and toys, to school desks and, eventually, to wooden furniture and flooring in homes or places of employment - seasoned timber is to be found. Yet how many people really understand what seasoned timber is?

Only when cracks appear in furniture or floor, orwhen a door shows some degree of warping, is anythought given to this concept. It is to be regretted thateven some people associated with the timber tradehave little knowledge of what seasoned timber is andthe best method of obtaining it. What is "seasoned" timber? The process of drying out the water from "wet" or"green" timber is termed "seasoning", or more simply"drying". Water is just as essential to the life of atree as it is for all living matter. Together with thevarious minerals, it enters through the roots of the treeand is carried in the sapwood - the outer woody part tothe leaves. The food, that is the sugars and starch,are made in the leaves by photosynthesis and aretransported in solution down the inner bark to thegrowing cells. The whole trunk of the tree is made upof cells, which are like small tubes, having walls ofcellulose and a more or less hollow' cavity filled withwater and other materials known as sap. Consequently,when the tree is felled and the resulting logis sawn into timber, the sawn sections consist ofinnumerable small cells containing water. Drying themoisture out of wood enhances its properties to suchan extent that the resulting timber is given the specialname "seasoned" rather than "dried" although theterms are identical. Why is timber seasoned? Seasoning timber causes many changes in its properties, and in practically every case the change is animprovement. There is only one principal disadvantagein drying timber, namely, the loss in volume dueto shrinkage. However, by a correct understandingof the shrinkage of timber this effect can be minimized,and timber can then be confidently usedwithout fear of adverse behaviour subsequently inservice. Types of Seasoning

(i) Natural Seasoning: It may be air seasoning or water seasoning. Air seasoning is carried out in a shed with a platform. On about 300 mm high platform timber balks are stacked as shown in Fig. 1.8. (ii) Care is taken to see that there is proper air circulation around each timber balk. Over a period, in a natural process moisture content reduces. A well-seasoned timber contains only 15% moisture. This is a slow but a good process of seasoning. Water seasoning is carried out on the banks of rivers. The thicker end of the timber is kept pointing upstream side. After a period of 2 to 4 weeks the timber is taken out. During this period sap contained in the timber is washed out to a great extent. Then timber is stalked in a shed with free air circulation.

117 * Under revision

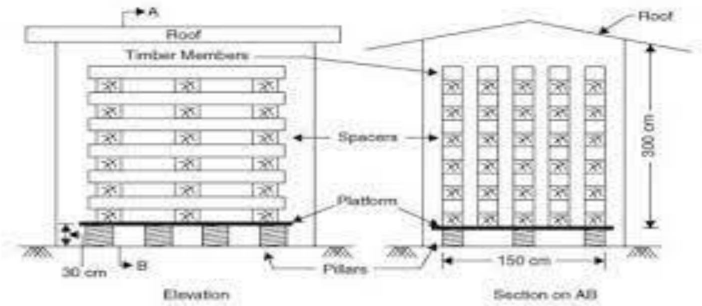


Fig. 1.8. Air seasoning

(iii) Artificial Seasoning: In this method timber is seasoned in a chamber with regulated heat,controlled humidity and proper air circulation. Seasoning can be completed in 4 to 5 days only. The different methods of seasoning are:

(a) Boiling (b) Kiln seasoning (c) Chemical seasoning (d) Electrical seasoning.

(a) Boiling: In this method timber is immersed in water and then water is boiled for 3 to 4 hours.Then it is dried slowly. Instead of boiling water hot steam may be circulated on timber.The process ofseasoning is fast, but costly.

(b) Kiln Seasoning: Kiln is an airtight chamber. Timber to be seasoned is placed inside it. Thenfully saturated air with a temperature 35°C to 38°C is forced in the kiln. The heat gradually reachesinside timber. Then relative humidity is gradually reduced and temperature is increased, and maintained till desired degree of moisture content is achieved. The kiln used may be stationary or progressive. In progressive kiln the carriages carrying timber travel from one end of kiln to other end gradually. The hot air is supplied from the discharging end so that temperature increase is gradual from charging end to discharging end. This method is used for seasoning on a larger scale. (c) Chemical Seasoning: In this method, the timber is immersed in a solution of suitablesalt.Then the timber is dried in a kiln. The preliminary treatment by chemical seasoning ensures uniform seasoning of outer and inner parts of timber.

(d) Electrical Seasoning: In this method high frequency alternate electric current is passed through timber. Resistance to electric current is low when moisture content in timber is high.

As moisture content reduces the resistance reduces. Measure of resistance can be used to stop seasoning at appropriate level.

However it is costly process. This technique has been tried in some plywood industries but not in seasoning of timber on mass scale.

Different methods of seasoning:

Air Seasoning

The traditional method for drying wood, air seasoning is also the longest, taking six to nine months. To air season wood, stack logs or planks outside on pallets in such a manner that air can circulate vertically and horizontally through the timbers. The raised pallets also keep wood away from vegetation and damp ground. Plank and log ends are often wrapped or sealed to prevent excessive moisture loss through these areas. Protect the drying wood from the elements with an overhead canopy.

Kiln Seasoning

The most common and effective commercial process for drying wood is kiln seasoning, which accelerates the process of removing moisture through the use of external energy. Drying takes two days to one weekend, depending on the type of wood. Two methods, progressive and compartmental, are used for kiln seasoning. In a progressive kiln, timber enters at one end and travels on a trolley through chambers with different air conditions to progressive dry the wood. This method produces a constant flow of seasoned timber. Wood seasoned via the compartmental process remains in a single building where it is subjected to a program of varying conditions until the moisture content is removed. This process is used for hard-to-dry or expensive wood.

Solar Kiln

This method combines the speed of kiln seasoning with the low energy of air drying. Solar kilns have single-thickness windows on the south side of the structure that work as collectors to trap the sun's energy. Heat collectors, made from black metal are attached near the top of the window sashes. Various methods force the heated air to circulate through the kiln to dry the wood. Some solar kilns have insulation to retain heat at night. This process takes approximately twice as long as traditional kiln seasoning. Because of its gentle nature, it is well suited to producing wood for furniture fabrication.

Microwave Seasoning

Microwave seasoning uses pulsed energy directed into timbers to drive out moisture in a manner that will not cause seasoning degrade. This method also provides advantages such as high speed and high quality and is well suited for seasoning lumber, blocks, veneer, chips, paper and wood-based composite materials. Areas in the wood with the most moisture absorb the most energy resulting in even temperature during the drying process and a uniform moisture content. These factors enhance quality and reduce timber checking and warping.

Advantages of seasoning:

Three most important advantages of seasoning have already been made apparent:

1. Seasoned timber lasts much longer than unseasoned. Since the decay of timber is due to the attacks of wood-destroying fungi, and since the most important condition of the growth of these fungi is water, anything which lessens the amount of water in wood aids in its preservation.
2. In the case of treated timber, seasoning before treatment greatly increases the effectiveness of the ordinary methods of treatment, and seasoning after treatment prevents the rapid leaching out of the salts introduced to preserve the timber.
3. The saving in freight where timber is shipped from one place to another. Few persons realize how much water green wood contains, or how much it will lose in a comparatively short time. Experiments along this line with lodge-pole pine, white oak, and chestnut gave results which were a surprise to the companies owning the timber.

Freight charges vary considerably in different parts of the country; but a decrease of 35 to 40 per cent in weight is important enough to deserve everywhere serious consideration from those in charge of timber operations.

When timber is shipped long distances over several roads, as is coming to be more and more the case, the saving in freight will make a material difference in the cost of lumber operations, irrespective of any other advantages of seasoning.

5.SURFACE PROTECTIVE MATERIALS

Paint is a liquid surface coating. On drying it forms a thin film on the painted surface. Paints are classified as oil paints, water paints, cement paints, bituminous paints and special paints such as fire proof paints, luminous paints, chlorinated rubber paints (for protecting objects against acid fumes), etc. The paintings are the coating of fluid materials

The functions of the paints are:

• To protect the coated surface against possible stresses mechanical or chemical; deterioration—physical or environmental;

• Decorate the structure by giving smooth and colourful finish; check penetration of water through R.C.C;

• Check the formation of bacteria and fungus, which are unhygienic and give ugly look to the walls;

• Check the corrosion of the metal structures;

• Check the decay of woodwork and to varnish the surface to display it to better advantage

Defects in Painting:

• A painted building with full colour effects gives complete satisfaction. But the appearance of defects becomes a ready source of complaint. Unfortunately painting defects are by no means uncommon. They may arise from a variety of causes but the principal reasons behind them are incorrect choice of paint in relation to backing materials, application of paint to a damp surface or one to which moisture may have access and; poor workmanship.

Effects of background:

• The factors affecting durability are dampness, cleanliness, movements, chemical reactions, etc. The traditional construction in brick, cement, etc. involves the use of wet procedures. If paint is applied on an insufficiently dry background the moisture is trapped and in the process of subsequent drying the adhesion of the paint breaks down. Emulsion paints are somewhat better in this respect.

• The painting processes can be delayed for proper results for movements caused by shrinkage and special paints should be used for thermal movements. • Chemical reaction between backing material and paint film may push the paint off the backing material and lead to softening or decolourise the paint. This effect generally occurs only if moisture is present and is noticeable in oil paints over materials containing cement or lime. The breakdown of bond is because of the crystallization of salts below the paint film and the discolouration is usually due to action of free lime on the pigments.

Effects of weather:

The paint film is subjected to chemical attack of atmosphere, sunlight and heat, all deteriorating it. Special chemical resistant paints should be applied in industrial areas. Alkali resistant paints weather well in coastal areas. Blue and green colours tend to fade when exposed to bright light. In addition the fierce heat of sun may breakdown the paint film because of the disintegration of the material itself and also because of the thermal movement. The most common defects noticed after paintings are as follow:

Blistering and peeling are swelling of the paint film and can be defined as localized loss of adhesion between one or more coatings or between primer and parent surface. When swelling is because of oil or grease on the surface it is known as blistering and in case of moisture it is called peeling. It occurs in nonporous coatings such as oil based paints and enamels. A special heat-resisting type of paint should be used for hot surfaces such as radiators. It is brought about by moist air, oily or greasy surface, or imprisoned gases between the painted surface and the paint film, which expand under the influence of heat. Emulsion paints provide a porous coating and allow the moisture to pass through.

Checking is a mild form of cracking. If hair cracks produced enclose small area it is known as crazing. In case the enclosed area is large the defects is called crocodiling. It is caused when the paint film lacks in tensile strength and occurs when paint is applied during very cold weather or because of insufficient drying of undercoat. When cracks are very small and do not enlarge with time, the top coating is flattened with emery paper and a fresh coat of paint is applied.

Cracking: The cracks extend throughout the entire paint system extending right down to the original surface. Cracks in the plaster or masonry do not let the paint to remain intact.

Paint applied on glossy surface. Premature application of top coat before the previous coat has completely dried. Painting improperly seasoned wood.

Flaking: It is detachment of paint film from the surface. The moisture penetrates through the cracks on the coatings and the bond between surface and paint film is lost. The curing methods are: Use of plastic

emulsion paints, Surface should be rubbed with emery paper before applying a fresh coat and All dirt or dust on surface should be removed prior to painting.
Chalking: Paint film becomes powder due to insufficient oil in primer.
Alligatoring: One layer of paint films sliding over the other one, when a hard paint is applied over a soft one or vice versa.
Wrinkling: or crawling appears when the paint film is quite thick or the oil in the paint is more than required. The lower portion of the paint does not dry due to greater thickness of the paint film which shrinks due to drying in course of time.
Running and sagging: Paints applied over smooth and glossy surface do not stick and flow back or towards the unpainted area. This is known as running and sagging. The surface to-be painted should, therefore, be rubbed with an emery paper before painting.

Bloom: is identified as dull patches on the finished, polished or painted surface due to defect in the quality of paint or poor ventilation.
Flashing: is characterized by the appearance of certain glossy patches on the painted surface. The reasons attributed to this defect are weathering actions, use of cheap paint, and poor workmanship.
Grinning: it is due to the imperfect opacity of the paint film even after the final coat. The background and its defects can be clearly visible in such a case.
Failure of Painting: The main causes of failure of painting are:

• Bad workmanship	• Conditions for painting
• Moisture	• Salt and alkalies
• Unsuitable surfaces	• Wrong choice of paint

Painting of various surfaces:
A. New plastered surface:
The procedures for paining a new plastered surface are:
1. **Surface preparation**: Paint cannot take care of construction defects. Before applying the paint, it is ensured that the surface is free from dust, dirt, loose matter, grease etc. and is rubbed with an emery paper, to provide a mechanical key between surface and paint for satisfactory adhesion.
2**. Sequence of Painting**: The primer (first coat) is applied with brush or spray on the prepared surface. It should be thinned with water or thinner in the recommended manner and proportion before application. After drying it is rubbed with emery paper. Dents and cracks, if any, are filled with putty using a knife applicator. Putty should not be applied thick. If the required thickness is large, it should be applied in two coats. After the putty has dried, the whole surface is rubbed down well in order to smoothen the putty andprovide a mechanical key to the finished coats. Two or three finish coats are applied. Each coat is allowed to dry before the application of next coat.
B. Old plastered surface

The procedure depends on the state of the existing coating. If any of the defects discussed below is very much pronounced it is completely removed and the surface is painted as a new surface.

C. Painting of new woodwork
Painting of woodwork should be done with great care. Normally 3–4 coats are sufficient for wood work.
• Surface preparation: The wood should be well seasoned, dried, cleaned and the surface made smooth with an emery paper. Nails, if any, should be driven down the surface by at least 3 mm.
• Knotting: Knots in the wood create lot of problems. These excrete resin which causes defects such as cracking, peeling and brown discolouration. Knotting is done so that resin cannot exude from the knots. Any of the following methods may be used suitably
Ordinary knotting: This is also known as size knotting. The knot is treated with a coat of hot red lead ground with a strong glue size in water. Then a coat of red lead ground in boiled linseed oil is applied. Lime knotting: The knot is covered with hot lime for 24 hours after which it is scrapped off. Thereafter, the process described in ordinary knotting is followed. Patent knotting: Two coats of varnish or shelac are applied.
• Priming coat: The main function of priming coat or primer is to form the base for subsequent ones. After knotting priming coat is applied over the entire surface to fill all the pores. A second priming coat is applied after first has dried. In general the ingredients are same as those of the subsequent coats but with a difference in proportion.
• Stopping: After the priming coat putty is applied to fill the pores of the surface. Then it is rubbed smooth. Colouring pigment is also added to it to match the shade of the finished coat. On drying, the selected paint is

applied with brushes to bring smoothness and uniformity in colour. After painting the surface in one direction, the brush is worked in the perpendicular direction to eliminate brush marks. This is known as crossing. All the successive coats are applied after drying and slight rubbing of previous coats for proper bond.

D. Painting of old woodwork:

The old paint is removed with a sharp glass piece, sand paper, paint remover or with a blow lamp. Any smoky or greasy substance should be washed with lime and subsequently rubbed with pumice stone. The surface is then washed with soap and water and dried completely. Then two coats of paints are applied in a way similar to that described in painting new surfaces.

E. Painting metal surfaces:

• New ironwork: The surface should be free from scales, rust and grease. Scales and rust are cleaned by hard wire brush. Grease is removed by using petroleum or by hot alkaline solution of Na_2CO_3 or NaOH, benzene, and lime water. A priming coat of red lead with barytes and raw linseed oil is then applied over the prepared surface. After drying of the priming coat, one or more undercoats with desired paint are applied. The second coat is given only after the first coat has dried. The finishing coat is applied carefully to produce a smooth fine surface.

• Old ironwork: The surface is prepared by scraping properly all the scales and rust with emery paper. The greasy substances are removed with lime water. The old paint may be burned with a blow lamp or by suitable solvents. After this the surface is brushed with hot linseed oil and painted as for new iron work.

• Structural steel: The major problem to overcome in painting iron and steel is corrosion due to electrolysis caused by the presence of air and moisture. Red lead is considered to be the best priming coat; it produces a tough elastic film, impervious to air and moisture. Pure linseed oil priming coat is detrimental in that it stimulates corrosion. The linseed oil film is rendered more impervious by the use of spar varnish. Graphite paint used for black colour, is very durable and is not affected by sulphur films, ammonia or chlorine gases. Silica-graphite paints are best; they do not crack and blister in course of time. Aluminium paint is also gaining popularity because of its shining and contrast properties and heat and chemical resistance. Bituminous paints may be very well adopted to paint inside of pipes, iron under waters, piles, ships and boats; they are unsatisfactory when exposed to sunlight. Lead or zinc paint should never be applied directly over the iron surface as it encourages galvanic action destroying the paint.

F. Painting of floor surfaces:

The enamels are used for painting of floor surfaces. The selected enamel should be strong enough to resist abrasion, moisture, and alkali actions. It should be of shinning nature and quick drying type.

G. Painting of concrete surfaces:

The cement paint is used to paint concrete surfaces. The paint is available in a powder form and it is dissolved in water to workable consistency. The paint thus prepared should be consumed with in 2 to 3 hours. The two coats are applied at an interval to provide curing of painted surface.

CONSTRUCTION TECHNOLOGY

1.INTRODUCTION

Classification of buildings based on occupancy

As we know that, a building may be classified based on different parameters like occupancy, load transfer in the structure, materials used, degree of fire resistance, etc. so today I'm going to be share about **Classification of buildings based on occupancy**.

The building based on occupancy are classified as follows:

1. Residential Building
2. Educational Building
3. Office Building
4. Historical Building
5. Industrial Building
6. Recreational Building
7. Institutional Building
8. Commercial Building
9. Hazardous Building
10. Storage Building
11. Assembly Building
12. Public Building

Residential Building

The **buildings in which an individual or a family or a group of families** reside temporarily or permanently are referred as residential buildings such as flat, cottage, house, bungalow, etc.

Educational Building

The buildings in which education is imparted to the children are referred as Educational Buildings such as school, college, library, coaching center, etc.

Office Building

The buildings which are used for official purposes by any department such as Income Tax, Telegraph, Telephone, Public health referred as Office Buildings.

Historical Building

The buildings which indicate the historic importance are referred as Historical Buildings such as Lal Quila, Taj Mahal, Jama Masjid, Qutub Minar, etc.

Industrial Building

The Buildings used for producing industrial goods or products are referred as Industrial Buildings such as factories, workshops, etc.

Recreational Building

The buildings used for recreation purposes are referred as Recreational Buildings such as cinemas, clubs, swimming, pools, etc.

Institutional Building

The buildings constructed for the care of persons suffering from various diseases mental as well as physical are referred as Institutional Buildings such as hospitals, sanitaria, etc.

Commercial Building

The buildings used for business purposes referred as Commercial Buildings such as shops, stores, banks etc.

Storage Building

The buildings used for the storage of various products are reffered as storage buildings such as cold storages, godowns etc.

Hazardous Building

The buildings used for the purposes of storage and handling of highly combustible materials are referred as Hazardous Buildings such as Building used for the storage of sulfur dioxide ammonia carbon dioxide etc,

Assembly Building

The buildings used for get together purposes are referred as Assembly Buildings such as Temples, townhalls mosque, etc.

Public Building

The buildings constructed in the interest of the public are referred as Public Buildings such as railway station, bus stands, airport etc.

2 FOUNDATION

The selection of the foundation type for a particular site depends on the following considerations: 1. Nature of subsoil. 2. Nature and extent of difficulties 3. Availability of expertise and equipment Depending upon their nature and depth, foundations have been categorized as follows:

(i)Open foundations or shallow foundations
(ii) Deep foundations
OPEN FOUNDATIONS
This is the most common type of foundation and can be laid using open excavation by allowing natural slopes on both sides. This type of foundation is practicable for a depth up to 5m and is normally convenient above the water table. The base of the structure is enlarged or spread to provide individual support. Since spread foundations are constructed in open excavations, therefore they are termed as open foundations. The various types of spread footings are:

1. Wall footings,
2. Isolated footings,
3. Combined footings,
4. Inverted arch footings,
5. Continuous footings
6. Cantilever footing
7. Grillage footing

1. Wall Footings: These footings can either be simple or stepped. The base course of these footings can be concrete or of entirely one material. They have only one projection beyond the width of the wall on either side. The width of the concrete base should be at least equal to twice the width of the wall. The depth of the concrete bed is at least equal to the projection. Generally the projection provided in the footing is 15cm, on either side. and the concrete mix comprises of cement, sand and aggregate in proportion of 1:3:6 or 1:4:8.

2. Isolated or Column Footings: They are used to support individual columns. In case of heavy loaded columns, steel reinforcements is provided. Generally, 15cm offset is provided on all sides of concrete bed. The footing of concrete columns may be slab, stepped or sloped type.

3. Combined Footings: A combined footing supports two or more columns in a row. The combined footing can be rectangular in shape if both the columns carry equal loads or can be trapezoidal if both the loads are unequal. Generally they are constructed of reinforced concrete. The location of the center of the gravity of the column loads and centroid of the footing should coincide

4. Inverted arch footing: This type of footing is used on soft soils to reduce the depth of the foundation. Loads above an opening are transmitted from supporting walls through inverted arches to the soil. In this type of footings the end columns must bes stable enough to resist the outward pressure caused by the arch action.

5. Continuous footings: In this type of footing a single continuous R.C. slab is provided as foundation of two or three or more columns in a row. This type of footing is suitable at locations liable to earthquake activities. This also prevents differential settlements in structures.

6. Strap or cantilever footings: Strap footing consists of two or more individual footings connected by a beam called strap. This type of footing is used where the distance between the columns is so great that the trapezoidal footing becomes quite narrow with bending moments.

7. Grillage footings: this type of footings is used to transmit heavy loads from steel columns to the soils having low bearing power. This type of arrangements prevents deep excavations and provides necessary area at base to reduce the intensity of the pressure.

RAFT FOUNDATIONS A raft or mat is a combined footing that covers the entire area beneath a structure and supports all the columns. They are used where the soil mass contains compressible lenses so that the differential settlement would be difficult to control. Raft foundation is also used to reduce the settlement above highly compressible soils by making the weight of the structure and raft approximately equal to the weight of the soil excavated. The raft is composed of reinforced concrete beam with a relatively thin slab underneath.

DEEP FOUNDATIONS These foundations carry loads from a structure through weak incompressible soils or fills on to the stronger and less compressible soils or rocks at depth. These foundations are in general used as basements, buoyancy rafts, caissons, cylinders, shaft and piles

1. Basements. They are constructed in place in an open excavations. They are hollow substructures designed to provide working space below ground level.

2. Buoyancy Rafts. They are hollow substructures designed to provide a buoyant substructure beneath which

reduce net loadings on the soil to the desired low density.

3.Caissons. They are hollow s8ubstructures designed to be constructed on or near the surface and then sunk as single units to their required level.

4.Cylinders. They are single small cell caissons.

5.Shaft Foundations. They are constructed within deep excavation supported by lining constructed in place and subsequently filled with concrete.

6.Pile Foundations. The pile foundation is a construction supported on piles. A pile is an element of construction composed of timber, concrete or steel or a combination of them. The piles may be placed separately or they may be placed in form of a cluster throughout the structure.

Classification of piles:

1. Classification based on function: Bearing Pile, Friction Pile, Screw Pile, compaction Pile, Uplift Pile, Batter Pile and Sheet Pile
2. Classification based on materials and composition: Cement concrete piles, Timber piles, Steel piles, Sand Piles, and Composite piles.

3 WALLS & MASONARY WORK

A cavity wall or hollow wall is the one which consists of two separate walls called leader or skins with a cavity or gap in between them.
The two leaves of a cavity wall may be of equal thickness if it is a non load bearing.
The internal leaf may be thicker than the external leaf to meet the structural requirements.
Cavity walls are often constructed forgiving better thermal insulation to the building.
It also prevents the dampness to enter and act as sound insulation.
The inner and outer skins should not be less than 10cm each(half brick).

ADVANTAGES :-

There is no direct contact between the inner and outer leaves of the wall (except at wall ties). Hence moister (dampness) can not travel inside the building.
The cavity between the two leaves is full of air which is bad conductor of heat. hence transmission of heat from external face to the inside the room is very much reduced.
Cavity wall have about 25% greater insulating value than the solid walls.
Cavity walls also offer good insulation against sound.
The nuisanceof efflorescence is also very much reduced.
They are cheap and economical .
Loads and foundation are reducedbecause offission solid.

GENERAL FEATURES OF CAVITY WALLS:-

In case of brick cavity wall ,each is half brick thick .such wall is capable of taking load of two storyedof the domestic type , if heavier loads are to be supported ,the thickness of inner leaf can be increased .
The cavity wall should neither be less then 40mm more for more than 100mm in width .
The inner and outer skins are adequately tied together by means of the special walls ties placed in suitable arrangement , at the rate of at least ties to a square meter of wall area .
The ties are staggered .ties must be placed at 300mm vertical intervals at all angles and doors and windows jambs to increase stability .
Since the cavity separates the two leaves of the wall, to prevent moisture to enter , it is essential to provide a vertical damp proof course at window and door reveals .
The damp proof course should be flexible.

PORPOSE FOR PROVIDING A CAVITY WALL:-

1.PREVENTATION OF DAMPNESS:-When cavity wall construction is adopted there is considerable decrease in the prevention of dampness from outside to inside of the building.
2.HEAT INSULATION:-The air in the cavity acts as a non-conductor of heat and hence the uniform temperature is maintained inside the building.
3.SOUND INSULATION:- The considerable portion of external noise is not allowed to enter inside the building by adopting cavity wall construction.
4.LOAD ON FOUNDATION:-Due to less solid thickness of wall the loads on foundation are considerably reduced.
5. EFFLORESCENCE:-The construction of cavity wall results in the reduction of nuisance of efflorescence to a great extent.
6.ECONOMICAL:-In addition to above mentioned advantages, it is found that the construction cost of a cavity wall is 20% less than the construction cost of a corresponding solid wall .

CONSTRUCTION DETAILS OF CAVITY WALL:-

A cavity wall is constructed of two leaves that is inner and outer with a hollow space in between them.
The width of cavity varies from 50mm to 100mm and it stands vertically. The outer is generally of ½ brick thickness and the inner wall may be of ½ of 1 brick thickness.
The two portions of the wall are connected by means of metal ties or specially prepared bonded bricks. The metal ties are generally of wrought iron or mild steel and they are coated with tar or galvanizedso as to have protection against rust.
Where corrosion is heavy, the metal ties of copper or bronze may be adopted. The metal ties are placed at a horizontal distance of 900 mm and a vertical distance of 450 mm. The arrangement of ties is kept staggered .
The outer wall is generally constructed in stretcher bond , but it may be constructed in the flemish bond or

english garden-wall bond or flemish garden-wall bond by using bats for headers.
As far as possible, there should be no intimate contact between two leaves of the cavity wall.

Construction at base:-

The cavity may be started from the top of foundation concrete& the hollow space, up to a level of about 100mm to 300mm below the damp-proofing course at plinth level, may be filled with plain cement concrete of proportion 1:2:4.
But, as the cavity below damp-proof course does not serve any purpose ,the brickwork up to a level of 100mm to 300mm below the damp-proofing course at plinth level may be constructed solidly.
The increased thickness of wall will also be helpful in supporting the load to be carried by the wall.

Construction at opening:-

In the plan, the cavity is discontinued at the opening such as doors, windows, etc. The jambs of openings for doors and windows are constructed solid either in brickwork or with layers of slates or tiles.
If metal windows are provided, specially prepared metal frames can be used for this purpose.
An inclined flexible D.P.C is provided to act as a bridge over the cavity. the D.P.C should be extend lengthwise beyond the frame for a distance of about 150mm on either side.

Construction at top:-

It is necessary to take adequate steps at top to prevent the entry of dampness to the inside portion of the wall.
The cavity may be constructed up to the coping of the parapet wall or alternatively it may be closed at the bottom of the parapet wall by a damp proofing course.
In case of a pitched roof, the tops of two portions are connected by solid brickwork to support the roof truss and damp-proofing course is inserted immediately below this solid portion.

Ventilation:-

It is necessary to provide enough ventilation to the hollow space of the cavity wall. This is achieved by providing openings at top at bottom of the wall so that a free current of air is established. The openings are to be fitted with gratings so that entry of rats and other varmintsto the hollow space is prevented. Sometimes, the air bricks are used for this purpose.

Shape and slope of ties:-

The metal ties which are used to connect the outer and inner portions should be so shaped and placed that water from outer portion does not pass along inner portions. They should thus be sloped away from the inner portion.

Dropping of mortar, bats etc.:-

During construction of a cavity wall, it should be seen that mortar , bats, etc., do not fall in the hollow space. The presence of such material in the hollow space seriously affects the working of a cavity wall. For this purpose, a wooden strip of width slightly less than that of the hollow space, is supported on ties and it is raised as the work proceeds. Also, some bricks at the bottom are left out and bats, etc. Falling in the cavity are removed from these holes. When the work is completed, this bottom portion is sealed by filling it with bricks. It also be seen that the vermins or mosquitoes do not find access in the cavity

4. DOORS AND WINDOWS

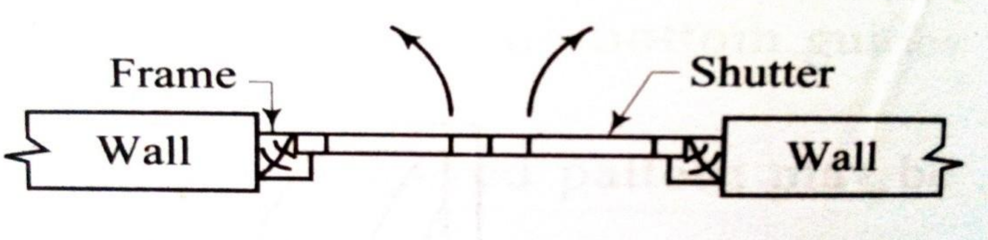
TYPES OF WINDOWS

Depending upon the manner of fixing, materials used for construction, nature of the operational movements of shutters , etc., the common varieties of windows used in the building can be grouped as follows:

1. Casement windows
2. Sliding windows
3. Metal windows
4. Corner windows
5. Gable windows bay windows
6. Lantern or lantern lights
7. Skylights

CASEMENT WINDOWS:

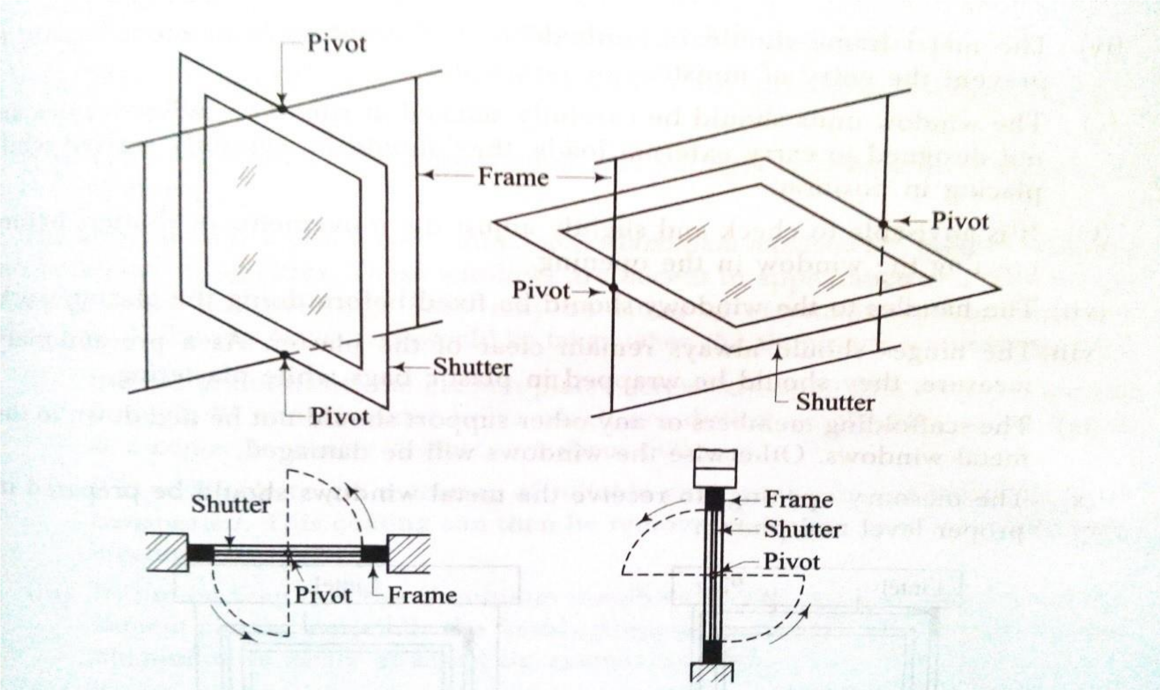
These are the windows, the shutters of which open like doors. The construction of a casement window is similar to the door construction.



Wooden casement window

SLIDING WINDOWS:

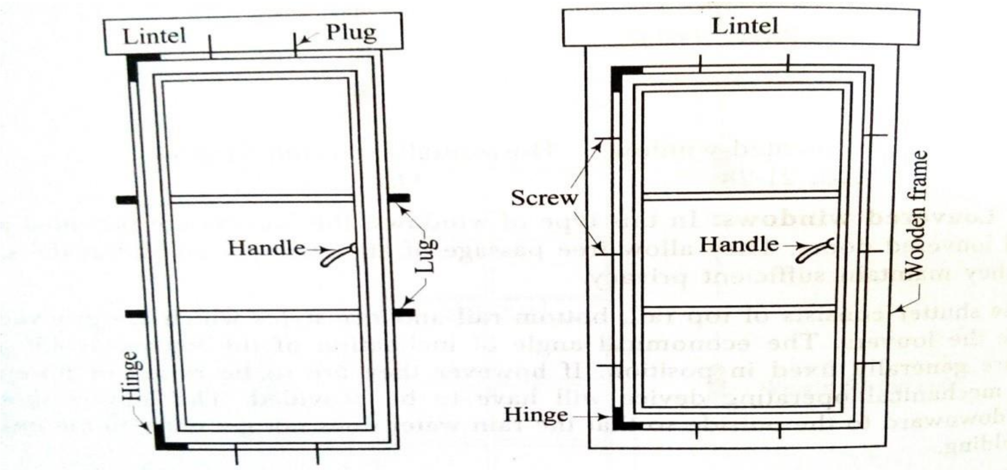
These windows are similar to the sliding doors and the shutters moves on the roller bearings, either horizontally or vertically. Such windows are provided in trains, buses, bank counter, shops etc.



Vertically pivoted window Horizontally pivoted window

METAL WINDOWS:

These are now a days widely used, especially for public building. The metal used in construction may be mild steel, bronze, or other alloys. The metal frame may be fixed direct to the wall or it may be fixed on a wooden frame.



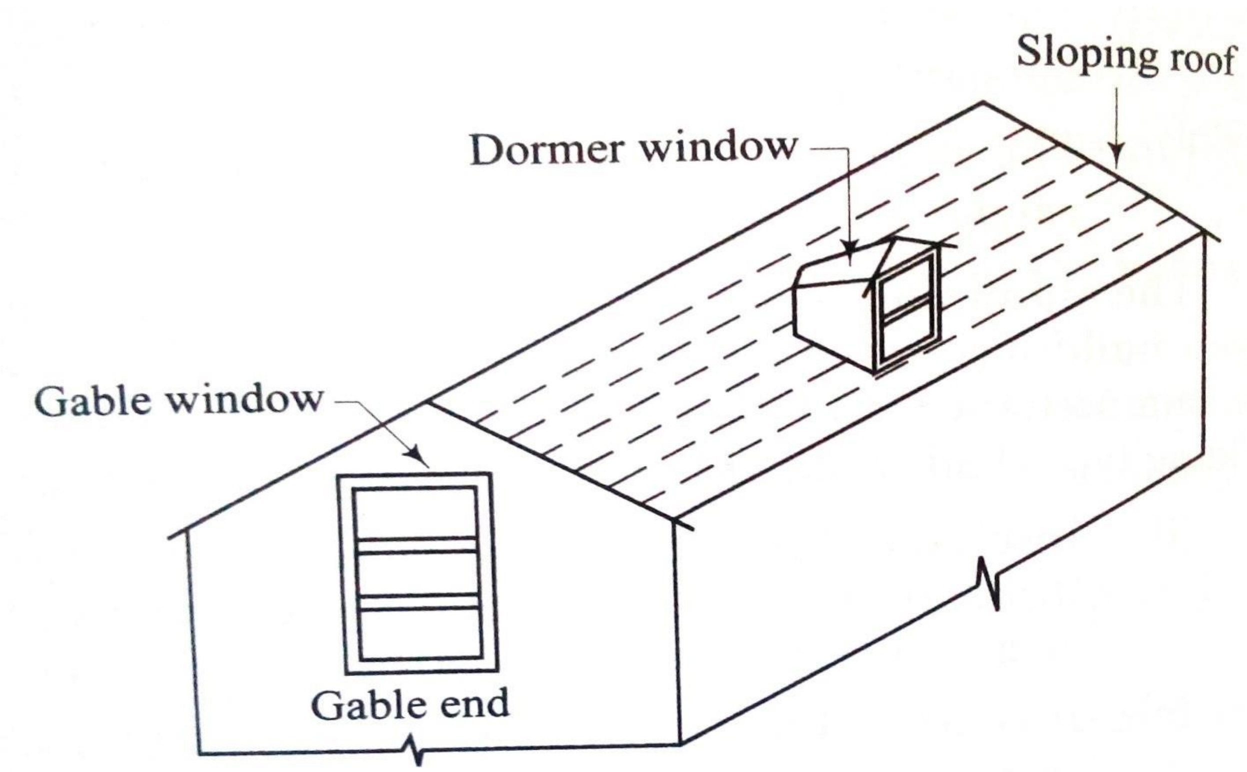
Metal window fixed to the wall Metal window fixed on a wooden frame

CORNER WINDOWS:

These windows are provided at the corner of a room .They are placed at the corner of the room and thus they have two faces in two perpendicular direction. Due to such situation,there is entry of light and air from two direction and in many cases , the elevation of building is also improved.

GABLE WINDOWS:

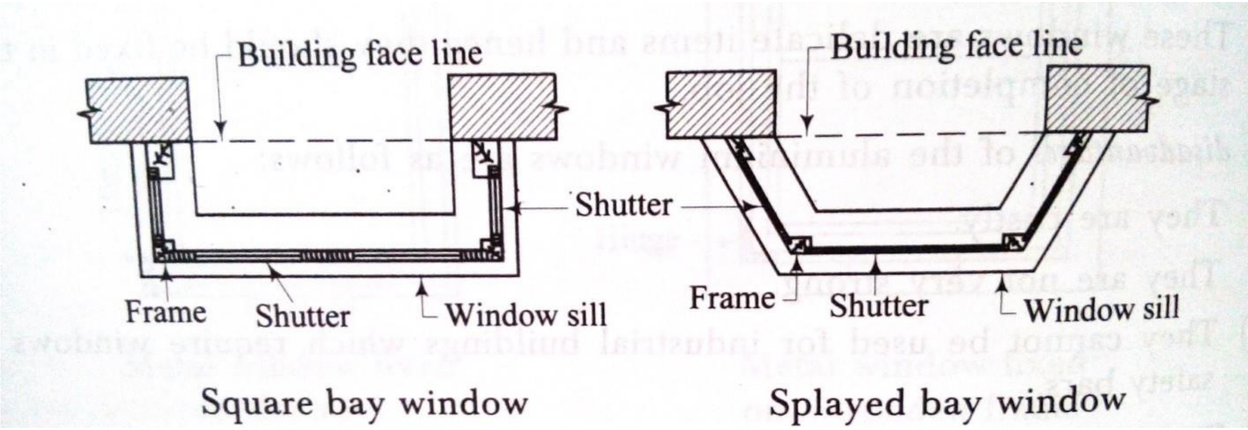
These are the windows which are provided in the gable ends of a roof.



Gable window and dormer window

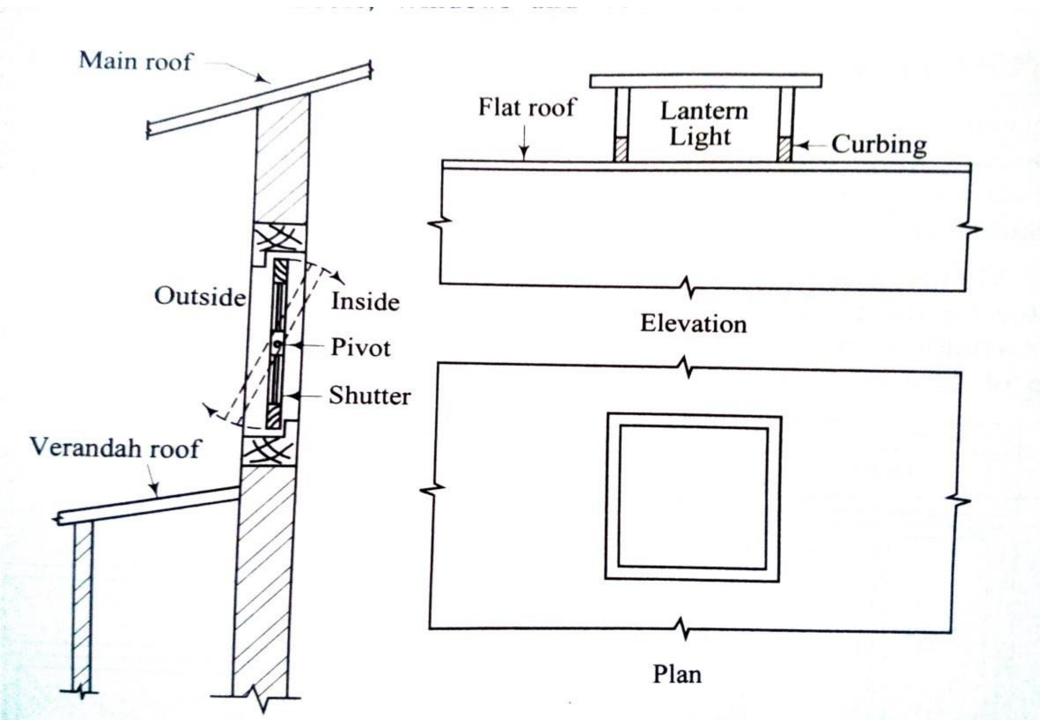
BAY WINDOWS:

These windows project outside the external wall of a room. They maybe square , splayed, circular, polygonal or of any shape. The projection of bay windows may start from floor level or sill level. These windows admit more lights, increase opening area , provide ventilation and improve the appearance of building.



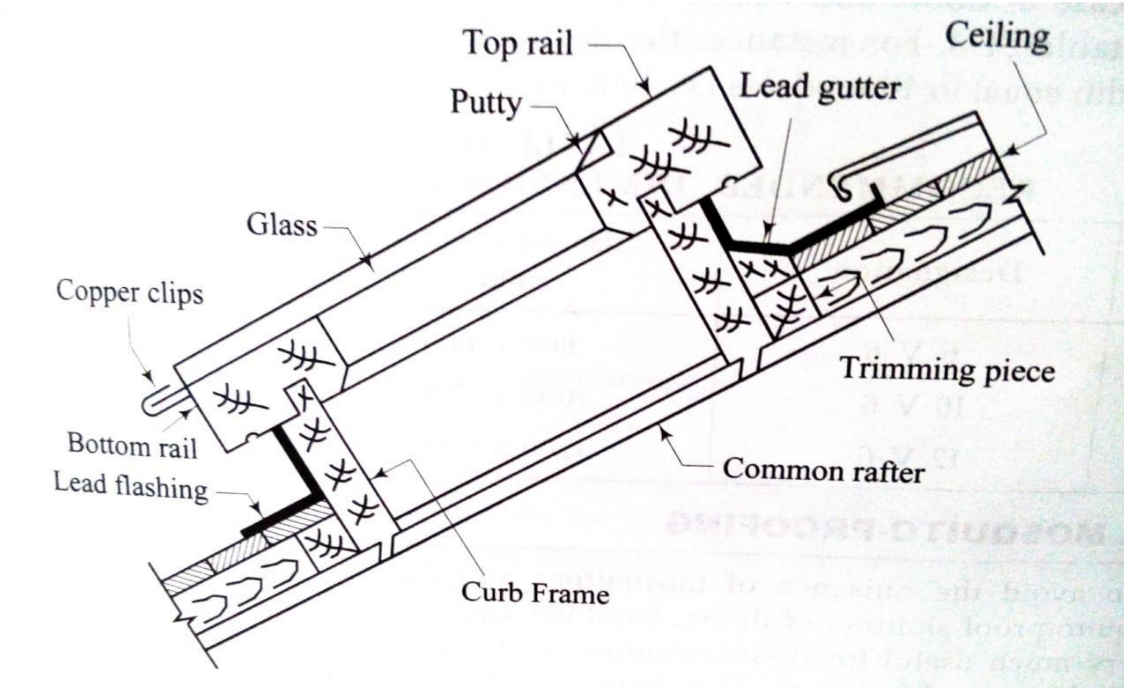
LANTERNS:

These are the windows which are fixed on flat roofs to provide light to the inner portion of building where light coming from external windows are insufficient. They maybe square or rectangular or curved.



SKYLIGHTS:

these are the windows which are provided on the sloping surface of a pitched roof. The common rafter are suitably trimmed and the skylight is erected on a curb frame. As skylight are mainly meant for light, they are usually provided with the fixed glass panel.



Skylight

TYPES OF DOORS

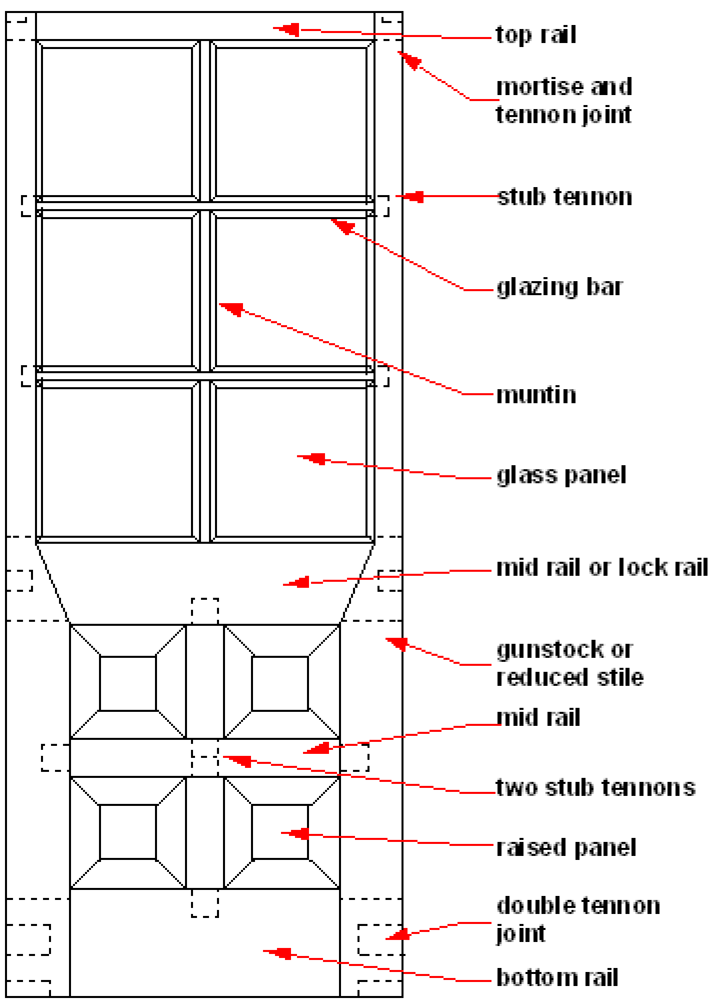
A **door** is a moving structure used to block off, and allow access to, an entrance to or within an enclosed space, such as a building or vehicle. Similar exterior structures are called gate. Typically doors have an interior side that faces the inside of a space and an exterior side that faces the outside of that space. While in some cases the interior side of a door may match its exterior side, in other cases there are sharp contrasts between the two sides, such as in the case of the vehicle door. Doors normally consist of a panel that swings on hinges or that slides or spins inside of a space.

Panel doors:

Panel doors, also called stile and rail doors, are built withframeand panel construction. EN 12519 is describing the terms which are officially used in European Member States. The main parts are listed below:

- Stiles - Vertical boards that run the full height of a door and compose its right and left edges. The hinges are mounted to the fixed side (known as the "hanging stile"), and the handle, lock, bolt, and/or latch are mounted on the swinging side (known as the "latch stile").

- Rails- Horizontal boards at the top, bottom, and optionally in the middle of a door that join the two stiles and split the door into two or more rows of panels. The "top rail" and "bottom rail" are named for their positions. The bottom rail is also known as "kick rail". A middle rail at the height of the bolt is known as the "lock rail", other middle rails are commonly known as "cross rails".
- Mullions - Smaller optional vertical boards that run between two rails, and split the door into two or more columns of panels, the term is used sometimes for verticals in doors, but more often (UK and Australia) it refers to verticals in windows.
- Muntin - Optional vertical members that divide the door into smaller panels.
- Panels - Large, wider boards used to fill the space between the stiles, rails, and mullions. The panels typically fit into grooves in the other pieces, and help to keep the door rigid. Panels may be flat, or in raised panel designs. Can be glued in or stay as a floating panel.
- Light or Lite - a piece of glass used in place of a panel, essentially giving the door a window.



Plank and batten doors:

Plank and batten doors are an older design consisting primarily of vertical slats:

- Planks - Vertical boards that extend the full height of the door, and are placed side by side filling the door's width.
- Battens - Smaller slats that extend horizontally across the door which the planks are affixed to. The battens hold the planks together. Sometimes a long diagonal slat or two are also implemented to prevent the door from skewing. On some doors, especially antique ones, the battens are replaced with iron bars that are often built into the hinges as extensions of the door-side plates.

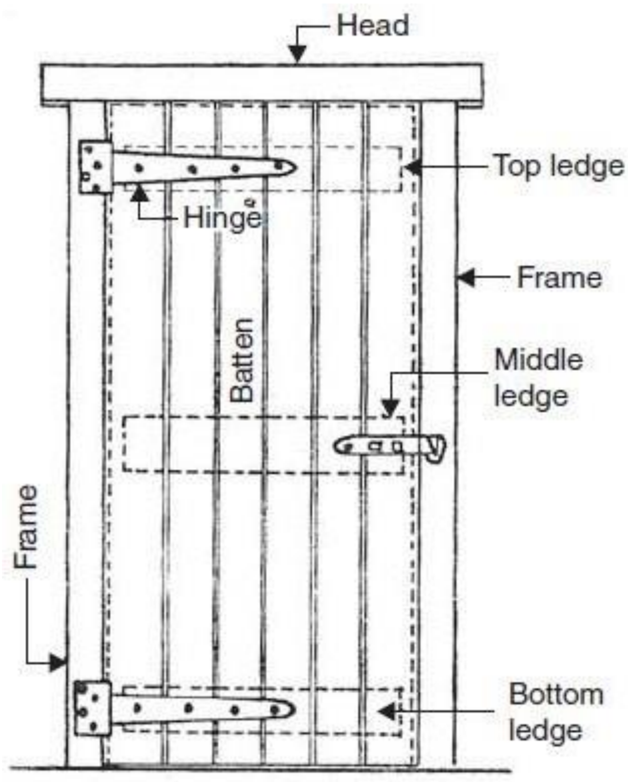
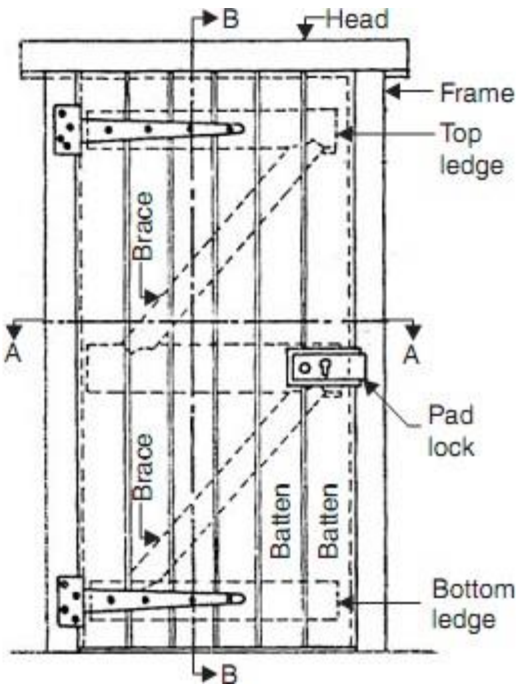


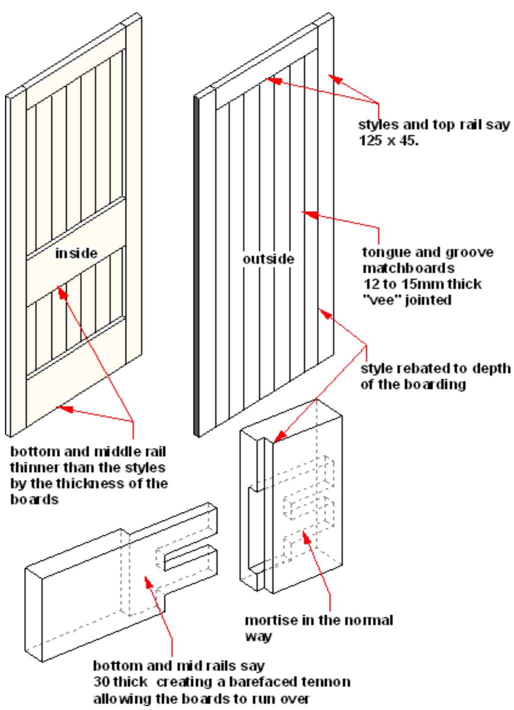
Fig. 8.21. Battened and ledged door

Ledged and braced doors:

This type consists of vertical tongue and grooved boards held together with battens and diagonal braces.



Frame and filled doors:

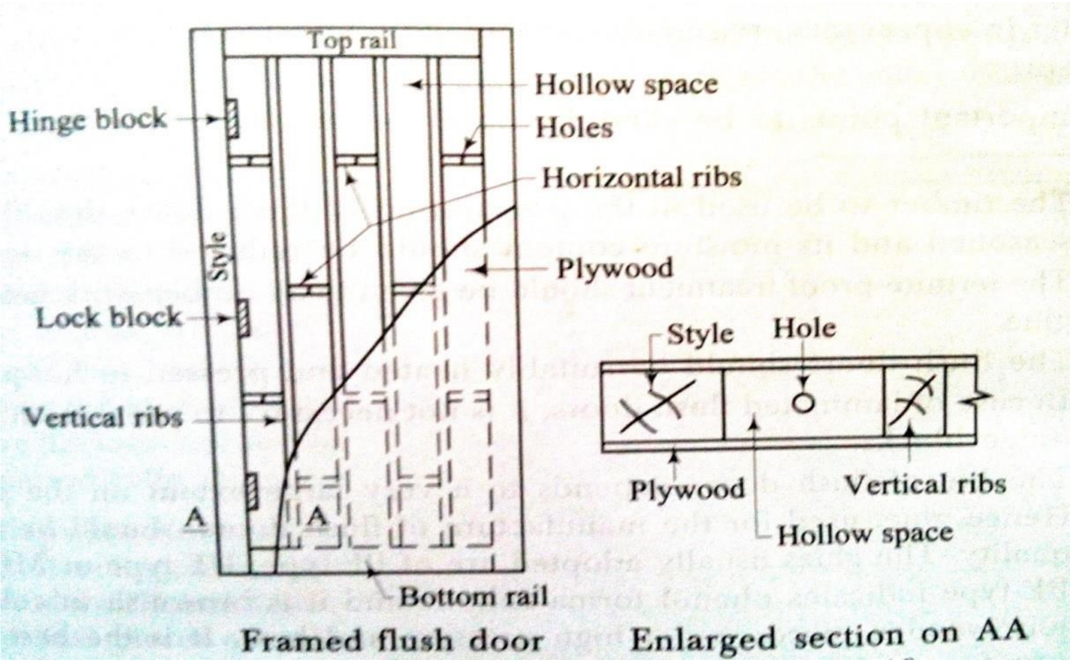


This type consists of a solid timber frame, filled on one face, face with Tongue and Grooved boards. Quite often used externally with the boards on the weather face.

Flush doors:

A flush door consists of a framework of rails and styles and it is covered with plywood. There are two varieties of flush doors

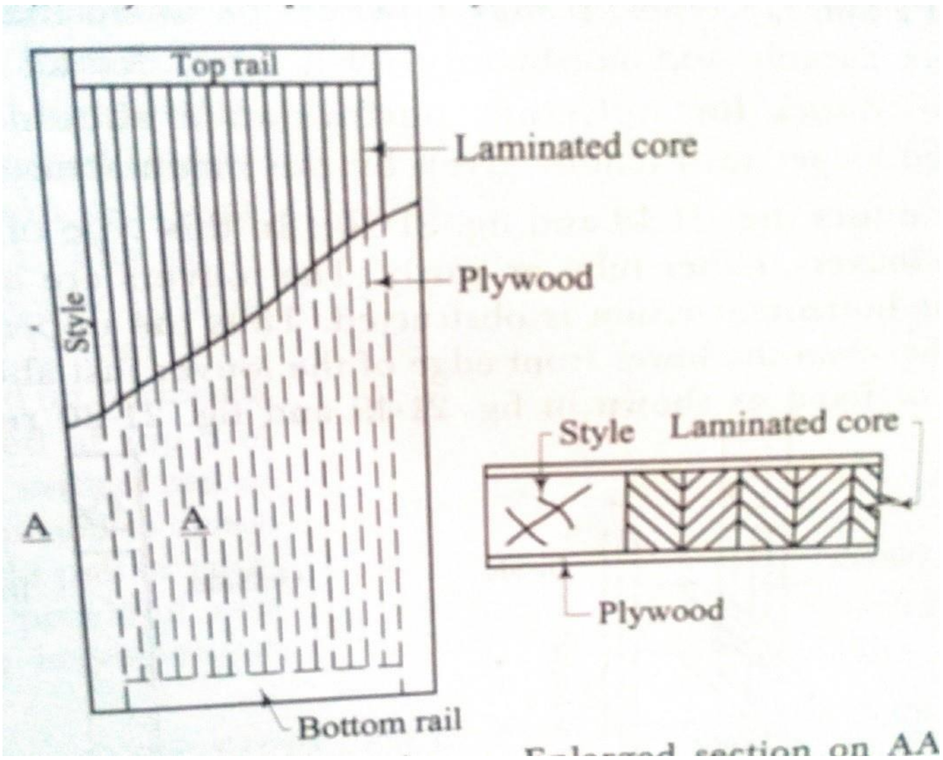
1.framed flush door :



It consists of styles, rails, horizontal ribs, vertical ribs, and plywood. As shown in fig.

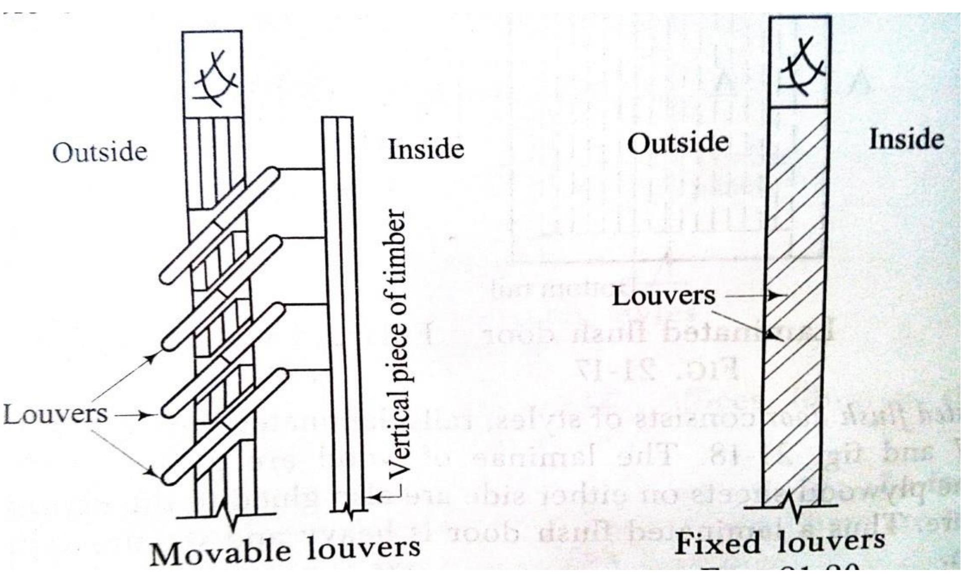
2.laminated flush door

It consists of styles, rails, laminated core and plywood as shown in fig.



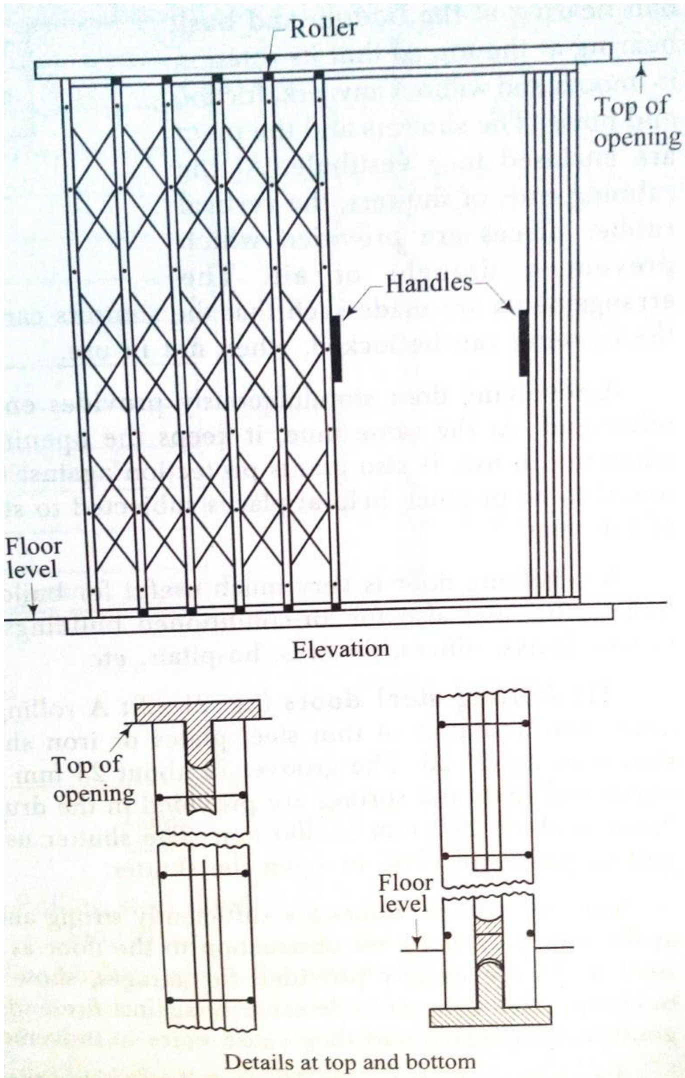
Louvered Doors:

In this type of doors, the shutters are provided with louvers, either fully or partly. The louvers are arranged at such an inclination that horizontal vision is obstructed. The louvers maybe movable or fixed as shown in fig.



Collapsible Steel Doors:

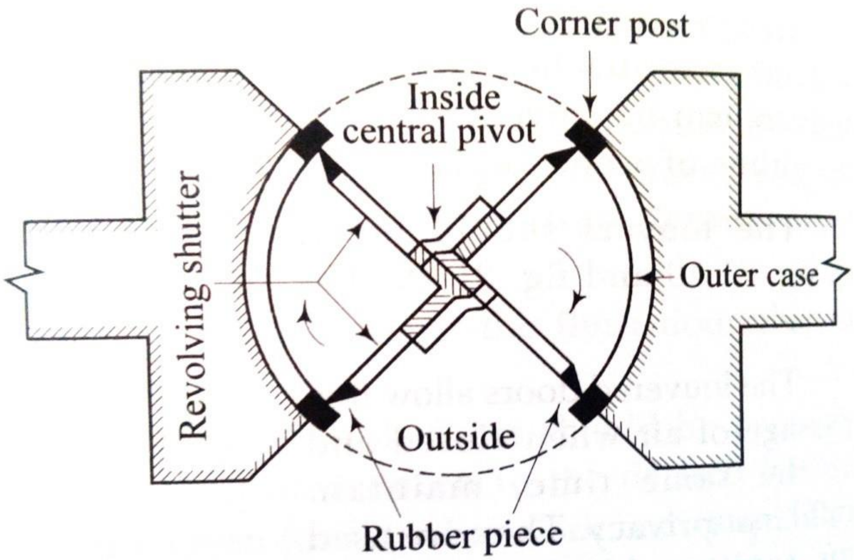
It consists of a mild steel frame. A collapsible steel door works without hinges and it is used for compound gates, residential building , schools, sheds, godowns , workshop, public building , etc.



Collapsible steel door

Revolving Doors:

It essentially consists of a centrally placed mullion in a circular opening revolving shutters which are 4 in number are radially attached to pivot as shown in fig.



Revolving door

5.FLOORS,ROOFS AND STAIRS

Floors Definition

A floor is the bottom surface of a room or vehicle. Flooring is the general term for a permanent covering of a floor, or for the work of installing such a floor covering. A lot of variety exists in flooring and there are different types of floors due to the fact that it is the first thing that catches your eye when you walk into a house, as it spans across the length and breadth of the house. It is also the surface that goes through the most wear and tear, and that's why choosing the right material is of utmost importance.

Types of Floors

Following are some of the major types of floors:

1. Mud Floor:

Earthen Flooring also commonly known as Adobe flooring is made up of dirt, raw earth or other unworked ground materials. In modern times, it is usually constructed with mixture of sand, clay and finely chopped straw.

Mud flooring is commonly constructed in villages where by using stabilizers the properties of the soil are enhanced by manipulating its composition by adding suitable stabilizers. The tensile and shear strength of the soil is increased and shrinkage is reduced.

Suitability:

These floors are not prepared in commercial or professional buildings but only in residential buildings in rural areas where the cheapest and easiest option is selected. The mud flooring is easy to maintain, remains warm in winter and cold in summer and hence it is most suitable for places where the temperature is extreme during these seasons.

2. Brick floor:

Brick flooring is one of the types of floors whose topping is of brick. These are easy to construct and repair but the surface resulting from these is not smooth and is rough, hence, easily absorbs and retains moisture which may cause dampness in the building.

Method of Construction of Brick Floor:

For constructing a brick floor, the top surface of earth or murram filling is properly consolidated. Over this compacted earth, a layer of clean sand about 10 cm thick is evenly spread. Then a layer of lime concrete (1:4:8) or lean cement concrete (1:4:16) is laid, compacted and cured. Over this base concrete well soaked bricks are laid in cement mortar (1:4) in any suitable bond. In case pointing is to be done, the minimum thickness of joints should not exceed 2 mm and and the mortar in joints is struck off with a trowel. When the pointing is to be done, the minimum thickness of joints is kept 6mm and the pointing may be done.

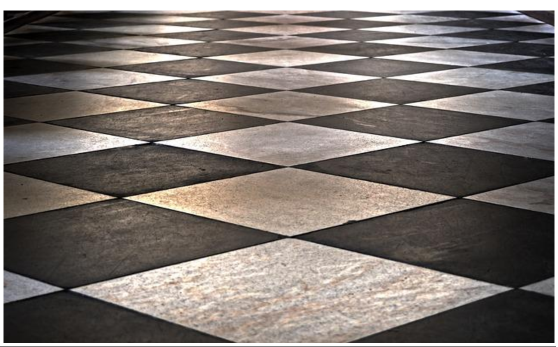
Suitability:

The floors are suitable for stores, godowns etc.

3. Tile floor:

The floor whose topping is of tiles is called tile floor. The tiles used may be of any desired quality, color, shape or thickness.

Method of construction of Tile Floor:



For constructing a tile floor, the base course is prepared in the same manner as in case of brick flooring.Over the base course thus prepared, a thin layer of lime or cement mortar is spread with the help of screed battens. Then the screeds are properly leveled and fixed at the correct height. When the surface mortar has hardened sufficiently, the specified tiles are laid on a 6 mm thick bed of wet cement mortar.(1:5). The surplus mortar which comes out of the joints is cleaned off. After 3 days, the joints are well rubbed a carborundum stone so as to smoothen the surface, specially the edges.

Suitability:

These floor are used for paving courtyard of buildings. Glazed tiles floors are used in modern buildings where a high class building is desired.

4. Flagstone floor:

The floors whose topping consists of stone slabs is called flagstone floor. The stone slabs used here may not be of the same size but should not be more than 75 cm length and not less than 35 cm in width and 3.8 cm in thickness.

Method of construction of Flagstone Floor:

For constructing a flagstone floor, the same method is applied as in case of tile floor. The slabs are soaked well in water at least one hour before laying. They should be evenly and firmly bedded in mortar. The thickness of joints should not exceed 4mm and they should be struck off with a trowel while laying.

Suitability:

These type of flooring are suitable in go-downs, motor sheds, stores, pavements etc.

5. Cement concrete floor:

The types of floors whose topping consists of cement concrete is called cement concrete floor or conglomerate floor. These floors consists of 2.5 cm to 5cm thick concrete layer laid over 10 cm thick base concrete and 10 cm thick clean sand over ground whose compaction and consolidation is done. These floors are commonly used these days.

Following are the advantages of concrete floors:

1. They are hard & Durable.
2. Provide a smooth & non absorbent surface.
3. They are more fire resistant.

4. They provide more sanitary surface as they can be cleaned & washed easily.
5. They are economical as they require negligible maintenance cost.
6. They can be finished with a pleasing appearance.

Types of cement concrete floors:

1. Non-Monolithic or bonded floor finish floor.
2. Monolithic floor finish floor

Terrazzo floor

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ROOFS

Common Roof Types

Flat roof:

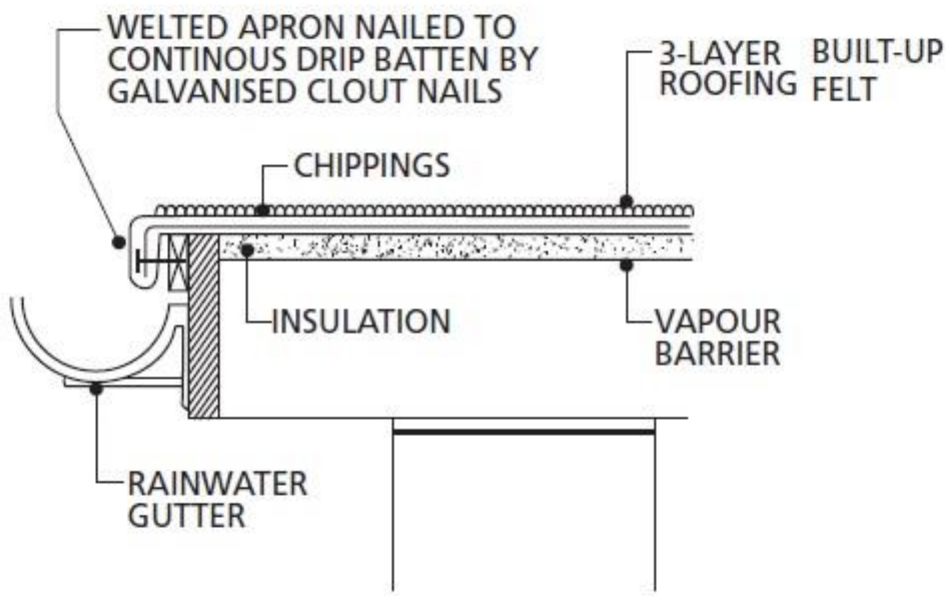
The flat roof is a simple design for large buildings in which columns are not a disadvantage. Although simple beams can be used for spans up to about 5 metres, with longer spans it is necessary to use deep beams, web beams or trusses for adequate support. As farm buildings often need large areas free of columns, it is not common to find flat roofs with built-up roofing. Flat roofs are prone to leaks. To prevent pools of water from collecting on the surface, they are usually built with a minimum slope of 1:20 to provide drainage.

The roof structure consists of the supporting beams, decking, insulation and a waterproof surface. The decking, which provides a continuous support for the insulation and surface, can be made of timber boards, plywood, chipboard, metal or asbestos-cement decking units or concrete slabs.

The insulation material improves the thermal resistance and is placed either above or below the decking. The most common design for a waterproof surface is the built-up roof using roofing felt. This material consists of a fibre, asbestos or glass fibre base that has been impregnated with hot bitumen. The minimum pitch recommended for built-up roofs is 1:20 or 3°, which is also near the maximum if creeping of the felt layers is to be prevented.

For flat roofs, two or three layers of felt are used, the first being laid at right angles to the slope commencing at the eaves. If the decking is made of timber, the first layer is secured with large flathead felting nails and the subsequent layers are bonded to it with layers of hot bitumen compound. If the decking is of a material other than timber, all three layers are bonded with hot bitumen compound. While it is still hot, the final coat of bitumen is covered with layers of stone chippings to protect the underlying felt, to provide additional fire resistance and to increase solar reflection. An application of 20 kg/m² of 12.5 mm chippings of limestone, granite or light-coloured gravel is suitable.

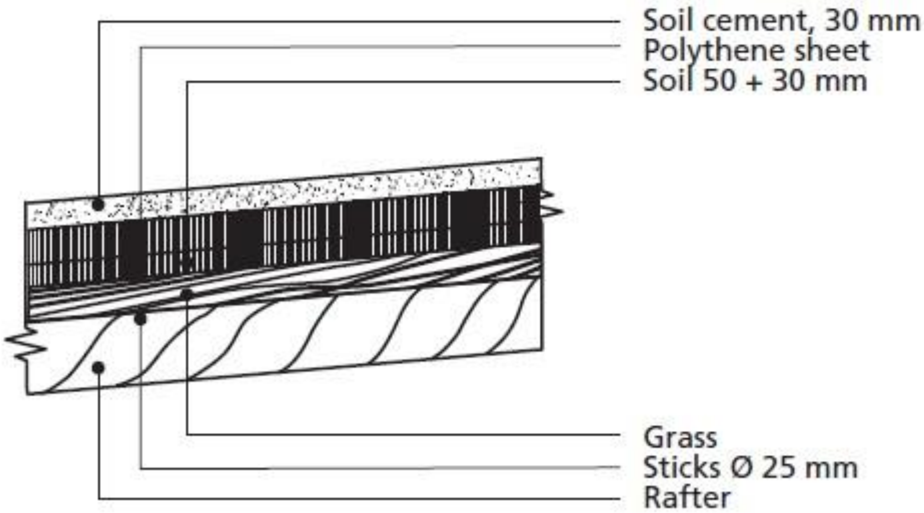
Where three layers of roofing felt are used and properly laid, flat roofs are satisfactory in rainy areas. However, they tend to be more expensive than other types and require maintenance every few years.

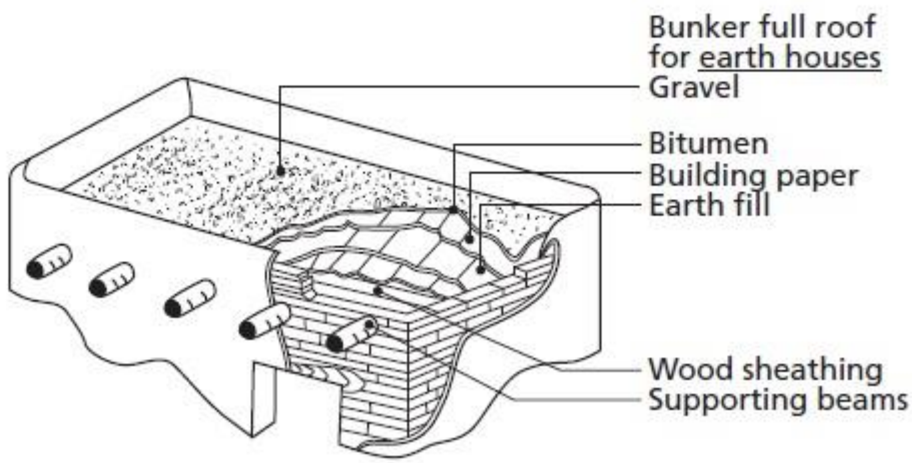


Earth roof:

Soil-covered roofs have good thermal insulation and a high capacity for storing heat. The traditional earth roof is subject to erosion during rain, and requires regular maintenance to prevent leakage. The roof is laid rather flat, with a slope of 1:6 or less.

The supporting structure should be generously designed of preservative-treated or termite-resistant timber or poles, and should be inspected and maintained periodically because a sudden collapse of this heavy structure could cause great harm. The durability of the mud cover can be improved by stabilizing the top layer of soil with cement, and it can be waterproofed by placing a plastic sheet under the soil. Figures below show two types of earth roof.





However, the introduction of these improvements adds considerably to the cost of the roof. Therefore the improved earth roof is a doubtful alternative for lowcost roofing and should be considered only in dry areas where soil roof construction is known and accepted.

Monopitch roof:

Monopitch roofs slope in only one direction and have no ridge. They are easy to build, comparatively inexpensive and recommended for use on many farm buildings. The maximum span with timber members is about 5 metres, so wider buildings will require intermediate supports. Also, wide buildings with this type of roof will have a high front wall, which increases the cost and leaves the bottom of the high wall relatively unprotected by the roof overhang. When using corrugated steel or asbestos-cement sheets, the slope should be not less than 1:3 (17° to 18°). A lower sloping angle may cause leakage, as strong winds can force water up the slope.

The rafters can be made of round or sawn timber or, when wider spans are required, of timber or steel trusses, which can be supported on a continuous wall or on posts. The inclined rafters of a pitched roof meet the wall plates at an angle and their load tends to make them slide off the plate. To reduce this tendency and to provide a horizontal surface through which the load can be transferred to the wall without excessively high compressive forces, the rafters in pitched roofs are notched over the plates. To avoid weakening the rafter, the depth of the notch (seat cut) should not exceed one third the depth of the rafter. When double rafters are used, a bolted joint is an alternative. The rafters should always be properly fixed to the walls or posts to resist the uplift forces of the wind.

Double-pitched (gable) roof:

:

- The bottom notch in the rafter that rests on the plate is called the 'seat cut' or 'plate cut'.
- The top cut that rests against the ridge A gable roof normally has a centre ridge with a slope to either side of the building. With this design, the use of timber rafters provides for a greater free span (7–8 metres) than a monopitch roof. Although the monopitch design may be less expensive for building widths up to 10 metres, the inconvenience of many support columns favours the gable roof. The gable roof may be built in a wide range of pitches to suit any of several types of roofing material. Figure below shows a number of the elements associated with a gable roof. The following description refers to Figure belowboard is called the 'ridge cut'.
- The line running parallel with the edge of the rafter from the outer point of the seat cut to the centre of the ridge is called the 'work line'.
- The length of the rafter is the distance along the work line from the intersection with the corner of the seat cut to the intersection with the ridge cut.
- If a ridge board is used, half the thickness of the ridge board must be removed from the length of each rafter.
- The 'rise' of the rafter is the vertical distance from the top of the plate to the junction of the workline at the ridge.
- The 'run' of the rafter is the horizontal distance from the outside of the plate to the centreline of the ridge.
- The portion of the rafter outside the plate is called the 'rafter tail'.
- The 'collar beam' or 'cross-tie' prevents the load on the rafters from forcing the walls apart, which would allow the rafter to drop at the ridge. The lower the collar beam is placed, the more effective it will be. Occasionally, small buildings with strong walls are designed without collar beams. The only advantage of this design is the clear space all the way to the rafters. Scissor trusses, as shown in Figure 8.51, at the same time allow some clear space.
- The right-hand rafter shows purlins spanning the rafters and supporting a rigid roofing material, such as galvanized steel or asbestos-cement roofing.
- The left-hand rafter is covered with a tight deck made of timber boards, plywood or chipboard. It is usually covered with a flexible roofing material such as roll asphalt roofing.
- The left-hand eave is enclosed with a vertical 'fascia' board and a horizontal 'soffit' board.
- The pitch is shown on the small triangle on the right side.

Hip roof:

A hip roof has a ridge in the centre and four slopes. Its construction is much more complicated, requiring compound angles to be cut on all of the shortened rafters and provision for deep hip rafters running from the ridge to the wall plate to carry the top ends of the jack rafters. The tendency of the inclined thrust of the hip rafters to push out the walls at the corners is overcome by tying the two wall plates together with an angle tie. At the hips and valleys, the roofing material has to be cut at an angle to make it fit. The valleys are prone to leakage, and special care has to be taken in the construction.

Four gutters are needed to collect the rainwater from the roof, but this does not necessarily mean that there will be an increase in the amount of water collected. As this is an expensive and difficult way to roof a building, it is only recommended in cases where it is necessary to protect mud walls or unplastered brick walls against heavy driving rain and, for wide buildings, to reduce the height of the end walls.

Conical roof:

The conical roof is a three-dimensional structure that is commonly used in rural areas. It is easy to assemble and can be built with locally available materials, making it inexpensive. It must be constructed with a slope appropriate to the roofing materials to prevent it from leaking. The conical roof design is limited to rather short spans and to either circular buildings or to small, square buildings. It does not allow for any extension. If modern roofing materials are used, there is considerable waste because of the amount of cutting needed to secure a proper fit.

A conical roof structure requires rafters and purling and, in circular buildings, a wall plate in the form of a ring beam. This ring beam has three functions:

1. To distribute the load from the roof evenly to the wall.
2. To supply a fixing point for the rafters.
3. To resist the tendency of the inclined rafters to press the walls outwards radially by developing tensile stress in the ring beam. If the ring beam is properly designed to resist these forces and secondary ring beams are installed closer to the centre, a conical roof can be used on fairly large circular buildings.

STAIRS:

The means of communication between various floors is offered by various structures such as stairs, lifts, ramps, ladders, escalators.

STAIR: A stair is a series of steps arranged in a manner as to connect different floors of a building. Stairs are designed to provide an easy and quick access to different floors.

- A staircase is an enclosure which contains the complete stairway.
- In a residential house stairs may be provided near the entrance.
- In a public building, stairs must be from main entrance and located centrally.

STAIRCASE: Room of a building where stair is located.

STAIRWAY: Space occupied by the stair.

TECHNICAL TERMS

1. BALUSTER: Vertical member which is fixed between stairway and horizontal to provide support to hand rail.
2. BALUSTRADE: Combined framework of baluster and hand rail.
3. STRING: Inclined member of a stair which supports ends of steps. They are of two types, (i) cut/open string, (ii) closed/housed string.
• In open string, upper edge is cut away to receive the ends of steps.
• In closed string, the ends of steps are layed between straight and parallel edges of the string.
4. FLIGHT : Unbroken series of steps between the landings.
5. GOING: horizontal distance between faces of two consecutive risers.
6. HANDRAIL: inclined rail over the string. Generally it is moulded. It serves as a guard rail. It is provided at a convenient height so as to give grasp to hand during ascent and descent.
7. HEAD ROOM: vertical distance between nosingsof one flight and the bottom of flight immediately above is called head room.
8. LANDING: horizontal platform between two flights of a stair. A landing facilitat

12. PITCH: angle of inclination of stair with floor. Angle of inclination of line of nosing with horizontal.
13. RISE: vertical distance between two successive treads.
14. RISER: vertical member of the step, which is connected to treads

15. RUN: length of a stair in a horizontal plane which includes length of landing.
16. SCOTIA: an additional finish provided to nosing to improve the elevation of the step which also provides strength to nosing.
17. SOFFIT: under surface of a stair. Generally it is covered with ceiling or finished with plaster.
18. STEP: combination of trade and riser. Different types are.
• *Commode steps*: it has curved riser and tread
• *Dancing step*: they don’t radiate from a common centre
• *Flier*: ordinary step of rectangular shape in plan
• *Round ended step*: similar to bullnose step except that its ends are sem-icircular in plan
• *Splayed step*: it has either one end/both ends splayed in plan
• *Winder* : this is a tapering step and is used to change the direction of a flight. The winders radiate from a common centre.
• *Tread*: horizontal upper portion of a step.
• *Waist*: thickness of structural slab in RCC stair
• *Carriage*: a rough timber supporting steps of wooden stairs

REQUIREMENT OF GOOD STAIRCASE

• Stairs should be so located that it is easily accessible from the different rooms of a building.
• It should have adequate light and proper ventilation.
• It should have sufficient stair width to accommodate no. of persons in peak hour/emergency.

Generally for interior stairs, clear width may be
✓ at least 50cm in one/two family dwellings
✓ at least 90cm in hotels, motels, apartment and industrial building
✓ at least 1.1m for other types like hospitals, temples etc.
• No. of steps in a flight should be restricted to a maximum of 12, minimum of 3.
• Ample head room should be provided for tall people to give feeling of spaciousness. It should be minimum of 2.15m.
• Risers and treads sizes should be provided from common point view.

Tread = 2.5cm – 32.5 cm (wide), excluding nosing.
Tread < 25cm, should have a nosing of about 2.5cm

Comfortable height of riser = 17.5cm-18.5cm.

✓ Riser * tread = (400-410). 426

✓ Riser + tread = (42.5-43.5) 40-45

✓ 2(riser) + tread = 60-64 cm 60

Take rise = 14cm, going = 30cm.for each 2cm substracted from going, add 1cm to rise.

 Stair width depends on purpose and importance of building.

• No. of stairways required should be controlled by maximum floor area contributory to stairway.
(No. of persons using stairs/floor/55cm stairwidth)
should be 15 for hospital and nursing home.
Should be 30 for institutional and residential building
Should be 45 for storage building
Should be 60 for mercantile, educational, industrial building, theatres, restaurants.
Should be 80 for church concert hall, museum
Should be 320 for stadium and amutementstructures.

• Minimum width of landing = width of stair

• Maximum and minimum pitch should be 40_0 and 25_0.

• Winder should be provided at lower end of flight when it is essential. Use of winder should be avoided.

• Live load to be considers n stairs have been stipulated by IS 875-1964

• Stairs and landings should be designed for live load of 3000kg/m.s2 in building where there are no possibilities of overcrowding in public building and warehouses where overcrowding is likely live load may be taken as 500kg

• Railing should be design for horizontal force of 55 and vertical force of 70 applied at top of rail

TYPES OF STAIRS

1. Straight stair:

➢ Here there is no change in the direction of any flight between two successive floors.

➢ It can be straight run with a single flight between floors or a series of flights without change indirection

Parallel stairs
Angle stairs
Scissors stair

➢ Straight stair can have a change in direction at any intermediate landing.

➢ In parallel stair, there is complete reversal of direction occurs.

➢ In angle stair, successive flights are at an angle to each other.

➢ Scissor stairs are comprised of a pair of straight runs in opposite direction and are placed on opposite sides of a fire resistive wall.

6.PROTECTIVE,DECORATIVE FINISHES,DAMP AND TERMITE PROOFING

Paint is a liquid surface coating. On drying it forms a thin film on the painted surface. Paints are classified as oil paints, water paints, cement paints, bituminous paints and special paints such as fire proof paints, luminous paints, chlorinated rubber paints (for protecting objects against acid fumes), etc. The paintings are the coating of fluid materials

The functions of the paints are:

- To protect the coated surface against possible stresses mechanical or chemical; deterioration—physical or environmental;
- Decorate the structure by giving smooth and colourful finish; check penetration of water through R.C.C;
- check the formation of bacteria and fungus, which are unhygienic and give ugly look to the walls;
- check the corrosion of the metal structures;
- Check the decay of woodwork and to varnish the surface to display it to better advantage

Defects in Painting:

- A painted building with full colour effects gives complete satisfaction. But the appearance of defects becomes a ready source of complaint. Unfortunately painting defects are by no means uncommon. They may arise from a variety of causes but the principal reasons behind them are incorrect choice of paint in relation to backing materials, application of paint to a damp surface or one to which moisture may have access and; poor workmanship.

Effects of background:

- The factors affecting durability are dampness, cleanliness, movements, chemical reactions, etc. The traditional construction in brick, cement, etc. involves the use of wet procedures. If paint is applied on an insufficiently dry background the moisture is trapped and in the process of subsequent drying the adhesion of the paint breaks down. Emulsion paints are somewhat better in this respect.

- The painting processes can be delayed for proper results for movements caused by shrinkage and special paints should be used for thermal movements.
- Chemical reaction between backing material and paint film may push the paint off the backing material and lead to softening or decolourise the paint. This effect generally occurs only if moisture is present and is noticeable in oil paints over materials containing cement or lime. The breakdown of bond is because of the crystallization of salts below the paint film and the discolouration is usually due to action of free lime on the pigments.

Effects of weather:

The paint film is subjected to chemical attack of atmosphere, sunlight and heat, all deteriorating it. Special chemical resistant paints should be applied in industrial areas. Alkali resistant paints weather well in coastal areas. Blue and green colours tend to fade when exposed to bright light. In addition the fierce heat of sun may breakdown the paint film because of the disintegration of the material itself and also because of the thermal movement. The most common defects noticed after paintings are as follow:

Blistering and peeling are swelling of the paint film and can be defined as localized loss of adhesion between one or more coatings or between primer and parent surface. When swelling is because of oil or grease on the surface it is known as blistering and in case of moisture it is called peeling. It occurs in nonporous coatings such as oil based paints and enamels. A special heat-resisting type of paint should be used for hot surfaces such as radiators. It is brought about by moist air, oily or greasy surface, or imprisoned gases between the painted surface and the paint film, which expand under the influence of heat. Emulsion paints provide a porous coating and allow the moisture to pass through.

Checking is a mild form of cracking. If hair cracks produced enclose small area it is known as crazing. In case the enclosed area is large the defects is called crocodiling. It is caused when the paint film lacks in tensile strength and occurs when paint is applied during very cold weather or because of insufficient drying of undercoat. When cracks are very small and do not enlarge with time, the top coating is flattened with emery paper and a fresh coat of paint is applied.

Cracking: The cracks extend throughout the entire paint system extending right down to the original surface. Cracks in the plaster or masonry do not let the paint to remain intact.

Paint applied on glossy surface. Premature application of top coat before the previous coat has completely dried. Painting improperly seasoned wood.

Flaking: It is detachment of paint film from the surface. The moisture penetrates through the cracks on the coatings and the bond between surface and paint film is lost. The curing methods are: Use of plastic emulsion paints, Surface should be rubbed with emery paper before applying a fresh coat and All dirt or dust on surface should be removed prior to painting.

Chalking: Paint film becomes powder due to insufficient oil in primer.

Alligatoring: One layer of paint films sliding over the other one, when a hard paint is applied over a soft one or vice versa.

Wrinkling: or crawling appears when the paint film is quite thick or the oil in the paint is more than required. The lower portion of the paint does not dry due to greater thickness of the paint film which shrinks due to drying in course of time.

Running and sagging: Paints applied over smooth and glossy surface do not stick and flow back or towards the unpainted area. This is known as running and sagging. The surface to-be painted should, therefore, be rubbed with an emery paper before painting.

Bloom: is identified as dull patches on the finished, polished or painted surface due to defect in the quality of paint or poor ventilation.

Flashing: is characterized by the appearance of certain glossy patches on the painted surface. The reasons attributed to this defect are weathering actions, use of cheap paint, and poor workmanship.

Grinning: it is due to the imperfect opacity of the paint film even after the final coat. The background and its defects can be clearly visible in such a case.

Failure of Painting: The main causes of failure of painting are:

• Bad workmanship	• Conditions for painting
• Moisture	• Salt and alkalies
• Unsuitable surfaces	• Wrong choice of paint

Painting of various surfaces:

A. New plastered surface:

The procedures for paining a new plastered surface are:

1. **Surface preparation**: Paint cannot take care of construction defects. Before applying the paint, it is ensured that the surface is free from dust, dirt, loose matter, grease etc. and is rubbed with an emery paper, to provide a mechanical key between surface and paint for satisfactory adhesion.
2. **Sequence of Painting:** The primer (first coat) is applied with brush or spray on the prepared surface. It should be thinned with water or thinner in the recommended manner and proportion before application. After drying it is rubbed with emery paper. Dents and cracks, if any, are filled with putty using a knife applicator. Putty should not be applied thick. If the required thickness is large, it should be applied in two coats. After the putty has dried, the whole surface is rubbed down well in order to smoothen the putty andprovide a mechanical key to the finished coats. Two or three finish coats are applied. Each coat is allowed to dry before the application of next coat.

B. Old plastered surface

The procedure depends on the state of the existing coating. If any of the defects discussed below is very much pronounced it is completely removed and the surface is painted as a new surface.

C. Painting of new woodwork

Painting of woodwork should be done with great care. Normally 3–4 coats are sufficient for wood work.

- **Surface preparation:** The wood should be well seasoned, dried, cleaned and the surface made smooth with an emery paper. Nails, if any, should be driven down the surface by at least 3 mm.
- **Knotting:** Knots in the wood create lot of problems. These excrete resin which causes defects such as cracking, peeling and brown discolouration. Knotting is done so that resin cannot exude from the knots. Any of the following methods may be used suitably.

Ordinary knotting: This is also known as size knotting. The knot is treated with a coat of hot red lead ground with a strong glue size in water. Then a coat of red lead ground in boiled linseed oil is applied.

Lime knotting: The knot is covered with hot lime for 24 hours after which it is scrapped off. Thereafter, the process described in ordinary knotting is followed.

Patent knotting: Two coats of varnish or shelac are applied.

- **Priming coat:** The main function of priming coat or primer is to form the base for subsequent ones. After knotting priming coat is applied over the entire surface to fill all the pores. A second priming coat is applied after first has dried. In general the ingredients are same as those of the subsequent coats but with a difference in proportion.
- **Stopping:** After the priming coat putty is applied to fill the pores of the surface. Then it is rubbed smooth. Colouring pigment is also added to it to match the shade of the finished coat. On drying, the selected paint is applied with brushes to bring smoothness and uniformity in colour. After painting the surface in one direction, the brush is worked in the perpendicular direction to eliminate brush marks. This is known as crossing. All the successive coats are applied after drying and slight rubbing of previous coats for proper bond.

D. Painting of old woodwork:

The old paint is removed with a sharp glass piece, sand paper, paint remover or with a blow lamp. Any smoky or greasy substance should be washed with lime and subsequently rubbed with pumice stone. The surface is then washed with soap and water and dried completely. Then two coats of paints are applied in a way similar to that described in painting new surfaces.

E. Painting metal surfaces:

- New ironwork: The surface should be free from scales, rust and grease. Scales and rust are cleaned by hard wire brush. Grease is removed by using petroleum or by hot alkaline solution of Na_2CO_3 or NaOH, benzene, and lime water. A priming coat of red lead with barytes and raw linseed oil is then applied over the prepared surface. After drying of the priming coat, one or more undercoats with desired paint are applied. The second coat is given only after the first coat has dried. The finishing coat is applied carefully to produce a smooth fine surface.

- Old ironwork: The surface is prepared by scraping properly all the scales and rust with emery paper. The greasy substances are removed with lime water. The old paint may be burned with a blow lamp or by suitable solvents. After this the surface is brushed with hot linseed oil and painted as for new iron work.
- Structural steel: The major problem to overcome in painting iron and steel is corrosion due to electrolysis caused by the presence of air and moisture. Red lead is considered to be the best priming coat; it produces a tough elastic film, impervious to air and moisture. Pure linseed oil priming coat is detrimental in that it stimulates corrosion. The linseed oil film is rendered more impervious by the use of spar varnish. Graphite paint used for black colour, is very durable and is not affected by sulphur films, ammonia or chlorine gases. Silica-graphite paints are best; they do not crack and blister in course of time. Aluminium paint is also gaining popularity because of its shining and contrast properties and heat and chemical resistance. Bituminous paints may be very well adopted to paint inside of pipes, iron under waters, piles, ships and boats; they are unsatisfactory when exposed to sunlight. Lead or zinc paint should never be applied directly over the iron surface as it encourages galvanic action destroying the paint.

F. **Painting of floor surfaces:** The enamels are used for painting of floor surfaces. The selected enamel should be strong enough to resist abrasion, moisture, and alkali actions. It should be of shinning nature and quick drying type.

G. **Painting of concrete surfaces:** The cement paint is used to paint concrete surfaces. The paint is available in a powder form and it is dissolved in water to workable consistency. The paint thus prepared should be consumed with in 2 to 3 hours. The two coats are applied at an interval to provide curing of painted surface.

7.GREEN BUILDING ,ENERGY MANAGEMENT AND ENERGY AUDIT OF BUILDING &PROJECT

TYPES OF GLASS:

(1) Soda-lime glass
(2) Potash-lime glass
(3) Potash-lead glass
(4) Common glass

(1) Soda-lime glass:

This is also known as soda-glass or soft glass. It is mainly a mixture of sodium silicate and calcium silicate.

Properties:

(i) It is available in clean and clear state.

(ii) It is cheap.

(iii) It is easily fusible at comparatively low temperature.

Uses: It is used in the manufacture of glass tubes and laboratory apparatus, plate glass, window glass, etc.

(2) Potash-lime glass:

Also known as bohemian-glass or hard glass.It is mainly a mixture of potassium silicate and calcium silicate.

Properties:

(i) it fuses at high temperature.

(ii) it is not easily affected by water and other solvents.

(iii) it does not melt so easily.

Uses: used in manufacture of glass articles.

(3) Potash-lead glass:

Also known as flint glass.It is a mixture of potassium silicate and lead sillacate.

Properties:

(i) Fuses very easily.

(ii) Easily attacked by aqueous solution.

(iii) Posses great refractive power.

(iv) Specific gravity is about 3 to 3.50.

(v) Turns black and opaque.

Uses: used in the manufacture of artificial gems, electric bulbs, lences, prisms etc.

(4) Common glass

Also known as bottle glass. Manufacture of sodium silicate, calcium silicate and iron silicate.

Properties:

(i) Fuses with difficulty.

(ii) It is brown, grey or yellow in colour.

(iii) easily attacked by acids.

Uses: it is mainly used for medicine bottles.

MANUFACTURING OF GLASS:

1. Batch processing system (batch house):

Batch processing is one of the initial steps of the glass-making process. The batch house simply houses the raw materials in large silos (fed by truck or railcar) and holds anywhere from 1–5 days of material. Some batch systems include material processing such as raw material screening/sieve, drying, or pre-heating (i.e. cullet). Whether automated or manual, the batch house measures, assembles, mixes, and delivers the glass raw material recipe (batch) via an array of chutes, conveyors, and scales to the furnace. The batch enters the furnace at the 'dog house' or 'batch charger'. Different glass types, colors, desired quality, raw material purity / availability, and furnace design will affect the batch recipe.

The hot end of a glassworks is where the molten glass is formed into glass products, beginning when the batch is fed into the furnace at a slow, controlled rate by the batch processing system (batch house). The furnaces are natural gas- or fuel oil-fired, and operate at temperatures up to 1,575°C. The temperature is limited only by the quality of the furnace's superstructure material and by the glass composition. Types of furnaces used in container glass making include 'end-port' (end-fired), 'side-port', and 'oxy-fuel'. Typically, furnace "size" is classified by metric tons per day (MTPD) production capability.

Forming process

There are, currently, two primary methods of making a glass container: the blow and blow method, used for narrow-neck containers only, and the press and blow method used for jars and tapered narrow-neck containers.

In both methods, a stream of molten glass, at its plastic temperature (1050°C-1200°C), is cut with a shearing blade to form a solid cylinder of glass, called a gob. Both processes start with the gob falling, by gravity, and guided, through troughs and chutes, into the blank moulds, two halves of which are clamped shut and then sealed by the "baffle" from above.

In the blow and blow process the glass is first blown through a valve in the baffle, forcing it down into the three piece "ring mould" which is held in the "neckring arm" below the blanks, to form the "finish", [The term "finish" describes the details (such as cap sealing surface, screw threads, retaining rib for a tamper-proof cap, etc.) at the open end of the container.]

Containers are made in two major stages. The first stage moulds all the details ("finish") around the opening, but the body of the container is initially made much smaller than its final size. These partly manufactured containers are called parisons, and quite quickly, they are blow-molded into final shape.

Referring to the mechanism, the "rings" are sealed from below by a short plunger. After the "settleblow" finishes, the plunger retracts slightly, to allow the skin that's formed to soften. "Counterblow" air then comes up through the plunger, to create the parison. The baffle rises and the blanks open. The parisonis inverted in an arc to the "mould side" by the "neckring arm", which holds the parison by the "finish".

As the neckring arm reaches the end of its arc, two mould halves close around the parison. The neckring arm opens slightly to release its grip on the "finish", then reverts to the blank side. Final blow, applied through the "blowhead", blows the glass out, expanding into the mould, to make the final container shape.

In the press and blow process, the parison is formed by a long metal plunger which rises up and presses the glass out, in order to fill the ring and blank moulds.[5] The process then continues as before, with the parisonbeing transferred to the final-shape mould, and the glass being blown out into the mould.

The container is then picked up from the mould by the "take-out" mechanism, and held over the "deadplate", where air cooling helps cool down the still-soft glass. Finally, the bottles are swept onto a conveyor by the "push out paddles" that have air pockets to keep the bottles standing after landing on the "deadplate"; they're now ready for annealing.

The forming machines hold and move the parts that form the container. The machine consist of basic 19 mechanisms in operation to form a bottle and generally powered by compressed air (high pressure - 3.2 bar and low pressure - 2.8 bar), the mechanisms are electronically timed to coordinate all movements of the mechanisms. The most widely used forming machine arrangement is the individual sectionmachine (or IS machine). This machine has a bank of 5–20 identical sections, each of which contains one complete set of mechanisms to make containers. The sections are in a row, and the gobs feed into each section via a moving chute, called the gob distributor. Sections make either one, two, three or four containers simultaneously. (Referred to as single, double, triple and quad gob). In the case of multiple gobs, the shears cut the gobs simultaneously, and they fall into the blank moulds in parallel.

COMPOSITION OF GLASS

The following is a list of the more common types of silicate glasses, and their ingredients, properties, and applications:

1. Fused quartz, also called fused silica glass, vitreous silica glass, is silica (SiO_2) in vitreous or glass form (i.e., its molecules are disordered and random, without crystalline structure). It has very low thermal expansion, is very hard, and resists high temperatures (1000–1500 °C). It is also the most resistant against weathering (caused in other glasses by alkali ions leaching out of the glass, while staining it). Fused quartz is used for high temperature applications such as furnace tubes, lighting tubes, melting crucibles, etc.

2. Soda-lime-silica glass, window glass: silica 72% + sodium oxide (Na_2O) 14.2% + lime (CaO) 10.0% + magnesia (MgO) 2.5% + alumina (Al_2O_3) 0.6%. Is transparent, easily formed and most suitable for window glass (see flat glass). It has a high thermal expansion and poor resistance to heat (500–600 °C). It is used for windows, some low temperature incandescent light bulbs, and tableware. Container glass is a soda-lime glass that is a slight variation on flat glass, which uses more alumina and calcium, and less sodium and magnesium which are more water-soluble. This makes it less susceptible to water erosion.
3. Sodium borosilicate glass, Pyrex: silica 81% + boric oxide (B_2O_3) 12% + soda (Na_2O) 4.5% + alumina (Al_2O_3) 2.0%. Stands heat expansion much better than window glass. Used for chemical glassware, cooking glass, car head lamps, etc. Borosilicate glasses (e.g. Pyrex) have as main constituents silica and boron oxide. They have fairly low coefficients of thermal expansion (7740 Pyrex CTE is 3.25×10^{-6}/°C[4] as compared to about 9×10^{-6}/°C for a typical soda-lime glass[5]), making them more dimensionally stable. The lower CTE also makes them less subject to stress caused by thermal expansion, thus less vulnerable to cracking from thermal shock. They are commonly used for reagent bottles, optical components and household cookware.
4. Lead-oxide glass, crystal glass: silica 59% + lead oxide (PbO) 25% + potassium oxide (K_2O) 12% + soda (Na_2O) 2.0% + zinc oxide (ZnO) 1.5% + alumina 0.4%. Because of its high density (resulting in a high electron density) it has a high refractive index, making the look of glassware more brilliant (called "crystal", though of course it is a glass and not a crystal). It also has a high elasticity, making glassware 'ring'. It is also more workable in the factory, but cannot stand heating very well.
5. Aluminosilicate glass: silica 57% + alumina 16% + lime 10% + magnesia 7.0% + barium oxide (BaO) 6.0% + boric oxide (B_2O_3) 4.0%. Extensively used for fiberglass, used for making glass-reinforced plastics (boats, fishing rods, etc.) and for halogen bulb glass.
6. Oxide glass: alumina 90% + germanium oxide (GeO_2) 10%. Extremely clear glass, used for fiber-optic waveguides in communication networks. Light loses only 5% of its intensity through 1 km of glass fiber.[6] However, most optical fiber is based on silica, as are all the glasses above.

PROPERTIES OF GLASS

The properties of glass are mainly governed by factors like composition of the constituents, state of surface, thermal treatment conditions, dimension of specimen etc.

Following are the properties of glass which have made the glass popular and useful:

I. It absorbs, refracts or transmits light.

II. It can take up a high polish and may be used as substitute for every costly gems.
III. It has no definite crystalline structure.
IV. It has no sharp melting point.
V. It is affected by alkalis.
VI. It is an excellent electrical insulator at elevated temperatures due to the fact that glass can be considered as an ionic liquid. The ions are not easily moved at room temperature because of the high viscosity. But when the temperature rises, the ions are permitted to flow and thus they will sustain an electric current.
VII. It is available in beautiful colours.
VIII. It behaves more as a solid than most solids in the sense that it is elastic. but when the elastic limit is exceeded, it fractures instead of deforming.
IX. It is capable of being worked in many ways. it can be blown,drawn,or pressed. But it is strange to note that it is difficult to cast in large pieces.
X. It is extremely brittle.
XI. It is not usually affected by air and water.
XII. It is not attacked by ordinary chemical reagents.
XIII. It is possible to intentionally alter some of its properties such as fusability,hardness,refractive power etc. To suit different purposes.
XIV. It is possible to obtain glasses with diversified properties. The glass may be clear, colourless, diffused and stained.
XV. It is possible to weld pieces of glass by fusion.
XVI. It is transparent and translucent. Transparency is the most used characteristic of glass and it is due to the absence of the free electron. For the same reason it also works as a good insulator.
XVII. When it is heated , it becomes soft and soft with rise in temperature . it is ultimately transformed into a mobile liquid. The liquid when allowed to cool , passes to all deegres of viscosity. The property of glass has made its manufacturing process easy. It can also be formed into articles of desired shape. Thus the amorphousness of glass permits it to be blown, drawn from furnaces and continuously worked.
XVIII. Due to advancement made in the science of the glass production , it is possible to make glass lighter than cork or softer than cotton or stronger than steel. The presence of glass however is considerably affected by foreign inclusions , internal defects and cords or chemically heterogeneous areas.
XIX. The glass panes can be cleaned easily by anyone of the following methods-
[i]By applying methylated spirit
[ii] painting the glass panes with lime wash and leaving it to dry and then washing with clean water.
[iii] rubbing damp salt for cleaning paint spots and;
[iv]rubbing finely powdered

1. Glossary of hyponyms related to repair

Repair

This is the action taken up on a building by patching up superficial defects and building finishes in order to bring back the architectural shape of the building so that all services start working and the functioning of building is resumed quickly. Repair does not pretend to improve the structural strength of the building

Reconstruction

If the original building or some elements of the building missing or critically damaged to carry out any repair, then they are re-created in all new, appropriate material. This is called reconstruction.

Rehabilitation

It is the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values. Here, although emphasis is provided to retain and repair the historic materials but more liberty is provided to replacement because it is assumed the structure severely damaged is severely damaged prior to work.

Retrofit

Retrofitting is the process of upgrading the building which is still in good condition; so that it becomes safe against future damage which may likely occur in near future. Thus retrofit involves making changes to the buildings at some point after its initial construction and occupation.

2. Building joints

A joint is a simple groove cut positioned on the surface of the concrete. These are provided to allow some cracking to occur there

Control/Contraction Joints

The purpose of a control joint is todivide a large area (brick, concrete,etc.) into smaller areas to make crackingless likely or to encourage any crackingto occur in the selected location.Control joints are usually non-workingjoints, except in the case of a brick wallwhere they act to accommodateexpansion and contraction due to heatingand cooling.

Isolation/ expansion joints

An isolationjoint prevents movement in one part of a building from affecting otherparts of the building. The most common isolation joint is the "expansion joint."Every building has major expansion joints that divide the building into segments;these joints go through the structure such as a wall or a roof and are continuousthrough the entire building.

Construction joints

A construction joint is a joint in concrete where one placement of concrete ends and the next placement were begun after the setting up of previous work. They are typically placed at the end of a day’s work but may be required when concrete placement is stopped for longer than the initial setting time of concrete.

3. Building cracks

A crack is a complete or incomplete separation of concrete or masonry into two or more parts produced by its breaking or fracturing.Cracks in buildings could be broadly classified as structural or non-structural type.

Structural crack: These occur due to *incorrect design*, *faulty construction* or *overloading* and these may endanger the safety of a building. E.g., extensive cracking of an RCC beam.

Non-structural crack: These cracksmostly developed due to internally induced stresses in buildings materials due to *moisture variations*, *emperature variation*, *elastic deformations*, *creep, chemical reaction*, *foundation movement*, *vegetation growth* etc. Non-structural crack do not endanger safety of a building but may look unsightly and create a feeling of instability and impression of faulty construction. Sometimes, these cracks may allow penetration of moisture through them thus resulting damages to internal finishes or corrosion of reinforcement thus affecting stability of structure in long run.

4. Types of building repairs

Day-to-day Repair

These repairs include service repairs which need to be attended on day to day basis during the services of the building. Examples for such repairs are removing chokage of drainage pipes, man holes, restoration of water supply, replacement of blown fuses, repairs to faulty switches, watering of plants, lawn mowing, hedge cutting, sweeping of leaf falls etc. The purpose of this maintenance service is to ensure satisfactory continuous functioning of various services in the buildings.

Annual or Periodic Repairs

These are the regular repair works which are carried out at a longer time intervals, say one year, to maintain the aesthetics of buildings and services as well as to preserve its life.

Special Repair

Special repairs of building are undertaken to replace the existing parts of buildings and services which get deteriorated on ageing of buildings. It is necessary to prevent the structure and services from deterioration and restore it back to its original conditions to the extent possible. Extensive floor improvement, replacement of roof tiles, major joinery replacement normally falls under this category.

5. Maintenance of Buildings

Building maintenance is work undertaken to keep, restore or improve every part of a building, its services to a currently acceptable standard and to sustain the utility and value of the facility.Building maintenance works can be classified into three categories: *preventive maintenance*, *routine maintenance* and *corrective maintenance*.

Preventive Maintenance (/Breakdown maintenance)

Preventive maintenance is carried out to avoid breakdown of machinery and occurrence of maintenance problems in buildings and services.

Routine Maintenance

This is the most frequently done activity of all and is done by performing routine and scheduled maintenance of the property. Changing equipment filters, cleaning gutters, removing debris from roof drains, caulking, office cleaning, window cleaning and repairs, and parking lot care are just a few of the many items that require scheduled maintenance.

Corrective Maintenance

These are actual repairs that keep the property functioning normally and usually need to be done as soon as possible. The repairs are usually done in response to something breaking or not working properly anymore. This type of maintenance includes replacing a broken air conditionin.