SUBJECT CODE: BT204

BANSAL INSTITUTE OF RESEARCH TECHNOLOGY AND SCIENCE
BHOPAL

BASIC CIVIL ENGINEERING AND MECHANICS

SUBJECT INCHARGE: PROF. PIYUSH KUMAR VERMA

UNIT 1

Course Contents:

Unit I

Stones, bricks, cement, lime, timber-types, properties, test & uses, laboratory tests concrete and mortar Materials: Workability, Strength properties of Concrete, Nominal proportion of Concrete preparation of concrete, compaction, curing. Elements of Building Construction, Foundations conventional spread footings, RCC footings, brick masonry walls, plastering and pointing, floors, roofs, Doors, windows, lintels, staircases – types and their suitability

Reference Books:

1. S. Ramamrutam & R. Narayanan; Basic Civil Engineering, Dhanpat Rai Pub.
2. PrasadI.B., Applied Mechanics, Khanna Publication.
3. BC Punmia ,Surveying, Standard book depot.
4. Shesha Prakash and Mogaveer; Elements of Civil Engg & Engg. Mechanics; PHI
5. S.P, Timoshenko, Mechanics of structure, East West press Pvt.Ltd.
6. Surveying by Duggal – Tata McGraw Hill New Delhi.

UNIT 1

Lecture Note

Unit 1

STONES

Stone is a 'naturally available building material' which has been used from the early age of civilization. It is available in the form of rocks, which is cut to required size and shape and used as building block. It has been used to construct small residential buildings to large palaces and temples all over the world. Red Fort, Taj Mahal, Vidhan Sabha at Bangalore and several palaces of medieval age all over India are the famous stone buildings.

Type of Stones

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

- Geological
- Physical
- Chemical

Geological Classification

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

Igneous Rocks:

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

Sedimentary Rocks:

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

Metamorphic Rocks:

UNIT 1

- Previously formed igneous and sedimentary rocks undergo changes due to metamorphic action of pressure and internal heat.
- For example due to metamorphic action granite becomes gneisses, trap and basalt change to schist and laterite, lime stone changes to marble, sand stone becomes quartzite and mud stone becomes slate.

Physical Classification

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

- Stratified rocks
- Unstratified rocks

Stratified Rocks:

- These rocks are having layered structure. They possess planes of stratification or cleavage.
- They can be easily split along these planes.
- Sand stones, lime stones, slate etc. are the examples of this class of stones.

Unstratified Rocks:

- These rocks are not stratified.
- They possess crystalline and compact grains.
- They cannot be split in to thin slab. Granite, trap, marble etc. are the examples of this type of rocks

Foliated Rocks:

- These rocks have a tendency to split along a definite direction only.
- The direction need not be parallel to each other as in case of stratified rocks.
- This type of structure is very common in case of metamorphic rocks.

Chemical Classification

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

- Silicious rocks
- Argillaceous rocks and
- Calcareous rocks

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

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

UNIT 1

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

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

Properties of Stones :

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

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

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

(iv) Appearance: A stone with uniform and attractive colour is durable, if grains are compact. Marble and granite get very good appearance, when polished. Hence they are used for face works in buildings.

(v) Strength: Strength is an important property to be looked into before selecting stone as building block. Indian standard code recommends, a minimum crushing strength of 3.5 N/mm^2 for any building block. Table 1.1 shows the crushing strength of various stones. Due to non-uniformity of the material, usually a factor of safety of 10 is used to find the permissible stress in a stone. Hence even laterite can be used safely for a single storey building, because in such structures expected load can hardly give a stress of 0.15 N/mm^2. However in stone masonry buildings care should be taken to check the stresses when the beams (Concentrated Loads) are placed on laterite wall.

(vi) Hardness: It is an important property to be considered when stone is used for flooring and pavement. Coefficient of hardness is to be found by conducting test on standard specimen in Dory's testing machine. For road works coefficient of hardness should be at least 17. For building works stones with coefficient of hardness less than 14 should not be used.

(vii) Percentage wear: It is measured by attrition test. It is an important property to be considered in selecting aggregate for road works and railway ballast. A good stone should not show wear of more than 2%.

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

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

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

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

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

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

Requirements of Good Building Stones

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

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

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

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

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

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

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

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

Tests on Stones

UNIT 1

To acertain the required properties of stones, the following tests can be conducted: (i) crushing strength test
(ii) water absorption test (iii) abrasion test
(iv) impact test (v) acid test.

(i) Crushing Strength Test: For conducting this test, specimen of size 40 × 40 × 40 mm are prepared from parent stone. Then the sides are finely dressed and placed in water for 3 days. The saturated specimen is provided with a layer of plaster of paris on its top and bottom surfaces to get even surface so that load applied is distributed uniformly. Uniform load distribution can be obtained satisfactorily by providing a pair of 5 mm thick playwood instead of using plaster of paris layer also. The specimen so placed in the compression testing machine is loaded at the rate of 14 N/mm^2 per minute. The crushing load is noted. Then crushing strength is equal to the crushing load divided by the area over which the load is applied. At least three specimen should be tested and the average should be taken as crushing strength.

(ii) Water Absorption Test: For this test cube specimen weighing about 50 grams are prepared and the test is carried out in the steps given below:
(a) Note the weight of dry specimen as W_1.
(b) Place the specimen in water for 24 hours.
(c) Take out the specimen, wipe out the surface with a piece of cloth and weigh the specimen. Let its weight be W_2.
(d) Suspend the specimen freely in water and weight it. Let its weight be W_3.
(e) Place the specimen in boiling water for 5 hours. Then take it out, wipe the surface with cloth and weigh it. W4
Then,
Percentage absorption by weight = (W2-W1)W1 × 100
Percentage absorption by volume = (W2-W1)/(W2-W3) × 100

(iii) Abrasion Test: This test is carried out on stones which are used as aggregates for road construction. The test result indicate the suitability of stones against the grinding action under traffic. Any one of the following test may be conducted to find out the suitability of aggregates:
(i) Los Angeles abrasion test (ii) Deval abrasion test (iii) Dorry's abrasion test
However Los Angeles abrasion test is preferred since these test results are having good correlation
with the performance of the pavements.
The Los Angeles apparatus [Fig. 1.1] consists of a hollow cylinder 0.7 m inside diameter and 0.5 m long with both ends closed. It is mounted on a frame so that it can be rotated about horizontal axis. IS code has standardised the test procedure for different gradation of specimen. Along with specified weight of specimen a specified number of cast iron balls of 48 mm diameter are placed in the cylinder.
Then the cylinder is rotated at a speed of 30 to 33 rpm for specified number of times (500 to 1000). Then the aggregate is removed and sieved on 1.7 mm. IS sieve. The weight of aggregate passing is found.
Then Los Angeles value is found as

= (wt. of aggregate passing through sieve/original weight) x 100.

The following values are recommended for road works:
For bituminous mixes – 30%
For base course – 50%

(iv) Impact Test: The resistance of stones to impact is found by conducting tests in impacting testing machine (Fig. 1.2). It consists of a frame with guides in which a metal hammer weighing 13.5 to 15 kg can freely fall from a height of 380 mm.
Aggregates of size 10 mm to 12.5 mm are filled in cylinder in 3 equal layers; each layer being tamped 25 times. The same is then transferred to the cup and again tamped 25 times. The hammer is then allowed to fall freely on the specimen 15 times. The specimen is then sieved through 2.36 mm sieve. Then,
Impact value = W2/W1 x 100
(v) Acid Test: This test is normally carried out on sand stones to check the presence of calcium carbonate, which weakens the weather resisting quality. In this test, a sample of stone weighing about 50 to 100 gm is taken and kept in a solution of one per cent hydrochloric acid for seven days. The solution is agitated at intervals. A good building stone maintains its sharp edges and keeps its surface intact. If edges are broken and powder is formed on the surface, it indicates the presence of calcium carbonate. Such stones will have poor weather resistance.

BRICKS:

The size of the bricks are of 90 mm × 90 mm × 90 mm and 190 mm × 90 mm × 40 mm. With mortar joints, the size of these bricks are taken as 200 mm × 100 mm × 100 mm and 200 mm × 100 mm x 50mm
Types of Bricks
Bricks may be broadly classified as:
(i) Building bricks
(ii) Paving bricks (iii) Fire bricks
(iv) Special bricks.

Properties of Bricks

The following are the required properties of good bricks:
(i) Colour: Colour should be uniform and bright.
(ii) Shape: Bricks should have plane faces. They should have sharp and true right angled corners.
(iii) Size: Bricks should be of standard sizes as prescribed by codes.
(iv) Texture: They should possess fine, dense and uniform texture. They should not possess fissures, cavities, loose grit and unburnt lime.
(v) Soundness: When struck with hammer or with another brick, it should produce metallic sound.
(vi) Hardness: Finger scratching should not produce any impression on the brick.
(vii) Strength: Crushing strength of brick should not be less than 3.5 N/mm^2. A field test for strength is that when dropped from a height of 0.9 m to 1.0 mm on a hard ground, the brick should not break into pieces.
(viii) Water Absorption: After immersing the brick in water for 24 hours, water absorption should not be more than 20 per cent by weight. For class-I works this limit is 15 per cent.

UNIT 1

(ix) Efflorescence: Bricks should not show white patches when soaked in water for 24 hours and then allowed to dry in shade. White patches are due to the presence of sulphate of calcium, magnesium and potassium. They keep the masonry permanently in damp and wet conditions.
(x) Thermal Conductivity: Bricks should have low thermal conductivity, so that buildings built with them are cool in summer and warm in winter.
(xi) Sound Insulation: Heavier bricks are poor insulators of sound while light weight and hollow bricks provide good sound insulation.
(xii) Fire Resistance: Fire resistance of bricks is usually good. In fact bricks are used to encase steel columns to protect them from fire.

Tests on Bricks

The following laboratory tests may be conducted on the bricks to find their suitability:
(i) Crushing strength
(ii)Absorption
(iii) Shape and size and
(iv) Efflorescence.
Classification of Bricks Based on their Quality
The bricks used in construction are classified as: (i) First class bricks
(ii) Second class bricks (iii) Third class bricks and (iv) fourth class bricks

(i) First Class Bricks: These bricks are of standard shape and size. They are burnt in kilns. They fulfill all desirable properties of bricks.
(ii) Second Class Bricks: These bricks are ground moulded and burnt in kilns. The edges may not be sharp and uniform. The surface may be somewhat rough. Such bricks are commonly used for the construction of walls which are going to be plastered.
(iii) Third Class Bricks: These bricks are ground moulded and burnt in clamps. Their edges are somewhat distorted. They produce dull sound when struck together. They are used for temporary and unimportant structures.
(iv) Fourth Class Bricks: These are the over burnt bricks. They are dark in colour. The shape is irregular. They are used as aggregates for concrete in foundations, floors and roads.

Uses of Bricks

Bricks are used in the following civil works:
(i) As building blocks.
(ii) For lining of ovens, furnaces and chimneys.
(iii) For protecting steel columns from fire.
(iv) As aggregates in providing water proofing to R.C.C. roofs.
(v) For pavers for footpaths and cycle tracks.
(vi) For lining sewer lines.

LIME

It is an important binding material used in building construction. Lime has been used as the material of construction from ancient time. When it is mixed with sand it provides lime mortar and when mixed with sand and coarse aggregate, it forms lime concrete.
The limes are classified as fat lime, hydraulic lime and poor lime:

Tests on Limestones

UNIT 1

The following practical tests are made on limestones to determine their suitability:
(i) Physical tests
(ii)Heat-test
(iii) Chemical test
(iv) Ball test.

(i) Physical Test: Pure limestone is white in colour. Hydraulic limestones are bluish grey, brown or are having dark colours. The hydraulic lime gives out earthy smell. They are having clayey taste. The presence of lumps give indication of quick lime and unburnt lime stones.

(ii) Heat Test: A piece of dry stone weighing W_1 is heated in an open fire for few hours. If weight of sample after cooling is W_2, the loss of weight is $W_2 - W_1$. The loss of weight indicates the amount of carbon dioxide. From this the amount of calcium carbonate in limestone can be worked out.

(iii) Chemical Test: A teaspoon full of lime is placed in a test tube and dilute hydrochloric acid is poured in it. The content is stirred and the test tube is kept in the stand for 24 hours. Vigorous effervescence and less residue indicates pure limestone. If effervescence is less and residue is more it indicates impure limestone.
If thick gel is formed and after test tube is held upside down it is possible to identify class of lime as indicated below:

- Class A lime, if gel do not flow.
- Class B lime, if gel tends to flow down.
- Class C lime, if there is no gel formation.

(iv) Ball Test: This test is conducted to identify whether the lime belongs to class C or to class B. By adding sufficient water about 40 mm size lime balls are made and they are left undisturbed for six hours. Then the balls are placed in a basin of water. If within minutes slow expansion and slow disintegration starts it indicates class C lime. If there is little or no expansion, but only cracks appear it belongs to class B lime.

CEMENT

Cement is a commonly used binding material in the construction. The cement is obtained by burning a mixture of calcarious (calcium) and argillaceous (clay) material at a very high temperature and then grinding the clinker so produced to a fine powder. It was first produced by a mason Joseph Aspdin in England in 1924. He patented it as portland cement.

Type of cement
(i) White Cement: The cement when made free from colouring oxides of iron, maganese and chlorium results into white cement. In the manufacture of this cement, the oil fuel is used instead of coal for burning. White cement is used for the floor finishes, plastering, ornamental works etc. In swimming pools white cement is used to replace glazed tiles. It is used for fixing marbles and glazed tiles.

UNIT 1

(ii) Coloured Cement: The cements of desired colours are produced by intimately mixing pigments with ordinary cement. The chlorium oxide gives green colour. Cobalt produce blue colour. Iron oxide with different proportion produce brown, red or yellow colour. Addition of manganese dioxide gives black or brown coloured cement. These cements are used for giving finishing touches to floors, walls, window sills, roofs etc.

(iii) Quick Setting Cement: Quick setting cement is produced by reducing the percentage of gypsum and adding a small amount of aluminium sulphate during the manufacture of cement. Finer grinding also adds to quick setting property. This cement starts setting within 5 minutes after adding water and becomes hard mass within 30 minutes. This cement is used to lay concrete under static or slowly running water.

(iv) Rapid Hardening Cement: This cement can be produced by increasing lime content and burning at high temperature while manufacturing cement. Grinding to very fine is also necessary. Though the initial and final setting time of this cement is the same as that of Portland cement, it gains strength in early days. This property helps in earlier removal of form works and speed in construction activity.

(v) Low Heat Cement: In mass concrete works like construction of dams, heat produced due to hydration of cement will not get dispersed easily. This may give rise to cracks. Hence in such constructions it is preferable to use low heat cement. This cement contains low percentage (5%) of tricalcium aluminate (C_3A) and higher percentage (46%) of dicalcium silicate (C_2S).

(vi) Pozzolana Cement: Pozzolana is a volcanic power found in Italy. It can be processed from shales and certain types of clay also. In this cement pozzolana material is 10 to 30 per cent. It can resist action of sulphate. It releases less heat during setting. It imparts higher degree of water tightness. Its tensile strength is high but compressive strength is low. It is used for mass concrete works. It is also used in sewage line works.
(vii) Expanding Cement: This cement expands as it sets. This property is achieved by adding expanding medium like sulpho aluminate and a stabilizing agent to ordinary cement. This is used for filling the cracks in concrete structures.

(viii) High Alumina Cement: It is manufactured by calcining a mixture of lime and bauxite. It is more resistant to sulphate and acid attack. It develops almost full strength within 24 hours of adding water. It is used for under water works.

(ix) Blast Furnace Cement: In the manufacture of pig iron, slag comes out as a waste product. By grinding clinkers of cement with about 60 to 65 per cent of slag, this cement is produced. The properties of this cement are more or less same as ordinary cement, but it is cheap, since it utilise waste product. This cement is durable but it gains the strength slowly and hence needs longer period of curing.

Physical properties: The following physical properties should be checked before selecting a Portland cement for the civil engineering works. IS 269–1967 specifies the method of testing and prescribes the limits:
(a) Fineness (b) Setting time
(c) Soundness (d) Crushing strength.

UNIT 1

(a) Fineness: It is measured in terms of percentage of weight retained after sieving the cement through 90 micron sieve or by surface area of cement in square centimetres per gram of cement. According to IS code specification weight retained on the sieve should not be more than 10 per cent. In terms of specific surface should not be less than 2250 cm^2/gm.

(b) Setting time: A period of 30 minutes as minimum setting time for initial setting and a maximum period of 600 minutes as maximum setting time is specified by IS code, provided the tests are conducted as per the procedure prescribed by IS 269-1967.

(c) Soundness: Once the concrete has hardened it is necessary to ensure that no volumetric changes takes place. The cement is said to be unsound, if it exhibits volumetric instability after hardening. IS code recommends test with Le Chatelier mould for testing this property. At the end of the test, the indicator of Le Chatelier mould should not expand by more than 10 mm.

(d) Crushing strength: For this mortar cubes are made with standard sand and tested in compression testing machine as per the specification of IS code. The minimum strength specified is 16 N/mm^2 after 3 days and 22 N/mm^2 after 7 days of curing.

Uses of Cement

- Cement is used widely for the construction of various structures. Some of them are listed below:
- Cement slurry is used for filling cracks in concrete structures.
- Cement mortar is used for masonry work, plastering and pointing.
- Cement concrete is used for the construction of various structures like buildings, bridges. water tanks, tunnels, docks, harhours etc.
- Cement is used to manufacture lamp posts, telephone posts, railway sleepers, piles etc.
- For manufacturing cement pipes, garden seats, dust bins, flower pots etc. cement is commonly used.

Timber

Timber refers to wood used for construction works. In fact the word timber is derived from an old English word 'Timbrian' which means 'to build'. A tree that yields good wood for construction is called 'Standing Timber.' After felling a tree, its branches are cut and its stem is roughly converted into pieces of suitable length, so that it can be transported to timber yard. This form of timber is known as rough timber. By sawing, rough timber is converted into various commercial sizes like planks, battens, posts, beams etc. Such form of timber is known as converted timber.

Classification of Timber

Various bases are considered for the classification of timbers. The following are the important basis: (i) Mode of growth
(ii) Modulus of elasticity (iii) Durability
(iv) Grading
(v) Availability.

UNIT 1

(i) Classification Based on Mode of Growth: On the basis of mode of growth trees are classified as (a) Exogeneous and (b) Endogenous

(a) Exogeneous Trees: These trees grow outward by adding distinct consecutive ring every year. These rings are known as annual rings. Hence it is possible to find the age of timber by counting these annual rings. These trees may be further divided into (1) coniferous and (2) deciduous.

Coniferous trees are having cone shaped leaves and fruits. The leaves do not fall till new ones are grown. They yield soft wood.

Deciduous trees are having broad leaves. These leaves fall in autumn and new ones appear in springs. They yield strong wood and hence they are commonly used in building construction.

The classification as soft wood and hard wood have commercial importance. The difference between soft wood and hard wood is given below:
1. In soft wood annual rings are seen distinctly whereas in hard wood they are indistinct. 2. The colour of soft wood is light whereas the colour of hard wood is dark.
3. Soft woods have lesser strength in compression and shear compared to hard woods.
4. Soft woods are light and hard woods are heavy.
5. Fire resistance of soft wood is poor compared to that of hard wood.
6. The structure of soft wood is resinous while structure of hard wood is close grained.

Properties of good timbers are:

Colour: It should be uniform.
Odour: It should be pleasant when cut freshly.
Soundness: A clear ringing sound when struck indicates the timber is good.
Texture: Texture of good timber is fine and even.
Grains: In good timber grains are close.
Density: Higher the density stronger is the timber.
Hardness: Harder timbers are strong and durable.
Warping: Good timber do not warp under changing environmental conditions.
Toughness: Timber should be capable of resisting shock loads.
Abrasion: Good timber do not deteriorate due to wear. This property should be looked into, if timber is to be used for flooring.
Strength: Timber should have high strength in bending, shear and direct compression.
Modulus of Elasticity: Timber with higher modulus of elasticity are preferred in construction.
Fire resistance: A good timber should have high resistance to fire.
Permeability: Good timber has low water permeability.
Workability: Timber should be easily workable. It should not clog the saw.
Durability: Good timber is one which is capable of resisting the action of fungi and insects attack
Defects: Good timber is free from defects like dead knots, shakes and cracks

Mortar

UNIT 1

Mortar is an intimate mixture of binding material, fine aggregate and water. When water is added to the dry mixture of binding material and the inert material, binding material develops the property that binds not only the inert material but also the surrounding stones and bricks. If the cement is the binding material, then the mortar is known as cement mortar. Other mortars commonly used are lime mortar and mud mortar. The inert material used is sand. In this chapter, first an introduction is given to the inert material sand and then the proportioning, mixing, curing, properties and uses of different mortars is explained. At the end of the chapter various tests conducted on mortars is presented.

Types of mortar

- cement mortar
- lime mortar
- mud mortar
- special mortar

Test On Mortar :

The following tests are conducted on the prepared mortars to ensure their quality: 1. Crushing Test
2. Tensile Strength Test 3. Adhesive Test.

Concrete

Plain concrete, commonly known as concrete, is an intimate mixture of binding material, fine aggregate, coarse aggregate and water. This can be easily moulded to desired shape and size before it loses plasticity and hardens. Plain concrete is strong in compression but very weak in tension. The tensile property is introduced in concrete by inducting different materials and this attempt has given rise to RCC, RBC, PSC, FRC, cellular concrete and Ferro cement. In this chapter proportioning, mixing, curing, properties, tests and uses of plain concrete is dealt in detail. The other improved versions of concrete are explained and their special properties and uses are pointed out.

Major ingredients of concrete are:
1. Binding material (like cement, lime, polymer) 2. Fine aggregate (sand)
3. Coarse aggregates (crushed stone, jelly)
4. Water.

Preparing and Placing of Concrete
The following steps are involved in the concreting: 1. Batching
2. Mixing
3. Transporting and placing and 4. Compacting.

Curing of Concrete

UNIT 1

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 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.

Workability

Workability: This is defined as the ease with which concrete can be compacted fully without segregating and bleeding. It can also be defined as the amount of internal work required to fully compact the concrete to optimum density. The workability depends upon the quantity of water, grading, shape and the percentage of the aggregates present in the concrete.
Workability is measured by
(a) The slump observed when the frustum of the standard cone filled with concrete is lifted and removed.
(b) The compaction factor determined after allowing the concrete to fall through the compaction testing machine.
(c) The time taken in seconds for the shape of the concrete to change from cone to cylinder when tested in Vee-Bee consistometer.

Tests on Concrete

The following are some of the important tests conducted on concrete:
1. Slump test.
2. Compaction factor test.
3. Crushing strength test

UNIT 1

Slump Test: This test is conducted to determine the workability of concrete. It needs a slump cone for test (Fig. 3.3). Slump cone is a vessel in the shape of a frustum of a cone with diameter at bottom 200 mm and 50 mm at top and 300 mm high. This cone is kept over a impervious platform and is filled with concrete in four layers. Each layer is tamped with a 16 mm pointed rod for 25 times. After filling completely the cone is gently pulled up. The decrease in the height of the concrete is called slump. Higher the slump, more workable is the concrete

Compaction Factor Test: This is another test to identify the workability of concrete. This test is conducted in the laboratory. The test equipment consists of two hoppers and a cylinder fixed to a stand, the dimensions and the distances between the three vessels being standardized. Vessel A and B are having hinged bottoms whereas cylinder C is having fixed bottom.

Top vessel A is filled with the concrete to be tested. As soon as it is filled, the hinged door is opened. Concrete is collected in vessel B. Then the hinged door of B is opened to collect concrete in cylinder C. The concrete in cylinder C is weighted. Let it be W_1.

Now cylinder is again filled with the sample of concrete in 50 mm layers, which is compacted by ramming and vibrating. Then the weight of compacted concrete is determined. Let this weight be W_2.

The ratio W_1/W_2 is termed as compaction factor

Crushing Strength Test: Metallic moulds of size 150 mm × 150 mm × 150 mm are used for casting concrete cubes. Before filling mould, it is properly oiled on its inner surfaces, so that cubes can be easily separated. Fresh cube is filled with concrete to be tested in 3 layers and kept in the room. After 24 hours, cube is removed from the mould and kept under water for curing. After 28 days of curing cubes are tested in the compression testing machine. In this test cubes are placed over the smooth surface which is in contact with side plates of mould. The crushing load is noted and crushing strength is found as load divided by surface area (150 × 150 mm^2).

Note : Code specify the desirable strength of concrete for 3 days and 7 days for quick assessment of strength of concrete.

The Basic Elements of a Building

The following are the basic elements of a building:

1. Foundation 2. Plinth
3. Walls and columns
4. Sills, lintels and chejjas 5. Doors and windows
6. Floors
7. Roofs
8. Steps, stairs and lifts
9. Finishing work 10. Building services.

UNIT 1

Foundation

Foundation is the most important part of the building. Building activity starts with digging the ground for foundation and then building it. It is the lower most part of the building. It transfers the load of the building to the ground. Its main functions and requirements are:

(a) Distribute the load from the structure to soil evenly and safely.
(b) To anchor the building to the ground so that under lateral loads building will not move.
(c) It prevents the building from overturning due to lateral forces.
(d) It gives level surface for the construction of super structure.

Types of foundation:

Shallow foundation

- Spread footing
- Isolated footing
- Combined footing
- Continuous footing
- Mat/raft footing
- Grillage footing
- Arch footing

Deep foundation

- Pile foundation
- Pier foundation
- Caisson foundation

CONVENTIONAL SPREAD FOOTINGS

This type of foundations are commonly used for walls and masonry columns. These foundations are built after opening the trenches to required depth. Such footings are economical up to a maximum depth of 3 m. As these foundations are suitable depth, they are grouped under *shallow foundations.*
Figure shows a conventional spread footing for a wall and 2^{nd} shows it for a masonry column.

UNIT 1

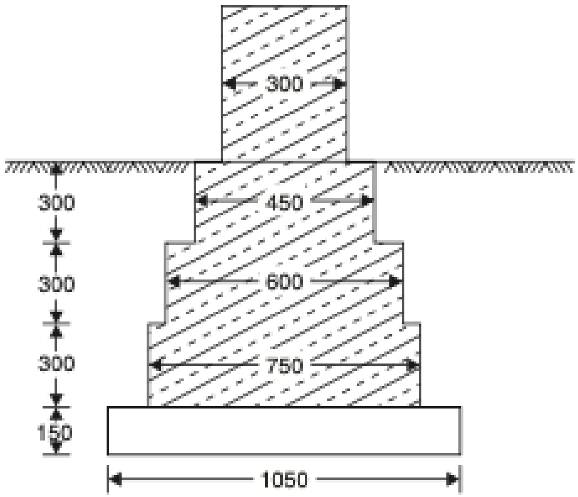


Fig. 7.1. Wall footing

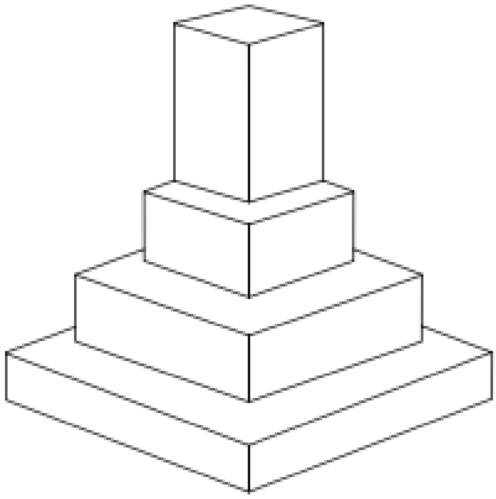


Fig. 7.2. Foundation for masonry pier

Before building these footing trenches are opened to required depth and the soil is rammed well. Then a plain concrete of mix 1 : 4 : 8 is provided. Its thickness varies from 150 to 200 mm. Over this bed, stone masonry footing is built. It is built in courses each course projecting 50 to 75 mm from the top course and height of each course being 150 to 200 mm. In case of wall footing the projections are only one direction while in case of columns, they are in both directions. The projection of bed concrete from the lowest course of foundation masonry is usually 150 mm.

R.C.C. FOOTINGS

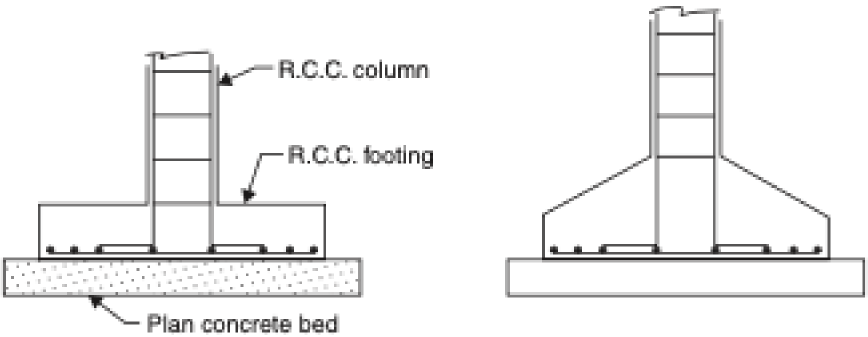
There are mainly two types of R.C.C. footings: 1. One way reinforced footings.
2. Two way reinforced footings.

1. **One Way Reinforced Footing:** These footings are for the walls. In these footings main reinforcements are in the transverse direction of wall. In longitudinal directions there will be only nominal reinforcement.

2. **Two Way Reinforced Footings:** For columns two way reinforced footings are provided. The following types of the footings are common:

(*i*) **Isolated Column Footings:** If separate footings are provided for each column, it is called isolated column footing. Figure 7.3 shows a typical isolated column footing. The size of footing is based on the area required to distribute the load of the columns safely over the soil . These footings are provided over a 100 to 150 mm bed concrete. Required reinforcements and thickness of footing are found by the design engineers. Thickness may be uniform or varying.

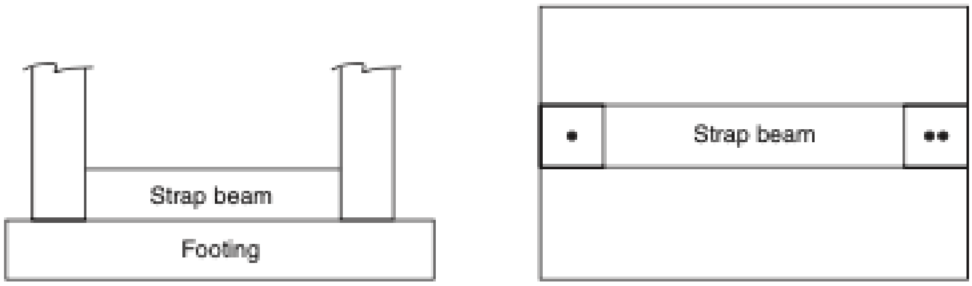
UNIT 1



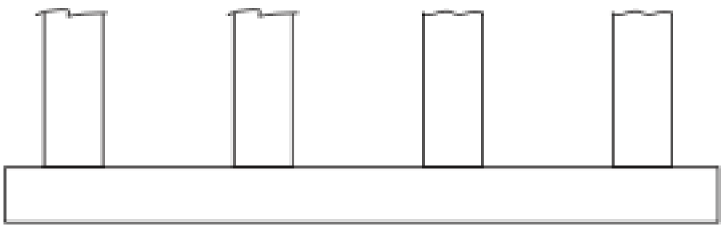
(a) Footing with uniform thickness

(b) Sloping footing

(*ii*) **Combined Footings:** Common footings may be provided for two columns. This type of footing is necessary when a column is very close to the boundary of the property and hence there is no scope to project footing much beyond the column face. Figure 7.4 shows a typical combined footing. The footing is to be designed for transferring loads from both columns safely to the soil. The two columns may or may not be connected by a strap beam.

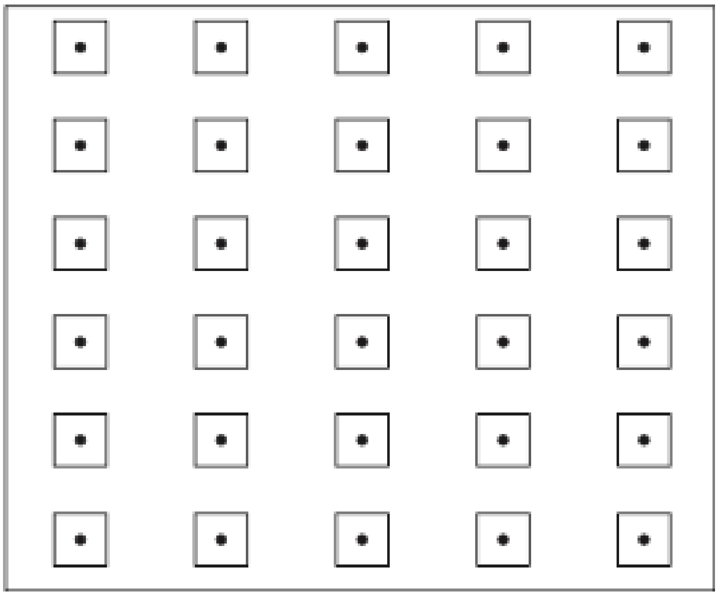


(*iii*) **Continuous Footings:** If a footing is common to more than two columns in a row, it is called continuous footing. This type of footing is necessary, if the columns in a row are closer or if SBC of soil is low. Figure 7.5 shows this type of footing.



(*iv*) **Mat Footing/Raft Footing:** If the load on the column is quite high (Multistorey columns) or when the SBC of soil is low, the sizes of isolated columns may work out to be to such an extent that they overlap each other. In such situation a common footing may be provided to several columns as shown in Fig. 7.6. Such footings are known as raft footings. If the beams are provided in both directions over the footing slab for connecting columns, the raft foundations may be called as grid foundation also. The added advantage of such footing is, settlement is uniform and hence unnecessary stresses are not produced.

UNIT 1



GRILLAGE FOOTING

High rise buildings are built with steel columns encased in concrete. Such columns carry very heavy load and hence they need special foundations to spread the load to a larger area of soil. Grillage foundation is one such special foundation. It consists of one tier or more tiers of I-sections steel beams. Figure 7.7 shows a typical two tier grillage foundation. Top tier consists of less number but large size steel section while lower tier consists of larger number but smaller size steel sections. Column load is transferred to the top tier through a base plate. The grillage beams are unpainted and are encased in concrete with minimum cover of 100 mm beyond the edges of steel sections. A minimum clear space of 75 mm should be maintained between the flanges of adjacent grillage beams so that concreting can be made properly. To maintain spacing, pipe separators are used.

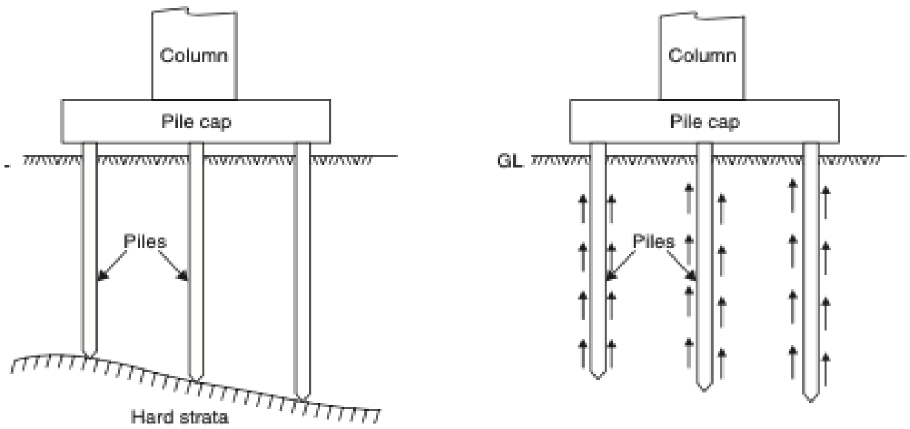
ARCH FOUNDATION

Inverted arch foundationsare provided in the places where the SBC of the soil is very poor and the load of the structure is through walls. In such cases inverted arches are constructed between the walls. End walls should be sufficiently thick and strong to withstand the outward horizontal thrust due to arch action. The outer walls may be provided with buttress walls to strengthen them. Figure 7.8 shows a typical inverted arch footing.

PILE FOUNDATIONS

These foundations are known as deep foundations. A pile is a slender column made of wood, concrete or steel. A pile is either driven into the soil or formed in situ by excavating a hole and then filling it with concrete. A group of piles are driven to the required depth and are capped with R.C.C. slab, over which super structure is built. The pile transfer the load to soil by friction or by direct bearing, in the latter case, piles being taken up to hard strata. This type of foundations is used when top soil is not capable of taking the load of the structure even at 3–4 m depth

UNIT 1



(a) Bearing pile (b) Friction pile

Pile foundations are classified according to the materials used and also on the nature of load transfer.

Classification According to Materials Used:

Piles may be classified as:

(*a*) Timber piles
(*b*) Concrete piles
(*c*) Steel piles and (*d*) Composite piles.

FOUNDATIONS IN BLACK COTTON SOIL

Black cotton soil swells during rainy season and cracks in summer due to shrinkage. These shrinkage cracks are 100 mm to 150 mm wide and 0.5 m to 2 m deep. Swelling creates upwards pressure on the structure and shrinkage creates downward pull. It results into cracks in foundations wall and roof. Hence foundation in black cotton soil need special care.

In case black cotton soil is only to a depth of 1.0 m and 2.0 m it is economical to remove entire black cotton soil from the site and build the foundation on red soil. Apart from this black cotton soil should be removed from the sides of the foundation and filled with sand and gravel.

In case the depth of black cotton soil is more, the following type of foundation may be provided

1. Strip or pad foundation
2. Pier foundation with arches and
3. Under reamed pile foundation.

TYPES OF SUPER STRUCTURES BASED ON THE METHOD OF LOAD TRANSFER

On this basis there are two types

1. Load Bearing Structures

UNIT 1

2. Framed Structures.

1. Load Bearing Structures: In this type of structure the load on the structure is transferred vertically downward through walls. Loads from roof and floors gets transferred to wall and then wall has to transfer these loads as well as self-weight. Such constructions are used in residential buildings where dimension of rooms is less. Residential buildings up to ground + 2 floors can be built economically with such structures.

2. Framed Structures: In this type of structures a frame work of columns, beams and floors are built first. Then walls are built to partion the living area. The walls are subjected to self- weight only. This type of super structures are required when number of stories in a building is more and also when larger areas are to be covered free from walls.

S. No.	*Load Bearing Structure*	*Framed Structure*
1.	Cost is less.	Cost is more.
2.	Suitable up to three stories.	Suitable for any number of stories.
3.	Walls are thicker and hence floor area is reduced.	Walls are thinner and hence more floor area available for use.
4.	Slow construction.	Speedy construction.
5.	Not possible to alter the position of walls, after the construction.	Position of walls may be changed, whenever necessary.
6.	Resistance to earthquake is poor.	Resistance to earthquake forces is good.

WALLS

S. No.	*Load Bearing Walls*	*Partition Walls*
1.	They carry loads from roof, floor, self-weight etc.	They carry self-weight only.
2.	They are thick and hence occupy more floor area.	These walls are thin and hence occupy less floor area.
3.	As the material required is more, the construction cost is more.	As the material required is less, the construction cost is less.
4.	Stones or bricks are used for the construction.	Stones are not used for the construction of partition walls.

STONE MASONRY

Masonry means construction of buildings using building blocks like stone, bricks, concrete blocks etc. Masonry is used for the construction of foundation, plinth, walls and columns. Mortar is the binding material for the building blocks. In this article different types of stone masonry used are explained and points to be observed while supervising stone masonry works are listed.

UNIT 1

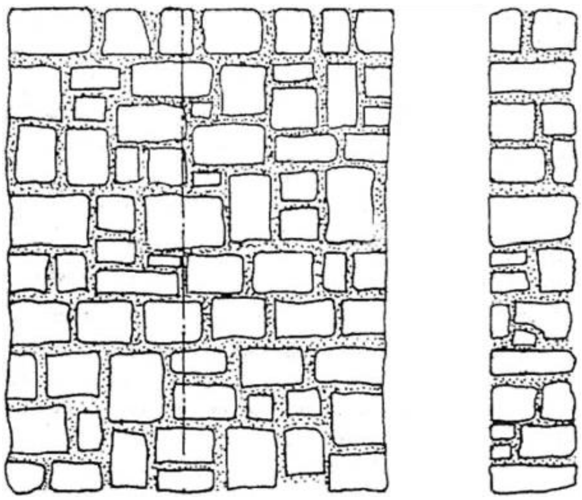
Types of Stone Masonry

Mainly there are two types of stone masonry:

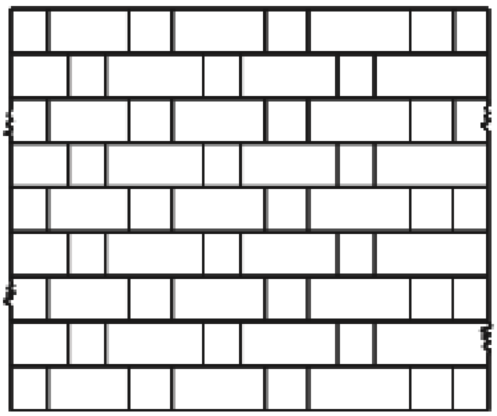
1. Rubble Masonry

2. Ashlar Masonry.

1. Rubble Masonry: In this type of constructions stones of irregular sizes and shapes are used. To remove sharp shapes they may be hammered. The rubble masonry may be *coursed* or In *uncoursed rubble masonry* the wall is brought to level at every 300 mm to 500 mm. The mortar consumed in these construction is more. Course rubble masonry is used for the construction of public and residential buildings. Uncoursed rubble masonry is used for the construction of foundations, compound walls, garages, labour quarters etc. A skilled mason may arrange the facing stones in *polygonal shapes* to improve the aesthetic of the wall.



Ashlar Masonry: In this type of masonry stones are dressed to get suitable shapes and sizes. The height of the stones varies from 250 mm to 300 mm. The length should not exceed three times the height. The dressing of the stone need not be very accurate on all sides. Usually good dressing is made on facing side. In such construction mortar consumption is less compared to rubble masonry.



UNIT 1

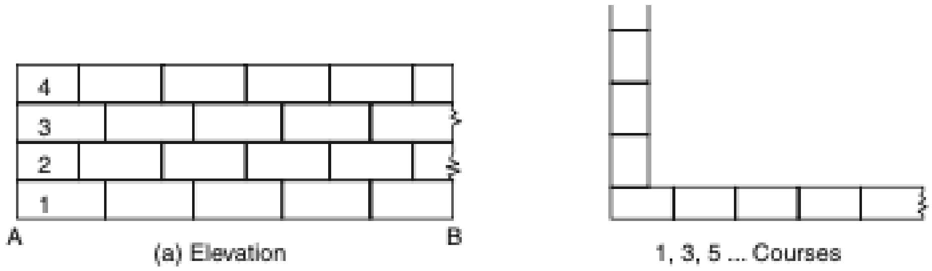
BRICK MASONRY

Brick masonry is built with bricks bonded together with mortar. For temporary sheds mud mortar may be used but for all permanent buildings lime or cement mortars are used.

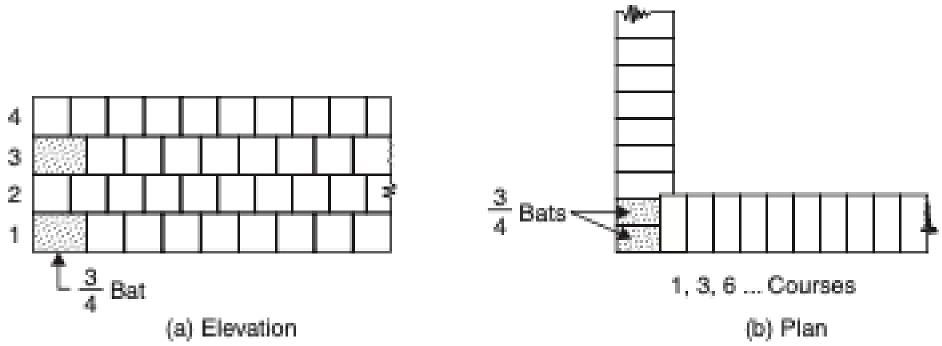
The various types of bonds generally used in brick masonry are

1. Stretcher bond
2. Header bond
3. English bond and
4. Flemish bond.

1. Stretcher Bond: A stretcher is the longer face of the brick as seen in the elevation. In the brick of size 190 mm × 90 mm × 90 mm, 190 mm × 90 mm face is the stretcher. In stretcher bond masonry all the bricks are arranged in stretcher courses as shown in Fig. 8.4. However care should be taken to break vertical joints. This type of construction is useful for the construction half brick thick partition wall.

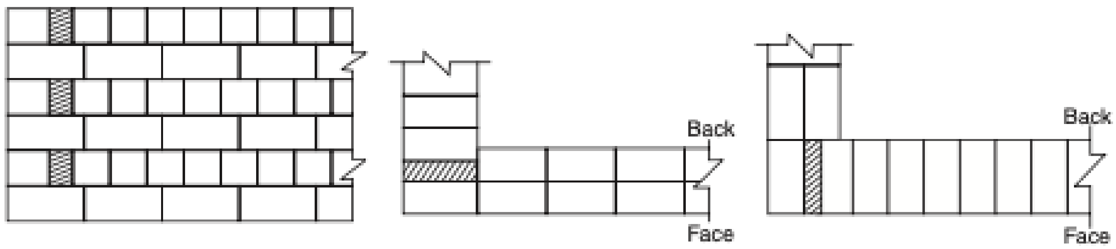


Header Bond: A header is the shorter face of the brick as seen in the elevation. In a standard brick it is 90 mm × 90 mm face. In header bond brick masonry all the bricks are arranged in the header courses as shown in Fig. 8.5. This type of bond is useful for the construction of one brick thick walls.



English Bond: In this alternate courses consist of headers and stretchers. This is considered to be the strongest bond. Hence it is commonly used bond for the walls of all thicknesses. To break continuity of vertical joints a brick is cut lengthwise into two halves and used in the beginning and end of a wall after first header. This is called queen closer. [Ref. Fig. 8.6]. Figure 8.6 shows typical one brick and one and half brick thick wall with English bond.

UNIT 1

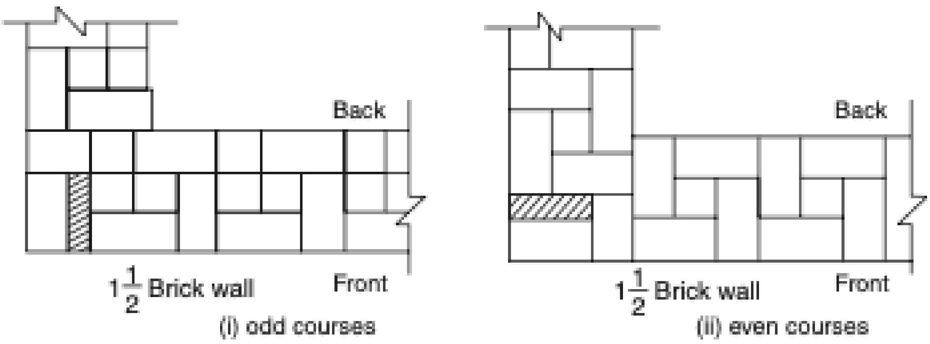


Elevation Plan of stretcher course Plan of header course

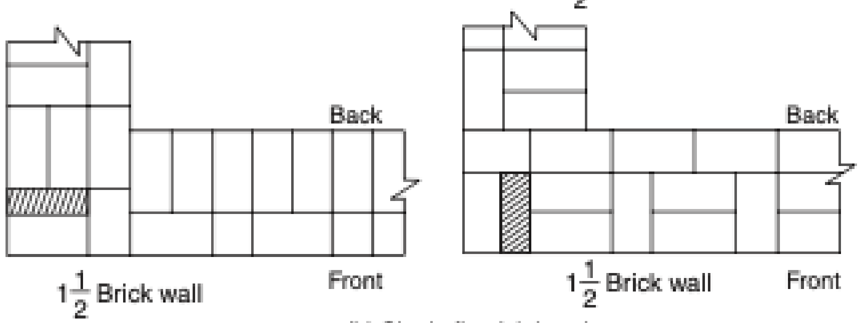
Flemish Bond: In this type of bond each course comprises of alternate header and stretcher [Fig. 8.7]. Alternate courses start with stretcher and header. To break the vertical joints queen closers are required, if a course starts with header. Every header is centrally supported on the stretcher below it.

Flemish bonds may be further classified as

(*a*) Double Flemish Bond
(*b*) Single Flemish Bond.



(a) Double flemish bond ($1\frac{1}{2}$ brick thick)



(b) Single flemish bond

Advantages and Disadvantages of Brick Masonry Over Stone Masonry

Advantages:

1. Since shape and size of bricks are uniform, it do not need skilled labour for the construction.
2. Bricks are light in weight and hence handling them is easy.
3. Bricks are easily available around cities and their transportation cost is less because their weight is less. Stones are to be brought from quarries which are located only at few places.

4. It is possible to use all types of mortar in brick masonry. For unimportant buildings even mud mortar can be used.
5. Thinner walls can be constructed with bricks but it is not so with stones.
6. It is easy to form openings for doors and windows.
7. Dead load of brick masonry is less.
8. In brick masonry mortar joints are thin and hence construction cost is reduced considerably.
9. Brick masonry has better fire and weather resistance compared to stone masonry.

Disadvantages:

1. Strength of brick masonry is less than that of stone masonry.
2. Durability of brick masonry is less.
3. Brick masonry needs plastering and plastered surface needs colour washing. Stone masonry don't need them and hence maintenance cost is more in brick masonry.
4. Brick masonry absorbs water and there are possibility of dampness. There is no such problem in stone masonry.
5. More architectural effects can be given in stone masonry compared to that in brick masonry.
6. Stone masonry gives massive appearance and hence monumental buildings are built in stone masonry.

PLASTERING

Applying mortar coats on the surfaces of walls, columns, ceiling etc. to get smooth finish is termed as plastering. Mortar used for plastering may be lime mortar, cement mortar or lime-cement mortar. Lime mortar used shall have fat lime to sand ratio of 1 : 3 or 1 : 4. If hydraulic lime is used mix proportion (lime: sand) is 1 : 2. Cement mortar of 1 : 4 or 1 : 6 mix is very commonly used for plastering, richer mix being used for outer walls. To combine the cost effectiveness of lime mortar and good quality of cement mortar many use lime-cement mortar of proportion (cement : lime : sand) of 1 : 1 : 6 or 1 : 1 : 8 or 1 : 2 : 8.

The *objective* of plastering are:
1. to conceal defective workmanship
2. to give smooth surface to avoid catching of dust. 3. to give good look.
4. to protect the wall from rain water and other atmospheric agencies. 5. to protect surfaces against vermit.

Requirement of good plaster are:

1. It should adhere to the background easily. 2. It should be hard and durable.
3. It should prevent penetration by moisture 4. It should be cheap.

POINTING

Instead of plastering entire surface of the masonry, special mortar finishing work is done to the exposed joints. This is called pointing. It consists of raking the joints to a depth of 10 mm to 20 mm and filling it with richer mortar mixes. In case of lime mortar pointing mix used is 1 : 2 and in case of cement mortar pointing mix used is 1 : 3. Pointing is ideally suited for stone masonry because stones are having attractive colours and good resistance to penetration by water. Pointing gives prefection to weaker part of masonry (*i.e.* to joints) and it adds to aesthetic view of the masonry.

UNIT 1

S. No.	Plastering	Pointing
1.	It is applied to entire surface.	It is provided only at exposed joints.
2.	It provides smooth surface.	It does not provide smooth surface.
3.	It conceals defective workmanship in the masonry construction.	It is used to expose beauty of well built masonry work.
4.	It provides a base for applying white/ colour washing.	White washing or colour washing are ruled out.

FLOORING

Purpose of flooring is to get a good hard, level and beautiful surface for living. The floors directly resting on the ground are known as ground floors while the floors of each storey are known as upper floors.

Ground Floor

Apart from giving good finished surface, these floors should have good damp resistance. The ground surface is rammed well and a layer of red earth or sand is placed which is compacted. A layer of broken bricks, stones etc. is provided up to 150 mm below floor finish level and rammed. While ramming the surface is kept moist to get good compaction. Then 1 : 4 : 8 concrete of 100 to 150 mm thickness is provided as base course. Over this bed floor finish is laid.

The types of flooring used are:

1. Mud and moorum
2. Brick
3. Flag stone
4. Cement concrete
5. Terrazo
6. Mosaic
7. Marble
8. Tiles
9. Timber
10. Rubber
11. P.V.C.

1. Mud and Moorum Flooring: These floorings are used in low cost housing, specially in villages. Over the hard layer of earth filling mud or moorum layer is provided. The floor needs a thin wash of cow dung at least once a weak.
2. Brick Flooring: This is also a cheap floor construction. It is commonly used in godowns and factories. Bricks are laid flat or on edges. Bricks of good quality should be used for the construction. Brick layer is provided on sand bed or on lean concrete (1 : 8 : 16) bed. In both cases joints are rendered flush and finished with cement mortar.
3. Flag Stone Flooring: Laminated sand stones or slates of 20 mm to 40 mm thick in the form of slabs of 300 mm × 300 mm or 450 mm × 450 mm or in the form of rectangles of size 450 mm × 600 mm are used as floor finishes. The stone slabs are laid on 20 to 25 mm thick mortar spread over concrete bed. The joints are to be finished with rich mortar.
4. Cement Concrete Floors: It is modestly cheap and durable floor and hence commonly used in residential, commercial and industrial buildings. It consists of two courses-base course and wearing coat. Base course is laid over well compacted soil. Its thickness is usually 75 mm to 100 mm. It consists of lean cement concrete mix (1 : 4 : 8) or lime concrete containing 40%

of 1 : 2 lime mortar and 60% of coarse aggregate of 40 mm size. After base coarse is hardened wearing coat of 40 mm is laid. It consists of panels of 1 m × 1 m, 2 m × 2 m or 1 m × 2 m. Alternate panels are laid with 1 : 2 : 4 concrete using wooden, glass or asbestos strip separators of 1.5 mm to 2.0 mm thickness. To get good bond between base coarse and wearing coat cement slurry wash is given before laying wearing coat panels. After 3–4 days of laying of one set of panel, another alternate panels are laid. Top of these panels are finished by tamping the surface with wooden floats and tapping with trowels, till cement slurry appears on top. It needs curing for 7 to 14 days. To get good appearance many times red-oxide finishing coat is provided.

5. Terrazo Flooring: Terrazo finishing coat is applied over concrete flooring to get pleasing appearance. Terrazo finish consists of 75 to 80% of surface marble chips embedded in cement mortar. Marble chips are mixed in cement in the proportion 1 : 1.25 to 1 : 2 and about 6 mm terrazo topping is laid. The top is tamped and rolled. Additional marble chips are spread during tamping to get proper distribution of marble chips on the surface. After drying it for 12 to 20 hours, it is cured for 2–3 days. Then grinding is made in the following three steps: Ist grinding—Using coarse grade (No. 60) carborundum stones. IInd grinding—Using medium grade (No. 120) carborundum stones. IIIrd grinding—Using fine grade (No. 320) carborundum stones. Plenty of water is used during grinding. After each grinding cement grout of cream-like consistency is applied and cured for 6–7 days. After final grinding and curing the floor is washed with plenty of water and then with dilute oxalic acid solution. Then floor is finished with polishing using machines and wax polish.

6. Mosaic Flooring: It consists of a finishing coat of small pieces of broken tiles of China glazed or of marble arranged in different patterns set in lime-surkhi or cement mortar. The base coarse is concrete flooring and on it 30 to 40 mm mortar layer is provided. On this mortar layer broken pieces of China glazed or marble are set to get different attractive patterns. After 20 to 24 hours of drying the top is rubbed with carborundum stone to get smooth and polished surface.
7. Marble Flooring: Marble slabs are cut to get marble tiles of 20 to 25 mm thickness. They are laid on floors similar to other tiles. With power driven machine surface is polished to get even and shining surface. This type of flooring is widely used in hospitals and temples.
8. Tiled Flooring: This is an alternative to terrazo flooring, used commonly used in residential, office and commercial buildings. Tiles of clay, cement or terrazo of standard sizes are manufactured in factories under controlled conditions. On the concrete base, 25 mm to 30 mm thick mortar is laid and these tiles are placed and pressed with trowel or wooden mallet. Before placing tiles care is taken to see that, neat cement slurry is applied to bottom side and sides of tiles to get good bond. Next day joints are cleaned of loose mortar and raked up to 5 mm depth. Then that is filled with coloured cement slurry to get uniform colour on the top surface. After curing for 7 days grinding and polishing is made as in the case of terrazo flooring.
9. Timber Flooring: Timber flooring are used in dancing halls and in auditoriums. Timber plates may be directly placed on concrete bed or may be provided over timber frame work. In latter case it is necessary to provide proper ventilation below the floor. This flooring is costly.
10. Rubber Flooring: Tiles or sheets of rubber with fillers such as cotton fibres, asbestos fibre or granulated cork are manufactured in variety of patterns and colours. These sheets or tiles may be fixed to concrete or timber floors. These floors are attractive and noise proof. However they are costly.
11. P.V.C. Flooring: Poly-Vinyl-Chloride (PVC) is a plastic which is available in different colour and shade. Nowadays tiles of this material are used widely. Adhesives are applied on concrete base as well as on bottom of PVC tiles. Then the tile is pressed gently with 5 kg wooden roller till the oozing of adhesive is seen. The oozed out adhesive is wiped and the floor is

UNIT 1

ROOF

Roof is the upper most portion of the building which protects the building from rain, wind and sun. Various types of roofs used may be divided broadly into three types:

1. Flat roofs 2. Pitched roofs 3. Shells and folded plates.

Flat roofs are used in plains where rainfall is less and climate is moderate. Pitched roofs are preferred wherever rainfall is more. Shells and folded plate roofs are used to cover large column free areas required for auditoriums, factories etc. Brief description of these roofs is presented below:

1. Flat Roofs: These roofs are nearly flat. However slight slope (not more than 10°) is given to drain out the rain water. All types of upper storey floors can serve as flat roofs. Many times top of these roofs are treated with water proofing materials-like mixing water proofing chemicals in concrete, providing coba concrete. With advent of reliable water proofing techniques such roofs are constructed even in areas with heavy rain fall.

The *advantages* of flat roofs are:

(*a*) The roof can be used as a terrace for playing and celebrating functions.

(*b*) At any latter stage the roof can be converted as a floor by adding another storey.

(*c*) They can suit to any shape of the building.

(*d*) Over-head water tanks and other services can be located easily.

(*e*) They can be made fire proof easily compared to pitched roof.

The *disadvantages* of flat roofs are:

(*a*) They cannot cover large column free areas.

(*b*) Leakage problem may occur at latter date also due to development of cracks. Once leakage problem starts, it needs costly treatments.

(*c*) The dead weight of flat roofs is more.

(*d*) In places of snow fall flat roofs are to be avoided to reduce snow load.

(*e*) The initial cost of construction is more.

(*f*) Speed of construction of flat roofs is less.

Pitched Roofs: In the areas of heavy rain falls and snow fall sloping roof are used. The slope of roof shall be more than 10°. They may have slopes as much as 45° to 60° also. The sloped roofs are known as pitched roofs. The sloping roofs are preferred in large spanned structures like workshops, factory buildings and ware houses. In all these roofs covering sheets like A.C. sheet, G.I. sheets, tiles, slates etc. are supported on suitable structures. The pitched roofs are classified into

(*a*) Single roofs (*b*) Double or purlin roofs
(*c*) Trussed roofs.

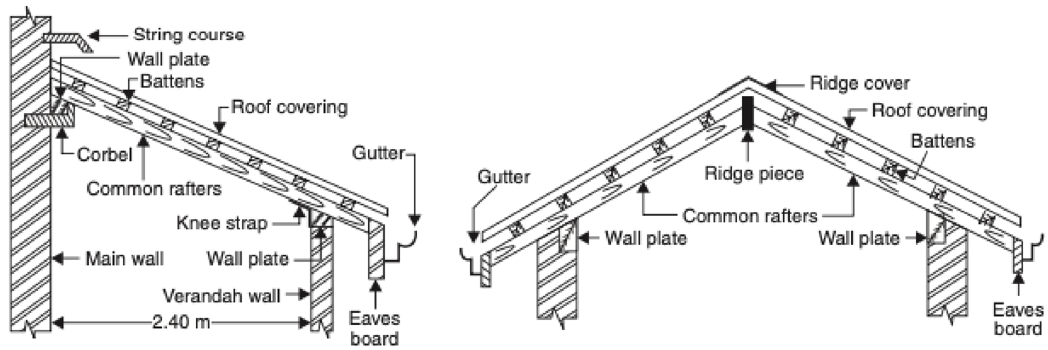
UNIT 1

Single Roof: If the span of roof is less than 5 m the following types of single roofs are used.

(*i*) Lean to roofs (*ii*) Coupled roofs

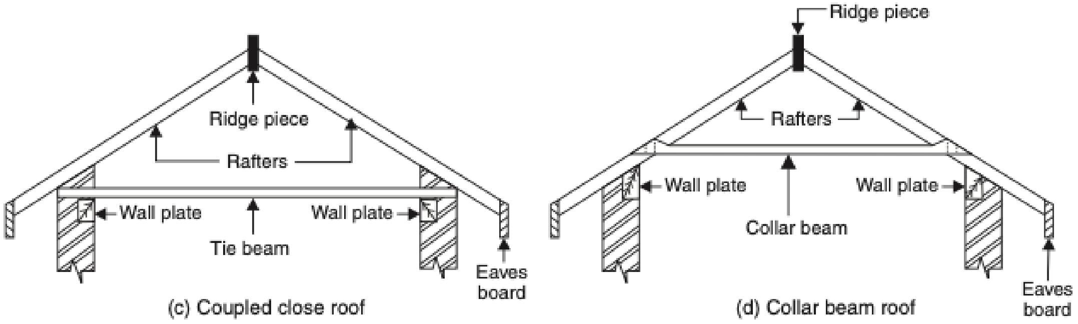
(*iii*) Coupled-close roof (*iv*) Collar beam roof

In all these roofs rafters placed at 600 mm to 800 mm spacing are main members taking load of the roof. Battens run over the rafters to support tiles.



(a) Lean to roof

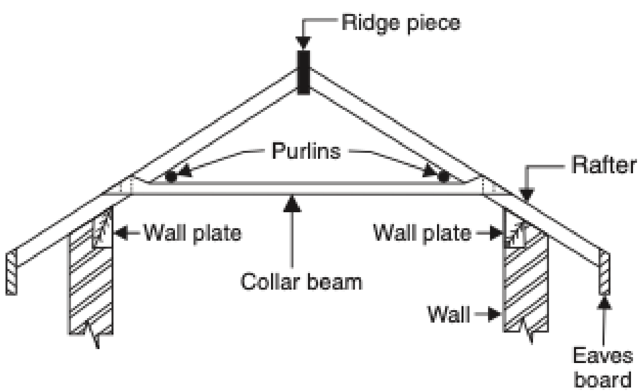
(b) Coupled roof



(c) Coupled close roof

(d) Collar beam roof

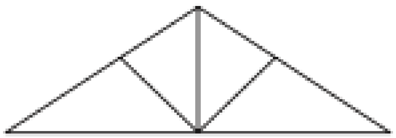
Double or Purlin Roofs: If span exceeds, the cost of rafters increase and single roof becomes uneconomical. For spans more than 5 m double purlin roofs are preferred. The intermediate support is given to rafters by purlins supported over collar beams. Figure 8.14 shows a typical double or purlin roof.



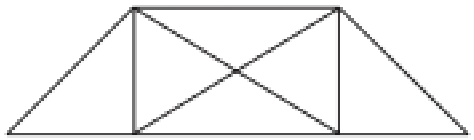
UNIT 1

Trussed Roof: If span is more, a frame work of slender members are used to support sloping roofs. These frames are known as trusses. A number of trusses may be placed lengthwise to get wall free longer halls. Purlins are provided over the trusses which in turn support roof sheets. For spans up to 9 m wooden trusses may be used but for larger

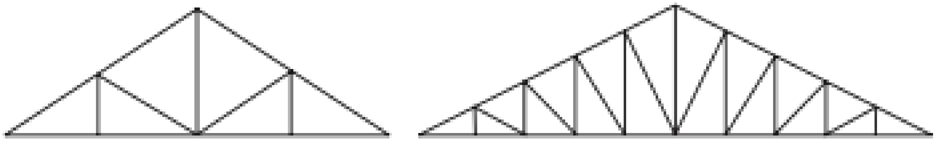
UNIT 1



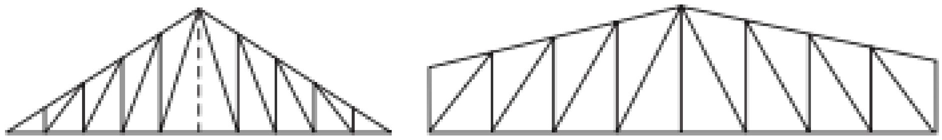
(a) King post spans up to 8 m



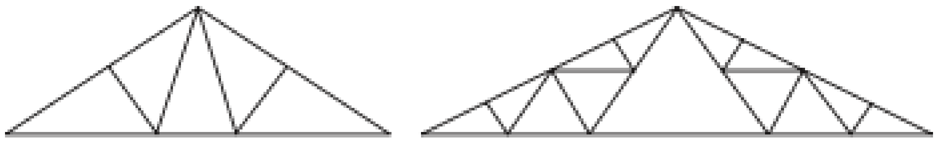
(b) Queen post spans up to 10 m



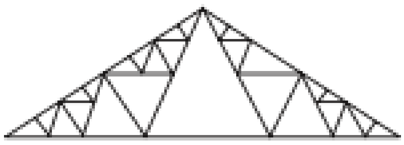
(c) Howe truss with 4 and 8 panels spans 6 m to 30 m



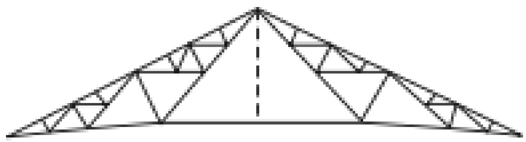
(d) Pratt truss spans 6 m to 100 m Modified pratt truss



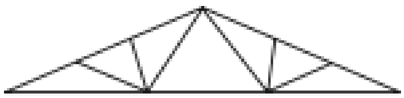
(e) Fink or french roof trusses spans up to 10 m



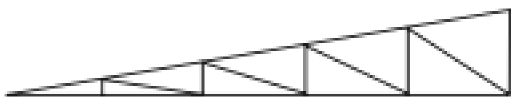
(f) Compound french truss
span 20 m to 30 m



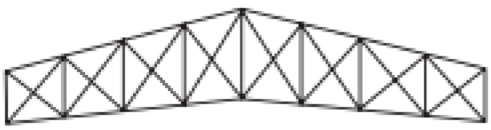
Cambered french roof truss
span 20 m to 30 m



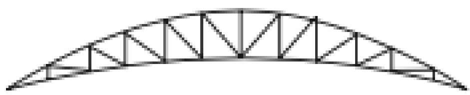
(g) Fan truss spans 10 m to 15 m



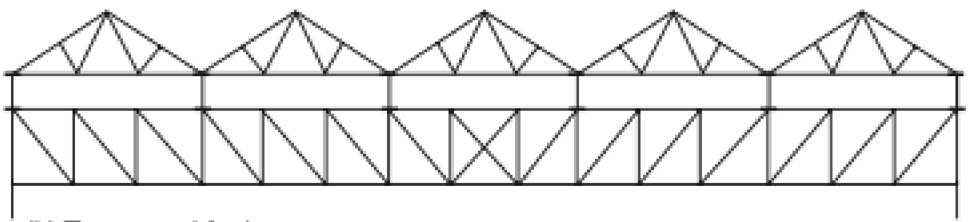
(h) North light roof truss span 8 m to 10 m



(i) Quadrangular truss



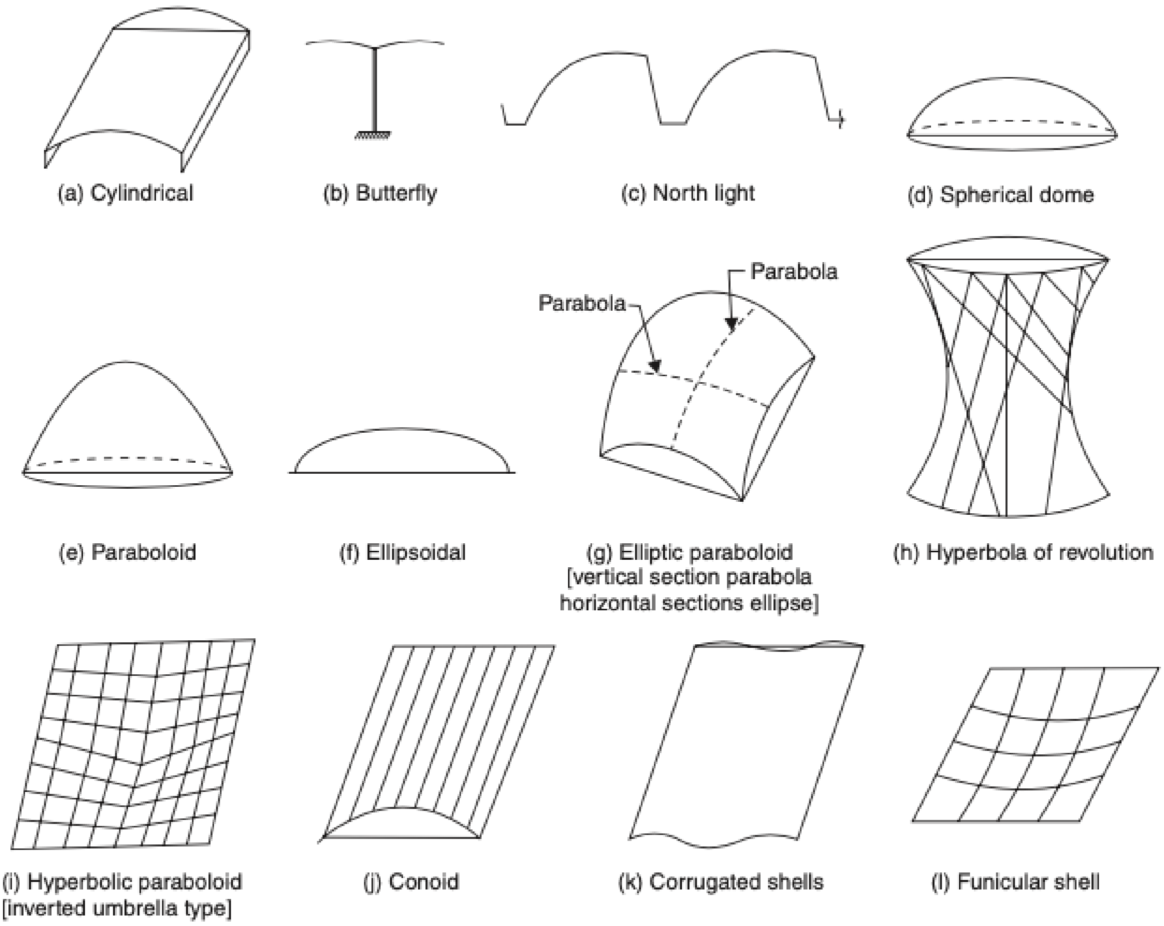
(j) Truss used for large span



(k) Truss used for large spans

UNIT 1

Shells and Folded Plate Roofs: *Shell roof* may be defined as a curved surface, the thickness of which is small compared to the other dimensions. In these roofs lot of load is transferred by membrane compression instead of by bending as in the case of conventional slab and beam constructions. Caves are having natural shell roofs. An examination of places of worships built in India, Europe and Islamic nations show that shell structures were in usage for the last 800 to 1000 years. However the shells of middle ages were massive masonry structures but nowadays thin R.C.C. shell roofs are built to cover large column free areas. Figure 8.18 shows commonly used shell roofs.



Advantages and Disadvantages of Shell Roofs

Advantages of shell roofs are:
(*a*) Good from aesthetic point of view
(*b*) Material consumption is quite less
(*c*) Form work can be removed early
(*d*) Large column free areas can be covered.

Disadvantages are:
(*a*) Top surface is curved and hence advantage of terrace is lost. (*b*) Form work is costly.

UNIT 1

Roof Coverings for Pitched Roofs

a) Thatch (*b*) Shingle (*c*) Tiles

(*d*) Slates (*e*) Asbestos cement (A.C.) sheets. (*f*) Galvanised iron (G.I.) sheets

DOORS AND WINDOWS

The function of a door is to give access to building and to different parts of the building and to deny the access whenever necessary. Number of doors should be minimum possible. The size of the door should be of such dimension as will facilitate the movement of the largest object likely to use the doors.

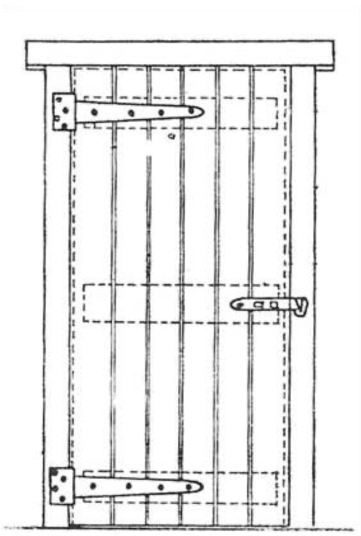
In case of the residental buildings, the size of the door should not be less than 0.9 m × 2.0 m. Larger doors may be provided at main entrance to the building to enhance the aesthetic view. Minimum sized doors are used for bath rooms and water closets. The size recommended is 0.75 m × 1.9 m. As a thumb rule height of door should be 1 m more than its width.

Windows are provided to give light and ventilation. They are located at a height of 0.75 m to 0.90 m from the floor level. In hot and humid regions, the window area should be 15 to 20 per cent of the floor area. It is preferable to have at least two openings in two different walls. Another thumb rule used to determine the size of the window opening is for every 30 m^3 inside volume there should be at least 1 m^2 window opening.

Types of Doors

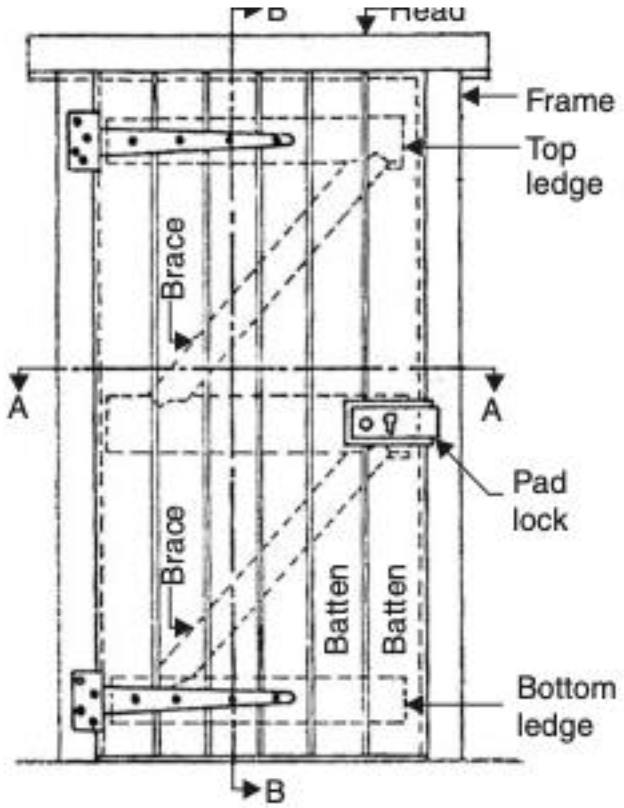
Various types of doors are in use which may be classified on the basis of arrangement of shutters, method of constructions, principles of working operations and materials used. Commonly used doors are briefly explained below:

1. Battened and Ledged Doors: Battens are 100 mm to 150 mm wide and 20 mm thick wooden boards. Their length is that of door opening. The battens are connected by horizontal planks, known as ledges of size 100 to 200 mm wide and 30 mm thick. Usually three ledges are used one at top, one at bottom and the third one at mid-height. This is the simplest form of door and the cheapest also. Battens are secured by tongued and grooved joint.

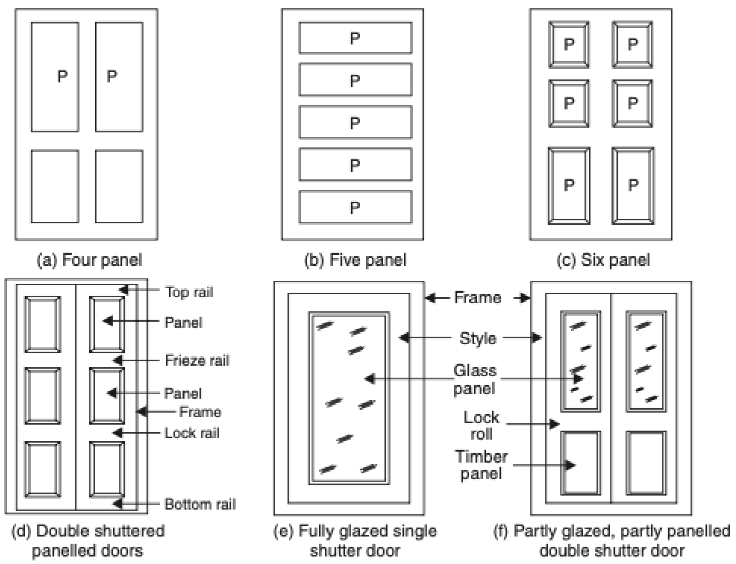


UNIT 1

Battened, Ledged and Braced Doors: If doors are wide apart from using battens and ledges diagonal members, known as braces, are provided to strengthen the door. Figure 8.22 shows a typical battened, ledged and braced door.

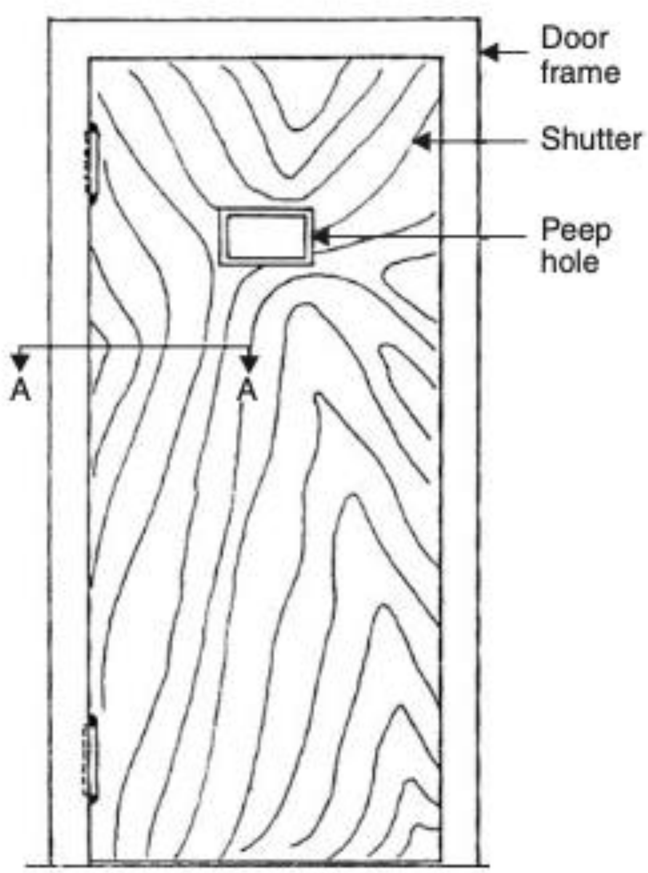


Framed and Panelled Doors: This type of door consists of vertical members, called styles and horizontal members called rails. The styles and rails are suitably grooved to receive panels. The panels may be of wood, A.C. sheet, glasses etc. The panels may be flat or of raised type to get good appearance. These are very commonly used doors. They may be of single shutter or of double shutter.

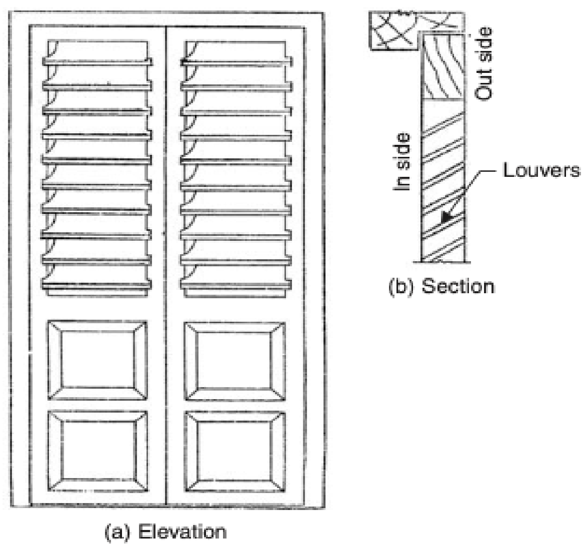


UNIT 1

Flush Doors: The shutters of these doors are made of plywood or block boards. They are of uniform thickness. These shutters are available with different attractive vineer finishes. The time consumed in making such doors at site is quite less. These doors are suitable for interior portion of a building. Nowadays flush doors are commonly used in residential and office buildings.

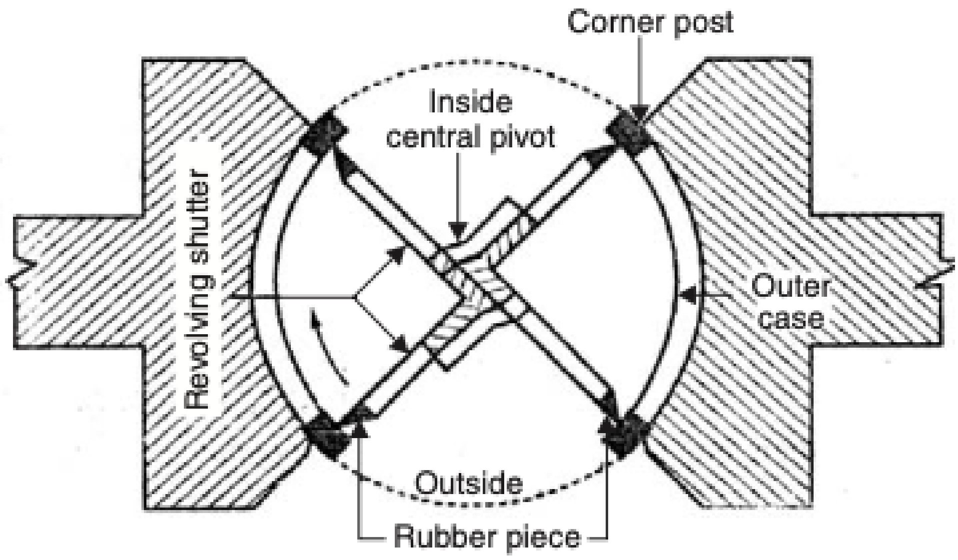


Louvered Doors: Whenever privacy as well as ventilation is required such doors can be used. Louvers are the glass, wooden or A.C. sheet strips fixed in the frame of shutter such that they prevent vision but permit free passage of air. The doors may be fully or partially louvered. Such doors are commonly used for public bathrooms and latrines.



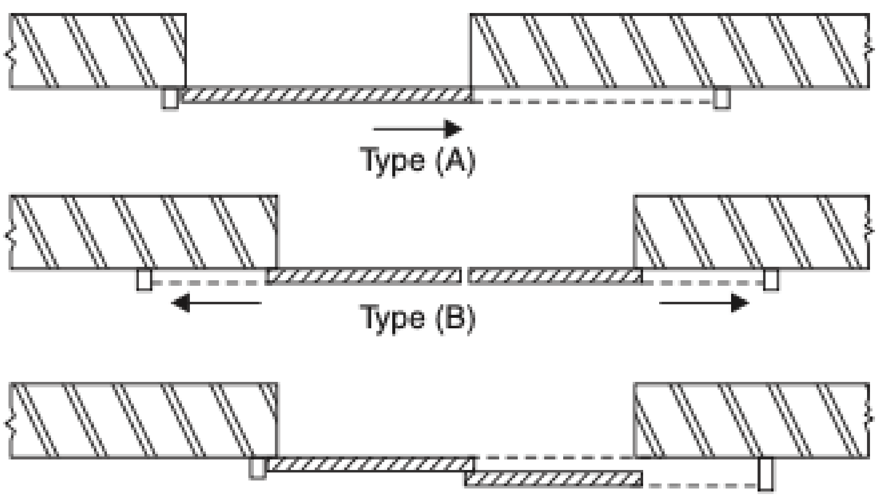
UNIT 1

Revolving Doors: It consist of a centrally placed pivot to which four radiating shutters are attached. The central pivot is supported on ball bearing at the bottom and has a bush bearing at the top. The shutters may be partly or fully madeup of glass. A circular space of entrance is provided within which shutters rotate. As shutters rotate they give entrance on one side and exit on other side. These doors are preferred in public buildings like stores, banks, hotels, theatres where continuous use of doors is necessary. They are very much required in entrance to air conditioned public buildings. Figure 8.26 shows a typical revolving door.



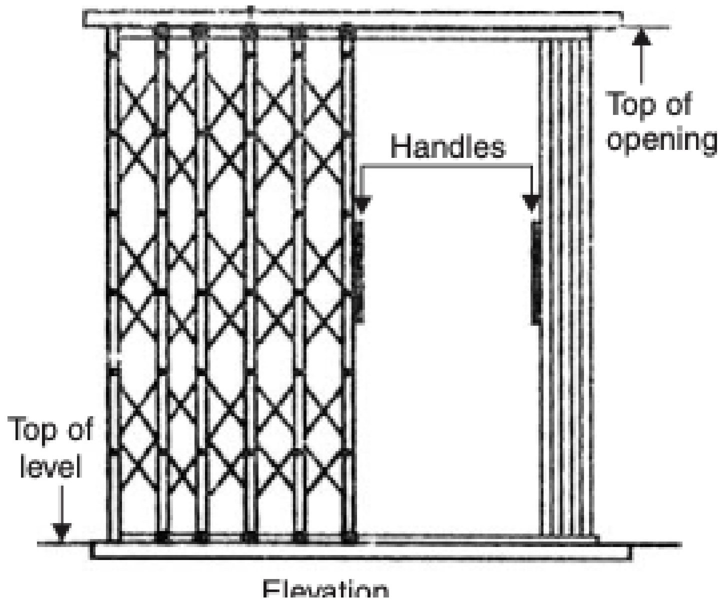
Swing Doors: Swing door has its shutter attached to the frame by means of double action springs. Hence shutter can move both inward and outward. They may be single shuttered or double shuttered. Such doors are preferred in offices and banks. Since these doors can open on both sides it is desirable to provide glass panels or peep holes to enable user to see the persons from other side.

Sliding Doors: In this type of doors, shutter slides on the sides. For this purpose runners and guide rails are provided. Sliding shutters may be one, two or even three. Such doors are used in banks, offices etc.



UNIT 1

Collapsible Doors: Steel channels 16 to 20 mm wide are used as verticals. They are placed with 12 to 20 mm gap. Steel flats 16 mm to 20 mm wide and 5 mm thick are hinged to them



Rolling Shutters: Figure 8.30 show a typical rolling shutter door. It consists of a frame, a drum and a shutter made of thin steel plates. The width of the door may vary from 2 to 3 m. The shutter moves on steel guides provided on sides and can easily roll up. For this counter- balancing is made with helical springs on the drum. The shutter can be easily pulled down. This type of doors are commonly used as additional doors to shops, offices, banks, factory, buildings from the point of safety.

S. No.	*Collapsible Doors*	*Revolving Doors*
1.	These doors do not provide privacy inside a room.	Provide privacy inside a room.
2.	These doors operate side ways.	These doors revolve
3.	These doors provide exit and entry from same side.	These doors provide exit from one side and entry from the other side
4.	These doors are not suitable for entry to air conditioned halls.	These doors are suitable for A.C. halls.
5.	These doors do not close automatically when not in use.	These doors close openings automatically when not in use.

Types of Windows

Various windows used may be classified on the basis of materials used, types of shutters, types of openings of shutters and the position of windows.

Timber, steel and aluminium are commonly used to make window frames. Timber may get termite attacks, steel may rust but aluminium do not have any such defects. However they are costly.

Shutters of windows may be panelled, glazed or louvered. Louvered windows are generally used for bathrooms and toilets where vision is not to be allowed but ventilation is required. Lower parts panelled and upper parts glazed windows are commonly used. Instead of panelled one may think of using translucent glasses. Figure 8.31 show a louvered windows.

Depending upon the position of windows, they may be classified as: (*a*) Casement windows
(*b*) Bay windows
(*c*) Corner windows (*d*) Clear storey windows (*e*) Gable windows (*f*) Sky light windows (*g*) Dormer windows (*h*) Ventilators

Casement windows are common type of windows, provided in the outer walls. They are provided over 50 to 75 mm sill concrete at a height of 750 to 900 mm from floor level.

Bay windows are provided on the projected portion of walls.

Corner windows are provided in the corner of a room. They need heavy lintels. Corner post of window should be strong enough to take load due to deflection of lintel and impact load from the shutters.

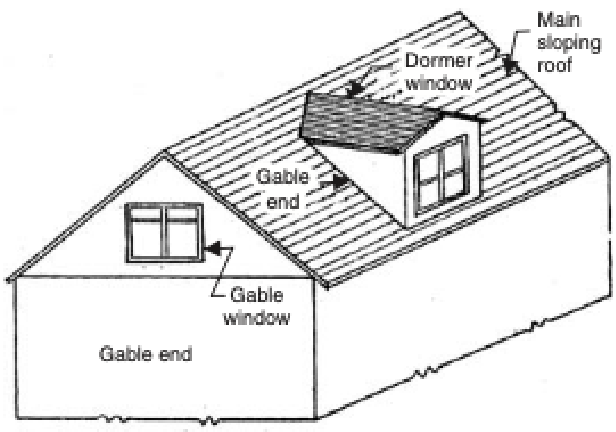
Clear storey windows are provided when the height of the room is much more than adjacent room/varandah. It is provided between the gap of low height room and the top of room with greater height.

Gable windows are provided in the gable portion of the building. They are required in the stair cases or in the halls with gable walls.

Sky light windows are provided on a sloping roof. It projects above the top sloping surface. The common rafters are to be trimmed suitably.

Dormer windows are vertical windows on the sloping roof.

Ventilators are provided close to roof level or over the door frames. They help in pushing out exhaust air. They may be provided with two split and separated glasses or with hung shutters.



UNIT 1

LINTELS

Lintel is a horizontal flexural member which spans over the openings in the walls for doors, windows, ventilators, cupboards etc. The load of masonry above the opening is transferred to the wall by flexural action of the lintel so that frames of doors, windows etc are not unduly loaded. The end bearings for the lintel should be at least 200 mm. The width of lintels is same as that of wall.

Lintels of various materials are used. They are:

(*a*) Wood

(*b*) Stone

(*c*) Brick

(*d*) R.C.C. and

(*e*) Steel.

(*a*) **Wood Lintel:** It may be a single piece or may be assembled by joining 2 to 3 pieces. Sometimes the wooden lintels are strengthened by steel plates at top and bottom. Such lintels are called as flitched beams.

(*b*) **Stone Lintels:** Wherever stones are available stone beams are used as lintels. As stone is weak in tension they can be used only for small spans. Their depth is kept about th span. 10

Stones are cut to the width of wall and dressed before using as lintels.

(*c*) **Brick Lintels:** Well burnt, good quality lintels are laid on ends or edges to form lintels . It needs temporary form work at the time of construction. The lintel is to be cured for 7–14 days before form work is removed. Such lintels are useful to span small openings.

(D) R.C.C. Lintels: It is possible to provide R.C.C. lintels of any span required in the building. They can be isolated or continuous over the openings. They are provided with suitable reinforcement—main reinforcements beings on lower side in the opening. Nowadays these lintels are used very commonly in buildings.

Steel Lintels: Steel angles or rolled steel I-sections are used as lintels. Tube separators may be provided to maintain the spacing between the sections. If the sections are opened to atmospheric action, regular painting is necessary. Many times they are encased in concrete to avoid maintenance problem. These lintels can be used for large openings.

STAIRS

Stairs give access from floor to floor. The space/room housing stairs is called staircase. Stairs consists of a number of steps arranged in a single flight or more number of flights.

The requirement of good stairs are

(*a*) **Width:** 0.9 m in residential buildings and 1.5 m to 2.5 m in public buildings.

UNIT 1

(*b*) **Number of Steps in a Flight:** Maximum number of steps in a flight should be limited to 12 to 14, while minimum is 3.

(*c*) **Rise:** Rise provided should be uniform. It is normally 150 mm to 175 mm in residential buildings while it is kept between 120 mm to 150 mm in public buildings. However in commercial buildings more rise is provided from the consideration of economic floor area.

(*d*) **Tread:** Horizontal projection of a step in a stair case is called tread. It is also known as going. In residential buildings tread provided is 250 mm while in public buildings it is 270 mm to 300 mm.

The following empirical formula is used to decide rise and tread:

$$\mathbf{2R + T > 550\ mm\ but < 700\ to\ 600\ mm}$$

Where R is rise in mm and T is tread in mm.

(*e*) **Head Room:** Head room available in the stair case should not be less than 2.1 m.

(*f*) **Hand Rails:** Hand rails should be provided at a convenient height of a normal person which is from 850 mm to 900 mm.

Types of Stairs

The stairs may be built with wood, concrete masonry or with cast iron. Wooden stairs are not safe, because of the danger of fire. However they are used in unimportant buildings to access to small areas in the upper floors. Cast iron or steel stairs in the spiral forms were used commonly to reduce stair case area. In many residential buildings masonry stairs are also used. Reinforced concrete stairs are very commonly used in all types of buildings.

Based on the shapes stairs may be classified as:

(*a*) Straight stairs
(*b*) Dog legged stairs. (*c*) Well or open-newel stairs (*d*) Geometrical stairs (*e*) Spiral stairs (*f*) Turning stairs.