BMS INSTITUTE OF TECHNOLOGY AND MANAGEMENT

DEPARTMENT OF CIVIL ENGINEERING

STUDY MATERIAL

COURSE NAME: BUILDING MATERIALS AND CONSTRUCTION

COURSE CODE :18CV34

TITLE OF THE COURSE: BUILDING MATERIALS AND CONSTRUCTION

SEMESTER:III

Course Coordinator	Mr.Vinod B R (VBR)		
Course Code	**18CV34**	CIE Marks	40
Number of Lecture Hours/Week	03	SEE Marks	60
Total Number of Lecture Hours	**40 (8 Hours per Module)**	Exam Hours	03
Prerequisite	Elements of civil engineering and engineering mechanics	Credits	04

VISION OF THE DEPARTMENT: To be an Exemplary Centre, disseminating quality education and developing technically competent civil engineers with professional integrity for the betterment of society

MISSION OF THE DEPARTMENT:

- To impart technical proficiency & professional ethics through state of art infrastructure and committed faculty
- To provide practical exposure through research, industry- interaction and motivate entrepreneurship to cater societal needs.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1		
Building Materials: Stone as building material; Requirement of good building stones, Dressing of stones, Deterioration and Preservation of stone work. Bricks; Classification, Manufacturing of clay bricks, Requirement of good bricks. Field and laboratory tests on bricks; compressive strength, water absorption, efflorescence, dimension and warpage. Cement Concrete blocks, Stabilized Mud Blocks, Sizes, requirement of good blocks. Mortar: types and requirements. Timber as construction material Fine aggregate: Natural and manufactured: Sieve analysis, zoning,	8 hours	L1,L2

specify gravity, bulking, moisture content, deleterious materials. Coarse aggregate: Natural and manufactured: Importance of size, shape and texture. Grading of aggregates, Sieve analysis, specific gravity, Flakiness and elongation index, crushing, impact and abrasion tests.		
Module -2		
Foundation: Preliminary investigation of soil, safe bearing capacity of soil, Function and requirements of good foundation , types of foundation , introduction to spread, combined , strap, mat and pile foundation . **Masonry:** Definition and terms used in masonry. Brick masonry, characteristics and requirements of good brick masonry, Bonds in brick work, Header, Stretcher, English, Flemish bond, Stone masonry, Requirements of good stone masonry, Classification, characteristics of different stone masonry, Joints in stone masonry. Types of walls; load bearing, partition walls, cavity walls	8 Hours	L1,L2
Module -3		
Lintels and Arches: Definition, function and classification of lintels, Balconies, chejja and canopy. Arches; Elements and Stability of an Arch. **Floors and roofs:** Floors; Requirement of good floor, Components of ground floor, Selection of flooring material, Laying of Concrete, Mosaic, Marble, Granite, Tile flooring, Cladding of tiles. Roof;-Requirement of good roof, Types of roof, Elements of a pitched roof, Trussed roof, King post Truss, Queen Post Truss, Steel Truss, Different roofing materials, R.C.C. Roof.	8 Hours	L3
Module -4		
Doors, Windows and Ventilators: Location of doors and windows, technical terms, Materials for doors and windows, Paneled door, Flush door, Collapsible door, Rolling shutter, PVC Door, Paneled and glazed Window, Bay Window, French window. Ventilators. Sizes as per IS recommendations. **Stairs:** Definitions, technical terms and types of stairs,	8 Hours	**L2 L3 L5**

Requirements of good stairs. Geometrical design of RCC doglegged and open-well stairs. **Formwork:** Introduction to form work, scaffolding, shoring, under pinning.		
Module -5		
Plastering and Pointing : purpose, materials and methods of plastering and pointing, defects in plastering-Stucco plastering, lathe plastering **Damp proofing**- causes, effects and methods. **Paints**- Purpose, types, ingredients and defects, Preparation and applications of paints to new and old plastered surfaces, wooden and steel surfaces.	8 Hours	L4 L5

Course Outcomes: After a successful completion of the course, the student will be able to:
1. Select suitable materials for buildings and adopt suitable construction techniques.
2. Adopt suitable repair and maintenance work to enhance durability of buildings.

Text Books:

1. Sushil Kumar "Building Materials and construction", 20th edition, reprint 2015,Standard Publishers
2. Dr. B.C.Punmia, Ashok kumar Jain, Arun Kumar Jain, "Building Construction, Laxmi Publications (P) ltd., New Delhi.
3. Rangawala S. C. "Engineering Materials", Charter Publishing House, Anand, India.

Reference Books:
1. S.K.Duggal, "Building Materials", (Fourth Edition)New Age International (P) Limited, 2016 National Building Code(NBC) of India
2. P C Vergese, "Buliding Materials", PHI Learning Pvt. Ltd
3. Building Materials and Components, CBRI, 1990, India
4. Jagadish.K.S, "Alternative Building Materials Technology", New Age International, 2007.
5. M. S. Shetty, "Concrete Technology", S. Chand & Co. New Delhi.

List of URLs, Text Books, Notes, Multimedia Content, etc
1. ttps://www.teachengineering.org › Teach Engineering › Lessons › Designing Bridges
2. https://www.aboutcivil.org/Bridge-designing.html

Module -1

Building Materials: Stone as building material; Requirement of good building stones, Dressing of stones, Deterioration and Preservation of stone work. Bricks; Classification, Manufacturing of clay bricks, Requirement of good bricks. Field and laboratory tests on bricks; compressive strength, water absorption, efflorescence, dimension and warpage. Cement Concrete blocks, Stabilized Mud Blocks, Sizes, requirement of good blocks. Mortar: types and requirements. Timber as construction material Fine aggregate: Natural and manufactured: Sieve analysis, zoning, specify gravity, bulking, moisture content, deleterious materials. Coarse aggregate: Natural and manufactured: Importance of size, shape and texture. Grading of aggregates, Sieve analysis, specific gravity, Flakiness and elongation index, crushing, impact and abrasion tests. **8 Hours**

Stone as building material

The stones are used in the construction of buildings from the ancient times and most of the ancient temples, forts and mosques of India were built with stones as the major material. The Taj Mahal, Red Fort, Jama Masjid, Parliament house and Rashtrapati Bhawan at Delhi and various other prominent structures spread throughout the length and breadth of our country furnish us the awesome examples of uses of the stone as building material. At present, they are largely used as the basic material for the manufacturing of the other construction materials like concrete, bricks etc.

Following are the various uses to which stones are employed:-

1. **Structural elements:** The stones are used for foundations, walls, columns, lintels, roofs, floor, damp proof courses etc.

2. **Facing:** The stones are adopted to give massive appearance to the structure. The walls are of bricks and facing is done in stones of desired shades. This is known as the composite masonry.

3. **Paving:** The stones are used to cover floor of buildings of various types such as residential, commercial, industrial etc. They are also adopted to form paving of roads, footpaths etc.

4. **Basic Material:** The stones are disintegrated and converted to form a basic material for cement concrete, murum of roads, calcareous cements, artificial stones, hollow blocks etc.

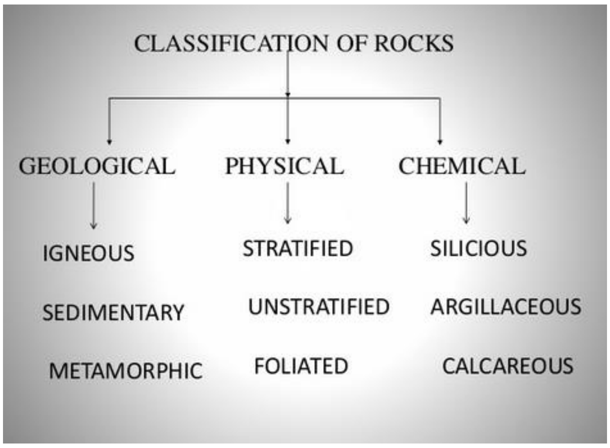
5. **Miscellaneous uses :** In addition to the above uses the stones are also used as:

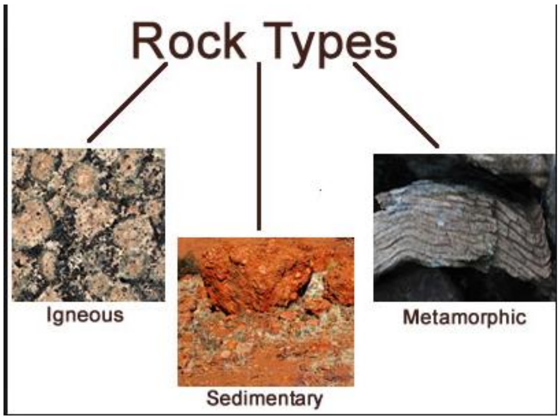
i. Ballast for railways,
ii. Blocks in construction of bridges, piers, abutments, retaining walls, light houses, dams etc.
iii. Flux in blast furnaces.

Classification 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.

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

2.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.

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

Physical Classification

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

- Stratified rocks
- Unstratified rocks

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

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

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

Chemical Classification

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

- Silicious rocks
- Argillaceous rocks and
- Calcareous rocks

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

2.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.

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

Properties of Stones

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

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

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

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

(*iv*) **Appearance:** A stone with uniform and attractive colour is durable, if grains are compact.Marble and granite get very good appearance, when polished.

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

(*vi*) **Hardness:** It is an important property to be considered when stone is used for flooring and pavement. Coefficient of hardness is to be found by conducting test on standard specimen in Dory's testing machine. For road works coefficient of hardness should be at least 17. For building works stones 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 causes disintegration. Absorption test is specified as percentage of water absorbed by the stone when it is immersed under water for 24 hours. For a good stone it should be as small as possible and in no case more than 5.

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

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

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

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

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

Requirements of Good Building Stones

The following are the quality requirements of good building stones:

1. Strength

Generally most of the building stones have high strength to resist the load coming on it. Therefore it is not of prime concern when it comes to check the quality of stones. But when the stones are to be used in large structures, it becomes necessary to check the compressive strength of stones.
Compressive strength of building stones generally fall within the range of 60 to 200N/mm2.

2. Durability

Building stones should be capable to resist the adverse effects of natural forces like wind, rain and heat. It must be durable and should not deteriorate due to the adverse effects of the above natural forces.

3. Hardness

When stones are used in floors, pavements or aprons of bridges, they become subjected to wearing and abrasive forces caused by movement of men or machine over them. So it is required to test hardness of stone. Hardness of stone is determined by Mohs scale.

4. Toughness

Toughness of stones means it ability to resist impact forces. 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.

5. Specific Gravity

The more the specific gravity of stone, the more heavier and stronger the stone is.

Therefore stones having higher specific gravity values should be used for the construction of dams, retaining walls, docks and harbors. The specific gravity of good building stone is between 2.4 and 2.8.

6. Porosity and Absorption

Porosity of building stones depend upon the mineral constituent and structural formation of the parent rock. If stones used in building construction are porous then rain water can easily enter into the pore spaces and cause damage to the stones. Therefore building stone should not be porous.

Water absorption of stone is directly proportional to the porosity of rock. If a stone is more porous then it will absorb more water and cause more damage to stone.

In higher altitudes, the freezing of water in pores takes place and it results into the disintegration of the stone.

7. 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.

8. 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.

Light colored stones are more preferred than dark colored stones as the colour are likely to fade out with time.

9. Seasoning

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

10. Workability

Stone should be workable. Stone is said to be workable when the work involved in stone working (such as cutting, dressing & shaping) is economical and easy to conduct.

11. Cost

Cost is an important consideration in selecting a building material. Proximity of the quarry to building site brings down the cost of transportation and hence the cost of stones comes down.

12. Fire Resistance

Stones should be free from calcium carbonate, oxides of iron, and minerals having different coefficients of thermal expansion. Igneous rock show marked disintegration principally because of quartz which disintegrates into small particles at a temperature of about 575°C. Limestone, however, can withstand a little higher temperature; i.e. up to 800°C after which they disintegrate.

Characteristics of stones

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

Granite

1. Igneous rock
2. Composed of quart, felspar and mica and minerals
3. Available in grey, green, brown and pink and red
4. Hard and durable
5. High resistance to weathering
6. The texture varies with its quality
7. Specify gravity 2.7 and compressive strength 700 to 1300kg/cm2
8. Used for ornamental, road metal, railway ballast, aggregatefor concrete; for construction of bridges, piers and marine works etc.

Sand Stone:

1. Sedimentary rock
2. It is available in variety of formations fine grained, coarse grained compact or porous
3. Available in white, green, blue, black, red and yellow.
4. Specific gravity 2.65 to 2.95
5. Compressive strength is 650kgs / cm2
6. Used for ashlar works

Lime Stone:

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

a. Compact lime stone
b. Granular lime stone
c. Magnesia lime stone
d. Kanker lime stone

f. Used for paving, road metal, etc

Marble

1. Metamorphic rock
2. Available in white, blue, green, yellow black and red colour
3. High compactness,
4. Suitable for decorative works, wall lining columns, pile, table slabs, hearths, tiled floors, steps of stair case etc.

Slate:

1. Metamorphic rock
1. Non absorbent, compact fine grained and produce metallic ringing sound when struck
2. Available in black, dark blue, grey, reddish brown etc.

3. Used for providing damp proof course, paving dados etc

Dressing of stones

Definition:

The Dressing of stone is defined as “The process of giving a proper size, shape and finish to the roughly broken stones as obtained from the quarry.” This process is done manually or mechanically. A dressed stone is fit for use in a particular situation in a building.

Objectives:

Stones obtained from the quarries are very rough and irregular in shape and quite bulky in size and weight.

With respect to the place of work, dressing can be divided into two types namely

- Quarry dressing
- Site dressing

Advantages of dressing, if it is carried out @ quarry site.

1. At quarry site, it is possible to get chap labour for the process of dressing of stones.
2. It is possible to sort out stones for different works, if quarry dressing is practiced.
3. The irregular and rough portions of the stones are removed which decrease the weight of stones and it also facilitates easy transportation of the stones.
4. The stones when quarried freshly contain quarry sap and hence they are comparatively soft and can be easily dressed.

Various objectives of dressing are below;

(a) To reduce the size of the big blocks of stones so that they are converted to easily lift-able pieces. This reduction in size is generally carried out at the quarry itself because that saves a lot of transportation cost.

(b) To give a proper shape to the stone. It is known that stones can be used at different places in the building, e.g., in foundations, in walls, in arches or for flooring, each situation will require a proper shape.This can be given at the quarry and also at the site of construction.

(c) To obtain an appealing finish. In a residential building, stones are used not only because of their extra strength, hardness, and durability but also because of their aesthetic value.

Methods / Types of Dressing of Stones.

As said earlier, dressing of stone can be done both manually as well as mechanically. *Manually,* skilled stone-smiths can work wonders on the suitable type of stones with chisels and hammers and abrasives. *Mechanically,* machines can cut the stone to any desired size and shape. Their surfaces can be made extra smooth by polishing through machines. There are, however, some traditional types of dressing of stones which are quite popular even at present. They are described below in brief.

(i) Pitched dressing:

In Pitched dressing, only the edges of a stone block are made level with the help of a hammer. The superfluous mass on the face is generally left intact.

(ii) Hammer dressing:

It is that type of dressing in which large raised portions of the stones are broken off, and the stone is shaped somewhat flat but rough due to hammer marks. These stone blocks are squared, and the bed and vertical sides are dressed to a distance of 8 to 10 cm from the face. This is done to enable the stone to have proper joints. This work is done by the use of waller’s hammer. The obtained stones are termed as hammer faced, quarry-faced or rustic faced.

(iii) Chisel drafting:

In this method, drafts or grooves are made with the help of a chisel at all the four edges. Any superfluous stone from the center is then removed. Chisel drafted stones are specially used in plinths and corners of the buildings.

(iv) Rough Tooling:

The edges are first squared by using a chisel and hammer. Then a series of grooves of variable width are developed over the surface of the stone.

(v) Punched Dressing:

In this method of dressing of stone, about 1 cm vertical or horizontal grooves are sunk with a chisel having it’s shaped as a hollow semi-circle. The sides of the rock are kept chamfered or sunk. It is done on the stones that have already been rough-tooled. With the help of Chisels, a series of parallel ridges are developed on the stone surface. It is also called furrowed finish.

(vi) Close Picked and Fine Tooling:

This is an extreme type of dressing of stone in which almost every projection is removed from all the sides of the stone. Its surface is given a fine-texture and appealing look.

(vii) Boasted or Droved finish:

It is a very common type of dressing of dressing of stone, in which the surface of the stone is covered with parallel marks that may run in any direction. A boaster which is actually a wide-edged chisel is used for this purpose. These marks may be horizontal or at any angle. The chisel marks are not continuous across the whole width of the stone.

(viii) Scabbling:

Irregular edges of the stones are broken off, and the stone is shaped. This work is generally done in a quarry, and the edges are broken with a scabbling hammer.

(ix) Reticulated finish:

In this type of dressing of stones, irregularly shaped sinking are made within the central portion of the stones having a 2 cm wide margin on its sides. These sinking are about 6 mm deep. The margin around the sinking is of constant width. The sunk surfaces may have punched marks to give a better appearance.

(x) Vermiculated finish:

This type of dressing of stone is the same as the reticulated finish except that they are more curved and give a worm-eaten type appearance. It is not very common as they need a lot of labor for construction.

(xi) Combed or Dragged finish:

This type of finish is done on soft stones. A comb is driven over the surface of this stone to remove it all elevating portions.

(xii) Picked Dressing:

This type of Dressing of stones is obtained by finishing the stone with a point, and the depression is smaller than the above type.

(xiii) Molded finish:

Molding is done to improve the appearance of stones. These are either handmade or machine made.

(xiv) Rubbed Finish:

In this method of dressing of stone, The surfaces of stones are rubbed to get a smoother finish. One piece of stone is rubbed against the other. Water and sand are added to aid the operation. It can also be rubbed by hand or machines.

(xv) Polished Surfaces:

Stones which can take polish, e.g., granites, marbles, limestones, etc., are first rubbed and then polished by using rubber, pad, sand, water, and putty powder. However, a machine can also be used for polishing.

(xvi) Sand Blasting:

This method of dressing of stone is done to imprint letterings and designs on the surface of granite. The polished surface is coated with a molten rubber-like compound which solidifies on cooling. The desired design is cut on this coating with a sharp tool thereby exposing the stone surface which is to be cut. A blast of sand is then blown with compressed air, the part which is exposed is cut to the depth needed.

Quarrying of stones:

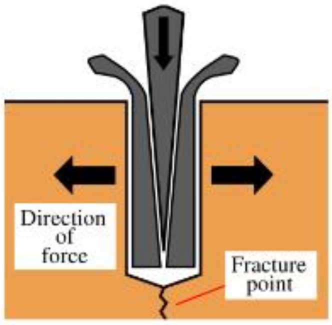
The method of removal of stones from their natural bed by using different operations is called quarrying.

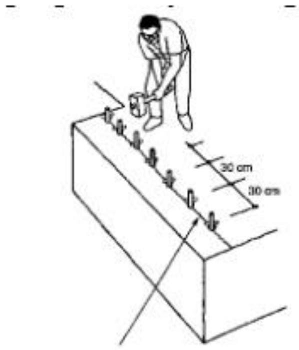
Methods of Quarrying

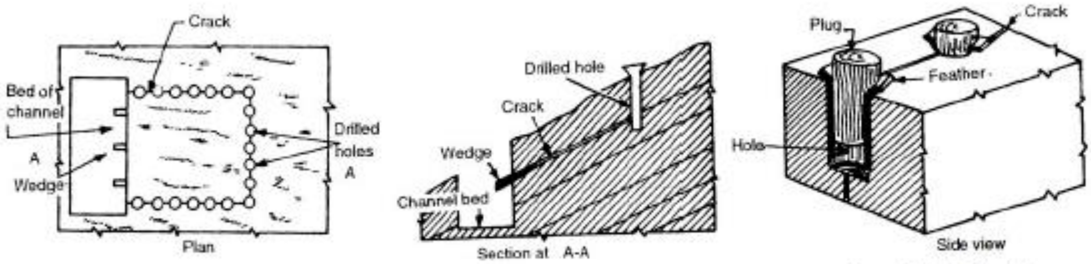
a)**Digging –**This method is used when the quarry consists of small & soft pieces of stones.

b)**Heating** –This method is used when the natural rock bed is horizontal * small in thickness.

c)**Wedging** –This method is used when the hard rock consists of natural fissure. When natural fissures are absent then artificial fissures are prepared by drilling holes.







Quarrying by Wedging

Wedging required tools –

i)Steel wedge

ii)Conical steel pin or plug

iii)Flat steel wedge

iv)Wooden plug

v)Pneumatic drill

d)**Blasting** –It is the process of removal of stones with the help of controlled explosives is filled in the holes of the stones. Line of least resistance plays very important role in the blasting process.

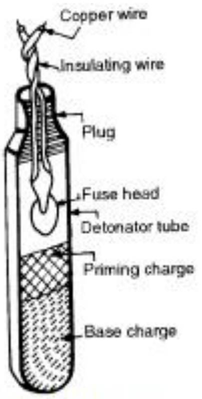
Following steps are used in the blasting process;

1) Drilling holes –Blast holes are drilled by using drilling machines.

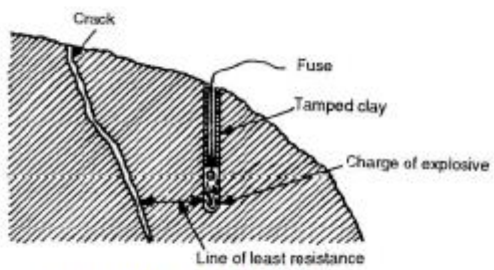
2) Charging –Explosive powders are fed into the cleaned & dried blast holes.

3) Tamping –The remaining portion of the blast holes are filled by clay, ash, fuse & wirings.

4)Firing –The fuses of blasting holes are fired by using electrical power supply or match sticks.



Electrical Detonator

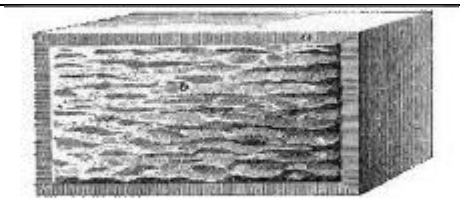
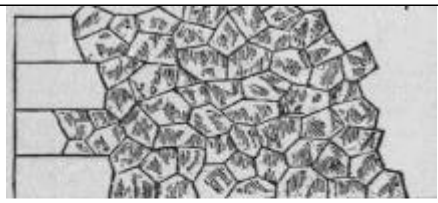
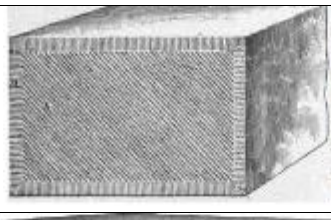
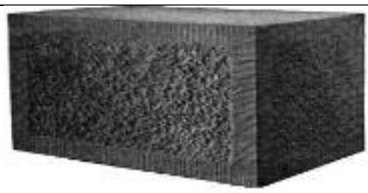


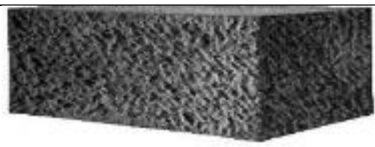
Tamped and Charged Blast Hole

Precautions in blasting *:*Accidents may take place during blasting. Following are some of the points which should be taken note of:

1. Blasting should not be carried out in late evening or early morning hours. The blasting hours should be made public and a siren should warn the workmen and nearby public timely to retire to a safe distance.
2. The danger zone, an area of about 200 m radius, should be marked with red flags.
3. First aid should be available.
4. The number of charges fired, the number of charges exploded and the misfires should be recorded.
5. Explosives should be stored and handled carefully.
6. Detonators and explosives should not be kept together.
7. Cartridges should be handled with rubber or polythene gloves.
8. A maximum of 10 bore holes are exploded at a time and that also successively and not simultaneously.

<u>Dressing of stones:</u>

1)Rough dressing quarry -It is the process of stone dressing which gives the broken stones in to the suitable pieces the shapes & sizes.	
2) Pitched face dressing - It is the process of stone dressing which gives the same plane & square of the surface.	
3) Hammer dressing -It is the process of stone dressing which gives the sharp less irregular corners of the surface distance by using hammer. It is suitable for mensory work.	
4) Rock face dressing -It is the process of stone dressing which gives the four edges having 2.5 cm surface distance by using chisels.	 
5) Rough tooling - It is the process of stone dressing which gives more or less parallel, horizontal , vertical at angle of the surface.	 

6) Punched dressing - It is the process of stone dressing which gives the parallel ridges with required gaps between the surfaces.	
7) Fine tooling –It is the process of stone dressing which gives the fine &smooth surface of the stones	

Preservation of stone work

Preservation of stone is essential to prevent its decay. Different types of stones require different treatments. But in general stones should be made dry with the help of blow lamp and then a coating of paraffin, linseed oil, light paint, etc. is applied over the surface. This makes a protective coating over the stone. However, this treatment is periodic and not permanent.

When treatment is done with the linseed oil, it is boiled and applied in three coats over the stone. Thereafter, a coat of dilute ammonia in warm water is applied.

The structure to be preserved should be maintained by washing stones frequently with water and steam so that dirt and salts deposited are removed from time to time. However, the best way is to apply preservatives. Stones are washed with thin solution of silicate of soda or potash. Then, on drying a solution of $CaCl_2$ is applied over it. These two solutions called Szerelmy's liquid, combine to form silicate of lime which fills the pores in stones. The common salt formed in this process is washed afterwards. The silicate of lime forms an insoluble film which helps to protect the stones. Sometimes lead paint is also used to preserve the stones, but the natural colour of the stone is spoilt. Painting stone with coal tar also helps in the preservation but it spoils the beauty of the stone. Use of chemicals should be avoided as far as possible, especially the caustic alkalis. Although cleaning is easy with chemicals, there is the risk of introducing salts which may subsequently cause damage to the stone.

In industrial towns, stones are preserved by application of solution of baryta, Ba(OH)2 — Barium hydrate. The sulphur dioxide present in acid reacts on the calcium contents of stones to form calcium sulphate. Soot and dust present in the atmosphere adhere to the calcium sulphate and form a hard skin. In due course of time, the calcium sulphate so formed flakes off and exposes fresh stone surface for further attack. This is known as *sulphate attack.* Baryta reacts with calcium sulphate deposited on the stones and forms insoluble barium sulphate and calcium hydroxide. The calcium hydroxide absorbs carbon dioxide from the air to form calcium carbonate.

$$Ba(OH)_2 + CaSO_4 \longrightarrow \underset{\text{(Barium sulphate)}}{BaSO_4} + \underset{\text{(Calcium hydroxide)}}{Ca(OH)_2}$$

$$Ca(OH)_2 + CO_2 \longrightarrow \underset{\text{(Calcium carbonate)}}{CaCO_3} + H_2O$$

The question whether or not stone preservatives should be used on old and decayed stone is a difficult one. Real evidence of the value of various treatments is most difficult to assess. The treatments, if carefully applied under favourable circumstances, may result in an apparent slowing down of the rate of decay. However, the rate of decay of stone is so slow that a short period experience is of very little value in establishing the effectiveness of the treatment. Also, there is some evidence that treatments which appear to be successful for few years, fail to maintain the improvement. In fact, the value of preservatives is not yet proved, and they may actually be detrimental if judged over a long period.

Deterioration of stone work:

The various natural agents such as rain, heat, etc. and chemicals deteriorate the stones with time.

Rain : Rain water acts both physically and chemically on stones. The physical action is due to the erosive and transportation powers and the latter due to the decomposition, oxidation and hydration of the minerals present in the stones.

Physical Action :Alternate wetting by rain and drying by sun causes internal stresses in the stones and consequent disintegration.

Chemical Action : In industrial areas the acidic rain water reacts with the constituents of stones leading to its deterioration.

Decomposition The disintegration of alkaline silicate of alumina in stones is mainly because of the action of chemically active water. The hydrated silicate and the carbonate forms of the alkaline materials are very soluble in water and are removed in solution leaving behind a hydrated silicate of alumina (Kaolinite). The decomposition of felspar is represented as

$$\underset{\text{(Orthoclase)}}{K_2Al_2O_3.6H_2O} + CO_2 + nH_2O = \underset{\text{(Alkaline carbonate)}}{K_2CO_3} + \underset{\text{(Kaolinite)}}{Al_2O_3.2SiO_2.2H_2O} + \underset{\text{(Hydrated silicate)}}{4SiO_2.nH_2O}$$

Oxidation and Hydration : Rock containing iron compounds in the forms of peroxide, sulphide and carbonate are oxidised and hydrated when acted upon by aciduated rain water. As an example the peroxide—FeO is converted into ferric oxide—Fe2O3 which combines with water to form FeO.nH2O. This chemical change is accompanied by an increase in volume and results in a physical change manifested by the liberation of the neighbouring minerals composing the rocks. As another example iron sulphide and siderite readily oxidize to limonite and liberates sulphur, which combines with water and oxygen to form sulphuric acid and finally to sulphates.

Frost: In cold places frost pierces the pores of the stones where it freezes, expands and creates cracks.

Wind: Since wind carries dust particles, the abrasion caused by these deteriorates the stones.

Temperature Changes : Expansion and contraction due to frequent temperature changes cause stone to deteriorate especially if a rock is composed of several minerals with different coefficients of linear expansion.

Vegetable Growth :

Roots of trees and weeds that grow in the masonry joints keep the stones damp and also secrete organic and acidic matters which cause the stones to deteriorate. Dust particles of organic or nonorganic origin may also settle on the surface and penetrate into the pores of stones. When these come in contact with moisture or rain water, bacteriological process starts and the resultant micro-organism producing acids attack stones which cause decay.

Mutual Decay
When different types of stones are used together mutual decay takes place. For example when sandstone is used under limestone, the chemicals brought down from limestone by rain water to the sandstone will deteriorate it.

Chemical Agent:
Smokes, fumes, acids and acid fumes present in the atmosphere deteriorate the stones. Stones containing $CaCO_3$, $MgCO_3$ are affected badly.

Lichens These destroy limestone but act as protective coats for other stones. Molluses gradually weaken and ultimately destroy the stone by making a series of parallel vertical holes in limestones and sand stones.

Selection of stones :

The conditions which govern the selection of stone for structural purposes are cost, fashion, ornamental value and durability, although the latter property is frequently overlooked or disregarded. Cost is largely influenced by transportation charges, difficulties in quarrying and cutting, the ornamental features, and the durability of stone. The type of dressing of stone may make a difference to the cost, particularly with the stones derived from igneous rocks. When the cost of quarried stone to cost of finished stone is considered, it will be found that the labour cost is far greater than the price of the stone. Thus, a difference in the price between two alternative stones is unimportant and it would be unwise to reject a more durable stone on the grounds that it was costly. Another factor which should be considered is the suitability of the stone for the type of design, for example, for a highly carved design if, by mistake, a harder stone such as granite is selected the cost will be affected. Colour, arrangement and shape of mineral constituents greatly influence fashion and ornamental value. One of the first factors influencing the selection of stone for a particular work will be colour. It is important that the designer is aware about how the colour is likely to change after long exposure and in particular how it may vary in polluted atmospheres. As an example limestone, being slightly soluble in water, will remain clean in portions facing rain but retain a film of soot in sheltered areas. This results in strong colour contrast. Resistance to fire and weathering—factors which are largely influenced by the mineral constitution of the rock—are the most important determinators of durability. It is very important to select a stone according to its exposure conditions. Limestones when used in areas not exposed to rain but acted upon by sulphur gases of polluted atmosphere, form a hard and impermeable surface skin which subsequently blisters and flakes off. It must be noted that flaking of this kind occurs mainly on external work only, although the air inside the building is almost equally polluted, probably due to the damper conditions inside.

Tests on Building Stones

Following are different tests on building stones:

1. Acid test
2. Attrition test

3. Crushing test
4. Crystalline test
5. Freezing and thawing test
6. Hardness Test
7. Impact test
8. Water absorption test
9. Microscopic Test
10. Smith’s Test

Acid Test on Building Stone

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

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

Attrition Test on Building Stone

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

The following procedure is adopted:

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

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

Crushing Test on Building Stone

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

Load bearing surface is then covered with plaster of paris of about 5mm thick plywood. Load is applied axially on the cube in a crushing test machine. Rate of loading is 140 kg/sq.cm per minute.

Crushing strength of the stone per unit area is the maximum load at which the sample crushes or fails divided by the area of the bearing face of the specimen.

Freezing and thawing test

Stone specimen is kept immersed in water for 24 hours. It is then placed in a freezing machine at -12 degC for 24 hours. Then it is thawed or warmed at atmospheric temperature.

This should be done in shade to prevent any effect due to wind, sun rays, rain etc. this procedure is repeated several times and the behaviour of stone is carefully observed.

Hardness Test on Building Stone

For determining the hardness of a stone, the test is carried out as follows:

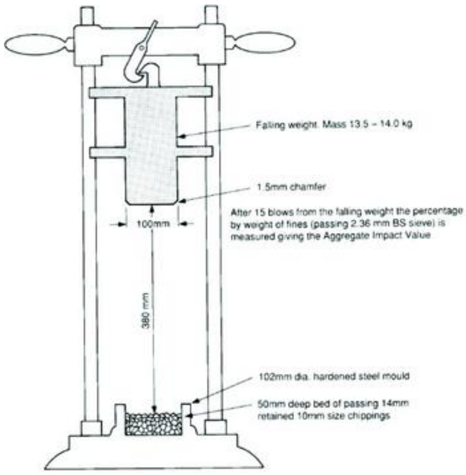
1. A cylinder of diameter 25mm and height 25mm is taken out from the sample of stone.
2. It is weighed.
3. The sample is placed in Dorry's testing machine and it is subjected to a pressure of 1250 gm.
4. Annular steel disc machine is then rotated at a speed of 28 rpm.
5. During the rotation of the disc,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

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

Impact Test

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

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

6. 

Microscopic Test

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

1. Average grain size
2. Existence of pores, fissures, veins and shakes
3. Mineral constituents
4. Nature of cementing material
5. Presence of any harmful substance
6. Texture of stones etc.

Smith's Test

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

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

Water Absorption Test

The test is carried out as follows:

1. From the sample of stone, a cube weighing about 50gm is prepared. Its actual weight is recorded as W1 gm.
2. Cube is then immersed in distilled water for a period of 24 hrs.
3. Cube is taken out of water and surface water is wiped off with a damp cloth.
4. It is weighed again. Let the weight be W2 gm.
5. Cube is suspended freely in water and its weight is recorded. Let this be W3 gm.
6. Water is boiled and cube is kept in boiling water for 5 hours.

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

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

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

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

Volume of displaced water = W2 – W3

Percentage porosity by volume = (W4 – W1) x 100 / (W2 – W3)

Density =W1 / (W2 – W3) kg/m3

Specific Gravity = W1 / (W2 – W3)

Saturation Coefficient = (Water Absorption/Total Porosity) = (W2 – W1) / (W4 – W1)

Bricks are obtained by moulding clay in rectangular blocks of uniform size and then by drying and burning these blocks. As bricks are of uniform size, they can be properly arranged, light in weight and hence bricks replace stones.

Classification:

Bricks can broadly be divided into two categories.

(i) Unburnt or sundried bricks

(ii) Burnt bricks

(i) Un burnt or Sun dried bricks- UN burn or sun dried with the help of heat received from sun after the process of moulding.

These bricks can only be used in the constructions of temporary and cheap structures. Such bricks should not be used at places exposed to heavy rains.

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

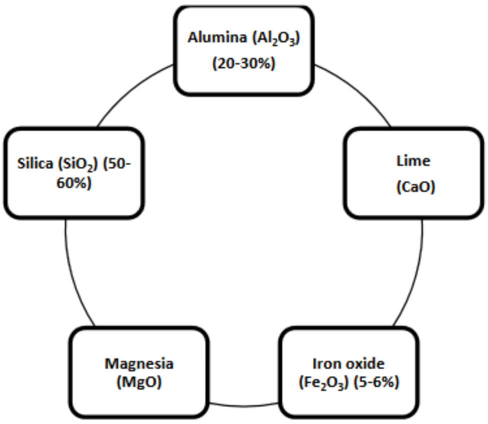
a. **First Class bricks:** These bricks are table moulded and of standard shape. The surface and edges of the bricks are sharp, square, smooth and straight. The comply all the qualities of good bricks and used for superior work of permanent nature.

b. **Second class bricks:** These bricks are ground moulded and they are burnt in kilns. The surface of bricks is some what rough and shape is also slightly irregular. These bricks are commonly used at places where brick work is to be provided with a coat of plaster.

c. **Third class bricks:** These bricks are ground moulded and they burnt in clamps. These bricks are not hard and they have rough surfaces with irregular and distorted edges. These bricks give dull sound when struck together. They are used for unimportant and temporary structures and at places where rainfall is not heavy.

d. **Fourth class bricks:** These are over burnt bricks with irregular shape and dark colour. These bricks are used as aggregate for concrete in foundation, floors, roads, etc because of the fact that the over burnt bricks have compacted structure and hence, they are some times found stronger than even first class bricks.

Composition - Manufacture Process.



Composition – Following are the constituents of good brick earth.

Alumina: - It is the chief constituent of every kind of clay. A good brick earth should contain 20 to 30 percent of alumina. This constituent imparts plasticity to earth so that it can be moulded. If alumina is present in excess, raw bricks shrink and warp during drying and burning.

Silica-A good brick earth should contain about 50 to 60 percent of silica. Silica exists in clay either as free or combined form. As free sand, it is mechanically mixed with clay and in combined form; it exists in chemical composition with alumina. Presence of silica prevents crackers shrinking and warping of raw bricks. It thus imparts uniform shape to the bricks. Durability of bricks depends on the proper proportion of silica in brick earth. Excess of silica destroys the cohesion between particles and bricks become brittle.

Lime – A small quantity of lime is desirable in finely powdered state to prevents shrinkage of raw bricks. Excess of lime causes the brick to melt and hence, its shape is last due to the splitting of bricks.

Oxide of iron- A small quantity of oxide of Iron to the extent of 5 to 6 percent is desirable in good brick to imparts red colour to bricks. Excess of oxide of iron makes the bricks dark blue or blackish.

Magnesia- A small quantity of magnesia in brick earth imparts yellow tint to bricks, and decreases shrinkage. But excess of magnesia decreases shrink leads to the decay of bricks.

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

Manufacture of bricks:

The manufacturing of brick, the following operations are involved

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

(i) Preparation of clay :- The preparation of clay involves following operations

a) **Unsoiling** :- Top layer of 20cm depth is removed as it contain impurities.

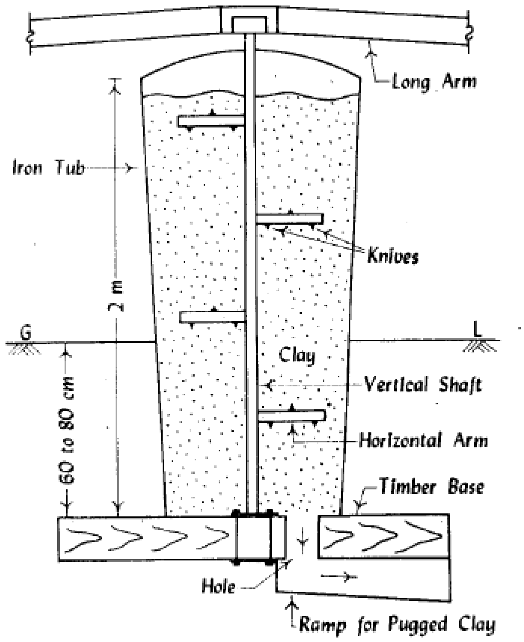
b) **Digging**: - Clay dug out from ground is spread on level ground about 60cm to 120cm heaps.

c) **Cleaning**:-Stones, pebbles, vegetable matter etc removed and converted into powder form.

d) **Weathering**:- Clay is exposed to atmosphere from few weeks to full season.

e) **Blending**:- Clay is made loose and any ingradient to be added to it is spread out at top and turning it up and down in vertical direction**.**

f) **Tempering**:- Clay is brought to a proper degree of hardness, then water is added to clay and whole mass is kneaded or pressed under the feet of men or cattle for large scale, tempering is usually done in pug mill as shown in the fig.

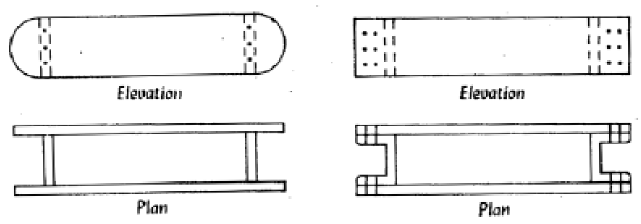


Pug Mill

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.

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

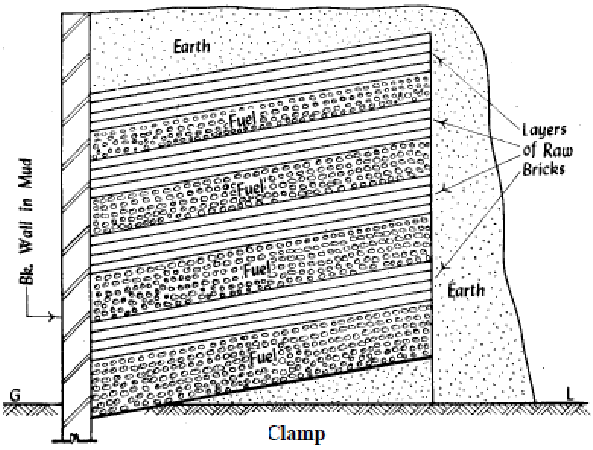
Hand Moulding: Moulds are rectangular boxes of wood or steel, which are open at top and bottom. Steel moulds are more durable and used for manufacturing bricks on large scale as shown in fig . Bricks prepared by hand moulding are of two types.



Wooden mould & Steel mould

a) Ground moulded bricks
b) Table moulded bricks
(a) **Ground moulded bricks:** ground is first made level and fine sand is sprinkled over it. Mould is dipped in water and placed over the ground to fill the clay. Extra clay is removed by wooden or metal strike after the mould is filled forced mould is then lifted up and raw brick is left on the ground. Mould is then dipped in water every time lower faces of ground moulded bricks are rough and it is not possible to place frog on such bricks.
Ground moulded bricks of better quality and with frogs on their surface are made by using a pair of pallet boards and a wooden block
(b) **Table-moulded bricks**: Process of moulding these bricks is just similar to ground bricks on a table of size about 2m x 1m.
(1) **Machine moulding:** This method proves to be economical when bricks in huge quantity are to be manufactured at the same spot. It is also helpful for moulding hard and string clay. These machines are broadly classified in two categories (a) Plastic clay machines
(b) Dry clay machines
a) **Plastic clay machines:** This machine containing rectangular opening of size equal to length and width of a brick. Pugged clay is placed in the machine and as it comes out through the opening, it is cut into strips by wires fixed in frames, so there bricks are called wire cut bricks.
b) **Dry clay machines:** In these machines, strong clay is first converted into powder form and then water is added to form a stiff plastic paste. Such paste is placed in mould and pressed by machine to form hard and well shaped bricks. These bricks are behavior than ordinary hand moulded bricks. They carry distinct frogs and exhibit uniform
texture.
(2) **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 1200C about 1 to 3 days
(ii) **Circulation of air**- Stacks are arranged in such a way that sufficient air space is left between them free circulation of air.
(iii)**Drying yard**- special yards should be prepared slightly higher level prevent the accumulation of rain water (iv)**Period for frying** – usually about 3 to 10 days to bricks to
become dry
(v) **Screens** – screens are necessary, may be provided to avoid direct exposure to wind or sun.
(3) **Burning:** This is very important operation in the manufacturing of bricks to impart hardness, strength and makes them dense and durable. Burning of bricks is done either in clamps or in kilns.

Clamps are temporary structures and they are adopted to manufacture bricks on small scale. Kilns are permanent structures and they are adopted to manufacture bricks on a large scale. A typical clamp is as shown in fig



Clamp

(1) A trapezoidal shape in plan with shorter is slightly in excavation and wider end raised at an angle of 150 from ground level
(2) A brick wall with mud is constructed on the short end and a layer of 70cm to 80cm thick fuel (grass, cow dung, ground nuts, wood or coal) laid on the floor.
(3) A layer consists of 4 or 5 courses of raw bricks laid on edges with small spaces between them for circulation of air.
(4) A second layer of fuel is then placed, and over it another layer of raw bricks is putap. The total height of clamp in alternate layers of brick is about 3 to 4 m
(5) When clamp is completely constructed, it is plastered with mud on sides and top and filled with earth to prevent the escape of heat
(6) The period of burning is about one to two months and allow the same time for coding
(7) Burnt bricks are taken out from the clamp

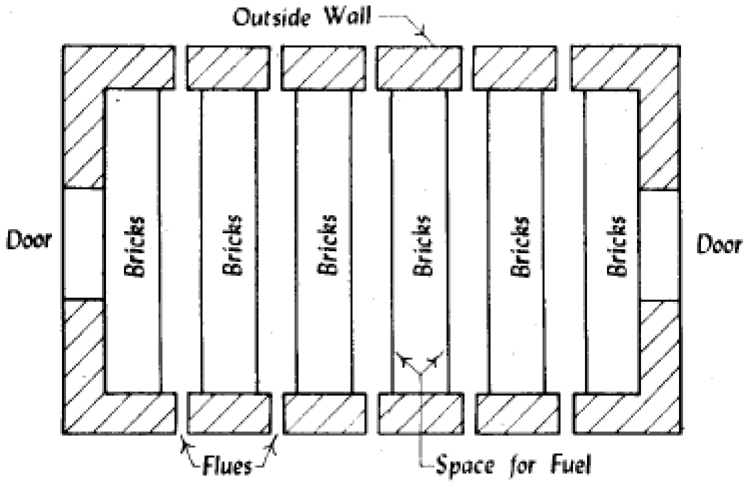
Advantages:
(i) The bricks produced are tough and strong because burning and cooling are gradual
(ii) Burning in clamps proves to be cheap and economical
(iii) No skilled labour and supervision are required for the construction of clamps
(iv) There is considerable saving of clamps fuel

Disadvantages:
(i) Bricks are not of required shape
(ii) It is very slow process
(iii) It is not possible to regulate fire in a clamp
(iv) Quality of brick is not uniform

Kilns: A kiln is a large oven, which is used to burnt bricks by
1) Intermittent kilns
2) Continuous kilns
1) Intermittent kilns: These intermittent in operation, which means that they are loaded, fired, cooled and unloaded.

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

a) Intermittent up-draught kiln: This is in the form of rectangular with thick outside walls as shown in the fig. wide doors are provided at each end for loading and unloading of kilns. A temporary roof may be installed to protect from rain and it is removed after kiln is fired. Flues are provided to carry flames or hot gases through the body of kiln.



Intermittent kiln

(i) Raw bricks are laid in row of thickness equal to 2 to 3 bricks and height 6 to 8 bricks with 2 bricks spacing between rows
(ii) Fuels are filled with brush wood which takes up a free easily
(iii) Loading of kiln with raw bricks with top course is finished with flat bricks and other courses are formed by placing bricks on edges
(iv) Each door is built up with dry bricks and are covered with mud or clay
(v) The kiln is then fired for a period of 48 to 60 hours draught rises in the upward direction from bottom of kiln and brings about the burning of bricks.
(vi) Kiln is allowed to cool down and bricks are then token out
(vi) Same procedure is repeated for the next burning

Bricks manufactured by intermittent up drought kilns are better than those prepared by clamps but bricks burnt by this process is not uniform, supply of bricks is not continuous and wastage of fuel heat.

(b) Intermittent down-draught kilns:

These kilns are rectangular or circular in shape. They are provided with permanent walls and closed tight roof. Floor of the kiln has opening which are connected to a common chimney stack through flues. Working is same as up-draught kiln. But it is so arranged in this kiln that hot gases are carried through vertical flues upto the level of roof and they are then released. These hot gases move down ward by the chimney draught and in doing so, they burn the bricks.

2. Continuous kilns:

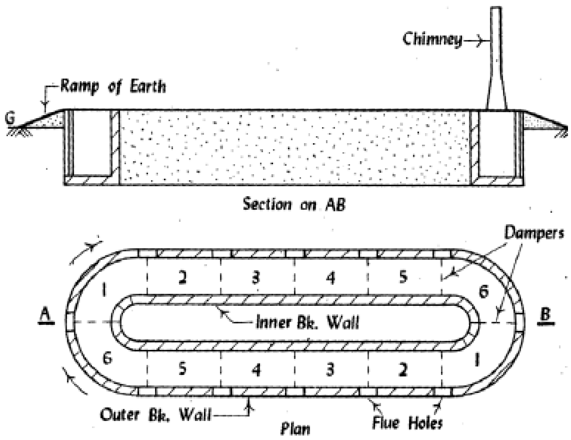
These kilns are continuous in operations. This means that loading, firing, cooling and unloading are carried out simultaneously in these kilns. There are three types of continuous kilns.

a) Bull's trench kiln

b) Hoffman's kiln

c) Tunnel kiln

a) Bull's trench kiln: This kiln may be of rectangular, circular or oval shape in the plan as shown in fig . It is constructed in a trench excavated in ground either fully under ground partially projecting above ground openings is provided in the outer walls to act as flue holes. Dampers are in the form of iron plates and they are used to divide the kilns in suitable sections and most widely used kiln in India.



Bull's trench kiln

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

Section 1 – loading

Section 2 – empty

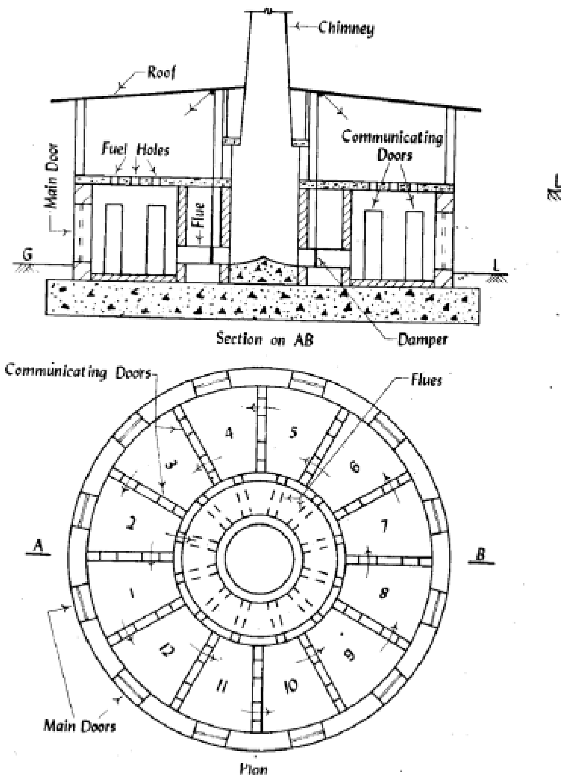
Section 3 – unloading

Section 4 – cooling

Section 5 – Burning

Section 6 – Heating

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



Hoffman's kiln

Chamber 1 - loading
Chamber 2 to 5 – drying and pre-heating

Chambers 6 and 7 - burning
Chambers 8 to 11 - cooling
Chamber 12 – unloading
The initial cost in stalling this kiln is high, the following advantages
(i) Good quality of bricks are produced
(ii) It is possible to regulate heat inside the chambers through fuel holes
(iii) Supply of bricks is continuous and regular
(iv) There is considerable saving in fuel due to pre heating of raw bricks by flue gases.

COMPARISON BETWEEN CLAMP-BURNING AND KILN-BURNING

No.	Item	Clamp-burning	Kiln-burning
1.	Capacity	About 20000 to 100000 bricks can be prepared at a time.	Average 25000 bricks can be prepared per day.
2.	Cost of fuel	Low as grass, cow dung, litter, etc. may be used.	Generally high as coal dust is to be used.
3.	Initial cost	Very low as no structures are to be built.	More as permanent structures are to be constructed
4.	Quality of bricks	Percentage of good quality bricks is small about 60% or so.	Percentage of good quality bricks is more about 90% or so.
5.	Regulation of fire	It is not possible to control or regulate fire during the process of burning	Fire is under control throughout the process of burning.
6.	Skilled supervision	Not necessary through-out the process of burn-ing.	Continuous skilled super vision is necessary.
7.	Structure	Temporary structure.	Permanent structure.
8.	Suitability	Suitable when bricks are to be manufactured on a small scale and when the demand of bricks is not continuous.	Suitable when bricks are to be manufactured on a large scale and when there is continuous demand of bricks.
9.	Time of burn-ing and cool-ing.	It requires about 2 to 6 months for burning and cooling of bricks.	Actual time for burning of one chamber is about 24 hours and only about 12 days are required for cooling of bricks.
10.	Wastage of heat.	There is considerable wastage of heat from top and sides and hot flue gas is not properly utilised.	Hot flue gas is used to dry and pre-heat raw bricks. Hence wastage of heat is the least.

Qualities of Good Brick:

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

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

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

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

(v) Bricks should not absorb water more than 20 percent by weight for first class bricks and 22 percent by weight for second class bricks, when soaked in cold water for a period of 24 hours.

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

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

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

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

(x) No brick should have crushing strength below 55kg/cm2.

Harmful ingredients of a brick earth:

1) Lime stone: It causes bricks to split into pieces.
2) Alkalis: It affects the overall appearance of the building as it causes ‘efflorescence’.
3) Iron pyrites: It causes decomposition of bricks.
4) Pebbles of stone and gravel: It breaks the uniformity of bricks.
5) Organic matter or vegetation: Due to the presence of this, brick becomes more porous.

Types of Special Bricks:

1.Acid resistant bricks: It is specially used for chemical plant.
2.Engineering bricks: It is used for paving purposes.
3.Silica bricks: It is used in the construction of chimney.
4.Refractory bricks:It is used in metallurgical process.
5.Sand-lime bricks:It is used for ornamental work.
6.Blue bricks: It is used for heavy engineering constructional work like bridges.
7.Coloured bricks: It is used for decorative work only.
8.Fire bricks: It is used for the construction of hearth, furnaces and chimney as they have to resist high temperature.

Field tests of the good quality bricks:

1.Uniformity in shape & size: A good brick should have rectangular plane surface and uniform in size. This check is made in the field by observation.
2.Uniformity in colour : A good brick will have uniform colour
3.Structure: Few bricks may be broken in the field and their cross-section is observed. The section should be homogeneous, compact and free from defects such as holes and lumps.
4.Sound test: If two bricks are struck with each other they should produce clear ringing sound. The sound should not be dull.
5.Hardness test: Scratch the brick with nail. If no impression is marked on the surface, the brick is sufficiently hard.
6.Water absorption: Brick specimen is weighted dry. Then they are immersed in water for 24 hrs. It is weighted again and the difference indicates amount of water absorption. This should not be more than 20%.

<u>Cement concrte blocks</u>

They are used as an alternate for bricks.

Raw Materials

Coarse aggregate, fine aggregate cement and water. The aggregates of various types have been used include crushed stones, gravel, volcanic cinders, foamed slag, furnace slag tec.

Manufacturing Process

Fully automatic plants are available for manufacturing of high strength concrete blocks on large scale. The manually operated machines are available. Following are the processes involved in the manufacture of Concrete blocks.

- Selection of Proper ingredients.
- Mining of Ingredients
- Placing and vibration
- Curing – Minimum 7 days – preferable 28days

Advantages – The use of concrete blocks as masonry unit are as follows.

- It increases the carpet area of the building compared to brick wall masonry.
- It provides better thermal insulation, enhanced fire resistance and sound absorption.
- Saving of precious agricultural land.
- Reuse skilled supervision
- Construction of concrete blocks masonry is faster, easier and stronger.
- The perfect shape and size of concrete blocks makes the work of mason much simpler.
- There is saving in construction of mortar becoz no of joints are reduced
- The utility can be further increased by producing the reinforced concrete blocks (RCB) masonry units.

Stabilized mud blocks:

Conventional burnt bricks utilize large amount of non-renewable natural resources like energy, minerals, top soil, forest cover etc. Around 1.5 billion bricks are produced manually consuming around 3 million m^3 of top soil, cost of it is fertile soil.

Stabilized mud blocks are simple, cost effective and technology is environment friendly developed by culture of science and technology IISc, Banglore.

The product of 230*190*100mm has nion process involves

- Sieving the soil
- mixing the soil with sand stabilizer such as cement and lime
- mixing of optimum quantity of water
- pressing the wet mixture into a dense solid block using a simple manually operated machine
- curing the blocks for a period of 3-4 weeks by sprinkling water

Type of soil: Soil containing predominantly non expansive clay materials are suited for cement stabilized blocks. Most of the red loamy soils are suitable with minor modification. Soil with 10-15% clay and greater than 65% sand is ideal for AMB production using cement as stabilizer.

Block Sizes : i) 305* 143* 100mm ii) 230*190*100mm have been standardized.

Advantages of SMB:

- Energy efficient – 70% savings when compared to burnt bricks
- Reduces the cost of bricks by 20-40%.
- Plastering of walls can be eliminated.
- Highly decentralized production.
- Aesthetically pleasing and better block finish
- Lesser quantity of mortar required for wall construction.

Strength of SMB:

Sandy soils with 7% cement can yield blocks of 3-4 Mpa. This strength will be sufficient to construct 2 storey load bearing building with span in the range of 3-4m.

<u>Mortar</u>

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 some times 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

Properties of good mortar

1. It should be capable of developing good adhesion with the
building units such as bricks, stones etc.
2. It should be capable of developing the designed stresses.
3. It should be capable of resisting penetration of rainwater.
4. It should be cheap.
5. It should be durable.
6. It should be easily workable.
7. It should not affect the durability of materials with which it comes into contact.

Uses:

1. To bind the building units such as bricks, stones etc.
2. To carry out painting and plaster works on exposed surfaces of masonry
3. To form an even bedding layer for building units

4. To form joints of pipes
5. To improve the appearance of structure.

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

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/m3 and prepared from heavy quartz
b. Lightweight mortars – bulk density is less than 1500/mg3 and prepared from light porous sands.
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 motor, 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 mortarmay 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.
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.
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.
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/m3 is used. The aggregates are obtained from heavy rock and suitable admixture are added to enhance protective property of such a mortar.

Preparation of cement mortar

For preparing mortar, water is added to intimate mixtures of binding material and sand. The water to be used for this purpose should be free from clay, earth and other impurities. Water which is fit for drinking should only be used for preparing mortar.

Cement mortar may be prepared by manual mixing or by mechanical mixing. Mechanical mixing is preferred when mortar is required in large quantities to be used in continuous order.

a. **Mixing in mechanical mixer:** In this case, cement and sand in desired proportion are fed in the mixer and mixed dry. Water is then added gradually and the wet mixing a continued for at least one minute to obtain the mortar of desired consistency. It is necessary to ensure that only the quantity of mortar which can be used within half an hour of its mixing should be prepared at a time. This is essential as after 30 minutes the mortar begins to set.

b. **Manual mixing:** In this case, specified quantity of sand is spread and leveled on clean dry masonry platform. Required quantity of cement bags are emptied over the sand layer. The ingredients are then mixed thoroughly by turning them over the sand layer. The ingredients are then mixed thoroughly by turning them over and over. Backward and forward several times with the help of spade. Dry mixing is continued till the mix have attains a uniform colour. A batch of dry mix is then put in the shallow masonry tank and just sufficient quantity of water is added to bring the mortar to the consistency of a paste. The quantity of dry mix taken in each batch should be such the mortar formed each time is consumed within half an hour.

Timber as construction material

Timber denotes wood which is suitable for building or carpentry or various other engineering purposes and it is applied to the trees measuring not less than 600mm in girth

Following three terms are to be noted in connection with timber.

- **Converted timber**: Indicates timber which is sawn and cut into suitable commercial sizes.
- **Rough timber**: Indicates timber which is obtained after tilling tree
- **Standing Timber**: Indicates the timber contained n the living tree.

Uses of timber – Various uses of timber in construction are listed below.

- It is used for window framing, shutters of the door and window, roofing material etc.
- It is used for frame work of cement concrete, centering of an arch, scaffolding etc.
- It is used for making furniture, agricultural instruments, sports goods, musical instruments etc.
- For making railway coach wagons.
- It is used for temporary bridges and boat construction.
- It is used for making toys, engraving work, packing cases.

Advantages of timber construction:

Timber has following advantages in preference to other engineering materials.

It can be easily handled and can be plamd sawn and joined with ordinary tools of the carpenter.

It combines light weight with strength and hence it is generally preferred for buildings with earth quake prom region.

It is easy to provide connection in timber construction

It is economical and cheap and it is possible to realizes some value even after timber construction has completed its useful life.

It is used to prepare furniture of decent appearance and comfortable design. Timber construction gives massive appearance.

The house with construction are found to be cool in summer and warm in winter because wood is nonconductor of heat.

Timber construction is quit durable, if properly protected against moisture, rain, wind etc.

The addition, alterations and repairs to timber construction can be carried out easily.

Timber is found to be superior to cement concrete and steel in respect of thermal insulation, sound absorption and electric resistance.

The other forms of timber such as ply woods, fiber board etc have made timber construction to match with present day requirements.

Characteristics of good timbers:

1. **Appearance**: A freshly cut surface of timber should exhibit hard and of shining appearance.
2. **Colour**: A colour should preferably be dark
3. **Defects**: A good timber should be free from series defects such as knots, flaws, shakes etc
4. **Durability**: A good timber should be durable and capable of resisting the action of fungi, insects, chemicals, physical agencies, and mechanical agencies.
5. **Elasticity:** The timber returns to its original shape when load causing its deformation is removed
6. **Fibres**: The timber should have straight fibres

7. **Fire resistance**: A dense wood offers good resistance to fire

8. **Hardness**: A good timber should be hard
9. **Mechanical wear**: A good timber should not deteriorate easily due to mechanical wear or abrasion
10. **Shape**: A good timber should be capable of retaining its shape during conversion or seasoning
11. **Smell**: A good timber should have sweet smell. Unpleasant smell indicates decayed timber
12. **Sound** : A good timber should give a clear ringing sound when struck
13. **Strength**: A good timber should be sufficiently strong for working as structural member such as joist, beam, rafter etc.

14. **Structure**: The structure should be uniform
15. **Toughness**: A good timber should be tough (i.e.) capable of offering resistance to shocks due to vibration
16. **Water permeability**: A good timber should have low water permeability, which is measured by the quantity of water filtered through unit surface area of specimen of wood.
17. **Weathering effects**: A good timber should be able to stand reasonably the weathering effects (dry & wet)
18. **Weight**: The timber with heavy weight is considered to be sound and strong.
19. **Working conditions**: Timber should be easily workable. It should not clog the teeth of saw.

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

<u>Fine aggregates (sand)</u>

Aggregates passing through 4.75mm sieve and predominantely retained on 75micron sieve is termed as fine aggregate.

Fine aggregate sand is important ingredient of mortar and cement concrete. Sand particles consists of small grains of silica. It is formed by decomposition of sand stone due to various effects of weather.

Sand is obtained from i] pit sand ii]river sand iii] sea sand (should be washed with river water after removing salts) river sand is widely used.

Sources of Sand: Sand particles consist of small grains of silica (Si02). 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. **Rive 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.
The natural product which is obtained as river sand & pit sand is called sand.

Requirement of good sand

1) It should be hard
2) It should be chemically inert
3) It should be free from salts
4) It should free from organic matters
5) It should be well graded

Uses of sand

1.It is used in mortars
2.It is used for the filling the gaps between the building blocks
3.It is used as binding materials in the form of paste
4.It prevents the shrinkages of cementing materials.

Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word.

Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost.

Since manufactured sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off river sand bed.

Thus, the cost of construction can be controlled by the use of manufactured sand as an alternative material for construction. The other advantage of using M-Sand is, it can be dust free, the sizes of m-sand can be controlled easily so that it meets the required grading for the given construction.

Advantages of Manufactured Sand (M-Sand)

It is well graded in the required proportion.

- It does not contain organic and soluble compound that affects the setting time and properties of cement, thus the required strength of concrete can be maintained.
- It does not have the presence of impurities such as clay, dust and silt coatings, increase water requirement as in the case of river sand which impair bond between cement paste and aggregate. Thus, increased quality and durability of concrete.

- M-Sand is obtained from specific hard rock (granite) using the state-of-the-art International technology, thus the required property of sand is obtained.
- M-Sand is cubical in shape and is manufactured using technology like High Carbon steel hit rock and then ROCK ON ROCK process which is synonymous to that of natural process undergoing in river sand information.
- Modern and imported machines are used to produce M-Sand to ensure required grading zone for the sand.

Sieve analysis

- Sieve analysis is done to obtain grading for aggregates. The particle size distribution is called grading. The main objective of this test is to determine the relative amount of various size of particle present in the aggregates.
- The process of dividing a sample of aggregate into fractions of sample particle size is called is called sieve analysis.
- Sieve sizes used for aggregates as per IS383-1970 are as follows
- For course aggregates- 80mm,40mm,20mm,10mm and 4.75mm.
- For fine aggregates- 4.75mm,.36mm, 1.18mm , 600microns , 300microns , 150 microns.

Sieve seizes	Weight of soil retained	%age soil retained	Cumulative % age retained	%age finer
4.75mm				
2.36mm				
1.18mm				
600mm				
300mm				
150mm				
75mm				
Pan				

Grading of aggregates:

The particles size distribution of an aggregate is determined by sieve analysis known as grading of aggregates.

The most important factor for producing a workable concrete is good gradation of aggregates. A sample of well graded aggregates containing minimum voids will require minimum paste to fillup voids in aggregates. minimum paste means less quantity of water and cement which increases the economy.

The particle size distribution of a mass of aggregate should be such that the smaller particles will fill the voids between the larger particle such grading is called good grading. The good grading of aggregates provides higher strength, lower shrinkage, greater durability and economy of concrete.

Types of grading

Grading may be of following types.

1. **WELL GRADED-** well graded aggregates contains all size of particles thus leading to dense and compact mass of concrete mix.
2. The aggregate is said to be well graded if the voids created by larger particles are almost filled by smaller size particles. This type of grading is considered best, because all size of particles are available.
3. **GAP GRADED-** The aggregate is said to be gap graded when there is lack of different size of particles. Particles of certain sizes will be missing in aggregates.
4. **POORLY GRADED-**It is grading in which the proportions of same intermediate size particle are in excess or deficient is known as poorly graded.
5. **CONTIUOUS GRADING –** It is the grading in which all size particles group from maximum to minimum size particles are available. Such grading are termed courser or finer depending upon the higher proportion of courser or finer particle.

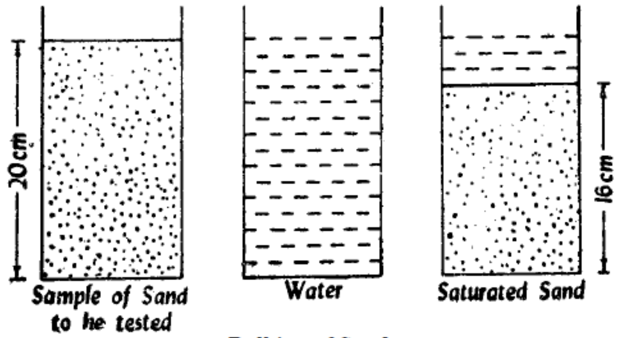
Effect of grading on concrete

1. **Strength:** Coarser grading is required if the concrete is having low water content ratio. Whereas for the concrete higher water content ratio finer grading is required. Grading of aggregate has no effect on strength but indirectly influence the strength parameters.
2. **Void:** well graded aggregate has lesser number of voids and hence produces dense concrete with less quantity of cement. Therefore the concrete produced is economical.
3. **Bleeding:** Lack of finer grading causes bleeding. Bleeding is less in case of fine aggregates than coarse aggregates.
4. **Seggregation:** If the required proportion of finer materials is not available to maintain cohesiveness than coarse aggregates leads to seggregation'
5. **Workability:** The workability isimproved when there is an excess of paste above that required to fill voids in the fine aggregates.

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 5 to 8 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.

When moisture content is increased by adding more water, sand particles pack near each other and the amount of bulking of sand is decreased. Thus the dry sand and the sand completely flooded with water have practically the same volume. For finding the bulking of sand, a test is carried out with following procedure as in the fig .

6. 

Bulking of Sand

I. A container is taken and it is filled two third with the sample of sand to be tested.
II. The height is measured, say 20cm.
III. Sand is taken out of container
IV. The container is filled with water
V. Sand is then slowly dropped in the container and it is thoroughly stirred by means of a rod.
VI. The height of sand is measured say 16cm, then bulking of sand =

$$= \frac{20 - 16}{16} = \frac{4}{16} \text{ or } 25\%$$

Alternatives to river sand

Sand is a vital ingredient in making two most used construction materials viz. Cement Concrete and mortar. Traditionally River sand, which is formed by natural weathering of rocks over many years, is preferred as fine aggregate. The economic development fuelling the growth of infrastructure and housing generates huge demand for building materials like sand. The indiscriminate mining of sand from riverbeds is posing a serious threat to environment such as erosion of riverbed and banks, triggering landslides, loss of vegetation on the bank of rivers, lowering the ground water table etc. Demand for sand is increasing day by day and at the same time mining threats cannot be ignored. Hence, sand mining from riverbeds is being restricted or banned by the authorities like National Green Tribunal, State Environmental Impact Assessment Authority and Pollution Control Board

Some of the Alternatives to River sand

- Manufacture Sand
- Processes Quarry dust
- Processed Crushed rock fines
- Offshore Sand
- Processed glass
- Aluminum saw mill waste
- Granite fines slurry
- Washed soil (filtered sand)
- Fly ash (bottom ash/ pond ash)
- Slag sand
- Copper Slag sand

 Construction Demolition waste.i

Deleterious materials :
Substances such as organic matters, clay, shale, coal, iron pyrites, etc. which are weak, soft, fine or may have harmful physical or chemical effects on the aggregates are considered to be deleterious. They affect the properties of concrete in green as well as in hardened state and are undesirable. They may be classified as those interfering with the process of hydration, i.e. organic matters, coatings such as clay, etc. affecting the development of bond between aggregate and the cement paste, and, unsound particles which are weak or bring about chemical reaction
between aggregate and cement paste. The surface coated impurities in aggregate can be removed by adequate washing. However, chemically-bonded stable coating which cannot be so removed may increase shrinkage cracks. The salts present in the sea-shore sand should be washed out otherwise efflorescence is caused afterwards. Mica, if present in sand, reduces the strength of concrete. Iron pyrites and sulphides produce surface staining and pop-outs.

Moisture content

The moisture content changes with weather and varies from one stockpile to another, thereby moisture content must be determined frequently.

The amount of water added at concrete batch palnt must be adjusted depending on the moisture content of the aggregate in order to accurately meet the water requirement of the mix design

Coarse aggregate :
Aggregate retained on 4.75 mm sieve are identified as coarse. They are obtained by natural disintegration or by artificial crushing of rocks. The maximum size of aggregate can be 80 mm. The size is governed by the thickness of section, spacing of reinforcement, clear cover, mixing, handling and placing methods. For economy the maximum size should be as large as possible but not more than one-fourth of the minimum thickness of the member. For reinforced sections the maximum size should be at least 5 mm less than the clear spacing between the reinforcement and also at least 5 mm less than the clear cover. Aggregate more than 20 mm size are seldom used for reinforced cement concrete structural members.

Flakiness Index and Elongation Index Test (IS: 2386 (Part I))
Because of large number of flaky particles in the coarse aggregate more voids are formed in the concrete consequently more mortar is required to fill the voids, resulting in uneconomy. Also, durability of concrete will be affected. For flakiness index (F.I) and elongation index (E.I) sufficient quantity of aggregate is taken so as to provide at least 200 pieces of any fraction to be tested.

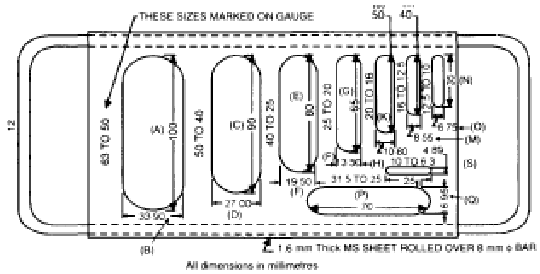


Fig. 6.4 Thickness Gauge

$$F.I = \frac{\text{Weight of aggregate passing through the slot of the thickness gauge}}{\text{Total wieght of sample}} \times 100$$

For determining F.I, the aggregate are sieved through the corresponding sieves. Aggregate retained on each sieve are separated. Then each aggregate piece is passed through the corresponding slot of length gauge (Fig. 6.5)

$$E.I = \frac{\text{Weight of the aggregate retained on length gauge}}{\text{Total wieght of aggregate}} \times 100$$

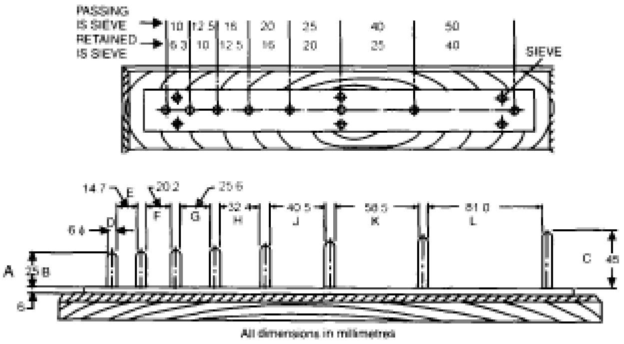


Fig. 6.5 Length Gauge

Coarse aggregate Sive analysis :

Fineness modulus of coarse aggregates represents the average size of the particles in the coarse aggregate by an index number. It is calculated by performing sieve analysis with standard sieves.

The cumulative percentage retained on each sieve is added and subtracted by 100 gives the value of fine aggregate. Higher the aggregate size higher the Fineness modulus hence fineness modulus of coarse aggregate is higher than fine aggregate.

Coarse aggregate means the aggregate which is retained on 4.75mm sieve when it is sieved through 4.75mm. To find fineness modulus of coarse aggregate we need sieve sizes of 80mm, 40mm, 20mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm and 0.15mm.

Fineness modulus is the number at which the average size of particle is known when we counted from lower order sieve size to higher order sieve. So, in the calculation of coarse aggregate we need all sizes of sieves.

Test Procedure for Fineness Modulus of Coarse Aggregates

Arrange the sieves in descending order and put the arrangement on mechanical shaker. It is suggested that, to know the exact value of fineness modulus for coarse aggregate, mechanical shaker will give better value than hand shaking because of more no. of sieves and heavy size particles.

After proper sieving, record the sample weights retained on each sieve and find out the cumulative weight of retained particles as well as cumulative % retained on each sieve. Finally add all cumulative percentage values and divide the result with 100. Then we get the value of fineness modulus.

Aggregate Impact Test

The property of a material to resist impact is known as toughness. Due to movement of vehicles on the road the aggregates are subjected to impact resulting in their breaking down into smaller pieces.

The aggregates should therefore have sufficient toughness to resist their disintegration due to impact. This characteristic is measured by impact value test.

The aggregate impact value is a measure of resistance to sudden impact or shock, which may differ from its resistance to gradually applied compressive load.

Recommended Aggregate Impact Test Values

Classification of aggregates using Aggregate Impact Value is as given below:

Aggregate Impact Value	**Classification**
<20%	Exceptionally Strong
10 – 20%	Strong
20-30%	Satisfactory for road surfacing
>35%	Weak for road surfacing

Procedure of Aggregate Impact Test

The test sample consists of aggregates sized 10.0 mm 12.5 mm. Aggregates may be dried by heating at 100-110° C for a period of 4 hours and cooled.

(i) Sieve the material through 12.5 mm and 10.0mm IS sieves. The aggregates passing through 12.5mm sieve and retained on 10.0mm sieve comprises the test material.

(ii) Pour the aggregates to fill about just 1/3 rd depth of measuring cylinder.

(iii) Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.

(iv) Add two more layers in similar manner, so that cylinder is full.

(v) Strike off the surplus aggregates.

(vi) Determine the net weight of the aggregates to the nearest gram(W).

(vii) Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.

(viii) Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.

(ix) Raise the hammer until its lower face is 380 mm above the surface of aggregate sample in the cup and allow it to fall freely on the aggregate sample. Give 15 such blows at an interval of not less than one second between successive falls.

(x) Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm. Also, weigh the fraction retained in the sieve.

Compute the aggregate impact value. The mean of two observations, rounded to nearest whole number is reported as the Aggregate Impact Value.

Observations of Impact Test

Observations	**Sample 1**	**Sample 2**
Total weight of dry sample (W_1 gm)		
Weight of portion passing 2.36 mm sieve (W_2 gm)		
Aggregate Impact Value (percent) = $W_2 / W_1 \times 100$		

Mean =

Result of Impact Test

Aggregate Impact Value =

Aggregate Crushing Value Test – Determine Aggregate Crushing Strength

Aggregate crushing value test on coarse aggregates gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load. Coarse aggregate crushing value is the percentage by weight of the crushed material obtained when test aggregates are subjected to a specified load under standardized conditions.

Aggregate crushing value is a numerical index of the strength of the aggregate and it is used in construction of roads and pavements.

Crushing value of aggregates indicates its strength. Lower crushing value is recommended for roads and pavements as it indicates a lower crushed fraction under load and would give a longer service life and a more economical performance.

The aggregates used in roads and pavement construction must be strong enough to withstand crushing under roller and traffic. If the aggregate crushing value is 30 or higher' the result may be anomalous and in such cases the ten percent fines value should be determined instead.

Procedure of Aggregate Crushing Value Test

1. Put the cylinder in position on the base plate and weigh it **(W)**.
2. Put the sample in 3 layers, each layer being subjected to 25 strokes using the tamping rod. Care being taken in the case of weak materials not to break the particles and weigh it **(W1)**.
3. Level the surface of aggregate carefully and insert the plunger so that it rests horizontally on the surface. Care being taken to ensure that the plunger does not jam in the cylinder.
4. Place the cylinder with plunger on the loading platform of the compression testing machine.
5. Apply load at a uniform rate so that a total load of 40T is applied in 10 minutes.
6. Release the load and remove the material from the cylinder.
7. Sieve the material with 2.36mm IS sieve, care being taken to avoid loss of fines.
8. Weigh the fraction passing through the IS sieve **(W2)**.

Calculation of Aggregate Crushing Value

The ratio of weight of fines formed to the weight of total sample in each test shall be expressed as a percentage, the result being recorded to the first decimal place.

Aggregate crushing value = (W2 x 100) / (W1-W)

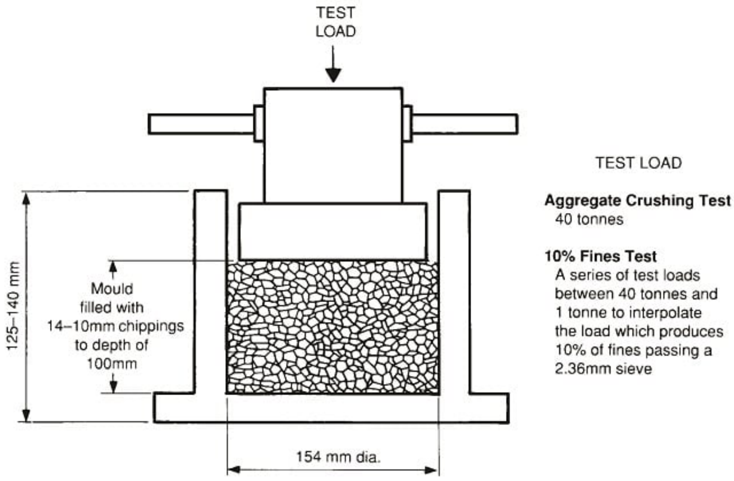
W2 =Weight of fraction passing through the appropriate sieve

W1-W =Weight of surface dry sample.

The mean of two result to nearest whole number is the aggregate crushing value.

Result

The aggregate crushing value of the given sample=



Los Angeles Abrasion Test on Aggregates

The aggregate used in surface course of the highway pavements are subjected to wearing due to movement of traffic.

When vehicles move on the road, the soil particles present between the pneumatic tyres and road surface cause abrasion of road aggregates. The steel rimmed wheels of animal driven vehicles also cause considerable abrasion of the road surface.

Therefore, the road aggregates should be hard enough to resist abrasion. Resistance to abrasion of aggregate is determined in laboratory by Los Angeles test machine.

The principle of Los Angeles abrasion test is to produce abrasive action by use of standard steel balls which when mixed with aggregates and rotated in a drum for specific number of revolutions also causes impact on aggregates.

The percentage wear of the aggregates due to rubbing with steel balls is determined and is known as Los Angeles Abrasion Value.

Procedure for Los Angeles Test

The test sample consists of clean aggregates dried in oven at 105° – 110°C. The sample should conform to any of the gradings shown in table 1.

1. Select the grading to be used in the test such that it conforms to the grading to be used in construction, to the maximum extent possible.
2. Take 5 kg of sample for gradings A, B, C & D and 10 kg for gradings E, F & G.
3. Choose the abrasive charge as per Table 2 depending on grading of aggregates.
4. Place the aggregates and abrasive charge on the cylinder and fix the cover.

5. Rotate the machine at a speed of 30 to 33 revolutions per minute. The number of revolutions is 500 for gradings A, B, C & D and 1000 for gradings E, F & G. The machine should be balanced and driven such that there is uniform peripheral speed.
6. The machine is stopped after the desired number of revolutions and material is discharged to a tray.
7. The entire stone dust is sieved on 1.70 mm IS sieve.
8. The material coarser than 1.7mm size is weighed correct to one gram.

Table 1: Grading of Test Samples – *Tolerance of ± 12 percent permitted.

Sieve size (square hole)	**Weight of test sample in gm**							
Passing (mm)	**Retained on (mm)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**
80	63					2500*		
63	50					2500*		
50	40					5000*	5000*	
40	25	1250					5000*	5000*
25	20	1250						5000*
20	12.5	1250	2500					
12.5	10	1250	2500					
10	6.3			2500				
6.3	4.75			2500				
4.75	2.36				5000			

Table 2: Selection of Abrasive Charge

Grading	**No of Steel balls**	**Weight of charge in gm.**
A	12	5000 ± 25
B	11	4584 ±25
C	8	3330 ± 20
D	6	2500 ± 15
E	12	5000 ± 25

F	12	5000 ± 25
G	12	5000 ± 25

Observations of Los Angeles Test

Original weight of aggregate sample = W_1 g

Weight of aggregate sample retained = W_2 g

Weight passing 1.7mm IS sieve = $W_1 – W_2$ g

Abrasion Value = $(W_1 – W_2) / W_1$ X 100

Results

Los Angeles Abrasion Value =

Text Books:

1. Sushil Kumar "Building Materials and construction", 20th edition, reprint 2015,Standard Publishers

2. Dr. B.C.Punmia, Ashok kumar Jain, Arun Kumar Jain, "Building Construction, Laxmi Publications (P) ltd., New Delhi.

3. Rangawala S. C. "Engineering Materials", Charter Publishing House, Anand, India.

Reference Books:

1. S.K.Duggal, "Building Materials", (Fourth Edition)New Age International (P) Limited, 2016 National Building Code(NBC) of India

2. P C Vergese, "Buliding Materials", PHI Learning Pvt. Ltd

3. Building Materials and Components, CBRI, 1990, India

4. Jagadish.K.S, "Alternative Building Materials Technology", New Age International, 2007.

5. M. S. Shetty, "Concrete Technology", S. Chand & Co. New Delhi.

Outcome

Gives Knowledge about different building materials used for construction of buildings.

Future Study

http://nptel.ac.in/courses/105102088/

MODULE -2

Foundation: Preliminary investigation of soil, safe bearing capacity of soil, Function and requirements of good foundation , types of foundation , introduction to spread, combined , strap, mat and pile foundation .

Masonry: Definition and terms used in masonry. Brick masonry, characteristics and requirements of good brick masonry, Bonds in brick work, Header, Stretcher, English, Flemish bond, Stone masonry, Requirements of good stone masonry, Classification, characteristics of different stone masonry, Joints in stone masonry. Types of walls; load bearing, partition walls, cavity walls. **8 Hours.**

Preliminary Investigation of Soil

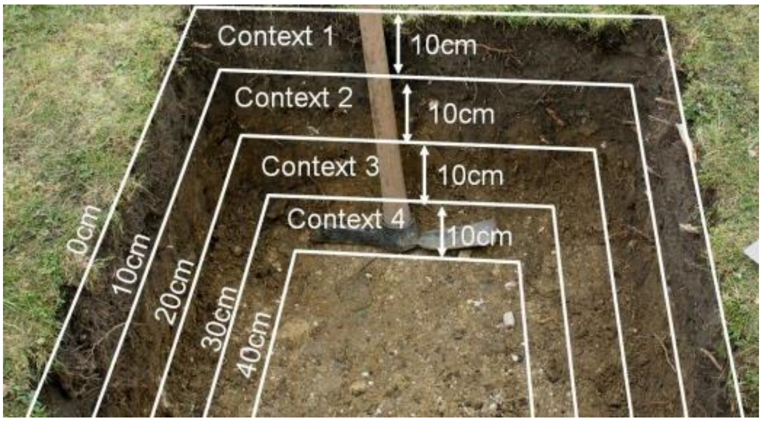
Purpose:

1) To fix the value of the safe bearing capacity of the soil
2) To select an economical yet safe type of foundation
3) To fix the depth upto which the foundations must be taken inside the ground
4) To predict the likely settlement of the selected foundation and to make allowance for the same in the design
5) To forecast the difficulties which are likely to be encountered due to nature of sub soil during construction.

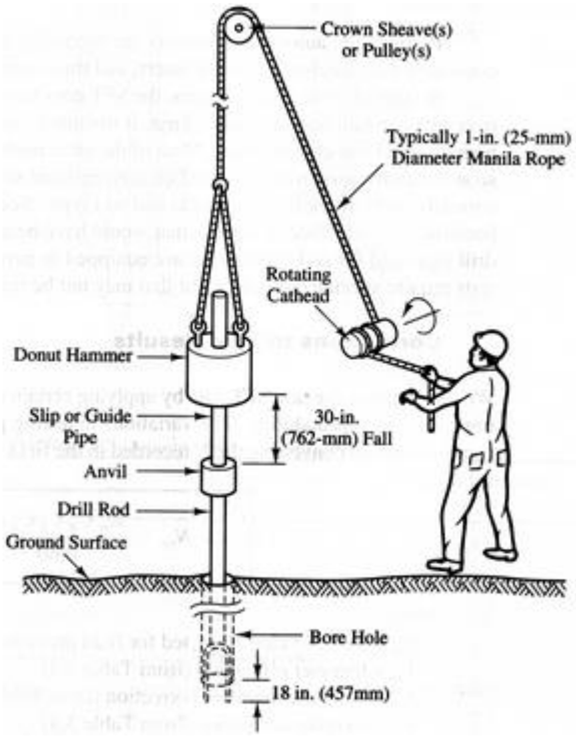
Methods of site exploration

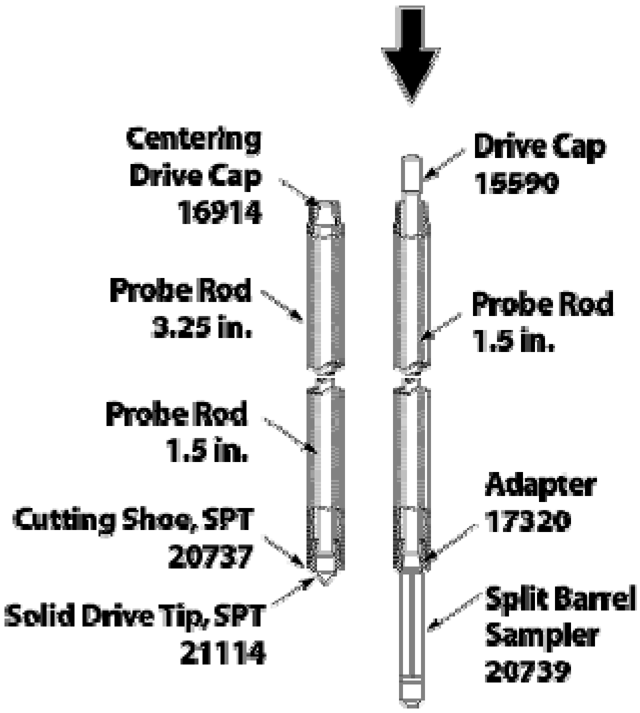
The following methods are commonly employed for site exploration:
(i)Test pits (ii) Probing (iii) Sub-surface sounding (iv) Boring (v) Geo-Physical method.

(i) Test pits: The best way to ascertain the nature of subsoil strata is to dig a hole and inspect. The dimensions of the pit depend largely upon depth up to which the excavation is to be made. Test pits are suitable for shallow foundations (up to 3mts).

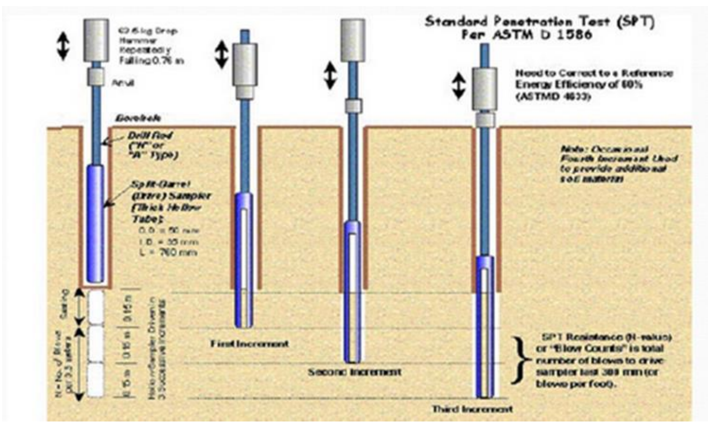


(ii) Probing: In this method, a steel bar of 25 to 40mm in diameter with a pointed end is driven in the ground until a hard sub-stratum is met with. The bar is driven by allowing it to fall vertically under its own weight or by drop hammer. At intervals, the bar is drawn-out and some idea of the nature of the soil is obtained by examining the soil sticking to the sides of the bar. This method is not always to be relied upon completely. More definite analysis should be done to ascertain the results arrived by this method.





(iii) Sub-surface sounding (SPT Test): In this method, the resistance of the soil with depth is measured by means of a tool known as pentrometer under static or dynamic loading.



Procedure: The penetrometer may consist of a 50mm diameter mild steel cone fitted loosely to a steel rod or a standard split spoon sampler. The penetrometer is driven in the ground with the help of blows from a 650N weight falling from a height of 750mm. The number of blows required to drive the penetrometer into the ground through a distance of 300mm is termed as Standard Penetration Resistance or SPT of the soil designated as N. The N values of soil are thus determined at different depths. The resistance offered by the soil to penetration is co-related with engineering properties of soil like density, consistency, permeability, bearing capacity.

(iv) Boring:

(a) Auger Boring: Augers are used in cohesive and other soft soils above water table. Hand augers are used up to a depth of 6m and mechanically operated augers are used for greater depths. They can also be used in gravelly soils. Augers are of two types: (i) Spiral Augers (ii) Post-hole Auger.

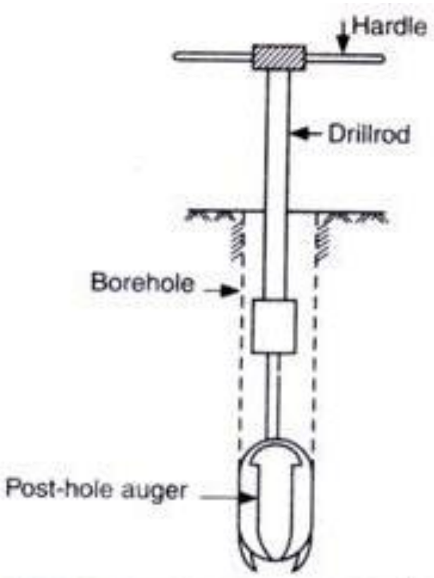
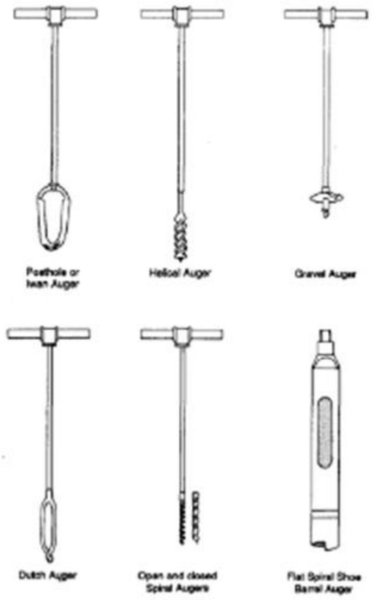
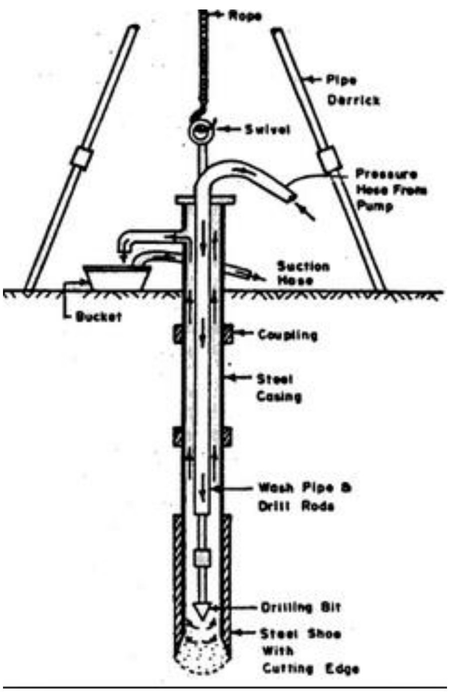


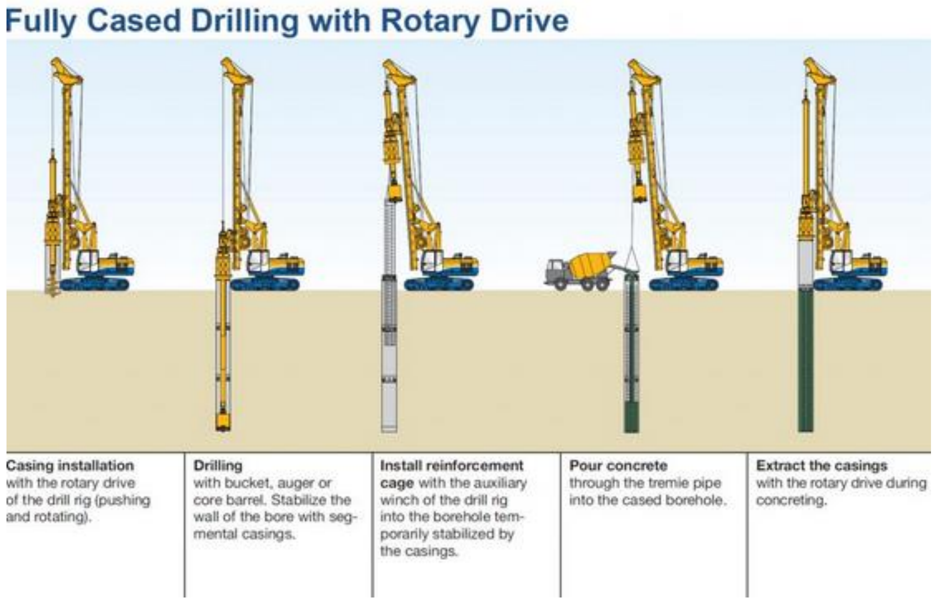
FIG. 10.1 (a) Auger boring



(b) Wash boring: This method consists of first driving a casing through which a hollow drilled rod with a sharp chisel or chopping bit at the lower end is inserted. Water is forced under pressure through the drill rod which is alternatively raised and dropped and also rotated. The resulting chopping and jetting action of the bit and water disintegrates the soil. The cuttings are forced up to the ground surface in the form of soil-water slurry through the annular space between the drill rod and the casing. The change in soil stratification could be guessed from the rate of progress and colour of wash water.



(c) Rotary boring: is a very fast method of advancing hole in both rocks and soils. A drill bit, fixed to the lower end of the drill rods, is rotated by a suitable chuck and is always kept in firm contact with the bottom of the hole. A drilling mud usually a water solution of bentonite with or without other admixtures is continuously forced down to the hollow drill rods. The mud returning upwards brings the cuttings to the surface.

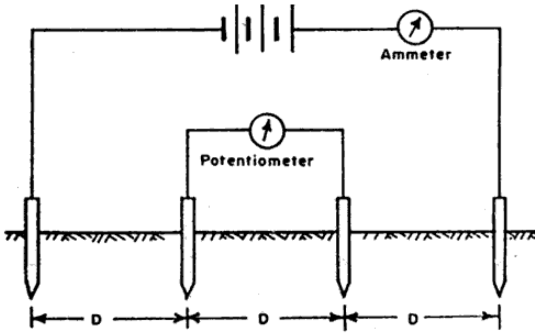


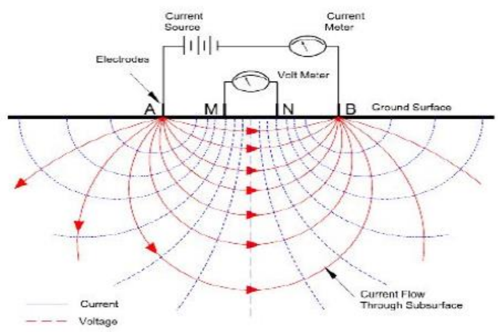
(v) Geo-Physical methods: are used when soil exploration is to be carried out over a large area and speed of investigation is of prime importance. These methods are mainly adopted to ascertain the depths at which useful minerals and oils are available.

The two most commonly adopted for civil engineering purposes are as follows:

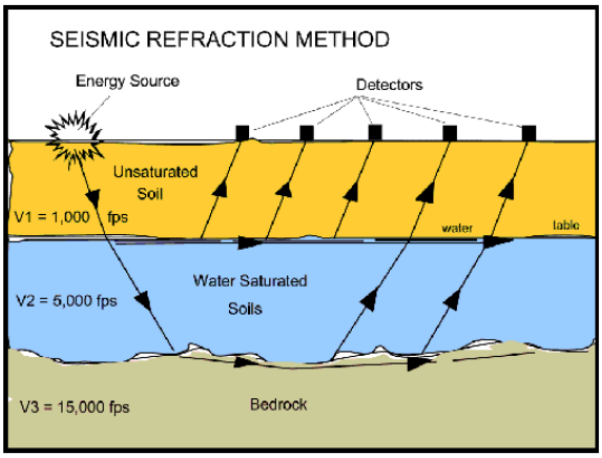
(a) Electrical Resistivity method: In this method, four electrodes are driven in ground at equal distance apart and in a straight line. The distance between the two electrodes indicates the depth of exploration or depth up to which the ground resistance is to be measured. Electrical current is then passed between the two outer electrodes and potential drop between the two inner electrodes is measured with the help of the potentiometer.

This method is based on the principle that each soil has different electrical resistivity depending on its water content, compaction and composition (Saturated soil have less electrical resistivity).





b) Seismic refraction method: This method is based on the principle that vibrations caused in the ground by artificial explosions travel faster in rock than in soil. This is due to the fact that velocity of sound waves is different in different media. The shock waves are developed into the soil either by exploding or by striking a plate on the soil by hammer. The shock waves so produced travel down in the subsoil strata and get refracted after striking a hard rock surface below. These refracted waves are picked up and their travel times are recorded in the instruments known as the geophones. The depth of various strata can be evaluated by knowing the times of travel of the primary waves and refracted waves and then preparing the distance-time graphs.

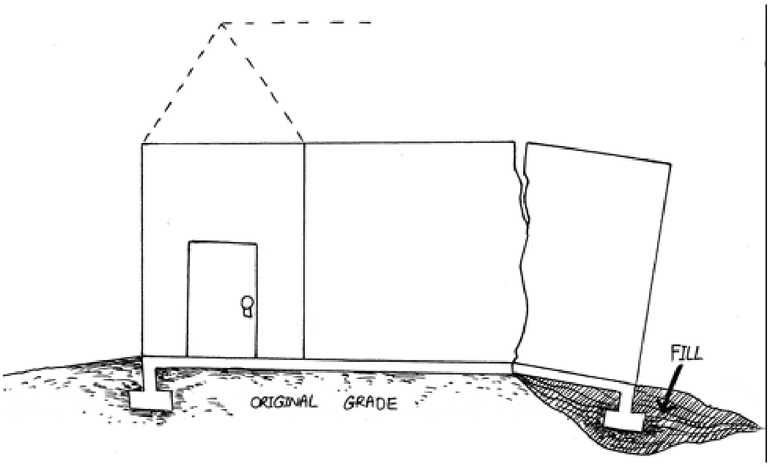


Bearing Capacity

The maximum load per unit area which the soil or rock can carry without displacement is termed as bearing capacity of soil or rock.

Safe Bearing Capacity

The maximum pressure which the soil can carry without the risk of shear failure is called safe bearing capacity. This is obtained by dividing the ultimate bearing capacity by a certain factor of safety and it is the value which is used in the design of foundation. The factor of safety normally varies from 2 to 3.



Methods of improving Bearing capacity of soils

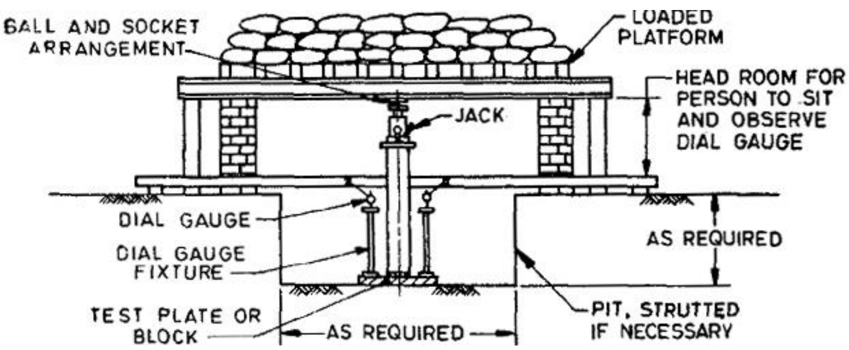
• By increasing the depth of foundation
• By drainage method

- By blending granular material
- By confining the soil
- By driving sand piles.

Methods of determining bearing capacity

1) Plate load test

This is a field test for determining ultimate bearing capacity of soil and the likely settlement under a given load. The test basically consists of loading a steel plate placed at the foundation level recording the settlement corresponding to each load increment. The test load is gradually increased till the plate starts to sink at a rapid rate. The total value of load on the plate in such a stage is divided by the area of the steel plate gives value of ultimate bearing capacity of soil. The ultimate bearing capacity is divided by a suitable factor of safety (varies from 2 to 3) to arrive at the value of safe bearing capacity of soil.



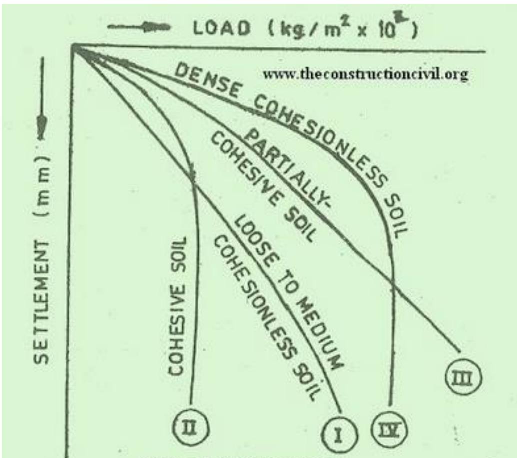
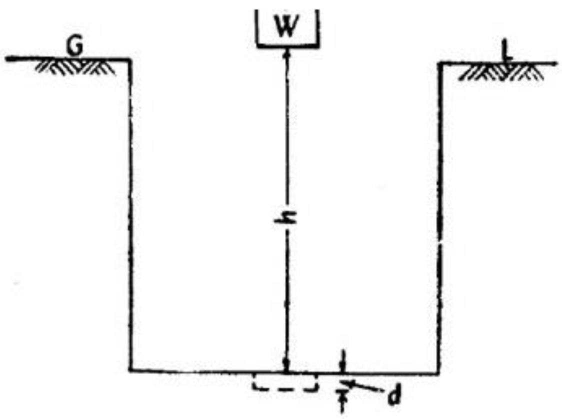


Fig. Load Settlement Curve

2) Method of loading: A square pit is made and at the centre of pit a square hole is dug. A square steel plate is put up in the hole and a wooden table platform is prepared as shown in fig. Initial load in the form of sand bags is placed on the platform and settlement is recorded with the help of a dumpy level. The load is to be kept till settlement of the ground ceases. Then the load is increased and corresponding settlement is noted. A graph of load versus settlement is plotted and max bearing is obtained and with a suitable factor of safety, safe bearing capacity is obtained.

3) Method of dropping a weight or penetration test: In this method, an object of known weight is dropped from a known height. The depth of impression made by the weight on the soil is noted.

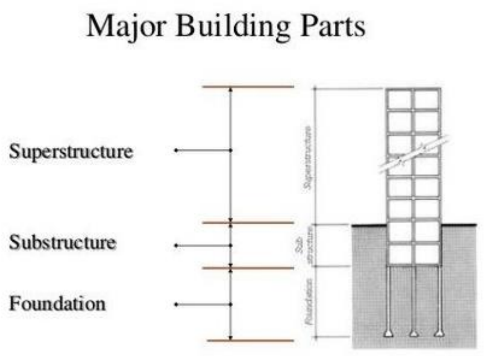


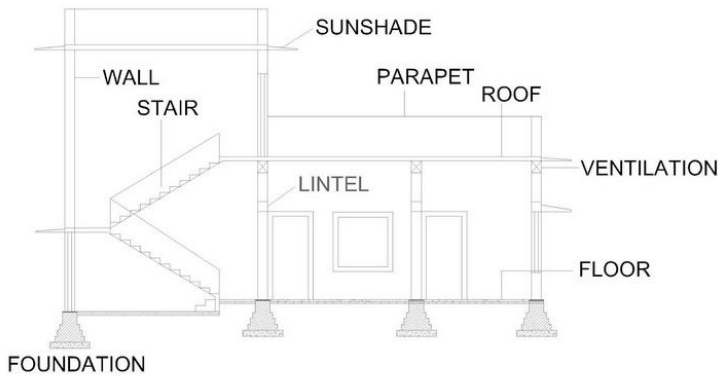
Method of Dropping Weight

Introduction
Building is an assemblage of various structural components like beams, columns, slabs and footings which resists deformation caused due to external loads. Therefore buildings are means of transferring forces and moments.
A building has two basic parts
1) Sub structure or foundations

2) Super-structure.

A foundation is 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.





Functions of Foundation:
1) **Reduction of load intensity**: Foundations distribute the loads of the Super-structure to a larger area So that the intensity of the load at its base does not exceed the safe bearing capacity of the Sub-soil.

2) **Even distribution of load:** Foundations distribute the non-uniform load of the Super-structure evenly to sub-soil.

3) **Provision of level surface**: It provides leveled and hard surface over which the super-structure can be built.

4) **Lateral stability:** It anchors the super-structure of the ground, thus imparting lateral stability to the super-structure.

5) **Safety against undermining**: It provides the structural safety against undermining or scouring due to burrowing animals and flood water.

6) **Protection against soil movements**: Special foundation measures prevent or minimize the distress (or cracks) in the super-structure due to expansion or contraction of the sub-soil because of movement in some soil like black cotton soil.

Objectives
To study the basic parts of a building
To study the requirements of good foundations
To gain the knowledge on types of foundations

Requirements of good Foundation
1) The foundation shall be constructed to sustain the dead and imposed loads and to transmit these to the sub-soil.

2) Foundation base be rigid so that differential settlements are minimized.

3) Foundation should be taken sufficiently deep to guard the building against damage caused by swelling or shrinking of sub-soil.

4) Foundation should be so located that its performance may not be affected due to any unexpected future influence .

Types of foundations

Foundation may be broadly classified under two headings:
I) Shallow foundations or Open Foundation : Depth is equal to or less than its width
II) Deep foundations: Depth is equal to or greater than its width

OPEN FOUNDATIONS

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

1. Wall footings,

2. Isolated footings,

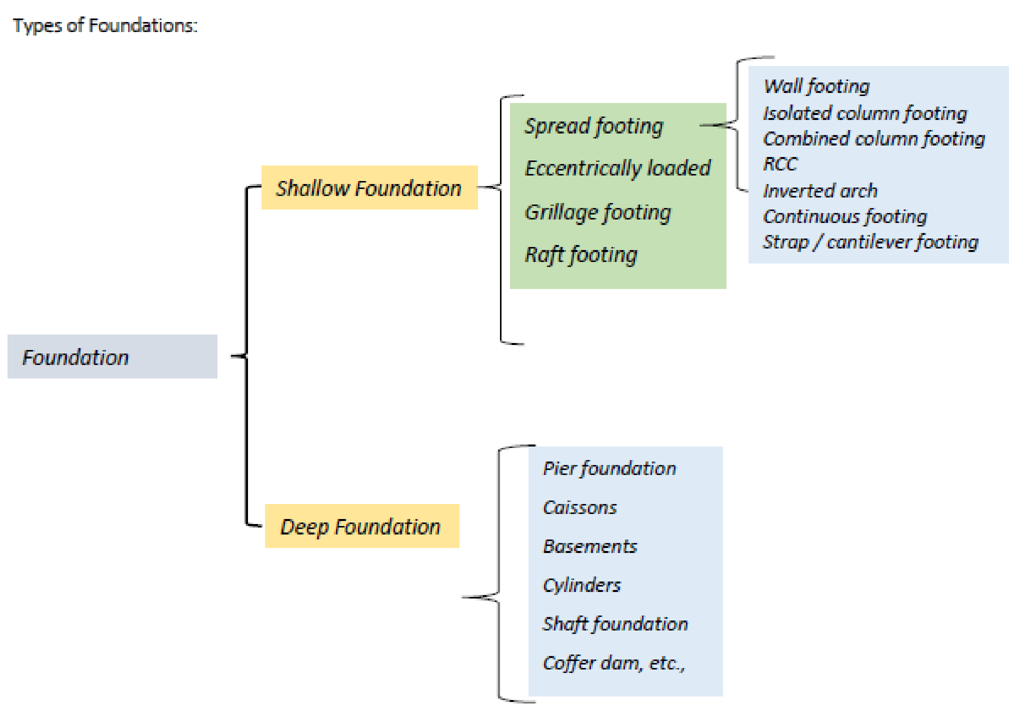
3. Combined footings,

4. Inverted arch footings,

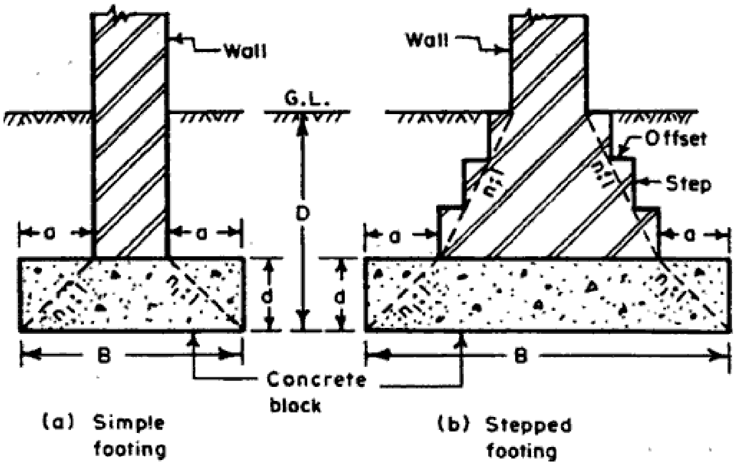
5. Continuous footings

6. Cantilever footing

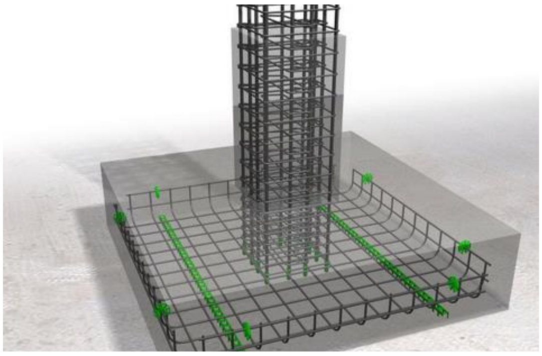
7. Grillage footing

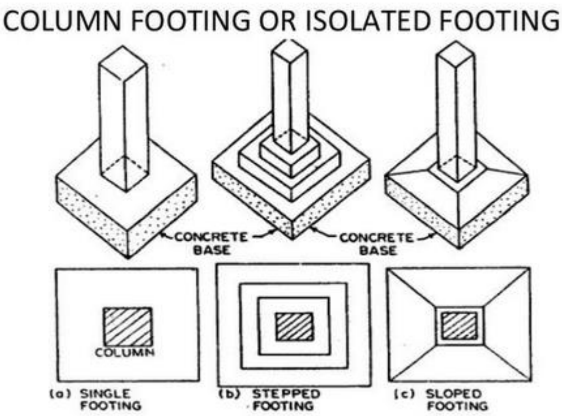


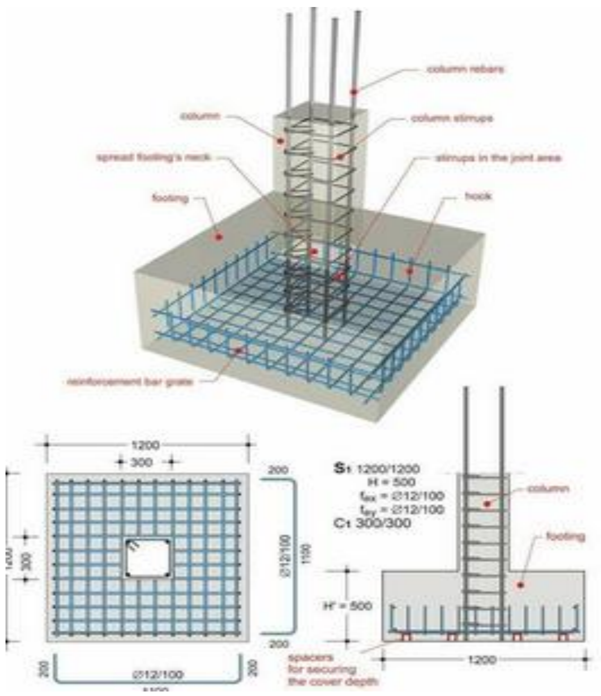
1.Wall Footings: These footings can either be simple or stepped. The base course of these footings can be concrete or of entirely one material. They have only one projection beyond the width of the wall on either side. The width of the concrete base should be at least equal to twice the width of the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



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

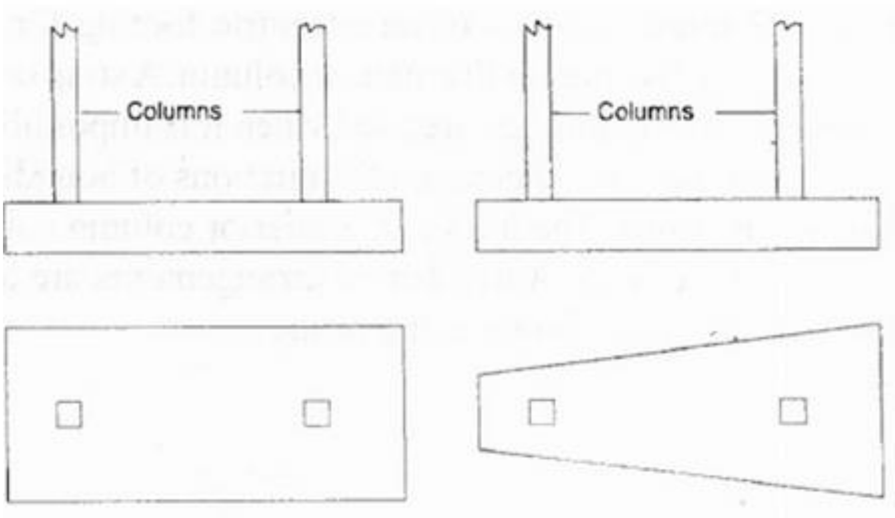






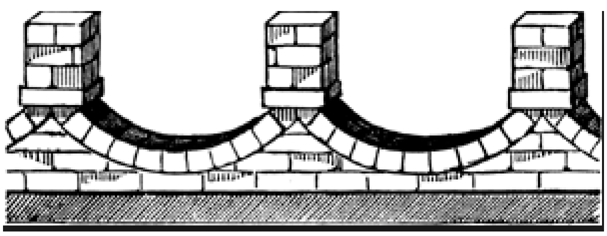
3. Combined Footings: A combined footing supports two or more columns in a row. The combined footing can be rectangular in shape if both the columns carry equal loads or can be trapezoidal if both the loads are unequal. Generally they are constructed of reinforced concrete. The location of the center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

COMBINED FOOTING

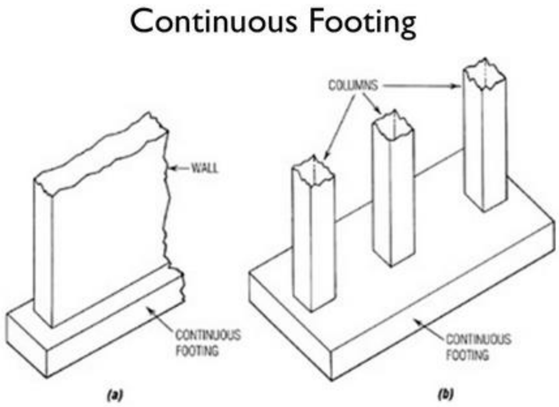


a) Rectangular combined footing b) Trapezoidal combined footing

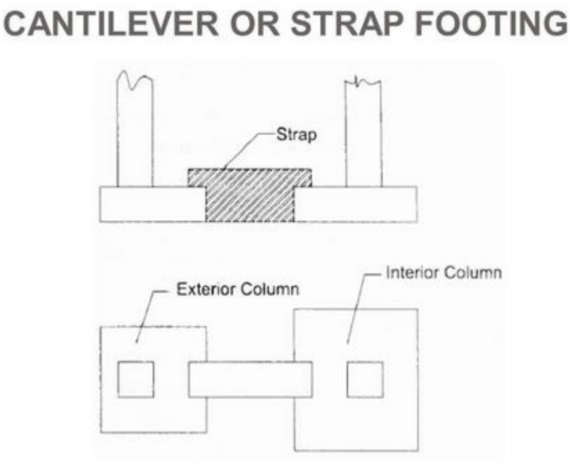
4. Inverted arch footing: This type of footing is used on soft soils to reduce the depth of the foundation. Loads above an opening are transmitted from supporting walls through inverted arches to the soil. In this type of footings the end columns must bes stable enough to resist the outward pressure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



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



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



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

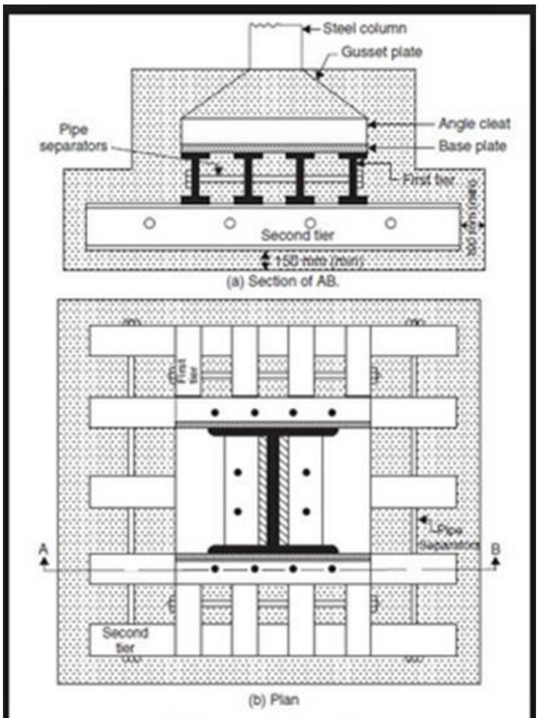
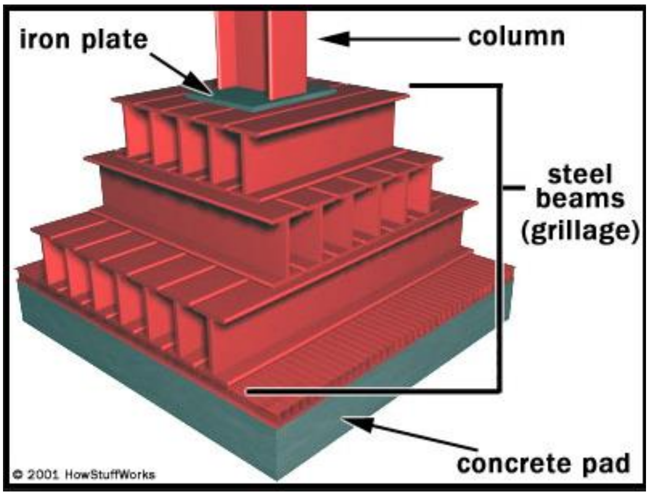
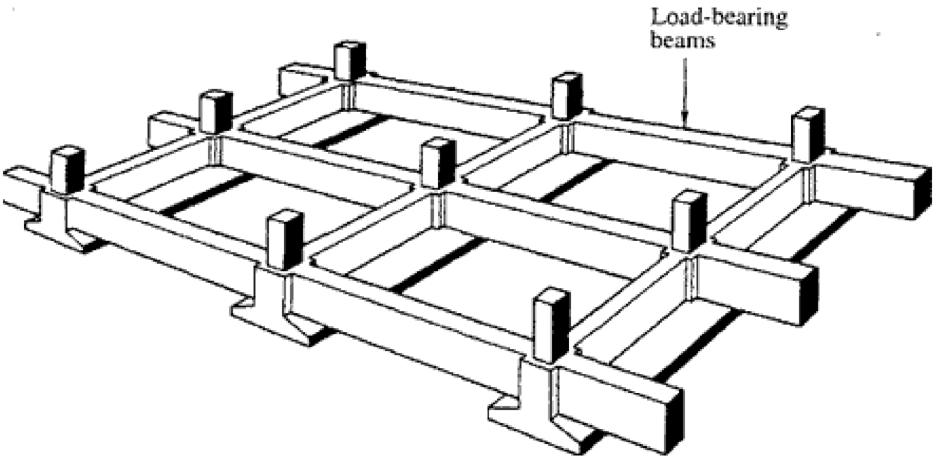


Fig. 7.7. Grillage foundation



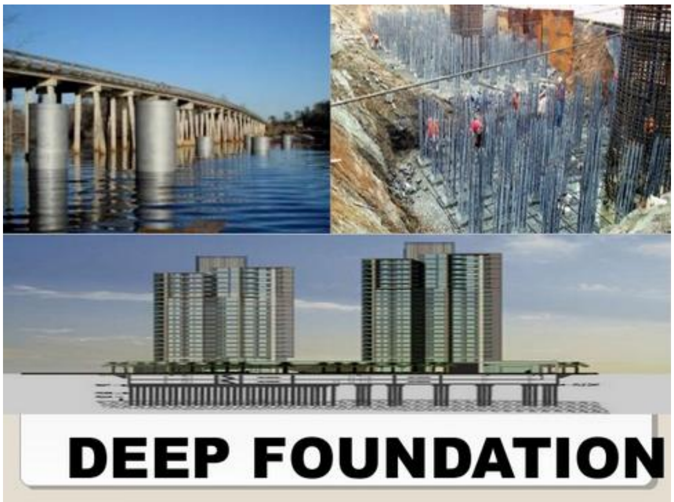
RAFT FOUNDATIONS

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



DEEP FOUNDATIONS

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



1. Basements. They are constructed in place in an open excavations. They are hollow substructures designed to provide working space below ground level.
2. Buoyancy Rafts. They are hollow substructures designed to provide a buoyant substructure beneath which reduce net loadings on the soil to the desired low density.
3.Caissons. They are hollow s8ubstructures designed to be constructed on or near the surface and then sunk as single units to their required level.

A **caisson** foundation also called as pier foundation is a watertight retaining structure used as a bridge pier, in the construction of a concrete dam, or for the repair of ships. It is a prefabricated hollow box or cylinder sunk into the ground to some desired depth and then filled with concrete thus forming a foundation.

C**aisson** foundation is Most often used in the construction of bridge piers & other structures that require foundation beneath rivers & other bodies of water. This is because caissons can be floated to the job site and sunk into place.

Caisson foundations are similar in form to pile foundations, but are installed using a different method. It is used when soil of adequate bearing strength is found below surface layers of weak materials such as fill or peat. It is a form of deep foundation which are constructed above ground level, then sunk to the required level by excavating or dredging material from within the caisson.

Caissons (also sometimes called “piers”) are created by auguring a deep hole into the ground, and then filling it with concrete. Steel reinforcement is sometimes utilized for a portion of the length of the caisson.

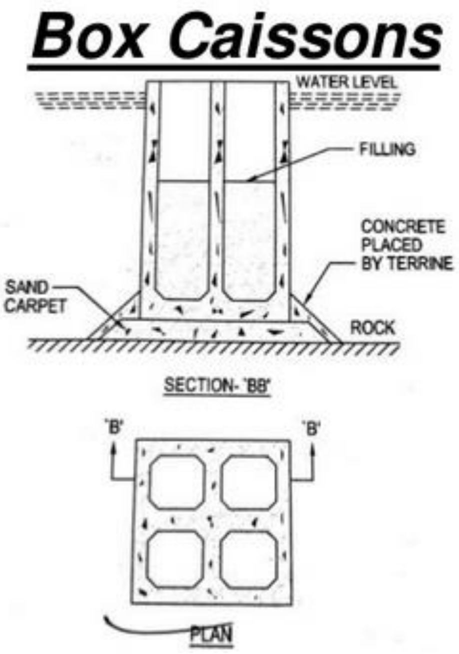
Caissons are drilled either to bedrock (called “rock caissons”) or deep into the underlying soil strata if a geotechnical engineer finds the soil suitable to carry the building load. When caissons rest on soil, they are generally “belled” at the bottom to spread the load over a wider area. Special drilling bits are used to remove the soil for these “belled caissons”.

Types of Caisson Foundations

- Box Caissons

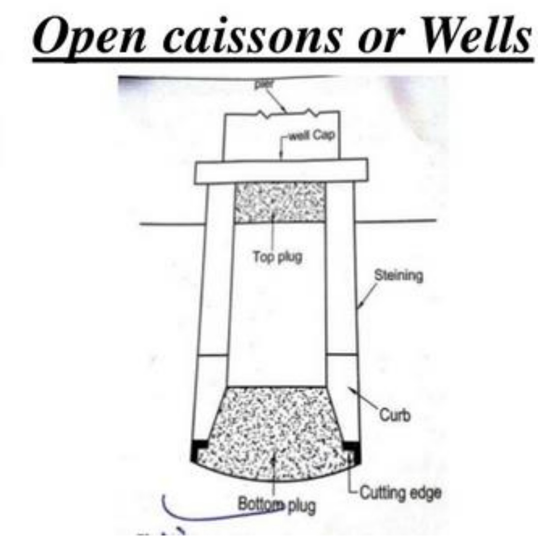
- Excavated Caissons
- Floating Caissons
- Open Caissons
- Pneumatic Caissons
- Sheeted Caissons

Box caissons are watertight boxes that are constructed of heavy timbers and open at the top. They are generally floated to the appropriate location and then sunk into place with a masonry pier within it.



Excavated caissons are just as the name suggests, caissons that are placed within an excavated site. These are usually cylindrical in shape and then back filled with concrete.

Floating caissons are also known as floating docks and are prefabricated boxes that have cylindrical cavities.



Open caissons are small cofferdams that are placed and then pumped dry and filled with concrete. These are generally used in the formation of a pier.

Pneumatic caissons are large watertight boxes or cylinders that are mainly used for under water construction.

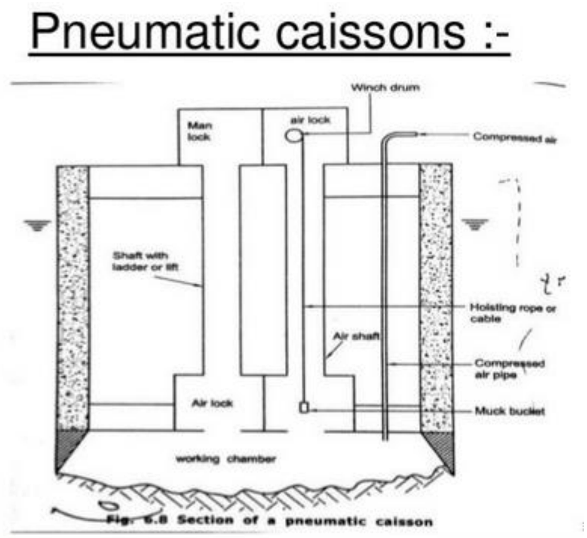


Fig. 6.8 Section of a pneumatic caisson

Advantages of Caissons:

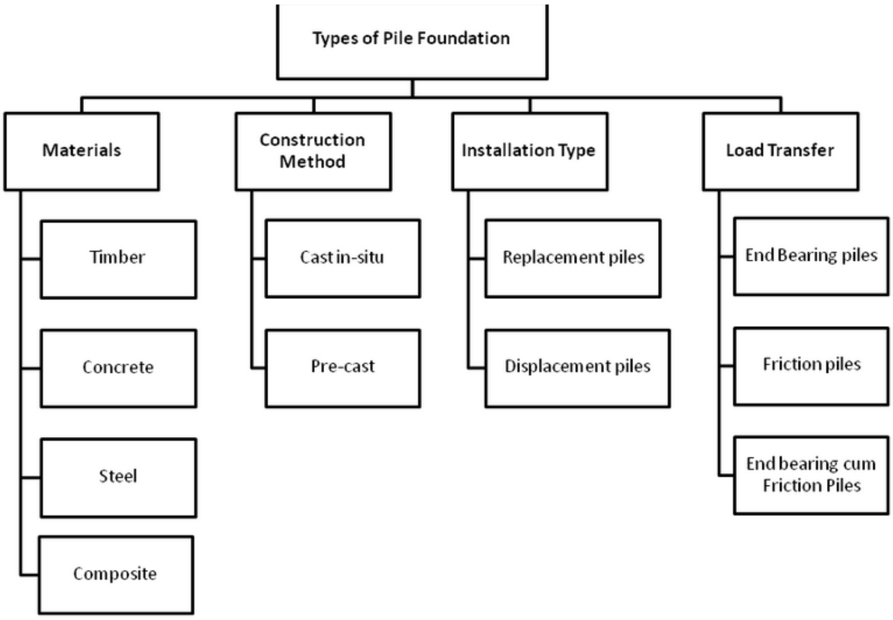
- Economics
- Minimizes pile cap needs
- Slightly less noise and reduced vibrations
- Easily adaptable to varying site conditions
- High axial and lateral loading capacity

Disadvantages of Caissons:

- Extremely sensitive to construction procedures
- Not good for contaminated sites
- Lack of construction expertise
- Lack of Qualified Inspectors

4.Cylinders. They are single small cell caissons.
5.Shaft Foundations. They are constructed within deep excavation supported by lining constructed in place and subsequently filled with concrete.

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



Classification of piles:

1. Classification based on function: Bearing Pile, Friction Pile, Screw Pile, compaction Pile, Uplift Pile, Batter Pile and Sheet Pile

2. Classification based on materials and composition: Cement concrete piles, Timber piles, Steel piles, Sand Piles, and Composite piles.

Functions of piles:

- To transmit a foundation load to solid ground
- To resist vertical, lateral and uplift load.

Depending upon their function or usage, piles may be classified into the following types:

(i) Load Bearing piles
(ii) Friction piles
(iii)Sheet piles
(iv) Anchor piles
(v) Batter piles
(vi) Fender piles
(vii) Compaction piles

i) Load bearing piles: are those which are driven into the ground until a hard stratum is reached. Such piles act as pillars supporting the superstructure and transmitting the load down to the level at which it can be safely borne by the ground.

ii) Friction piles: When loose soil extends to a great depth piles are driven up to such a depth that the frictional resistance developed at the sides of the piles (skin friction) equals the load coming on the piles. The friction piles are driven in the type of soils whose strength does not increase with depth or when rate of increase in strength with depth is very low.

Depending upon the material used in their manufacture, piles can be broadly classified as:

a) Timber piles,
b) Concrete piles
c) Composite piles
d) Steel piles

a) Timber piles: Transmission of load through timber piles takes place by the frictional resistance of the ground and the pile surface. Timber piles prove economical for supporting light structures to be located in compressive soils constantly saturated with water. Piles are driven with the help of pile – driving machine in which a drop hammer delivers blows on the pile head. To facilitate driving, the lower end of the pile is pointed and is provided with a cast iron conical shoe.

Advantages:

• They are economical

• They can be driven rapidly

• They do not need heavy machinery and elaborate technical supervision

• Due to their elasticity, timber piles can be used where lateral forces are subjected

Disadvantages: • They have low bearing capacity

• They are liable to decay

• They cannot be used where long piles are needed

b) Concrete piles: may be classified as:

(i) Pre-cast piles

(ii) Cast-in-situ piles.

(i) Pre-cast piles: are reinforced concrete piles which are cast and cured in casting yard and then transported to the site for driving. The function of reinforcement in pre-cast piles is to resist the stresses produced by its handling, driving and loading which the pile is finally expected to receive.

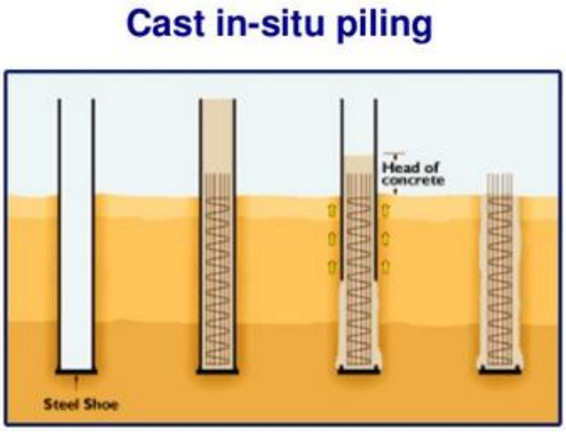
Advantages

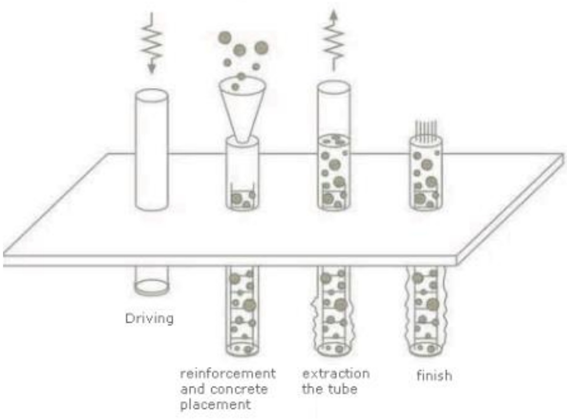
- Proper control in casting
- Not affected by chemical action of ground soil
- Can be subjected to load immediately after driving
- Can be driven under water

Disadvantages

- Difficult for transport
- Handling and driving stresses are high
- Extra steel is requires at top and bottom
- Length of pile is restricted

(ii) Cast-in-situ piles: are those piles which are cast in position inside the ground. Since the piles are not subjected to handling or driving stresses it is not necessary to reinforce the pile in ordinary cases. However, if the piles are subjected to lateral loads.





Advantages
- No handling & driving stresses, hence lighter reinforcement
- Piles can be cast in required length

Disadvantages
- Position of reinforcement may get disturbed during inst
- Difficult to be cast under water.

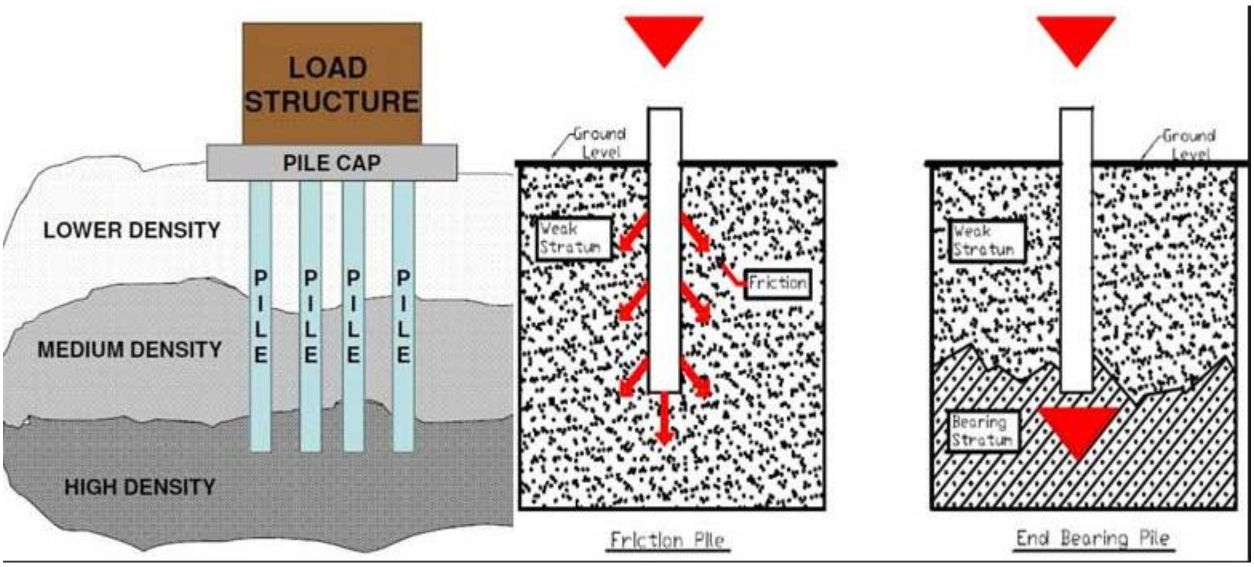
Bored (friction) Piles

Bored piles are those which are formed by forming a bore hole in the ground and then concreting it either with the help of casing tube or without casing. These piles have advantage over the driven piles, in those locations and those situations where the vibrations and noise caused by driving of piles are to be avoided or the strata of adequate bearing capacity is so deep that they are difficult to reach by driven piles. Bored piles are of three types:

a) Pressure piles: They are formed with the help of casing tube, boring auger and compressed air equipment. These are especially suitable for those congested sites where heavy vibrations and noise are not permissible and also where heavy pile driving machinery cannot move in

b) Under reamed piles: These type piles have one or more bulbs formed by enlarging the bore hole for the pile stem by an under-reaming tool. These types of piles are suitable for expansive soils or to obtain adequate capacity for downward, upward or lateral loads or to take foundations below scour level and for moments.

c) Bored compaction piles: The method of boring the piles and concreting the pile is same as for the under-reamed pile, except that the reinforced cage is driven into the freshly laid concrete. Due to this compaction of the freshly laid concrete as well as surrounding soil takes place.



Steel Piles: are suitable if the hard strata are available at greater depths. They have very small soil displacement owing to their small cross sections. Piles are welded during driving to achieve longer lengths. They are used in the form of H-Piles, Box-piles and tube piles.

Advantages

- Can be subjected to load immediately after driving
- Suitable for deeper depths.

Disadvantages

- Requires heavy machinery for driving
- Need skilled operators
- Transportation to site is difficult
- Subject to vibration during pile driving

Foundations in Black Cotton Soil

Black cotton soil is dangerous for the buildings due to its volumetric changes with the change in atmospheric conditions. It swells excessively when wet and shrinks excessively when dry. The differential settlement of the structure caused by the movement of the ground on account of alternate swelling and shrinkage results in formation of cracks ranging from 15 to 20cm wide and 2.5 to 4m deep.

Precautions to be taken for safety of foundations in Black cotton soil

1) Limit the loads on the soil to 5.5 tonnes/m2

2) Take the foundation to such depths where the cracks cease to extend (minimum 1.5m). If the depth of Black cotton soil is less than 1.5m, the entire Black cotton soil above the hard bed may be completely removed

3) Construction in Black cotton soil should be undertaken during dry season

4) The swelling of soil in direct contact with the foundation material causes maximum damage. By making wider trenches for foundation and filling spaces on either side of foundation masonry with sand or moorum, we can prevent direct contact of black cotton soil with the masonry work

5) For important structures, raft foundation should be provided to avoid differential settlement

6) The bed of foundation trench should be made firm or hard by ramming it well. On the rammed bed a 30 cm layer of good hard moorum should be spread in layer of 15cm and rammed. On top of this layer, either stone or sand bed is laid.

7) The RCC ties or bands (10 to 15cm deep) should be placed at plinth level, lintel level and eaves level Recommended type of foundation: raft or mat, Under-reamed pile.

Causes of failure of good foundation

1. Non-uniform settlement of subsoil and masonry
2. Alternative swelling and shrinkage of subsoil.
3. Action of weathering agencies like sun, rain, wind, and earthquake forces etc.
4. Root trees and shrubs which penetrate into the soil which has more affinity towards water which may leads to the failure of the foundation.

1 (a) What are different types of foundations? What are the circumstances in which they are adopted?

(b) What do you mean by "safe bearing capacity" of soil? Explain plate loading test to determine the same

2 (a) What are characteristics of black cotton soil? What precautions are taken in designing and laying foundations in black cotton soil?

(b) Under what circumstances the following are used?

(i) Combined footing (ii) Mat foundation (iii) Pile foundation

3 (a) What is bearing capacity of soil? Explain various methods of improving safe bearing capacity of soils

(c) List the objects of foundation

(d) Write a note on pile foundation

4 (a) What are the different methods of soil investigation? Discuss any two methods

(b) Sketch the following types of foundation and briefly discuss:

(i) Grillage foundation (ii) RCC Raft foundation .

Masonry: Definition and terms used in masonry. Brick masonry, characteristics and requirements of good brick masonry, Bonds in brick work, Header, Stretcher, English, Flemish bond, Stone masonry, Requirements of good stone masonry, Classification, characteristics of different stone masonry, Joints in stone masonry. Types of walls; load bearing, partition walls, cavity walls.

Masonry may be defined as the construction of building units bonded together with mortar.

The masonry is used for the construction of foundations, walls, columns and other similar components of a structure.

Depending on the type of building units used, masonry may be classified into the following:

1.Stone masonry
2.Brick masonry
3.Reinforced brick masonry
4.Hallow concrete blocks masonry
5.Composite masonry





Definition of terms used in Masonry
Following are some of the technical terms used in masonry work

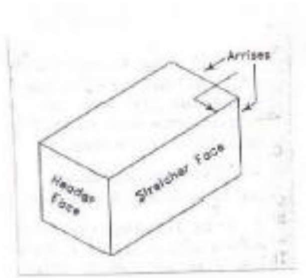
1. **Arrises:** The edge formed by the intersection of plane surfaces of brick are called the arrises.

2. **Bed :** The lower surface of a brick or stone in each course.

3. **Course:** a Course is a horizontal layer of masonry

4. **Bed joint:** the horizontal layer of mortar upon which the bricks or stones are laid is known as a bed joint.

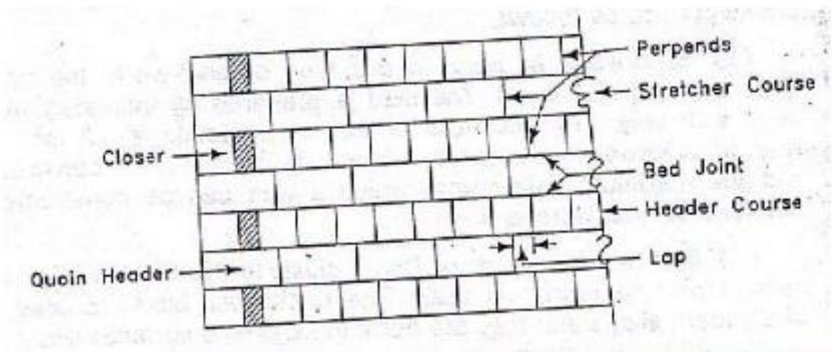
5. **Stretcher:** a stretcher is the longer face of the brick (23cmX11.4cm) as seen in the elevation of the wall. A course of bricks in which all the bricks are laid as stretcher on facing is known as a stretcher course.



6. **Header:** it is the shorter face of the brick (11.4cm X 7.6cm) as seen in the elevation of the wall. A course of bricks in which all the bricks are laid as headers on facing is known as header course.

7. **Quions**: the exterior angle or corner of a wall is known as quoin. The stones or bricks forming the quoins are known as stone quoins or quoin bricks.

8. **Lap:** the horizontal distance between the vertical joints in successive courses is termed lap.



9. **Perpend:** It is a imaginary vertical line which includes the vertical joint separating two adjoining bricks.

10. **Racking back:** it is a termination of a wall in a stepped fashion.

11. **Toothing:** it is the termination of the wall in such a fashion that each alternate course at the end projects in order to provide adequate bond if the wall is continued horizontally at a later stage.

12. **Closer:** A piece of brick which is used to close up the bond at the end of brick courses is known as a closer. Following are the types of closers:

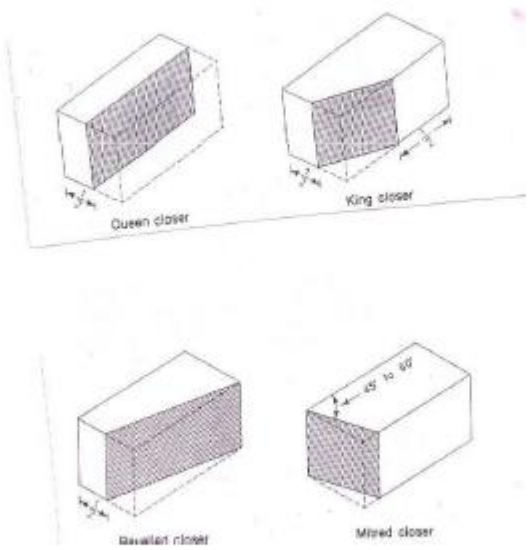
i. Queen closer

ii. King closer

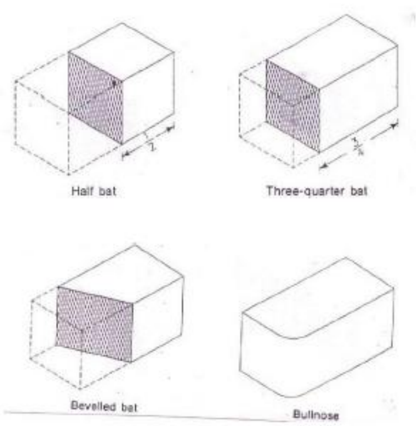
iii. Beveled closer

iv. Mitred closer

King Closer: This is obtained by cutting a rectangular portion of the brick such that half a header and half a stretcher are obtained on the adjoining sides. A king closer is used near door and window openings to get a satisfactory arrangement of mortar joints.
Queen Closer: It is the portion of the brick obtained by cutting a brick length-wise into two portions.
Beveled Closer: It is a special form of King closer in which the whole length of brick is beveled in such a way that half width is maintained at one end and full width is obtained at the other end
Mitred Closer: It is a brick whose one end is cut splayed or mitred for full width



13. **Bat:** It is the portion of the brick cut across the width. Thus, a bat is smaller in length than the full brick.



14. **Face:** The surface of wall exposed to the weather is known as the facing.

15. **Back:** The inner surface of wall which is not exposed to the weather

16. **Backing:**The material used in the formation of the back of the wall.

17. **Facing:** The material used in the face of the wall.

18. **Hearting:** The inner portion of the wall between the facing and backing.
19. **Thresh hold**: is the arrangement of steps provided from the plinth level of external door or verandah to the ground level.
20. **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
21. Offsets: These are narrow horizontal surfaces which are formed by reducing the thickness of the wall.
22.Spalls: are the chips or small pieces of stones obtained as a result of reducing big blocks of stones into the regular stone blocks
23.Stooling: These are horizontal stones provided to receive jambs and mullions
24.Template or Bed Block: 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.
25.Column: It is a vertical load bearing member of masonry which is constructed in an isolation from the wall and whose width does not exceed four times its thickness.
26.Pier or 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 then it is called Pilaster.
27.Blocking course: It is another course of stone placed immediately above the cornice. Apart from improving appearance, it adds to the stability of cornice against overturning.
28.Toothing: These are the bricks left projecting in alternate courses for the purpose of bonding future masonry work
29.Lacing course: It is the horizontal course of stone bricks provided to strengthen a wall made of irregular courses of small stones.
30.Cornice: It is the projecting ornamental course near the top of a wall or at the junction of wall and the ceiling
31.Coping: It is a covering of stone, concrete, brick of terracotta, placed on the exposed top of a wall to prevent seepage of water.
32.Weathering: It is the term used to denote provision of slope on the upper surface as sills, cornices, copings etc...
33.Throating: It is a groove provided on the underside of projecting elements such as sills cornices copings etc... so that the rain water can be discharged clear of the wall surface
34.Parapet: It is the portion of low height wall constructed along the edge of the roof to protect the users.
35.Arch: Arch is a structural construction of masonry constructed by mechanical arrangement of wedge shaped blocks of stone or brick arranged in the form of a curve supporting wall or load above the opening.
36.Gable: It is a triangular shaped masonry work provided at the end of a sloped roof
37.Freeze: It is a course of stone placed immediately below the cornice along the external

face of the wall intended to improve the appearance of the wall.

38.Frog: It is an indentation or depression on the top face of brick made with the object of forming a key for the mortar. This prevents the displacement of the brick above

39.Quoins: The exterior angle or corner of a wall is known as quoin.

40.Through stone: is a stone header

41.Sill: The bottom surface of a door or window opening is known as Sill

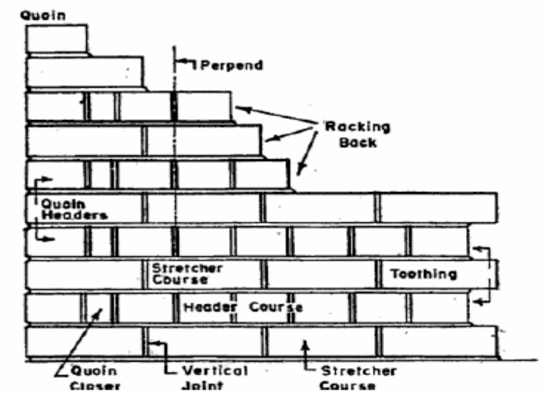
42.Lintel: It is horizontal member of stone or brick, wood steel, reinforced concrete used to support the masonry and super-imposed load above an opening

43.Plinth: Plinth is the horizontal projecting course of stone or brick provided at the base of the wall above the ground level. Plinth raises the level of ground floor above the natural ground level thus protecting the building from rain, water and other weather effects

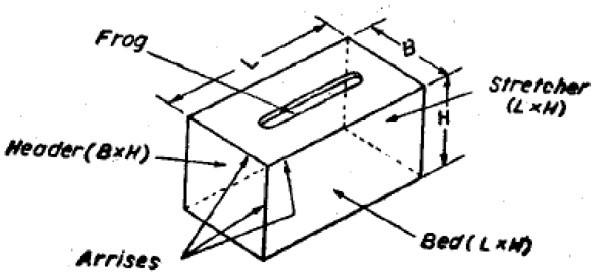
44.Plinth course: It is the uppermost course of the plinth masonry

45.String Course: It is 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 imparts aesthetic appearance to the structure.

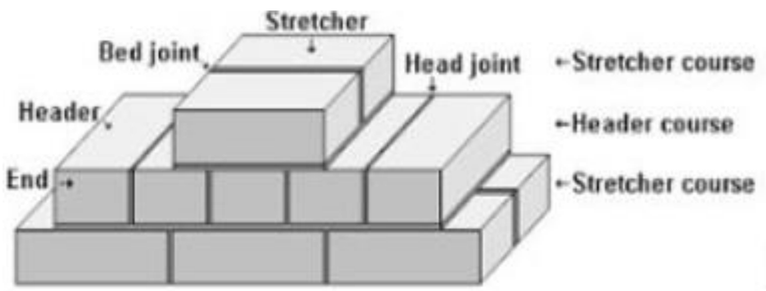
46.Jambs: are the vertical sides of a finished opening for the door, window or fire place.

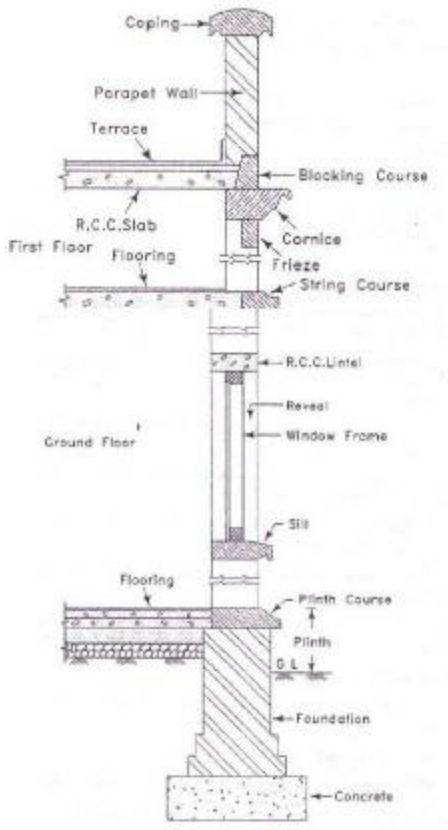


Elevation of a brick wall



Full brick





Section of a wall of a two-storeyed building

Introduction:

Brick masonry is a unified mass obtained by systematic arrangement of laying bricks and bonding together with mortar. It is used in foundations, walls, buttresses, retaining structures, copings, ornamental brickwork, circular brickwork, fire places, flumes, tall chimneys, steps, arches etc.,. The strength of brick masonry works depends upon the quality of bricks and type of mortar used. Mortar not only imparts strength but holds the bricks together to act as homogenous mass.

Generally mortars are following types used for brick masonry

(i) Mud mortar

(ii) Cement mortar

(iii) Cement lime mortar

(iv) Lime surkhe mortar

General principles in brick masonry construction:

1. A good brick masonry should utilize bricks, which are sound, hard, well burnt and tough with uniform colour, shape and size.
2. The bricks should be compact, homogeneous, free form holes, cracks, flaws, air-bubbles and stone lumps and soaked in water for at least two hours before use
3. In the brickwork, the bricks should be laid on their beds with the frogs pointing upwards
4. The brick courses should be laid truly horizontal and should have truly vertical joints
5. as far as possible the use of brick – bats should be discouraged

6. as far as possible the brick wall should be raised uniformly less than 1.5m in day with proper bond.
7. When the mortar is green the face joints should be racked to a depth of 12 to 19mm in order to have a proper key for plastering or pointing.
8. In order to ensure continuous bond between the old and the new, the wall should be stopped with a toothed end.

Masonry Wall Requirements
The usual functional requirements of a masonry wall include:
i) Adequate strength to support imposed loads
ii) Sufficient water tightness
iii) Sufficient visual privacy and sound transmission
iv) Appropriate fire resistance
v) Ability to accommodate heating, air conditioning,
electrical, and plumbing equipment
vi) Ability to receive various finish materials Cost
vii) Ability to provide openings such as doors and window.

Types of brick bonds:
Bonding is a process of arranging bricks and mortars to tie them together in a mass of brickwork. It should have a minimum of vertical joints in any part of the work.

Characteristics of brick bond or rules for bonding:

1. The brick masonry should have bricks of uniform shape and size

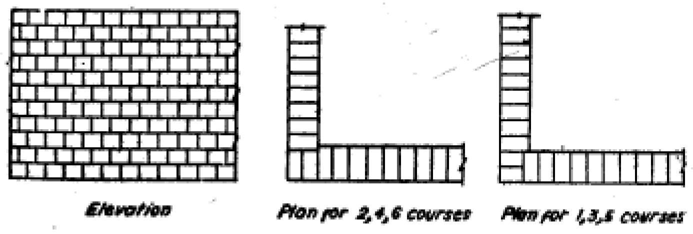
2. For satisfactory bondage the lap should be one-fourth of the brick along the length of the wall and half brick across thickness of the wall
3. The brick bats use should be discouraged
4. The vertical joints in the alternate courses should coincides with the centre line of the stretcher
5. The alternate courses the centre line of header should coincide with the centre line of stretcher, in course below or above it.
6. The stretcher should be used only in the facing while hearting

1. should be done in the headers only

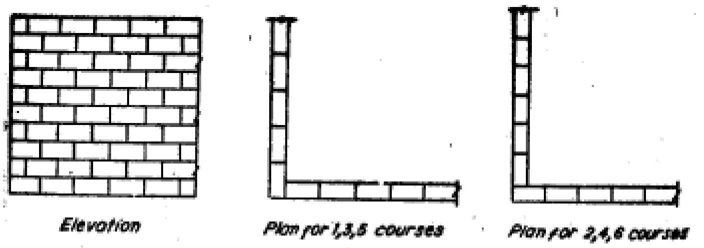
Classifications of bonds: The bonds can be classified as follows:
(i) Stretcher bond
(ii) Header bond
(iii) English bond
(iv) Double Flemish bond
(v) Single Flemish bond
(vi) Garden wall bond
(vii) Facing bond
(viii) Dutch bond
(ix) Raking bond
(x) Zigzag bond
(xi) English cross bond
(xii) Bonds in columns
(xiii) Brick on edge bond or soldier course

(xiv) Bonds at junction and squint junction

Header bond: In this type of bond all the bricks are laid with their ends towards the face of the wall. This arrangement is suitable for one brickwall of curved wall and footings for better load distribution as shown in fig.



Stretcher bond: In this type of bond all the bricks are laid with their lengths in the direction of the wall. This pattern is used only for wall having thickness of 9cm only as shown in fig .



English bond

This is the most commonly used bond. It is considered to be the strongest bond. Following are the features of English bond

1. It consists of alternate courses of headers and stretchers

2. In this bond, vertical joints of the header courses come over each other, similarly the vertical joints of the stretcher courses also come over each other.

3. There is no continuous vertical joint

4. Every alternate header comes centrally over the joint between two stretchers in course below.

5. Queen closer is put next to the quoin header to develop the face lap.

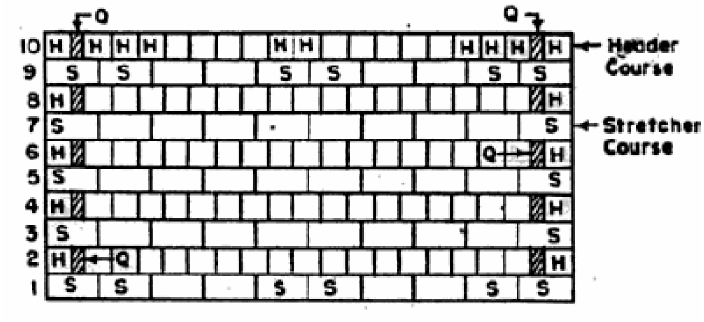
6. In the stretcher course, the stretchers have a minimum lap of 1/4th their length over headers.

7. Walls of even multiple of half bricks represent the same appearance on both faces. Thus a course showing stretchers on the front face will also show stretchers on the back face.

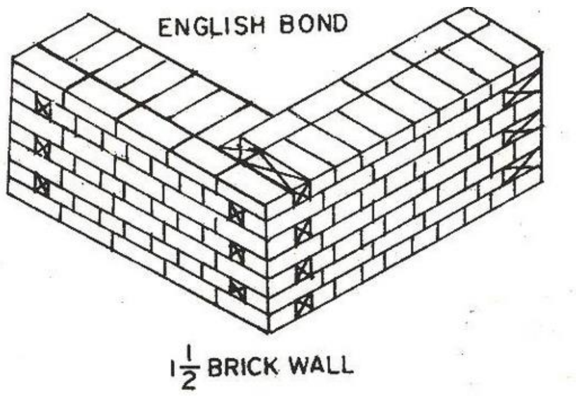
8. Wall of odd multiple of half bricks will show stretchers on one face and headers on the other face.

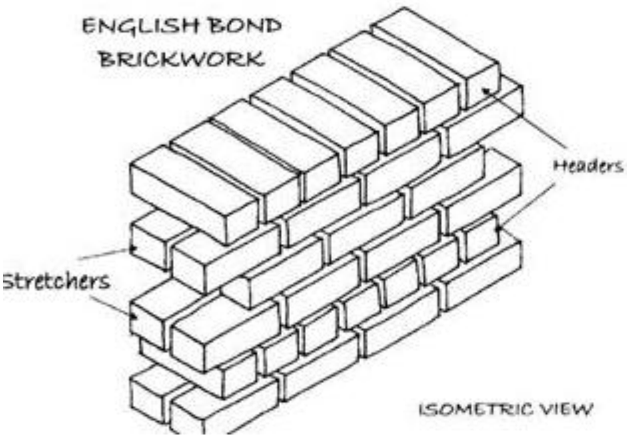
9. The hearting (middle portion) of each of the thicker walls consists entirely of headers.

10. The queen closers are not required in stretcher courses.

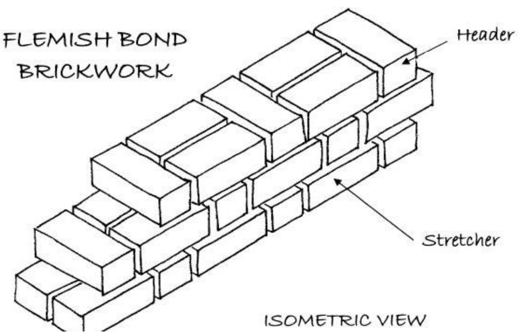


S = STRETCHER ; H = HEADER ; Q = QUEEN CLOSER
FIG. 6.6. ENGLISH BOND.





Flemish bond
In this type of bond, each course is comprised of alternate headers and stretchers. Every alternate course starts with a header at the corner (quoin header). Quoin closers are placed next to the quoin header in alternate courses to develop the face lap. Every header is centrally supported over the stretcher below it. Flemish bonds are two types:



1. Single Flemish bond

2. Double Flemish bond

1. Single Flemish bond
Special features of single Flemish bond are
1. This bond is a combination of English and Flemish bond.

2. This bond uses the strength of the English bond and appearance of Flemish bond

3. In this work the facing of the wall consists of Flemish bond and the backing consists of English bond in each course.

4. It is used for those walls having thickness atleast equal to 1 1/2 brick.

2. Double Flemish bond

Special features of double Flemish bond are

1. Alternate headers and stretcher are laid in each course.

2. The facing and backing of the wall, in each course have the same appearance.

3. In walls having thickness equal to odd multiple of half bricks, half bats and 3 1/4 bats are amply used

4. For walls having thickness equal to even multiple of half bricks, no bats are required. A header or stretcher will come out as header or stretcher on the same course in front as well as back faces.

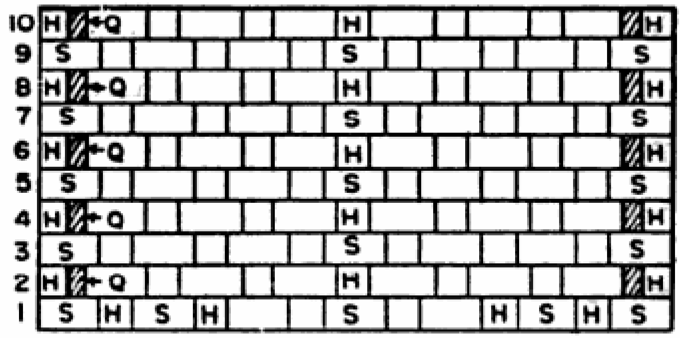


FIG. 6.9. FLEMISH BOND (ELEVATION).

Comparison of English Bond and Flemish bond

Sr No.	English Bonds	Flemish bond
1	This bond consists of headers and stretchers laid in alternative courses.	This bond consists of headers and stretchers laid alternatively in each course.
2	It is strongest of all the bonds.	It is less strong for walls having thickness more than 13 ½ inches.
3	It provides rough appearance especially for one brick thick walls.	It provides good appearance for all thickness of walls.
4	There are no noticeable continuous vertical joints in the structure built in this bond.	There are partly continuous vertical joints in the structure built in this bond.
5	Much attention is not required in providing this bond.	Special attention is required in providing this bond.
6	Progress of work is more.	Progress of work is less.
7	It is costly because the use of brick bats is not allowed.	It is economical because brick bats are allowed for forming this bind.

STONE MASONRY

Stone masonry is similar in many ways to unit masonry, but there are also some differences. Stone is a natural material, so its size and shape are not uniform, and it's also a very heavy material. Stone is dimensionally stable and does not expand and contract with changes in temperature or moisture content, so stone masonry construction does not require expansion or control joints.


Uses of stone masonry:

Stone masonry construction is used in

1. Building foundations, dams, monumental structures

2. Building walls, piers, columns, pillars, light houses and architectural works.

3. Arches, domes, lintels and beams

4. Roofs, flems, paving jobs

5. Railway, bullest, black boards and electrical switch boards .

Selection of stone for stone masonry:

The selection of stones for stone masonry depends upon

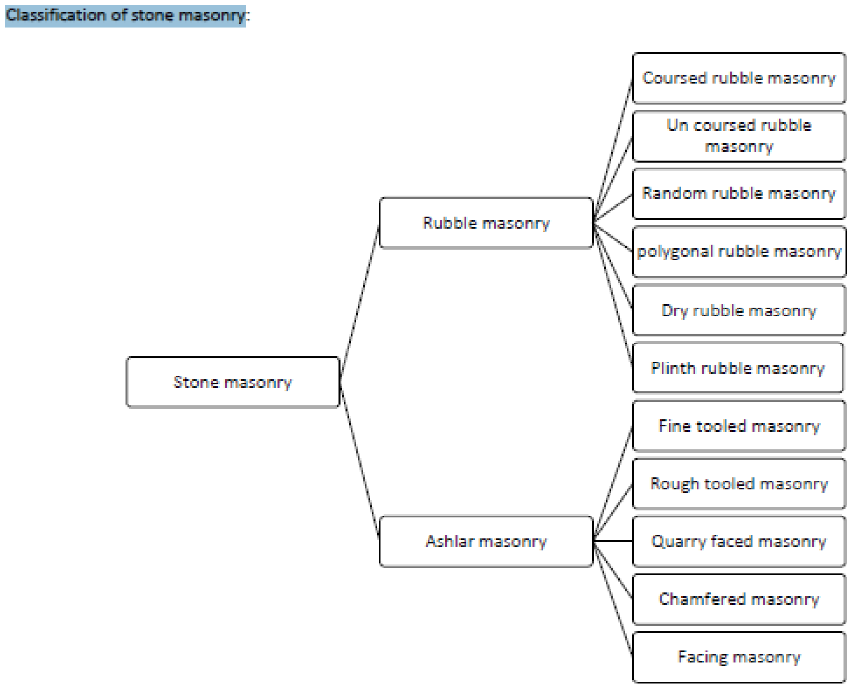
a. Availability
b. Ease of working
c. Appearance
d. Strength and stability
e. Polishing characteristics
f. Economy
g. Durability.

General principles in the stone masonry construction

1. The stones to be used for stone masonry should be hard, tough and durable.
2. The pressure acting on stones should be vertical
3. The stones should be perfectly dressed as per the requirements
4. The heads and bond stones should not be of a dumb bell shape.
5. In order to obtain uniform distribution of load, under the ends of griders, roof trusses etc large flat stones should be used
6. The beds of the stones and plan of the course should be at right angles to the slope in the case of sloping retaining wall
7. Wood boxing should be filled into walls having fine dressed stone work to protect it during further construction
8. The mortar to be used should be good quality and in the specified faces.
9. The instruction work of stone masonry should be raised uniformly.

10. The plumb bob should be used to check the vertically of erected wall
11. The stone masonry section should always be designed to take compression and not the tensile stresses
12. The masonry work should be properly cured after the completion of work for a period of 2 to 3 weeks
13. As per as possible broken stones or small stones chips should not Used
14. Double scaffolding should be used for working at higher level
15. The masonry hearting should be properly packed with mortar and chips if necessary to avoid hallows
16. The properly wetted stones should be used to avoid mortar moisture being sucked.

Classification of different stone masonry



Depending upon the arrangement of stones in the construction, degree of refinement used in shaping the stone and finishing adopted, stone masonry can be classified as follows:
(1) Rubble masonry
(2) Ashlar Masonry

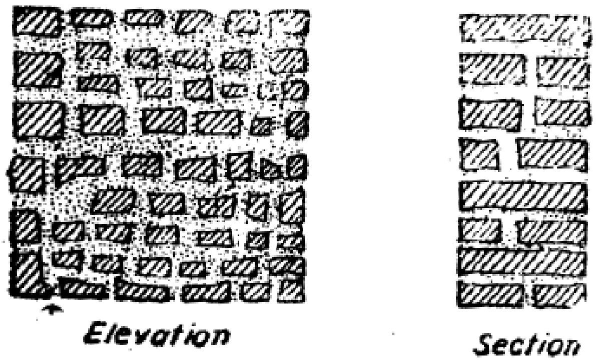
1.Rubble masonry: In this category, the stones used are either undressed or roughly dressed having wider joints. This can be further subdivided as uncoursed, coursed, random, dry, polygonal and bint.

(i) **Uncoursed rubble masonry**: This is the cheapest, roughest and poorest form of stone masonry. The stones used in this type of masonry very much vary in their shape and size and are directly obtained from quarry. Uncoursed rubble masonry can be divided into the following.

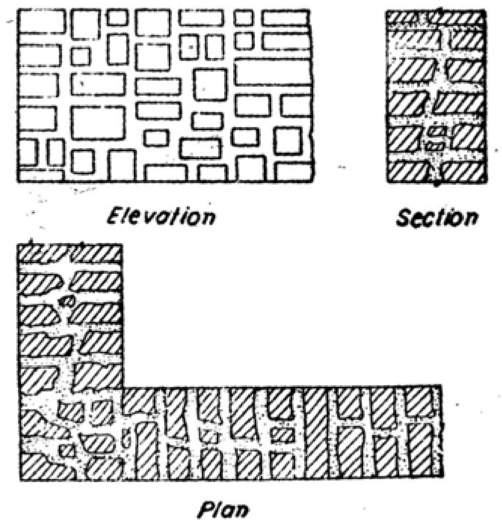
a) Uncoursed random rubble

b) Uncoursed squared rubble

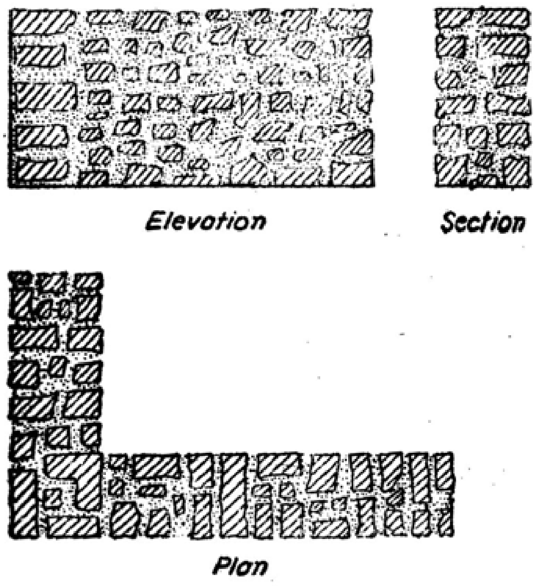
a) **Uncoursed random rubble masonry:** The weak corners and edges are removed with mason’s hammer. Generally, bigger stone blocks are employed at quoins and jambs to increase the strength of masonry.



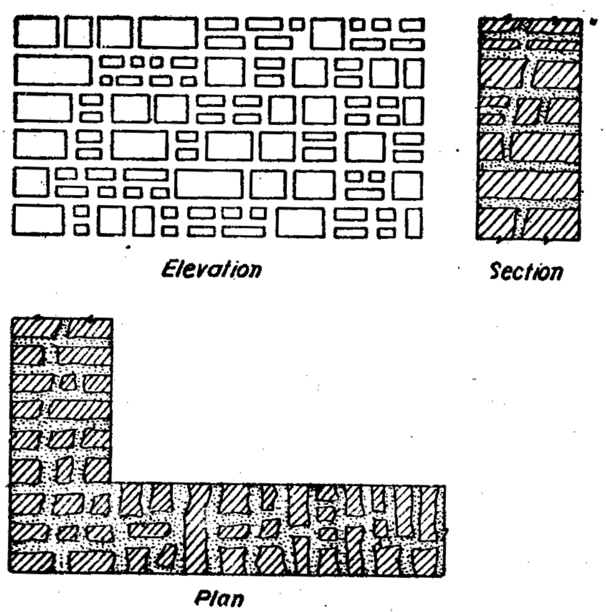
b) **Uncoursed squared rubble:** In this type the stone blocks are made roughly square with hammer. Generally the facing stones are given hammer-dressed finish. Large stones are used as quoins. As far as possible the use of chips in bedding is avoided as shown in fig.



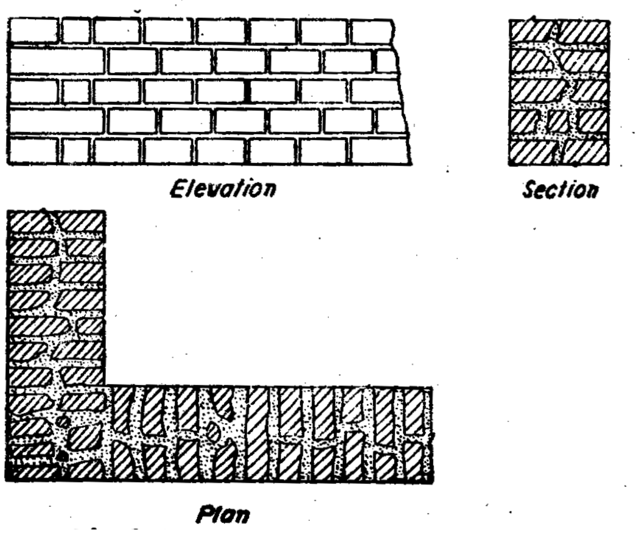
(ii) **Coursed random rubble:** This type of masonry is commonly used in the construction of low height walls of public buildings, residential buildings, abutment and piers of ordinary bridges. The stones of 5 to 20cm size are used in each course as shown in fig.



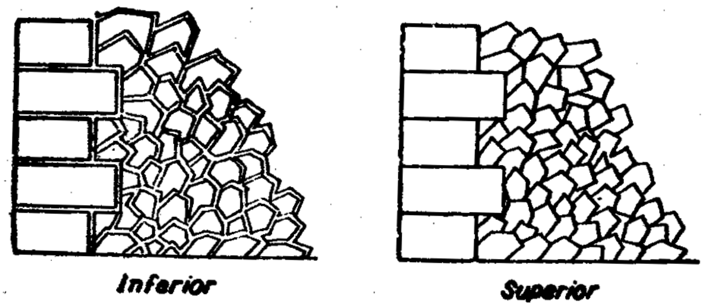
(iii)**Coursed squared rubble:** This type of masonry is made up of hammer squared stones facing with bonded backing of uncoursed random rubble masonry. The stones employed in each course are of equal height. The backing and facing construction, should be carried simultaneously. In order to avoid thick mortar joints, small chips may be used as shown in the fig



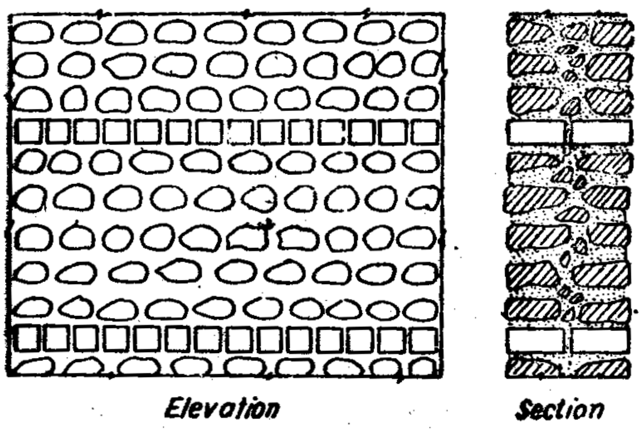
(iv)**Built to regular course:** In this type of stone masonry the uniform height stones are used in horizontal layers not less than 13cm in height. Generally, the stone beds are hammered or chisel dressed to a depth of atleast 10cm from the face. The stones are arranged in such a manner so that the vertical joints of two consecutive curse do not coincide with each other as shown in fig



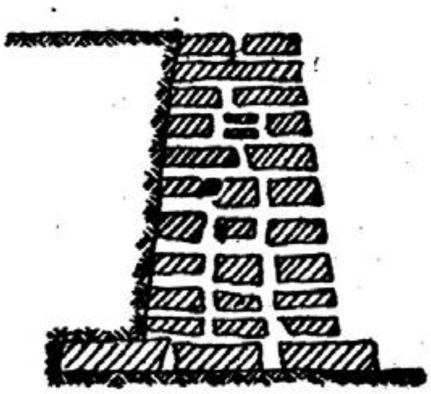
Polygonal rubble masonry: In this type of masonry the stones are roughly dressed to an irregular polygonal shape. The stones should be so arranged as to avoid long vertical joints in face work and to break joints as much as possible. Small stone chips should not be used to support the stones on the facing as shown in fig



(vi) **Plint rubble masonry:** This type of masonry is used in the areas where the flint is available in plenty. The flint stones varying in thickness from 8 to 15cm and in length from 15 to 30cm are arranged in the facing in the form of coursed or uncoursed masonry as shown in fig



(vii) **Dry rubble masonry:** This type of masonry is used in the construction of retaining walls pitching earthen dams and canal slopes in the form of random rubble masonry without any mortar. The hallow spaces left around stones should be tightly packed with smaller stone pieces as shown in fig.



2. **Ashlar Masonry:** This type of masonry is built from accurately dressed stones with uniform and fine joints of about 3mm thickness by arranging the stone blocks in various patterns. The backing of ashlar masonry walls may be built of ashlar masonry or rubble masonry. The size of stones blocks should be in proportion to wall thickness. The various types of masonry can be classified under the following categories .

(i) Ashlar fine

(ii) Ashlar rough

(iii) Ashlar rock or quarry faced

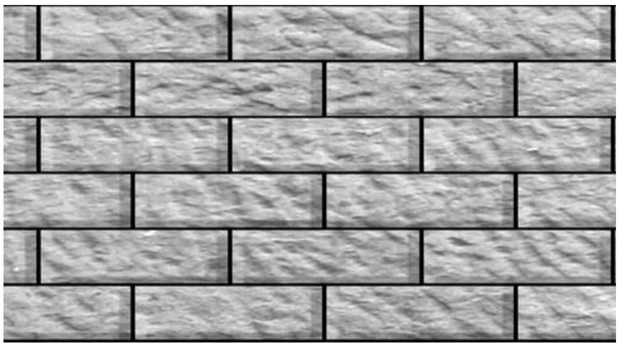
(iv) Ashlar facing

(v) Ashlar chamfered

(vi) Ashlar block in course.

The following are the different types of ashlar masonry:

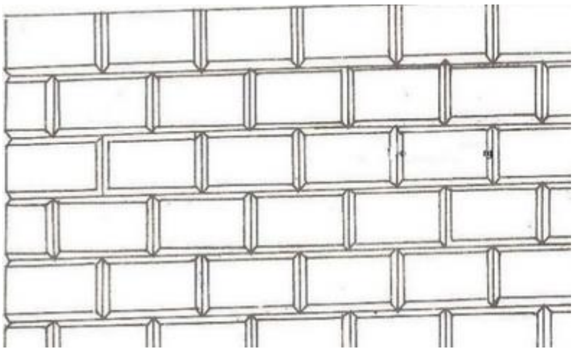
1.**Ashlar fine masonry**: In this type of ashlar masonry, the beds, sides, and faces are finely chisel-dressed. The stones are arranged in proper bond and thickness of the mortar joints does not exceed 3mm. This type of construction gives perfectly smooth appearance but it is costly in construction.



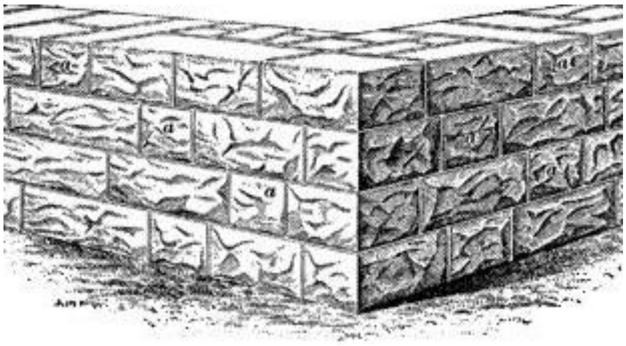
2.Ashlar rough-tooled masonry: In this type of ashlar masonry, the beds and sides, are finely chisel-dressed. But the face is made rough by means of tools. A strip about 25mm wide and made by means of a chisel is provided around the perimeter of every stone exposed for view. The thickness of the mortar joints does not exceed 6mm. This type of work is also known as the bastard ashlar.

(iii) **Ashlar rock or quarry faced masonry**: In this type of ashlar masonry, a strip about 25mm wide and made by means of a chisel is provided around the perimeter of every stone exposed for view. But the remaining portion of the face is left in the same form as received from quarry. Only projections on the face known as bushings exceeding 80mm are removed by a hammer. This type of construction gives massive appearance.

(iv) **Ashlar chamfered masonry**: In this type of ashlar masonry, a strip is provided as above but it is chamfered or beveled at an angle of 45 degrees by means of chisel for a depth of about 25mm. Another strip 12mm wide is then provided on the remaining exposed face of the stone and the surface inside this strip is left in the same form as received from the quarry. Only projections on the face known as bushings exceeding 80mm are removed by a hammer.



(v) **Ashlar block-in-course masonry**: This type of ashlar masonry occupies an intermediate position between the rubble masonry and the ashlar masonry. The faces of the stones are generally hammer-dressed and thickness of mortar joints does not exceed 6mm. The depth of courses varies from 200mm to 300mm. This type of construction is used for heavy engineering works such as retaining walls, sea walls bridges, public buildings etc.



Precautions In The Construction Of Stone Masonry

Stones should have homogenous structure. They should be strong, hard, tough, close grained and should be of uniform texture.

Stones should be well watered before using in the construction so that they do not absorb moisture from the mortar instantaneously.

Immediate withdrawal of water from the mortar affects the hardening process of mortar and renders it to be weak.

Stones should be free from defects, flows, soft patches, cavities and cracks. They should be dressed well as per the requirement.

Cement mortar, lime mortar, cement and lime mortar, lime surkhi mortar may be used for stone masonry construction.

Stone masonry in foundations may be constructed with 1:3 cement sand mortar in case if the soil has sulphate content. In other cases 1:1:6 cement, lime, sand mortar can be used.

The mortar used should have adequate workability.

Stones should be laid on their natural bed.

Proper bond should be maintained throughout the work.

Continuous vertical joints should always be avoided.

Stone masonry is least resistant to tensile stresses, hence it should be ensured that no tensile stresses are allowed to develop anywhere in the masonry.

The face and back of the stone wall should be well bonded together by using bond stones at frequent intervals. Bond stones should be laid in staggered fashion in successive courses with a maximum internal distance of 1.50 meters. The whole masonry work should be raised uniformly so that no unequal loading occurs in foundation.

If it becomes necessary to break the uniformity the wall should be racked back at 450 to allow proper connection between the old and the new work.

Quoins used at corners and at door and windows should be of full height of the course.

Length and breadth of stones used at quoins should be at least twice or 1 ½ times their depth.

Very small size stones should not be used in the masonry.

All the cavities in the masonry must be filled up with spalls and mortar mixture. All the exposed joints should be raked to a depth of 25mm and pointing should be done with rich cement mortar.

The entire masonry should be cured for at least 10 days.

The scaffolding used in stone masonry construction should be strong enough to bear the load. Double scaffolding is most suitable one since no holes need to be left in the masonry for putlogs.

The bed joints should be uniform and should be thoroughly filled up. Stones should have level surfaces at bottom so that no hollow is left in the bed joints. Hollow addressed bed joints may lead to cracks in the stone under loaded condition.

Hard stones without flaws should be used as bed blocks below the beams.

Before constructing new stone masonry work over old one, the old stone masonry should be cleaned with wire brushes and watered sufficiently. Chases for dowels, clamps etc. should be made prior to starting of work. Suitable lifting devices should be used to lift large sized stones.

The entire work should be carried out under good supervision and good workman ship.

Comparison of Brick Masonry and Stone Masonry

Brick Masonry

1) Brick work is cheaper at places where stones are not available
2) Generally brick masonry can be constructed with less skilled masons
3) Bricks are easy to handle, no special lifting equipment is required
4) Brick masonry can be constructed in any type of mortar
5) Bricks are of regular shape and size. Due to this proper bond can be maintained
6) Brick works requires lesser mortar because of thin mortar joints
7) Because of plane surface obtained, the thickness of plaster is much less
8) Since bricks are in regular sizes, thinner walls can be constructed
9) The dead load of brick wall is much less
10) It is easy to form openings in brick work
11) Good quality bricks can resist various atmospheric effects

Stone masonry

1) Stone masonry is stronger than brick masonry of the same wall thickness
2) The life span of stone masonry is much more than the bricks masonry
3) Stone work gives massive appearance
4) Stone masonry does not require external plaster
5) Better architectural effects given
6) There is no requirement of fuels as requires for bricks
7) Stone work is more water tight.

Joints in Masonry

In order to secure the stones firmly with each other, the following joints are provided

i. But tor square joint

ii. Rebated or lapped joint

iii. Tongued or grooved joint

iv. Tabled joint

v. Rusticated joint

vi. Plugged joint

vii. Dowelled joint

viii. Cramped joint .

1.But tor square joint:

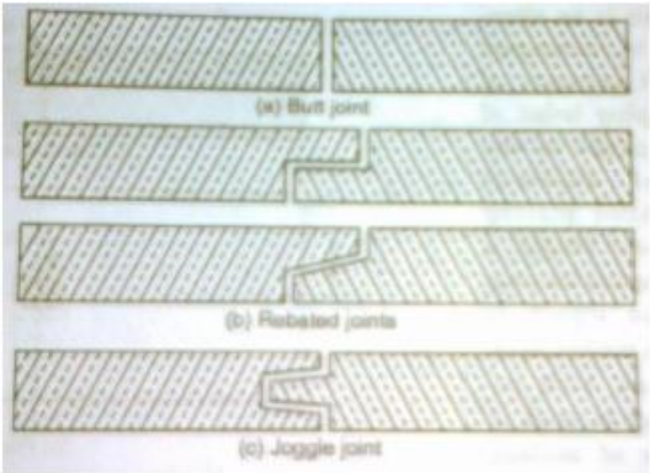
This is the most commonly used joint in stone masonry. The dressed edges of two adjacent stones are placed side by side.

2.Rebated or Lapped Joint

This type of joint is provided in arches, gables, copings etc., to prevent the possible movement of the stones. The length of the rebates or lap depends upon the nature of the work, but it should not be less than 70mm.

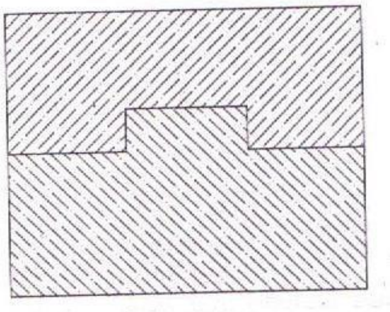
3.Tongue and Grooved Joint or Joggle Joint

This type of joint is provided to prevent sliding along the side joints. The joint is made by providing projection or tongue in one stone and a corresponding groove or sinking on the adjacent stone.



4. **Tabled or Bed Joint**

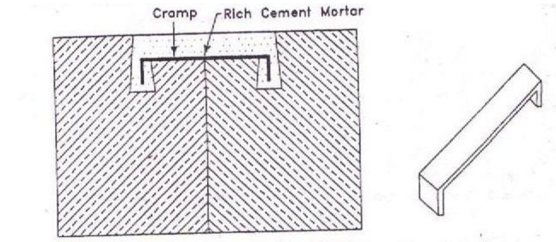
This joint is used to prevent lateral movement of stones such as in sea walls where the lateral pressure is heavy. The joint is made by forming a joggle in the bed of the stone. The height of the projection is kept about 30 to 40 mm, while the width is kept equal to above the breadth of the stone.



Tabled joint

5.Cramped Joint

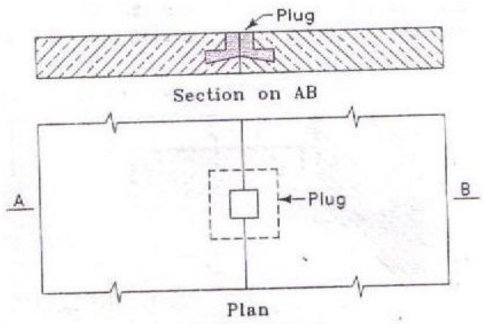
The joint uses metal cramp instead of dowels. Holes made in the adjacent stones should be of dovetail shape. The cramps are usually of non-corrosive metals such as gunmetal, copper etc with their ends turned down to a depth of 4 to 5 cm. The length, width and thickness of cramps vary from 20 to 30cm, 2 to 4 cm and 5 mm to 10 mm respectively. Wrought iron cramps may also be used but they must be either galvanized or dipped in oil while hot, to prevent their corrosion. After placing the cramps in position, the joint is grouted and covered with cement, lead or asphalt. Cramps prevent the tendency of the joints to open out due to slippage of the stones.



Cramped joint

6.Plugged Joint

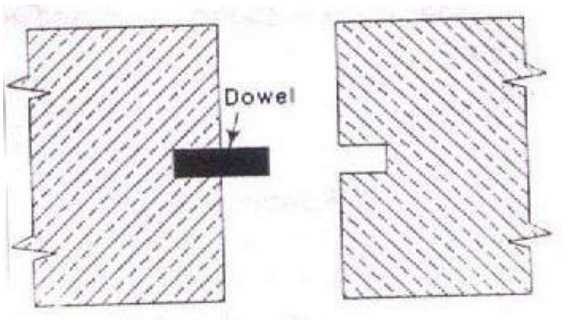
This is an alternative to cramped joints. It consists of making plug holes of dovetail shape in the sides of adjacent stones. After placing the adjacent stones, a common space for plug is formed which is filled with molten lead. Sometimes, rich cement grout is used in the place of molten lead.



Plugged joint

7.Dowelled Joint

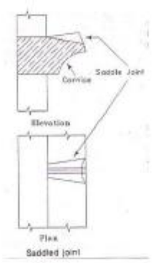
This is a simple type of joint used to ensure stability of the adjacent stones against displacement or sliding. The joint is formed by cutting rectangular holes in each stone and inserting dowels of hard stone, gun metal, brass, or copper. These dowels are set in cement mortar.

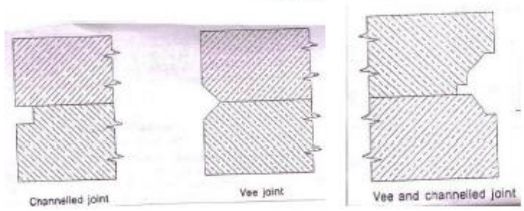


Dowelled joint

8.Rusticated Joint
This joint is used in those stones whose edges are sunk below the general level, such as for plinth, quoin, outer walls of lower storeys etc. Such a joint gives massive appearance to the structure.Various forms of rusticated joints.

9.Saddled or Water Joint
This type ofjoint is used in cornices and such others weathered surfaces, to divert the watermoving on the weathered surface away from the joint. The saddle is beveled backwards from the front edge as shown below





Wall:
Wall is one of the most essential components of a building. The primary function of a wall is to enclose or divide space of a building to make it more functional & useful. Walls provide privacy, afford security and give protection against heat, cold, sun & rain. Walls provide support to floors & roofs.
Definition: A wall may be defined as a vertical load bearing member, length of which exceeds four times the thickness.

Load Bearing and Partition 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 are basically divided into 2 types:
a) Load bearing walls b) Non-load bearing

Load bearing walls are those which are designed to carry super-imposed loads, in addition to their own weight. Non load bearing walls carry their own-load only. They generally serve as divide walls or partition walls. A partition wall is a thin internal wall which is constructed to divide the space within the building into rooms or areas.

Load Bearing walls: Design considerations
These are subjected to a variety of loads, namely live loads, dead loads, wind loads etc. load bearing walls are structurally efficient when the load is uniformly distributed and when the structure is so planned that eccentricity of loading on the wall is as small as possible. In order to ensure uniformity of loading, openings in walls should not be too large and bearings for lintels and bed blocks under beams should be liberal in size.

The thickness of load bearing wall should be sufficient at all points to ensure that the stresses due to the wall conditions of loading for which the structure is designed are within the limits prescribed for that particular type of wall. Thus, the actual thickness is computed as the average dimensions of masonry units together with the specified joint thickness.

Partition walls:

A partition wall, separating two adjoin rooms must often provide a barrier to the passage of sound from one to other. A partition wall should fulfill the following requirements:

1. The partition wall should be strong enough to carry its own load.

2. The partition wall should be strong enough to resist impact to which the of the building is likely to subject them.

3. The partition wall should have the capacity to support suitable decorative surface.

4. A partition wall should be stable and strong enough to support some wall.

5. A partition wall should be light.

6. A partition wall should be fire resistant.

Types of partition walls:

1. Brick 2. Clay block 3. Concrete 4. Glass 5. Asbestos sheet or GI sheet partitions 6. Timber partitions

Brick Partitions: Brick partitions are quite common since they are cheapest. They are of 3 types:

1. Plain brick partitions

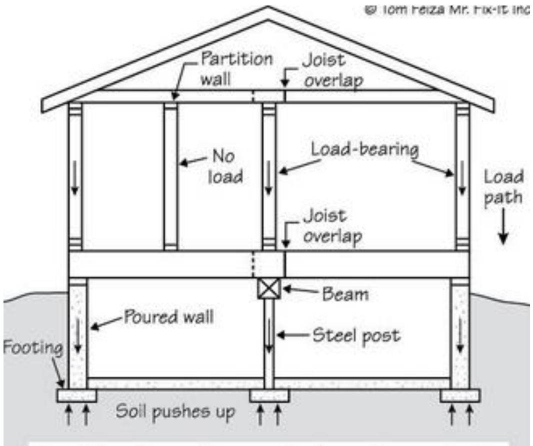
2. Reinforced brick partitions

3. Brick noggin partitions

1. Plain brick partitions: These are usually half brick thick. The bricks are laid as stretches, in cement mortar; vertical joints are staggered alternate blocks. The wall is plastered on both the sides.

2. Reinforced brick partitions: This is stronger than the ordinary brick partitions and is used when better longitudinal bond is required. The reinforcement consists of steel meshed strips called Exmet made from thin rolled steel plates which are cut and stretched by a machine to a diamond network.

3. **Brick Nogging partitions:** It consists of brickwork built up within the frame work of wooden members. The timber framework consists of vertical members called studs and horizontal members called as noggin pieces. The vertical members or studs are spaced at 4 to 6 times the brick length. The noggin pieces are placed into the studs at vertical interval of 60 to 90cm.

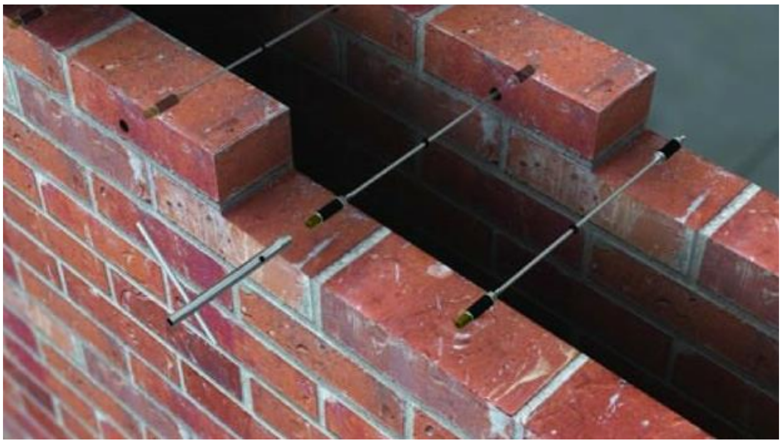


S. No.	*Load Bearing Walls*	*Partition Walls*
1.	They carry loads from roof, floor, self-weight etc.	They carry self-weight only.
2.	They are thick and hence occupy more floor area.	These walls are thin and hence occupy less floor area.
3.	As the material required is more, the construction cost is more.	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.

CAVITY WALL

A **cavity wall** or hollow wall is the one which consists of two separate walls called leader or skins with a cavity or gap in between them.
The two leaves of a cavity wall may be of equal thickness if it is a non load bearing.
The internal leaf may be thicker than the external leaf to meet the structural requirements.

Cavity walls are often constructed forgiving better thermal insulation to the building.
It also prevents the dampness to enter and act as sound insulation.
The inner and outer skins should not be less than 10cm each(half brick).



ADVANTAGES :-

There is no direct contact between the inner and outer leaves of the wall (except at wall ties). Hence moister (dampness) can not travel inside the building.

The cavity between the two leaves is full of air which is bad conductor of heat. hence transmission of heat from external face to the inside the room is very much reduced.
Cavity wall have about 25% greater insulating value than the solid walls.
Cavity walls also offer good insulation against sound.
The nuisance of efflorescence is also very much reduced.
They are cheap and economical .
Loads and foundation are reduced because of fission solid.

GENERAL FEATURES OF CAVITY WALLS:-
In case of brick cavity wall ,each is half brick thick .such wall is capable of taking load of two storyedof the domestic type , if heavier loads are to be supported ,the thickness of inner leaf can be increased .

The cavity wall should neither be less then 40mm more for more than 100mm in width .
The inner and outer skins are adequately tied together by means of the special walls ties placed in suitable arrangement , at the rate of at least ties to a square meter of wall area .
The ties are staggered .ties must be placed at 300mm vertical intervals at all angles and doors and windows jambs to increase stability .
Since the cavity separates the two leaves of the wall, to prevent moisture to enter , it is essential to provide a vertical damp proof course at window and door reveals .
The damp proof course should be flexible.

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

CONSTRUCTION DETAILS OF CAVITY WALL:-
A cavity wall is constructed of two leaves that is inner and outer with a hollow space in between them.
The width of cavity varies from 50mm to 100mm and it stands vertically. The outer is generally of ½ brick thickness and the inner wall may be of ½ of 1 brick thickness.

The two portions of the wall are connected by means of metal ties or specially prepared bonded bricks. The metal ties are generally of wrought iron or mild steel and they are coated with tar or galvanized so as to have protection against rust.
Where corrosion is heavy, the metal ties of copper or bronze may be adopted. The metal ties are placed at a horizontal distance of 900 mm and a vertical distance of 450 mm. The arrangement of ties is kept staggered .
The outer wall is generally constructed in stretcher bond , but it may be constructed in the Flemish bond or English garden-wall bond or Flemish garden-wall bond by using bats for headers.
As far as possible, there should be no intimate contact between two leaves of the cavity wall.

Construction at base:-

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

Construction at opening:-

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

Construction at top:-

It is necessary to take adequate steps at top to prevent the entry of dampness to the inside portion of the wall.
The cavity may be constructed up to the coping of the parapet wall or alternatively it may be closed at the bottom of the parapet wall by a damp proofing course.

In case of a pitched roof, the tops of two portions are connected by solid brickwork to support the roof truss and damp-proofing course is inserted immediately below this solid portion.

Ventilation:-

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

Shape and slope of ties:-

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

Dropping of mortar, bats etc.:-

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

Outcomes

Able to study the brick masonry work
Able to distinguish brick and stone masonry work
Will be knowing the types of brick and stone masonry

Future Study

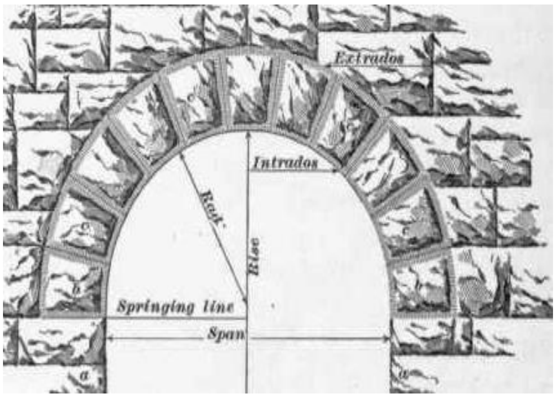
https://www.vssut.ac.in/lecture_notes/lecture1424085991.pdf1

Module -3

Lintels and Arches: Definition, function and classification of lintels, Balconies, chejja and canopy. Arches; Elements and Stability of an Arch.

Floors and roofs: Floors; Requirement of good floor, Components of ground floor, Selection of flooring material, Laying of Concrete, Mosaic, Marble, Granite, Tile flooring, Cladding of tiles. Roof;-Requirement of good roof, Types of roof, Elements of a pitched roof, Trussed roof, King post Truss, Queen Post Truss, Steel Truss, Different roofing materials, R.C.C. Roof. **8 Hours**

Both lintels as well as arches are structural members designed to support the loads of the portion of the wall situated above the openings and then transmit the load to the adjacent wall portions (jambs) over which these are supported.



Lintels are simple and easy to construct, while special centering/formwork is required for the construction of an arch.
Arches are preferred under following circumstances:
1) Where loads are heavy
2) Span is more
3) Strong abutments are available
4) Special architectural appearance is required.

LINTEL

A lintel is a horizontal member, which is fixed over the opening, viz., doors, windows recesses, etc. to support the structure over the opening. Lintels are thus a sort of rectangular beam which afford facilities for fixing the door and window frames, wherever they are used. Lintels may be made of several materials such as wood, stone, brick, reinforced brickwork, reinforced concrete or rolled steel sections embedded in cement concrete.
The width of lintel should be equal to the width of the wall. A proper bearing of lintel ends on supports is very essential. As a general rule, the bearing of the lintel at its ends should be either 10 cm or 4.0 cm for every 30 cm of span, whichever is greater. For very long spans, the bearing to the lintel ends should at least be equal to the depth of the lintel. Further, as a rule, the depth of the lintel can be adopted as $1/12^{th}$ of the span or 15 cm whichever is greater. The depth can be adjusted to

course heights of brick or stone. The lintels should be strong enough to resist failure due to the forces of compression, tension and shear.

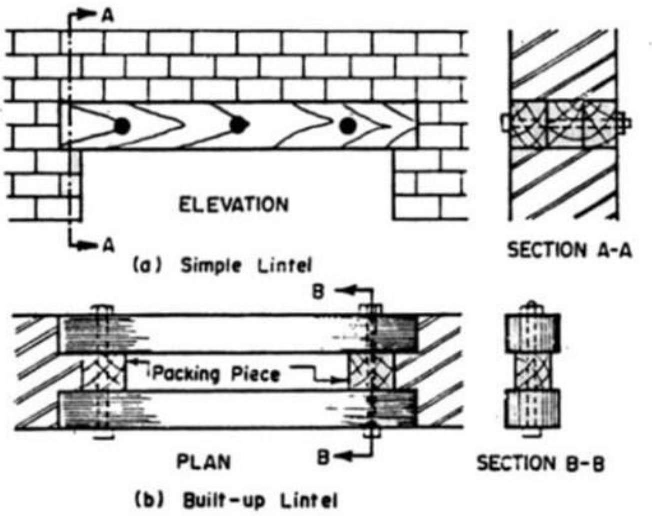
CLASSIFICATION OF LINTELS

Lintels are classified into the following types, according to the materials of their construction :

(a)Wooden lintels
(b)Stone lintels
(c)Brick lintels
(d)Reinforced concrete lintels
(e)Steel lintels

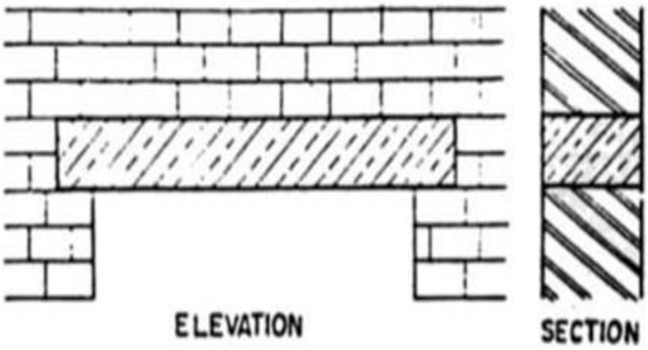
Wooden Lintels

Wooden lintels are oldest types of lintels. These lintels are not very common except in hilly areas. Wooden lintels are relatively costlier, structurally weak and vulnerable to fire. They are also liable to decay if not properly ventilated. Figure shows a wooden lintel provided over the full width of the wall, by jointing together three wooden pieces with the help of steel bolts. Sometimes, wooden lintels are strengthened by the provision of mild steel plates at their top and bottom, such lintels are called flitched lintels.



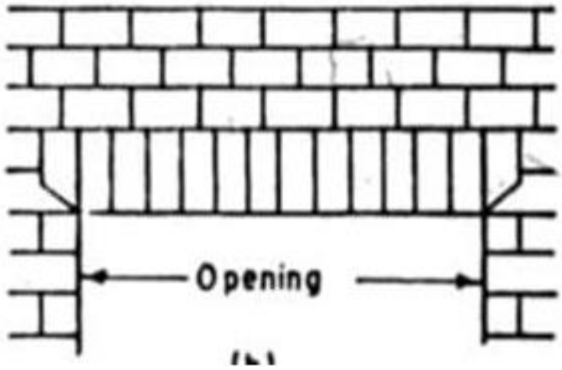
Stone Lintels

A stone lintel consists of a simple stone slab of greater thickness. Stone lintels can also be provided over openings in brick walls. Stone lintels are the mostly used at the places, where stone is abundantly available. Dressed stone lintels give good architectural appearance. Stone lintels are constructed of slabs of stones of sufficient length without flaws either in single piece or combination of more pieces. The thickness of the stone lintel should be 80 cm, or 4 cm for every 30 cm span, whichever is more. Stone is very weak in tension. Also, it cracks if subjected to vibratory loads. Hence stone lintels should be used with caution where shock waves are quite common.



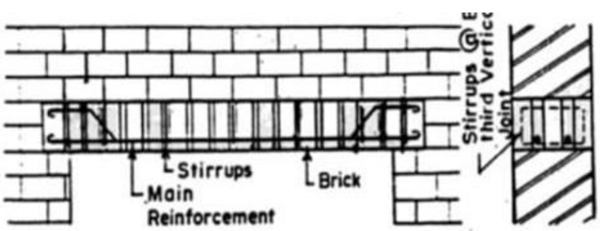
Brick Lintels

For openings lesser than 1 m and for lighter loads, lintels made from bricks are used. These are not very strong from structural point of view. A brick lintel consists of bricks placed on end or edge, as shown in Figure . The depth of brick lintel varies from 10 to 20 cm, depending upon the span. It is constructed over temporary wooden centering. The bricks with frogs are more suitable for the construction of lintel, since the frogs, when filled with mortar, form joggles which increase the shear resistance of end joints. Such lintel is known as joggled brick lintel.



Reinforced Brick Lintels

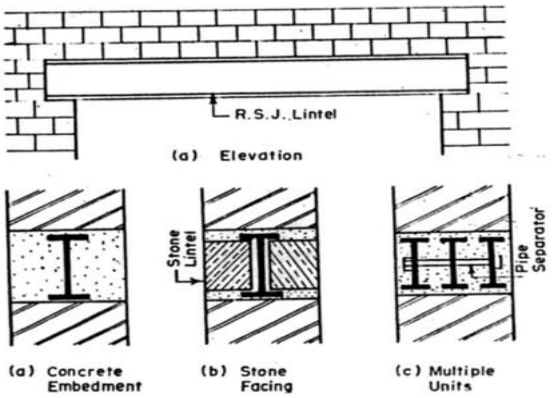
Heavy loadings and larger span length are the problems for brick lintels. These can be overcome by using the reinforcement bars. Reinforced brick lintels thus provide more support than the brick lintels. The depth of the reinforced brick lintels is equal to 10 cm. or multiple of 10 cm (or one brick thickness). The arrangement of the bricks should be such as that there is enough space in lengthwise between the adjacent bricks for the insertion of mild steel bars as reinforcement. After insertion bars, the remaining gap is filled with 1:3 cement mortar. 6 mm bars are used as vertical stirrups at every 3rd vertical joints. 8 to 10 mm bars placed at the bottom are used as main reinforcement.

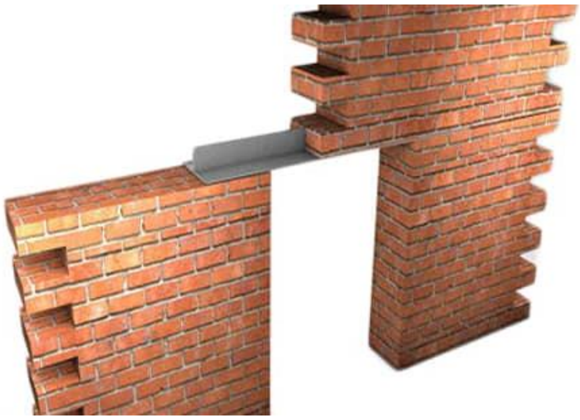


(a) LONGITUDINAL SECTION (b) CROSS SECTION

Steel Lintels

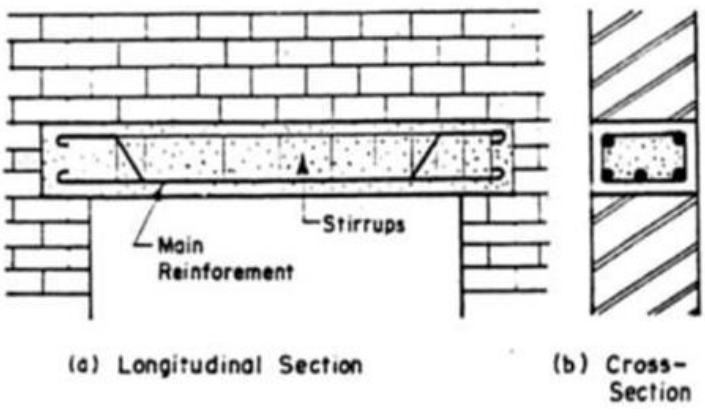
Where the opening is large and the super-imposed loads are heavy, lintels made from steel are used. This type of lintel consists of rolled steel joists or channel sections either used singly or in combination of two or three units. When a single joist is used, it is either embedded in concrete, or cladded with stone facing, so as to increase its width to match with the width of the wall. When more than one unit is placed side by side, they are kept in position by pipe separators





Reinforced Cement Concrete Lintels

Reinforced cement concrete lintels are the most commonly used these days. They have replaced all other types of lintels because of their strength, rigidity, fire resistance, economy and ease in construction. These can be used on any span. Its width is kept equal to the width of the wall. The depth of RCC lintel and the reinforcement depends upon the span and the magnitude of loading. Longitudinal reinforcement, consisting of mild steel bars are provided near the bottom of lintel to take up tensile stresses. Half these bars, are however cranked up near the ends. Shear stirrups are provided to resist transverse shear. A typical RCC lintel is shown in Figure.



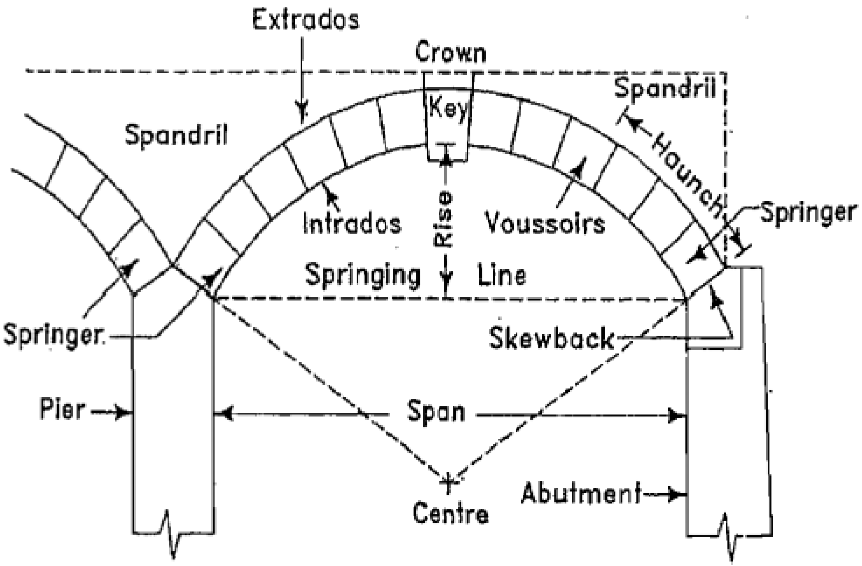
Arches

An arch is a structure constructed of wedge-shaped units (brick or stone) joined together with mortar and spanning an opening to support the weight of the wall above it along with super-imposed loads.

Due to wedge like form, the units support each other, the load tends to make them compact and enables them to transmit the pressure outwards to their support.

An arch is a structure constructed of wedge-shaped units (bricks or stone), jointed together with mortar and spanning an opening to support the weight of the wall above it along with other super-imposed loads. Due to wedge-like form, the units support each other, the load tends to make them compact and enables them to transmit the pressure downwards to their supports. In common with lintels, the function of an arch is to carry the weight of the structure above the opening. Lintels are simple and easy to construct, while special centering formwork is required for the construction of an arch. However, arches are constructed where loads are heavy, span is more, strong abutments are available and special architectural appearance is required.

Technical Terms



Abutment :This is the end support of an arch.
Pier :This is an intermediate support of an arcade.
Intrados :This is the inner curve of an arch.
Soffit :It is the inner surface of an arch. Sometimes, intrados and soffit are used synonymously.
Extrados :It is the upper or external curve of an arch.
Voussoirs :These are wedge-shaped or tapered units of bricks, stones or concrete works, forming the courses of an arch.
Crown :It is the highest part of extrados of an arch.
Key :It is the wedge-shaped unit fixed at the crown of the arch.
Spandril :This is a curved-triangular space formed between the extrados and the horizontal line through the crown.
Skew Back :This is the inclined or splayed surface on the abutment, which is so prepared to receive the arch and from which the arch springs.
Springing Points :These are the points from which the curve of the arch springs.
Springing Line :It is an imaginary line joining the springing and points of either end.
Pringer :It is the first voussoir at springing level; it is immediately adjacent to the skewback.
Arcade :It is a row of arches supporting a wall above and being supported by piers.

Haunch :It is the lower half portion of the arch between the crown and the skew-back or springer.
Ring :It is a circular course forming an arch. An arch may be made of one ring or more than one ring.
Impost :It is the projecting course at the upper part of a pier or abutment to stress the springing line.
Bed Joints :These are the joints between the voussoirs, which radiate from the centre.
Centre or Striking Point :This is the geometrical centre point from where the arcs forming the extrados, arch rings and intrados are described or struck.
Span :It is the clear horizontal distance between the supports or springing points.
Rise :It is the clear vertical distance between the springing line and the highest point on the intrados.
Depth or Height :It is the perpendicular distance between the intrados and extrados.
Thickness (or Breadth of Soffit) :This is the horizontal distance measured perpendicular to the front and back faces of an arch.

Stability of an arch

An arch transmits the superimposed load to the abutments or piers or side walls through the combined action of friction between the surfaces of voussoirs and the cohesion of mortar. Following are the four ways of failure o an arch:

1. Crushing of the masonry
2. Rotation of some joint about an edge
3. Sliding of voussoir.
4. Uneven settlement of abutment or pier.

1. Crushing of the masonry:

In this case, the compressive stress or thrust exceeds the safe crushing strength of the materials and the arch fails due to crushing of the masonry. The measures to avoid failure of arch due to this reason are as follows:

a) The material used for construction should be of adequate strength.

b) The size of voussoirs should be properly designed to bear the thrust transmitted through them.

c) If necessary the voussoirs of variable heights may be provided i,e less height near crown and max height at skewback.

2. Rotation of some joint about an edge:

To prevent the rotation of joint, the line of resistance should be kept within intrados and extrados. The line of thrust should also be made to cross the joint away from the edge so as to prevent the crushing of that edge. It should fall within the middle third portion of the arch height.

3. Sliding of voussoir:

To safeguard against the sliding of adjacent voussoirs due to transverse shear, the voussoir of greater height should be provided.

4. Uneven settlement of abutment or pier:

The secondary stresses in the arch are developed due to the uneven settlement of the supports of arch and to avoid such conditions, the following precautions should be taken

a) The arch should be symmetrical so that unequal settlements of the two abutments or abutment and pier are minimized.

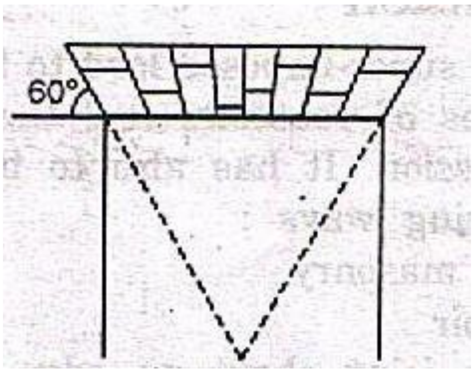
b) The supports of arch should be strong enough to take or resist the thrust as well as to bear all the loads transferred to them through the arc.

Classification of arches

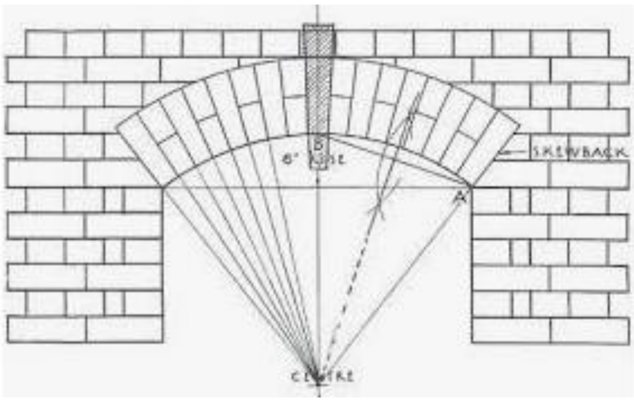
An arch can be classified to according to (i) shape (ii) number of centers (iii) materials and workmanship

Classification of arches according to shape

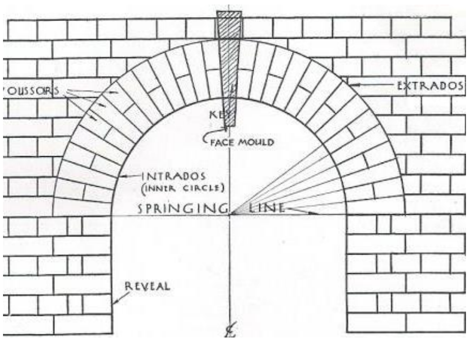
1.Flat arch: A flat arch has usually the angle formed by skewbacks as 600 with the horizontal, thus forming an equilateral triangle with intrados as the base. Flat arches are used only for light loads and spans up to 1.5m.



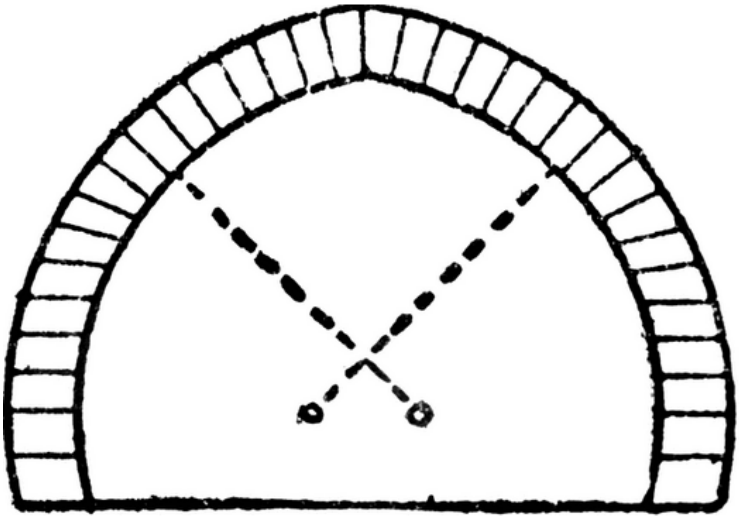
2.**Segmental arch**: The centre of the arch lies below the springing line. The thrust transferred to the abutment is in an inclined direction.



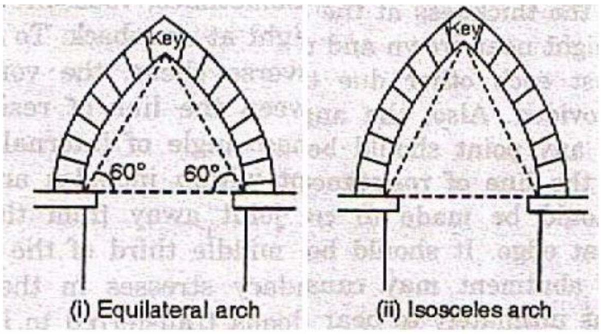
3.**Semi-circular arch**: The shape of the arch curve is that of a semi circle and the arch centre lies on the springing line. The thrust transferred to the abutments is perfectly vertical direction since the skewback is horizontal.

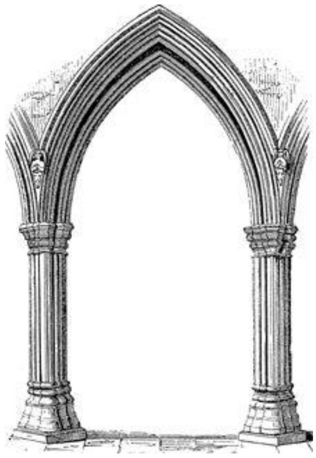


4.Horse shoe arch: Such type of arch is provided only for architectural consideration.



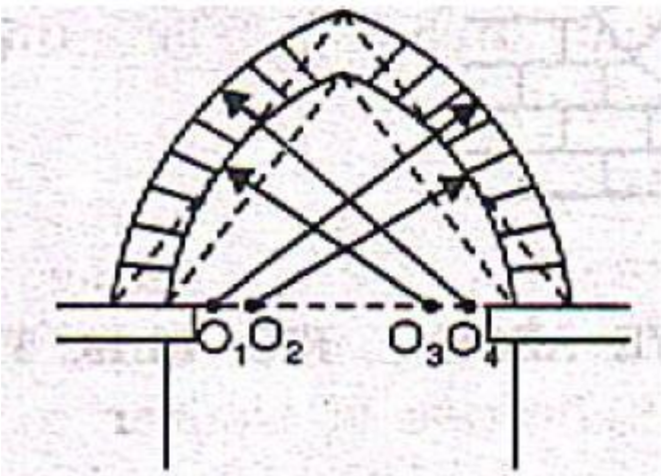
5.Pointed (Gothic) arch: It consists of two arcs of circles meeting at the apex of a triangle. The triangle formed may be equilateral or isosceles (Lancet).



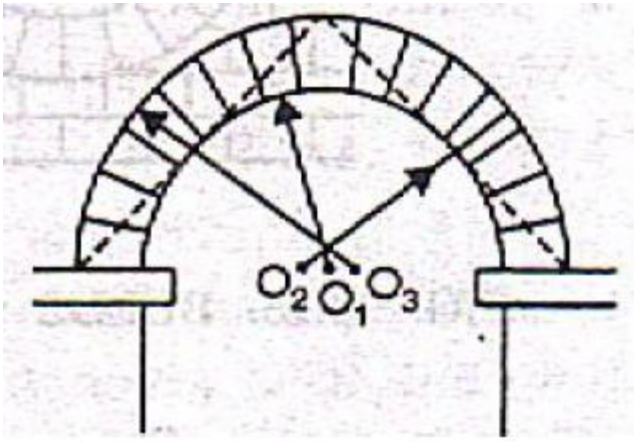


6.Venetian arch: This is another form of pointed arch which has deeper depth at crown than at springing. It has four centres, all located on the springing line.

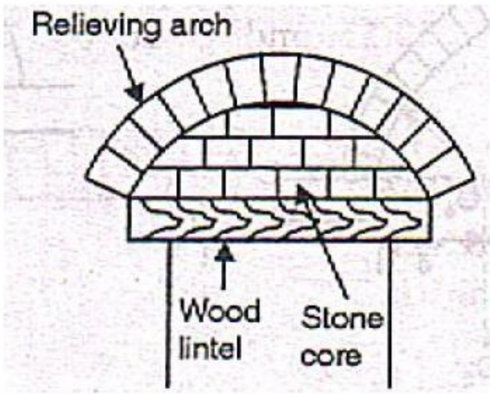
7.



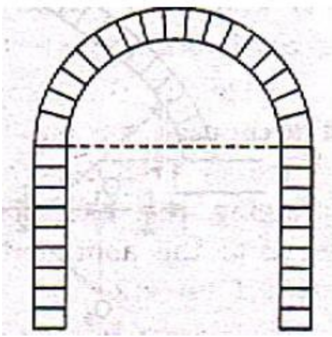
Florentine arch: This is similar to Venetian arch except that the intrados is a semi-circle. The arch has thus three centre all located on the springing line.



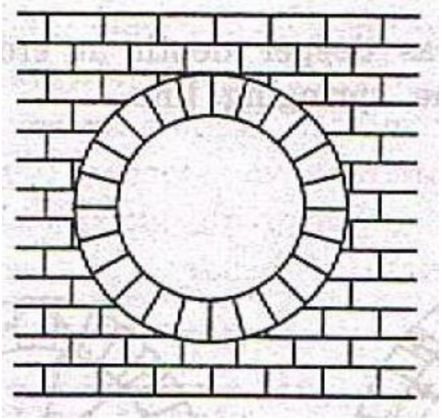
8.Relieving Arch: This arch is constructed either on a flat arch on a wooden lintel to provide greater strength. The ends of relieving arch should be carried sufficiently into the abutments. The relieving arch makes it possible to replace the decayed lintel later, without disturbing the stability of the structure.



9.Stilted arch: It consists of a semi-circular arch with two vertical portions at the springing. The centre of the arch lies horizontal line through the tops of the vertical portions.



10.Bull's eye arch: This type of arch has one centre only.



Classification of arches based on number of centres

(i) One-centred arches (Segmental, semi-circular, flat, horse-shoe, stilted arches)

(ii) Two-centered arches (Pointed, semi-elliptical,)

(iii) Three-centred arches (Elliptical arches, Florentine arches)

(v) Five-centred arches (semi-elliptical arches).

Classification of arches based on materials and workmanship

1.Stone arches

Stone arches: Depending upon workmanship, stone arches are of two types:

a. Rubble arches

b. ***Ashlars arches***

These arches can be constructed in rubble or ashlar masonry. Rubble masonry is weak and is used for inferior type of work. Rubble masonry stone arch spans about 1m or so. Ashlar masonry are constructed from the wedge shaped stones.


(ii) Brick arches:Can be constructed with ordinary or purposed made bricks. Ordinary bricks are not cut to shape of voussoirs & hence rough brick arches are formed. For getting the arch curve, joints are made wedge shaped with greater thickness at extrados and small thickness at intrados. Hence arch appearance is spoiled, thus rough brick arches are not suitable for exposed brick work. Purpose made bricks are special bricks of different sizes which are suitable for good quality arch work.


(iii) Concrete arches: Constructed with precast cement concrete blocks or monolithic concrete. Blocks are similar to stones & are prepared by casting cement concrete in specially prepared molds. Monolithic concrete arches are constructed from cast in site concrete and are suitable for big spans, hence they are employed in construction of culverts & bridges.


Classification based on workmanship

a) Rough arch: Constructed from ordinary uncut bricks, as the bricks are rectangular in shape, the mortar joints become wider at the extrados than at the intrados. IT is constructed where appearance is of secondary importance or when it is intended to plaster face of arch.
b.Axed or rough cut arch: Constructed from bricks which are cut to a wedge shape by means of an axe, according to class of work the bricks are rough axed or fine axed. Mortar joint thickness = 3 – 6 mm.
c.Gauged arch: Constructed from bricks which are finely cut by means of wire saw. Brick surface is finished with file. Mortar joint thickness = 1.5 – 0.75mm.

Sl.NO	Two hinged arches	Three hinged arches
1.	Statically indeterminate to first degree	Statically determinate
2.	Might develop temperature stresses.	Increase in temperature causes increases in central rise. No stresses
3.	Structurally more efficient	Easy to analyse. But, in construction, the central hinge may involve additional expenditure.
4.	Will develop stresses due to sinking of supports	Since this is determinate, no stresses due to support sinking

Comparison of Arches with Lintels:

Sl.No	Arches	Lintels
1	Curved in shape.	Horizontal in shape.
2.	Giving unnecessary rises over door and window openings.	There is no un necessary rises in lintels.
3.	Good for uniformly distributed loads and weak in point loads.	Strong in U.d.l. as well as point loads.
4.	Joints should be in radial shape.	Joints should be vertical
5.	Supported at the abutments and piers.	There is no supports like piers and abutments.
6.	Arches giving good appearance to the buildings.	Giving ordinary appearance to the buildings.

'Canopy' or 'Porch' means a projection over any entrance and if provided in setbacks, shall be either cantilevered or supported on columns

Classification of canopy:

- Straight slope canopy
- Gable canopy
- Concave canopy
- Convex canopy
- Dome canopy
- Elongated dome canopy
- Hip end canopy
- Rounded canopy
- Patio canopy
- Pyramid canopy

Sun Shade:Sun shade is a slab that is cast on the top of doors and windows. Sun shade protects doors and windows from sun and rain. Sun shade is cast monolithically with the lintel.

Balcony is platform projecting from the wall of a building either cantilevered or supported on columns and enclosed with a balustrade. Various types of balconies are as follows:

(i) Cantilevered balconies:

These are balconies constructed in a manner so that the balcony protrudes from the face of the building without any visible supports other than the fixing to the face of the building. This type of balcony, while possessing the most aesthetic end result, will require the most designing in and will impose larger point loads on the building. This type of balcony cannot be added on but must be predesigned.

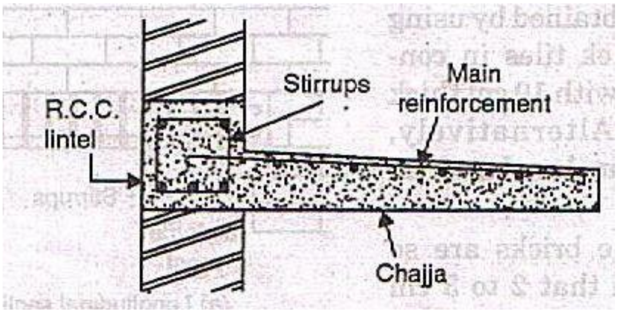
(ii) Stacked balconies or balconies on pillars

This is the most popular type of balcony structure, mainly because of the simplicity of implementation and the minimal load implications on the building. The balcony structure is supported using vertical pillars or posts. The weight of the balcony is supported by these pillars and transferred to the ground. The size of these pillars is an element of the size, weight and number of balconies stacked on top.

(iii) Hung balconies

Another form of supporting the balcony structure is using stainless steel cables that fix to the walls and hang the balcony or balconies. The balcony sits perpendicular to the building and a steel cable fixes to the edge of the balcony and at forty five degrees is connected via a large plate to the building. The fixing at the wall makes maximum use of the bolt strength as it is using fifty percent shear and fifty percent pull out forces. This is a very aesthetic solution but is not very common.

'Chajja' means a sloping or horizontal structure overhung usually provided for protection from sun and rain or for architectural considerations.



Purpose of chajja:

1. The purpose of chajja or sun shade is to prevent direct entry of sun light into the room to a certain extent.
2. Also, it acts as a barrier to direct entry of rain water into the room through the opening.
3. It also adds on to the aesthetic appeal of a building.
4. Usually it is provided at a height of around 7 ft from floor level.
5. If it is made of concrete, it is casted along with lintel monolithically.
6. An equal bearing of 9 inch-1ft has to be provided on both the sides of opening.
7. It can be either cast-in-situ or precast.

Floors :In order to sub-divide the portion between the plinth level or basement level and roof level, solid constructions are Carrie out. These constructions are known as floors and exposed top surface of floors are termed as floorings. Ground floors or basement floors, which directly rest on the ground, do not require the provision of a floor. But they are provided with suitable type of flooring.

Following are the requirements of the floor:

• Should be of adequate strength & stability.

• Should have adequate fire resistance.

• Should have sound insulation.

• Should be damp resistance.

• Should have thermal insulation.

Factors that govern the choice of flooring

1. Initial Cost. 2. Appearance calc 3. Cleanliness 4. Durability 5. Damp-resistance 6. Sound Insulation 7. Thermal Insulation: 8. Smoothness: 9. Hardness: 10. Maintenance

1.Initial Cost.

The cost of construction is very important in the selection of type of floor. A floor covering of marble, granite, special clay tiles, etc. is considered to be very expensive, whereas a flooring of cork, slate, vinyl tile, etc. is moderately expensive. The floors made of concrete and brick offer the cheapest type of floor construction. It should be ensured during the comparison of cost for different floors that the cost of both covering and sub-floor has been accounted for.

2. Appearance calc

Flooring should produce the desired color effect and architectural beauty in conformity with its use in the building. Generally, flooring of terrazzo, tiles, marble and cement mortar provides a good appearance whereas the asphalt covering gives an ugly appearance.

3. Cleanliness

A floor should be non-absorbent and capable of being easily and effectively cleaned. All joints in flooring should be such as to offer a watertight surface. Moreover, greasy and oily substances should neither spoil the appurtenance nor have a destroying effect on the flooring materials.

4. Durability

The flooring material should offer sufficient resistance to wear and tear, temperature, chemical action, etc. so as to provide long life to the floors. From the durability point of view, flooring of marble, terrazzo, tiles and concrete is considered to be of the best type. Flooring of other materials such as linoleum, rubber, cork, bricks, wood blocks, etc. can be used where heavy floor traffic is not anticipated.

5. Damp-resistance

All the floors, especially ground floors, should offer sufficient resistance against the dampness in buildings to ensure a healthy environment. Normally, floors of clay tiles, terrazzo, concrete bricks, etc. are preferred for use where the floors are subjected to dampness.

6. Sound Insulation

According to modern building concepts, a floor should neither create noise when used nor transmit noise. Sometimes, it is required that any movement on the top floors should not disturb the persons working on the other floors. Suitable flooring is provided which is somewhat noiseless when traveled over.

7. Thermal Insulation:

It should be possible for a building to maintain constant temperature or heat the inside the building irrespective of the temperature changes outside. Thermal insulation is needed to reduce the demand of heating in winter and refrigeration in summer. It is important in the case of wooden floors where heat losses are considerable and in solid floors with heating pipes or cables where the heat looses at the edges of the floor slab can be higher. Floors of word, corck, etc. are best suited for this purpose.

8. Smoothness:

The floor covering should be of superior type as to exhibit a smooth and even surface. However, at the same times, it should not be too slippery which will otherwise endanger safe movements over it, particularly by old people and children.

9. Hardness:

It is desirable to use good quality floor covering, which do not give rise to any form of indentation marks, imprints, etc. when used for either supporting the loads or moving the loads over them. Normally, the hard surfaces rendered by concrete, marble, stone, etc. do not show any impressions, whereas the coverings like asphalt, cork, plastics, etc. do form marks on the surfaces when use in traffic.

10. Maintenance

It is always desired that the maintenance cost should be as low as possible. Generally, a covering of tiles, marble, terrazzo or concrete requires less maintenance cost as compared to the floors of word blocks, cork, etc. it should, however, be noted that the repairing of a concrete surface is more difficult than the flooring of tiles, marbles. Etc.

A domestic ground floor should have three components.

Hard core. This is a suitable filling material to make up the topsoil removal and reduced level excavations.

Damp proof membrane. This is an impervious layer.

Concrete bed. This provides solid level surface to which finishes or screeds could be applied.

Selection Of Flooring Material

Following are the factors that affect the choice of an flooring materials:

Initial Cost: The cost of the material should be in conformity with the type of building, and its likely use. Floor coverings of marble, granite and so are very costly and may be used only for residential buildings.

Appearance: Covering should give pleasing appearance. It should produce a desired colour effect and architectural beauty. Floorings of terrazzo, mosaic, tiles and marble give good appearance.

Cleanliness: The flooring should be capable of being cleaned easily, and it should be non-absorbent. It should have effective resistance against absorption of oil, grease etc.

Durability: The flooring should have sufficient resistance to wear, temperature changes, disintegration with time and decay, so that long life is obtained. From this point of view, flooring of marble, terrazzo, tiles, concrete, mosaic etc. are considered to be of best type.

Damp resistance: Flooring should offer sufficient resistance against dampness, so that healthy environment is obtained in the building. Flooring of concrete, terrazzo, mosaic etc. are preferred for this purpose, while flooring of cork, wood rubber, linoleum, brick etc. are not suitable for damp conditions.

Sound Insulation: Flooring should insulate the noise. Also, it should not be such that noise is produced when users walk on it. Cork flooring, rubber flooring and timber flooring are good from this point of view.

Thermal Insulation: The flooring should offer reasonably good thermal insulation so that comfort is imparted to the residents of the building. Floor covering of wood, rubber, cork, P.V.C. tiles are better for this purpose.

Fire Resistance: This is more important for upper floors. Flooring material should offer sufficient fire resistant so that fire barriers are obtained between different levels of a building. Concrete, tiles, terrazzo , mosaic , marble have good fire resistance. Cork, asphalt, rubber and P.V.C. coverings, if used , should be laid on fire resistance base only.

Smoothness: The flooring material should be smooth, and should have even surface. However, it should not be slippery.

Hardness: It should be sufficiently hard so as to have resistance to indentation marks, imprints etc. likely to be caused by shifting of furniture, equipment etc.

Maintenance: The flooring material should require least maintenance. However, whenever repairs are required, it should be such that repairs can be done easily, with least possible expenditure. Hard coverings like tiles, marble, terrazzo, concrete etc. require less maintenance in comparison to materials like cork, wood etc.

Types of flooring

1) Granolithic flooring
2) Mosaic flooring
3) Ceramic flooring
4) Marble flooring
5) Polished granite flooring
6) Industrial flooring

Granolithic flooring: It is a finishing coat provided over the concrete surface to form a hard, resistant to abrasion and durable flooring. Granolithic concrete is composed of cement, sand and specially selected aggregates. The grading of aggregates is important.Coarse aggregates from basalt or limestone or quartzite are suitably graded from 13mm to I.S sieve No240. The concrete mix is usually of 1:1:2 or 1:1:3. In order to get monolithic construction, the granolithic concrete should be laid before the base concrete has set. The minimum thickness of finishing should be 13mm. After laying, the surface is tamped and floated with wooden floats and finally smoothened by means of steel trowel.

Mosaic flooring: Mosaic flooring is made of small pieces of broken tiles of china glazedor of cement or of marble arranged in different pattern. These pieces are cut to desired shapes and sizes. A concrete base is prepared as in the case of concrete flooring and over it 5 to 8cm thick lime-surkhi mortar is spread and leveled. On this, a 3mm thick cementing material, in the form of paste of two parts of slaked lime, one part of powdered marble and one part of puzzolana material is spread and is left to dry for about 4 hours. Thereafter, small pieces of broken tiles or marble pieces of different colours are arranged in definite patterns and hammered into the cementing layer. The surface is gently rolled rolled by a stone roller of 30cm dia and 40 to 60cm long, sprinkling water over the surface so that cementing material comes up through the joints and an even surface is obtained. The surface is allowed to dry for 1 day and is thereafter rubbed with a purmice stone fitted with a long wooden handle to get smooth and polish surface. The floor is allowed to dry for two weeks before use.

Ceramic flooring: Are characterized by their glazed or matt surface and are used for flooring in kitchens, supermarkets, swimming pool surrounds, and changing rooms, where a high degree of cleanliness is essential.

Marble flooring: It is a superior type of flooring, used in residential buildings, hospitals, temples etc. where extra cleanliness is required. Marble slabs are laid in different sizes usually in square or rectangular shapes. The base concrete is prepared in the same manner as that for concrete flooring. Over the base concrete, 20mm thick bedding mortar of either 1:4 cement: sand mix is spread under each slab. Marble is then laid over it, gently pressed with wooden mallet and leveled. Marble slab is then again lifted up fresh mortar is added to the hollows of the bedding mortar. The mortar is allowed to harden slightly, cement slurry is spread over it, the edges of already laid slabs are smeared with cement slurry paste and marble slab in question is placed in position. It is gently pushed with wooden mallet so that cement paste oozes out from the joints. The oozed out cement is cleaned with cloth. The paved area is properly cured for about a week.

Polished granite flooring: Of all the natural stones granite is by far the hardest and durable material. It is also resistant to staining, acid and alkaline chemicals. This is the reason it is the flooring material of choice. Its smooth polish brings a classically elegance. Granite tile is a perfect choice for hard surface applications where durability and low maintenance is important, such as high traffic floors and tile flooring for commercial applications.

Industrial flooring: Concrete surface become less effective where there are specific requirements of chemical resistance, hygiene, cleanliness, and resistance to high impact or abrasion. Industrial flooring system is based on liquid synthetic resin system in which curing takes place by polymerization of the resin components. Factories, food industry, hospitals, airports etc.. are some of examples where industrial flooring is required.

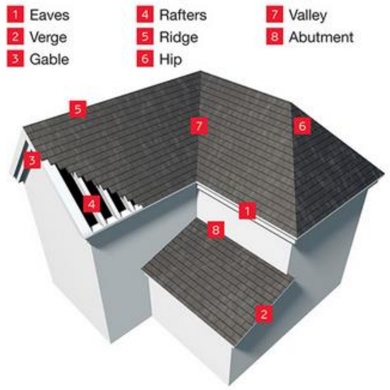
Types of Industrial flooring system:

- Heavy duty flooring system
- Medium to light traffic flooring system
- Coating system
- Art flooring

Advantages

- Strong permanent bond to the substrate
- Improved resistance to a wide spectrum of aggressive chemicals
- Impermeable to liquids
- Hygienic and easy cleaned surface
- Grater resistance to cracking
- Lower applied thickness
- - Rapid installation and curing with minimum disruption to normal operations

Roof;- A roof is defined as the uppermost part of a building which is constructed in the form of a frame work to given protection to the building against rain, heat, snow, wind etc. A roof basically consists of structural elements provided at the top of building for the support of roof coverings.



Requirements of a roof

1) It should be structurally stable and sound it should be capable of taking loads likely to come over it
2) It should be durable against the adverse effects of various elements such as rain, wind, snow, sun etc...
3) It should have water proofing and drainage arrangements
4) It should be fire resistant
5) It should provide adequate insulation against heat and sound

Factors that govern the selection of roof covering:

1) Shape and plan of the building
2) Climatic conditions
3) Type of construction materials available
4) Cost
5) Fire resistance
6) Insulation against heat and sound

Types of roofs-Methods of construction:

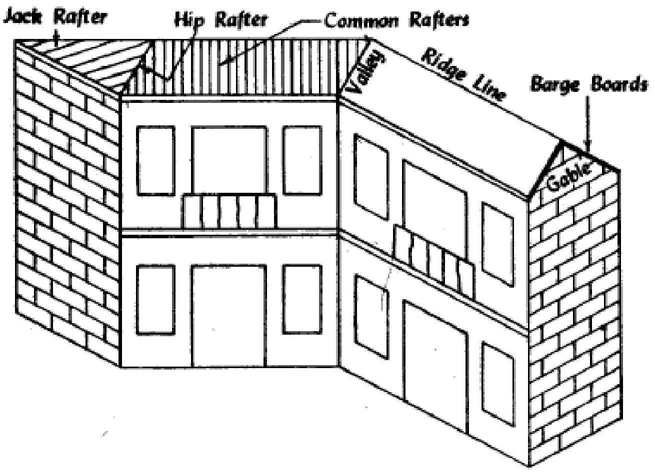
The roofs classified into the following three categories;

(i) Pitched roofs

(ii) Flat roofs

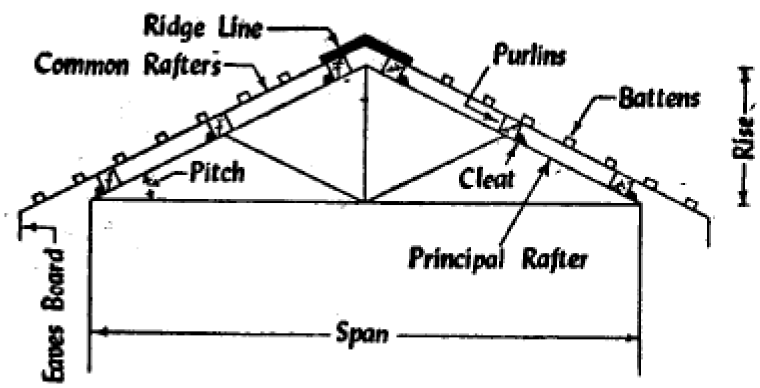
(iii) Curved roofs

Pitched roofs: A sloping roof is known as pitched roof as shown in the fig. The technical terms in connection with the pitched roof are given below:



(i) **Barge Boards:** Wooden planks or boards which are fixed on the gable end of the roof

(ii) **Battens**: Thin strips of wood which are fixed on rafters or ceiling to support the roof ceiling.
(iii) **Cleats**: Small blocks of wood which are fixed on truss to prevent the sliding of purlins.
(iv) **Dragon beam**: The diagonal piece of wood which is laid across the corner of the wall.
(v) **Eaves**: The lower edge of a roof which are resting upon or projecting beyond the supporting walls are known as eave as shown in the fig
(vi) **Gable**: The triangular upper part of a wall formed at the end of a pitched roof is known as gable.
(vii) **Hip**: The angle formed at the intersection of two roof slopes is known as hip.
(viii) **Pitch**: The inclination of sides of a roof to the horizontal plane is known as pitch, expressed in degrees or as a ratio of rise to span.
(ix) **Purlins**: The wooden pieces which are placed horizontally on principal rafters to carry the common rafters are known as purlins.
(x) **Rafters**: There are the pieces of timber which extend from the caves to the ridge
a) **Common rafters**: These are the intermediate rafters, which give support to the roof coverings a shown in the fig .
b) **Hip rafters**: Which provided at the junction of two roof slopes
c) **Jack rafters**: Any rafters, which is shorter than common rafters is known as Jack Rafters.
d) **Principal rafters**: These are the inclined members of a truss
(xi) **Ridge**: A wooden piece provided at the ridge line of a sloping roof is known as ridge or ridge board or ridge piece
(xii) **Span**: The horizontal distance between the internal faces of walls or supports is known as span or clear span.
(xiii) **Template**: A bidding block generally provided at the end of a truss. This block is known as template and it helps in spreading load over a large area. A template may be of wood or stone or R.C.C.
(xiv) **Verge**: The edge of a gable, running between the caves and ridge is known as a verge
(xv) **Valley**: When two roof surfaces meet together and form an internal angle, a valley is formed
(xvi) **Wall-plate**: These are long wooden members which are embedded on top of walls to receive the common rafters



Types of pitched roofs:
(i) Single roof
(ii) Double or purlin roof
(iii) Trussed roofs
(i) Single roof: In this type of roofs, common rafters are provided to each slope without any intermediate support.

The following are
the varieties of single roof.
a) Lean to roof
b) Couple roof
c) Couple close roof
d) Collar beam roof

a) **Lean to roof:** It is the simplest form of a pitched roof and it is known as pent roof or Aisle roof. In this type of roof, one wall is carried up sufficiently higher than the other to give necessary slope to the roof. A lean-to roof is generally used for sheds, out-houses attached to main buildings verandah etc. This is suitable for a maximum span of 2.40m as shown in fig 13.3.

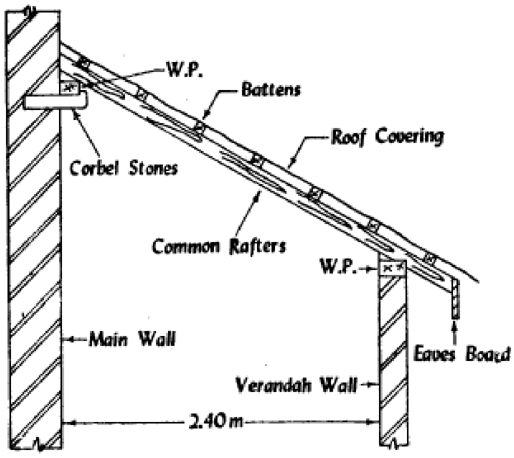


Fig 13.3 Lean-to roof

b) **Couple roof:** In this type of roof the common rafters slope upwards from the opposite walls and they meet on a ridge piece in the middle as shown in the fig 13.4. A couple roof is suitable for spans upto about 3.6m.

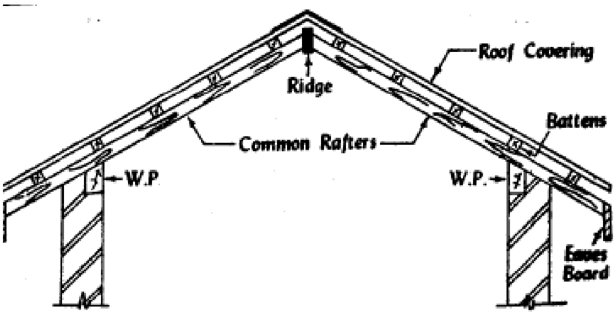


Fig 13.4 Couple roof

c) **Couple close roof**: This roof is just similar to couple roof except that the legs of the common rafters are connected by a tie beam as shown in the fig 13.5. The tie beam prevents the tendency of rafters to spread out and thus danger of overturning of the walls is avoided. This roof can be adopted economically upto the span of 4.2m.

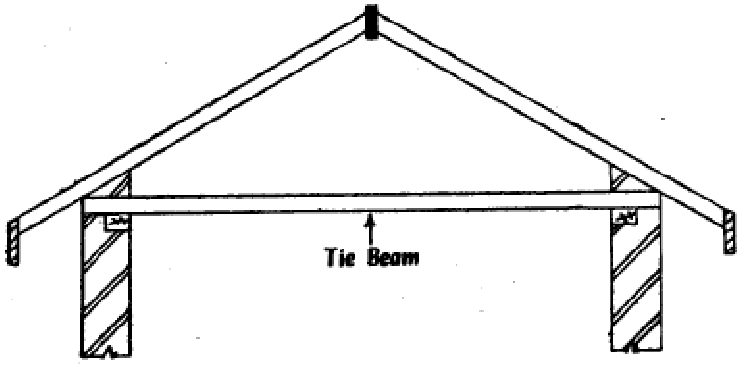


Fig 13.5 Couple close roof

d) **Collar beam roof:** The tie beam is raised and placed at a higher level as shown in fig 13.6 known as collar or collar beam. This beam roof is adopted to economise the space and to increase the height of a room. This roof can be adopted upto a maximum span of 4.8m.

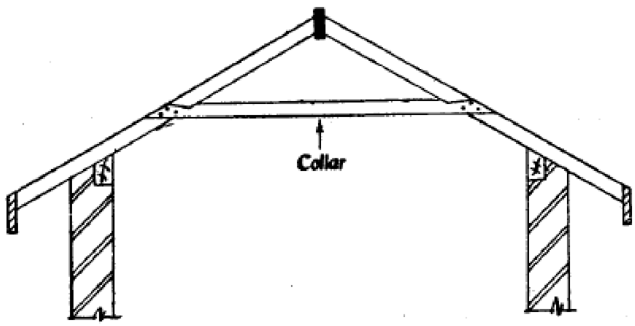


Fig 13.6 Collar beam roof

(i) **Double or purlin roofs:** When the span exceeds 2.4m, the necessary size for the rafters becomes uneconomical. Hence in order to reduce the size of rafters, intermediate supports called purlins are introduced under the rafters as shown in fig 13.7. This roof can be adopted economically upto 4.8m.

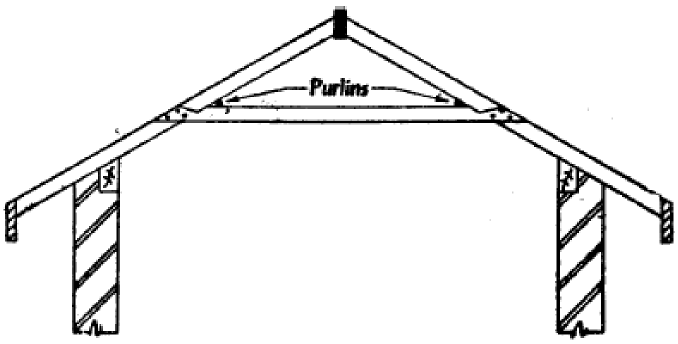


Fig 13.7 Double or Purlin roof

Trussed roofs: When the span exceeds 4.8m and when there are no inside supporting walls or partitions for purlins, framed structure known as trusses are on the roof, position of cross walls, span and material of the truss. The spacing is 3m for wooden trusses. Trusses carry the ridge piece and purlins on which the common rafters rest. Some of the usual forms of roof truss are given below.

a) King-post truss
b) Queen post truss
c) Mansard truss
d) Truncated truss
e) Bel-fast truss
f) Steel trusses
g) Composite trusses

a) **King post truss:** In this type of truss, the central post known as king-post forms support for the tie beam. The inclined members, known as structs, prevents the principal rafters from bending in the middle. A king-post truss suitable for roofs of span varying from 5 to 8 m as shown in fig 13.8.

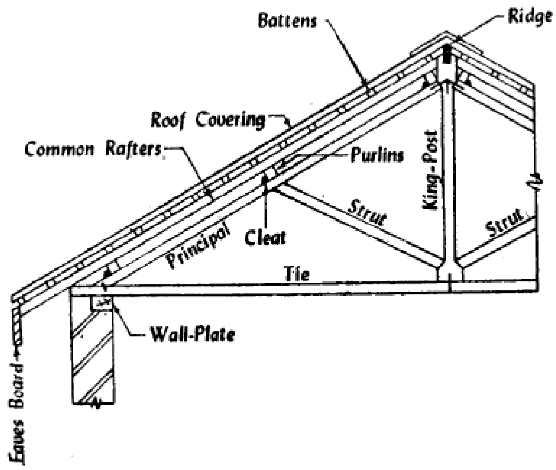


Fig 13.8 King post truss roof

b) **Queen post truss:** This truss is differ from a king-post truss in having two vertical members known as queen posts. The upper ends of the queen posts are kept in position by means of a horizontal member known as straining beam. Additional purlins are supported on the queen posts. A queen post truss is suitable for roof spans varying 8 to 12 m as shown in fig 13.9.

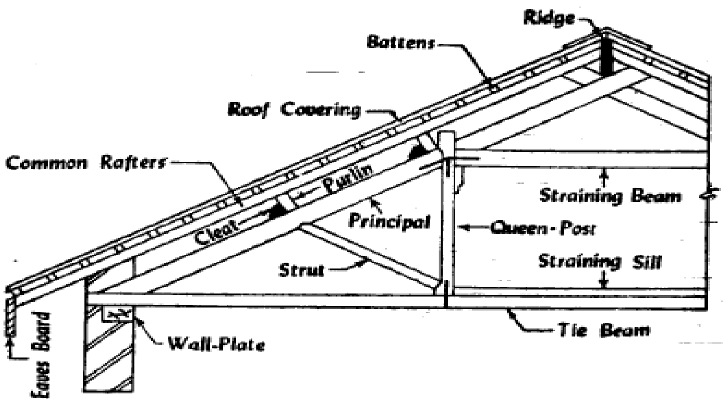


fig 13.9 Queen post truss

Flat roofs

A roof laid at angle of less than 100 to the horizontal is known as flat roof. Flat roofs may be of reinforced concrete, reinforced brick work, precast concrete, flag stones etc...Efficient water-proofing and roof drainage is an important requirement of a flat roof. Although flat roofs are comparatively expensive yet keeping in view of their numerous advantages, they are commonly constructed these days.

Advantages

1) Construction and maintenance is easier
2) They can be easily made fire proof
3) They avoid enclosure of the triangular space
4) They have better insulating properties
5) They are more suitable against high winds
6) Do not require false ceiling
7) Require lesser area of roofing material
8) Suitable for multi-storey buildings

Disadvantages

1) Span of the flat roof is restricted unless intermediate columns are introduced
2) The self weight of the slab is very high
3) Unsuitable at places of heavy rainfall or snow fall or hilly areas
4) The initial cost is high
5) Progress of construction is slower than pitched roof
6) The leak in flat is difficult to trace.

- **Pitched roofs:**
  - Pitched roofs are those which have the decks or surface with considerable slope for covering the building structure.
  - In pitched roofs, the slope of roof may vary from 1:1 or 1:3. in areas of heavy snowfall steeper slopes of 1:1.5 or 1:1 are provided to reduce the incidence of snow load on the roof.

- **Advantages :**

1. These are the cheapest types of roof.
2. Pitched roofs are ideally suited for hill area.
3. These are suitable for building in coastal areas.
4. Self weight of pitched roof is less as compared to flat roof.
5. Construction is faster.

- **Disadvantages:**

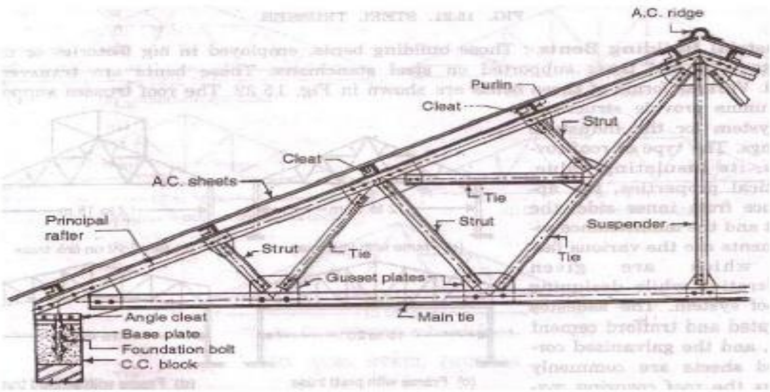
1. These roofs cannot be used as terrace.
2. Upper floors cannot be constructed over pitched roof.
3. It is not fire proof.
4. It has no insulating properties.
5. It is not stable against high wind velocity.
6. Construction is difficult.

Steel Roof Truss

Steel trusses are more common due to the following advantages:

1) Economical
2) Easy to fabricate
3) Fire-proof
4) More rigid
5) Permanent

When span exceeds 10m, timber trusses become heavy and uneconomical. Steel trusses are more economical for larger spans. Steel trusses are fabricated from rolled steel structural members such as channels, angles, T-sections and plates. Most of the roof trusses are fabricated from angle sections because they can resist effectively both tension as well as compression.



Weather proof course for RCC Roof

All RCC roofs should be made water proof by employing any one of the following four methods.

(i) *Finishing*: of flat roof is carried out in cement mortar (1:4)

(ii) *Bedding concrete and flooring*: The surface of RCC slab is kept rough and on this surface, a layer of concrete is laid (either brickbat lime concrete, 1:6:12 or brickbat cement concrete, 1:5:10). The thickness of concrete layer is about 100mm.

(iii) *Mastic Asphalt and jute cloth*: A layer of hot mastic asphalt is laid on the surface and a jute cloth is spread over this layer. Then one more layer of mastic asphalt is applied so that jute cloth is sand-witched between two layers of mastic asphalt. The sand is then sprinkled over the entire surface of roof

(iv) *Water proofing compounds*: like Pudlo, Impermo are added to cement during construction to prevent seepage, leakage and damp caused by the capillary absorption of the moisture in cement, mortar and concrete. The quantity of water proofing compound to be added is about 2%.

Different roofing materials

1. Solar tiles

Advanced solar collectors integrate seamlessly into existing shingles, generating up to 1 kilowatt of energy per 100 square feet. They're particularly good for sunny roofs in homeowners' associations that forbid typical solar panels. While they may help offset energy costs with solar power, they also cost more than traditional solar options.

2. Asphalt shingles

Asphalt shingles are the most common roofing materials in America because they're effective in all environmental conditions. Quality varies widely, so ask whether they pass the ASTM D3161, Class F (110 mph) or ASTM D7158, Class H (150 mph) wind tests and the AC438 durability test. Upfront costs are low, but you should expect to replace the shingles after about 20 years. If you live in a hail prone area, consider impact resistant shingles which have a UL 2218 Class 4 rating. Impact resistant shingles may qualify for a discount on your homeowner's premium.

3. Metal roofing

Metal roofing comes in vertical panels or shingles resembling slate, tile and shake – and lasts about 60 years. Metal excels at sloughing off heavy snow and rain, won't burn and resists high winds. It is lightweight and can be installed over existing roofs. However, metal can be noisy during rainstorms, and may dent from hail. Average costs range between $5 and $12 per square foot, depending on type and style of metal – which is more than asphalt but less than concrete tiles. Corrosion also varies by material.

4. Stone-coated steel

Interlocking panels mimic slate, clay or shingles and resist damage caused by heavy rains (up to 8.8 inches per hour), winds of 120 miles per hour, uplifting, hail and freeze-thaw cycles. Consequently, they're an economical, effective choice for wet, windy regions or areas prone to wildfires. Some stone-coated steel roofs are warranted for the lifetime of the house.

5. Slate

Slate roofing lasts more than 100 years. It won't burn, is waterproof and resists mold and fungus. Slate is effective in wet climates but is expensive, heavy and may be easily broken when stepped on. Keep this in mind if you live in an area that experiences hail.

6. Rubber slate

Rubber slate looks natural and can be cut with a knife to fit intricate roofs like those found on Victorian homes. Rubber slate roofs can last 100 years but can be damaged by satellite dishes and walking – so may also be susceptible to damage by hail, similar to slate. Roofing professionals that are trained to install rubber slate may be hard to find.

7. Clay and concrete tiles

Clay and concrete roof tiles can withstand damage from tornadoes, hurricanes or winds up to 125 miles per hour and even earthquakes, according to "A Summary of Experimental Studies on Seismic Performance of Concrete and Clay Roofing Tiles" by the University of Southern California for the Tile Roofing Institute. They are good in warm, dry climates. They may require extra support to bear their weight, and they are likely to break when walked on.

8. Green roofs

Green roofs are covered with plants and can improve air quality, reduce water runoff and insulate homes to reduce urban heat islands. However, they need extra structural support, a vapor barrier, thermal insulation, waterproofing, drainage, water filtration, soil, compost and plants. Their estimated lifespan is 40 years.

9. Built-up roofing

This heavy roofing consists of layers of asphalt, tar or adhesive topped with an aggregate and is only for flat roofs. Tar and gravel roofs, also for flat roofs, are best for roof-top decks with heavy foot traffic. These roofs may become sticky in summer, and it is harder to shovel snow off of these roofs when compared to smooth surfaces. They can last 20 to 25 years.

Roof covering types:

1. Thatch covering


• This is a very light roof covering, but its combustible, absorbs moisture rapidly & easily liable to decay.

• Framework to support the thatch consists of round bamboo rafters spaced at 30cm apart & tied with split bamboos laid at right angles to the rafter.

• Used in rural areas because of its cheap and simple in construction.

2.Shingles

• Use of shingles is generally restricted to hilly areas where wood is easily available at low cost.

• Wooden shingles are cut from well-seasoned timber, are laid in similar manner as slates or tiles.

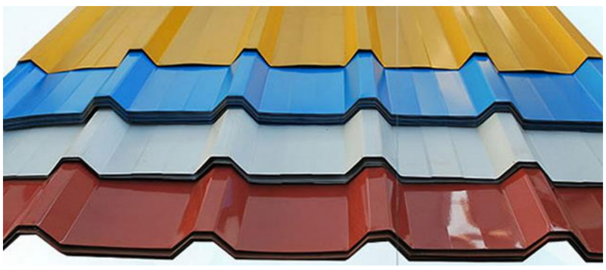
• Shingles length varies from 30 -38 cm 7 width varies from 6 – 25cm.

3. G I sheets

• GI sheets are prepared by pressing slat rough wrought iron plates between rollers with grooves or teeth & then galvanized with a coat of zinc.

• Available in lengths 1.2 – 3.6 m & width 0.6 – 0.9m

• They are costly and do not offer resistance to fire & sound

4. Slates

• These are fire resisting, lite and cool

• Not easily affected by weather

• About 8 slates are required for covering 1 m2 of roof area

• Generally available in grey, black and red colors.

5. Asbestos cement sheets

• Cement is mixed with about 15% of asbestos fibers & paste so formed is pressed under rollers with grooves or teeth. Thus sheets commonly known as the A.C sheets with a series of waves or corrugations formed.

• Used for factories, workshops, garages, big halls, etc.,

• Corrugations help to increase strength & rigidity & permit easy flow of rain water


6. Tiles

• They are named according to their shape & pattern & manufactured in similar manner as bricks.

• The commonly used tiles are flat pan tiles, half round country tiles, Mangalore tiles, quilon & other similar tiles.


Raw Materials for RCC Slab Roof

1. Cement
2. Coarse aggregate
3. Fine aggregate
4. M.S. Steel bar
5. Binding wire
6. Water
7. Shuttering materials such as wooden Ballies, Planks, and Iron Plates etc.

Advantages of RCC Slab

- Energy efficient.
- Does not catch fire.
- Provides solid and durable roofing.
- Very versatile and provides greater protection.
- Reduces costs of insurance and has resale value.

Outcome

Gives knowledge about Chejja, function and method of construction
Able to study the arches and lintels work Able to distinguish arches and lintels work
Able to know the types of balcony, arches and lintels
Able to study the arches
Able to distinguish arches
Able to know the types of arches.

Future study

http://nptel.ac.in/courses/107103002/9

http://nptel.ac.in/courses/105105109/pdf/m5l33.pdf

http://nptel.ac.in/courses/105105109/32

Text Books:

1. Sushil Kumar "Building Materials and construction", 20th edition, reprint 2015,Standard Publishers
2. Dr. B.C.Punmia, Ashok kumar Jain, Arun Kumar Jain, "Building Construction, Laxmi Publications (P) ltd., New Delhi.
3. Rangawala S. C. "Engineering Materials", Charter Publishing House, Anand, India.

Reference Books:

1. S.K.Duggal, "Building Materials", (Fourth Edition)New Age International (P) Limited, 2016 National Building Code(NBC) of India
2. P C Vergese, "Buliding Materials", PHI Learning Pvt. Ltd
3. Building Materials and Components, CBRI, 1990, India
4. Jagadish.K.S, "Alternative Building Materials Technology", New Age International, 2007.
5. M. S. Shetty, "Concrete Technology", S. Chand & Co. New Delhi.

Module -4

Doors, Windows and Ventilators: Location of doors and windows, technical terms, Materials for doors and windows, Paneled door, Flush door, Collapsible door, Rolling shutter, PVC Door, Paneled and glazed Window, Bay Window, French window, Ventilators. Sizes as per IS recommendations.

Stairs: Definitions, technical terms and types of stairs, Requirements of good stairs. Geometrical design of RCC doglegged and open-well stairs.

Formwork: Introduction to form work, scaffolding, shoring, under pinning. **8 Hours**

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

Location of Doors and Windows:
The following guidelines should be kept in view while deciding the location of doors and windows in a building.
1. Doors should as for as possible be located near the corner of a room, about zoom a way 20 cm from the corner.

2. The number of doors in a room should be kept minimum to achieve optimum utilization of space. Large number of doors besides causing obstruction, consume more area in circulation.

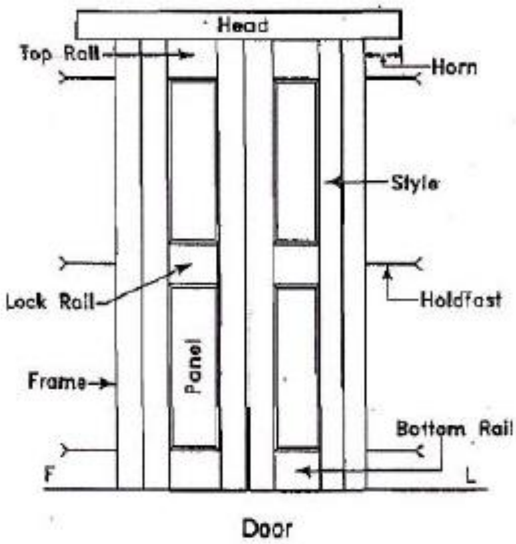
3. The window still should be placed at 75 to 100 cm above the floor lever.

4. Windows should be located opposite to each other wherever possible.

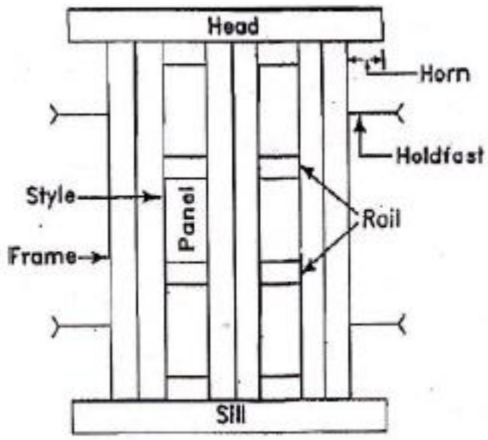
5. The size and number of windows should be sufficient to provide adequate light, ventilation and privacy in the room.

6. The shutters of windows in external walls should open outside.

Definition of technical terms:
Door frame or Window frame : Door frame or window frame is made up of two vertical members and which are secured by one or two cross Pieces at top and bottom.
Shutter : Shutters are generally made up of timber frame work with panel insets of glass, timber or plywood. Shutter frame work should have styles, top rail, bottom rail, locking rail and panel.
Style : The vertical members in both sides of shutter in style.
Top rail : The horizontal member in the top of shutter is termed as top rail.
Bottom rail: The horizontal member in the bottom of shutter is called as bottom rail.
Lock rail : The horizontal member in the shutter in between top rail and bottom rail to fit locks is called as lock rail.



Panel: The portion inside the shutter frame work in termed as panel.
Sash: The frame made for glass like panels is called as sash.
Mullion: The vertical member which separates the shutter in the middle is mullion.
Transom: The horizontal member which divides the shutter into two parts is called as transom.
Louver: The small strips of wood fixed inclined in the shutter is called as louver.



Putty: The mixture of lime and lined oil used for fixing the glass with shutters is termed as putty.

Types of Doors:
1. Ledged doors.
2. Ledged and braced doors.
3. Ledged and framed doors.
4. Ledged, braced and framed doors
5. Framed and paneled doors.
6. Glazed doors
7. Flush doors.
8. Louvered doors.

9. Collapsible doors.

10. Revolving doors.

11. Rolling doors.

12. Sliding doors.

1) **Framed and panelled door**: The door consists of timber frame work of stiles and rails which are grooved on the inside to receive one or more panels. The door may be of single or multi panelled. The panels can be of timber, plywood, block board or hard board. Timber panels are fixed within the grovves in the frame. Additional timber beading is also provided either one or both sides to improve elevation of door. This type of door is commonly used in all types of buildings

Salient features of panelled doors

(i) The stiles are continuous from bottom to top

(ii) Different rails, i.e top rail, bottom rail, lock rail and frieze rail are jointed to the stiles

(iii) Mullions or muntins, if any are jointed to the rails

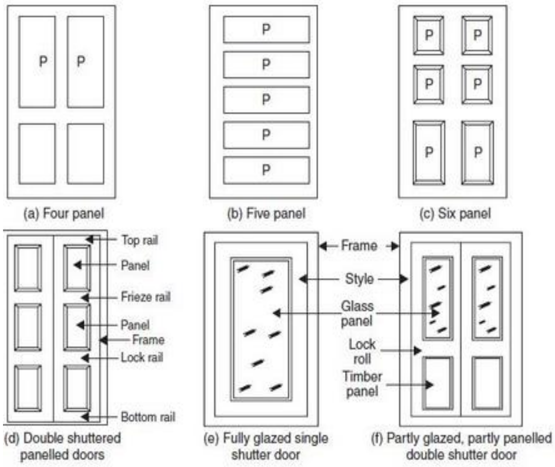
(iv) Bottom and lock rails are of bigger size than the top and frieze rails

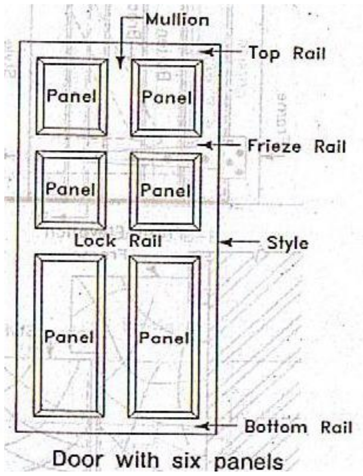
(v) The lock rail is so placed that its centre line is at height of 800mm from the bottom of the shutter

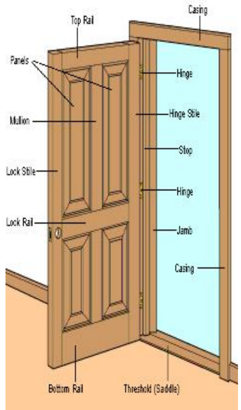
(vi) The minimum width and thickness of timber panels should be 150 x15mm

(vii) In case of plywood, particle board or hard board panels, there is no restriction of minimum of or maximum size of panel. However thickness should not be less than 12mm

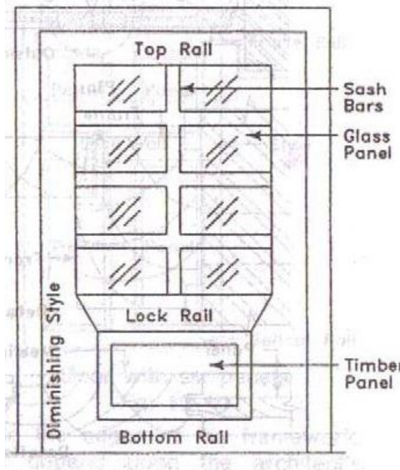
(viii) The width of stiles normally 10cm and the height of bottom and lock rails are 15cm each.







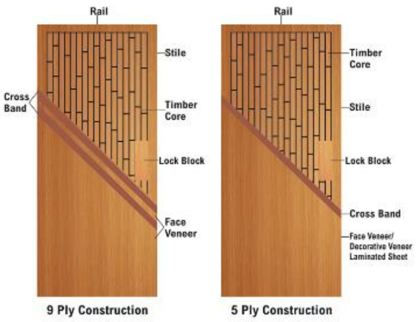
2) **Glazed (sash) door**: This type of doors are provided where additional light is required to be be admitted to the room through the door or visibility of the interior of the room is required from adjacent room. The doors may be either fully glazed or partly glazed and partly panelled (glazed:panel ration is kept at 2:1). The bottom one third height is panelled and top two-thirds height is glazed. The glass is received into rebates provided in the wooden sash bars and secured by “rails putty” or by “wooden beads”

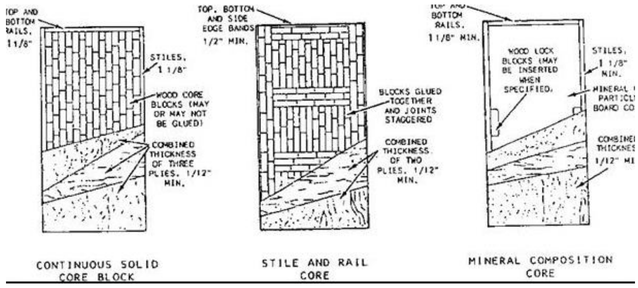


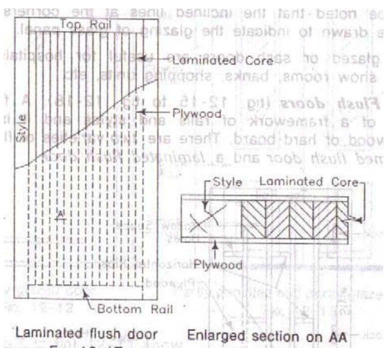
Door with diminishing styles

3) **Flush doors**: These doors consists of solid or semi-solid skeleton or core covered on both sides with plywood, face veneers etc. presenting flush and joint less surface which can be neatly polished. Fluhed doors are of two types:

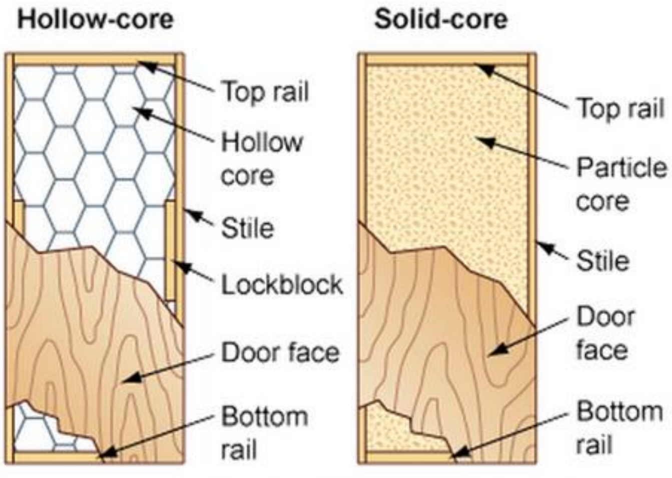
(a)* Solid core flush door or laminated core flush door*: Such a door consists of the wooden frame consisting of styles and top and bottom rails is used for holding the core. The core consists either of core strips of timber glued together under high pressure and faced on each side by plywood sheets or of block board. This type of doors are becoming increasingly popular due to its simplicity, cost and appearance.

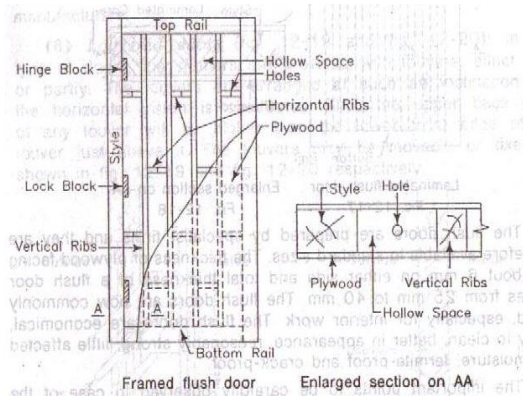




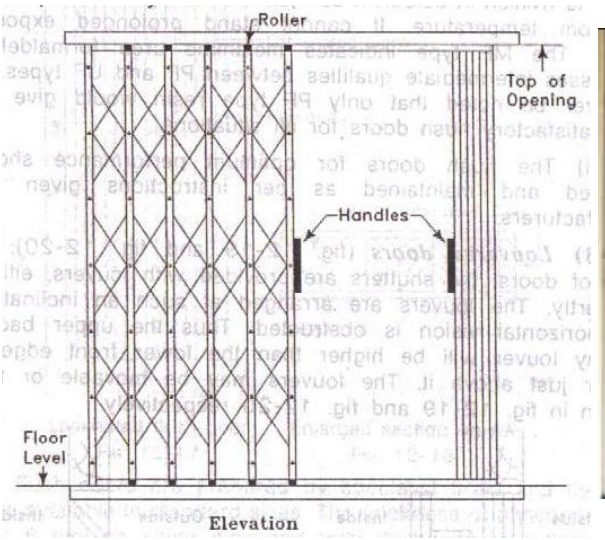


(b) **Hollow and cellular core flush door:** A hollow core flush door consists of frame made up of styles, top rail, bottom rail and minimum two intermediate rails. The inner space of the frame is provided with equally spaced battens creating voids between them. The shutter is formed by glueing under pressure, plywood sheets or face veneers to both faces of the core. This type of doors light in weight and cheap. But they are weak and practically become obsolete.

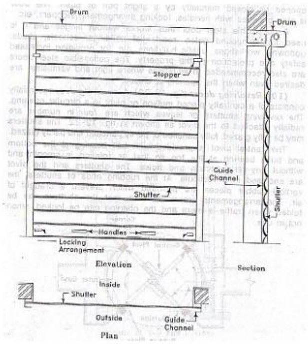




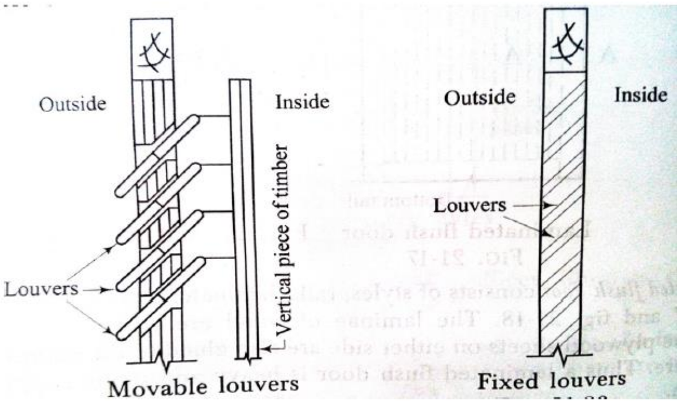
4) **Collapsible and Rolling shutters**: Collapsible doors are extensively used for shops, garrages, public buildings, godowns, etc.. and in situations where width of opening is large and provision of hinged shutter becomes difficult. These doors are also used from consideration of increased safety and protection to property. The door essentially consists of vertical double channels joined together with hollows channels on the inside and are braced with flat iron diagonal. The shutter opeartes between two T-iron rails. The door shutter slides over roller mounted at its bottom.



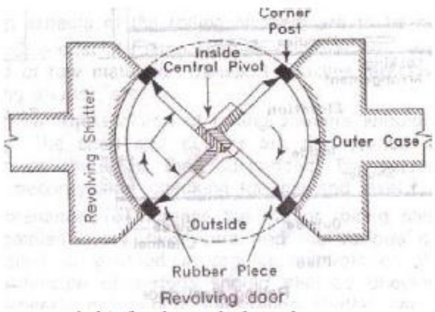
Rolling shutters are commonly used for shops, stores and godowns etc.. The door shutter acts like a steel curtain and provides adequate protection and safety. The shutter consists of thin steel slabs (laths or slabs) interlocked to each other and coiled upon specially designed pipe shaft (drum) mounted at the top of opening. The door shutter travels in two vertical steel guide channels installed at either end of the opening. The shutter can be of push pull type or mechanical type.



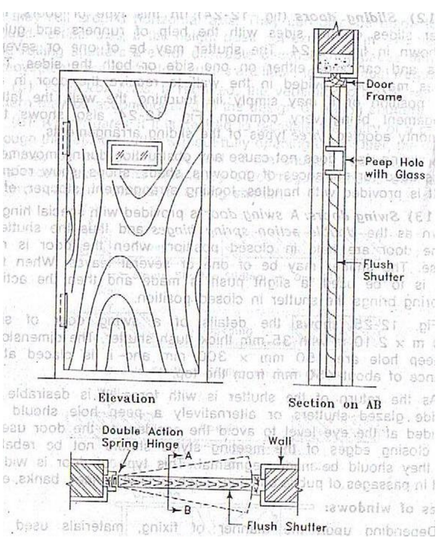
5) **Louvered doors**: permit free ventilation through them and at the same time maintain privacy of the room. However these doors harbour dust which is very difficult to clean. The doors may be of fully louvered or partly louvered and partly panelled. Louvers may be either fixed or movable. The louvers are arranged at such an inclination that vision is obstructed while they permit free passage of air.

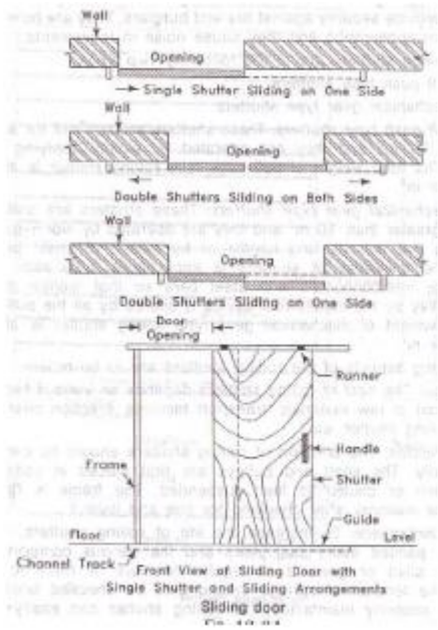


6) **Revolving, sliding and swing doors**: Revolving door provides entrance on one side and exit on the other simultaneously keeping the opening automatically closed when not in use. The door essentially consists of four leaves radially attached to a centrally placed mullion in a circular opening. The mullion or central member is provided with ball bearing at the bottom and bush bearing at the top so as to enable the door to revolve smoothly without producing jerks. Such doors are commonly used in hotels, banks, offices and other public buildings.



Sliding doors are suitable for shops, sheds, godowns, garrage etc.. and in places where the use of hinges for fixing the shutter is to be avoided. The door is provided with top and bottom guide rails or runners which in which the shutters slide. The guide rails run past the opening for a distance equal to the width of the shutter.





Swing doors are generally provided in passage of public buildings. The doors may have single or two shutters. The shutters are fixed with special hinges known as double action spring hinges which hold the shutter in closed position when not in use.

Plank and batten doors:

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

• Planks - Vertical boards that extend the full height of the door, and are placed side by side filling the door's width.

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

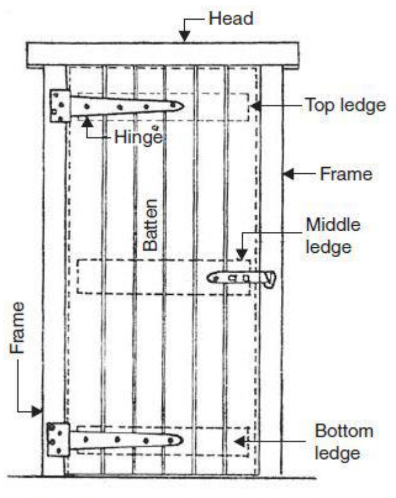
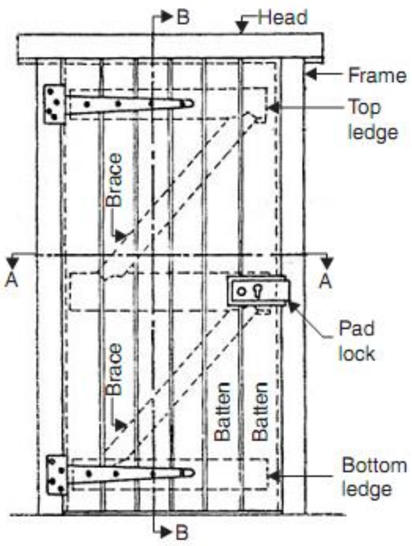


Fig. 8.21. Battened and ledged door

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

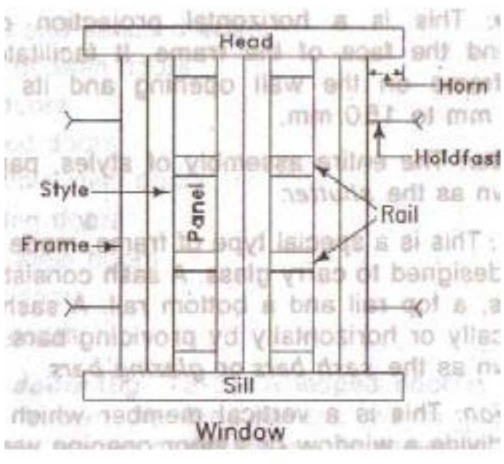


TYPES OF WINDOWS

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

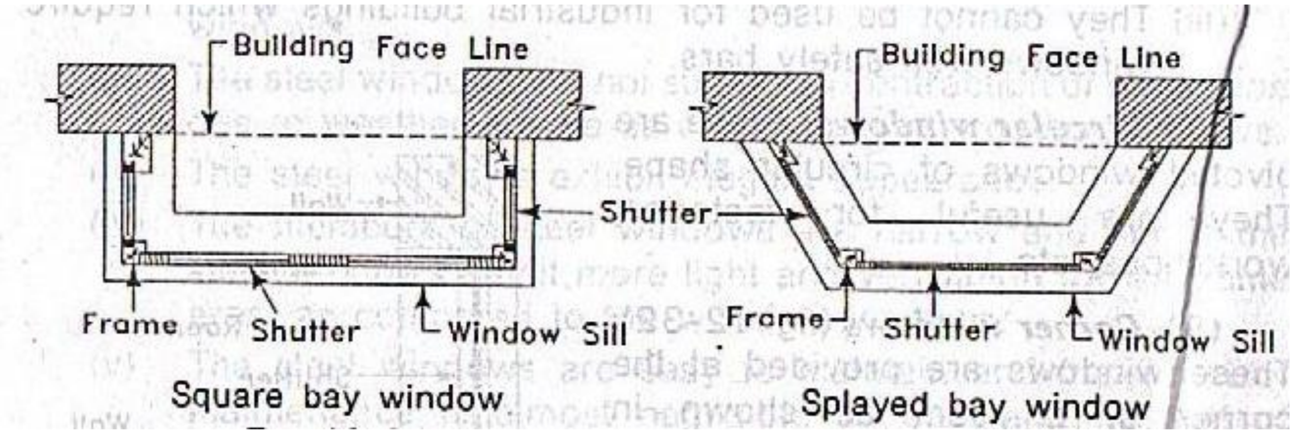
1. Casement windows
2. Sliding windows
3. Metal windows
4. Corner windows
5. Gable windows bay windows
6. Lantern or lantern lights
7. Skylights

1) Paneled (casement) window: These are the main common type of windows usually provided in builidngs. The shutters of the windows open like shutters of the doors. The window has a frame which is rebated to receive the shutters. The shutters consists of styles, top rails, bottom rails and intermediate rails, thus dividing it into panels. The panels may be either be glazed or partly galzed or unglazed

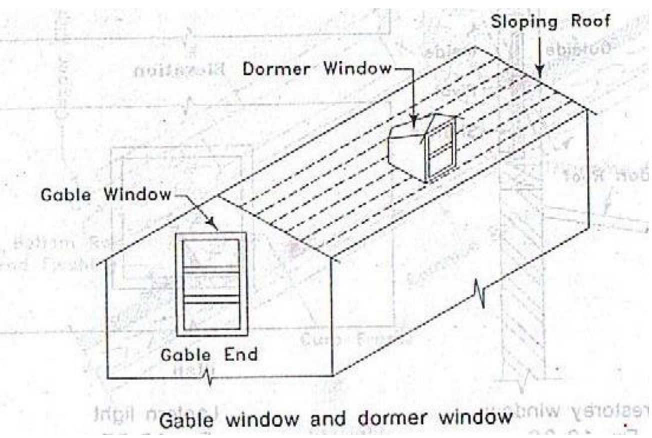


***2)* Glazed(sash) window:** A sash window is type of casement (paneled) window in which panels are fully glazed. The frame of each shutter consists of two vertical styles, top rail. Bottom rail. The space between the top and bottom rails is devided into small panles by means of small timber members placed horizontally and vertically. These timber members known as sash bars or glazing *bars* are rebated to receive glass panels. Glass panels are fixed to these sash bars by means of timber beads known as glazing beads. This type of windows may have central vertical member (mullion) and central horizontal member (transome), if the size of window is large.

3) Bay window: These windows project outside the external walls of a room. The projection of a bay windows may start from floor level or sill level. These windows admit more light, increases opening area provide ventilation and improve the appearance of the building.

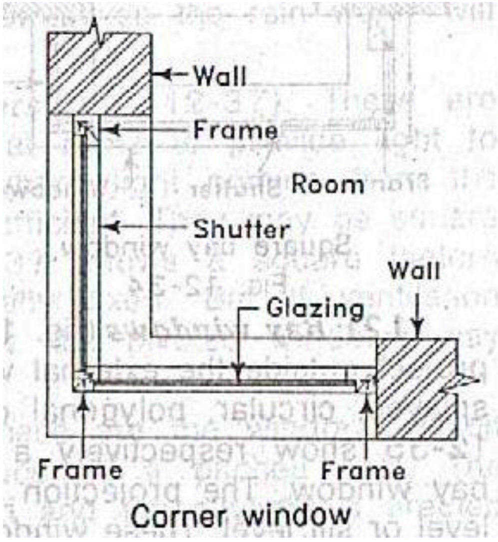


***4)* Dormer window**: is a vertical window provided on the sloping roof. It provides ventilation and lighting to the enclosed space below the roof and at the same time improve the appearance of the building.

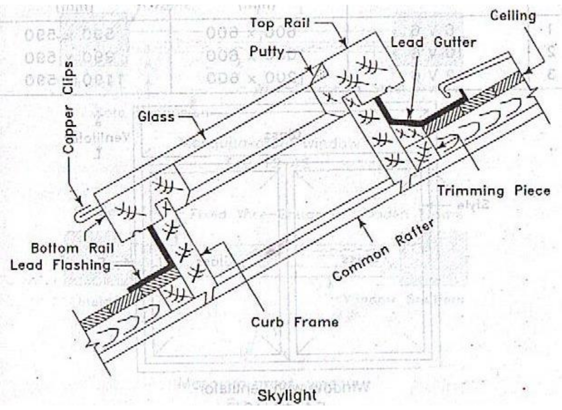


5) Louvered and corner window: In Louvered type of window, the stiles are grooved to receive a series of louvers. The louvers are set within the grooves in an inclined position so that they slope downward to the outside in order to run off the rain water and obstruct the horizontal vision at the same time.

Corner windows are provided at the corner of a room and thus they have two faces in perpendicular directions. Due to such situation, entry of light and air are obtained from two directions. A special lintel have to be cast at the corner.

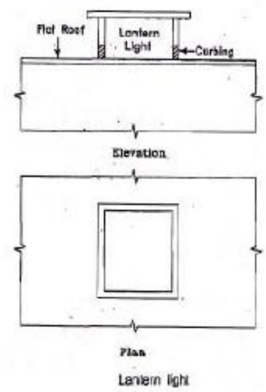


6) Sky lights: are provided on a sloping roof to admit light. The window projects above the top sloping surface. They run parallel to the sloping surface. The common rafters are suitably trimmed and skylight is erected on a curb frame. Louvered type of window, the stiles are grooved to receive a series of louvers. The louvers are set within the grooves in an inclined position so that they slope downward to the outside in order to run off the rain water and obstruct the horizontal vision at the same time.



7) Lantern Window

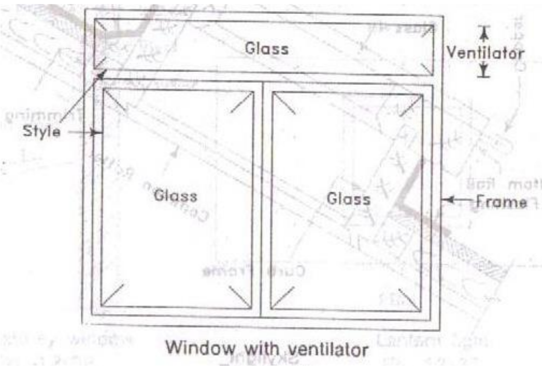
If the light from the windows on the walls is not enough, windows are provided on the roof also. These are called as lantern window. It should be square or rectangular in shape.

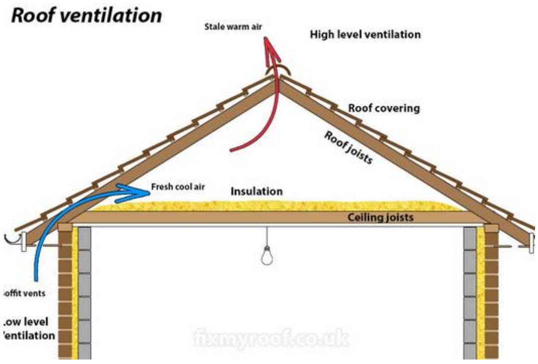


French window **:** a pair of casement windows that reaches to the floor, opens in the middle, and is placed in an exterior wall

Ventilators

Ventilators are small windows fixed at a greater height than the window, generally about 30 to 50 cm below the roof level. The ventilator has a frame shutter, generally glazed which is horizontally piovetd. The shutter can be opened or closed by means of two chords one attached to its top rail and the other to the bottom rail. Ventilators may also be provided in continuation of a window or a door at its top. Such a ventilator is know as a fan light.





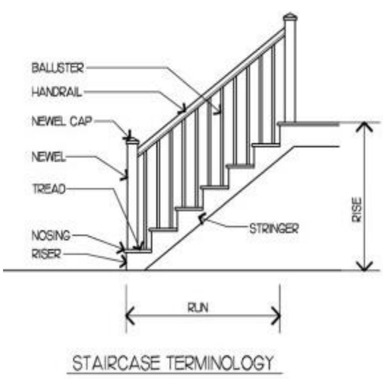
Stairs:

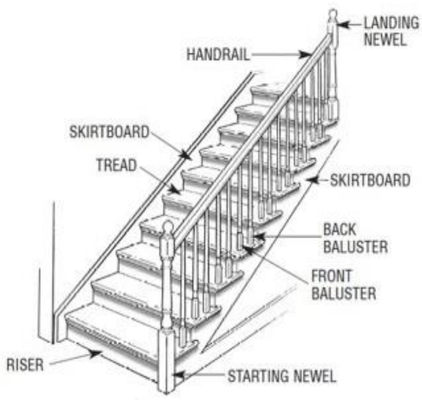
The means of communication between various floors is offered by various structures such as stairs, lifts, ramps, ladders, escalators.
STAIR: A stair is a series of steps arranged in a manner as to connect different floors of a building. Stairs are designed to provide an easy and quick access to different floors.
• A staircase is an enclosure which contains the complete stairway.
• In a residential house stairs may be provided near the entrance.
• In a public building, stairs must be from main entrance and located centrally.

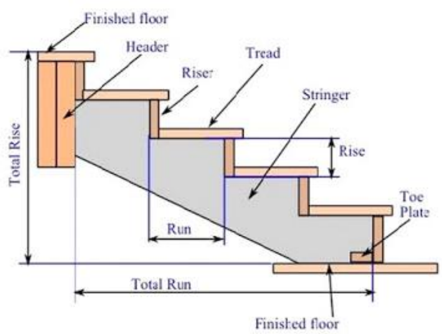
STAIRCASE: Room of a building where stair is located.
STAIRWAY: Space occupied by the stair.

TECHNICAL TERMS
1. BALUSTER: Vertical member which is fixed between stairway and horizontal to provide support to hand rail.
2. BALUSTRADE: Combined framework of baluster and hand rail.
3. STRING**:** Inclined member of a stair which supports ends of steps. They are of two types,
(i) cut/open string, (ii) closed/housed string.
• In open string, upper edge is cut away to receive the ends of steps.
• In closed string, the ends of steps are layed between straight and parallel edges of the string.
4. FLIGHT : Unbroken series of steps between the landings.
5. GOING: horizontal distance between faces of two consecutive risers.
6. HANDRAIL: inclined rail over the string. Generally it is moulded. It serves as a guard rail. It is provided at a convenient height so as to give grasp to hand during ascent and descent.

7. HEAD ROOM: vertical distance between nosings of one flight and the bottom of flight immediately above is called head room.
8. LANDING: horizontal platform between two flights of a stair. A landing facilitates change of direction and provides an opportunity to take rest.
9. NEWEL POST: vertical member placed at ends of flights to connect ends of string and hand rail.
10. NOSING: projection part of tread beyond face of riser.
11. LINE OF NOSING: imaginary line parallel to strings and tangential to nosings. The underface of hand rail should coincide with line of nosing.
12. PITCH: angle of inclination of stair with floor. Angle of inclination of line of nosing with horizontal.
13. RISE: vertical distance between two successive treads.
14. RISER: vertical member of the step, which is connected to treads.
15. RUN: length of a stair in a horizontal plane which includes length of landing.
16. SCOTIA: an additional finish provided to nosing to improve the elevation of the step which also provides strength to nosing.
17. SOFFIT: under surface of a stair. Generally it is covered with ceiling or finished with plaster.
18. STEP: combination of trade and riser. Different types are.
• Commode steps: it has curved riser and tread
• Dancing step: they don’t radiate from a common centre
• Flier: ordinary step of rectangular shape in plan
• Round ended step: similar to bullnose step except that its ends are sem-icircular in plan
• Splayed step: it has either one end/both ends splayed in plan
• Winder : this is a tapering step and is used to change the direction of a flight. The winders radiate from a common centre.
• Tread: horizontal upper portion of a step.
• Waist: thickness of structural slab in RCC stair
• Carriage: a rough timber supporting steps of wooden stairs







Components Of Stair

Requirements of a good stair

1) **Location:** It should be so located as to provide easy access to the occupants of the building. It should be so located that it is well lighted and ventilated directly from exterior

2) **Width of stair**: It should be wide enough to carry the user without much crowd and inconvenience. Width of the stair depends on its location and the type of building. In a domestic building, a 90 cm wide stair is sufficient and for public building 1.4m to 1.8m may be required

3) **Length of flight**: For the comfortable ascent of stairway the number of steps in a flight should be restricted to a maximum of 12 and a minimum of 3.

4) **Pitch of stair**: In general the pitch of stair should never exceed 400 and should not be flatter than 250

5) **Head room**: The clear distance between the tread and the soffit of the flight immediately above it should be a minimum of 2.14m.

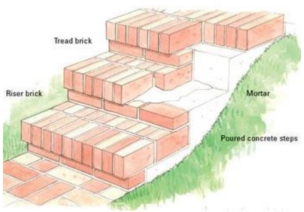
6) **Balustrade**: The open well stairs should be provided with balustrade so as to minimize the damage or accidents

7) **Step dimensions**: The rise and tread of each step in a stair should be of uniform dimension throughout so as to provide comfort to users (Going should be between 25-30cm and rise should be between 10-15cm). The width of the landing should not be less than the width of stair

8) **Materials of construction**: The stair should preferably constructed of materials which posses fire-resisting qualities.

Types of Stairs:

The stair of different materials here been given below.

1. Brick stairs. 2. Wooden stairs 3. Stone stairs 4. Steel stairs 5. Concrete stairs	3. Stone stairs 	5. Concrete stairs 
1. Brick stairs. 	2. Wooden stairs 	4. Steel stairs 

Wooden stair

As they are light in weight, mostly used for residential building.

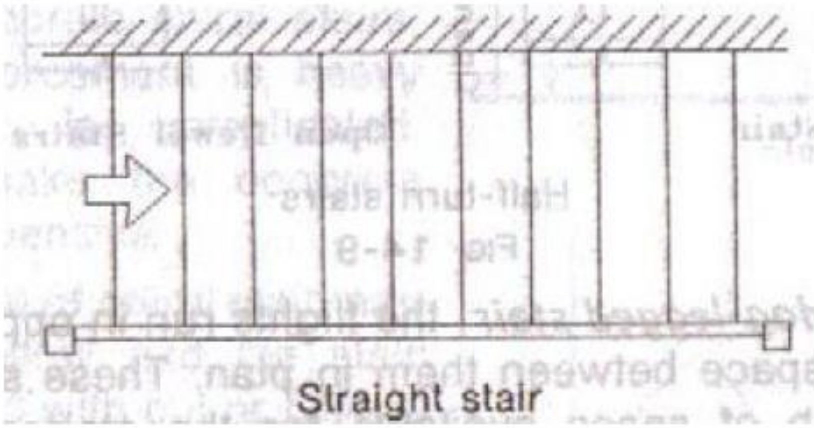
The main objection to this stair is that it is easily attacked by fire and thus, in fire, the occupants of upper floor can't escape.

If it is made from good timber like Teak, and thickness is about 45mm, it becomes sufficiently fire proof and allows enough time for occupants on upper floor to escape.

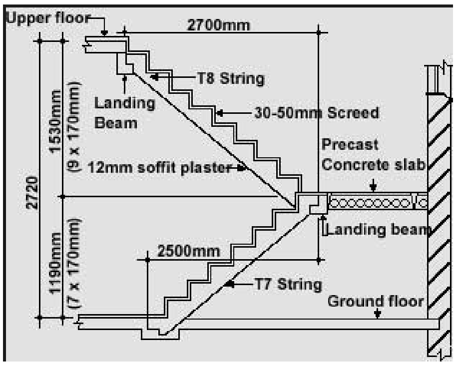
Factors to be considered here are,
The string supporting ends of wooden steps may be a cut string/closed string.
Scotia blocks may be provided to give additional finish to wooden steps.
Small triangular wooden blocks called glue blocks may be provided at inner angle formed between a trade and riser, to provide additional strength.
A metal strip may be provided on nosing of wooden step to increase its resistance against wear and tear.
The landing may be formed by providing wooden beams of suitable sizes.
Sometimes risers are omitted. trades are housed in strings and soffit is covered with wooden battens/metal sheets.
The timber used should be free from fungal decay, insect attack, or any defect. Edges may be finished smooth and excess light timber should not be used.

• Metal Stair
They are not frequently/commonly used stairs.
The external fireescape stairs are generally made of metal.
Common metals are CI, bronze, and mild steel.
Widely used in factories, workshop, and godowns.
Main features are,
Stringers are usually of channel section
Tread and riser of a step may be of one unit or may not be
Tread and risers are supported on angles, which are connected to stringers.
Risers may be totally omitted.
Spirals stairs of CI consists of CI newel fixed in center around which the CI steps are fixed.
For metal stairs metal balusters with pipe handrail are used.
• RCC Stair
Commonly used in all type of construction.
They resist better fire and wear than any other material and can be moulded to desired shape.
The step can be provided with suitable finishing material such as marble, terrazzo, tiles etc.
They can be easily maintained, strong, durable and pleasing in appearance.
They can be designed for greater widths and layer spans.
The steps may cast in situ/pre cast.
It is possible to pre cast a flight and place it in position by equipments.

Classification of stairs
(i) ***Straight stairs*****:** In this form of stair, all steps rise in same direction. If the ascending is steep, the straight flight may be broken at an intermediate landing. This type stair is usefull where the stair case is long and narrow and the possibility of any other form of stair may not be practically possible.

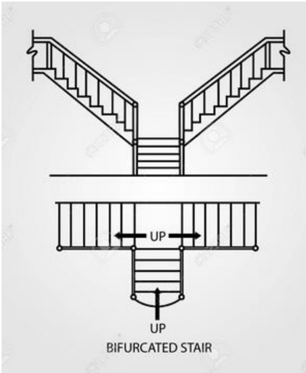


(ii) **Dog-legged stair**: The flights run in opposite direction and there is no space between them in plan. These stairs are useful where total width of space available for the staircase is equal to twice the width of space.



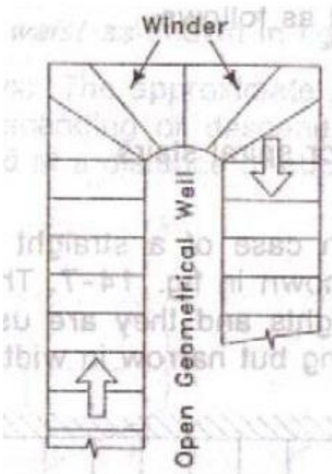
(iii) **Open-Newel stairs**: It consists of two or more straight flights arranged in such a manner that a clear space called a "well" occurs between the backward and forward flights.

(iv) ***Bifurcated stairs:*** In this type of stairs, the flights are so arranged that there is a wide flight at the start which is divided into narrow flights at the mid-landing. The two narrow flights start from either side of the mid-building.



(v) **Circular or helical or spiral stairs**: In this type of stairs. The steps radiate from the centre and they do not have either any landing or intermediate newel post. This type of stairs is commonly provided at the backside of the building.

(vi)Geometrical stairs: This is similar to the open-newel stair with the difference that open well between the forward and backward flight is curved. In this form of stairs, change of direction is obtained through winders.



Formwork

Cenetering, shuttering or formwork is a sort of temporary construction provided for laying cast-in-situ concrete to required shape.

Types of formwork

1) **Steel formwork**:

- Stronger, durable and longer life span
- Can be reused upto 120 times
- Installation and dismantling is easy
- Quality of exposed concrete wll be good and saves cost on plastering
- Steel formwork will not absorb moisture from concrete and chances of honeycombing are minimised
- Steel formwork will not shrink or distort
- Initial cost is high

2) **Timber formwork**

- Intitial cost is less and suitable for small projects
- Formwork can be reused upto 12 times
- Timber formwork should be neither too dry nor too wet and free from knots

3) **Plywood formwork**

- Formwork can be reused upto 25 times
- Gives smooth and plane surface and hence plastering can be eleminated
- Large size panels can be used thereby minimize the cost

Precautions to be taken while removing formwork

The formwork should be removed in the following order of sequence:

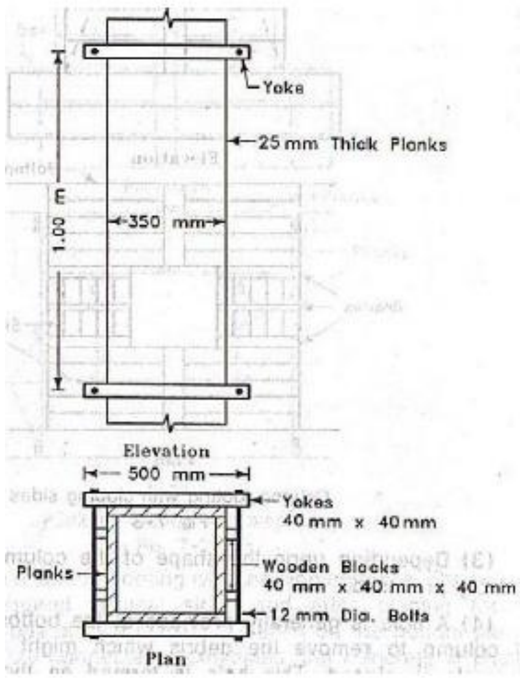
(i) Shuttering forming vertical faces of walls, beams and columns should be removed first

(ii) Shuttering forming soffit of slabs should be removed next

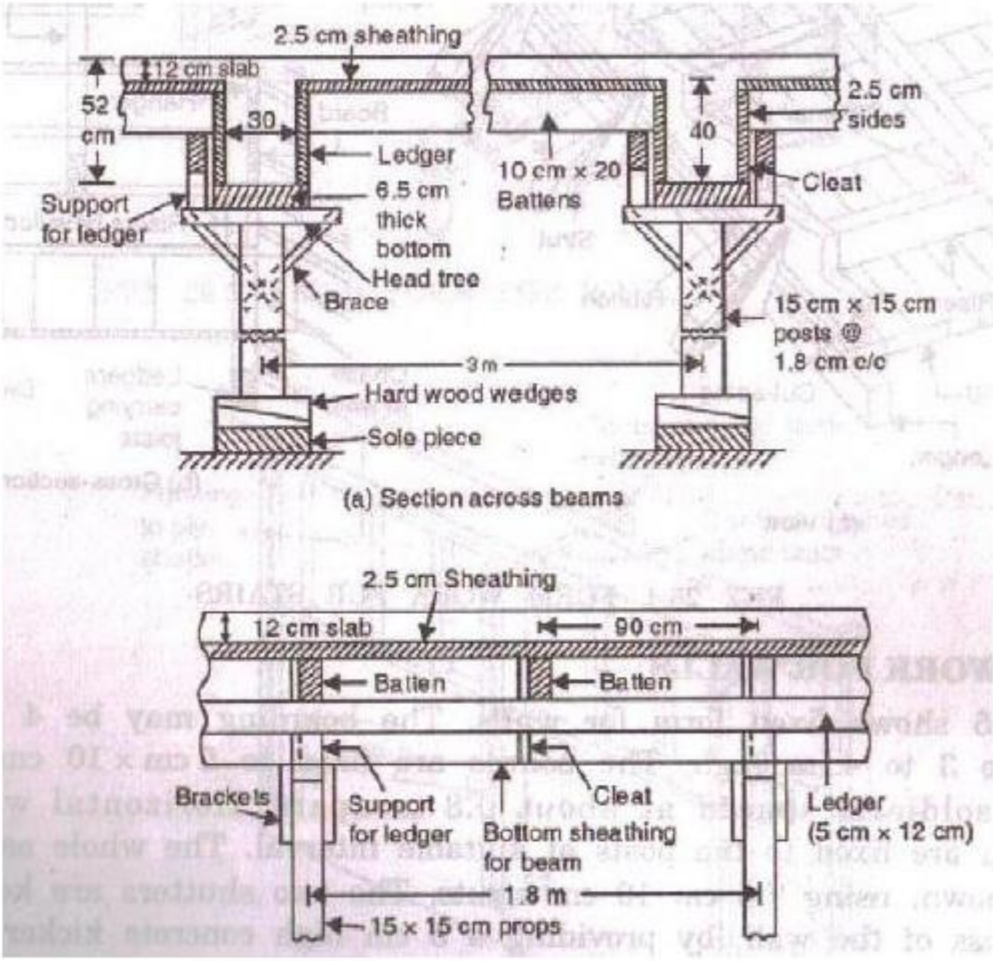
(iii) Shuttering forming soffit of beams, girders or other heavily loaded shuttering should be removed in the end

Formwork Details

1) *Formwork for RCC Columns:*



2) *Formwork for Beams and floors:*



Slip forming

The forms are raised while the concrete is in a plastic state and such forms are also known as climbing forms. Slip forms are suitable for vertical structures like piers, chimneys, towers, water reservoirs, silos etc..

Advantages

(i) The constructions joints are eleminated as the concrete can be placed continoulsy

(ii) The construction work can be carried out speedily

(iii) Economical as there is less wastage of forms

Requirements of good formwork

1) *Easy removal*: Form work should be able to remove easily to prevent damage

2) *Economy*: Formwork is not part of permanent work. Hence it should be economical

3) *Less Leakage*: This is achieved by providing light joists between adjacent sections of formwork

4) *Quality*: The forms should be designed and built accurately so that desired size, shape and finish of the concrete is attained

5) Rigidity: The formwork should be rigid enough so as to retain the shape without any deformation

6) Smooth surface: To achieve good concrete surface, formwork should have smooth surface

7) Strenghth: To withstand the self weight of concrete as well as live load, formwork should be sufficiently strong

8) *Supports*: The formwork should rest on sound, hard and non-yielding support

Scaffolding

Scaffold is a temporary rigid structure having plate forms raised up as the building increases in height i.e, when the height above floor level exceeds about 1.50m a temporary structure, usually of timber, is erected close to the work to provide a safe working platform for the workers and to provide a limited space for the storage of building materials. It is useful in construction, demolition, maintenance or repair works.

Types of Scaffolding

The following different types of scaffolds are

1. Cantilever or needle scaffolding
2. Single scaffolding
3. Suspend scaffolding
4. Trestle scaffolding
5. Steel scaffolding
6. Patented scaffolding

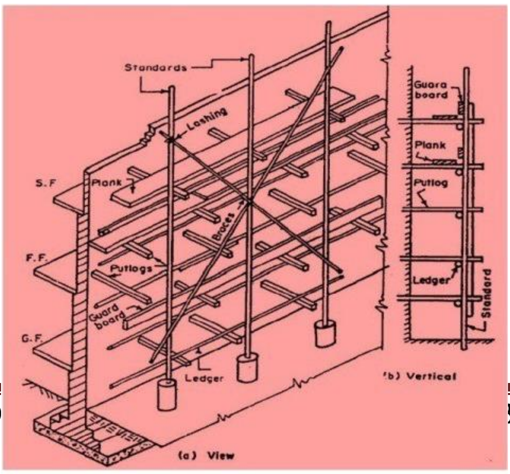
Single Scaffolding / Brick Layer's Scaffolding

In this type of scaffolding, a series of vertical members made of bamboo or timber (named as **Standards**), are firmly fixed into the ground in a row parallel to the building wall. The distance in between two standards is generally kept within 2.4 to 3 m.

These standards are connected to each by a longitudinal horizontal member (named as **Ledgers**). Ledgers are tied with standards at every rise of 120 cm to150 cm (i.e. 4 ft to 5 ft). Rope lashing is used to tie the standard with ledgers.

The **putlogs** (or transverse horizontal members) are placed at a horizontal spacing of 120 cm such that one end is supported on the ledgers and the other end is held in the holes made in the wall. Rope lashing is used to fasten the putlogs with ledgers.

If the height of the scaffolding is very high, to maintain its stability, sometimes diagonal members (named as **Braces**) are provided. Braces are cross diagonally fitted with the standards using rope lashing.



Brick layers scaffolding or Single scaffolding

Double Scaffolding / Mason's Scaffolding

This type of scaffolding is commonly used in case of stone masonry. It is stronger than brick layer's scaffolding.
The primary differences between brick layer's scaffolding and mason's scaffolding are as follow:

- In case of brick layer's scaffolding single row of standard is fixed into the ground. But in case of mason's scaffolding two rows of standards are fixed into the ground. First row of standards is fixed close to the wall and second row of standard is fixed at a distance of 1.5 m from the first row. This is why it is named as double scaffolding.
- In case of brick layer's scaffolding one end of putlog is fixed with wall. But in double scaffolding, putlogs are not fixed with the wall. Put logs are supported at both ends on ledgers. Therefore mason's scaffolding is completely independent of the wall surface. And there is no need to make any hole on the wall surface.

Sometime **raking shores** are provided to prevent the slipping of scaffolding away from the wall.

Steel or Tubular Scaffolding

The method of construction of steel scaffolding is similar to that of brick layer's and mason's scaffolding. The primary differences are

- Instead of using timber, steel tube of diameter of 40 m to 60 mm are used
- Instead of using rope lashing, special types of steel couples are used for fastening
- Instead of fixing the standards into the ground, it is placed on base plate

The gap between two standards in a row is generally kept within 2.5 m to 3 m. These standards are fixed on a square or round steel plate (known as **Base Plate**) by means of welding.
Ledgers are spaced at every rise of 1.8 m. Length of the putlogs are normally 1.2 m to 1.8m.

Advantages of the Steel Scaffolds are as follow:

- It can be **erected or dismantled more rapidly** in comparison to timber scaffolding. This helps in saving construction time.
- It is more **durable** than timber. Therefore it is economical in long run.
- It has more **fire resisting** capacity
- It is more **suitable and safe** to work at any height.

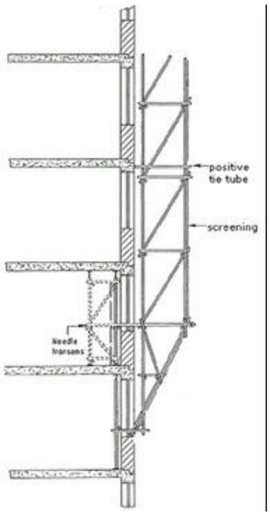
Needle Scaffolding / Cantilever Scaffolding

Needle scaffolding or cantilever scaffolding is required in the following cases

- When it is not possible to fix standard into the ground
- When construction is done on the side of a busy street
- When construction work is carried out at very high level in case of tall building

In this type of scaffolding instead of fixing the standard into the ground, it is placed at some height above the ground level. The platform on which stands are placed is called **needle**. A needle is a cantilever structure, made of timber, projected out from the holes in wall.
To prevent lifting up of the needle, the inside end of the needles are supported by struts wedged between the needles and the head pieces.
The projected outward end of the needle is supported by an inclined strut which rests on the window sill.

The joints between the inclined strut and the needle are clamped by means of **dogs**.



The American National Standards Institute describes **scaffolding** as "a temporary elevated or suspended work unit and its supporting structure used for supporting worker(s) or materials, or both," while the same agency describes **shoring** as " The vertical supporting members in a formwork system."

Shoring is the process of temporarily supporting a building, vessel, structure, or trench with shores (props) when in danger of collapse or during repairs or alterations. *Shoring* comes from *shore* a timber or metal prop.Shoring may be vertical, angled, or horizontal.

Shoring is a general term used in construction to describe the process of supporting a structure in order to prevent collapse so that construction can proceed. The phrase can also be used as a noun to refer to the materials used in the process.

Shoring, **form** of prop or support, usually temporary, that is used during the repair or original **construction** of buildings and in excavations. Temporary support may be required, for example, to relieve the load on a masonry wall while it is repaired or reinforced.

Uses of Shoring in Building Construction

Shoring is used to support the beams and floors in a building while a column or wall is removed. In this situation vertical supports are used as a temporary replacement for the building columns or walls.

Trenches – During excavation, shoring systems provide safety for workers in a trench and speed excavation. In this case, shoring should not be confused with shielding.

Shoring is designed to prevent collapse where shielding is only designed to protect workers when collapses occur. concrete structures shoring, in this case also referred to as falsework, provides temporary support until the concrete becomes hard and achieves the desired strength to support loads.

Types of shoring

1. Raking shoring
2. Flying shoring
3. Dead shoring

1. Raking Shoring

In this method, inclined members known as rakers are used to give lateral supports to walls. A raking shore consists of the following components:

1. Rakers or inclined member
2. Wall plate
3. Needles
4. Cleats
5. Bracing
6. Sole plate

The following points are to be kept in view for the use of the raking shores:

1. Rakers are to be inclined in the ground at 45^0. However the angle may be between 45^0 and 75^0.
2. For tall buildings, the length of the raker can be reduced by introducing rider raker.

3. Rakers should be properly braced at intervals.
4. The size of the rakers is to be decided on the basis of anticipated thrust from the wall.
5. The centre line of a raker and the wall should meet at floor level.
6. Shoring may be spaced at 3 to 4.5m spacing to cover longer length of the bar.
7. The sole plate should be properly embedded into the ground on an inclination and should be of proper section and size.
8. Wedges should not be used on sole plates since they are likely to give way under vibrations that are likely to occur.

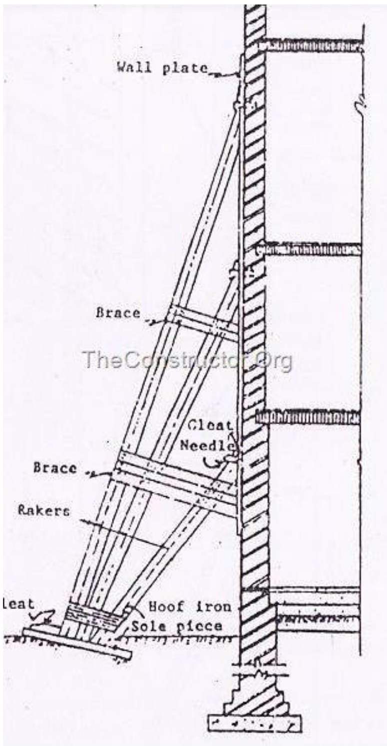


Fig.1: Raking Shores Wall Support

2. Flying Shoring

Flying shores is a system of providing temporary supports to the party walls of the two buildings where the intermediate building is to be pulled down and rebuilt (figure 4 and 5). All types of arrangements of supporting the unsafe structure in which the shores do not reach the ground come under this category.

The flying shore consists of wall plates, needles, cleats, horizontal struts (commonly known as horizontal shores) and inclined struts arranged in different forms which varies with the situation. In this system also the wall plates are placed against the wall and secured to it.

A horizontal strut is placed between the wall plates and is supported by a system of needle and cleats. The inclined struts are supported by the needle at their top and by straining pieces at their feet. The straining piece is also known as straining sill and is spiked to the horizontal shore. The width of straining piece is the same as that of the strut

When the distance between the walls (to be strutted apart) is considerable, a horizontal shore can not be safe and a trussed framework of members is necessary to perform the function of flying shore.

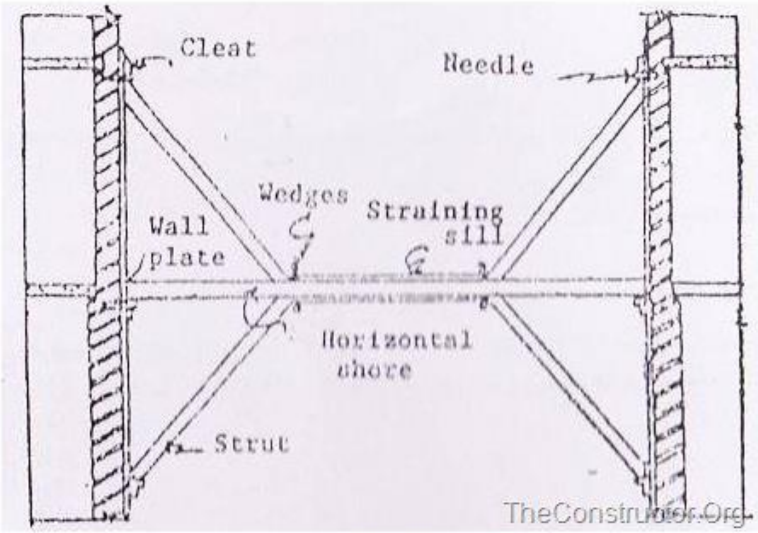


Fig.4: Flying Shore

3.Dead Shoring

Dead shore is the system of shoring which is used to render vertical support to walls and roofs, floors, etc when the lower part of a wall has been removed for the purpose of providing an opening in the wall or to rebuild a defective load bearing wall in a structure .

The dead shore consists of an arrangement of beams and posts which are required to support the weight of the structure above and transfer same to the ground on firm foundation below.

When opening in the wall are to be made, holes are cut in the wall at such a height as to allow sufficient space for insertion of the beam or girder that will be provided permanently to carry the weight of the structure above.

Distance at which the holes are cut depends upon the type of masonry and it varies from 1.2m to 1.8m centre. Beams called needles are placed in the holes and are supported by vertical props called dead shores at their ends on either side of the wall. The needles may be of timber or steel and are of sufficient section to carry the load above.

The dead shores stand away from wall on either side so as to allow for working space when the needle and the props are in position. The props are tightened up by folding wedges provided at their bases while the junction between the prop and the needle is secured with the help of dogs.

Before the dismantling work is started, all the doors, windows or other openings are well strutted. In order to relieve the wall of load of floors and roof above, they are independently supported.

Vibrations and shocks are bound to occur when wall cutting is done as such a measure of safety raking shores are sometimes erected before commencement of wall cutting operation.

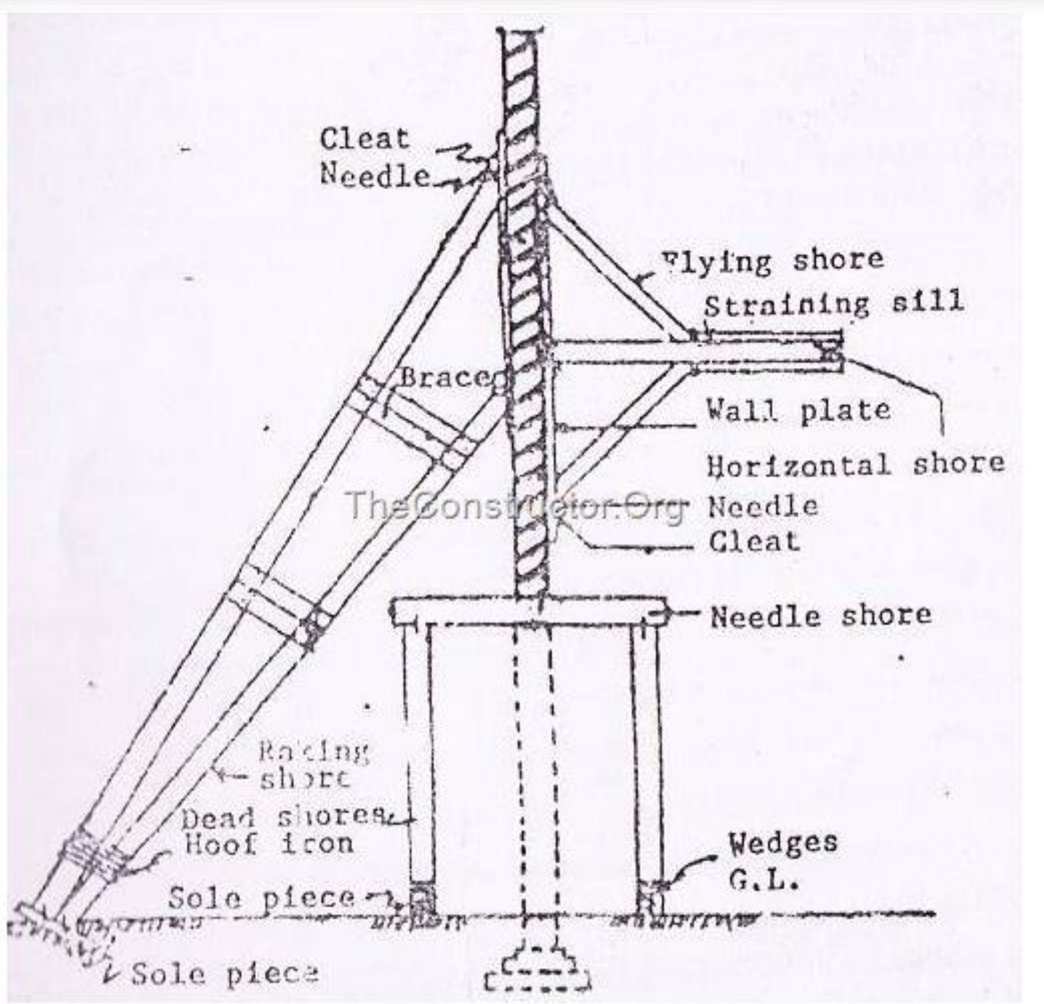


Fig.6: Dead Shore

Underpinning is a method for repair and strengthening of building foundations. Underpinning methods, procedures and their applications in strengthening of different types of foundations is discussed in this article.

There are situations where a failure in foundation or footing happens unexpectedly after the completion of whole structure (both sub and superstructure). Under such an emergency situation, a remedial method has to be suggested to regain the structural stability.

The **method of underpinning** help to strengthen the foundation of an existing building or any other infrastructure. These involve installation of permanent or temporary support to an already held foundation so that additional depth and bearing capacity is achieved.

Types of works for selection of underpinning methods:

Conversion Works

The structure has to be converted to another function, which requires stronger foundation compared to existing

Protection Works

The following problems of a building has to undergo protection works:

- The existing foundation is not strong or stable
- Nearby excavation would affect the soil that supports existing footing.
- Stabilization of the foundation soil to resist against natural calamities
- Requirement of basement below an already existing structure

Remedial Works

- Mistakes in initial foundation design caused subsidence of the structure
- Work on present structure than building a new one

Structural Conditions which Requires Underpinning

There are many reasons that make an engineer to suggest underpinning method for stabilization of the substructure such as:

- The degradation of timber piles used as a foundation for normal buildings would cause settlement. This degradation of structures is due to water table fluctuations.
- Rise and lowering of the water table can cause a decrease of bearing capacity of soil making the structure to settle.
- Structures that are built over soil with a bearing capacity not suitable for the structure would cause settlement.

Need for Underpinning

The decision of underpinning requirement can be made based on observations. When an already existing structures start to show certain change through settlement or any kind of distress, it is necessary to establish vertical level readings as well as at the offset level, on a timely basis. The time period depends upon the how severe is the settlement.
Now, before the excavation for a new project, professionals have to closely examine and determine the soil capability to resist the structure that is coming over it. Based on that report the need for underpinning is decided. Sometimes such test would avoid underpinning to be done after the whole structure is constructed.

Methods of Underpinning

Following are the different underpinning methods used for foundation strengthening:

- Mass concrete underpinning method (pit method)
- Underpinning by cantilever needle beam method
- Pier and beam underpinning method
- Mini piled underpinning
- Pile method of underpinning
- Pre-test method of underpinning

Whatever be the types of underpinning method selected for strengthening the foundation, all of them follow a similar idea of extending the existing foundation either lengthwise or breadthwise and to be laid over a stronger soil stratum. This enables distribution of load over a greater area.

Different underpinning methods are mentioned briefly in the following sections. The choice of method depends on the ground conditions and the required foundation depth.

1. Mass Concrete Underpinning Method (Pit Method)

Mass concrete underpinning method is the traditional method of underpinning, as it has been followed by centuries. The method involves extending the old foundation till it reaches a stable stratum.

The soil below the existing foundation is excavated in a controlled manner through stages or pins. When strata suitable is reached, the excavation is filled with concrete and kept for curing, before next excavation starts.

In order to transfer the load from old foundation to new one, a new pin is provided by means of placing dry sand-cement pack. This is a low-cost method suitable for the shallow foundation.

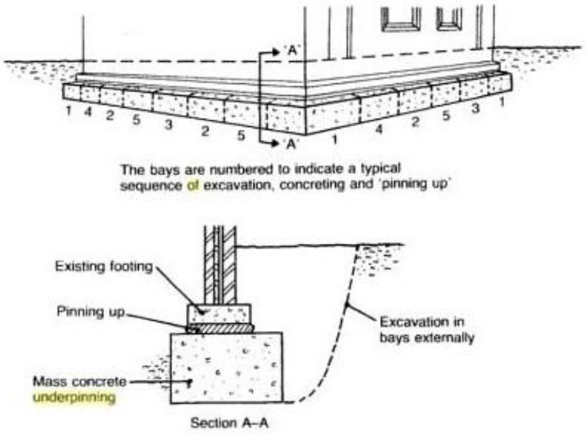


Fig.1: Mass Concrete Underpinning

For more complicated problems related to the foundation other superior methods have to chosen.

2. Underpinning By Cantilever Needle Beam Method

Figure-2 represents the arrangement of cantilever pit method of underpinning, which is an extension of pit method. If the foundation has to be extended only to one side and the plan possess a stronger interior column, this method can be used for underpinning.

Advantages of Cantilever Needle Beam Method:

- Faster than traditional method
- One side access only
- High load carrying capability

Disadvantages:

- Digging found uneconomical when existing foundation is deep
- Constraint in access restricts the use of needle beams

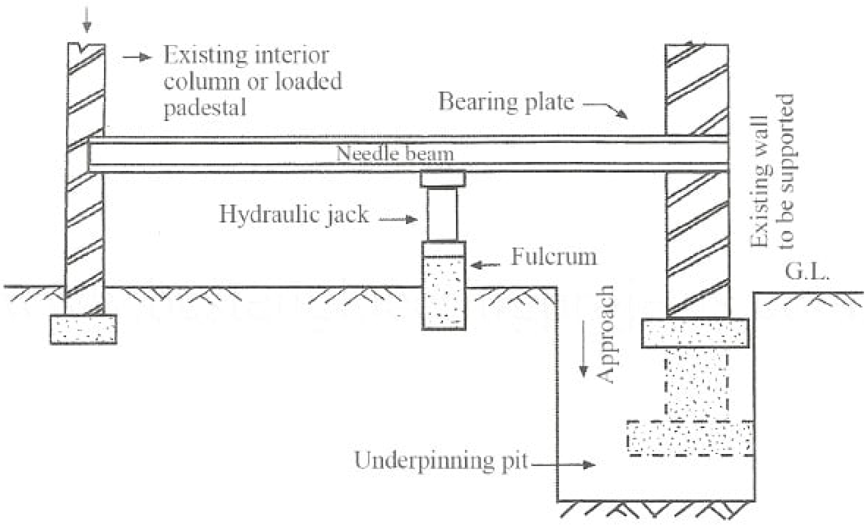


Fig.2: Cantilever Needle Beam Underpinning Method

3. Pier and Beam Underpinning Method

It is also termed as base and beam method which was implemented after the second world war. This method progressed because the mass concrete method couldn't work well for a huge depth of foundation.

It is found feasible for most of the ground conditions. Here reinforced concrete beams are placed to transfer the load to mass concrete bases or piers as shown in figure 2.

The size and depth of the beams are based on the ground conditions and applied loads. It is found economical for depth shallower than 6m.

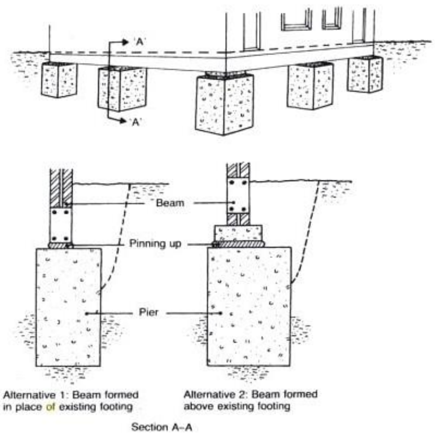


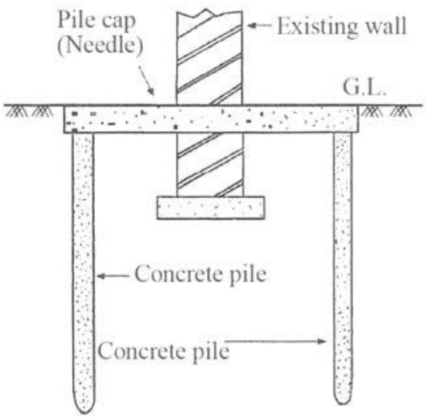
Fig.3: Pier and Beam Underpinning Method

4. Mini Piled Underpinning

This method can be implemented where the loads from the foundation have to transferred to strata located at a distance greater than 5m. This method is adaptable for soil that has variable nature, access is restrictive and causes environmental pollution problems.
Piles of diameter between 150 to 300mm in diameter is driven which may be either augured or driven steel cased ones.

5. Pile Method of Underpinning

In this method, piles are driven on adjacent sides of the wall that supports the weak foundation. A needle or pin penetrates through the wall that is in turn connected to the piles as shown in figure-3. These needles behave like pile caps. Settlement in soil due to water clogging or clayey nature can be treated by this method



Outcomes
Able to study the terms related to doors and windows
Able to distinguish different types of doors and windows
Will be able to know the types of doors and windows.
Able to study the different types of stairs
Able to study the terms used in stairs
Will be knowing the types of and uses of stairs
Able to study the form works in detail
Able to distinguish different types of form works for different types of construction

Further readings
https://www.vssut.ac.in/lecture_notes/lecture1424085991.pdf1

Text Books:

1. Sushil Kumar "Building Materials and construction", 20th edition, reprint 2015,Standard Publishers
2. Dr. B.C.Punmia, Ashok kumar Jain, Arun Kumar Jain, "Building Construction, Laxmi Publications (P) ltd., New Delhi.
3. Rangawala S. C. "Engineering Materials", Charter Publishing House, Anand, India.

Reference Books:

1. S.K.Duggal, "Building Materials", (Fourth Edition)New Age International (P) Limited, 2016 National Building Code(NBC) of India
2. P C Vergese, "Buliding Materials", PHI Learning Pvt. Ltd
3. Building Materials and Components, CBRI, 1990, India
4. Jagadish.K.S, "Alternative Building Materials Technology", New Age International, 2007.
5. M. S. Shetty, "Concrete Technology", S. Chand & Co. New Delhi.

Module -5

Plastering and Pointing : purpose, materials and methods of plastering and pointing, defects in plastering-Stucco plastering, lathe plastering
Damp proofing- causes, effects and methods.
Paints- Purpose, types, ingredients and defects, Preparation and applications of paints to new and old plastered surfaces, wooden and steel surfaces. **8 Hours**

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

Requirement of good plaster are:
• It should adhere to the background easily.
• It should be hard and durable.
• It should prevent penetration by moisture.
• It should be cheap and economical.
• It should possess good workability.
• It should efficiently check entry or penetration of moisture from surface.

Materials for plastering:
Lime mortar is usually applied in 3 coats while cement mortar is applied in two or three coats for the stone and brick masonry. For concrete surfaces cement mortar may be applied in two or three coats. For concrete building blocks many times only one coat of cement mortar is applied.The first coat provides means of getting level surface. The final coat provides smooth surface. If three coats are used second coat is known as floating coat. The average thickness of first coat is 10 to 15 mm. Middle coat thickness is 6–8 mm. The final coat is just 2 to 3 mm thick. If single coat is used its thickness is kept between 6 to 12 mm. Such coats are used on concrete surfaces not exposed to rain.
The mortar used for plastering work can be classified into three categories:
• **Lime mortar**: it consists of equal volume of lime and sand these two materials are carefully ground in mortar mill. Flat lime is recommended for plastering work.

a) Three-coat plaster :In the 3-coat plaster, the first coat is known as rendering coat second coat is known as floating coat and the third coat is known as setting coat or finishing coat.

1. Application of rendering coat

The mortar is forcibly applied with mason's trowel and pressed well into joints and over the surface. The thickness of coat should be such as to cover all inequalities of the surface; normal thickness is 12 mm. This is allowed to slightly harden, and then scratched criss - cross with the edge of trowel (or with devil float); the spacing of scratches may be 10 cm. The surface is left to set at least for 7 days. During this period, the surface is cured by keeping it damp and then allowed to dry completely.

2. Application of floating coat

The rendering coat is cleaned off all dirt, dust and other loose mortar dropping. It is lightly wetted. Patches 15 cm x 15 cm or strips 10 cm wide are applied at suitable spacing’s to act as gauges. The mortar is then thrown with mason's trowel, spread and rubbed to the required plain surface with wooden float. The surface so obtained should be true in all directions. In case of lime-sand plaster, the finishing coat is applied immediately. In the case of lime surkhi plaster, the floating coat is allowed to slightly set and then lightly beaten criss - cross with floats edge at close spacing of 4 cm. It is then cured to set completely for at least 10 days and then allowed to dry out completely. In either case, the thickness of coat varies from 6 to 9 mm.

3. *Application of finishing*

In the case of lime-sand mortar the finishing coat is applied immediately after the floating coat. The finishing coat consists of cream of lime (called neeru or plasters putty, having lime cream and sand in the ratio of 4:1) applied with steel trowel and rubbed and finished smooth. The rubbing is continued till it is quite dry. It is left for 1 day, and then curing is done for at least 7 days. In the case of lime-surkhi mortar, the finishing coat is applied 7 days after the floating coat, after cleaning the surface of all dirt, dust and mortar droppings and after fully wetting the surface of previous coat. The finishing coat is rubbed hard and finished smooth.

b) Two-coat plaster

In the case of two-coat plaster, the rendering coat is a combination of the rendering floating coats of three-coat plaster and is done under one continuous operation exc6pt that the scratching of rendering coat, as specified in the three-coat plaster, is not done- The total thickness may be about 12 mm. The finishing is then applied in a manner similar to the three-coat plaster.

2. CEMENT PLASTER AND CEMENT LIME PLASTER :Cement plaster is applied either in two coats or in three coats, the former being more common. For interior work, single coat plaster is sometimes provided.

a) Two-coat plaster. The following procedure is adopted:

1. The background is prepared by racking the joint to a depth of 20mm, cleaning the surface and well-watering it.

2. If the surface to be plastered is very uneven, a preliminary coat is applied to fill up the hollows, before the first coat

3. The first coat or rendering coat of plaster is applied, the thickness being equal the specified thickness of plaster less 2 to 3 mm. In order to maintain uniform thickness of plaster, screeds are formed of plaster on

Wall surface by fixing dots of 15cm x 15 cm size. Two dots are so formed in vertical line, at a distance of about

2m, and are plumbed by means of a plumb bob. A vertical strip of mortar known as screed, is then formed. A number of such vertical screeds are formed at suitable spacing. Cement mortar is then applied on the surface between the successive screeds and the surface is properly finished.

4. Before rendering hardens, it is suitably worked to provide mechanical key for the final or finishing coat. The rendering coat is trowelled hard forcing mortar into joints and over the surface. The rendering coat is kept wet for at least 2 days and then allowed to dry completely.

5. The thickness of final or finishing coat may vary between 2 and 3 mm. Before applying the final coat, the rendering coat is damped evenly. The final coat is applied with wooden floats to a true even surface and finished with steel trowels. As far as possible, the finishing coat should be applied starting from top towards bottom and completed in one operation to eliminate joining marks.

(b) *Three-coat Plaster.*

The procedure for applying three-coat plaster is similar to the two-coat plaster except that an intermediate coat, known as floating coat is applied. The purpose of this coat of plaster is to bring the plaster to an even surface. The thickness of rendering coat, floating coat and finishing coat are kept 9 to 10 mm, 6 to 9 mm and 2- 3 mm resp. The rendering coat is made rough. The floating coat is applied about 4 to 7 days after applying the first coat.

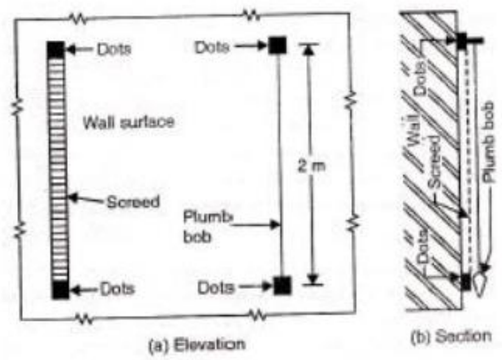


FIG. 19.2. DOTS AND SCREEDS.

(c) *single-coat plaster*.

This is used only in inferior quality work, It is applied similarly as two coat plaster except that the rendering coat, as applied for two-coat plaster, is finished off immediately after it has sufficiently hardened'

• **Cement mortar**: the cement mortar consists of one part of cement to four part of clean, coarse and angular river sand. The materials are thoroughly mixed in dry condition before water is added to them. The mixing of materials is done on a watertight platform.

• **Water proof mortar**: This mortar is water proof and it is prepared by mixing one part of cement and two parts of sand and pulverised alum at the rate of 120 N per m3 sand.

Method of Plastering:

The plastering could be done on the surfaces either in one, two and three coats. The plasterings for two coats are as follows:

• The mortar joints are racked out to a depth of 20 mm and surface is cleaned and well watered. If it is found that the surface to be plastered is very rough and uneven, a primary coat is applied to fill up the hollows before the first coat of plaster is put on the surface.

• The first coat of plaster is now applied on the surface. The usual thickness of first coat for brick masonry is 9 mm to 10 mm. In order to maintain uniform thickness, the screeds are formed on the wall surface by fixing dots.

• The cement mortar is placed between successive screeds and surface is properly finished. The second coat is applied after six hours and thickness of second coat is 3 mm to 2 mm. The completed work is allowed to rest for 24 hours and then, the surface is kept well watered for rest of week.

For plastering in three coats are similar to two coats. The thickness of first coat (rendering coat) 9 to 10 mm, second coat (rendering coat) 9 to 10 mm, and third coat (setting coat) thickness around 3 mm.

The techniques for plastering various surfaces:

• **Internal Plastering on surfaces of Brick and Concrete:**

Initially, the Surface where plastering is to be done will be cleaned. Level pegs on walls will be fixed with reference to the off lines to brick walls set out in floors. (Using centre plumb bob and nylon thread). All the brick walls will be watered before pasting mortar on walls. First coat mortar filling (1:4 Cement and Sand) up to 15 mm will be applied on surfaces where required mortar thickness exceed 25mm. Walls and columns will be plastered 1:4 Cement and Sand to achieve semi rough finished surface. Vertical joint of structural columns / walls & brick walls will be treated by fixing 200mm width chicken mesh with wire nails / concrete nails by centering the mesh to the vertical wall joint. All the embedded service lines and provisions (Conduits, Boxes and etc.) will be completed on brick walls and check with the MEP drawings. Joints between walls and beams will be formed up to a maximum of 20mm and will be sealed using 30 minutes fire rated flexible filler. (Material descriptions will be submitted for the approval of the Engineer) Internal plastering on surfaces of concrete columns, beams & walls which are aligned with surfaces of brick walls will be plastered and other concrete surfaces will be finished with cement base easy plaster. (Material descriptions will be submitted for the approval of the Engineer).

External Wall Plastering:

Alignment and fixing level pegs on external wall surfaces will be done using the surveying instrument / centre plumb bobs. Projections on the wall surfaces will be chipped off and cleaned after completing the level pegs on walls. First coat mortar filling (1:4 Cement and Sand) up to 15 mm will be applied on surfaces where required mortar thickness exceed 25mm.Cement paste on concrete surfaces will be applied to improve the bonding of plaster to the concrete surfaces. Maximum width of 20mm horizontal grooves between walls and beams will be formed by cutting using grinders with diamond wheels after plastering the wall surface. This groove will be filled with approved weather sealant. External wall plaster will be finished with rough surface. 1:10 slope at the external side of the window sill will be formed while plastering the window reveals.

• **Soffit Plastering / Soffit Finishing with Cement Based Easy Plaster**

The slab soffits and beams' sides and soffits which are to be smooth surfaced painted finished will be smoothen with easy plaster (Material literature will be submitted separately) and places where concrete surfaces are uneven, will be roughen & leveled with cement and sand mortar plaster before applying easy plaster to make surface smooth.

• **Improving Joints of Brick Wall & Structural Concrete**

• 200mm wide Chicken Mesh will be fixed at the joint.

• Concrete surfaces will be washed and cleaned.

• Concrete surface which are to be plastered will be roughen or put spot cement slurry.

Different plastering techniques:

• There are numerous plastering techniques used to plaster ceilings and walls. It all depends on the requirements of the client as well as the nature of the area that needs plastering. Let’s take a look at some general plastering techniques:

Dry Lining Plastering

• Over the years, traditional Melbourne homes made use of wet plastering to ensure a smooth finish to ceilings and walls. During the last 3 to 4 decades, dry plastering or dry lining plastering techniques are being used instead. This method is favoured due to the ease of using a plasterboard. After all, plasterboards are solid and available in sheet form in standard sizes of around 2.4 x 1.2 meters. Plasterers Melbourne found it a breeze to handle and put plaster on. What is more, dry lining is a complete dry procedure which allow plasterers to quickly fix any mishaps. Paint can easily be applied to any surface to ensure a warm and welcoming finish.

• The biggest reason why most builders or plasterers prefer using dry lining is due to the speed of applying it and the load being reduced on structures of any kind. As plasterboard walls are lightweight, they offer better flexibility when it comes to planning interior or exterior spaces on the drawing board. In addition, dry lining is a plastering technique that saves you money and time. Yet another reason why it is the most preferred plastering method as far a construction work in timber frames are concerned.

Wet Plastering

• Known to be the most common of all plastering techniques used is wet plastering. It enables experiences plasterers Melbourne to obtain a clean and smooth finish by covering any surface in need of plastering with mortar, then smoothening it using trowels. Dried wet plastered surfaces can be painted or papered according to individual preferences. Like most plastering techniques, it requires skilled plasterers and enough drying time. Wet plastering is prone to shrinkage, cracks, and often times in need of re-plastering in order to cover any cracks.

Defects in Plastering

The following defects may arise in plaster work.

1. **Blistering of plastered surface:** This is the formation of small patches of plaster swelling out beyond the plastered surface, arising out of late slaking of lime particles in the plater

2. **Cracking:** Cracking consists of formation of cracks or fissures in the plaster work resultin gfrom the following reasons. i. Imperfect preparation of background

ii. Structural defects in building

iii. Discontinuity of surface

iv. Movements in the background due to its thermal expansion or rapid drying

v. Movements in the plaster surface itself, either due to expansion or shrinkage.

vi. Excessive shrinkage due to application of thich coat

vii. Faulty workmanship.

3. **Efforescene:** It is the whitish crystalline substance which appears on the surface due to presence of salts in plaster making materials as well as building materials like bricks, sand, cement etc and even water. This gives a very bad appearance. It affects the adhesion of paint with wall surface. Efforescene can be removed to some extent by dry bushing and washing the surface repeatedly.

4. **Flaking:**It is the formation of very loose mass of pastered surface, due to poor bond between sucessive coats.

5. **Peeling:** It is the complete dislocation of some portion of plastered surface, resulting in the formation of a patch. This also results from imperfect bond.

6. **Popping:** It is the formation of conical hole in the plastered surface due to presence of some particles which expand on setting

7. **Rust Stains:** These are sometimes formed when plaster is applied on metal laths

8. **Uneven surface:** This is obtained purely due to poor workman ship.

Materials of Plastering:

Special materials are used in plastering or over the plastered surface to meet some specific requirements of the finished surface, such as increased durability, better or attractive appearance, fire proofing, heat insulation, sound insulation etc.,

Following are the usual special materials used for plastered surfaces.

1. *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 halIs, auditoriums etc., The plaster is applied in two coats each of 6 mm thickness, using wooden float.

2. Asbestos marble plaster.

This plaster is made of cement, asbestos and finely crushed marble, imparting marble like finish.

3. *Barium plaster.*

It is made from cement, sand and barium sulphate, and is provided in X-ray rooms, to protect the persons working in it.

4. Granite silicon plaster.

This plaster is used for superior type of construction since it is quick setting & possess highly elastic properties which eliminate cracks.

5. *Gypsum plaster*

(plaster of Paris) Plaster of Paris is obtained from heating finely ground gypsum heated at 160 to 170 degree centigrade. It hardens within 3 to 4 minutes of adding water. To extend the setting time, suitable retarders are used. Plaster of Paris is generally used in combination with lime, for ornamental work, and for repairing holes and cracks.

6. Kenee's cement plaster.

Kenee's cement is obtained by the calcination plaster of Paris with alum. This is very hard and sets in few days, taking white, glass-Like polish. It is used for situations such as angles, skirting's etc., Because of its polishing characteristics, it is also useful for ornamental work and decorative plastering.

7. Martins cement plaster.

Martin's cement is obtained when pearl ash is calcined with Plaster of Paris. It has quick setting properties, and forms a white hard surface on drying. It is used for internal finishing work

8. parian cement plaster.

Parian cement is obtained when borax is calcined with Plaster of Paris. Like Kenee's cement, it is also used for interior work. However it is cheaper than Kenee's cement'

9. Scagliola plaster.

Scagliola is obtained by dissolving Kenee's cement and coloring pigments in glue. It is used for plastering pilasters, panels, columns etc., It appears like marble.

10. *Sirapite plaster.*

Sirapite is obtained when plaster of Paris is slaked in petroleum. It is quick setting and fire resisting. It produces white hard surface on drying.

11. Snowcrete and colourcrete cements.

These are the trade names given to white and coloured cement respectively. These are used on external walls to create good appearance.

12. Thistle hard wall.

It is a product of high grade gypsum. It sets rapidly and produces excellent finish. It is used for interior work.

The term **Pointing** in construction is applied to the finishing of mortar joints in masonry (stone or brick). In exposed masonry, joints are considered to be the weakest and most vulnerable spots from which rain water or dampness can enter. Pointing means implementing the joints to a depth of 10 to 20mm and filling it with better quality mortar in desired shape.

Mortar required for pointing work:

1. Lime mortar of 1:2 (1 fat lime : 2 sand or surkhi)
2. Cement mortar of 1:3 (1 cement : 3 sand)

Above mortar mixes will give good results in pointing.

Preparation of surface:

All the joints in masonry are raked down to a depth of 20mm while the mortar is still soft. The joints and surface are cleaned and then thoroughly wetted.

Methods of pointing:

After preparing the surface as mentioned above, mortar is carefully placed in joints using a small trowel. The placed mortar should be of desired shape. Whenever the fresh mortar is placed in the joints it should be pressed hardly to gain strong bond with old interior mortar. Care should be taken while using ashlar or 1st class brick work otherwise the mortar does not cover the face edges. The pointed surface is kept wet for at least a week or till it sets after application.

Types of pointing:

1. Flush pointing
2. Recessed pointing
3. Beaded Pointing
4. Struck Pointing
5. Rubbed, keyed or grooved pointing
6. Tuck Pointing
7. V- pointing
8. Weathered pointing

Flush pointing:

In This type of pointing mortar is pressed hard in the raked joints 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. But, flush pointing is more durable because of resisting the provision of space for dust, water etc., due to this reason, flush pointing is extensively used.

Recessed pointing:

In case of recessed pointing mortar is pressing back by 5mm or more from the edges. During placing of mortar the face of the pointing is kept vertical, by a suitable tool. This type of pointing gives very good appearance.

Beaded pointing:

It is a special type of pointing which is formed by a steel or ironed with a concave edge. It gives good appearance, but it will damage easily when compared to other types

Struck pointing:

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

Rubbed, keyed or grooved pointing:

This pointing is also a modification of flush pointing in which groove is formed at its mid height, by a pointing tool. It gives good appearance.

Tuck pointing:

In case of tuck pointing mortar is pressed in the racked joint first and finishing flush with the face. While the pressed mortar is green, groove or narrow channel is cut in the center of groove which is having 5mm width and 3mm depth. This groove is then filled 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.

V- Pointing:

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

Weathered pointing:

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

Damp prevention is a chief requirement to ensure safety of building against dampness.
One of the basic requirements in all the buildings is that structure should be dry as far as possible.
If this is not satisfied it is likely that building may become inhabitable and unsafe from structural point of view.

In order to prevent entry of damp into a building the courses known as damp proofing courses are provided at various levels of entry of damp into a building.
Presently all buildings are given DPC treatment
So DPC prevent entry of moisture from walls floors and basements of a buildings

The treatment given to roofs of buildings for some cause is called water proofing.

Cause Of Dampness

Responsible causes are one or more of the followings
1. Faulty design of structure

2. Faulty construction / poor workmanship

3. Use of poor quality of material in construction

These causes give rise to an easy access to moisture to the building from different points, such as rain penetration through walls, roofs and floors etc. The moisture entering into the buildings from foundation and roofs travels in different directions further under the effect of capillary action and gravity respectively. The entry of water and its movement in different parts of the buildings are positively due to one or more of the causes listed above
(1) Rising Of Moisture From The Ground

The subsoil or ground on which the building is constructed may be made of soils which easily give an access to water to create dampness in building. Generally the foundation dampness is caused when the building structures are constructed on low lying water logged areas where a sub soil of clay or peat is commonly found through which dampness will easily rise under capillary action unless properly treated.

This dampness further finds its way to the floors, walls etc. through the plinth.

(2) Action Of Rain Water
Whenever the faces of walls are not suitably protected from the exposer to heavy shower of rains, they become the sources of dampness in a structure. Similarly the poor mortar joints in walls and cracked roofs also allow dampness to enter the building structure. Sometimes due to faulty eave courses and eave gutters, the rain water may percolate through the roof coverings

(3) Rain Penetration From Top Of The Wall
All parapet walls and compound walls of the buildings which have not been protected from rain penetration by using dam proof courses or by such measures on their exposed tops are subjected to dampness. This dampness in the buildings is of serious nature and may results in unhealthy living condition or even in structurally unsafe conditions.

(4) Condensation Due To Atmospheric Moisture Whenever the warm air in the atmosphere is cooled it gives rise to process of condensation. On account of condensation the moisture is deposited on the whole area of walls, floors, and ceilings. However the sources of dampness is prevalent only in certain places in India, where very cold climate exist.

(5) Miscellaneous Sourses Or Causes

The various other sources responsible for dampness in buildings are mentioned bellow:-

(a) Poor Drainage Of Site

The structure if located on low lying site causes water logged conditions where impervious soil is present underneath the foundation.

So such structures which are not well drained cause dampness in buildings through the foundations.

(b) Imperfect Orientation

Whenever the orientation of the buildings is not proper or geographical conditions are such that the walls of buildings get less of direct sunrays and more of heavy showers of rains, then such walls become prone to dampness.

(c) Constructional Dampness

If more water has been introduced during construction or due to poor workmanship, the walls are observed to remain in damp condition for sufficient time.

(d) Dampness Due To Defective Construction

Dampness in buildings is also caused due to poor workmanship or methods of construction viz inadequate roof slopes, defective rain water pipe connection, defective joints in roofs in proper connection of walls etc.

Effect Of Dampness

The various effects (indirectly defects), caused due to dampness in buildings are mentioned below

All effects mainly result in poor functional performance, ugly appearance and structural weakness of the buildings.

(a) A damp building creates unhealthy living and working conditions for occupants.

(b) Presence of damp conditions causes efflorescence on building surface, which ultimately may result in the dis-integration of bricks, stones, tiles etc. and hence in the reduction of strength.

(c) It may cause bleaching and flaking of the paint which results in the formation of coloured patches on the wall surfaces and ceilings.

(d) It may result in corrosion of metals used in the construction of buildings.

(e) The material used as floor coverings, such as tiles, are damaged because they lose adhesion with the floor base.

(f) Timber, when in contact with damp conditions, gets deteriorated due to the effects of warping, buckilng and rolling of timber.

(g) All electrical fittings get deteriorated, causing leakage of electric current with the potential danger of a short circuit.

(h) Dampness promotes the growth of termites and hence creates unhygienic conditions in buildings.

(i) Dampness when accompanied by the warmth and darkness, breeds the germs of tuberculosis, neuralgia, acute and chronic rheumatism etc.which sometimes result in fatal diseases.

Techniques And Methods Of Damp Prevention

The following precautions should be taken to prevent the dampness in buildings, before applying the various techniques and methods described later :

(I) The site should be located on a high ground and well drained soil to safeguard against foundation dampness. It should be ensured that the water level is at least 3m. below the surface of ground or lowest point even in the wet season. For better drainage the ground surface surrounding th building should also slope away.

(II) All the exposed walls should be of sufficient thickness to safe guard against rain penetration. If walls are of bricks they should be at least 30 cm thickness

(III) Bricks of superior quality which are free from defects such as cracks, flaws, lump of lime stones should be used. They should not absorb water more than 1/8 of their own weight when soaked in water for 24 hours.

(IV) Good quality cement mortars should be used to produce a definite pattern and perfect bond in building units throughout the construction work. This is essential to prevent the formation cavities and occurrence of differential settlement.

(V) Cornices and string courses should be provided. Window sills, coping of plinth and string courses should be slopped on top and throated on the undesirable to throw the rain water away from walls.

(VI) All the exposed surfaces should be covered with waterproofing cement plaster

(VII) Hollow walls are more reliable than solid walls in preventing dampness and hence the cavity wall construction should be adopted wherever possible.

Prevention of dampness

Use of damp proofing courses or membranes-

These are the layers or membranes of water repellent material such as bituminous felts, mastic asphalts, plastic sheets, cement concrete, mortar, metal sheets which are interposed in the building structure at all location wherever water entry is anticipated. These damp proof courses of suitable materials should be provided at appropriate location for their effective use. Basically D.P.C is provided to prevent the water rising from the sub soil and getting into the different part of the buildings. The best location for D.P.C in case of buildings without basement lies at the plinth level or in case of structure without plinth should be laid at least 15 cm above the ground. These damp proof courses may be provide horizontally or vertically in floors, walls etc. in case of basement laying of D.P.C is known as tanking.

While providing damp-proof courses in buildings, the following general principles should be observed in practice.

• The DPC should cover the full thickness of the walls excluding rendering, in order to act as an effective barrier to moisture under all conditions.

• The mortar bed upon which the DPC is laid should be level, even and free from any projections.

• The DPC course should be placed in correct relation with other DPC courses so as to provide a complete course should be placed in correct relation with other DPC courses so as to provide a complete and continuous barrrier to the passage of moisture from below, top or sides. Therefore, the junctions and corners, formed by walls, or walls and floors, should be laid continuous.

• Where a vertical DPC is to be laid continuous with a horizontal DPC(i.e., forming angle projection), a fillet 75mm in radidius should be provided. the DPC should not be exposed on the wall surface, otherwise it is likely to be damaged by carpainters, tile layers,etc.

(2) Waterproof (or damp proof) surface treatment

The surface treatment consists in filling of the pores of the material exposed to moisture by providing a thin film of water repellent material over the surface. These surface treatments can be either external or internal, the external treatment is effective in preventing dampness where as internal one only reduces it to a certain extent.

Many surface treatments like pointing, plastering. Painting, distempering, are given to the exposed surfaces and also to the internal surfaces. Most commonly used treatments, to protect the walls against dampness, is lime cement plaster of mix (one cement : one lime : six sand) proportions. A thin film of water proofing can be materials, generally employed as waterproofing agent in surface treatments are : sodium or potassium silicates, aluminium or zinc sulphates, barium hydroxide and magnesium sulphate in alternate applications, soft soap and alum also in alternate applications, lime and linseed oil, coal tar, bitumen, waxes and fats, resins, and gum, etc.

Some of the abve mentioned materials, like the waxes and fats, are unsuitable in the tropics as they melt with rise in temperature, resins and gums and also not lasting materials are coal tar and bitumen disfigure the original surface.

(3) Integral damp-proofing treatment

The integral treatment consists adding certain compounds to the concrete or mortar during the process of mixing, which when used in construction act as barriers to moisture penetration under different principles. Compounds like chalk, talc, fuller's earth, etc.have mechanical action principle, i.e., they fill the pores present in the concrete or mortar and make them denser and water proof. The compounds, like alkaline, silicates, aluminium sulphates, calcium chlorides,etc.work on chemical action principle i.e., they react chemically and fill in the pores to act as water resistant. Similarly , some compounds like soaps, petroleum oils, fatty acid compounds such as stearates of calcium,sodium ammonium

etc.work on repulsion principle i.e., they are used as admixtures in concrete to react with it and become water repellent.

The synthetic compound prepared under this principles are available in commercial forms, like Pudlo, Sika, Novoid, Ironite, Dampro, Permo Rainers,etc.

(4) cavity walls

A cavity wall consist of two parallel walls/leaves/skins of masonry, separated by a continuous air space/cavity.

They consists of three parts.

- Out wall/leaf(exterior wall part 10cm thick)
- Cavity/air space(5cm-8cm)
- Inner wall/leaf(minimum 10cm thick)

The two leaves forming a cavity in between may be of equal thickness or may not be. The inner wall thickness may more to take larger properties of imposed loads transmitted by floor and roof.

Provision of continuous cavity in the wall efficiently prevents the transmission of dampness from outer to inner wall.

Under climatic conditions of India (hot-dry/hot-humid), cavity type construction is most desirable as it offers many advantages such as better living and comfort conditions, economic construction and preservation of buildings against dampness.

1. As there is no contact between outer and inner walls of a cavity wall except at wall ties, which are of impervious material, so possibility of moisture penetration is reduced to a minimum.
2. It has been verified a cavity wall of 10cm thick internal and external walls with 5cm cavity/air space in between is better or more reliable than solid wall of 20cm thickness w.r.t damp prevention.
3. The cavity wall offers good insulation against sound.
4. It reduces the nuisance of efflorescence.
5. It offers other advantages like,

- Economy
- Better comfort
- Hygienic conditions in buildings.

(5) Shot concrete(gunting)

This consists in forming an impervious layer of rich cement mortar(1:3) for water proofing over the exposed concrete surface or over the pipes, cisterns, etc. for resisting water pressure. Gunite is a mixture of cement and sand on well graded fine aggregate, the usual proportion being 1:3 or1:4. A machine known as cement gun, having a nozzle for spraying the mixture and a drum of compressed air for forcing the mixture under desired pressure, is used for this purpose, Any surface which is to be treated is first thoroughly cleaned of any dirt, greese or loose particles and then fully wetted. The mix of cement and sand is then shot under a pressure of 2-3kg/sq.cm by holding the nozzle of cement gun at a distance of 75-99 cm from wall surface. The necessary quality of water is added by means of regulating valve soon after the mixture comes out from cement gun. So mix of desired consistency and thickness can be sprayed, to get an impervious layer, the impervious surface should be watered for about 10 days.

By this technique impervious layer of high compressive strength can be obtained (28 days strength) and so it is useful method for reconditioning/repairing old concrete works, bricks and masonry works, which have deteriorated.

(6) Pressure grouts (cementation)

Cementation is the process of forcing the cement grout (mix of cement, sand, water) under pressure into cracks, voids, fitters present in structural components/ground. All the components of a structure in general and foundation, which are liable to moisture penetration are consolidated and so made water resistant by this process.

Here heels are drilled at selected points in structure and cement grout of sufficiently thin consistency is forced under pressure to ensure complete penetration onto cracks. This makes structure water tight and restores stability and strength.

When structure is resting on hard but loose textured ground its strength can be increased, by this process. This technique is used for repairing structures, consolidator ground to improve bearing capacity forming water cut offs to prevent seepage.

Materials used for damp proofing

1. An effective damp proofing materials should have the following properties.

2. It should be impervious

3. It should be strong and durable and should be capable of withstanding both dead or wet or live load without damage.

4. It should be dimensionally stable.

5. It should be free from deliquescent salts like sulphates, chlorides and nitrates.

Introduction to painting:

Paints are the liquid composition 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.

Characteristics of good paint:

An ideal paint should possess the following characteristics

(1) Paint should form hard and durable surface.
(2) IL should give attractive appearance.
(3) It should be cheap and readily available.
(4) It should be such that it can be applied easily to the surfaces.
(5) It should have good spreading quality, so as to cover maximum area in minimum quantity.
(6) It should dry in reasonable time.
(7) It should not show hair cracks on drying.
(8) It should form film of uniform colour, on drying.
(9) It should be stable for a longer period.
(10) It should not be affected by atmospheric agencies.

Constituents of paints:

A paint generally is made up of the following constituents

1. A base.
2. Inert filler or extender
3. Colouring pigment
4. Vehicle
5. solvent or thinner
6. Drier

1. Base

It is generally a metallic oxide and is used in a paint. Base is an essential pigment which forms the chief ingredient of a paint. The most important purpose of adding a base in a paint is to form an opaque coating to hide the surface to be painted. It also makes the paint film resistant to abrasion and prevents shrinkage crack likely to be formed in the film during drying cement, white lead, red lead, zinc oxide, ferrous oxide are the bases commonly used.

2. Inert filler or extender

It is the cheap pigment which is added to a paint to reduce its cost. In addition it modifies the weight of the paint and makes it more durable. The commonly used inert filler are $BaSo4$, silica, gypsum, charcoal, etc.,

3. Colouring pigment

As the name indicates it is white or coloured pigment mixed into a paint to get desired colour of a paint.

4. Vehicle

It is a liquid which acts as a binder for the various pigments like base extender and colouring pigment. The vehicle makes the paint in the state of fluid and thus helps to spread the ingredients present in the paint uniformly over the surface to be painted. This forms a surface resistant to abrasion and also impermeable film on drying.

Refined linseed oil is commonly used vehicle in the case of oil paint, soyabean, sunflower, tobacco, etc., are also being used as vehicle in various combination with or without linseed oil.

5. Solvent / thinner

It is a liquid which thins the consistency of the paint and evaporates after the paint has applied to the surface. It imparts smoothness and easy flow of paint.

Turpentine, pure oil, petroleum spirit are commonly used as solvent or thinner

6. Drier

These are the materials containing metallic compounds and are used in small quantities for accelerating the drying of a paint. The driers should not be used in excess (not more than 10% of volume) if used in excess they tend to destroy the elasticity of the paint which finally leads to its flaking. Lead acetate, Mno2, cobalt are the commonly used driers.

Types of paints:

1. Aluminium paint: It consists of finely ground aluminium suspended in either quick-drying spirit varnish or slow drying oil varnish as per actual requirements. A thin metallic film of aluminium is formed When the spirit or oil evaporates. It is used for painting wood work or metal surfaces.

2. Anticorrosive paint: this paint is generally used as a metal protection paint for preserving structural steel work against the adverse effect of acid etc.,

3. Asbestos paint: this type of paint is especially suitable for patch work or stopping leakage of metal roof. It is also used for painting gutters in order to prevent rusting. Asbestos paint is sometimes used as damp proof cover for the outer surface of the wall

4. Bituminous paint: these are alkali resistant and it is used for painting exterior brick work and plastered surfaces, they are also used for water proofing and protection of iron and steel work which are under water. These paints get deteriorated when exposed to direct sunlight.

5. Bronze paint: this type of paint is often used for painting interior or exterior metallic surface on amount of its high reflective property it is commonly applied on radiators

6. Cellulose paint: this type of paint is made from celluloid sheet, it dries very quickly and possess additional advantage of hardening, flexibility and smoothness. It can be cleaned very easily and remain unaffected by hot water or acidic atmosphere, it is much superior to ordinary house paint and also very expensive. On amount of its high cost its usage is generally restricted for painting to motor cars, aero planes, etc.,

7. Casein paint: Casein is a protein substance extracted from milk curd which is mixed up with the base consisting of white pigment like titanium to form the paint, it is usually applied on walls, ceiling, cement blocks, etc., to enhance the appearance of the substance.

8. Cement based paint: this is a type of water paint in which cement farms the base. No oil or other organic matter is used in making this paint. This type of paint I available in packed powder form under different names (snow cem). This paint can be made by adding paint powder to water to obtain thick paste and thereafter diluting the paste with water to brush able consistence. This paint has to be used within one hour after mixing since the paint gets spoiled due to the settling of cement.

9. Enamel paint: it is made of adding pigments like white lead to a vehicle, here the vehicle is varnished. This paint can be used for interiors as well as exterior surface. They are not affected to any atmospheric changes

10. Oil paint: This type of paint can be used for almost all surfaces such as wooden, masonry, metal, etc.,

11. Rubber based paint: this type of paint has an excellent acid, alkali and water resistant property, it can be readily used for application on new concrete and lime plastered surface .

Defects in Painting:

The following defects may occur in painting work:

1. *Blistering*. It is the defect caused due to the formation of bubbles under the film of paint. The bubbles are formed by water vapors trapped behind the painted surface.

2. *Bloom*. In this defect, dull patches are formed on finished polished surface- This may be either due to defect paint or due to bad ventilation.

3. *Crawling or sagging*. This defect occurs due to the application of too thick a paint.

4. *Fading*. This is the gradual loss of colour of paint, due to the effect d sunlight on pigments of the paint.

5. *Flaking.* Flaking is the dislocation or loosening of some portion of the painted surface, resulting from poor adhesion

6. *Flashing.* It is the formation of glossy patches on the painted surface, resulting from bad workmanship, cheap paint or weather action.

7. *Grinning.* This defect is caused when the final coat does not have sufficient opacity so that background is clearly seen.

8. *Running*. This defect occurs when the surface to be painted is too smooth. Due to this, the paint runs back and leaves small areas of the surface uncovered.

9. *Sponification.* This is the formation of soap patches on the painted surface due to chemical action of alkalies.

Application of paints to new and old surfaces:

Repainting old work:

Before repainting old work, the old paint having cracks and blisters should be removed, by applying any one of the following solvents or paint removers:

1. Applying solution containing 1kg of caustic soda in 5 litres of water. The paint gets dissolved.

2. Applying mixture containing one part of soft soap, two parts of potash and one part of quick lime, while in hot state. After 24hs of the application, surface is washed with hot water.
3. Applying mixture of equal parts of washing soda and quicklime to the required consistency. After 1 hour or application, the surface is washed with water.

After removing the old paint, the surface is properly cleaned and then rubbed with pumice stone or glass paper. The cleaned surface is given two or three coats of paint to obtain the desired finish.

PAINTING NEW IRON AND STEEL WORK

Iron and steel surfaces are painted so that rusting is prevented. Hence surface should be prepared very carefully

1. The surface is cleaned off scale and rust etc. by scrapping or brushing with steel wire brushes. Oil, grease, etc., is removed by washing the surface with petrol, benzene or lime water.

2. The cleaned surface is treated with a film of phosphoric acid. This film protects the surface from rusting and provides better adhesive surface for the paint.

3. First coat is then applied with a brush. The coat consists of dissolving 3 kg of red lead in 1 litre of boiled linseed oil.

4. After prime coat dry. Two or three under coats are applied either with a brush or with spray gun. Each coat has to be applied only after previous coat gets completely dried. Under coat may consists of 3kg of red oxide, dissolved in 5liters of boiled linseed oil.

5. After the undercoat has dried, the final coat of the desired type of paint is applied. Finishing coat should present smooth finish.

Repainting old iron and steel work:

Before repainting, the old surface is thoroughly cleaned by application of soap water. The grease, if any, may be removed by washing the surface with lime and water. However if the old paint has cracked, it has to be removed by flame – cleaning. A flat oxy-acetylene flame is passed over the metal, burning off the old paint and loosening rust and scale, the surface is then scrapped with wire brush and washed with solution of caustic soda and fresh slaked lime. After the surface is thus prepared, painting is carried out as for the new surface.

Outcomes
Able to study the plastering in detail
Able to study the paints in details
Will be able to know the defects in plastering

Future Study
http://nptel.ac.in/syllabus/105102088/

Text Books:

1. Sushil Kumar "Building Materials and construction", 20th edition, reprint 2015,Standard Publishers
2. Dr. B.C.Punmia, Ashok kumar Jain, Arun Kumar Jain, "Building Construction, Laxmi Publications (P) ltd., New Delhi.
3. Rangawala S. C. "Engineering Materials", Charter Publishing House, Anand, India.

Reference Books:

1. S.K.Duggal, "Building Materials", (Fourth Edition)New Age International (P) Limited, 2016 National Building Code(NBC) of India
2. P C Vergese, "Buliding Materials", PHI Learning Pvt. Ltd
3. Building Materials and Components, CBRI, 1990, India
4. Jagadish.K.S, "Alternative Building Materials Technology", New Age International, 2007.
5. M. S. Shetty, "Concrete Technology", S. Chand & Co. New Delhi.

BUILDING MATERIALS AND CONSTRUCTION

MODULE WISE QUESTIONS

MODULE 1

1. List any four commonly used building stones and state their suitability in construction. (Dec.2013/Jan.2014)
2. Write the requirements of good building stones. (Dec.2016/Jan.2017)
3. Explain the factors causing deterioration of stonework and preservation of stonework. (Dec.2016/Jan2017)
4. Briefly explain the tests conducted on bricks. (Dec.2016/Jan.2017)
5. Write the requirements of good mortar. (Dec.2016/Jan.2017)
6. Briefly explain the tests conducted on fine aggregates. (a) Sieve analysis. (b) Specific gravity test. (Dec.2016/Jan.2017)
7. Mention the qualities of good bricks. (June 2012)
8. List any four commonly used building stones and state their suitability in construction. (Dec.2013/Jan2.2014)
9. Explain physical and chemical classification of rocks. (Dec.2018/Jan.2019)
10. List and explain laboratory tests on bricks. (Dec.2018/Jan.2019)
11. Explain bulking of sand. (Dec.2018/Jan.2019)
12. Which are the constituents of good brick earth? Explain. (Dec.2018/Jan.2019)
13. What is quarrying of stones? Explain methods of quarrying. (Dec.2018/Jan.2019)
14. Explain the importance of shape, size and texture of coarse aggregates in cement concrete making. (Dec.2018/Jan.2019)
15. What are the requirements of good building stone? Explain the dressing of stones. (June/July2018)
16. List the various tests conducted on coarse aggregate. Explain any one of them in brief. (June/July2018)
17. Explain the different types of preservations commonly adopted in the preservation of stones. (June/July2018)
18. What are the requirements of good bricks and explain the field and laboratory tests on bricks. (June/July2018)

MODULE 2

1. Explain the essential requirements of good foundation. (Dec.2013/Jan.2014)
2. What is the safe bearing capacity of a soil? Briefly explain various methods adopted to improve it. (Dec.2013/Jan.2014)
3. Draw neat labelled sketches of the following types of foundations and explain where they are adopted (a) raft foundation. (b) strap foundation. (Dec.2013/Jan.2014)
4. Explain any two of the following: (a) Reinforced brick work. (b) Partition walls. (c) Cavity walls. (Dec.2013/Jan.2014)
5. Draw neat sketches of the following and explain: (a) Ashlar masonry. (b) rubble masonry. (Dec.2013/Jan.2014)
6. Explain the essential requirements of good foundation. (Dec.2016/Jan2017)
7. What is the safe bearing capacity of a soil? Briefly explain various methods adopted to improve it. (Dec.2016/Jan.2017)
8. Two loads of 1000KN and 1500KN are carried by square columns 500mm*500mm and 600mm*600mm respectively. The center to center distance between the columns is 5m. th footing is not to project more than 250mm beyond the outer edge of the smallest column. The allowable bearing capacity of the soil on which the columns are to rest is 250KN/m^{2-}. determine the dimensions of the combined footing. (Dec.2016/Jan.2017)
9. Sketch the elevation of brick wall build in a) English Bond b) Flemish Bond. Compare the merits and demerits of English bond and Flemish bond. (Dec.2016/Jan.2017)
10. Draw neat sketches of the following and explain: (a) Ashlar masonry. (b) Rubble masonry. (Dec.2016/Jan.2017)
11. Explain the essential requirements of good foundation. (Dec.2016/Jan2017)
12. With neat sketches, explain the following types of foundation: a) Combined footing b) strap footing. (Dec.2016/Jan2017)
13. With neat sketches, write the features of English bond and Flemish bond. (Dec.2016/Jan2017)
14. Briefly explain the classification of stone masonry. (Dec.2016/Jan2017)
15. With neat sketch, explain various joints provided in the stone masonry. (Dec.2016/Jan2017)
16. Write the advantages of cavity walls. (Dec.2016/Jan2017)
17. Explain the essential requirements of good foundation. (Dec.2015/Jan2016)
18. Explain with neat sketches various types of foundation. (Dec.2015/Jan2016)
19. What is meant by combined footing? What do you adopt it? (Dec.2015/Jan2016)
20. What is the safe bearing capacity of a soil? Briefly explain various methods adopted to improve it. (Dec.2015/Jan.2016)
21. Compare English bond, Flemish bond and double Flemish bond. (Dec.2015/Jan2016)
22. Explain classification of stone masonry. (Dec.2015/Jan2016)
23. Compare brick masonry and stone masonry. (Dec.2015/Jan2016)
24. Explain the essential functions and requirements of good foundation. (Dec.2014/Jan2015)
25. With neat sketches, explain the following types of foundation: a) mat foundation. b) pile foundation. (Dec.2014/Jan2015)
26. Find the dimensions of a combined rectangular footing for two columns A and B carrying loads of 500KN and 700KN respectively. Column A is 30cm*30cm in size and column B is

40cm*40cm in size. The center to center spacing of columns is 3.4m. the SBC of the soil may be taken as 150KN/m^2. (Dec.2014/Jan2015)

27. Explain the classification of masonry briefly explain with neat sketches: a) Stretcher b) types of closure c) header d) quoin. (Dec.2014/Jan2015)
28. With a neat figure explain various types of joints used in stone masonry. (Dec.2014/Jan2015)
29. Lit the requirements hat foundation should satisfy. (Dec2011)
30. Define shallow and deep foundation. Explain with neat sketches. (Dec2011)
31. Explain the meaning of masonry bonds. Indicate which component of masonry is a weaker component. For brick masonry, indicate what features of masonry bonds that increase the strength of soil. (Dec2011)
32. Sketch the plans of consecutive two layers of English and Flemish bonds for a single brick thick wall. Name bricks in different locations on the sketch. (Dec2011)
33. Sketch random rubble masonry in stones in elevation and section. Mark through stone and lap length on the sketch. (Dec2011)
34. Define foundation and discuss various functions of foundation. (June/July2013)
35. What are the causes of failure of foundation? (June/July2013)
36. Mention different types of foundations? Under what circumstances pile foundation being adopted? (June/July2013)
37. Explain with neat sketch random rubble masonry. (June/July2013)
38. Draw the plan of $1^1/_2$ brick wall of English bond. (June/July2013)
39. What are the different types of foundations? Under what circumstances they are adopted? (June2012)
40. Define SBC of soil. Explain in detail, procedure for proportioning a rectangular footing for two columns carrying unequal load. (June2012)
41. List different methods of site exploration and explain any one of them. (June2012)
42. With reference to masonry construction, briefly explain the following terms: a) header and stretcher b) bond and course (June2012)
43. Write on Flemish bond in brick masonry. (June2012)
44. State advantages and disadvantages of stone masonry construction over brick masonry construction. (June2012)
45. Explain in detail the plate load test for SBC of soil. (Dec2012)
46. Enumerate the various methods of sub soil exploration. What are the factors on which the choice of a particular method depends? (Dec2012)
47. Mention the situations in which the pile foundations are adopted and also explain the classification of pile foundation. (Dec2012)
48. Sketch the elevation of a brick wall built in a) English bond b) Flemish bond. Compare the merits and demerits of both. (Dec2012)
49. Explain the sketches, various types of joints in stone masonry. (Dec2012)
50. Explain the essential requirements of good foundation. (June/July2018)
51. With the help of neat sketches explain various types f joints used in stone masonry. (June/July2018)
52. What is SBC? Briefly explain various methods adopted to improve SBC. (June/July2018)
53. Explain the following: a) header b) Flemish bond c) load bearing d) partition walls. (June/July2018)
54. What is foundation? Explain the functions of foundation. (Dec.2018/Jan2019)
55. Explain strip footing and strap footing with sketches. (Dec.2018/Jan2019)

56. What are special features of English bond? Explain $1^1/_2$ brick thick wall. (Dec.2018/Jan2019)
57. What is pile foundation? Explain with sketches the classification of pie foundation based on its function. (Dec.2018/Jan2019)
58. Differentiate between random rubble masonry and course rubble masonry. (Dec.2018/Jan2019)
59. Draw the plan of $1^1/_2$ brick thick Flemish bond and explain its salient features. (Dec.2018/Jan2019)

MODULE 3

1. Explain the following terms with respect to an arch: key stone, span, intrados, rise, voussoirs. (Dec.2013/Jan2014)
2. Define lintel and chajja. Draw a neat labelled diagram of a reinforced concrete lintel with chajja projection showing the position of reinforcement. (Dec.2013/Jan2014)
3. Give the classification of arches and explain stability of an arch. (Dec.2013/Jan2014)
4. Discuss the advantages of a flat roof. Briefly explain its advantages. (Dec.2013/Jan2014)
5. List he types of pitched roof. (Dec.2013/Jan2014)
6. Discuss the various flooring material used briefly. Explain any two of them in detail. (Dec.2013/Jan2014)
7. What are the advantages of an arch over a beam of same span? (Dec.2016/Jan.2017)
8. Sketch an RCC lintel for windows in brick masonry. Show arrangement of steel bars in it. (Dec.2016/Jan.2017)
9. Give the classification of arches and explain stability of an arch. (Dec.2016/Jan.2017)
10. Sketch a king post truss with timber, provided with tile roofing. Name various components of truss on the sketch. Indicate which members are subjected to compression and tension. (Dec.2016/Jan.2017)
11. What are the factors affecting the choice of flooring material? (Dec.2016/Jan.2017)
12. What are the materials used for flooring? (Dec.2016/Jan.2017)
13. Define lintel and write the function of lintel. (Dec.2016/Jan.2017)
14. With neat sketch explain various components of segmental arch. (Dec.2016/Jan.2017)
15. Write the requirements of good floor and factors affecting the selection of flooring material. (Dec.2016/Jan.2017)
16. Write the requirements of good roof. (Dec.2016/Jan.2017)
17. How do u classify arches? (Dec.2015/Jan.2016)
18. Define lintel How are they classified according to the materials of their construction. (Dec2015/Jan2016)
19. Draw a neat sketch of a segmental arch and explain various technical terms used in arch work (Dec2015/Jan2016)
20. Explain types of pitched roof. (Dec2015/Jan2016)
21. Write the advantages and disadvantages of flat roof over pitched roof. (Dec.2016/Jan.2017)
22. Factors affecting the choice of a flooring materials, briefly explain. (Dec2015/Jan2016)
23. With the help of neat sketch, explain various components of queen post truss. (Dec.2016/Jan.2017)
24. Draw a neat sketch of king post truss and show the various components. (Dec2015/Jan2016)
25. Distinguish clearly between a lintel and an arch. How does a flat stone arch differ from a stone lintel? (Dec2014/jan2015)
26. Briefly explain the functions of chejja, canopy nd balcony. (Dec2014/jan2015)
27. Explain briefly with the neat sketches: pitched roofs, flat roofs. (Dec2014/jan2015)
28. Explain types of flooring and factors affecting the selection of flooring materials. (Dec2014/jan2015)
29. Sketch a semi circular arch and show on it the following: keystone, springing line, voussers, intrados, extrados, rise, span, spandrel. (Dec2011)
30. Indicate structural advantage of a arch over a beam of same span. (Dec2011)
31. Sketch an RCC lintel for window in brick masonry. Show arrangement of steel bars in it. (Dec2011)

32. Sketch a king post truss with timber, provided with tile roofing. Name various components of truss on the sketch. Indicate which members are subjected to compression and which members are subjected to tension. (Dec2011)
33. Name different types of floorings used in buildings. Indicate types of floorings suitable for following situations: a) floor should not make noise while in use. B) floor should be warm in winter and cool in summer. c) flooring should be inexpensive. D) floor should be waterproof. (Dec2011)
34. Sketch an RCC flat roof and indicate details of reinforcements. Discuss two advantages and disadvantages of such a roof. (Dec2011)
35. Define a lintel. Explain RCC lintel with neat sketch. (June/July2013)
36. Suggest suitable measures to avoid failure of an arch. (June/July2013)
37. Draw he neat sketch of the following: segmental arch and relieving arch. (June/July2013)
38. Define roof. What are the requirement of a good roof? (June/July2013)
39. What are the factors affecting selection of flooring materials? (June/July2013)
40. Sketch neatly lean to roof and name the parts. (June/July2013)
41. Explain with neat sketch functions of lintel, chezza and canopy n buildings. (June2012)
42. How are arches classified? How do you asses the stability of an arch? (June2012)
43. Draw a neat sketch of an arch and label vairous technical terms used in construction. (Dec2012)
44. Explain briefly different types of roof covering materials used in our country. (June2012)
45. What are the factors affecting that govern the selection of roofing materials? List the different types of flooring. (June2012)
46. Classify various types of lintels and discuss their importance. (Dec2012)
47. Draw a neat sketch of steel roof truss indicting bearing plate, purlins, and roof coverings. Name all the parts. (June2012)
48. Sketch the elevation of wooden queen post truss. Label the different parts. (Dec2012)
49. Write short notes on the following types of flooring: asphalt flooring, linoleum flooring, PVC flooring. Cork flooring and rubber flooring. (Dec2012)
50. Explain following terms with respect to arch: keystone, span, intrados, rise, vousoirs. (Dec2013/Jan2014)
51. Define lintel and chajja. Draw a neat labelled diagram of a reinforced concrete lintel with chajja projection showing the position of reinforcement. (Dec2013/Jan2014)
52. Give the classification of arches and explain stability of an arch. (Dec2013/Jan2014)
53. Discuss the advantages of a flat roof. Briefly explain its advantages. (Dec2013/Jan2014)
54. List the types of pitched roof. (Dec2013/Jan2014)
55. Discuss the various flooring materials used briefly. Explain any two of them in detail. (Dec2013/Jan2014)
56. Define lintel and mention its functions and classification. (June/July2018)
57. Sketch a king post truss made of timber, which has to support tile roofing. Name the components. (June/July2018)
58. Give the classification of arches and explain its stability. (June/July2018)
59. Discuss the various flooring materials used and explain any two of them in detail. (June/July2018)
60. Explain the following with sketch; a) RCC lintel b) stone lintel. (Dec2018/Jan2019)
61. Discuss various modes of failure of an arch and what are its remedies? (Dec2018/Jan2019)
62. Draw a neat sketch of king post wooden roof truss and label its parts. (Dec2018/Jan2019)

63. Mention the types of sloped roof. Explain any three types of sloped roof with sketches. (Dec2018/Jan2019)
64. What are the requirements of good floor? What are the components of ground floor with mosaic flooring? (Dec2018/Jan2019)
65. What is an arch? Draw the sketch of elemental arch. (Dec2018/Jan2019)

MODULE 4

1. Write short notes on the following: collapsible steel door and bay window. (Dec2013/Jan2014)
2. Explain the factors to be considered while locating th positions of doors and windows in a building. (Dec2013/Jan2014)
3. What are the salient features o a framed paneled door? Explain. (Dec2013/Jan2014)
4. Draw the plans of the following types of stairs. Briefly explain them. Dog legged stairs and open newel stairs. (Dec2013/Jan2014)
5. Draw the section of a typical stair and level all the parts explain each part. (Dec2013/Jan2014)
6. Explain the terms: shoring, slip forming and guiniting. (Dec2013/Jan2014)
7. Write a neat sketch of a door with a single shutter and its door frame. Name different components of frame and shutter. (Dec2016/Jan2017)
8. Explain along with sketch: collapsible door and bay window. (Dec2016/Jan2017)
9. State and briefly explain the requirement of good stair. (Dec2016/Jan2017)
10. Explain different types of stairs. (Dec2016/Jan2017)
11. Define shoring. Explain different types of shoring. (Dec2016/Jan2017)
12. Explain the following with neat sketches: partly paneled, glazed doors and revolving doors. (Dec2016/Jan2017)
13. Explain the following with sketches: bay window and corner window (Dec2016/Jan2017)
14. Write the requirements of good stairs. (Dec2016/Jan2017)
15. Explain the classification of stairs. (Dec2016/Jan2017)
16. Write short notes on: shoring and underpinning. (Dec2016/Jan2017)
17. List the factors affecting the selection of doors and windows. (Dec2015/Jan2016)
18. Explain types of doors. (Dec2015/Jan2016)
19. Write a note on the following: bay windows and clear- storey window. (Dec2015/Jan2016)
20. What are the requirements of good stair. (Dec2015/Jan2016)
21. Explain classification of stairs. (Dec2015/Jan2016)
22. Draw plan and section of typica dog legged RCC stair. (Dec2015/Jan2016)
23. What do you understand by underpinning? When do you require it? Explain the pit method of underpinning. (Dec2015/Jan2016)
24. Explain briefly any five with neat sketch: landing, newel post, hand rail, flight, baluster, riser and tread. (Dec2014/Jan2015)
25. Explain briefly any five with neat sketch: casement window. Sash door, battened and legged doors, framed and paneled doors, dormer window, corner window. (Dec2014/Jan2015)
26. Define with neat sketch: frame, shutter, panel and style. (Dec2014/Jan2015)
27. Define: smart materials, form work and scaffolding. (Dec2014/Jan2015)
28. Sketch a door with a single shutter and its door frame. Name different components of frame and shutter. (Dec2011)
29. Write a note on windows function in northern hemisphere of the earth. (Dec2011)
30. Explain with a neat sketch louvered window with glass louvers. explain use of plastic louvers in an office building. (Dec2011)
31. Sketch a dog legged stair case in RCC in plan and elevation for a residential building. (Dec2011)
32. Define roof. What are the requirement of a good roof. (June/July2013)

33. Define the terms used in doors and windows: frame, shutters, style, panel, loclrail. (June/July2013)
34. Write briefly on any one of the following with sketches: panneled door, bay window, ventilators and revolving doors. (June/July2013)
35. Draw the elevation and section of a glazed window. (June/July2013)
36. What are requirements of a good stairs? (June/July2013)
37. What are the requirements of good formwork? (June/July2013)
38. What do you mean by shoring and underpinning? (June/July2013)
39. Explain briefly with sketches: fully paneled door, rolling shutters. (June2012)
40. List all the fixtures and fastenings for doors and windows. (June2012)
41. List different types of windows used in buildings and explain an two of them. (June2012)
42. List different types of staircases and explain under what circumstances they are used. (June2012)
43. Sketch the section across the beam, the formwork required for beam and slab floor giving details of its components. (July2012)
44. What are the factors considered while locating doors and windows. (Dec2012)
45. Draw labelled sketch of battened legged and braced door. (Dec2012)
46. Write notes on following: landing, nosing, going, stringer, newelpost, handrail. (Dec2012)
47. State briefly the requirements of good stairs. (Dec2012)
48. Differentiate between a) helical stair and spiral stair. b) RCC stair with slab spanning horizontally and slab spanning longitudinally. (Dec2012)
49. Write short notes on: a) scaffolding b) underpinning. (Dec2012)
50. Write short notes on: a) collapsible steel door b) bay window. (Dec2013/Jan2014)
51. What are the factors considered while locating doors and windows. (Dec2013/Jan2014)
52. What ae salient features of framed paneled door? (Dec2013/Jan2014)
53. Draw the plans of the following type of stairs. Briefly explain them: dog legged stairs, open newel stairs. (Dec2013/Jan2014)
54. Draw the section of a typical stair and level all the parts? Explain each part. (Dec2013/Jan2014)
55. Explain the terms: shoring, slip forming and guiniting. (Dec2013/Jan2014)
56. Explain salient features of framed and paneled door with sketch. (Dec 2018/Jan2019)
57. Differentiate between bay window and corner window with sketches. (Dec 2018/Jan2019)
58. What are the requirements of good stair? (Dec 2018/Jan2019)
59. What is shoring/ explain raking shore with a sketch. (Dec 2018/Jan2019)
60. What are the requirements of locating doors and windows? (Dec 2018/Jan2019)
61. Briefly explain the factors to be considered while locating doors and windows. (June/July208)
62. With the help of a neat sketch briefly explain the do legged staircase and its components. (June/July208)
63. With the help of a neat sketch explain the following: wooden paneled door and collapsible door. (June/July208)
64. Write a note o different type of stairs and explain the requirements of a good stair. (June/July208)

MODULE 5

1. Explain various defects in plastering. (Dec2013/Jan2014)
2. List the various constituents of good paint. (Dec2013/Jan2014)
3. Explain the process of distempering. (Dec2013/Jan2014)
4. Discuss the causes and effects of dampness in a building. (Dec2013/Jan2014)
5. List the important properties and uses of the following building materials: aluminum, plastic and varnish. (Dec2013/Jan2014)
6. Mention and explain different types of paints. (Dec2016/Jan2017)
7. What are the defects in plastering? (Dec2016/Jan2017)
8. What is pointing? Explain different types of pointing. (Dec2016/Jan2017)
9. Explain damp proofing? What are the causes of dampness? (Dec2016/Jan2017)
10. Write the objectives of plastering and requirement of good plaster. (Dec2016/Jan2017)
11. Discuss the defects in plastering. (Dec2016/Jan2017)
12. Briefly explain method of applying stucco plastering. (Dec2016/Jan2017)
13. Briefly explain the method of damp proofing. (Dec2016/Jan2017)
14. Explain in brief defects in painting and constituents of paint. (Dec2016/Jan2017)
15. Describe the procedure of painting on new wood work. (Dec2016/Jan2017)
16. What are the main objectives of plastering? (Dec2015/Jan2016)
17. Explain types of plaster finishes. (Dec2015/Jan2016)
18. What are the defects in painting? (Dec2015/Jan2016)
19. Explain the procedure of painting: a) wood surface b) plastered surface c) iron and steel surface. (Dec2015/Jan2016)
20. Explain methods of damp proofing. (Dec2015/Jan2016)
21. What are the materials used for damp proofing course? (Dec2015/Jan2016)
22. Explain purpose of plastering. Explain methods of plastering. (Dec2014/Jan2015)
23. Explain in brief defects in painting and constituents of a paint. (Dec2014/Jan2015)
24. Define: a) smart materials b) form work and scaffolding. (Dec2014/Jan2015)
25. Explain in brief causes and effects of dampness in building. (Dec2014/Jan2015)
26. Describe procedure for application of pant on wood surface and on new plastered surface with cement mortar. (Dec2011)
27. Discuss defects in plastering. (Dec2011)
28. Describe procedure of providing stucco plastering. (Dec2011)
29. Write short notes on: a) damp proof course b) varnish. (Dec2011)
30. What are the objects of plastering? List the requirements of a good plaster. (June/July2013)
31. What are the defects arise in plastering? (June/July2013)
32. Explain the procedure of painting for iron and steel surfaces. (June/July2013)
33. What is damp course? Explain its necessity I a building. (June/July2013)
34. Briefly explain the constituents of paint. (June2012)
35. Mention the type of paint to be used and procedure of applying them on the following: inner walls of residential buildings, outer walls of building and doors and windows. (June2012)
36. Explain different types of plaster finishes. (July2012)
37. What is damp proof course? Explain its necessity in building. (July2012)
38. Explain the purpose of plastering. Explain the various type of mortars used for plastering. (Dec2012)
39. What is the purpose of painting? (Dec2012)
40. Mention the characteristics of an ideal paint. (Dec2012)

41. What are the effects of dampness? Mention the methods of damp proofing. (Dec2012)
42. Explain various defects in plastering. (Dec2013/Jan2014)
43. List the various constituents of paint. Discuss each constituent of paint. (Dec2013/Jan2014)
44. Explain the process of distempering. (Dec2013/Jan2014)
45. Discuss the causes and effects of dampness in a building. (Dec2013/Jan2014)
46. List the important properties and uses of the following building materials: aluminum, plastic, varnish. (Dec2013/Jan2014)
47. Briefly explain the purpose of plastering and explain the various methods of plasters. (June/July2018)
48. Explain in briefly causes and effects of dampness in a building. (June/July2018)
49. What are the objects of plastering and painting? (June/July2018)
50. Describe the different types of paints available in market and their specific usage. (June/July2018)
51. Discuss the defects in plastering. (Dec2018/Jan2019)
52. Name and explain the constituents of oil paint. (Dec2018/Jan2019)
53. What are the causes of damping in the building and what are its remedies? (Dec2018/Jan2019)
54. Explain the objects of plastering and types of plaster finishing. (Dec2018/Jan2019)
55. Explain the procedure of painting for the following: new wood work surface and new plastered surface. (Dec2018/Jan2019)
56. Differentiate between stucco plastering and lathe plastering. (Dec2018/Jan2019)