SPINTRONIC TECHNOLOGY & ADVANCE RESEARCH

DEPARTMENT OF CIVIL ENGINEERING

DIPLOMA

LECTURE NOTES

ON

BUILDING MATERIAL & CONSTRUCTION TECHNOLOGY(3rd Sem)

Compiled by

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RECOMMENDED BOOKS :

1 .N. Subramanian :-Building materials & Construction

2. Rangwala Engineering Materials

STONE

Topics to be covered

Classification of rock, uses of stone, natural bed of stone
Qualities of good building stone,
Dressing of stone
Characteristics of different types of stone and their uses

Classification of rock, uses of stone, natural bed of stone

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

A. Geological classification
B. Physical classification
C. Chemical classification

Geological Classification:

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

a. **Igneous rocks:** Rocks that are formed by cooling of Magana (molten or pasty rocky material) are known as igneous rocks.
   Eg: Granite, Basalt and Dolerite etc.
b. **Sedimentary rocks:** these rocks are formed by the deposition of products of weathering on the pre-existing rocks.
   Examples: gravel, sandstone, limestone, gypsum, lignite etc.
c. **Metamorphic rocks.** These rocks are formed by the change in character of the pre-existing rocks. Igneous as well as sedimentary rocks are changed in character when they are subject to great heat and pressure. Known as metamorphism.
   Examples: Quartzite, Schist, Slate, Marble and Gneisses.

Physical Classification:

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

a. **Stratified Rocks:** These rocks possess planes of stratification or cleavage and such rocks can be easily split along these planes
   Ex: sedimentary rocks
b. **Unstratified rocks:** The structure may be crystalline granular or compact granular.
   Examples: Igneous rocks and Sedimentary rocks affected by movements of the earth.
c. **Foliated Rocks:** These rocks have a tendency to split up in a definite direction only.
   Ex: Metamorphic rocks.

Chemical Classification:

According to this classification rocks are classified into three types.

a. **Siliceous rocks:** In these rocks, silica is predominates. The rocks are hard; durable and not easily effected by weathering agencies.
   Ex: Granite, Quartzite, etc.
b. **Argillaceous Rocks:** In these rocks, clay predominates. The rocks may be dense and compact or may be soft.
   Ex: slates, Laterites etc.

c. **Calcareous rocks:** In these rocks, calcium carbonate predominates. The durability to these rocks will depend upon the constituents present in surrounding atmosphere.
Ex: Lime Stone, marble etc.

Uses of stones:

The stones are used in the construction of buildings from the ancient times and most of the ancient temples and forts of our country were built with stone. Even at present they form a basic material for cement concrete and bricks.

Following are the various uses to which stones are employed

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

Natural bed of stone

a. **definition**

The building stones are obtained from rocks. These rocks have a distinct plane of division along which stones can easily be split. This plane is known as natural bed of stone and it thus indicates the plane or bed on which the sedimentary stone was originally deposited.

b. **Importance**

The direction of natural bed of all sedimentary stones should be perpendicular or nearly so to the direction of pressure. Such an arrangement gives maximum strength to the stone work.

The natural bed of stones can be detected by pouring water and examining the direction of layers. The stones break easily along these natural bed.

i. Arches : Stones are placed with their natural beds radial
ii. Cornices, String Courses: Stones should be placed with direction of natural beds as vertical. For corner stones, stones without natural beds should be adopted
iii. Wall : Stones should be placed with the direction of their natural beds horizontal

Qualities of a good building stone:

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

1. **Crushing strength:** For a good building stone, the crushing strength should be greater than l000kg per cm^2.
2. **Appearance**: Good building stone should be a uniform colour, and free from clay holes, spots of other colour bands etc capable of preserving the colour for long time.
3. **Durability**: A good building stone should be durable. The factors like heat and cold alternative wet and dry, dissolved gases in rain, high wind velocity etc affect the durability.
4. **Fracture**: For good building stone its fracture should be sharp, even and clear.
5. **Hardness**: The hardness greater than 17, treated as hard used in road works. It is between 14 to 17, medium hardness, less 14 said be poor hardness.
6. **Percentage wear**: For a good building stone, the percentage wear should be equal to or less than 3 percent.
7. **Resistance to fire**: A good building stone be fire proof. Sandstone, Argillaceous stone resists fire quite well
8. **Specific gravity**: For a good building stone the specific gravity should be greater than 8.7 or so.
9. **Texture**: A good building stone should have compact fine crystalline structure should be free from cavities, cracks or patches of stuff or loose material.
10. **Water absorption:** For a good building stone, the percentage absorption by weight after 24 hours should not exceed 0.60.
11. **Seasoning**: Stones should be well seasoned before putting into use. A period of about 6 to 12 months is considered to be sufficient for proper seasoning.
12. **Toughness Index**: Impact test, the value of toughness less than 13 – Not tough, between 13 and 19 – Moderate, greater than 19- high

Dressing of stone

The stones, after being quarried, are to be cut into suitable sizes and with suitable surfaces. This process is known as the dressing of stones

It is carried out for the following purposes

- To get the desired appearance from stone work
- To make the transport from quarry easy and economical
- To suit to the requirement of stone masonry
- To take advantage of local men near quarry who are trained for such type of work

Following are the varieties of finishes obtained by the dressing of stones

a. **Axed finish** : when the surfaces of hard stones such as granite are dressed by means of an axe is called axed finish

b. **Boasted or droved finish** : in this type of finish, the boaster is used to make non-continuous parallel marks on the stone surface

c. **Chisel-draughted margins** : in order to obtained uniform joint in stone work, the margins are placed which may be either squared or pitched or chamfered.

d. **Circular finish** : in this type of finish, the surface of the stone is made round or circular as in case of a column

e. **Moulded finish** : the surface of the stone can be moulded in any desired shape so as to improve the appearance of the work

f. **Hammer-dressed finish** : in this type of finish the stones are made roughly square or rectangular by means of a Waller's hammer

g. **Plain finish** : in this type of finish, the surface of the stone is made approximately smooth with a saw or with a chisel

h. **Polish finish** : the surface of the stones such as marbles, granites etc. can be policed either with hand or with machine

i. **Punched machine** : on the stone surface, the depressions are made by using a punch. The surface of the stones takes the form of a series of hollows and ridges

j. **Rubbed finish** : this type of finish is obtained by rubbing a piece of stone with the surface or by rubbing the surface with the help of a suitable machine

k. **Scabbling finish** : in this type of finish, the irregular projections are removed with a scabbling hammer.

l. **Sunk finish** : this finish is obtained by sinking the surface below the original level in the form of wide grooves, chamfers, inclined surfaces

Characteristics of different type of stone and their uses

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

1. **Granite**
   a. Igneous rock
   b. Composed of quart, felspar and mica and minerals
   c. Available in grey, green, brown and pink and red
   d. Hard and durable
   e. High resistance to weathering
   f. The texture varies with its quality
   g. Specify gravity 2.7 and compressive strength 700 to 1300 kg/cm^2
   h. Used for ornamental, road metal, railway ballast, aggregate for concrete; for construction of bridges, piers and marine works etc.
2. **Basalt**
   a. Igneous rock
   b. It is compact, hard and heavy
   c. Available in red, yellow grey, blue and greenish black colour
   d. Specific gravity is 3 and compressive strength varies 1530 to 1890 kg/cm^2.
   e. Used for ornamental, rail road ballast, aggregates for concrete etc.
3. **Sand Stone:**
   a. Sedimentary rock
   b. It is available in variety of formations fine grained, coarse grained compact or porous
   c. Available in white, green, blue, black, red and yellow.
   d. Specific gravity 2.65 to 2.95

e. Compressive strength is 650kgs / cm^2
f. Used for ashlar works

4. **Lime Stone:**
   a. Sedimentary rock: It is available in a variety of forms which differ from one another in colour Compaction, texture, hardness and durable
   b. Compact lime stone
   c. Granular lime stone
   d. Magnesia lime stone
   e. Kanker lime stone
   f. Used for paving, road metal, etc
5. **Marble**
   a. Metamorphic rock
   b. Available in white, blue, green, yellow black and red colour
   c. High compactness
   d. Suitable for decorative works, wall lining columns, pile, table slabs, hearths, tiled floors, steps of stair case etc.
6. **Slate:**
   a. Metamorphic rock
   b. Non-absorbent, compact fine grained and produce metallic ringing sound when struck
   c. Available in black, dark blue, grey, reddish brown etc.
   d. Used for providing damp proof course, paving dados etc.
7. **Chalk**
   a. Sedimentary rock
   b. Pure white lime stone, soft and easy to form powder
   c. Suitable for preparing glazier's putty as colouring material in manufacture of Portland cement
8. **Kankar**
   a. Sedimentary rock
   b. Impure lime stone
   c. Used as road metal, manufacture of hydraulic lime
9. **Murum**
   a. Metamorphic rock
   b. Decomposed laterite, deep brown or red in color
   c. Used as blindage for metal road, for fancy paths and garden walls
10. **Quartzite**
    a. Metamorphic rock
    b. Hard, brittle, crystalline and compact
    c. Difficult to work and dress
    d. Suitable for construction of retaining walls, road metals, concrete aggregate, pitching, rubble masonry, facing of buildings

Bricks

Brick earth – its composition

Brick making – Preparation of brick earth, Moulding, Drying, Burning in kilns (continuous Process)

Classification of bricks, size of traditional and modular bricks, qualities of good building bricks

Brick earth – its composition

Composition – Following are the constituents of good brick earth.

a. **Alumina**: - It is the chief constituent of every kind of clay. A good brick earth should contain 20 to 30 percent of alumina. This constituent imparts plasticity to earth so that it can be moulded. If alumina is present in excess, raw bricks shrink and warp during drying and burning.
b. **Silica**-A good brick earth should contain about 50 to 60 percent of silica. Silica exists in clay either as free or combined form. As free sand, it is mechanically mixed with clay and in combined form; it exists in chemical composition with alumina. Presence of silica prevents cracking, shrinking and warping of raw bricks. It thus imparts uniform shape to the bricks. Durability of bricks depends on the proper proportion of silica in brick earth. Excess of silica destroys the cohesion between particles and bricks become brittle.
c. **Lime** – A small quantity of lime is desirable in finely powdered state to prevent shrinkage of raw bricks. Excess of lime causes the brick to melt and hence, its shape is lost due to the splitting of bricks.
d. **Oxide of iron**- A small quantity of oxide of Iron to the extent of 5 to 6 percent is desirable in good brick to impart red colour to bricks. Excess of oxide of iron makes the bricks dark blue or blackish.
e. **Magnesia**- A small quantity of magnesia in brick earth imparts yellow tint to bricks, and decreases shrinkage. But excess of magnesia leads to the decay of bricks.

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

Brick making – Preparation of brick earth, Moulding, Drying, Burning in kilns (continuous Process)

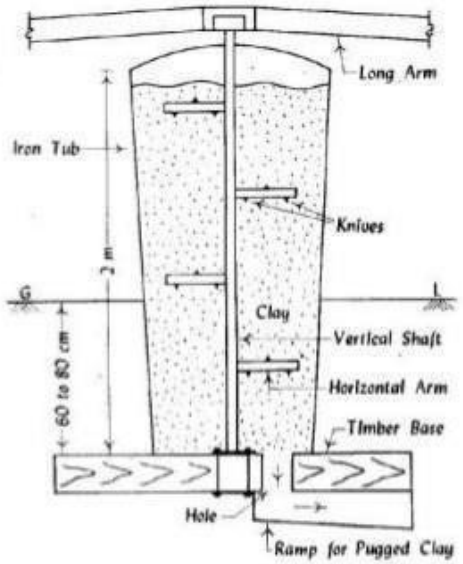
In the process of manufacturing bricks, the following operations are involved

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

1. **Preparation of clay :-** The preparation of clay involves following operations
   a. **Unsoiling** :- Top layer of 20cm depth is removed as it contain impurities.

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

Tempering



Pug mill

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

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

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

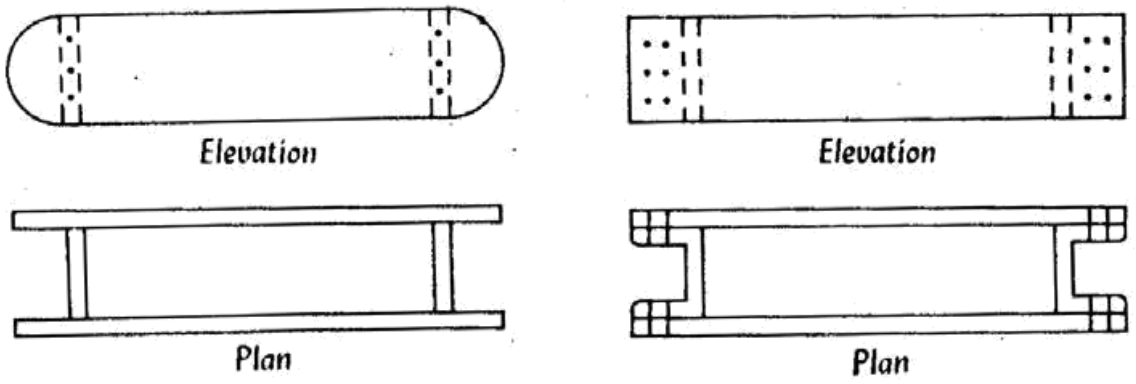


Fig : wooden mould and steel mould

i. Ground moulded bricks
ii. Table moulded bricks

i. **Ground moulded bricks:** ground is first made level and fine sand is sprinkled over it. Mould is dipped in water and placed over the ground to fill the clay. Extra clay is removed by wooden or metal strike after the mould is filled by pressing or forcing, mould is then lifted up and raw brick is left on the ground. Mould is then dipped in water every time lower faces of ground moulded bricks are rough and it is not possible to place frog on such bricks. Ground moulded bricks of better quality and with frogs on their surface are made by using a pair of pallet boards and a wooden block.
ii. **Table-moulded bricks**: Process of moulding these bricks is just similar to ground bricks on a table of size about 2m x 1m.

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

i. Plastic clay machines
ii. Dry clay machines

i. **Plastic clay machines:** This machine containing rectangular opening of size equal to length and width of a brick. Pugged clay is placed in the machine and as it comes out through the opening, it is cut into strips by wires fixed in frames, so these bricks are called wire cut bricks.
ii. **Dry clay machines:** In these machines, strong clay is first converted into powder form and then water is added to form a stiff plastic paste. Such paste is placed in mould and pressed by machine to form hard and well shaped bricks. These bricks are heavier than ordinary hand moulded bricks. They carry distinct frogs and exhibit uniform texture.

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

i. **Artificial drying** – drying by tunnels usually 120^{o}C about 1 to 3 days
ii. **Circulation of air**- Stacks are arranged in such a way that sufficient air space is left between them for free circulation of air.
iii. **Drying yard**- special yards should be prepared slightly higher level prevent the accumulation of rain water.
iv. **Period for drying** – usually about 3 to 10 days to bricks to become dry.

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

4. **Burning:** This is very important operation in the manufacturing of bricks to impart hardness, strength and makes them dense and durable. Burning of bricks is done either in clamps or in kilns.

   Clamps are temporary structures and they are adopted to manufacture bricks on small scale.
   Kilns are permanent structures and they are adopted to manufacture bricks on a large scale.

Kilns: A kiln is a large oven, which is used to burnt bricks and of two types

i. Intermittent kilns
ii. Continuous kilns

i. Intermittent kilns: These are intermittent in operation, which means that they are loaded, fired, cooled and unloaded. They are classified in two types

a. Intermittent up-draught kilns
b. Intermittent down-draught kilns

ii. Continuous kilns:

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

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

a. Bull's trench kiln: This kiln may be of rectangular, circular or oval shape in the plan as shown in fig. It is constructed in a trench excavated in ground either fully underground partially projecting above ground openings is provided in the outer walls to act as flue holes.

Dampers are in the form of iron plates and they are used to divide the kilns in suitable sections and most widely used kiln in India.

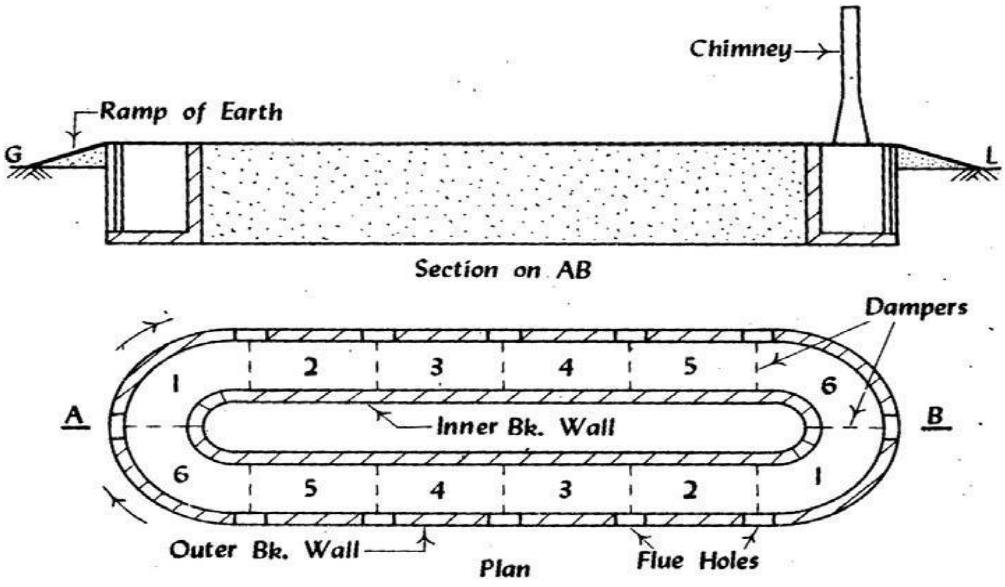


Fig ; bulls trench kiln

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

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

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

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

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

Such a kiln will manufacture about 25000 bricks daily or about 8 to 9 million bricks annually.

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

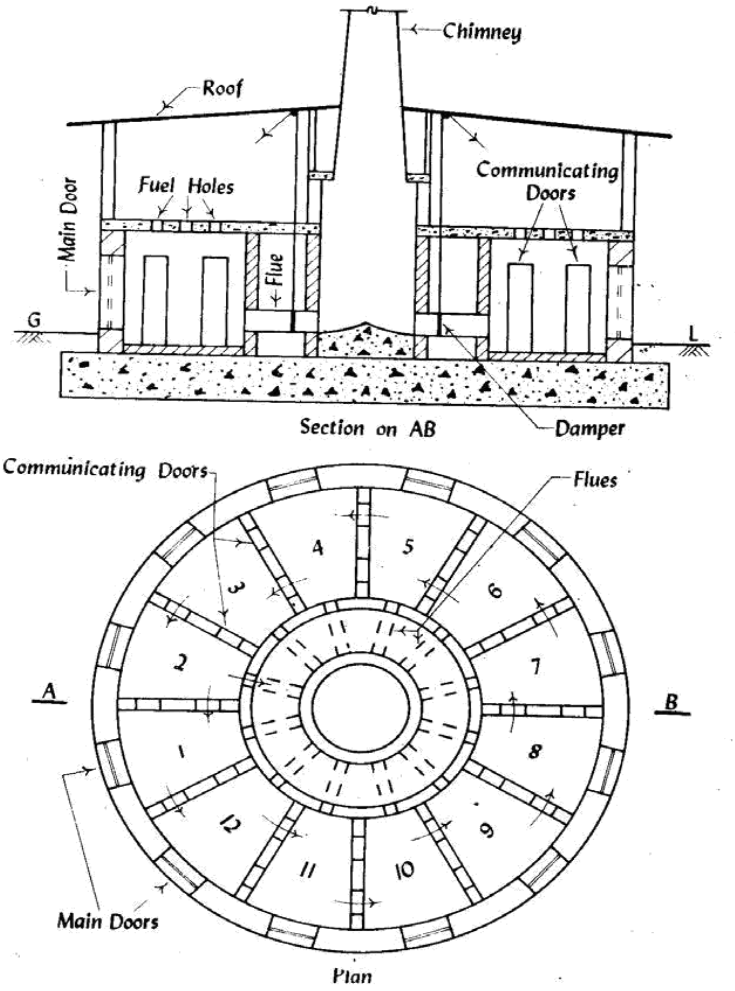


Fig : Hoffman's kiln

Classification of bricks, size of traditional and modular bricks, qualities of good building bricks

Classification:

Bricks can broadly be divided into two categories.

i. Unburnt or sundried bricks
ii. Burnt bricks

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

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

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

b. **Second class bricks:** These bricks are ground moulded and they are burnt in kilns. The surface of bricks is somewhat rough and shape is also slightly irregular. These bricks are commonly used at places where brick work is to be provided with a coat of plaster.
c. **Third class bricks:** These bricks are ground moulded and they burnt in clamps. These bricks are not hard and they have rough surfaces with irregular and distorted edges. These bricks give dull sound when struck together. They are used for unimportant and temporary structures and at places where rainfall is not heavy.
d. **Fourth class bricks:** These are over burnt bricks with irregular shape and dark colour. These bricks are used as aggregate for concrete in foundation, floors, roads, etc because of the fact that the over burnt bricks have compacted structure and hence, they are sometimes found stronger than even first class bricks.

Size of traditional and modular bricks

The bricks are prepared in various sizes. The custom in the locality is the governing factor for deciding the size of a brick. Such bricks which are not standardised are known as the traditional bricks.

Brick of standard size 190 mm x 90 mm x 90 mm is recommended by the BIS. With mortar thickness, the size of such a brick becomes 200 mm x 100 mm x 100 mm and it is known as the nominal size of the modular brick.

Qualities of good building bricks

- Bricks should be table moulded, well burnt in kilns, copper coloured, free from cracks and with sharp and square edges.
- Bricks should be uniform shape and should be of standard size.
- Bricks should give clear ringing sound when struck each other.
- Bricks when broken should show a bright homogeneous and compact structure free from voids.
- Bricks should not absorb water more than 20 percent by weight for first class bricks and 22 percent by weight for second class bricks, when soaked in cold water for a period of 24 hours.
- Bricks should be sufficiently hard no impression, should be left on brick surface, when it is scratched with finger nail.
- Bricks should be low thermal conductivity and they should be sound proof.
- Bricks should not break when dropped flat on hard ground from a height of about one meter.
- Bricks, when soaked in water for 24hours, should not show deposits of white salts when allowed to dry in shade.
- No brick should have crushing strength below 55kg/cm^2

Cement, Mortar and Concrete

3.1.Cement: Types of cements, Properties of cements, Manufacturing of cement.

3.2.Importance and application of blended cement with fly ash and blast furnace slag.

3.3.Mortar: Definition and types of mortar.

Sources and classification of sand, Bulking of sand.

Use of gravel, morrum and fly ash as different building material.

Concrete: Definition and composition- Water cement ratio- Workability, mechanical properties and grading of aggregates, mixing, placing, compacting and curing of concrete.

Cement: Types of cements, Properties of cements, Manufacturing of cement

Cement in its broadest term means any substance which acts as a binding agent for materials. Natural cement (Roman Cement) is obtained by burning and crushing the stones containing clay, carbonates of lime and some amount of carbonate of magnesia. The clay content in such stones is about 20 to 40 percent. Natural cement resembles very closely eminent hydraulic lime. It is not strong as artificial cement, so it has limited use in practice.

Artificial cement is obtained by burning at very high temperature a mixture of calcareous and argillaceous materials in correct proportion. Calcined product is known as clinker. A small quantity of gypsum is added to clinker and it is then pulverized into very fine powder is known as cement. The common variety of artificial cement is known as normal setting cement or ordinary cement or Portland cement.

Types of cements

In addition to ordinary cement, the following are the other varieties of cement.

a. **Acid Resistance Cement**: This is consists of acid resistance aggregates such as quartz, quartzite's, etc, additive such as sodium fluro silicate (Na_2SiO_6) and aqueous solution of sodium silicate. This is used for acid resistant and heat resistant coating of installations of chemical Industry. By adding 0.5 percent of linseed oil or 2 percent of ceresit, its resistance to water is increased and known as acid water resistant cement.
b. **Blast Furnace Cement:** For this cement slag as obtained from blast furnace in the manufacture of pig iron and it contains basic elements of cement, namely alumina, lime and silica. The properties of this cement are more or less the same as those of ordinary cement and prove to be economical as the slag, which is waste product, is used in its manufacture.
c. **Coloured Cement:** Cement of desired colour may be obtained by intimately mixing mineral pigments with ordinary cement. The amount of colouring may vary from 5 to 10 percent and strength of cement is affected if it is exceeds 10 percent. Chromium oxide gives brown, red or yellow for different proportions. Coloured cements are used for finishing of floors, external surfaces, artificial marble, windows etc.

d. Expanding Cement : This type of cement is produced by adding an expanding medium like sulpho – aluminate and a stabilizing agent to ordinary cement. Hence this cement expands where as other cement shrinks. Expanding cement is used for the construction of water retaining structures and also for repairing the damaged concrete surfaces.

e. High alumina Cement: This cement is produced by grinding clinkers formed by calcining bauxite and lime. The total content should not be less than 32 percent and the ratio by weight of alumina to lime should be between 0.85 and 1.30.

Advantages

- Initial setting time is about 3½ hours therefore, allows more time for mixing and placing operations.
- It can stand high temperatures.
- It evolves great heat during setting therefore not affected by frost.
- It resists the action of acids in a better way.
- It lets quickly and attains higher ultimate strength.

Disadvantages:

- It is costly.
- It cannot be used in mass construction as it evolves great heat and as it sets soon.
- Extreme care is to taken to see that it does not come in contact with even traces of lime or ordinary cement.

f. Hydrophobic Cement: This type of cement contains admixtures, which decreases the wetting ability of cement grains. The usual hydrophobic admixtures are acidol, napthenesoap, oxidized petrolatum etc. When hydrophobic cement is used, the fine pores in concrete are uniformly distributed and thus the frost resistance and the water resistance of such concrete are considerably increased.

g. Low Heat Cement: Considerable heat is produced during the setting action of cement. In order to reduce the amount of heat, this type of cement is used. It contains lower percentage of tricalcium aluminates C_3A and higher percentage of dicalcium silicate C_2S. This type of cement is used for mass concrete works because it processes less compressive strength.

h. Pozzolana Cement: Pozzolana is a volcanic powder and the percentage should be between 10 to 30.

Advantages

- It attains compressive strength with age.
- It can resist action of sulphates.
- It evolves less heat during setting.
- It imparts higher degree of water tightness.
- It imparts plasticity and workability to mortar and concrete prepared from it.
- It offers great resistance to expansion.
- It possesses higher tensile strength.

- Compressive strength in early days is less.
- It possesses less resistance to erosion and weathering action.

i. **Quick Setting Cement:** This cement is prepared by adding a small percentage aluminum sulphate which reduce the percentage of gypsum or retarder for setting action and accelerating the setting action of cement. As this cement hardens in less than 30 minutes, mixing and placing operations should be completed. This cement is used to lay concrete under static water or running water.

j. **Rapid Hardening cement:** This cement has same initial and final setting times as that of ordinary cement. But it attains high strength in early days due to

- Burning at high temperature.
- Increased lime content in cement composition.
- Very fine grinding.

- Construction work may be carried out speedily.
- Formwork of concrete can be removed earlier.
- It is light in weight.
- It is not damaged easily.
- This cement requires short period of curing.
- Use of this cement allows higher permissible stresses in the design.
- Structural member constructed with this cement may be loaded earlier.

k. **Sulphate Resisting Cement:** In this cement percentage of tricalcium aluminates is kept below 5 to 6 percent and it results in the increase in resisting power against sulphate. This cement is used for structure which are likely to be damaged by sever alkaline condition such as canal linings, culverts, siphons etc.

l. **White Cement:** This is a variety of ordinary cement and it is prepared form such raw materials which are practically free from colouring oxides of Iron, manganese or chromium. For burning of this cement, oil fuel is used instead of coal. It is used for floor finish; plaster work, ornamental works etc.

Properties of cements

Following are the physical, mechanical and chemical properties of cement.

A. Physical properties of cement

Following are the important physical properties of a good cement which primarily depends upon its chemical composition, thoroughness of burning and fineness of grinding

1. It gives strength to the masonry.
2. It is an excellent binding material.
3. It is easily workable.
4. It offers good resistance to the moisture.
5. It possesses a good plasticity.
6. It stiffens or hardens early.
7. A thin paste of cement with water should feel sticky between the fingers.
8. A cement thrown in water should sink and should not float on the surface.
9. The particles should have uniformity of fineness. Specific surface area should not be less than 2250 cm^2/gm.
10. The initial setting time for ordinary Portland cement is about 30 minutes.

11. The final setting time for ordinary Portland cement is about 10 hours.
12. The expansion of cement after heating and cooling the mould, should not exceed 10mm.

B. Mechanical properties of cement

1. The compressive strength at the end of 3 days should not be less than 11.5 N/mm^2 and that at the end of 7 days should not be less than 17.5 N/mm^2.
2. The tensile strength at the end of 3 days should not be less than 2 N/mm^2 and that at the end of 7 days should not be less than 2.50 N/mm^2.

C. Chemical properties of cement

1. The ratio of percentage of alumina to iron oxide should not be less than 0.66.
2. The ratio of percentage of lime to alumina, iron oxide and silica, known as lime saturation factor (LSF) should not be less than 0.66 and should not be more than 1.02.
3. Total loss on ignition should not be more than 4 percent.
4. Total sulphur content should not be more than 2.75 percent.
5. Weight of insoluble residue should not be more than 1.5 percent.
6. Weight of magnesia should not exceed 5 percent.

Manufacturing of cement

Following three distinct operations are involved in the manufacture of normal setting or ordinary or Portland cement

1. Mixing of raw material
2. Burning
3. Grinding

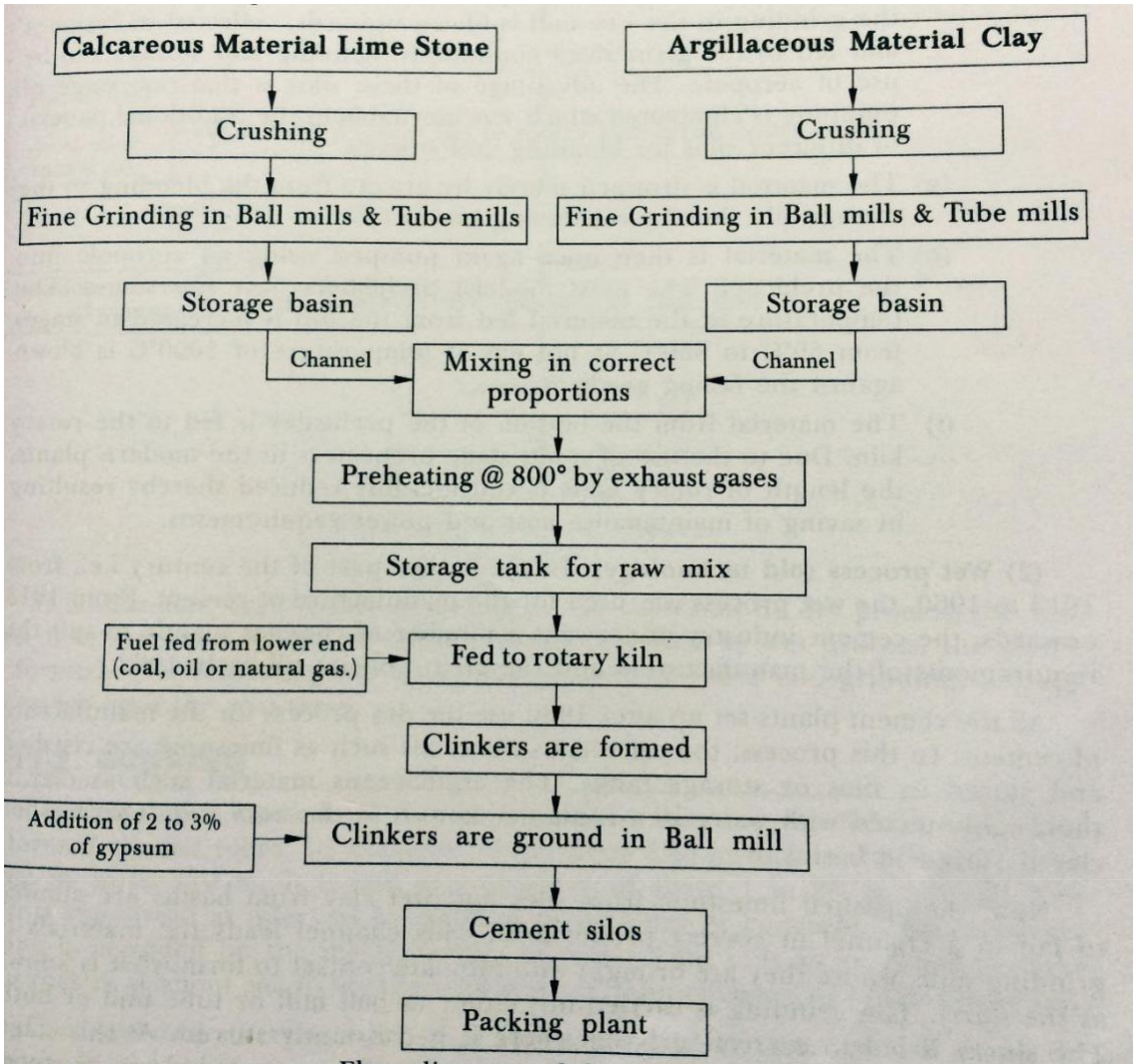
1. Mixing of raw material

The raw materials such as lime stone or chalk and shale or clay may be mixed either in dry condition or wet condition, accordingly known as the dry process or the wet process of mixing.

a. Dry process

The both calcareous and argillaceous raw materials are firstly crushed in the gyratory crushers to get 2.5cm size pieces separately. The crushed materials are again grinded to get fine particles in ball mills or tube mills.

Each finely grinded material is stored in hopper after screening. Now these powdered minerals are mixed in required proportion to get dry raw mix which is then stored in silos and kept ready to be sent into rotary kiln. Fig shows the flow diagram of raw materials by dry process.



Flow diagram of dry process

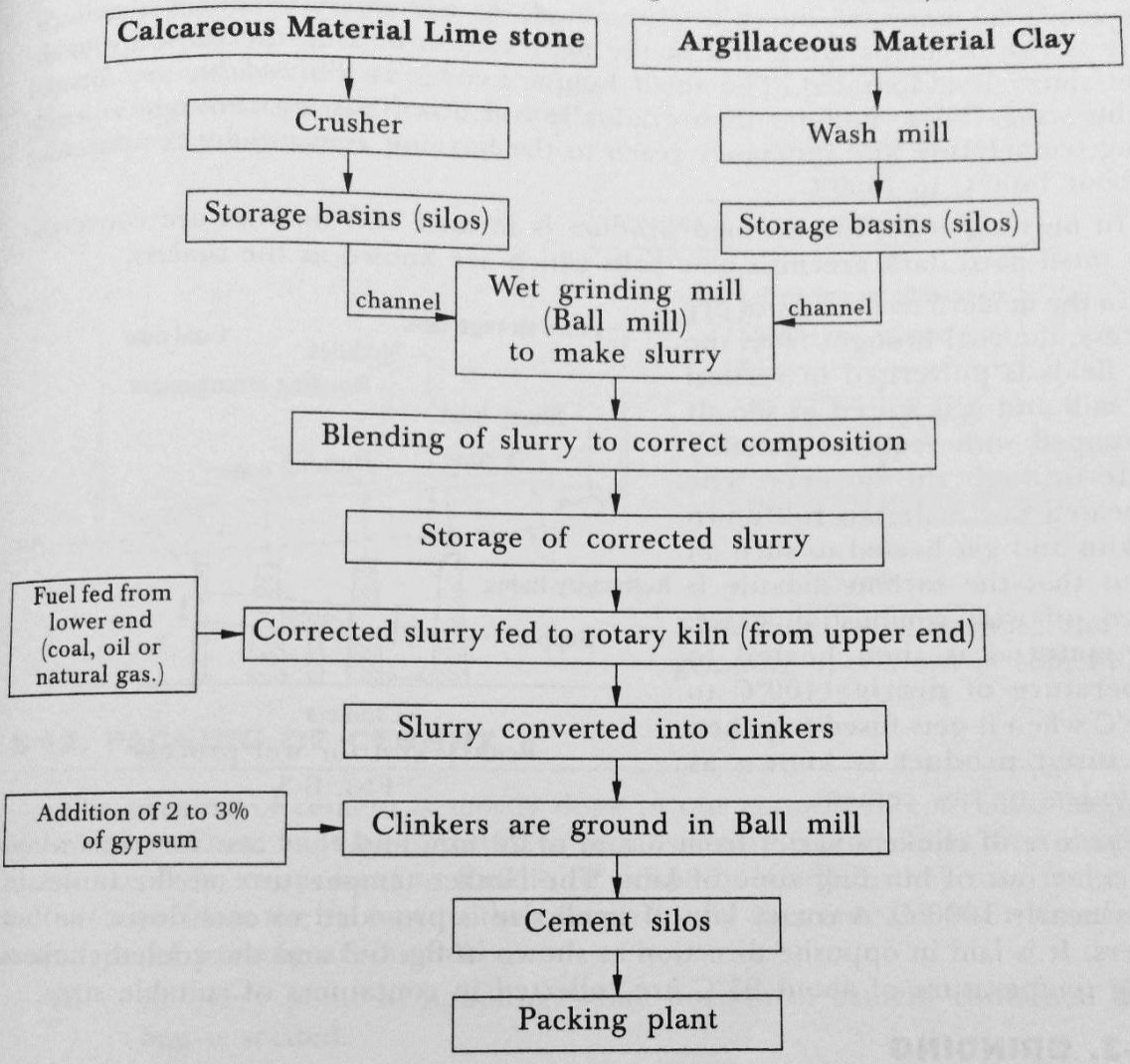
FIG. 6-1

b. Wet process

The raw materials are firstly crushed and made into powdered form and stored in silos. The clay is then washed in washing mills to remove adhering organic matters found in clay. The powdered limestone and water washed clay are sent to flow in the channels and transferred to grinding mills where they are completely mixed and the paste is formed, i.e., known as slurry.

The corrected slurry is stored in storage tanks and kept ready to serve as feed for rotary kiln.

Fig. 6-2 shows the flow diagram of mixing of raw materials by the wet process.



Flow diagram of wet process

FIG. 6-2

2. Burning

Corrected slurry is feed to rotary kiln, which is about 2.5 to 3 m in diameter and 90 to 120 m in length and temperature arrangement is up to 1400-1500 ^{o}C. At this temperature slurry losses moisture and forms into small lumps, after that changes to clinkers. Clinkers are cooled in another inclined tube similar to kiln but of lesser length.

3. Grinding

Grinding is the final process where clinker is grinded, it is first cooled down to atmospheric temperature. Grinding of clinker is done in large tube mills. After proper grinding gypsum (Calcium sulphate $CaSO_4$) in the ratio of 01-04 % is added for controlling the setting time of cement.

Finally, fine ground cement is stored in storage tanks from where it is drawn for packing.

Importance and application of blended cement with fly ash and blast furnace slag.

Blended cement are produced by intergrinding portland cement clinker with other specified materials or by blending portland cement with the other materials, or a combination of intergrinding and blending. Binary blended cements contain two constituent materials, while ternary blended cements contain three constituent materials Fly ash is a fine powder that is a byproduct of burning pulverized coal in electric generation power plants. Fly ash is a pozzolana, a substance containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water, fly ash forms a compound similar to Portland cement. This makes fly ash suitable as a prime material in blended cement. When used in concrete mixes, fly ash improves the strength and segregation of the concrete and makes it easier to pump.

Blast furnace slag is a nonmetallic coproduct produced in the production of iron, iron ore, iron scrap, and fluxes. It consists primarily of silicates, aluminosilicates, and calcium-alumina-silicates.

- It reduces water demand and therefore water-cement ratio can be reduced.
- It improves workability for the same water content.
- The blended cements are finer as compared to OPC, therefore the permeability of concrete is less. This results into improved durability

Energy saving: Blended cements are obtained by adding mineral admixtures with OPC. The energy, which would have otherwise been utilized for production of OPC, is thus saved. This saving is to the tune of 0.8 to 1.2 MWH/ton of cement.

Conservation of natural resources: The used mineral admixtures are the waste products of thermal and steel plants. By using these products, we are conserving the precious minerals like lime stone, clay and silica etc.

Pollution control: By reducing the production of cement, pollution is also controlled as cement is an energy intensive product. It has been estimated that 7% of total pollution is only due to cement production which can proportionately be reduced if more blended cement is used.

Mortar: Definition and types of mortar

The term mortar is used to indicate a paste prepared by adding required quantity of water to a mixture of binding material like cement or Lime and fine aggregates like sand. The two components of mortar namely the binding material and fine aggregates are sometimes referred to as matrix. The durability, quality and strength of mortar will mainly depends on quantity and quality of the matrix. The combined effect of the two components of mortar is that the mass is able to bind the bricks or stones firmly.

Types of Mortar

The mortar are classified on the bases of the following

1. Bulk density
2. Kinds of binding material
3. Nature of application
4. Special mortars

1. **Bulk density:**
   According to bulk density of mortar in dry state, the mortars are two types
   a. **Heavy mortars** bulk density is more than 1500kg/m^3 and prepared from heavy quartz.
   b. **Lightweight mortars** – bulk density is less than 1500kg/m^3 and prepared from light porous sands.
2. **Kinds of binding Material**
   According to the kinds of binding material, several factors such as expected working conditions, hardening temperature, moisture conditions, etc should be considered. The mortars are classified into four categories.
   a. **Lime Mortar -** in this mortar, lime is used as binding material. Lime may be fate lime or Hydraulic lime. Fat lime mortar 1:2 to 1:3 and hydraulic lime mortar may be 1:2 by volume.
   b. **Cement mortar:** In this mortar, cement is used as binding material. Depending upon the strength required and importance of work, the proportion of cement to sand varies from 1:2 to 1:6 or more.
   c. **Gauged Mortar or composite mortar:** The process of adding cement to lime mortar to improve the quality of lime mortar is known as gauging. It makes lime mortar economical, strong and dense. The usual proportion of cement to lime by volume is about 1:6 to 1:8.
   d. **Gypsum mortar:** These mortars are prepared from gypsum binding material such as building gypsum and anhydrite binding materials.
3. **Nature of Application:**
   According to the nature of application, the mortars are classified into two categories.
   a. **Brick laying mortars:** Mortars for brick laying are intended to be used for brick works and walls. Depending up on the working conditions and type of construction, the composition of masonry mortars with respect to the kind of binding materials is decided.
   b. **Finishing Mortars:** these mortars include common plastering work and mortars for developing architectural or ornamental effects. Generally cement or lime is used as binding material.
4. **Special Mortars:**
   a. **Fire resistant mortar-** This mortar is prepared by adding 1:2 ratio of aluminous cement with crushed powder of fire bricks used for fire brick lining furnaces, fire places, ovens etc.
   b. **Light weight mortar –** This mortar is prepared by adding sawdust, wood powder to lime or cement mortar for sound proof and heat proof construction.
   c. **Packing Mortar –** To pack of oil wells, special mortars possessing the properties of high homogeneity, water resistance, predetermined setting time, ability to form solid water proof plugs in cracks and voids of rocks, resistance to subsoil water pressure etc. have to be formed with cement sand, cement loam and cement sand loam mortars.
   d. **Sound absorbing mortars:** To reduce the noise level, sound absorbing mortars with Portland cement, lime, gypsum, slag Portland cement etc as the binding materials employed in its composition. The aggregates re selected from lightweight porous material such as pumice, cinders etc.

e. **X-ray shielding mortar:** This type of mortar is used for providing the plastering coat to walls and celling of x-ray cabinets. This is heavy mortar with bulk density over 2200kg/m^3 is used. The aggregates are obtained from heavy rock and suitable admixture are added to enhance protective property of such a mortar.

Sources and classification of sand, Bulking of sand

Sand is an important building material used in the preparation of mortar, concrete, etc.

Sources of Sand:

Sand particles consist of small grains of silica ($Si0_2$). It is formed by the decomposition of sand stones due to various effects of weather. The following are the natural sources of sand.

a. **Pit Sand:** This sand is found as deposits in soil and it is obtained by forming pits to a depth of about 1m to 2m from ground level. Pit sand consists of sharp angular grains, which are free from salts for making mortar, clean pit sand free from organic and clay should only be used.
b. **River Sand:** This sand is obtained from beds of rivers. River sand consists of fine rounded grains. Colour of river sand is almost white. As the river sand is usually available in clean condition, it is widely used for all purposes.
c. **Sea Sand:** This sand is obtained from sea shores. Sea sand consists of rounded grains in light brown colour. Sea sand consists of salts which attract the moisture from the atmosphere and causes dampness, efflorescence and disintegration of work. Due to all such reasons, sea sand is not recommendable for engineering works. However be used as a local material after being thoroughly washed to remove the salts.

Classification of sand

According to the size of grains, the sand is classified as fine, coarse and gravelly.

- The sand passing through a screen with clear openings of 1.5875 mm is known as the fine sand. It is mainly used for plastering.
- The sand passing through a screen with clear openings of 3.175 mm is known as the coarse sand. It is mainly used for masonry works.
- The sand passing through a screen with clear openings of 7.62 mm is known as the gravelly sand. It is mainly used for concrete work.

Bulking of Sand:

The presence of moisture in sand increases the volume of sand. This is due to fact that moisture causes film of water around the sand particles which result in the increase of volume of sand. For a moisture content of 5 to 8 percent, the increase in volume may be about 20 to 40 percent, depending upon the grading of sand. The finer the material, the more will be the increase in volume for a given moisture content. This phenomenon is known as bulking of sand.

Use of gravel, morrum and fly ash as different building material

Gravel as building material

Gravel is widely used for industrial and personal projects. It is an integral component of concrete and outdoor design alike. It is used to build homes and highways as well as make concrete, mortar and plaster. Gravel can be both decorative and functional. It can be used as mulch in a home garden or as a method of erosion control. Many industries use this material in their day-to-day functions. Industries that are involved with commercial or private construction often use gravel as an ingredient for building materials.

Morrum

Morrum is used for construction material for building, raw material for construction of dam, raw material for road construction, paving etc. Morrum can be frequently used as sub-base materials. They are good material for building huts and paths, as they can be compacted easily to form hard surfaces.

Fly Ash

It is a by-product in coal based thermal plants. Its particles can fly in ordinary air. At one time it was considered a nuisance but now it is used as a useful material in manufacturing bricks, for stabilizing soil and to improve workability.

Fly ash can be used as prime material in many cement-based products, such as poured concrete, concrete block, and brick. One of the most common uses of fly ash is in Portland cement concrete pavement or PCC pavement. Road construction projects using PCC can use a great deal of concrete, and substituting fly ash provides significant economic benefits. Fly ash has also been used as embankment and mine fill. It can be utilised for manufacturing bricks. Fly ash can be utilised for construction of embankment and roads.

Concrete: Definition and composition- Water cement ratio- Workability, mechanical properties and grading of aggregates, mixing, placing, compacting and curing of concrete.

Concrete Definition

Cement concrete is a mixture of cement, sand, pebbles or crushed rock and water. When placed in the skeleton of forms and allowed to cure, becomes hard like a stone.

Concrete composition

The main constituents of concrete are

a. **Cement / Lime:** Before introduction of ordinary Portland cement, lime was used as cementing material. At present most of the cement concrete works in the building construction is done with ordinary Portland cement. But other special varieties of cement such as rapid hardening cement, high alumina cement are used under certain circumstances. The cement should comply with all standard specifications.
b. **Fine Aggregates:** The material, which is passed through 4.7625mm B.S.test sieve, is termed as fine aggregates. Usually natural river sand is used as fine aggregates. But places where natural sand is not available economically, finely crushed stone may be used as fine aggregates.
c. **Coarse Aggregates**: The material retained on 4.7625mm size B.S.test sieve is termed as coarse aggregates. Broken stone is generally used as coarse aggregates. For thin slabs, and walls, the maximum size of coarse aggregates should be limited to one third the thickness of the concrete section.
d. **Water**: Water to be used in the concrete work should have the following properties.
    - It should be free from oils.
    - It should be free from acids or alkalies.
    - It should be free from Iron, Vegetables matter or other substance, which is likely to have adverse effect on concrete.
    - It should be fit for drinking purpose.

Water cement ratio

The water in concrete has to perform the following two function

i. The water enters into chemical action with cement and this action causes the setting and hardening of concrete.
ii. The water lubricates the aggregates and it facilitates the passage of cement through voids of aggregate. Water makes the concrete workable.

It is found theoretically that water requires for these two functions is about 0.5 to 0.6 times the weight of cement. This ratio of the amount of water to the amount of cement by weight is termed as the water cement ratio and the strength and quality of concrete primarily depends upon this ratio.

Workability of Concrete is a broad and subjective term describing how easily freshly mixed concrete can be mixed, placed, consolidated, and finished with minimal loss of homogeneity. The important facts in connection with workability are as follows

- If more water is added to attain the required degree of workmanship, it results into concrete of low strength and poor durability.
- The workability of concrete is also affected mainly by water content, water cement ratio and aggregate cement ratio.
- It is also affected by the grading, shape, texture and maximum size of the coarse aggregate to be used in the mixture.

Mechanical properties

Performance of concrete is evaluated from mechanical properties which include shrinkage and creep, compressive strength, tensile strength, flexural strength, and modulus of elasticity. But compressive strength of concrete is the most important characteristic and it is generally assumed that an improvement in concrete compressive strength will improve its mechanical properties.

Compressive strength

Characteristic strength of concrete is the strength of concrete specimens casted and tested as per given code of practice and cured for a period of 28 days; 95% of tested cubes should not have a value less than this value.

The compressive strength of concrete is calculated by applying load in cube of size 150 mm and dividing the maximum applied load with the cube area.

Grading of aggregates

In order to obtain concrete of denser quality, the fine and coarse aggregates are properly graded. The grading of fine aggregates is expressed in terms of BIS test sieve nos. 480, 240, 120, 60, 30 and 15.

The grading of fine aggregates has a marked effect on the uniformity, workability and finishing qualities of concrete. Table shows the grading limits for fine aggregates.

	Percentage by weight passing through sieve	
BIS sieve	Natural or crushed gravel sand	Crushed stone sand
No. 480	95-100	90-100
No. 240	70-95	60-90
No. 120	45-85	40-80
No. 60	25-60	20-50
No. 30	5-30	5-30
No. 15	0-10	0-15

The grading of coarse aggregates may be varied through wider limits than those of sand without appreciable effect on the workability of concrete.

Mixing

The process of rolling, folding and spreading of particles is known as the mixing of concrete. There are two types of concrete mixing

1. Hand mixing
2. Machine mixing

1. **Hand Mixing:** For hand mixing, the materials are stacked on a water tight platform, which may be either of wood, brick or steel.
   The materials should be thoroughly mixed, at least three times, in dry condition before water is added. The prepared mix should be consumed in 30 minutes after adding water. The mixing by hand is allowed in case of small works or unimportant works where small quantity of concrete is required. It is advised to add 10% extra cement to guard against the possibility of inadequate mixing by this method.
2. **Machine mixing:** For machine mixing, all the materials of concrete including water, are collected in a revolving drum and then the drum is rotated for a certain period. The resulting mix is then taken out of the drum.

Placing

Concrete is placed on form works. The form works should be cleaned and properly oiled. If concrete is to be placed for foundation, the soil bed should be compacted well and is made free from loose soil.

Concrete should be dropped on its final position as closely as possible. If it is dropped from a height, the coarse aggregates fall early and then mortar matrix. This segregation results into weaker concrete.

Compacting

In the process of placing concrete, air is entrapped. The entrapped air reduces the strength of concrete up to 30%. Hence it is necessary to remove this entrapped air. This is achieved by compacting the concrete after placing it in its final position. Compaction can be carried out either by hand or with the help of vibrators.

a. ***Hand Compaction:*** In this method concrete is compacted by ramming, tamping, spading or by slicing with tools. In intricate portions a pointed steel rod of 16 mm diameter and about a metre long is used for poking the concrete.
b. ***Compaction by Vibrators:*** Concrete can be compacted by using high frequency vibrators. Vibration reduces the friction between the particles and set the motion of particles. As a result entrapped air is removed and the concrete is compacted. The use of vibrators reduces the compaction time. When vibrators are used for compaction, water cement ratio can be less, which also help in improving the strength of concrete. Vibration should be stopped as soon as cement paste is seen on the surface of concrete. Over vibration is not good for the concrete.

The following types of vibrators are commonly used in concreting:

i. Needle or immersion vibrators
ii. Surface vibrators
iii. Form or shutter vibrators
iv. Vibrating tables.

Needle vibrators are used in concreting beams and columns. Surface vibrators and form vibrators are useful in concreting slabs. Vibrating tables are useful in preparing precast concrete elements.

Curing of concrete

Curing may be defined as the process of maintaining satisfactory moisture and temperature conditions for freshly placed concrete for some specified time for proper hardening of concrete. Curing in the early ages of concrete is more important. Curing for 14 days is very important. Better to continue it for 7 to 14 days more. If curing is not done properly, the strength of concrete reduces. Cracks develop due to shrinkage. The durability of concrete structure reduces.

The following curing methods are employed:

a. Spraying of water
b. Covering the surface with wet gunny bags, straw etc.
c. Ponding
d. Steam curing and
e. Application of curing compounds.

a. Spraying of water: Walls, columns, plastered surfaces are cured by sprinkling water.

b. Wet covering the surface: Columns and other vertical surfaces may be cured by covering the surfaces with wet gunny bags or straw.

c. Ponding: The horizontal surfaces like slab and floors are cured by stagnating the water to a height of 25 to 50 mm by providing temporary small hunds with mortar.

d. Steam curing: In the manufacture of pre-fabricated concrete units steam is passed over the units kept in closed chambers. It accelerates curing process, resulting into the reduction of curing period.

e. Application of curing compounds: Compounds like calcium chloride may be applied on the curing surface. The compound shows affinity to the moisture and retains it on the surface. It keeps the concrete surface wet for a long time.

Other Construction Materials

4.1 Timber: Classification and Structure of timber.

Seasoning of timber – Importance.

Characteristics of good timber.

Clay products and refractory materials – Definition and Classification.

Properties and uses of refractory materials- tiles, terracotta, porcelain glazing.

Iron and Steel: Uses of cast iron, wrought iron, mild steel and tor steel

Timber: Classification and Structure of timber.

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

Classification of trees

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

(i) **Endogeneous trees –** These trees grow inwards and fibrous mass is seen in their longitudinal sections. Timber from these trees has very limited engineering applications Ex: bamboo, cane, palm etc.

(ii) **Exogeneous trees:** These increases in bulk by growing outwards and used for engineering purposes. Exogeneous trees are further sub divided into two groups
a) conifers
b) deciduous

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

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

Structure of timber

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

1. Macro structure
2. Micro structure

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

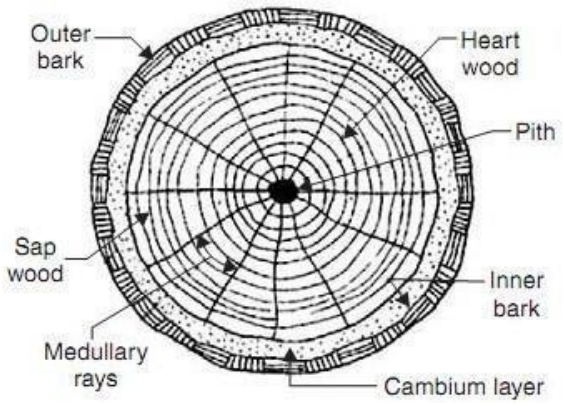


Fig : Cross-section of an exogenous tree

Pith: The innermost central portion or core of the tree is called pith or medulla
Heart wood: The inner annual rings surrounding the pith is known as heart wood. It imparts rigidity to tree
Sap wood: The cuter annual rings between heart wood and cambium layer is known as sap wood
Cambium layer: Thin layer of sap between sap wood and inner bark is known as cambium layer
Inner bark: The inner skin or layer covering the cambium layer is known as inner bark
Outer Bark: The outer skin or cover of the tree is known as outer bark
Medullary rays: The thin radial fibres extending from pith to cambium layer are known as medullary rays

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

Seasoning of timber – Importance.

Seasoning of timber is the process of drying timber or removing moisture or sap, present in a freshly felled timber, under more or less control condition.

Freshly felled timber contains a large quantity of moisture roughly from 100 to 200 % , based on dry weight of wood. A well seasoned piece of wood may contain about 10 to 12 % moisture and will be in equilibrium with atmospheric humidity of a particular place.

The importance of seasoning of timber is

- To check/minimise the tendency of timber to shrink, warp and split.
- To increase strength, durability and electrical resisting power of the timber.
- To make timber safe from attack of fungi and insect.
- To reduce the weight of transport purposes, handling and there by reduction in cost.
- To make timber fit for receiving treatment of paints, preservatives, varnishes etc.
- To make timber suitable for gluing.
- To make timber easily workable and to facilitate operations during conversion.

Methods of seasoning of timber

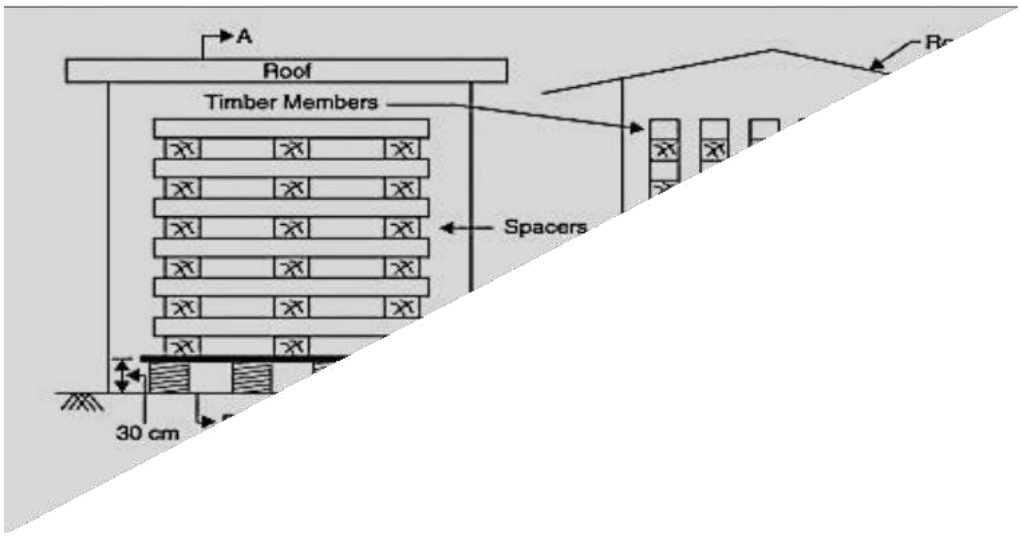
Seasoning of timber may be carried out in two ways

i. Natural seasoning
ii. Artificial seasoning

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.

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.



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.

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 of seasoning is fast, but costly.

Kiln Seasoning: Kiln is an airtight chamber. Timber to be seasoned is placed inside it. Then fully saturated air with a temperature 35°C to 38°C is forced in the kiln. The heat gradually reaches inside 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.

Chemical Seasoning: In this method, the timber is immersed in a solution of suitable salt. Then the timber is dried in a kiln. The preliminary treatment by chemical seasoning ensures uniform seasoning of outer and inner parts of timber.

Electrical seasoning: In this method, the use is made of high frequency alternating currents. The timber, when it is green, offers less resistance to the flow of electric current. The resistance increases as the wood dries internally which also results in the production of heat. This is the most rapid method of seasoning and uneconomical.

Characteristics of good timber.

The principal characteristics of timber of concern are strength, durability and finished appearance.

1. Narrow annual rings, closer the rings greater is the strength.
2. Compact medullary rays.
3. Dark colour.
4. Uniform texture.
5. Sweet smell and a shining fresh cut surface.

6. When struck sonorous sound is produced.
7. Free from the defects in timber.
8. Heavy weight.
9. No woolliness at fresh cut surface.
10. It should have regular annular ring etc.

4.3 Clay products and refractory materials – Definition and Classification.

Other Construction Materials

Timber: Classification and Structure of timber.
Seasoning of timber – Importance.
Characteristics of good timber.
Clay products and refractory materials – Definition and Classification.
Properties and uses of refractory materials- tiles, terracotta, porcelain glazing.
Iron and Steel: Uses of cast iron, wrought iron, mild steel and tor steel

Timber: Classification and Structure of timber.

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

Classification of trees

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

(i) **Endogeneous trees –** These trees grow inwards and fibrous mass is seen in their longitudinal sections. Timber from these trees has very limited engineering applications Ex: bamboo, cane, palm etc.

(ii) **Exogeneous trees:** These increases in bulk by growing outwards and used for engineering purposes. Exogeneous trees are further sub divided into two groups
a) conifers
b) deciduous

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

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

Structure of timber

From the visibility aspect, the structure of a tree can be divided into two categories
1. Macro structure
2. Micro structure

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

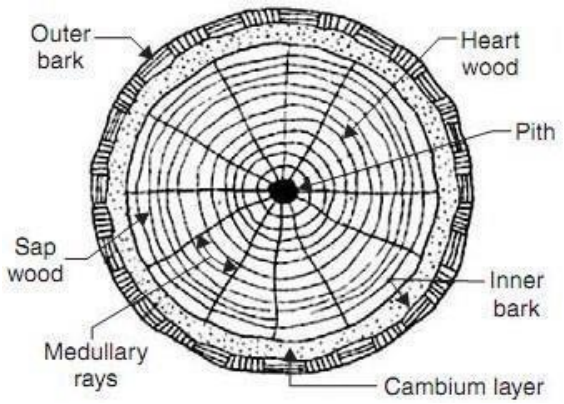


Fig : Cross-section of an exogenous tree

Pith: The innermost central portion or core of the tree is called pith or medulla
Heart wood: The inner annual rings surrounding the pith is known as heart wood. It imparts rigidity to tree
Sap wood: The cuter annual rings between heart wood and cambium layer is known as sap wood
Cambium layer: Thin layer of sap between sap wood and inner bark is known as cambium layer
Inner bark: The inner skin or layer covering the cambium layer is known as inner bark
Outer Bark: The outer skin or cover of the tree is known as outer bark
Medullary rays: The thin radial fibres extending from pith to cambium layer are known as medullary rays

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

Seasoning of timber – Importance.

Seasoning of timber is the process of drying timber or removing moisture or sap, present in a freshly felled timber, under more or less control condition.

Freshly felled timber contains a large quantity of moisture roughly from 100 to 200 % , based on dry weight of wood. A well seasoned piece of wood may contain about 10 to 12 % moisture and will be in equilibrium with atmospheric humidity of a particular place.

The importance of seasoning of timber is

- To check/minimise the tendency of timber to shrink, warp and split.
- To increase strength, durability and electrical resisting power of the timber.
- To make timber safe from attack of fungi and insect.
- To reduce the weight of transport purposes, handling and there by reduction in cost.
- To make timber fit for receiving treatment of paints, preservatives, varnishes etc.
- To make timber suitable for gluing.
- To make timber easily workable and to facilitate operations during conversion.

Methods of seasoning of timber

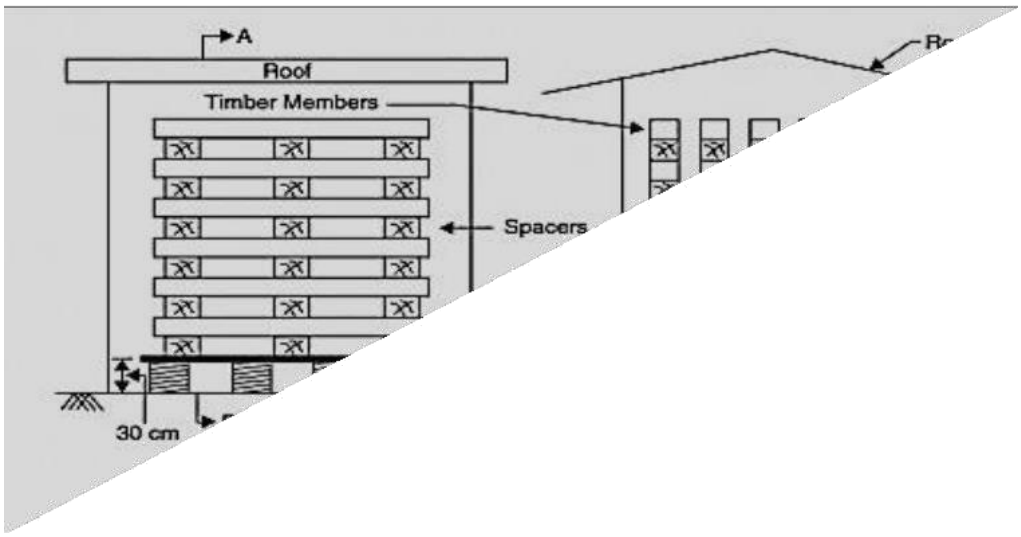
Seasoning of timber may be carried out in two ways

i. Natural seasoning
ii. Artificial seasoning

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.

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.



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.

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Clay products and refractory materials – Definition and Classification.

Clay products are one of the most important classes of structural materials. The raw materials used in their manufacture are clay blended with quartz, sand, chamatte (refractory clay burned at 1000–1400°C and crushed), slag, sawdust and pulverized coal. Structural clay products or building ceramics are basically fabricated by moulding, drying and burning a clay mass. Higher the bulk specific gravity, the stronger is the clay product.

According to the method of manufacture and structure, bricks, tiles, pipes, terracotta, earthenwares, stonewares, porcelain, and majolica are well recognized and employed in building construction.

REFRACTORIES

These materials are capable of withstanding high temperature in different industrial processes. In addition to the thermal endurance, a refractory should be able to resist the chemical action of the material being heated and withstand the mechanical load. They have high dimensional and chemical stability and do not lose their physical shape and chemical composition. Refractories confine the heat and prevent the heat loss to the atmosphere from the outside walls of furnaces.

Classification

0n the Basis of Chemical Behaviour

- **Acid refractories**: Combine readily with bases. Their chief constituent is silica: quartz, sand, ganister and silica bricks.
- **Basic refractories: C**onsist mainly of basic oxides: magnesite and dolomite.
- **Neutral refractories: C**onsist of materials which do not combine with either basic or acidic oxides: silicon carbide, chromite and carbon.

- **Low quality** used in the manufacture of fire-bricks, as lining material for furnaces. The melting point of such materials is more than 1580 ^{o}C.
- **High quality** stable even at high temperature and they are used in the construction of modern aeroplanes such as jets, rockets etc. These materials are composed of either pure clay or metals or combination of clay and metals.

Properties and uses of refractory materials- tiles, terracotta, porcelain glazing.

TILES

Tiles are thin slabs of low melting clays used for various purposes in engineering constructions. These give a very pleasing appearance and good service properties. Roofing tiles, flooring tiles, wall tiles and partition tiles are some of the examples.

Following are the characteristics of a good tile:

i. It should be free from any cracks, flaws or bends.
ii. It should be regular in shape and size.
iii. It should be sound, hard and durable.
iv. It should be well burnt.
v. It should give a clear ringing sound when struck with hand or with one another or with light hammer.

vi. It should fit in properly, when placed in position.
vii. It should give an even and compact structure when seen on its broken surface.
viii. It should possess uniform colour.

Tiles are widely used for flooring in kitchen, bathrooms, parking lots, rooftops and also used as tabletops for dining rooms, old factory floors, garages, gyms and sports complexes, schools and shops etc.

The terra means earth and cotta means baked. Hence the terra-cotta means the baked earth. It is thus a type of earthenware or porous pottery made from local clays and glazed with glazes containing galena. It is soft enough to be scratched by a knife. Following are the properties of terra-cotta:

i. It is strong and durable material.
ii. It is available in different colours.
iii. It is cheaper than ordinary finely dressed stones.
iv. It is easily cleaned.
v. It is easily moulded in desired shapes.
vi. It is fire-proof and can therefore be conveniently used with R.C.C. work.
vii. It is light in weight.
viii. It is not affected by atmospheric agencies and acids and is capable of withstanding weathering actions better than most kinds of stone.
ix. It is twisted due to unequal shrinkage in drying and burning.

The hollow terra-cotta blocks are used for various ornamental purposes such as facing work, arches, cornices, casing for columns, etc. It is adopted for all sorts of ornamental work. It is used as a decorative material in place of stones for ornamental parts of buildings such as cornices, string courses, sills, copings, bases of pillars, fire places, etc.

PORCELAIN

The term porcelain is used to indicate fine earthenware which is white, thin and semi-transparent. Since the colour of porcelain is white, it is also referred to as the whiteware.

The clay of sufficient purity and possessing high degree of tenacity and plasticity is used in preparing porcelains. It is hard, brittle and non-porous. It is prepared from clay, felspar, quartz and minerals. The constituents are finely ground and then they are thoroughly mixed in liquid state. The mixture is given the desired shape and it is burnt at high temperature.

The various types of porcelains are available and they are adopted for various uses such as sanitarywares, electric insulators, storage vessels, reactor chambers, crucibles, etc. The porcelains are of two types, namely low voltage porcelain and high voltage porcelain. The low voltage porcelain is prepared by dry process and it is mainly used for switch block, insulating tubes, lamp sockets, etc. If some quantity of alumina or silicate of magnesia is added, it can resist high temperature to a certain extent.

GLAZING

It is the process of forming some transparent film over the surfaces of bricks, tiles, earthenware or stoneware to improve upon their appearance and also to protect them from the action of weather, sewage, chemicals or other destroying agents.

A glaze is a glassy coat of thickness about 0.1 to 0.2 mm applied on the surface of an item and then fused into place by burning at high temperature.

Glazing should be such that it does not craze when the article is exposed to any change of temperature.

Glazing may be transparent like glass or opaque like enamels. For obtaining coloured glazes, the oxides and salts of various metals or special refractory colouring agents are added.

Transparent Glazing

Transparent glazing is of two types

1. Salt glazing
2. Lead glazing.

Salt glazing

- In this method, common salt (sodium chloride) is thrown into the kiln, containing the articles to be glazed at the close of the burning operation when the temperature reaches to about 1300 °C. The salt vapourizes and attaches itself chemically to all exposed surfaces of the clay products, thus forming a thin layer of transparent glass over the surfaces. The quantity of salt and throwing at proper time should be done with extreme care.
- This method is useful for sanitary pipes and chemical stonewares.

- Lead glazing is preferred to salt glazing for getting articles of better quality.
- In this method, hot article to be glazed is dipped in a bath containing oxide of lead and tin when particles of these materials adhere to the article dipped. The article is then withdrawn and reburnt when high temperature of the finance melts it forming a film of glass over the exposed surface.
- In this method of glazing, the glaze does not penetrate into the body of the ware and as a matter of fact, it can be easily detached from the surface of the ware.

Uses: This method is used for terracolta, earthenwares and fire-clay wares.

- The glazing materials consist of quartz, felspar, boric oxides, oxide of tin, zinc, lead, china clay etc. A mixture of these materials is prepared and ground to fine paste (known as slip) in the presence of water.
- The clay product to be glazed is first dried and dipped into the slip (paste) and then fired into the furnace at a temperature of about 120°C.During the process of firing the composition of glaze gets completely vitrified and forms uniform glaze of desired colour over the surface of the burnt clay product.
- In this glazing process, burning and glazing of the clay products are simultaneously achieved

Uses: Opaque glazing is used where it is desired to give the whole or any part of the article a better appearance than that presented by the burnt material. Basins, dishes, cups, etc., are opaque glazed.

Iron and Steel: Uses of cast iron, wrought iron, mild steel and tor steel

PIG-IRON

The crude impure iron which is extracted from iron ores is known as the pig-iron and it forms the basic material for the manufacture of cast-iron, wrought-iron and steel.

CAST-IRON

The cast-iron is manufactured by re-melting pig-iron with coke and limestone. This re-melting is done in a furnace known as the cupola furnace. It is more or less same as the blast furnace, but it is smaller in size.

Following are the important uses of cast-iron:

- For making cisterns, water pipes, gas pipes and sewers, manhole covers and sanitary fittings.
- For making ornamental castings such as brackets, gates, lamp posts, spiral staircases, etc.
- For making parts of machinery which are not subject to heavy shocks.
- For manufacturing compression members like columns in buildings, bases of columns, etc.
- For preparing agricultural implements.
- For preparing rail chairs, carriage wheels, etc.

WROUGHT-IRON

The wrought-iron is almost pure iron and it hardly contains carbon more than 0.15 per cent or so. But the process of its manufacture is laborious and tedious.

USE

The wrought-iron is replaced at present to a very great extent by mild steel. It is therefore produced to a very small extent at present. It is used where a tough material is required.

The wrought-iron, at present, is used for rivets, chains, ornamental iron work, railway couplings, water and steam pipes, raw material for manufacturing steel, bolts and nuts, horse shoe bars, handrails, straps for timber roof trusses, boiler tubes, roofing sheets, armatures, electro-magnets, etc.

PART: B (CONSTRUCTIONS TECHNOLOGY)

Introduction

1.1.Buildings and classification of buildings based on occupancy.
1.2.Different components of a building.
1.3.Site investigation — objectives, site reconnaissance and explorations.

Buildings and classification of buildings based on occupancy **Buildings**

It simply indicates anything that is built with walls and a roof. The term building in civil engineering parlance is used to mean a structure having various components like foundations, walls, columns, floors, roofs, doors, windows, ventilators, stairs, lifts, various types of surface finishes, etc.

As per National Building Code of India, buildings are classified into nine groups based on occupancy as follows:

Group A: Residential buildings.
Group B: Educational buildings.
Group C: Institutional buildings.
Group D: Assembly buildings.
Group E: Business buildings.
Group F: Mercantile buildings.
Group G: Industrial buildings.
Group H: Storage buildings.
Group I: Hazardous buildings.

Different components of a building.

A building has two basic parts:

i. Sub-structure or foundations, and
ii. Super-structure.

Sub-structure or Foundation is the lower portion of the building, usually located below the ground level, which transmits the loads of the super-structure to the supporting soil. A foundation is therefore that part of the structure which is in direct contact with the ground to which the loads are transmitted.

Super-structure is that part of the structure which is above ground level, and which serves the purpose of its intended use. A part of the super-structure, located between the ground level and the floor level is known as plinth.

Plinth is therefore defined as the portion of the structure between the surface of the surrounding ground and surface of the floor, immediately above the ground. The level of the floor is usually known as the plinth level. The built-up covered area measured at the floor level is known as plinth area.

A building has the following components:

1. Foundations.
2. Masonry units: walls and columns.
3. Floor structures.
4. Roof structures.

5. Doors, windows and other openings.
6. Vertical transportation structures, such as stairs, lifts, ramps etc.
7. Building finishes

Site investigation — objectives, site reconnaissance and explorations.

Since the foundations have to transfer the load to the sub-soil, surface conditions at any given site must be adequately explored to obtain information required for the design and construction of foundations.

Site investigation is done for the following purposes:

a. For New Structures
    1. The selection of type and depth of foundation.
    2. The determination of bearing capacity of the selected foundation.
    3. The prediction of settlement of the selected foundation.
    4. The determination of the ground water level.
    5. The evaluation of the earth pressure against walls, basements, abutments etc.
    6. The provision against constructional difficulties.
    7. The suitability of soil and degree of compaction of soil.
b. For Existing Structures
    1. The investigation of the safety of the structure.
    2. The prediction of settlement.
    3. The determination of remedial measures if the structure is unsafe or will suffer detrimental settlement.

SITE RECONNAISSANCE

An inspection of the site and study of topographical features is often helpful in setting useful information about the soil and ground water conditions and in deciding the future programme of exploration. On going over the site, a study of the following features may be useful: local topography, excavations, cuttings, quarries, escarpments evidence of erosion or landslides, fills, water level in wells and drainage pattern for the building site. If there has been an earlier use of the site, information should be gathered, in particular about the underground workings, if any, and about the location of fills and excavations.

SITE EXPLORATION

The object of the site exploration is to provide reliable, specific and detailed information about the soil and ground water conditions of the site which may be required for a safe and economic design of foundations. For this purpose, an exploration of the region likely to be affected by the proposed works should yield precise information about the following:

i. The order of occurrence and extent of soil and rock strata.
ii. The nature and engineering properties of the soil and rock formation, and
iii. The location of ground water and its variation.

FOUNDATIONS

2.1 Concept of foundation and its purpose

2.2 Types of foundations — shallow and deep

Shallow foundation-constructional details of : Spread foundations for walls, thumb rules for depth and width of foundation and thickness of concrete block

Deep foundations: Pile foundations-their suitability, classification of piles based on materials, function and method of installation.

Concept of foundation and its purpose

Every structure consists of the following two parts:

i. Foundations; and
ii. Superstructures.

The lowest artificially prepared parts of the structures which are in direct contact with the ground and which transmit the loads of the structures to the ground are known as the foundations or substructures. The solid ground on which the foundations rest is called the foundation bed or foundation soil and it ultimately bears the load and interacts with the foundations of buildings. The lowermost portion of the foundation which is in direct contact with the sub-soil is called the footing.

Purposes of foundation

The foundations are provided for the following purposes.

- To distribute the total load coming on the structure on a larger area so as to bring down the intensity of load at its base below the safe bearing capacity of sub-soil;
- To support the structures;
- To give enough lateral stability to the structures against various disturbing horizontal forces such as wind, rain, earthquake, etc.;
- To prepare a level and hard surface for concreting and masonry work;
- To transmit the super-imposed loads through side friction and end bearing in case of deep foundations;
- To distribute the non-uniform load of the superstructure evenly to the sub-soil;
- To provide the structural safety against undermining or scouring due to animals, flood water, etc.;
- To prevent or minimize cracks due to movement of moisture in case of weak or poor soils; etc.

Types of foundations — shallow and deep

Foundations may be broadly classified into 2 types;

a) Shallow Foundations
b) Deep Foundation

According to Terzaghi, A foundation is shallow if its depth is equal to or less than its width. Foundation is said to be deep if its depth is greater than its width.

a) SHALLOW FOUNDATIONS

From the point of view of design, shallow foundations may be of the following types:

1. Spread footings.
2. Combined footings
3. Strap footings.
4. Mat foundation.

A brief description of these is given below.

1. Spread Footings

Spread footings are those which spread the super-imposed load of wall or column over a larger area. Spread footings support either a column or wall. Spread footings may be of the following kinds:

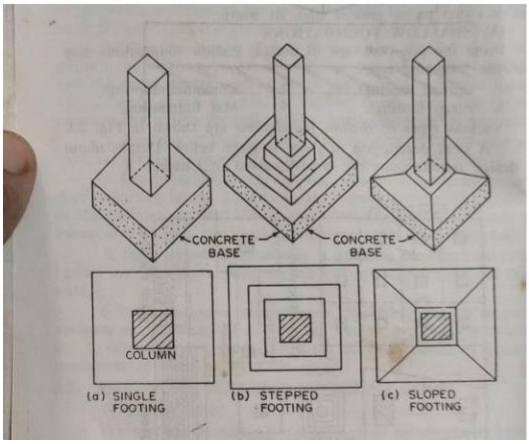
i. Single footing for a column
ii. Stepped footing for a column
iii. Sloped footing for a column
iv. Wall footing without step
v. Stepped footing for wall
vi. Grillage foundation

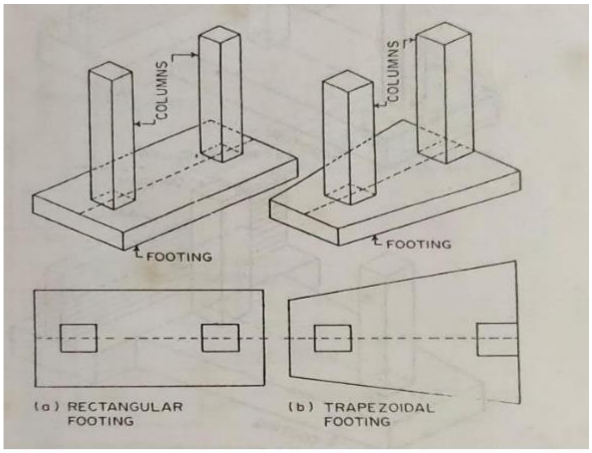
2. Combined Footings

A spread footing which supports two or more columns is termed as combined footing. The combined footings may be of the following kinds:

i. Rectangular combined footing
ii. Trapezoidal combined footing
iii. Combined column-wall footings

Combined footings are invariably constructed of reinforced concrete.



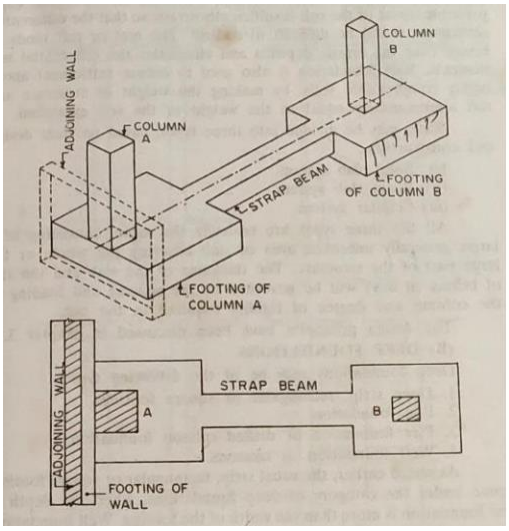


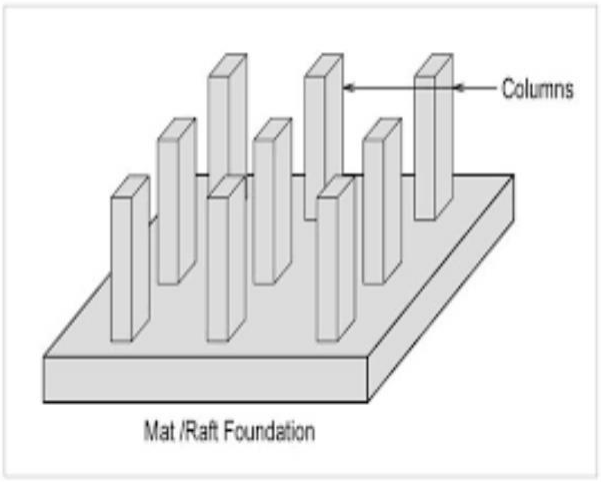
3. Strap Footings

If the independent footings of two columns are connected by a beam, it is called a strap footing. A strap footing may be used where the distance between the columns is so great that a combined trapezoidal footing becomes quite narrow, with high bending moments.

4. Mat Foundation (Raft Foundation)

A raft or mat is a combined footing that covers the entire area beneath a structure and supports all the walls and columns, when the allowable soil pressure is low, or the building loads are heavy, the use of spread footings would cover more than one half the area and it may prove more economical to use mat or raft foundation.





b) DEEP FOUNDATIONS

Deep foundations may be of the following types:

- Deep strip, rectangular or square footings.
- Pile foundation.
- Pier foundation or drilled caisson foundation.
- Well foundation or caissons.

As stated earlier, the usual strip, rectangular or square footings come under the category of deep foundations, when the depth of the foundation is more than the width of the footing. Well foundations are generally adopted for bridge piers etc. and not for building foundations.

Shallow foundation-constructional details of : Spread foundations for walls, thumb rules for depth and width of foundation and thickness of concrete block

Spread foundations for walls

Fig. 2.3 (a) shows the spread footing for a wall, consisting of concrete base without any steps. Usually, masonry walls have stepped footing as shown in Fig. 2.3 (b), with a concrete base.

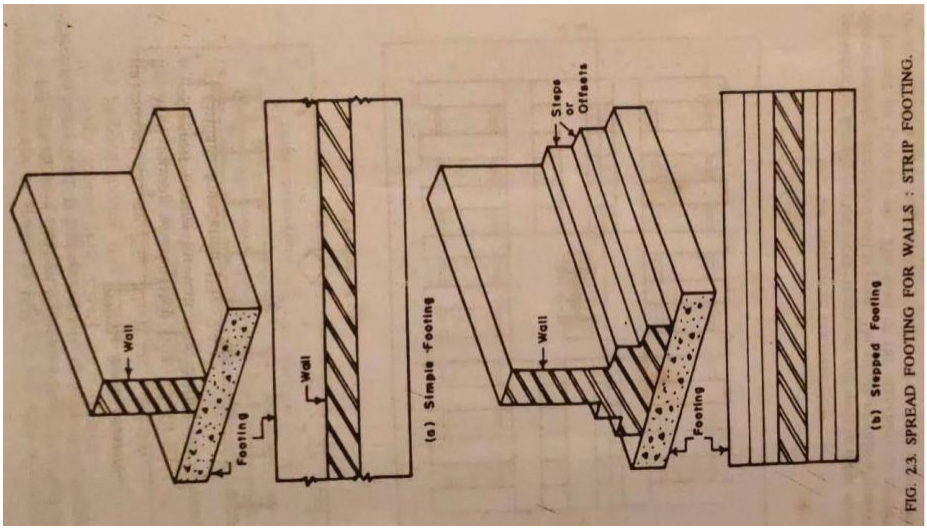
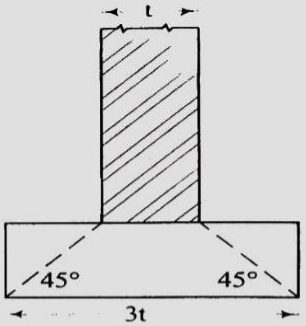


FIG. 2.3. SPREAD FOOTING FOR WALLS : STRIP FOOTING.

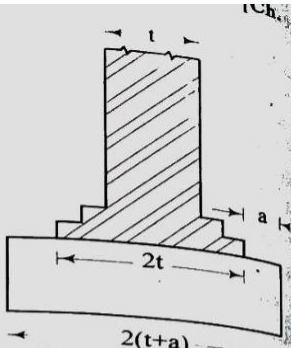
Thumb rules for depth and width of foundation and thickness of concrete block

(1) Width of foundations: The width of foundations is decided by adopting the following rules:

(i) If no footings are to be provided to the wall i.e. for simple footing, the width of foundations should be equal to three times the thickness of wall as shown in fig. 5-4.



Simple footing
FIG. 5-4



Stepped footing
FIG. 5-5

(ii) The total load including dead load, live load and wind load coming on the wall per metre length or in case of a pier, at the centre of the pier, is worked out. Then the width of foundation is obtained from the following relations:

$$\text{For walls,} \quad \text{width of foundations} = \frac{\text{total load per metre length}}{\text{allowable bearing capacity of the soil}}$$

$$\text{For piers,} \quad \text{width of foundations} = \left\{ \frac{\text{total load on the pier}}{\text{allowable bearing capacity of the soil}} \right\}^{\frac{1}{2}}$$

(iii) Usually the walls and piers are given footings such that the width at the base becomes equal to twice the width of wall at the plinth level as shown in fig. 5-5. By adding the width of offsets of concrete, the total width of foundations can be obtained for stepped footing.

If t = thickness of wall, and

a = offset of concrete.

width of foundation = $2\ (t + a)$.

Note: The greater result obtained from rules (ii) and (iii) should be adopted.

(2) Depth of foundations: The depth of foundations is obtained by keeping in view the following rules:

(i) As a general rule, all the shallow foundations should be taken to a minimum depth of 800 mm below natural ground level unless hard soil is available within 800 mm.

(ii) The total load to be transferred to the soil per square metre can be worked out and after the study of the results of the trial pits, the foundations should be taken to such a depth at which the soil has allowable bearing capacity greater than this value.

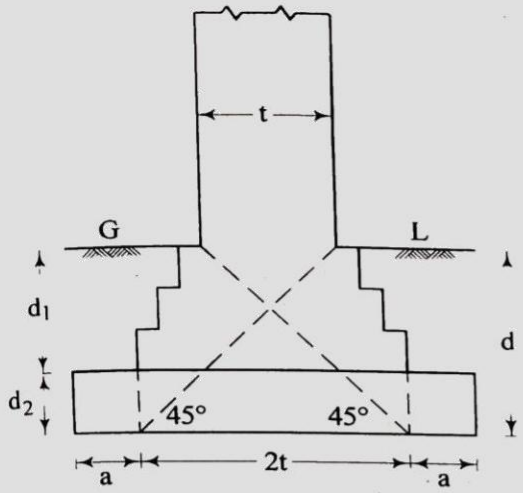
(iii) The depth of foundations can also be obtained by drawing the lines of angles 45° and 60° as shown in fig. 5-6 and fig. 5-7 respectively.

Let d_1 = Depth of footings

d_2 = Depth of concrete block.

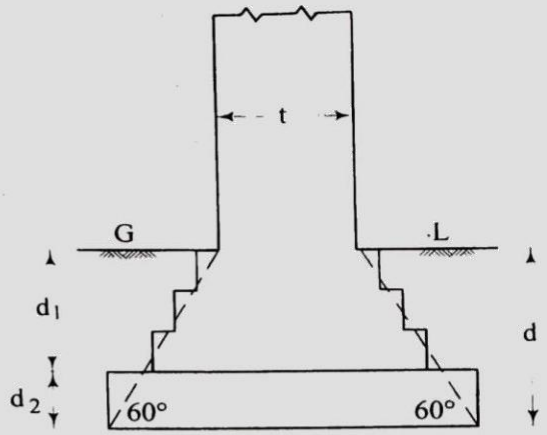
d = Total depth of foundations

Then, $d = d_1 + d_2$.



Depth of foundations

FIG. 5-6



Depth of foundations

FIG. 5-7

(iv) For loose soil, Rankine's formula, as given below, can be used to find the minimum depth of foundations:

$$d = \frac{p}{w}\left(\frac{1 - \sin\phi}{1 + \sin\phi}\right)^2$$

where d = minimum depth of foundation in metres

w = weight of soil in kg/m^3 or kN/m^3

ϕ = angle of repose

p = load on soil in kg/m^2 or kN/m^2.

The above formula is not to be used when the building to be constructed rests on hard soil. The values of angles of repose of some of the soils are given in table 5-1.

TABLE 5-1

ANGLES OF REPOSE OF VARIOUS SOILS

No.	Type of soil	Angle of repose in degrees
1.	Loose earth	30 to 45
2.	Compact earth	50
3.	Dry sand	25 to 35
4.	Moist sand	30 to 45
5.	Wet sand	15 to 30
6.	Clay	25 to 45
7.	Gravel	30 to 40
8.	Ashes	40
9.	Gravel and sand	25 to 40

(v) For finding out the depth of concrete block, the following formula can be used:

(a) Depth of concrete block in cm $= \frac{1}{58}\sqrt{\frac{pa^2}{m}}$

(b) Depth of concrete block in cm $= \frac{5}{6}\,t.$

Deep foundations: Pile foundations-their suitability, classification of piles based on materials, function and method of installation. Pile foundations-their suitability

Deep foundations are those in which the depth of the foundation is very large in comparison to its width. Deep foundations are not constructed by ordinary methods of open pit excavations. Deep foundations are of the following types:

a. Pile foundation.
b. Pier foundation
c. Caisson or well foundation.

Out of these, pile foundation is more commonly used in building construction. Following are the situations in which a pile foundation is preferred:

- The load of the super structure is heavy and its distribution is uneven.
- The top soil has poor bearing capacity.
- The subsoil water level is high so that pumping of water from the open trenches for the shallow foundations is difficult and uneconomical.
- There is large fluctuations in subsoil water level.
- If deep strip foundation is attempted, timbering of sides is difficult to maintain or retain the soil of sides of the trench.
- The structure is situated on the sea shore or river bed, where there is danger of scouring action of water.
- Canal or deep drainage lines exist near the foundations.
- The top soil is of expansive nature.

Classification of piles based on materials

Timber piles:

Timber piles are made from tree trunks and are well seasoned, straight and free from all defects. In India, timber piles mostly made up of sal tree trunks. These piles are available in length between 4 to 6 m. Timber piles are used where good bearing stratum is available at a relatively shallow depth.

Concrete piles:

Concrete piles are either precast or cast in situ. Precast piles are cast and cured at the casting site and then transported to the site for installation. These piles are adequately reinforced to withstand handling stresses along with working stresses. Precast piles are normally suitable for short lengths. Cast-in-situ piles are constructed by drilling hole in the ground and then filling the hole by concrete after placing the reinforcement.

Steel piles:

Steel piles are usually of rolled H-sections or thick pipe sections. These piles are used to withstand large impact stresses and where less disturbance from driving is desired. Steel sheet piles and H-piles are generally used to support the open excavation and to provide seepage barrier.

Composite piles:

A pile which is made up of two materials like concrete and timber or concrete and steel is called composite pile. Composite piles are used in situations where a part of the pile is permanently under

water. The part of the pile which will be under water can be made of untreated timber and the other part can be of concrete.

Classification of piles based on function

Based on the function or the use, piles may be classified as:

1. End bearing pile
2. Friction pile
3. Compaction pile
4. Tension pile or uplift pile
5. Anchor pile
6. Fender pile and dolphins
7. Sheet pile.

End bearing piles are used to transfer load through water or soft-soil to a suitable bearing stratum [Fig 4.1(a)].

Friction piles are used to transfer loads to a depth of a friction load carrying material by means of skin friction along the length of piles (Fig. 4.1(b)).

Compaction piles are used to compact loose granular soils, thus increasing their bearing capacity. The compaction piles themselves do not carry any load. Hence they may be of weaker material-sometimes of sand only. The pile tube, driven to compact the soil, is gradually taken out and sand is filled in its place thus forming a 'sand pile [Fig. 4.1 (c)]

Tension or uplift piles anchor down the structures subjected to uplift due to hydrostatic pressure or due to over-turning moment [Fig. 4.1 (d)]

Anchor piles provide anchorage against horizontal pull from sheet piling or other pulling forces (Fig. 4.1 (e)].

Fender piles and dolphins are used to protect water from structures against impact from ships or other floating objects.

Sheet piles are commonly used as bulkheads, or as impervious cut off to reduce seepage and uplift under hydraulic structures. The batter piles are used to resist large horizontal or inclined forces [Fig. 4.1 (f)].

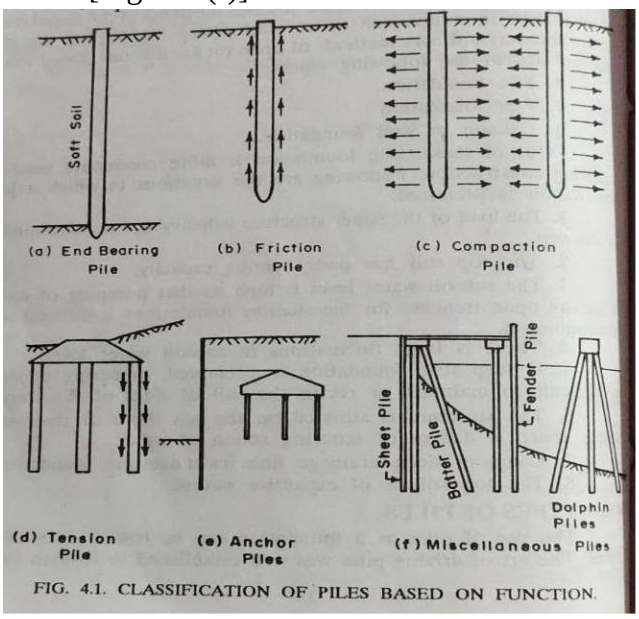


FIG. 4.1. CLASSIFICATION OF PILES BASED ON FUNCTION.

Classification of piles based on method of installation

According to the method of construction, there are three types of piles

1. DRIVEN PILES

   Piles may be of timber, steel or concrete. When the piles are of concrete, they are to be precast. They may be driven either vertically or at an angle to the vertical. Piles are driven using a pile hammer. When a pile is driven into granular soil, the soil so displaced, equal to the volume of the driven pile, compacts the soil around the sides since the displaced soil particles enter the soil spaces of the adjacent mass which leads to densification of the mass. The pile that compacts the soil adjacent to it is sometimes called a *compaction pile*. The compaction of the soil mass around a pile increases its bearing capacity.

2. CAST-IN-SITU PILES

   Cast-in-situ piles are concrete piles. These piles are distinguished from drilled piers as small diameter piles. They are constructed by making holes in the ground to the required depth and then filling the hole with concrete. Straight bored piles or piles with one or more bulbs at intervals maybe cast at the site. The latter type are called under-reamed piles. Reinforcement may be used as per the requirements.

3. DRIVEN AND CAST-IN-SITU PILES

   A steel shell is driven into the ground with the aid of a mandrel inserted into the shell. The mandrel is withdrawn and concrete is placed in the shell. The shell is made of corrugated and reinforced thin sheet steel (mono-tube piles) or pipes (Armco welded pipes or common seamless pipes). The piles of this type are called a shell type. The shell-less type is formed by withdrawing the shell while the concrete is being placed. In both the types of piles the bottom of the shell is closed with a conical tip which can be separated from the shell. By driving the concrete out of the shell an enlarged bulb may be formed in both the types of piles.

Walls & Masonry Works :

Purpose of walls

Classification of walls – load bearing, non-load bearing walls, retaining walls. 3.3.Classification of walls as per materials of construction: brick, stone, reinforced brick,

reinforced concrete, precast, hollow and solid concrete block and composite masonry walls (Concept Only).

3.4.Partition Walls : Suitability and uses of brick and wooden partition walls

3.5.Brick masonry : Definition of different terms.

Bond – meaning and necessity: English bond for 1and 1-1/2 Brick thick walls. T, X and right angled corner junctions. Thickness for 1and 1-1/2 brick square pillars in English bond

Stone Masonry :

Glossary of terms –String course, corbel, cornice, block-in-course, grouting, mouldings, templates, throating, through stones, parapet, coping, pilaster and buttress

Purpose of walls

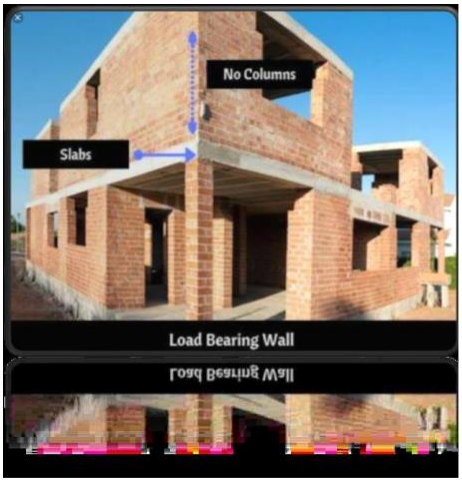
Wall is one of the most essential components of a building. The primary function of a wall is to enclose or divide space of the building to make it more functional and useful. Walls provide privacy, afford security and give protection against heat, cold, sun and rain. Walls provide support to floors and roofs. Walls should therefore be so designed as to have provision of adequate.

i. Strength and stability
ii. Weather resistance
iii. Durability
iv. Fire resistance
v. Thermal insulation and
vi. Sound insulation

Classification of walls – load bearing, non-load bearing walls, retaining walls.

Load Bearing Walls

- Load bearing wall is a structural element.
- It carries the weight of a house from the roof and upper floors, all the way to the foundation. It supports structural members like beams, slab and walls on above floors above. A wall directly above the beam is called load bearing wall.
- It is designed to carry the vertical load. In another way, if a wall doesn't have any walls, posts or other supports directly above it, it is more likely to be a load-bearing wall.
- Load bearing walls also carry their own weight. This wall is typically over one another on each floor.
- Load bearing walls can be used as interior or exterior wall. This kind of wall will often be perpendicular to floor joists or ridge.
- Concrete is an ideal material to support these loads. The beams go directly into the concrete foundation. Load bearing walls inside the house tend to run the same direction as the ridge



Non load bearing wall:-

- A wall which doesn't help the structure to stand up and holds up only itself is known as a non-load bearing wall.
- It doesn't support floor roof loads above. It is a framed structure. Most of the time, They are interior walls whose purpose is to divide the structure into rooms. They are built lighter.
- One can remove any non-load bearing walls without endangering the safety of the building. Non-load bearing walls can be identified by the joists and rafters.
- They are not responsible for gravitational support for the property. It is cost effective. This wall is referred to as "curtain wall".

  - Hollow Concrete Block
  - Facade Bricks
  - Hollow Bricks
  - Brick Walls

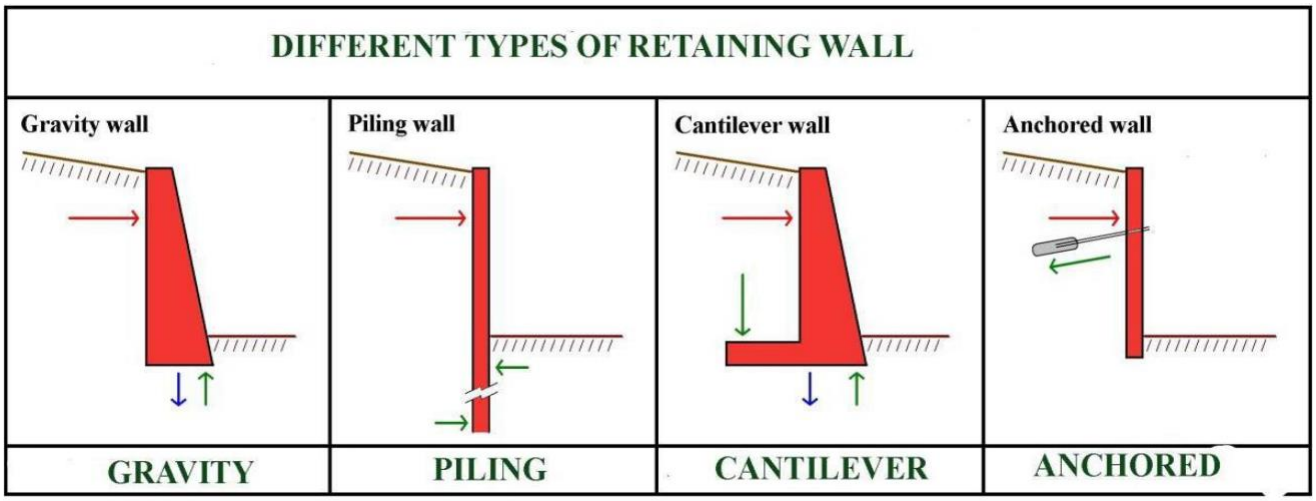
Retaining wall:-

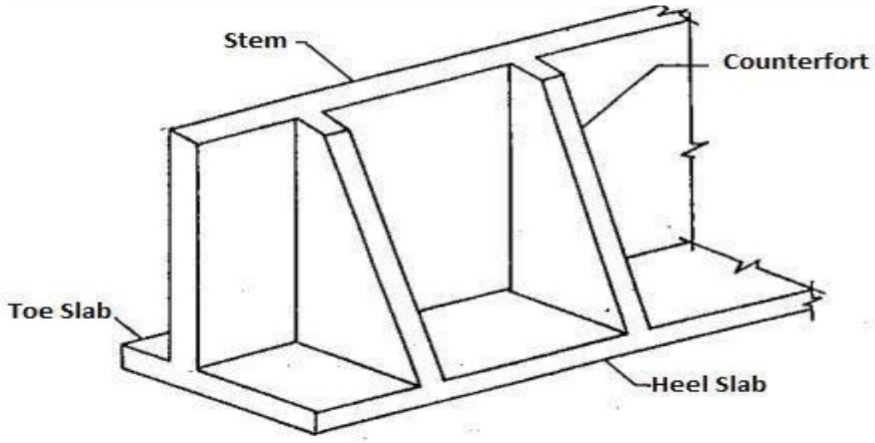
Retaining wall is a structure that retain (holds back) any material (usually earth) and prevents it from sliding or eroding away. It is designed so that to resist the material pressure of the material that it is holding back.

Types of Retaining Wall

An earth retaining structure can be considered to have the following types:

- Gravity Walls
- Reinforced Gravity Walls
- Concrete Cantilever retaining wall
- Counter-fort / Buttressed retaining wall
- Precast concrete Retaining wall
- Pre-stressed retaining wall





Classification of walls as per materials of construction: brick, stone, reinforced brick, reinforced concrete, precast, hollow and solid concrete block and composite masonry walls (Concept Only).

Brick wall

- Brickwork is masonry produced by a bricklayer, using bricks and mortar. Typically, rows of bricks called courses are laid on top of one another to build up a structure such as a brick wall.

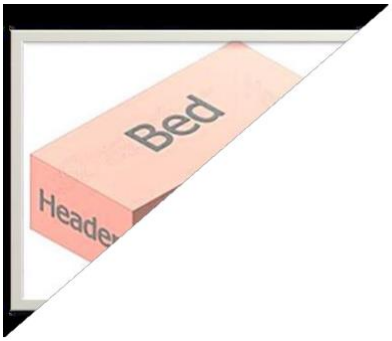
  Bricks may be differentiated from blocks by size.

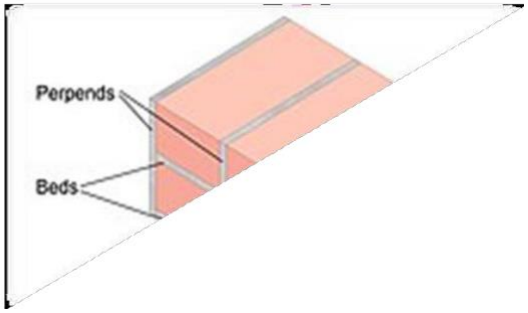
As the most common bricks are rectangular prisms, six surfaces are named as follows:

- Top and bottom surfaces are called Beds
- Ends or narrow surfaces are called Headers or header faces
- Sides or wider surfaces are called Stretchers or stretcher

faces Mortar terminology-showing perpends and bed.

- Mortar placed between bricks is also given separate names with respect to their position. Mortar placed horizontally below or top of a brick is called a bed, and mortar Placed vertically between bricks is called perpend.





Stone wall

Stone walls are a kind of masonry construction that has been used for thousands of years. The first stone walls were constructed by farmers and primitive people by piling loose field stones into a dry stone wall. Later, mortar and plaster were used, especially in the construction of city walls, castles, and other fortifications before and during the Middle Ages.

Reinforced brick wall

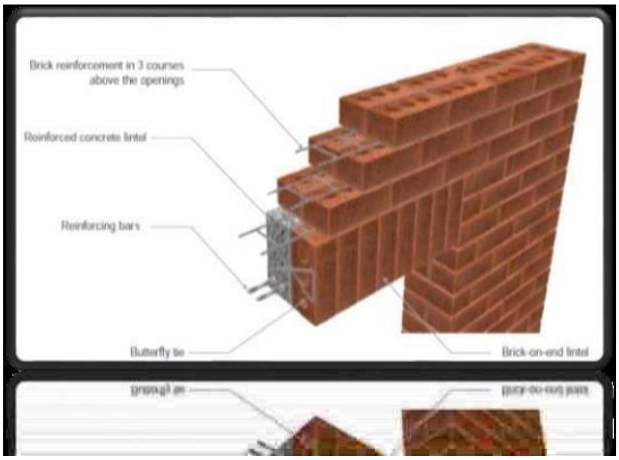
- Reinforced Brick Wall: Walls that are prone to tensile forces are needed to be reinforced, and both horizontal and vertical reinforcement is required.
- Horizontal reinforcement is provided at every third or fourth course, consists of steel mesh spread flat on the cement mortar and pressed uniformly.

Reinforced concrete wall

These wall are of 3 types

1. Solid concrete block
2. Hollow concrete Block
3. Precast concrete block

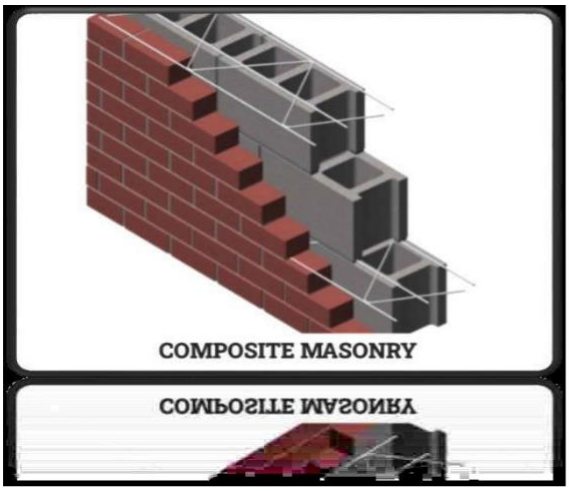
The residential and commercial construction industries make wide use of a form of concrete building material known officially as a concrete masonry unit (CMU). These hollow-core blocks can be made of standard concrete with traditional sand and gravel aggregate held together with Portland cement. Or, they can substitute lighter-weight industrial waste materials, such as fly ash or coal cinders, for the sand and gravel aggregate, in which case they are usually known as cinder block.

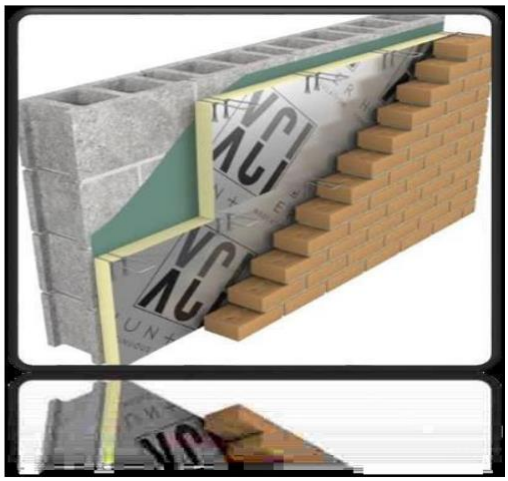


Composite Masonary Wall:-

Composite masonry is a masonry constructed with two or more types of construction units or different types of construction materials, i.e. bricks, stones, etc. Composite masonry is adopted for the following reasons:

1. This masonry reduces the overall cost of construction.
2. It makes the structure more durable by providing better quality and good workmanship material in the faces.
3. Also, improves the appearance of the structure by concealing the inferior function.
4. It achieves optimum economy using locally available materials





Partition Walls : Suitability and uses of brick and wooden partition walls

- A partition wall is defined as a wall or division made up of bricks, studding, glass or other such material and provided for dividing from one room to another room.
- Partition Wall can be constructed as a load-bearing wall or non-load bearing wall. The load-bearing partition wall is known as the internal wall.
- These internal walls do not carry any weight. Sometimes partition wall may be folded, collapsible, or fixed type.
- Partition walls or walls can be constructed in various shapes like –thin, light, or thick, heavy, etc. Mainly, these walls' requirements are based on building materials and design.

1. Plain brick partitions
2. Reinforced brick partitions.
3. Brick nogging partitions.

Plain Brick Partitions

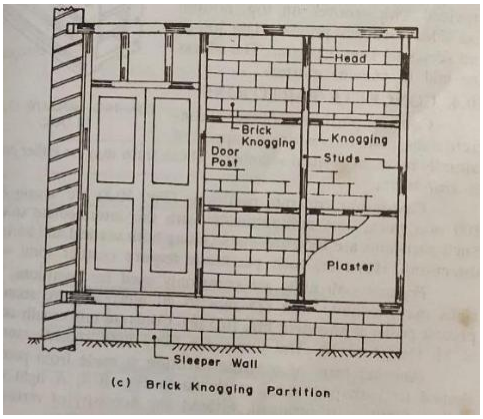
Plain brick partitions are usually half brick thick. The bricks are laid as stretchers , in cement mortar. Vertical joints are staggered alternate blocks. The wall is plastered on both the sides. The wall is considerably strong and fire resistant.

Reinforced Brick Partitions

These are stronger than the ordinary brick partitions, and is used when better longitudinal bond is required, and when the partition wall has to carry other super-imposed loads. The thickness of the wall is kept equal to half brick (10 cm). The reinforcement consists of steel meshed strips, called Exmet.

Brick Nogging Partitions

Brick nogging partition wall consists of brick work (half brick thickness) built up within the frame work of wooden members. The timber frame work consists of (i) sill, (ii) head, (iii) vertical members, called studs, and (iv) horizontal members called nogging pieces. The vertical members or studs are spaced at 4 to 6 times the brick length. The nogging pieces are housed into the studs at vertical interval of 60 to 90 cm. The framework provided stability to the partition against lateral loads and vibrations caused due to opening the adjoining door.



(c) Brick Knogging Partition

TIMBER PARTITIONS

Timber partitions consist of wooden frame work, properly supported on floor and fixed to the side walls. This frame work, made of horizontal and vertical members, can either be plastered or covered with boarding etc. from both the sides. Wooden partitions are light weight, but are costlier. It is likely to decay, or eaten away by termites. Also, it is not fire resistant. It's use is reducing day by day.

Two types of wooden partitions may be used:

i. Common or stud partition.
ii. Trussed or braced partition.

1. Common or stud partition

It consists of a frame work of vertical members (called studs), and short horizontal pieces, called noggings. Horizontal pieces impart rigidity to studs. A stud of short length, such as the one provided on an opening, is called, puncheon. The upper and lower horizontal members of the frame are known as head and sill respectively.

2. Trussed or braced partitions

Such partitions are provided where there is no means of supporting the partition except at their ends. The frame work is similar to the stud partition, but inclined members called braces, and steel straps and bolts are additionally used. Sometimes, such partitions carry floor load also, in addition to its own weight. For more rigidity and strength, an additional horizontal member, known as inter-tie is provided between head and sill.

Brick masonry : Definition of different terms.

Brick masonry is made of brick units bonded together with mortar. Two essential components of brick masonry are therefore:

i. Bricks
ii. Mortar

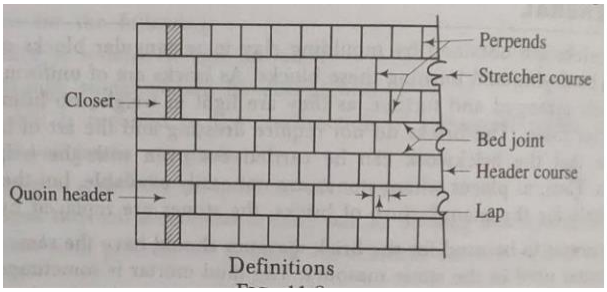
Mortar acts as a cementing material and unites the individual brick units together to act as a homogeneous mass. Following types of mortar may be used in brick masonry :

1. Cement mortar
2. Lime mortar
3. Cement-lime mortar
4. Lime-surkhi mortar and
5. Mud mortar

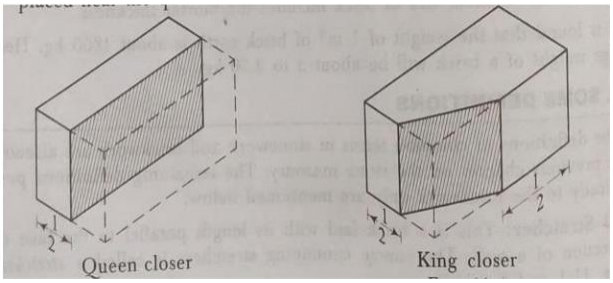
Mud mortar is used only for low-rise buildings which carry light loads. Cement mortars are used for high-rise buildings, where strength is of prime importance. Lime mortar and lime-surkhi mortars are used for all types of construction.

Bricks are manufactured by moulding clay in rectangular blocks of uniform predetermined size, drying them and then burning them in a kiln.

Definition of different terms



Definitions



Lap: The horizontal distance between the vertical joints in successive courses is termed as a lap and for a good bond, it should be one-fourth of the length of a brick.

Closer: A piece of brick which is used to close up the bond at the end of brick courses is known as a closer and it helps in preventing the joints of successive courses to come in a vertical line. Generally the closer is not specially moulded. But it is prepared by the mason with the edge of the trowel. Following are the types of closers

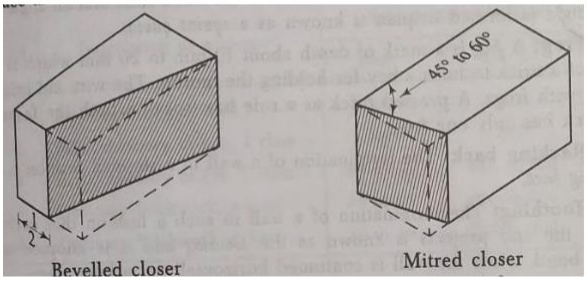
Queen closer: This is obtained by cutting the brick longitudinally in two equal parts.

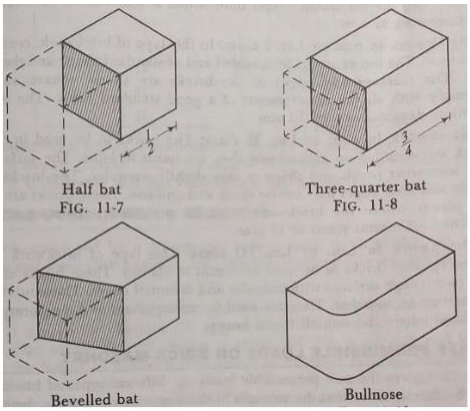
King closer: This is obtained by cutting a triangular portion of the brick such that half a header and half a stretcher are obtained on the adjoining cut faces.

Bevelled closer: This is obtained by cutting a triangular portion of half the width but of full length.

Mitred closer: This is obtained by cutting a triangular portion of the brick through its width and making an angle of 45° to 60° with the length of the brick.

Bat: This is a piece of brick, usually considered in relation to the length of brick and accordingly known as half bat or three-quarter bat





Bullnose: A brick moulded with a rounded angle is termed as a bullnose and it is used for a rounded quoin. A connection which is formed when a wall takes a turn is known as a quoin.

Cownose: A brick moulded with a double bullnose on end is termed as a cownose.

Frog: A frog is a mark of depth about 10 mm to 20 mm which is placed on the face of a brick to form a key for holding the mortar. The wire cut bricks are not provided with frogs. A pressed brick as a rule has frogs on both the faces. A hand- made brick has only one frog.

Racking back: The termination of a wall in a stepped fashion is known as the racking back.

Toothing: The termination of a wall in such a fashion that each alternate course at the end projects is known as the toothing and it is adopted to provide adequate bond, when the wall is continued horizontally at a later stage.

Bond – meaning and necessity: English bond for 1and 1-1/2 Brick thick walls. T, X and right angled corner junctions. Thickness for 1and 1-1/2 brick square pillars in English bond

Bond- meaning and necessity

It is the method of arranging the bricks in courses so that individual units are tied together and the vertical joints of the successive courses do not lie in same vertical line. Bond of various types are distinguished by their elevation or face appearance. Bricks used in masonry are all of uniform size. If they are not arranged (or bonded) properly, continuous vertical joints will result. An unbonded wall, with its continuous vertical joints has little strength and stability. Bonds help in distributing the concentrated loads over a larger area. Since bricks are small units, having uniform dimensions, the process of bonding is easily performed.

Following are the types of bonds provided in brick work:

1. Stretcher bond.
2. Header bond.
3. English bond.
4. Flemish bond.
5. Facing bond.

6. English cross bond.
7. Brick on edge bond.
8. Dutch bond.
9. Raking bond.
10. Zigzag bond.
11. Garden wall bond.

English bond

This is the most commonly used bond, for all wall thicknesses. This bond is considered to be the strongest. The bond consists of alternate courses of headers and stretchers. In this bond, the vertical joints of the header courses come over each other, similarly, the vertical joints of the stretcher courses also come over each other. In order to break the vertical joints in the successive courses, it is essential to place queen closer after the first header (quoin header) in each heading coarse. Following are the essential features of English bond.

1. Alternative courses will show either headers or stretchers in elevation.
2. Every alternate header comes centrally over the joint between two stretchers in course below.
3. In the stretcher course, the stretchers have a min. lap of ¼ th their length over headers.
4. There is no continuous vertical joint.
5. Walls of even multiple of half bricks (i.e. 1 brick thick wall, 2-bricks thick wall, 3-bricks thick wall) present the same appearance on both faces. Thus a course showing stretchers on the front face will also show stretchers on the back face.
6. Wall of odd multiple of half bricks (i.e. 1 ½ brick thick wall, 2 ½ brick thick wall etc.) will show stretchers on one face and headers on the other face.
7. Since the number of vertical joints in the header course are twice the number of vertical joints in the stretcher course, the joint in the header course are made thinner than the joints in the stretcher course.

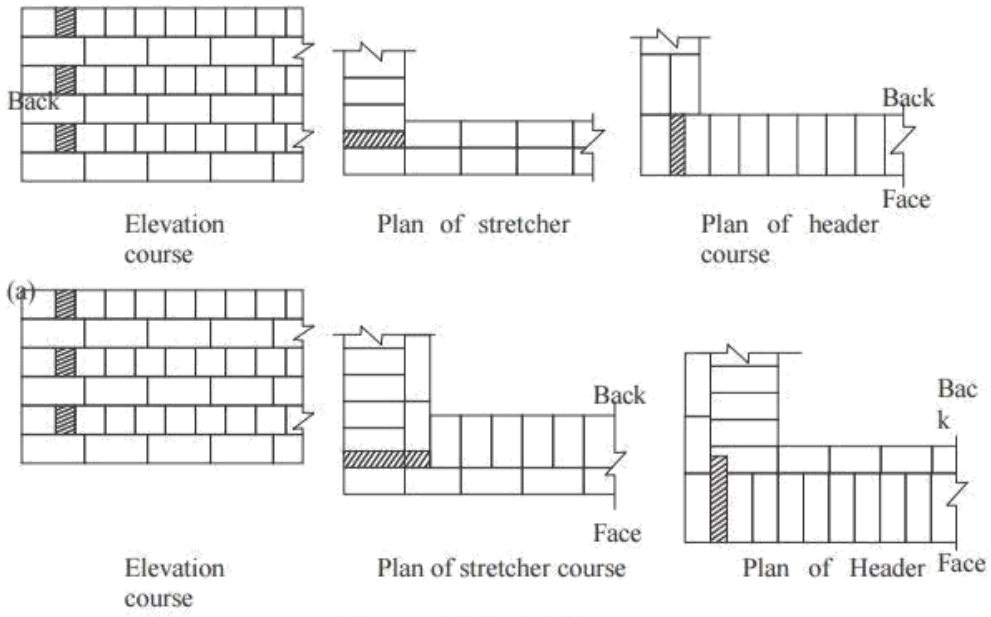


Fig. 2.6.3 English bond

T, X and right angled corner junctions

Junctions: A connection between a main wall and a partition wall is termed as a junction.

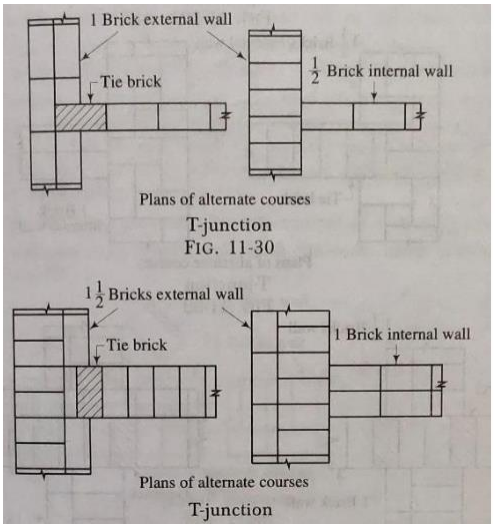
A junction is classified in two categories:

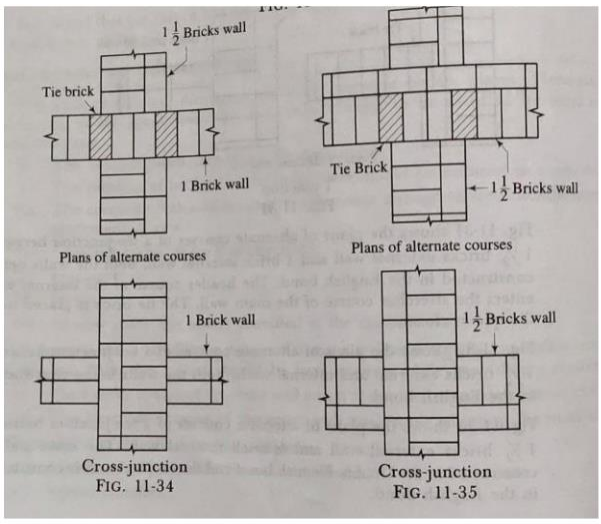
i. Right-angled junction
ii. Squint junction.

a. Tee-junction
b. Cross-junction or intersection.

Tee-junction: This type of right-angled junction forms the shape of the English letter T in plan.

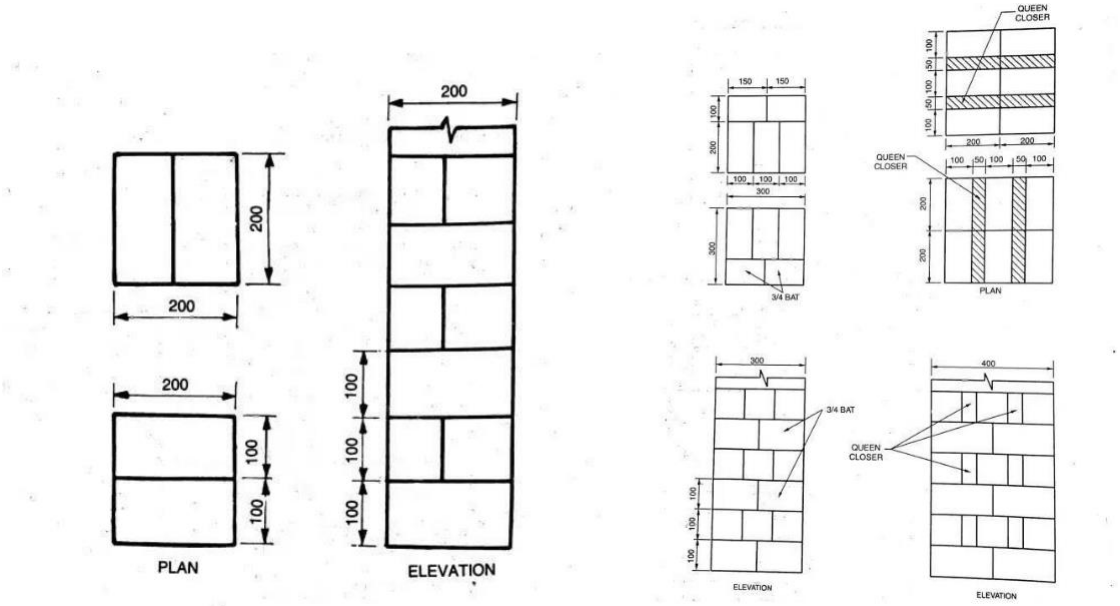
Cross-junction or intersection: When two continuous walls cross or intersect each other, a cross-junction or an intersection.





Thickness for 1and 1-1/2 brick square pillars in English bond

Fig. Shows alternate courses of pillar for various thickness along with their elevation in English Bond



Stone Masonry :

- Masonry may be defined as the construction of building units bonded together with mortar. The building units (commonly known as masonry units) may be stones, bricks or precast blocks of concrete. When stones are used as the building units or building blocks, we have stone masonry.
- Masonry work is one of the major building crafts and one of the oldest. It has built itself great reputation as one of the premier traditional materials of building. Even though new principles of construction and new materials become prominent in building construction practices, masonry has got the highest importance in building industry.
- Masonry is normally used for the construction of foundations, walls, columns and other similar structural components of buildings. The basic advantage of masonry construction lies in the fact that in load-bearing structures, it performs a variety of functions such as
  i. Supporting loads,
  ii. Subdividing space,
  iii. Providing thermal and acoustic insulation,
  iv. Affording fire and weather protection etc,

3.7.Glossary of terms

The meanings, attached to some technical terms used in the masonry, are given below for ready reference.

String course

It is the continuous horizontal course of masonry, projecting from the face of the wall for shedding rain water off the face. It is generally provided at every floor and sill level. A string course breaks the monotony of a plane surface, and thus imparts aesthetic appearance to the structure. The string course is suitably weathered and throated so as to throw off water clear of the wall surface.

Corbel

A corbel is a projecting stone which is usually provided to serve as support for joist, truss, weather shed etc. Corbels are generally moulded and given ornamental treatment. Corbels should extend at least two-thirds of their length into the wall, so that they do not overturn or come out of the wall.

Cornice

It is a projecting ornamental course near the top of a wall or at the junction of wall and the ceiling. It penetrates the full width of the wall. It is weathered and throated to dispose off rain water. In order to prevent overturning of cornice, extra weight in the form of parapet wall should be provided.

Block-in-course

It is another course of stone placed immediately above the cornice. Apart from improving the appearance of the wall, it adds to the stability of the cornice against overturning.

Grouting

The process of filling voids in masonary of stone is known as grouting.

Templates

It is defined as the block of stone or concrete provided under a beam or girder to distribute the concentrated load over a greater area of the bearing surface.

Throating

It is a groove provided on the underside of projecting elements such as sills cornices, copings etc., so that rain water can be discharged clear of the wall surface.

Through stones

A through stone is a stone header. Through stones are placed across the wall at regular interval. If the thickness of the wall is small, through stone may be of length equal to the full width of the wall. If, however the wall is considerably thick, two through stones with an overlap are provided, Through stones should be strong, and non-porous, and should be of sufficient thickness.

Parapet

It is the portion of low height wall constructed along the edge of the roof to protect the users.

Coping

It is a covering of stone, concrete, brick of terracota, placed on the exposed top of a wall, to prevent seepage of water. It may also be provided on the top of compound wall. A coping is suitably weathered and throated.

Pilaster

Pier is an isolated vertical mass of stone or brick masonry to support beams, lintels, arch etc, the width of which exceeds four times its thickness. If it is made monolithic with the wall and projecting a little beyond to support the ends of a beam or truss etc, then it is called a pilaster.

Buttress

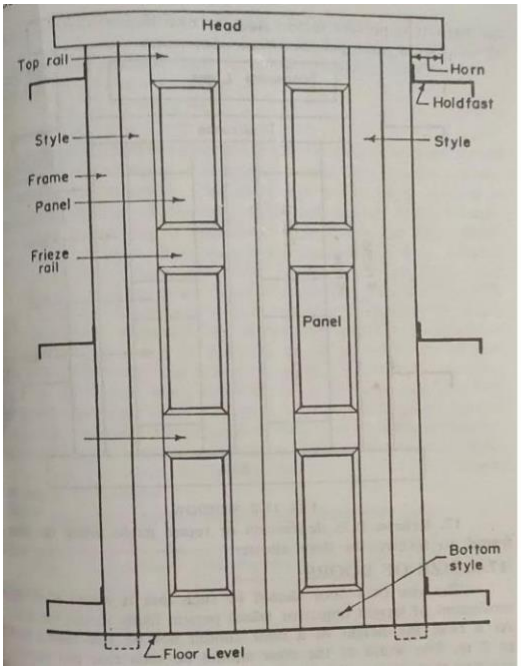
It is a sloping or stepped masonry projection from a tall wall intended to strengthen the wall against the thrust of a roof or arch.

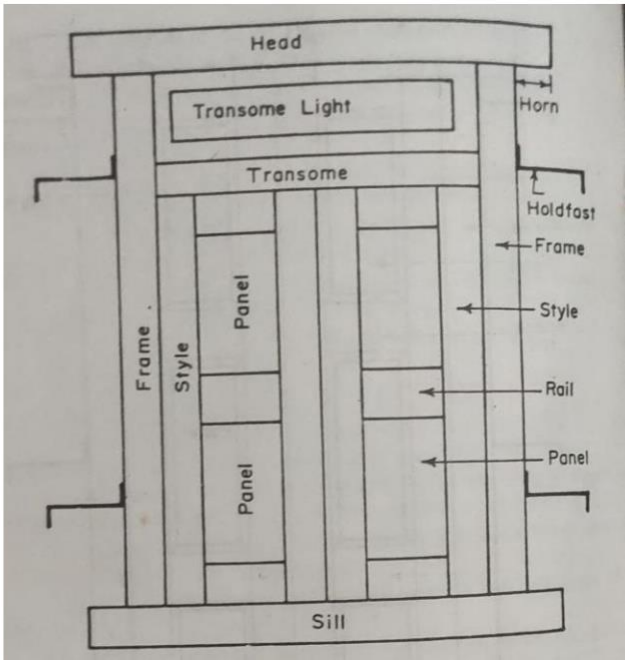
Doors, Windows And Lintels

4.1.Glossary of terms used in doors and windows
4.2.Doors – different types of doors
4.3.Windows – different types of windows
4.4.Purpose of use of arches and lintels

Glossary of terms used in doors and windows

Figs. show respectively a door and a window. The following are the technical terms applied to doors and windows:





1. **Frame**. It is an assembly of horizontal and vertical members, forming an enclosure, to which the shutters are fixed.
2. **Shutters**. These are the openable parts of a door or window. It is an assembly of styles, panels and rails.
3. **Head**. This is the top or uppermost horizontal part of a frame.
4. **Sill**. This is the lowermost or bottom horizontal part of a window frame. Sills are normally not provided in door frames.
5. **Horn**. These are the horizontal projections of the head and sill of a frame to facilitate the fixing of the frame on the wall opening. The length of horns is kept about 10 to 15 cm.
6. **Style**. Style is the vertical outside member of the shutter of a door or window.
7. **Top rail**. This is the top most horizontal member of a shutter.
8. **Lock rail**. This is the middle horizontal member of a door shutter, to which locking arrangement is fixed.
9. **Bottom rail**. This is the lowermost horizontal member of a shutter.
10. **Intermediate or cross-rails**. These are additional horizontal rails, fixed between the top and bottom rails of a shutter. A rail fixed between the top rail and lock rail is called frieze rail.
11. **Panel**. This is the area of shutter enclosed between the adjacent rails.
12. **Mullion**. This is a vertical member of a frame, which is employed to sub-divide a window or a door vertically.

13. **Transom**. This is a horizontal member of a frame, which is employed to sub-divide a window opening horizontally.
14. **Hold fasts**. These are mild steel flats (section 30 mm X 6 mm), generally bent into Z-shape, to fix or hold the frame to the opening. The horizontal length of hold fast is kept about 20 cm, and is embedded in the masonry.
15. **Jamb**. This is the vertical wall face of an opening which supports the frame.
16. **Reveal**. It is the external jamb of a door or window opening at right angles to the wall face.
17. **Rebate**. It is depression or recess made inside the door frame, to receive the door shutter.

Doors – different types of doors

A door may be defined as an openable barrier secured in a wall opening. A door is provided to give as access to the inside of a room of a building. It serves as a connecting link between the various internal portions of a building. Basically, a door consists of two parts:

i. Door frame, and
ii. Door shutter.

The door shutter is held in position by the door frame which in turn is fixed in the opening of the wall by means of hold-fasts etc.

Depending upon the type of materials, arrangement of different components, method of construction, etc., the common types of doors used in the buildings can be grouped as follows:

1. Ledged doors
2. Ledged and braced doors
3. Ledged and framed doors
4. Ledged, framed and braced doors
5. Framed and panelled doors
6. Glazed or sash doors
7. Flush doors
8. Louvered doors
9. Collapsible steel doors
10. Revolving doors
11. Rolling steel doors
12. Sliding doors
13. Swing doors.

Ledged doors

A ledged door is formed of the vertical boards, known as the battens, which are secured by horizontal supports, known as the ledges.

Ledged and braced doors

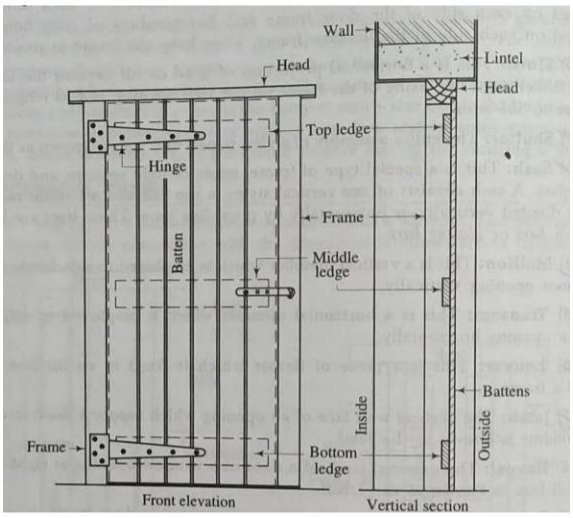
These are similar to the ledged doors except that the diagonal members, known as the braces, are provided as shown.

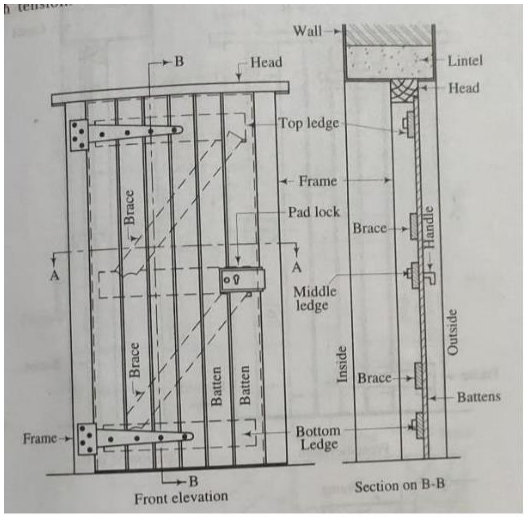
Ledged and framed doors

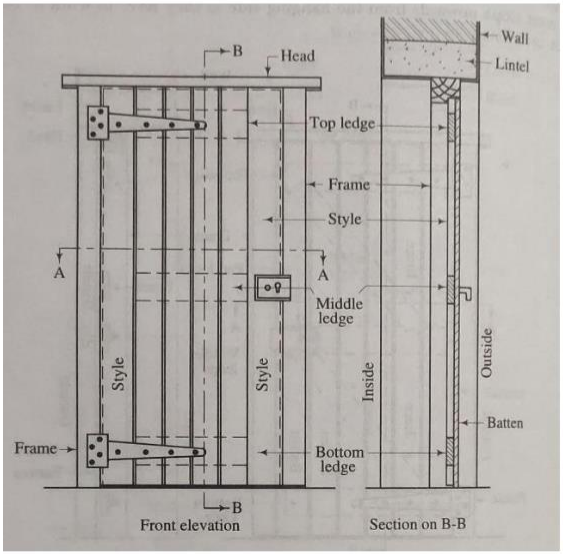
In this type of doors, a framework for shutters is provided to make the doors stronger and better in appearance as shown.

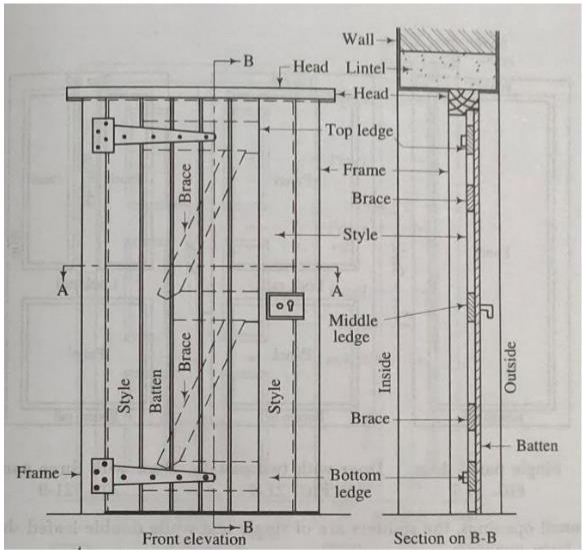
Ledged, framed and braced doors

This is just similar to the above type except that the braces are introduced as shown. This type of door is more durable and stronger and hence it can be adopted for external use.









Framed and panelled doors

This is the most usual variety of door and it consists of a framework in which panels are fitted. This type of door reduces the tendency of shrinkage and presents a decent appearance. The styles are continuous from top to bottom and rails are joined to the styles. The mullions, if any, are joined to rails. The panels are secured in position by grooves made inside the edges of the framework. The number and size of panels depend upon the architect's design or owner's desire. But the number varies from one to six and panels are moulded to add to the beauty of the door.

Glazed or sash doors

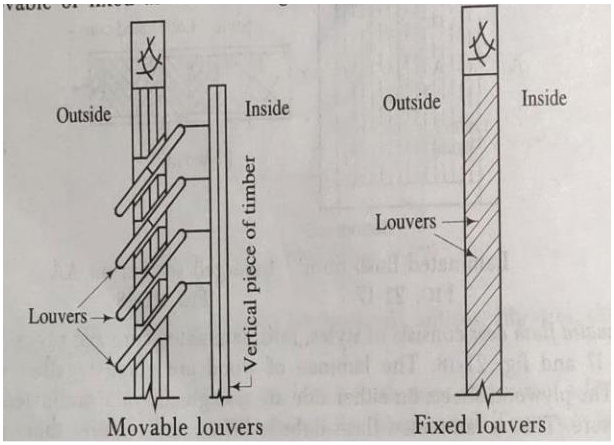
In order to admit more light, in addition to that coming from the windows, the fully glazed or partly panelled and partly glazed doors are used.

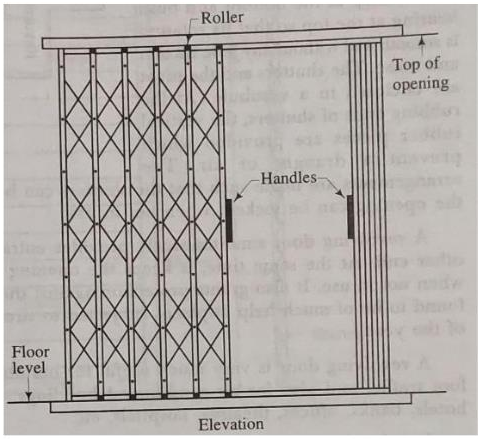
Flush doors

A flush door consists of a framework of rails and styles and it is covered with plywood or hard-board. There are two varieties of flush doors a framed flush door and a laminated flush door.

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 the horizontal vision is obstructed. The louvers may be movable or fixed as shown.





Collapsible steel doors

A collapsible steel door consists of a mild steel frame. The rollers, mounted on horizontal piece, are provided at top and bottom ends of the vertical pieces. The door can be opened or closed manually by a slight pull or push. The door is also provided with handles, locking arrangement, stoppers, etc.

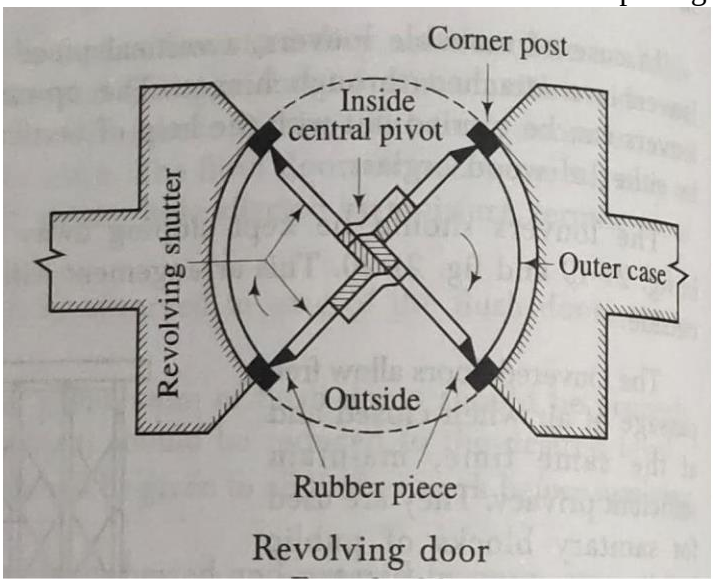
Revolving doors

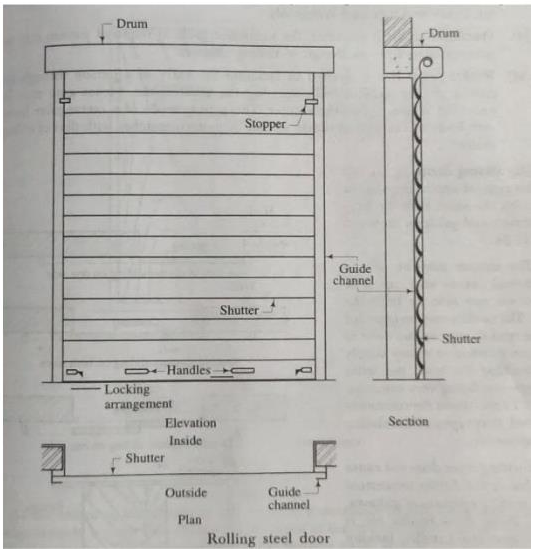
A revolving door essentially consists of a centrally placed mullion or pivot in a circular opening. The revolving shutters or leaves which are four in number are radially attached to the pivote as shown. A revolving door simultaneously provides entrance on one side and exit on the other end.

Rolling steel doors

A rolling steel door consists of a frame, a drum and a shutter of thin steel plates or iron sheets of thickness about 1 mm, as shown. The shutter usually rolls in turns. Thus a slight pull or push will close or open the shutter.

The rolling steel doors are sufficiently strong and as they can be easily rolled up at the top, they cause no obstruction to the floor as well as the opening.





Sliding doors

In this type of doors, the shutter slides on the sides with the help of runners and guide. The shutter may be of one or several leaves and can slide either on one side or both the sides. The cavities may be provided in the wall to receive the door in an open position or it may simply lie touching the wall.

Swing doors

A swing door is provided with special hinges known as the double action spring hinges and thus the shutters of the door are held in closed position, when the door is not in use. The shutter may be of one or several leaves. When the door is to be used, a slight push is made and then the action of spring brings the shutter in closed position.

Windows – different types of windows

A window is also a vented barrier secured in a wall opening. The function of the window is to admit light and air to the building and to give a view to the outside. Windows must also provide insulation against heat loss, and in some cases, against sound. Some windows are also required to give a measure of resistance to fire. A window also consists of two parts:

i. Window frame, secured to the wall opening with the help of hold fasts, and
ii. Window shutters held position by the window frame.

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

1. Casement windows
2. Double-hung windows
3. Pivoted windows
4. Sliding windows
5. Louvered windows
6. Sash or glazed windows
7. Metal windows
8. Circular windows
9. Corner windows
10. Gable windows
11. Dormer windows
12. Bay windows
13. Clerestorey windows
14. Lanterns or lantern lights
15. 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 and it consists of a frame, styles, rails, vertical and horizontal sash bars and sometimes, it also includes mullions and transoms.

Double-hung windows

These windows consist of a pair of shutters which can slide within the grooves provided in the frame. A pair of metal weights connected by cord or chain over pulleys is provided for each sash. It is so arranged that the upper sash moves in the downward direction, thus opening at the top and the lower sash moves in the upward direction, thus opening at the bottom.

Pivoted windows

In this type of windows, the shutters are allowed to swing round the pivots. The frame of a pivoted window is just similar to casement window except that no rebates are provided. The windows may be vertically pivoted or horizontally pivoted. The pivoted windows are easy to clean and they admit more light than the side-hung windows.

Sliding windows

These windows are similar to the sliding doors and the shutters move on the roller bearings, either horizontally or vertically. Suitable openings are provided in the walls to receive the shutters when windows are opened out.

Louvered windows

In this type of windows, the louvers are provided as in case of louvered doors. They allow free passage of air when closed and at the same time, they maintain sufficient privacy.

Sash or glazed windows

These are fully glazed casement windows. The sashes are rebated to receive glass panels.

Metal windows

These are now-a-days widely used, especially for public buildings. The metal used in the construction may be mild steel, bronze or other alloys. The steel windows are manufactured in standard sizes and are widely used.

Circular windows

These are pivoted windows of circular shape. They are useful for factories, workshops, etc.

Corner windows

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

Gable windows

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

Dormer windows

These are the windows provided on the sloping roofs. The main purpose of providing dormer windows is to admit light and air to rooms which are constructed within or below the roof slopes.

Bay windows

These windows project outside the external walls of a room. They may be square, splayed, circular, polygonal or of any shape. These windows admit more light, increase opening area, provide ventilation and improve the appearance of the building.

Clerestorey windows

These windows are provided near the top of main roof. The pivoted windows are used for this purpose. The clerestorey windows provide ventilation to the inside of the room as the front is blocked by the verandah. They also improve the appearance of building. The care should be taken to see that the upper part opens inside and the lower part opens outside. Otherwise the rain water will accumulate in the room.

Lanterns or lantern lights

These are the windows which are fixed on flat roofs to provide light to the inner portion of the building where light coming from the windows in the external walls is insufficient. They may be square or rectangular or curved. The glass panels are generally fixed. But if ventilation is also required in addition to light, the pivoted windows may be provided.

Skylights

These are the windows which are provided on the sloping surface of a pitched roof. As skylights are mainly meant for light, they are usually provided with the fixed glass panels. The opening of skylight is properly treated by lead flashing to make water proof the roof area surrounding the opening.

Purpose of use of arches and lintels

The openings for doors, windows, ventilators, cupboards, wardrobes, etc., are invariably required in a wall. These openings are bridged by the provision of either an arch or a lintel. Thus the arch as well as the lintel are structural members which are designed to support the loads of the portion of wall above the openings and to transmit such loads to the ends of walls or piers or jambs or columns over which they are supported.

A lintel is a horizontal member which is placed across an opening to support the portion of the structure above it. The function of a lintel is just the same as that of an arch or a beam. However the lintels are easy and simple in construction. The ends of lintels are built into the masonry and thus the load carried by lintels is transferred to the masonry in jambs. At present, the lintels of R.C.C. are widely used to span the openings for doors, windows, etc. in a structure. Arch and lintel are provided above doors, windows and passages. The function of an arch and a lintel is to carry the weight of the structure above the opening.

Floors, Roofs and Stairs

Floors: Glossary of terms ,Types of floor finishes – cast-in-situ, concrete flooring(monolithic, bonded), terrazzo tile flooring, cast in situ Terrazzo flooring, timber flooring (Concept only)

Roofs: Glossary of terms, Types of roofs, concept and function of flat, pitched, hipped and Sloped roofs

Stairs: Glossary of terms; Stair case, winder, landing, stringer, newel, baluster, rise, tread, width of stair case, hand rail, nosing, head room, mumty room.

Various types of stair case – straight flight, dog legged, open well, quarter turn, half turn (newel and geometrical stairs), bifurcated stair, spiral stair, cantilever stair, tread riser stair.

Floors: Glossary of terms ,Types of floor finishes – cast-in-situ, concrete flooring(monolithic, bonded), terrazzo tile flooring, cast in situ Terrazzo flooring, timber flooring (Concept only)

The purpose of a floor is to provide a level surface capable of supporting the occupants of a building, furniture, equipment and sometimes, internal partitions. To perform this function, and in addition, others which may vary according to the situation of the floor in the building and the nature of the building itself, a floor must satisfy the following requirements:

i. Adequate strength and stability
ii. Adequate fire resistance.
iii. Sound insulation
iv. Damp resistance
v. Thermal insulation.

The floors resting directly on the ground surface are known as ground floors, while the other floors of each storey, situated above the ground level are known as upper floors.

Glossary of terms

A floor is composed of two essential components:

i. Sub-floor, base course or floor base
ii. Floor covering, or simply, flooring.

The floor base is a structural component, which supports the floor covering. For the ground floors, the object of floor base is to give proper support to the covering so that it does not settle, and to provide damp resistance and thermal insulation.

When you look at your floors, you may only think of the one layer that you see. Like the ground you stand on, there are several layers underneath the top one that ensures the stability and function of your floor.

Joists

At the very bottom of the layers that make up your floors is what we call joists. Think of these as the bones of your flooring. They are used to frame the layer that will sit upon your home's foundation. It's crucial that joists are installed correctly because if not, it will result in a great deal of noise, squeaking, and shifting when you walk on your floors.

Subfloor

After the joists, you'll find the subfloor. This is the solid base that your floor will stand on and will support the floor covering. The subfloor is most often constructed with concrete. It's crucial that the subfloor has room to breathe, as in expanding and contracting over the years to make your floor function properly.

Underlayment

On top of the subfloor is the underlayment. The underlayment is installed for noise control because it softens any noise that will result from someone walking on the floor. Not only is it installed for noise cancellation, but underlayment gives the floor covering a smooth surface to sit on. Most often made of foam or cork, underlayment is required for "floating" floors such as laminate or engineered wood. These floors are not attached to the subfloor so they "float" on top.

Floor Covering

The last part of your flooring is the top layer called the floor covering. Floor coverings come in a variety of materials and styles. They can be hardwood, tile, stone, carpet, vinyl, or laminate. This is what you think of when you think of floors.

Adhesive

Floor coverings are often secured to subfloor or underlayment depending on the material. With tile, thinset is used to adhere the tiles to the subfloor. Thinset will need to be expertly removed when looking to install new flooring where the tile was once installed.

Types of floor finishes

Concrete flooring

This is commonly used for residential, commercial and even industrial building, since it is moderately cheap, quite durable and easy to construct. The floor consists of two components:

- Base concrete, and
- Topping or wearing surface.

The two components of the floor can be constructed either monolithically (i.e. topping laid immediately after the base course is laid) or non-monolithically. When the floor is laid monolithically, good bond between the two components is obtained resulting in smaller over all thickness. However, such a construction has three disadvantages:

- The topping is damaged during subsequent operations,
- Hair cracks are developed because of the settlement of freshly laid base course which has not set, and
- Work progress is slow because the workman has to wait at least till the initial setting of the base course.

Hence in most of the cases, non-monolithic construction is preferred:

The base course may be 7.5 to 10 cm thick, either in lean cement concrete (1:3:6 to 1:5:10) or lime concrete containing 40% mortar of 1:2 lime-sand (or 1 lime : 1 surkhi: 1 sand) and 60% coarse aggregate of 40 mm nominal size. The base course is laid over well-compacted soil, compacted properly and levelled to rough surface. It is properly cured.

Terrazzo flooring

Terrazzo flooring is another type of floor finish that is laid in thin layer over concrete topping. It is very decorative and has good wearing properties. Due to this, it is widely used in residential buildings, hospitals, offices, schools and other public buildings. Terrazzo is a specially prepared concrete surface containing cement (white or grey) and marble chips (of different colours), in proportion to 1:1$\frac{1}{2}$ to 1:2. When the surface has set, the chips are exposed by grinding operation.

Marble chips may vary from 3 mm to 6 mm size. Colour can be mixed to white cement to set desired tint. The flooring is, however, more expensive.

Timber flooring

Timber flooring is used for carpentry halls, dancing halls, auditoriums, etc. They are not commonly used in residential buildings in India, because timber flooring is also quite costlier. However, in hilly areas, where timber is cheaply and readily available, and where temperature drop very low, timber flooring is quite common. One of the major problems in timber flooring is the damp prevention. This can be done by introducing D.P.C. layer below the flooring.

Roofs: Glossary of terms, Types of roofs, concept and function of flat, pitched, hipped and Sloped roofs

A roof may be defined as the uppermost part of the building, provided as a structural covering, to protect the building from weather (i.e. from rain, sun, wind, etc.). Structurally, a roof is constructed in the same way as an upper floor, though the shape of its upper surface may be different. Basically, a roof consists of structural elements which support roof coverings. The structural element may be trusses, portals, beams, slabs (with or without beams), shells or domes. The roof coverings may be A.C. sheets, G.I. sheets, wooden shingle, tiles, slates or slab itself.

Types of roofs

Roofs may be divided into three categories:

1. Pitched or sloping roofs,
2. Flat roofs or terraced roofs, and
3. Curved roofs.

The selection of the type of roof depends upon the shape or plan of the building, climatic conditions of the area and type of constructional materials available. Pitched roofs have sloping top surface. These are suitable in those areas where rainfall/snowfall is very heavy. Flat roofs are considered suitable for buildings in plains or in hot regions, where rainfall is moderate, and where snowfall is not there. Flat roofs are equally applicable to buildings of any shape and size. Curved roofs have their top surface curved. Such roofs are provided to give architectural effects. Such roofs are more suitable for public buildings like libraries, theatres, recreation centres etc.

Pitched or Sloped roofs

A roof with sloping surface is known as a pitched roof. Pitched roofs are basically of the following forms:

1. Lean-to-roof
2. Gable roof
3. Hip roof
4. Gambrel roof
5. Mansard or curb roof
6. Deck roof.

Lean-to-roof: This is the simplest type of sloping roof, provided either for a room of small span, or for the verandah. It has slope only one side (Fig. 15.1 a).

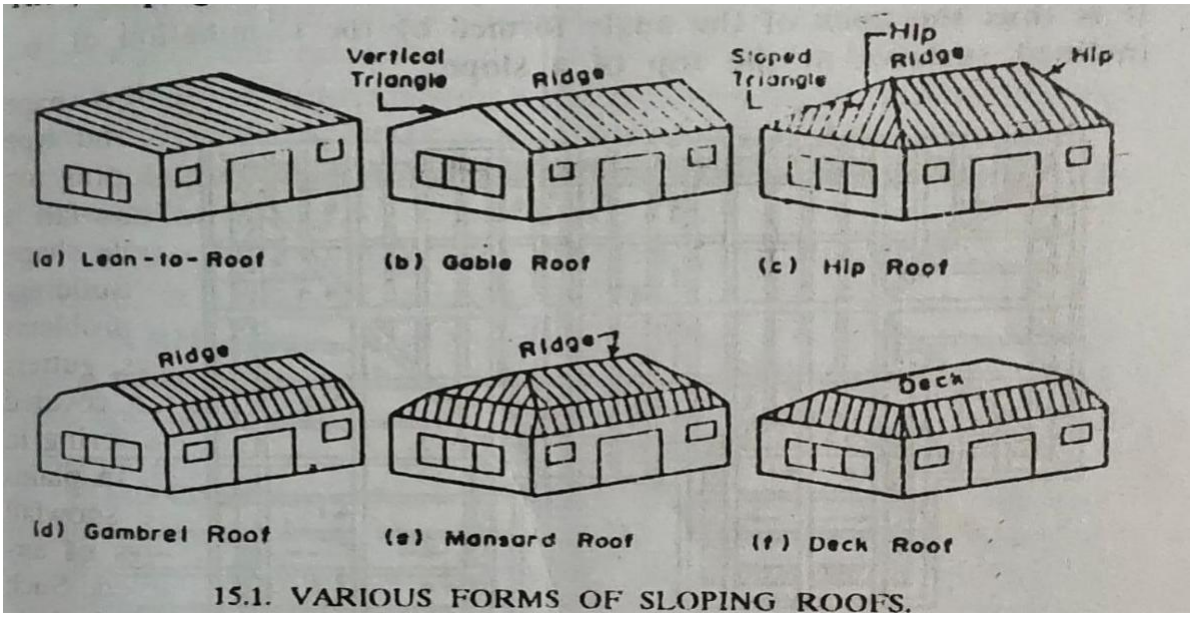
Gable roof: This is the common type of sloping roof which slopes in two directions. The two slopes meet at the ridge. At the end face, a vertical triangle if formed (Fig. 15.1 b).

Hip roof: This roof is formed by four sloping surfaces in four directions (Fig. 15.1c). At the end faces, sloped triangles are formed.

Gambrel roof: This roof, like gable roof, slopes in two directions, but there is a break in each slope, as shown in Fig. 15.1(d). At each end, vertical face is formed.

Mansard roof: Mansard roof, like a hip roof, slopes in the four directions, but each slope has a break, as shown in Fig. 15.1(e). Thus, sloping ends are obtained.

Deck roof: A deck roof has slopes in all the four directions, like a hip roof, but a deck or plane surface is formed at the top, as shown in Fig. 15.1 (f).



15.1. VARIOUS FORMS OF SLOPING ROOFS.

Glossary of terms

Barge boards: These are the wooden planks or boards which are fixed on the gable end of a roof as shown in fig. 24-1. They connect the ends of ridge, purlins and wall-plates.

Battens: These are the thin strips of wood which are fixed on the rafters or ceiling as shown in fig. 24-2. They support the roof ceiling.

Cleats: These are small blocks of wood which are fixed on the trusses to prevent the sliding of purlins as shown in fig. 24-2.

Dragon beam: The lower end of a hip rafter is generally supported on a diagonal piece of wood which is laid across the corner of the wall. This diagonal piece is known as a dragon beam or a dragon tie or an angle tie.

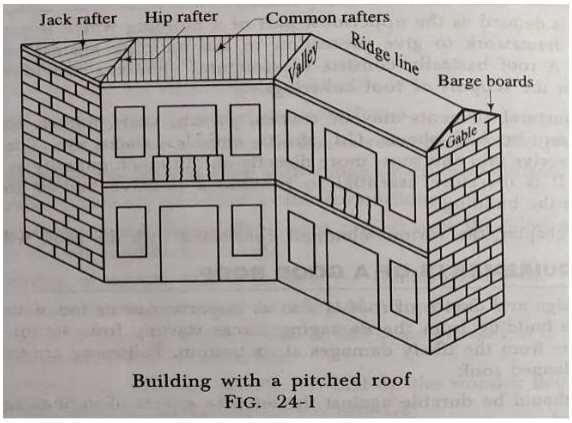
Eaves: The lower edges of a roof which are resting upon or projecting beyond the supporting walls are known as the eaves. Sometimes a thin board of wood is provided at the eaves to cover the ends of the common rafters. Such a board is known as an eaves board or facia board as shown in fig. 24-2. It is usually 25 mm thick and 250 mm wide.

Gable: The triangular upper part of a wall formed at the end of a pitched roof is known as a gable as shown in fig. 24-1.

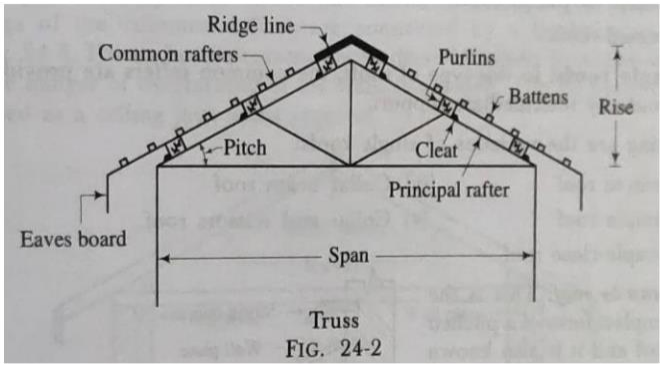
Hip: The angle formed at the intersection of two roof slopes is known as the hip.

Pitch: The inclination of sides of a roof to the horizontal plane is known as the pitch and it can be expressed either in terms of degrees or as a ratio of rise to span.

Purlins: The wooden pieces which are placed horizontally on principal rafters to carry the common rafters are known as the purlins as shown in fig. 24-2.



Building with a pitched roof
FIG. 24-1



Truss
FIG. 24-2

Rafters: These are the pieces of timber which extend from the eaves to the ridge. Following are the various types of rafters:

i. **Common rafters**: These are the intermediate rafters which give support to the roof covering as shown in fig. 24-1 and fig. 24-2.

ii. **Hip rafters**: These are the rafters which are provided at the junction of two roof slopes as shown in fig. 24-1.

iii. **Jack rafters**: Any rafter which is shorter than a common rafter is known as a jack rafter as shown in fig. 24-1.

iv. **Principal rafters**: These are the inclined members of a truss as shown in fig. 24-2.

Ridge: A wooden piece provided at the ridge line of a sloping roof is known as the ridge or ridge board or ridge piece.

The common rafters are attached to the ridge. A ridge line indicates the apex line of a sloping roof as shown in fig. 24-1 and fig. 24-2.

Span: The horizontal distance between the internal faces of walls or supports is known as a span or a clear span as shown in fig. 24-2. The effective span indicates the horizontal distance between the centres of wall or supports.

Template: A bedding block is generally provided at the end of a truss. This block is known as a template and it helps in spreading the load over a large area. A template may be of wood or stone or R.C.C.

Truss: The framework, usually of triangles and designed to support the roof covering or ceiling over rooms, is known as a roof truss.

Verge: The edge of a gable, running between the eaves and ridge, is known as a verge.

Valley: When two roof surfaces meet together and form an internal angle, a valley is formed as shown in fig. 24-1.

Wall-plates: These are the long wooden members which are embedded on top of walls to receive the common rafters. They actually connect the walls to the roof.

Flat terraced roofs

Flat roof is the one which is either horizontal, or practically horizontal with slope less than 10°. Even a perfectly horizontal roof has to have some slope at top so that rain water can be drained off easily and rapidly. Similar to the upper floor, the flat roofs can be constructed of flag stones, R.S.J.

and flag stones, reinforced cement concrete, reinforced brick work, jack arch roof or precast cement concrete units. However, the flat roof differ from the upper floor only from the point of view of top finish, commonly called terracing, to protect it from adverse effects of rain, snow, heat etc.

Stairs: Glossary of terms; Stair case, winder, landing, stringer, newel, baluster, rise, tread, width of stair case, hand rail, nosing, head room, mumty room.

Stair case

A stair is a set of steps leading from one floor to the other. It is provided to afford the means of ascent and descent between various floors of a building. The room or enclosure of the building, in which the stair is located is known as stair-case.

Winder

This is a tapering step and it is used to change the direction of a flight. The winders radiate from a common centre.

Landing

The horizontal platform between two flights of a stair is known as the landing. A landing facilitates change of direction and provides an opportunity for taking rest during the use of a stair.

Stringer

These are the sloping members which support the steps in a stair. They run along the slop of the stair.

Newel post

This is the vertical member which is placed at the ends of flights to connect the ends of strings and handrails

Baluster

This is the vertical member which is fixed between string and handrail to give support to the handrail

Rise

This is the vertical distance between two successive treads.

Tread

The horizontal upper portion of a step is known as a tread.

Width of stair case

Staircase width refers to the side-to-side distance if you were walking up or down the stairs. **Hand rail**

The inclined rail over the string is known as a handrail. The handrail serves as a guard rail and it should be provided at a convenient height so as to give grasp to the hand during ascent and descent.

Nosing

The projecting part of the tread beyond the face of riser is known as a nosing. It is usually rounded off from architectural considerations.

Head room

The vertical distance between the nosing of one flight and the bottom of flight immediately above is known as the headroom and it should be of sufficient value so as not to cause any difficulty to the persons using the stair.

Mumty room

A small room with only one purpose; to provide a roof over staircase.

Various types of stair case – straight flight, dog legged, open well, quarter turn, half turn (newel and geometrical stairs), bifurcated stair, spiral stair, cantilever stair, tread riser stair.

Stairs can be classified in two broad heads:

1. Straight stairs
2. Turning stairs
    i. Quarter turn stairs
    ii. Half turn stairs (dog-legged and open well stairs
    iii. Three-quarter turn stairs
    iv. Bifurcated stairs.

a. Newel stairs
b. Well or open-newel stairs, and
c. Geometrical stairs

1. Straight stairs

In this type, the stair runs straight between the two floors. It is used for small houses where there are restrictions in available width. The stair may consist of either one single flight or more than one flight (usually two) with a landing,

2. Quarter turn stairs

A quarter turn stair is the one which changes its direction either to the left or to the right, the turn being affected either by introducing a quarter space landing or by providing winders. Quarter turn stairs are of two types:

a. Newel quarter turn stairs
b. Geometrical quarter turn stairs.

Newel quarter turn stairs

These stairs have the conspicuous newel posts at the beginning and end of each flight. At the quarter turn, there may either be quarter space landing or there may be winders.

Geometrical quarter turn stairs

In geometrical stairs, the stringer as well as the hand rail is continuous, with no newel post at the landing.

3. Half turn stairs

Half turn stair is the one which has its direction reversed, or changed for 180°. Such stairs are quite common. These may be of three types :

a. Dog-legged or newel half turn stairs.
b. Open newel half turn stairs.
c. Geometrical half turn stairs.

Dog-legged stairs

This name is given because of its appearance in sectional elevation. The flights run in opposite directions and there is no space between them in plan. These stairs are useful where total width of space available for the staircase is equal to twice the width of steps.

Open newel half turn stair

Open well or open newel half turn stair has a space or well between the outer strings. This is the only aspect in which it differs from the dog-legged stair. The additional width is required between

the two flights; the space between the two strings may vary from 15 cm (min) to 100 cm. When the space left is more, a small flight containing two to four steps may be introduced at the turn, between the two quarter space landings. Otherwise, for small width well, a half space landing may be provided.

Geometrical half turn stairs

The essential features of such stairs are that the stringers and the hand rails are continuous, without any intervening newel post. These may be either with half-space landing or without landing.

4. Bifurcated stairs

This type of stair is commonly used in public building at their entrance hall. The stair has a wider flight at the bottom, which bifurcates into two narrower flights, one turning to the left and the other to the right, at the landing. It may be either of newel type with a newel or of geometrical type, with continuous stringer and rails.

5. Spiral stair

Such a stair is usually made either of R.C.C. or metal, and is employed at a location where there are limitations. These are also used as emergency stairs, and are provided at the back side of a building. All the steps are winders. The stair is, therefore, not comfortable.

6. Cantilever tread slab steps

In this type, the steps are formed by treads only, made of thick stone slabs, without any riser. The tread slab is fixed at one end into the wall, and acts as cantilever. The steps may either be rectangular or triangularly shaped.

7. Slab tread and riser steps

In this type, flag stone slabs are used as tread and risers. The stone slab risers and treads may be connected through dowels. The thickness of the stone slabs may vary from 5 cm to 8 cm.

Protective, Decorative Finishes, Damp and Termite Proofing

Plastering – purpose – Types of plastering, Types of plaster finishes – Grit finish, rough cast, smooth cast, sand faced, pebble dash, acoustic plastering and plain plaster etc. Proportion of mortars used for different plasters, preparation of mortars, techniques of plastering and curing.

Pointing – purpose –Types of pointing.

Painting – objectives – method of painting new and old wall surfaces, wood surface and metalsurfaces – powder coating and spray painting on metal surfaces.

White washing – Colour washing – Distempering – internal and external walls.

6.6.Damp and Termite proofing – Materials and Methods.

Plastering – purpose – Types of plastering, Types of plaster finishes – Grit finish, rough cast, smooth cast, sand faced, pebble dash, acoustic plastering and plain plaster etc.

Plastering

Plastering is the process of covering rough surfaces of walls, columns, ceilings and other building components with thin coat of plastic mortars to form a smooth durable surface. The coating of plastic material (i.e. mortar) is termed as plaster. Plastering on external exposed surfaces is known as rendering,

Purpose

Plastering is done to achieve the following objects:

1. To protect the external surfaces against penetration of rain water and other atmospheric agencies.
2. To give smooth surface in which dust and dirt cannot lodge.
3. To give decorative effect.
4. To conceal inferior materials or defective workmanship.

Types of plastering

There are different types of plasters available such as

- Lime mortar
- Cement mortar
- Lime cement mortar

Lime mortar

The lime mortar consists of equal volumes of lime and sand, and these two materials are carefully ground in a mortar mill. The fat lime is recommended for plaster work because the fat lime contains 75% of CaO and it combines with CO_2 of atmosphere and gives $CaCO_3$ quickly. Thus, the lime sets quickly, but it imparts low strength and hence, it can be used only for plaster work. The hydraulic lime contains particles which slake slowly as they come in contact with atmosphere. This results into blisters on the surface known as the blowing. The sand to be used for preparing lime mortar for plastering work should be clean, coarse and free from any organic impurities.

Cement mortar

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

Lime cement mortar

Lime-cement mortar contains properties of both the lime mortar as well as cement mortar. Cement mortar as such does not possess sufficient plasticity. Addition of lime to it imparts plasticity, resulting in smooth plastered surface. Mix proportions generally used are 1:1:6 (cement : lime : sand), 1:1:8 or 1: 2: 8. Generally, fat lime is used.

Types of plaster finishes

Plastered surface may be finished in the following varieties:

1. **Smooth cast finish**. In this finish, smooth, levelled surface is obtained. The mortar for the finish may be made of cement and fine sand in the ratio of 1: 3. Mortar is applied with the help of wooden float. Steel floats are not recommended for external renderings since they give a very smooth finish which is liable to cracking and crazing under exposure to atmospheric conditions.
2. **Sand faced finish**. This is obtained by plastering in two coats. The first coat is applied in 1: 4 cement sand mortar for 12 mm thickness. It is provided with zig-zag lines. After curing it for 7 days, the second coat is applied in the thickness of 8 mm. The mortar for the second coat is prepared from cement sand mix ratio 1 : 1. The sand for this is perfectly screened so that uniform size is obtained. Sponge is used in the second coat when it is still wet. The surface of final coat is finished by rubbing clean and washed sand of uniform size by means of wooden float. This results in the surface having sand grains of equal and uniform density.
3. **Rough cast finish or spatter dash finish**. In this, the mortar for the final coat contains fine sand as well as coarse aggregate in the ratio of 1:1.5: 3 (cement : sand : aggregate). The coarse aggregate may vary from 3 mm to 12 mm in size. The mortar is dashed against the prepared plastered surface by means of large trowel. The surface is then roughly finished using a wooden float. Such a finish is water proof, durable and resistant to racking and crazing, and may be used for external renderings.
4. **Pebble dash or dry dash finish**. In this the final coat, having cement : sand mix proportion of 1 : 3 is applied in 12 mm thickness. Clean pebbles of size varying from 10 to 20 mm size are then dashed against the surface, so that they are held in position. The pebbles may be lightly pressed into the mortar, with the help of wooden float.
5. **Depeter finish**. This is similar to pebble dash finish in which the 12 mm coat is applied and while it is still wet, the pieces of gravel or flint are pressed with hand on the surface. Flints of different colours may be used to obtain beautiful patterns.
6. **Scrapped finish**. In this, the final coat of 6 to 12 mm thick is applied and after it has stiffened for few hours, the surface is scrapped in patterns for a depth of 3 mm. For scrapping, steel straight edge, old saw blade or such other tool may be used. Such scrapped surface is less liable to cracks.
7. **Textured finish**. This is used with stucco plastering. Ornamental patterns or textured surfaces are made on the final coat of stucco plastering, by working with suitable tools.
8. **Acoustic plaster**. This contains gypsum mixtures applied as final coat in finishing the plastered surface. Such a coat undergoes chemical reaction resulting in production of gas bubbles and consequent formation of tiny openings in the coat. These honey-combed minute openings absorb sound. Such plaster is useful in the interior walls of halls, auditoriums etc. The plaster is applied in two coats each of 6 mm thickness, using wooden float.

Proportion of mortars used for different plasters, preparation of mortars, techniques of plastering and curing.

Proportion of mortars used for different plasters

Mix Ratio of Mortar	General Usage Recommended
1:3	Very rich mortar mix. Not recommended for general usage at sites. Can act as a repair mortar with a waterproofing/bonding agent
1:4	For External Plaster and for ceiling plaster
1:5	Brickwork Mortar and for Internal plaster (If sand is not fine Fineness Modulas > 3)
1:6	For Internal Plaster (if fine sand is available)

Preparation of mortars

Mortar is mixed on-site in a mechanical mixer but can be mixed in smaller amounts by hand, using a hoe and a mixing tub or wheelbarrow.

1. Use a dry bucket to measure out the materials.
2. Pre-wet mortar containers before filling them with fresh mortar.
3. Prepare a container with a flat, solid surface base and tall sides for mixing mortar, if mixing by hand.
4. Add the masonry cement, lime, and sand in the appropriate amounts to your mixing container, then add water on top of the dry ingredients.
5. Fold the mortar mix from the bottom into the water, when mixing by hand. Keep mixing until the water is mixed in. Then, add more water and keep mixing. Keep adding water until the mortar attains a smooth consistency.
6. Stop mixing when the mortar is wet enough to slip easily off the shovel but holds its shape if you make a hollow in the mix. Mortar has attained the correct viscosity when you can make a few ledges in the mortar mix and ledges stand up.

Techniques of plastering and curing

Preparation of Surface for Plastering

1. Keep all the mortar joints of wall rough, so as to give a good bonding to hold plaster.
2. Roughen the entire wall to be plastered.
3. Clean all the joints and surfaces of the wall with a wire brush, there should be no oil or grease etc. left on wall surface.
4. If there exist any cavities or holes on the surface, then fill it in advance with appropriate material.
5. If the surface is smooth or the wall to be plastered is old one, then rake out the mortar joint to a depth of at least 12 mm to give a better bonding to the plaster.
6. Wash the mortar joints and entire wall to be plastered, and keep it wet for at least 6 hours before applying cement plaster.
7. If the projection on the wall surface is more than 12 mm, then knock it off, so as to obtain a uniform surface of wall. This will reduce the consumption of plaster.

1. In order to get uniform thickness of plastering throughout the wall surface, first fix *dots* on the wall. A dot means patch of plaster of size 15 mm * 15 mm and having thickness of about 10 mm.

2. Dots are fixed on the wall first horizontally and then vertically at a distance of about 2 meters covering the entire wall surface.
3. Check the verticality of dots, one over the other, by means of plumb-bob.
4. After fixing dots, the vertical strips of plaster, known as *screeds*, are formed in between the dots. These screeds serve as the gauges for maintaining even thickness of plastering being applied.

1. In case of brick masonry the thickness of first coat plaster is in general 12 mm and in case of concrete masonry this thickness varies from 9 to 15 mm.
2. The ratio of cement and sand for first coat plaster varies from 1:3 to 1:6.
3. Apply the first coat of plaster between the spaces formed by the screeds on the wall surface. This is done by means of trowel.
4. Level the surface by means of flat wooden floats and wooden straight edges.
5. After leveling, left the first coat to set but not to dry and then roughen it with a scratching tool to form a key to the second coat of plaster.

1. After completion of the plastering work, it is kept wet by sprinkling water for at least 7 days in order to develop strength and hardness.
2. Use of gunny bags or other materials is used to keep the plastering works wet in external works.
3. Improper curing may lead to cracks formation or efflorescence in plaster work.

Pointing – purpose –Types of pointing.

The term pointing is used to denote the finishing of mortar joints of either stone masonry or brick masonry. The joints are raked out to a depth of about 20 mm and then, these spaces are filled up by suitable mortar in the desired shape.

Following are the main objects for providing pointing and plastering to the exposed surfaces:

- To improve the appearance of the structure as a whole and to give smooth surface.
- To protect the exposed surfaces from the effects of atmospheric actions.
- To rectify the defective workmanship or to conceal inferior materials.

Types of pointing

Pointing is carried out in the following common shapes:

1. Flush pointing (Fig. 19.3 a)

This type of pointing is formed by pressing mortar in the raked joint and by finishing off flush with the edge of masonry units. The edges are neatly trimmed with trowel and straight edge. It does not give good appearance. However, the pointing is more durable since it does not provide any space for the accumulation of dust, water, etc. Due to this reason, flush pointing is extensively used.

2. Recessed pointing (Fig. 19.3 b)

The pointing is done by pressing the mortar back from the edges by 5 mm or more. The face of the pointing is kept vertical, by a suitable tool. The pointing gives very good appearance.

3. Rubbed, keyed or grooved pointing (Fig. 19.3 c)

This pointing is a modification of flush pointing by forming a groove at its mid height, by a pointing tool. It gives better appearance.

4. Beaded pointing (Fig. 19.3 d)

This is the special type of pointing formed by a steel or ironed with a concave edge. It gives good appearance, but is liable to damage easily.

5. Struck pointing (Fig. 19.3 e)

This is a modification of flush pointing in which the face of the pointing is kept inclined, with its upper edge pressed inside the face by 10 mm. This pointing drains water easily.

6. Tuck pointing (Fig. 19.3 S).

The pointing is formed by first pressing the mortar in the racked joint and finishing flush with the face. While the pressed mortar is green, groove or narrow channel, having 5 mm width and 3 mm depth is cut in the centre of the groove. This groove is then filled in or tucked in with white cement putty, kept projecting beyond the face of the joint by 3 mm. If projection is done in mortar, it is called Bastard pointing or half tuck pointing.

7. V-pointing (Fig. 19.3 g)

This pointing is formed by forming V-groove in the flush finishing face.

8. Weathered pointing (Fig. 19.3 h)

This pointing is made by making a projection in the form of V- shape.

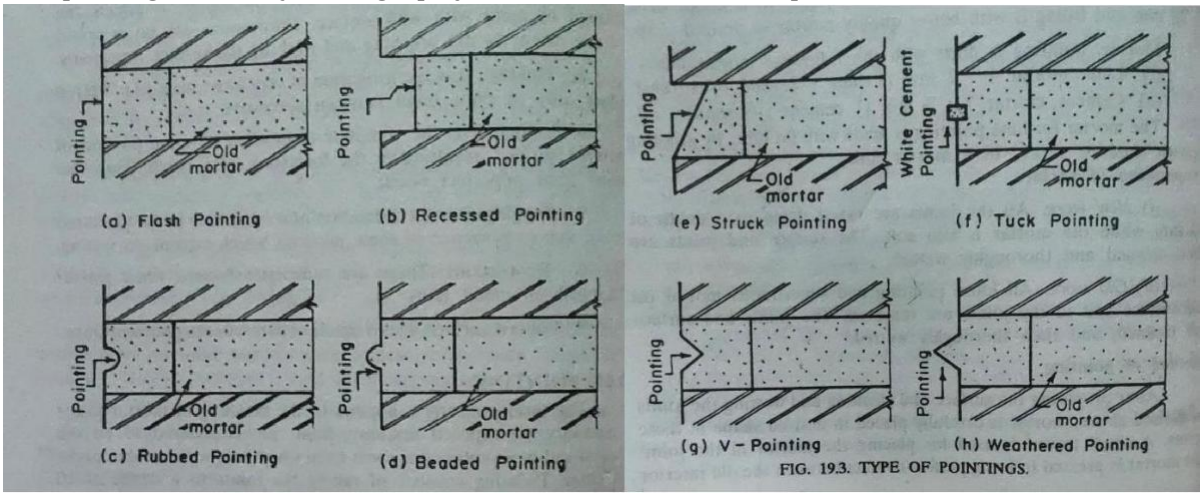


FIG. 19.3. TYPE OF POINTINGS.

Painting – objectives – method of painting new and old wall surfaces, wood surface and metal surfaces – powder coating and spray painting on metal surfaces.

Paints are liquid compositions of pigments and binders which when applied to the surface in thin coats dry to form a solid film to impart the surface a decorative finish, apart from giving protection to the base material (i.e., concrete, masonry and plaster surfaces) from weathering, corrosion and other chemical and biological attacks.

Following are the objects of painting a surface:

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

Method of painting

The process of painting depends on the nature of the surface to be painted. A brief description of painting on each of the various surfaces is given below:

New woodwork: Normally four coats of paint are required for new woodwork. The process of painting is carried out as follows:

- The surface of woodwork is prepared to receive the paint. For satisfactory working, it is necessary that the woodwork is sufficiently seasoned and it does not contain more than 15 per cent moisture at the time of painting. The surface of woodwork is thoroughly cleaned and the heads of nails are punched to a depth of 3 mm below the surface.
- The surface of the woodwork is then knotted.
- The priming coat is then applied on the surface of new woodwork. Generally, the priming coat is applied before the woodwork is placed in position.
- The process of stopping is then carried out.
- The subsequent coats of paint, namely, under coats and finishing coats, are then applied on the surface. The extreme care should be taken to see that the finishing coat presents smooth and even surface and that no brush marks are seen on the finished work.

Repainting old woodwork: If the paint on the old woodwork has cracked or has developed blisters, it is to be removed. If the surface has become greasy, it should be cleaned by rubbing down sand-paper or fine pumice stone. The old paint can also be removed by applying any one of the following three paint solvents:

- A solution containing 2 N of caustic soda to a litre of water is prepared and used to wash the surface. The paint dissolves and the surface becomes clean.
- A mixture consisting of one part of soft soap and two parts of potash is prepared and one part of quicklime is then added afterwards. This mixture is applied on the surface in a hot state and allowed to stay for about 24 hours. The surface is then washed with hot water.
- A mixture consisting of equal parts of washing soda and quicklime is brought to a paste form by adding required quantity of water. It is applied on the surface and kept for about an hour. The surface is then washed with water.

After removing old paint from the surface, the woodwork is painted as in case of painting on new woodwork.

Metals: The surface of the metal to be painted should be clean and free from dirt, grease, etc. It should be such as to provide key for the paint. Depending upon the nature of metal, suitable paint is selected. For instance, the priming coat for aluminium surface should be of zinc chromate and that for zinc surface, it should be of zinc oxide.

Plastered surfaces: For successful application of paint on cement plastered surfaces, the following factors should be carefully considered:

- There is considerable amount of moisture in newly constructed wall with cement plaster. It is necessary to allow the moisture content to escape. The actual time required for drying of wall surface will depend on atmospheric conditions and ventilation. But it usually requires about 3 to 6 months for the surface to be ready to receive paint. The artificial heating may in some cases be employed in combination with ventilation.
- The cement plaster is alkaline in nature because lime is liberated during the hydration of cement. Hence the oil based paints and distempers are liable for alkali attack, especially in presence of moisture. Hence the coats of alkali resistant primer paints should be applied or paints not containing any oil should be used.
- The defects in cement plastered surfaces develop due to various reasons. Such defects should be removed and the surface should be prepared to receive the paint.

- The spots showing efflorescence should be brushed off and the surface should be watched for few days. If spots of efflorescence develop again, the process of brushing off should be repeated. It is desirable to postpone painting till such spots cease to appear.
- If there are chances for the discolouration of the painted surface, it is necessary to clean the surface and to sterilise it with an antiseptic wash. The organisms responsible for discolouration are algae, mould, lichen, etc. They may be black, green purple or red in colour. The conditions favourable for their easy and free growth are dampness and high humidity.

With the above remarks in view, the usual paints recommended for cement plastered surfaces are cement paints, emulsion paints, oil paints, silicate paints, etc.

Powder coating and spray painting on metal surfaces

Powder coating uses an oven-cured dry powder to provide a thick, highly-durable coating for metal and other high-temperature resistant objects such as a fence, appliance face or deck furniture. The parts require disassembly and shipping because it is done offsite at a specialty shop.

Spray Painting uses a wet finish sprayed or electrostatically applied in a thin coat for both corrosion protection and appearance. Usually done on-site, it requires masking for overspray and curing times of up to 24 hours.

White washing – Colour washing – Distempering – internal and external walls.

Whitewashing

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

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

The whitewash is applied with jute brush and the brush is so worked that a surface with uniform colour is obtained. The three coats are generally applied, each after the previous coat has completely dried.

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

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

Colourwashing

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

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

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

Distempering- internal and external walls

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

Preparation of surface: The surface to receive the distemper is thoroughly rubbed and cleaned. The important facts to be kept in mind are:

- The new plastered surfaces should be kept exposed for a period of two months or so to dry out before distemper is applied on them. The presence of dampness on the surface results in failure of distemper coating.
- The surface to receive distemper should be free from any efflorescence patches. These are to be wiped out by clean cloth.
- The irregularities such as cracks, holes, etc. of the surface are to be filled by lime putty or gypsum and allowed to become hard before distemper is applied on the surface.
- If distemper is to be applied on the existing distempered surfaces, the old distemper should be removed by profuse watering

Priming coat: After preparing the surface to receive the coats of distemper, a priming coat is applied and it is allowed to become dry. For ready made distempers, the priming coat should be composed of materials as recommended by the makers of distempers. For local made distempers, the milk is used for priming coat. One litre of milk will cover about 10 m^2 of the surface.

Coats of distemper: The first coat of distemper is then applied on the surface. It should be of a light tint and applied with great care. The second coat of distemper is applied after the first coat has dried and become hard. Following facts are to be remembered:

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

Damp and Termite proofing – Materials and Methods.

Damp proofing

One of the basic requirement of a building is that it should remain dry or free from moisture travelling through walls, roofs or floors. Dampness is the presence of hygroscopic or gravitational moisture. Dampness gives rise to unhygienic conditions, apart from reduction in strength of structural components of the building. Damp prevention is therefore one of the important items of building design. Every building should be damp proof. Provision of damp proof courses prevent the entry of moisture in the building.

Materials

Following are the materials which are commonly used for the damp-proofing:

1. Hot bitumen
2. Mastic asphalt
3. Bituminous felts

4. Metal sheets
5. Combination of sheets and felts
6. Stones
7. Bricks
8. Mortar
9. Cement concrete
10. Plastic sheets

Methods

Following methods are adopted to make a building damp proof :

1. Use of damp proofing course (D.P.C.) : membrane damp proofing
2. Integral damp proofing.
3. Surface treatment.
4. Cavity wall construction.
5. Guniting.
6. Pressure grouting.

Termite proofing

Termites, popularly known as white ants cause considerable damage to wood work, furnishings etc. of buildings. In some countries the loss caused due to termites is estimated to be as high as 10% of the capital outlay of the buildings. Anti-termite treatment is, therefore, necessary so that damages are either reduced or stopped all together.

Methods

The methods of termite proofing can broadly be classified into the following two groups:

1. Soil treatment with chemicals
2. Structural barriers.

Soil treatment with chemicals: The soil insecticides are thoroughly mixed and well spread in soil so as to provide an effective chemical barrier for termites. The various patented chemical insecticides such as DDT, BHC, PCP, etc. are available.

Structural barriers

To prevent the entry of termites through walls, the impenetrable physical structural barriers may be provided continuously at plinth level. Such structural barrier may be in the form of a cement concrete layer or metal layer at plinth level.

REFERENCES BOOKS:

Sl.No.	Name of Authors	Titles of Book	Name of Publisher
1.	N.Subhramanian	Building materials & construction	Oxford publication
2.	Rangwala	Engineering materials	Charor publishing house
3.	Rangwala	Building construction	Charorar publishing house
4.	Sarkar & Saraswati	Construction Technology	Oxford Publication