Unit 1 properties of construction materials

Stones (Dressed) – Bricks – Cement – Steel – Sand and Quarry Dust – Timber – FRP (Fibre Reinforced Polymer) – Composite Materials – Physical And Chemical Properties – Manufacturing Process – Classification – Test On Materials – IS Standards And Specifications For Use In Construction As Per SP 21:1983

Dressed stone. A **stone** that has been worked to a desired shape; the faces to be exposed are smooth, usually ready for installation.




Stone found in nature, have to be quarried from their thick beds. After quarrying large pieces of rocks, it is essential to break them into smaller sizes so that they can be used in buildings.
A place where exposed surfaces of good quality natural rocks are abundantly available is known as “quarry,” and the process of taking out stones from the natural bed is known as “quarrying.”
This is done with the help of hand tools like a pickaxe, chisels, etc., or with the help of machines. Blasting using explosives is another method used in quarrying.

The dressing of stones is important so that they are dressed in suitable shapes and polished to give a smooth surface if desired.

The stones are used in different types of masonry; therefore, it has to be cut and shaped to fit in the type of work needed.

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

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 costs.

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(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.
Stone surfaces can be made very decorative and of appealing appearance, which will last for a considerable time. A stone house has its distinct individuality in a city of concrete structures.

Stages in the Dressing of Stone (manufacturing process)

The different stages of dressing of stones are:

1. Sizing:
It is the process of inducing the irregular blocks to the desired dimensions by removing extra portions. It is done with the help of hand hammers and chisels.

2. Shaping:
This follows sizing and involves removing the sharp projections. Many stones are used in common construction after shaping.

3. Planning:
This is rather an advanced type of dressing in which the stone is cleared off all the irregularities from the surface.

4. Finishing:
This is done only in case of specially dressed stones and consists of rubbing of the surface of stones with suitable abrasive materials such as silicon carbide.

5. Polishing:
This is the last stage in dressing and is only done on marbles, limestone, and granite.

Methods 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.

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(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.

A hammered-dressed stone has no sharp and irregular corners and has a comparatively even surface to fit well in the masonry.
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 using the 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, and any excessive stone from the center is then removed.

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 (4-5 cm), more or less parallel to the tool marks, 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:
A punched stone is then further dressed so as to obtain a finer surface.

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 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 is 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.

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(xv) Polished Surfaces:
Stones that 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 lettering and design on the surface of the granite.

The polished surface is coated with a molten rubber-like compound that 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.

Classification:

There are several types of finish that can be achieved by stone dressing:

- Axed: Hard stones such as granite are dressed using a stone axe.
- Boasted: A boaster is used to create parallel horizontal, vertical or inclined lines.
- Combed: A steel comb with sharp teeth is dragged in all directions across the surface of soft stones.
- Circular: Predominantly used for columns, circular finished stones are made into a rounded shape.
- Chisel-drafted margins: A chisel is used on stones forming uniform joints to create pitched, square or chamfered margins.
- Furrowed: The middle portion of the stone projects from the sides by around 15 mm, and deep grooves made across it.
- Moulded: Stones are moulded into decorative strips of various shapes.
- Polished: Usually for marbles, granites and so on.
- Punched: A machine depresses the stone surface creating hollows and ridges.
- Reticulated: A margin is left around the surface, and irregular shapes formed in the finish.
- Rusticated: A rough or patterned surface is cut into the visible face of masonry blocks.
- Scrabbling: Irregular projections are removed using a scrabbling hammer leaving a rough finish.
- Sunk: The original surface is depressed into wide grooves, marks, and so on.
- Vermiculated: Similar to reticulated but the shapes are curved, giving a 'worm-eaten' aesthetic.

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ENGINEERING & PHYSICAL PROPERTIES OF STONES

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

1. 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.

2. TEXTURE

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

3. DENSITY

Denser stones are stronger. Light weight stones are weak. Hence stones with specific gravity less than 2.4 are considered unsuitable for buildings.

4. APPEARANCE

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

5. STRENGTH

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

Crushing strength of common building stones

Name of Stone	**Crushing Strength in N/mm^2**
Trap	300 to 350

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Basalt	153 to 189
Granite	104 to 140
Slate	70 to 210
Marble	72
Sand stone	65
Lime stone	55
Laterite	1.8 to 3.2

6. 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.

7. 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%.

8. POROSITY AND ABSORPTION

All stones have pores and hence absorb water. The reaction of water with 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.

9. WEATHERING

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

10. TOUGHNESS

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

11. RESISTANCE TO FIRE

Sand stones resist fire better. Argillaceous materials, though poor in strength, are good in resisting fire.

12. 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.

13. 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.

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

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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.

This test is usually carried out on sandstones.

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.

Crystalline Test on Building Stone

At least four cubes of stone with side as 40mm are taken. They are dried for 72 hrs and weighed. They are then immersed in 14% solution of Na_2SO_4 for 2 hours. They are dried at 100 degree C and weighed. Difference in weight is noted.

This procedure of drying, weighing, immersion and reweighing is repeated at least 5 times. Each time, change in weight is noted and it is expressed as a percentage of original weight.

Crystallization of $CaSO_4$ in pores of stone causes decay of stone due to weathering. But as $CaSO_4$ has low solubility in water, it is not adopted in this test.

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.

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: A **brick** is a type of block used to make walls, pavements and other elements in masonry construction. Traditionally, the term brick referred to a unit composed of fired clay, but it is now used to denote rectangular units made of clay-bearing soil, sand, and lime, or concrete materials. Bricks can be joined together using mortar, adhesives or by interlocking them.[1][2] Bricks are produced in numerous classes, types, materials, and sizes which vary with region and time period, and are produced in bulk quantities. Two basic categories of bricks are fired and non-fired bricks.

Block is a similar term referring to a rectangular building unit composed of similar materials, but is usually larger than a brick. Lightweight bricks (also called lightweight blocks) are made from expanded clay aggregate.

Fired bricks are one of the longest-lasting and strongest building materials, sometimes referred to as artificial stone, and have been used since circa 4000 BC. Air-dried bricks, also known as mudbricks, have a history older than fired bricks, and have an additional ingredient of a mechanical binder such as straw.

Bricks are laid in courses and numerous patterns known as bonds, collectively known as brickwork, and may be laid in various kinds of mortar to hold the bricks together to make a durable structure.

Types

This wall in Beacon Hill, Boston shows different types of brickwork and stone foundations

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There are thousands of types of bricks that are named for their use, size, forming method, origin, quality, texture, and/or materials.

Categorized by manufacture method:

- Extruded – made by being forced through an opening in a steel die, with a very consistent size and shape.
  - Wire-cut – cut to size after extrusion with a tensioned wire which may leave drag marks
- Moulded – shaped in moulds rather than being extruded
  - Machine-moulded – clay is forced into moulds using pressure
  - Handmade – clay is forced into moulds by a person
- Dry-pressed – similar to soft mud method, but starts with a much thicker clay mix and is compressed with great force.

Categorized by use:

- Common or building – A brick not intended to be visible, used for internal structure
- Face – A brick used on exterior surfaces to present a clean appearance
- Hollow – not solid, the holes are less than 25% of the brick volume
  - Perforated – holes greater than 25% of the brick volume
- Keyed – indentations in at least one face and end to be used with rendering and plastering
- Paving – brick intended to be in ground contact as a walkway or roadway
- Thin – brick with normal height and length but thin width to be used as a veneer

Specialized use bricks:

- Chemically resistant – bricks made with resistance to chemicals
  - Acid brick – acid resistant bricks
- Engineering – a type of hard, dense, brick used where strength, low water porosity or acid (flue gas) resistance are needed. Further classified as type A and type B based on their compressive strength
  - Accrington – a type of engineering brick from England
- Fire or refractory – highly heat-resistant bricks
  - Clinker – a vitrified brick
  - Ceramic glazed – fire bricks with a decorative glazing

Bricks named for place of origin:

- Cream City brick – a light yellow brick made in Milwaukee, Wisconsin
- Dutch – a hard light coloured brick originally from the Netherlands
- Fareham red brick – a type of construction brick

- London stock – type of handmade brick which was used for the majority of building work in London and South East England until the growth in the use of machine-made bricks
- Nanak Shahi bricks – a type of decorative brick in India
- Roman – a long, flat brick typically used by the Romans
- Staffordshire blue brick – a type of construction brick from England
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  Clay bricks are classified as first class, second class, third class and fourth class based on their physical and mechanical properties.

  - **First Class Bricks**
  -
  - 1. These are thoroughly burnt and are of deep red, cherry or copper colour.
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  - 2. The surface should be smooth and rectangular, with parallel, sharp and straight edges and square corners.
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  - 3. These should be free from flaws, cracks and stones.
  - 4. These should have uniform texture.
  - 5. No impression should be left on the brick when a scratch is made by a finger nail.
  - 6. The fractured surface of the brick should not show lumps of lime.
  - 7. A metallic or ringing sound should come when two bricks are struck against each other.

  - 9. Water absorption should be 12-15% of its dry weight when immersed in cold water for 24 hours. The crushing strength of the brick should not be less than 10 N/mm^2. This limit varies with different Government organizations around the country.

  - Uses: First class bricks are recommended for pointing, exposed face work in masonry structures, flooring and reinforced brick work.

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- **Second Class Bricks** are supposed to have the same requirements as the first class ones except that
- 1. Small cracks and distortions are permitted.
- 2. A little higher water absorption of about 16-20% of its dry weight is allowed.

- 3. The crushing strength should not be less than 7.0 N/mm^2.
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- Uses: Second class bricks are recommended for all important or unimportant hidden masonry works and centering of reinforced brick and reinforced cement concrete (RCC) structures.

- **Third Class Bricks** are underburnt. They are soft and light-coloured producing a dull sound when struck against each other. Water absorption is about 25 per cent of dry weight.
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- Uses : It is used for building temporary structures.
- **Fourth Class Bricks** are overburnt and badly distorted in shape and size and are brittle in nature. Uses: The ballast of such bricks is used for foundation and floors in lime concrete and road metal.

Properties of bricks:

The essential properties of bricks may be conveniently discussed under the following four headings: physical, mechanical, thermal and durability properties.

- **(1) Physical Properties of Bricks.**
- These properties of bricks include shape, size, color, and density of a brick.

- (i) Shape.
- The standard shape of an ideal brick is truly rectangular. It has Well defined and sharp edges. The surface of the bricks is regular and even.
- Special purpose bricks may, however, be either cut or manufactured in various other shapes. These are generally modifications of rectangular shapes.

- (ii) Size.
- The size of brick used in construction varies from country to country and from place to place in the same country.

- **In India,** the recommended standard size of an ideal brick is 19 x 9 x 9 cm which with mortar joint gives net dimensions of 20 x 10 x 10 cm.
- These dimensions have been found very convenient in handling and making quantity estimates. Five hundred such bricks will be required for completing 1 m^3 brick masonry.

- It may be interesting to note that **in U.K, U.S**, the commonly used bricks have following dimensions:
- **The Standard size of Brick in India, US, UK.**

Country	**Length (cm)**	**Thickness (cm)**	**Height (cm)**
Standard Size of Brick in UK.	20	9.5	5.5
Standard Size of Brick in US.	20	10	10
Standard Size of Brick in India.	19	9	9

- (iii) Color.
- The most common color of building bricks falls under the class RED. It may vary from deep red to light red to buff and purple.

- Very dark shades of red indicate over burnt bricks whereas yellow color is often indicative of under-burning.
- (iv) Density.
- The density of bricks or weight per unit volume depends mostly on the type of clay used and the method of brick molding (soft-mud, Stiff-mud, hard-pressed etc.).
- In the case of standard bricks, density varies from 1600 kg/cubic meter to 1900 kg/cubic meter.

- A single brick (19 x 9 x 9 cm) will weigh between 3.2 to 3.5 kg. depending upon its density.

2) Mechanical Brick Properties.
Under this heading of properties of bricks, compressive strength and flexure strength are included.

(i) Compressive Strength of Bricks.
It is the most important property of bricks especially when they are used in load-bearing walls.

The compressive strength of a brick depends on the composition of the clay and degree of burning. It may vary from 35 kg/cm^2 to more than 200 kg/cm^2 in India.
It is specified under the I.S.S. codes that an ordinary type building brick must possess a minimum compressive strength of 35 kg/cm^2 .
The first and 2nd class bricks shall have a compressive strength not less than 70 kg/cm^2 and 140 kg/cm^2 respectively.

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(ii) Flexure Strength.
Bricks are often used in situations where bending loads are possible in a building. As such, they should possess sufficient strength against transverse loads.

It is specified that the flexural strength of a common building brick shall not be less than 10 kg/cm^2.
Best grade bricks often possess flexural strength over 20 kg/cm^2.
Similarly, it is required that a good building brick shall possess a shearing strength of 50-70 kg/cm^2.
Read More: Reinforced Cement Concrete | Advantages, Uses, Types, & Purpose.
(3) Thermal Properties of Building Bricks.
Besides being hard and strong, ideal bricks should also provide an adequate insulation against heat, cold and noise.

The heat and sound conductivity of bricks vary greatly with their density and porosity.

Very dense and heavy bricks conduct heat and sound at a greater rate. They have, therefore, poor thermal and acoustic (sound) insulation qualities.
For this reason, bricks should be so designed that they are light and strong and give adequate insulation.

(4) Durability.
By durability of bricks, it is understood that the maximum time for which they remain unaltered and strong when used in construction.

Experience has shown that properly manufactured bricks are among the most durable of man-made materials of construction. Their life can be counted in hundreds of years.
The durability of bricks depends on some factors such as: absorption value, frost resistance, and efflorescence.

(i) Absorption Value.
This property is related to the porosity of the brick.

True Porosity is defined as the ratio of the volume of pores to the gross volume of the sample of the substance.

Apparent porosity, more often called Absorption value or simply absorption, is the quantity of water absorbed by the (brick) sample. This is expressed in percentage terms of the dry weight of the sample:

Absorption=$W_2 - W_1 / W_1 \times 100$
Where W2 is weight after 24 hours of immersion in water and W1 is the oven dry weight of the sample.

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The absorption values of bricks vary greatly.

It is, however, recommended that for first class bricks, they shall not be greater than 20 percent and for ordinary building bricks, not greater than 25 percent.

The absorption characteristic of bricks effects their quality in many ways:

Firstly: higher porosity means less solid materials; hence, strength is reduced.
Secondly: higher absorption will lead to other water-related defects such as frost-action and efflorescence.
Thirdly: higher absorption results in deeper penetration of water which becomes a source of dampness.
(ii) Frost Resistance.
Water on freezing expands by about 10% in volume and exerts a pressure on the order of 140 kg/cm^2.
When bricks are used in cold climates, their decay due to this phenomenon of "frost action" may be a common process.

This is especially so because bricks are quite porous materials (apparent porosity = 20-25%). It is, therefore, essential that bricks in these areas should be properly protected from rain to minimize absorption.

(iii) Efflorescence.
It is a common disfiguring and deteriorating process of bricks in hot and humid climates.

Brick surface gets covered with white or gray colored patches of salts. These salts are present in the original brick clay.

When rain water penetrates into the bricks, the salts get easily dissolved. After the rains, evaporation starts.

The salts move out along with the water and form thin encrustations on the surface of the bricks.

Salts which are commonly precipitated during efflorescence are: sulfates of calcium, magnesium, sodium and potassium.

It is why great emphasis should be laid while testing the chemical composition of the clay for brick manufacturing.

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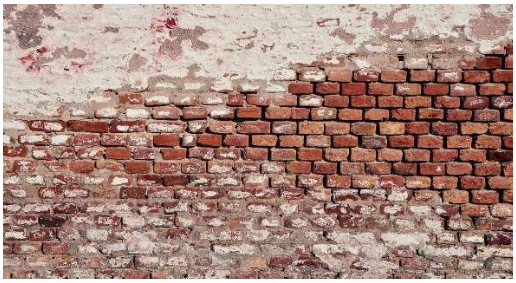

SUMMARY (Properties of Bricks).

1. It should have a rectangular shape, regular surface and red colored appearance.

2. It should confirm in size to the specified dimensions (19 x 9 x 9 cm).

3. It should be properly burnt. This can be ascertained by holding two bricks freely, one in each hand, and striking them.
A sharp metallic sound indicates good burning whereas a dull thud would indicate incomplete burning.

4. A good building brick should not absorb water more than 20 percent of its dry weight. Absorption should not exceed 25 percent in any case.

5. A good building brick should possess requisite compressive strength, which in no case should be less than 35 kg/cm^2 .
A rough test for the strength of the brick is to let it fall freely from a height of about one meter on to a hard floor. It should not break.

6. Brick should be hard enough so that it is not scratched by a finger nail.

7. A good brick has a uniform color and structure through its body. This can be checked by taking a brick from the lot and breaking it into two parts.
The broken surface in both the halves should have same appearance and structure.

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Testing bricks

There are several different ways to test bricks, including:

Compressive strength test

A sample brick is placed on a compression testing machine and pressure is applied until it fails. The 'ultimate pressure' level is recorded. Generally, five bricks are tested one at a time, with the average ultimate pressure level being taken as the compressive strength of the bricks.

Water absorption test

Bricks are weighed in their normal dry condition and then immersed in fresh water for 24 hours. They are then weighed again. The difference between the weights indicates the amount of water that has been absorbed by the brick. The less water is absorbed the greater the quality. The amount should not exceed 20% of the dry weight.

Efflorescense test

Efflorescence is a crystalline, salty deposit that can occur on the surfaces of bricks. It is generally a white or off-white colour with a powdery appearance. To test for alkalis that may cause efflorescense, a brick is immersed in fresh water for 24 hours and then left to dry.

If the whitish layer is not visible on the surface then it demonstrates an absence of alkalis in the brick. The ranges that should be followed are:

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- About 10% of brick surface: Acceptable range.
- About 50% of brick surface: Moderate range.
- Over 50% of brick surface: Severely affected by alkalis.

Hardness test

The brick surface is scratched. If no impression is left then it is of good quality.

Size, shape and colour test

Twenty bricks chosen at random are stacked lengthwise, width-wise and height-wise, and inspected for uniformity of shape, size and colour.

Soundness test

Two bricks are held in each hand and struck together. They should not break and a clear metallic ringing sound should be made if they are good quality.

Structure test

A sample brick is broken and carefully inspected. If it is good quality there should be no flows, cracks or holes on the broken face.

Manufacturing process of bricks

There are four different operations are involved in the process of manufacturing of bricks:

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

1. Preparation of clay for brick manufacturing:

Preparation of clay for bricks manufacturing is done in six steps: **Unsoiling of clay** We need pure clay for the preparation of bricks. The top layer of soil may contains impurities, so the clay in top layer of soil about 200mm depth is thrown away. This is calledunsoiling. **Digging** After the removal of top layer, the clay is dug out from the ground and spread on the plain ground. **Cleaning** In this stage, the clay is cleaned of stones, vegetable matter etc. if large quantity of particulate matter is present, then the clay is washed and screened. The lumps of clay are converted into powder with earth crushing rollers.

Weathering The cleaned clay is exposed to atmosphere for softening. The period of weathering may be 3 to 4 weeks or a full rainy season. Generally, the clay is dug out just

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before the rainy season for larger projects. **Blending** If we want to add any ingredient to the clay, it is to be added in this stage by making the clay loose and spread the ingredient over it. Then take small portion of clay into the hands and tuning it up and down in vertical direction. This process is called blending of clay. **Tempering** In this stage, water is added to clay and pressed or mixed. The pressing will be done by cattle or with feet of men for small scale projects, pug mill is used as grinder for large scale projects. So, the clay obtains the plastic nature and now it is suitable for molding.

2. Molding of clay for brick manufacturing

In the molding process, prepared clay is mold into brick shape (generally rectangular). This process can be done in two ways according to scale of project.

- Hand molding (for small scale)
- Machine molding (for large scale)

Hand molding of bricks

If manufacturing of bricks is on a small scale and manpower is also cheap then we can go for hand molding. The molds are in rectangular shape made of wood or steel which are opened at the top and bottom. The longer sides of molds are projected out of the box to serve it as handles. If we take durability in consideration steel molds are better than wooden molds. In hand molding again there are two types and they are

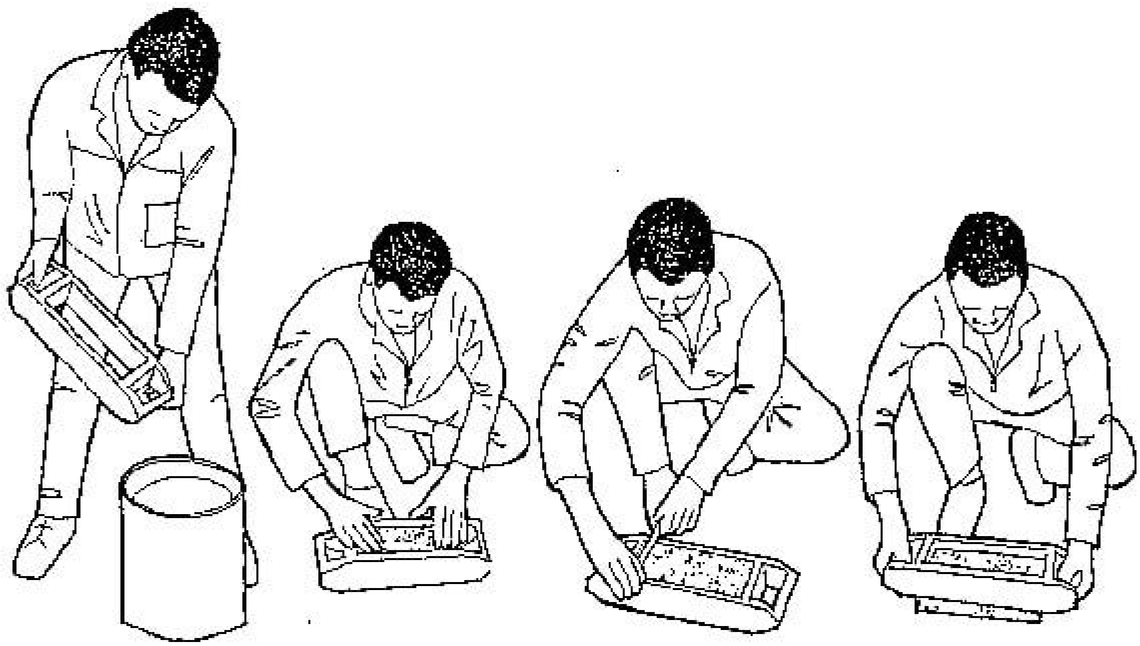
1. Ground molded bricks
2. Table-molded bricks

Ground molded bricks

- In this process of ground molding, first level the ground and sand or ash is sprinkled over it.
- Now place the wet mold in the ground and filled it with tempered clay and press hard to fill all corners of the mold. Extra clay is removed with metal strike or wood strike or with wire.
- The mold is then lifted up and we have raw brick in the ground. And again wet the mold by dipping it in water and repeat the same process. The process of dipping mold every time to make bricks is called slop molding.
- Sometimes, the inside surface of mold is sprinkled with sand or ash instead of dipping in water this is called sand molding
- Frog mark of bricks are made by using a pair of pallet boards. Frog mark means the mark of depth which is placed on raw brick while molding. The depth may be 10mm to 20mm.
- Frog mark stats the trademark of manufacturing company and also it is useful to store mortar in it when the bricks is placed over it.

Table molded bricks

- This process is similar to ground molding process, but here the bricks on molded on the table of size 2m x 1m.
- Ground molding is economical when compared to table molding.



Machine molding of bricks

The bricks required are in large quantity, then machine molding is economical and also saves more time. Here also we are having two types of machines,

1. Plastic clay machines
2. Dry clay machines

Plastic clay machines This machines contain an opening in rectangular shape and when we place the tempered clay in to this machine it will come out through this opening. Now, the rectangular strips coming out the opening are cut by wires to get required thickness of brick. So, these are also called wire cut bricks. Now these raw bricks are ready for the drying process. **Dry clay machines** Dry clay machines are more time saving machines. We can put the blended clay into these machines directly without tempering. Means tempering is also done in this machine by adding some water. When the required stiffness is obtained the clay is placed in mold and pressed hard and well-shaped bricks are delivered. These

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are calledpressed bricks and these do not require drying they may directly sent to burning process.

3. Drying of raw bricks

- After molding process the bricks contain some amount of moisture in it. So, drying is to be done otherwise they may cracked while burning. The drying of raw bricks is done by natural process.
- The bricks are laid in stacks. A stack consists 8 to 10 stairs. The bricks in these stacks should be arranged in such a way that circulation of air in between the bricks is free.
- The period of drying may be 3 to 10 days. It also depends upon the weather conditions.
- The drying yards are also prepared on higher level than the normal ground for the prevention of bricks from rain water.
- In Some situations artificial drying is adopted under special dryers or hot gases.

4. Burning of bricks

- In the process of burning, the dried bricks are burned either in clamps (small scale) or kilns (large scale) up to certain degree temperature. In this stage, the bricks will gain hardness and strength so it is important stage in manufacturing of bricks.
- The temperature required for burning is about 1100^{o}C. If they burnt beyond this limit they will be brittle and easy to break. If they burnt under this limit, they will not gain full strength and there is a chance to absorb moisture from the atmosphere.
- Hence burning should be done properly to meet the requirements of good brick.

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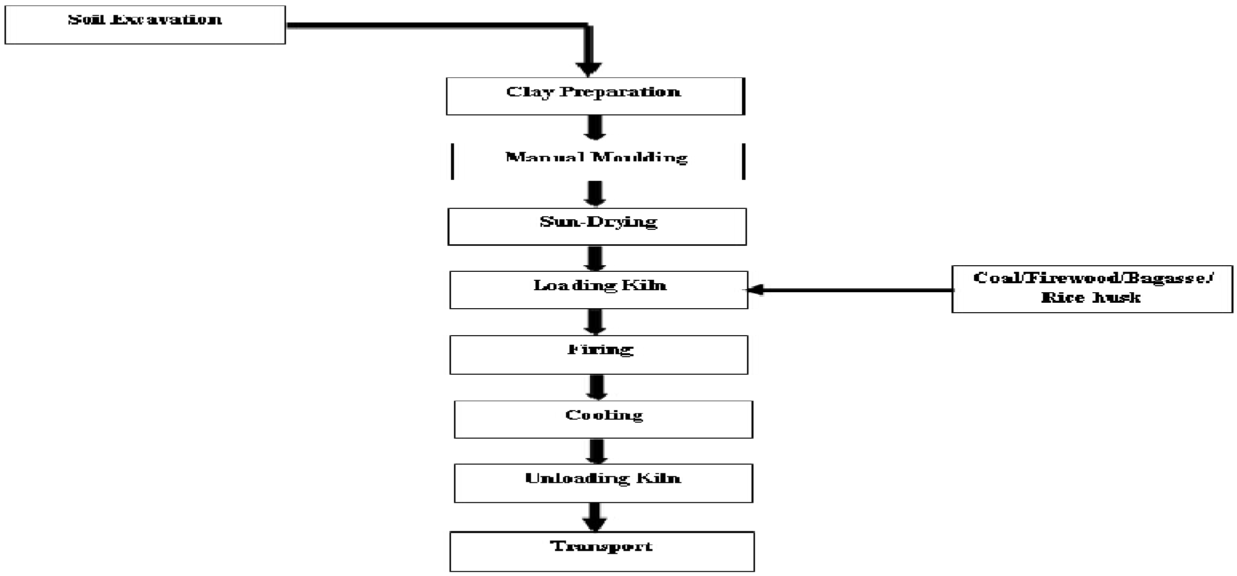

Flow chart of brick manufacturing

Cement: A **cement** is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is only behind water as the planet's most-consumed resource.

Cements used in construction are usually inorganic, often lime or calcium silicate based, which can be characterized as **non-hydraulic** or **hydraulic** respectively, depending on the ability of the cement to set in the presence of water (see hydraulic and non-hydraulic lime plaster).

Non-hydraulic cement does not set in wet conditions or under water. Rather, it sets as it dries and reacts with carbon dioxide in the air. It is resistant to attack by chemicals after setting.

Hydraulic cements (e.g., Portland cement) set and become adhesive due to a chemical reaction between the dry ingredients and water. The chemical reaction results in mineral hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet conditions or under water and further protects the hardened material from chemical attack. The chemical process for hydraulic cement was found by ancient Romans who used volcanic ash (pozzolana) with added lime (calcium oxide).

The word "cement" can be traced back to the Roman term opus caementicium, used to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder. The volcanic ash and pulverized brick supplements that were added to the burnt lime, to obtain a hydraulic binder, were later referred to as cementum, cimentum, cäment, and cement. In modern times, organic polymers are sometimes used as cements in concrete.

Modern hydraulic development began with the start of the Industrial Revolution (around 1800), driven by three main needs:

- Hydraulic cement render (stucco) for finishing brick buildings in wet climates
- Hydraulic mortars for masonry construction of harbor works, etc., in contact with sea water
- Development of strong concretes

Classification of cement:

13 Types of Cement and their Uses

1. Ordinary Portland Cement (OPC)
2. Portland Pozzolana Cement (PPC)
3. Rapid Hardening Cement
4. Quick setting cement
5. Low Heat Cement
6. Sulfates resisting cement
7. Blast Furnace Slag Cement
8. High Alumina Cement
9. White Cement
10. Colored cement
11. Air Entraining Cement
12. Expansive cement
13. Hydrographic cement

1. Ordinary Portland Cement (OPC)

Ordinary Portland cement is the most widely used type of cement, which is suitable for all general concrete construction. It is the most commonly produced and used type of cement around the world, with annual global production of around 3.8 million cubic meters per year. This cement is suitable for all kinds of concrete construction.

2. Portland Pozzolana Cement (PPC)

Portland pozzolana cement is prepared by grinding pozzolanic clinker with Portland cement. It is also produced by adding pozzolana with the addition of gypsum or calcium sulfate or by intimately and uniformly blending Portland cement and fine pozzolana.

This cement has a high resistance to various chemical attacks on concrete compared with ordinary portland cement, and thus, it is widely used. It is used in marine structures, sewage works, sewage works, and for laying concrete underwater, such as bridges, piers, dams, and mass concrete works, etc.

3. Rapid Hardening Cement

Rapid hardening cement attains high strength in the early days; it is used in concrete where formworks are removed at an early stage and are similar to ordinary portland cement (OPC). This cement has increased lime content and contains higher c3s content and finer grinding, which gives higher strength development than OPC at an early stage.

The strength of rapid hardening cement at the three days is similar to 7 days strength of OPC with the same water-cement ratio. Thus, the advantage of this cement is that formwork can be removed earlier, which increases the rate of construction and decreases the cost of construction by saving formwork cost.

Rapid hardening cement is used in prefabricated concrete construction, road works, etc.

4. Quick setting cement

The difference between the quick setting cement and rapid hardening cement is that quick-setting cement sets earlier. At the same time, the rate of gain of strength is similar to Ordinary Portland Cement, while quick hardening cement gains strength quickly. Formworks in both cases can be removed earlier.

Quick setting cement is used where works is to be completed in very short period and for concreting in static or running water.

5. Low Heat Cement

Low heat cement is produced by maintaining the percentage of tricalcium aluminate below 6% by increasing the proportion of C2S. A small quantity of tricalcium aluminate makes the concrete to produce low heat of hydration. Low heat cement suitable for mass concrete construction like gravity dams, as the low heat of hydration, prevents the cracking of concrete due to heat.

This cement has increased power against sulphates and is less reactive and initial setting time is greater than OPC.

6. Sulfates Resisting Cement

Sulfate resisting cement is used to reduce the risk of sulfate attack on concrete and thus is used in the construction of foundations where the soil has high sulfate content. This cement has reduced the contents of C3A and C4AF.

Sulfate resisting cement is used in construction exposed to severe sulfate action by water and soil in places like canals linings, culverts, retaining walls, siphons, etc.

7. Blast Furnace Slag Cement

Blast furnace slag cement is obtained by grinding the clinkers with about 60% slag and resembles more or less in properties of Portland cement. It can be used for works where economic considerations are predominant.

8. High Alumina Cement

High alumina cement is obtained by melting a mixture of bauxite and lime and grinding with the clinker. It is a rapid hardening cement with initial and final setting time of about 3.5 and 5 hours, respectively.

The compressive strength of this cement is very high and more workable than ordinary portland cement and is used in works where concrete is subjected to high temperatures, frost, and acidic action.

9. White Cement

It is prepared from raw materials free from Iron oxide and is a type of ordinary portland cement, which is white. It is costlier and is used for architectural purposes such as precast curtain wall and facing panels, terrazzo surface, etc. and for interior and exterior decorative work like external renderings of buildings, facing slabs, floorings, ornamental concrete products, paths of gardens, swimming pools, etc.

10. Colored cement

It is produced by mixing 5- 10% mineral pigments with ordinary cement. They are widely used for decorative works on floors.

11. Air Entraining Cement

Air entraining cement is produced by adding indigenous air-entraining agents such as resins, glues, sodium salts of sulfates, etc. during the grinding of clinker.

This type of cement is especially suited to improve the workability with a smaller water-cement ratio and to improve frost resistance of concrete.

12. Expansive Cement

Expansive cement expands slightly with time and does not shrink during and after the time of hardening. This cement is mainly used for grouting anchor bolts and prestressed concrete ducts.

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13. Hydrographic cement

Hydrographic cement is prepared by mixing water-repelling chemicals and has high workability and strength. It has the property of repelling water and is unaffected during monsoon or rains.

Hydrophobic cement is mainly used for the construction of water structures such as dams, water tanks, spillways, water retaining structures, etc.

Properties of cement:

Ordinary Portland Cement

This cement is also called **basic Portland cement** and is best suited for use in general concrete construction where there is **no exposure to sulphates in the soil or in groundwater.** This cement is obviously produced in the maximum quantity than other cements. It is produced by grinding Portland clinker with the possible addition of a small quantity of gypsum, water or both and not more than 1 % of air-entraining agents. This very useful types of cement.

The clinker of Portland consists of calcium silicate and is obtained by heating to incipient fusion a predetermined and homogeneous mixture of materials mainly containing 59% – 64% lime (CaO) and 19% – 24% silica (SiO2) with 3% – 6% of alumina (Al2O3) and 1% – 4% iron oxide (Fe2O3).

The setting and hardening of cement after the addition of water to it is due to the dissolution and reaction of the constituents.

The calcium aluminate is the first to set and harden, then comes calcium trisilicate (3CaO.2SiO2.3H2O) which is responsible for the early gain in strength during the first 48 hours. Calcium disilicate reacts slowly and contributes to the strength at a later stage usually from 14 to 28 days.

Typical **chemical reactions** are as follows:

$3CaO.Al_2O_3 + 6H20 \rightarrow 3CaO.Al_2O_3.6H_2O$

$(3CaO.SiO_2) + 6H_2O \rightarrow 3\ CaO.2SiO_2.3H_2O + 3Ca(OH)_2$

$3\ (2CaO.SiO_2) + 6\ H_2O \rightarrow 3CaO.2SiO_2.3H_2O + 3\ Ca(OH)_2$

Types of Ordinary Portland cement

- **33 grade** ordinary Portland cement,
- **43-grade** ordinary portland cement,
- **53 grade** ordinary Portland cement,

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Portland Pozzolana cement

Portland pozzolana cement is prepared either by grinding clinker and pozzolana or by blending **Portland cement** and fine pozzolana. The proportion of pozzolana may vary between **10% to 25%** by weight of cement.

PPC cement is suitable for the following conditions: For **waterfront structure** or for **marine structure** as in **dams, bridge piers** and **thick foundation** where mass concrete is used, also used for **sanitation sys**tem like **Sewers**.

The history behind PPC: The **Romans** and Greeks knew that certain volcanic materials if finely ground and mixed with lime and sand could be used as building mortars of good strength. The Roman builders used the red or purple volcanic tuff found near the Bay of Naples, notably in the neighborhood of Pozzuoli. This was a good building material and became known as pozzolana, a name that is now frequently used to describe a range of materials both natural and artificial.

The main use of pozzolana is to replace a proportion of cement in a mix and this can result in a significant economy particularly if the materials are locally available.

The pozzolana one of the **Siliceous material, therefore,** it has no cementitious properties or less binding property but in the finely divided form with the presence of water can react with calcium hydroxide at a suitable temperature to form compounds having sufficient binding properties. Other natural volcanic materials having pozzolanic properties like diatomaceous earth, calcined clay, and fly ash.

Advantages of PPC (Portland Pozzolana cement)

- The production is economical because costly clinker is replaced by cheaper.
- This cement **reduces the permeability** so, suitable for hydraulic structure. But it requires very fast curing is tedious.
- It produces a very slow rate of the heat of hydration and also reduces the heat.
- The particle size of PPC is smaller than OPC, so it improves the **pore size distribution** and also reduces micro-cracks.
- PPC mortar is **more volume** than OPC mortar.
- The **Ultimate long term Strength** of PPC is more than OPC if enough curing for pozzolanicaction.

Rapid hardening Portland cement

The cement is manufactured by intimately mixing together calcareous and argillaceous and/or other silica, alumina or iron oxide bearing materials.

This cement has the same chemical composition as the ordinary Portland cement but is more finely ground. Its 24 hours strength is nearly equal to that attained by ordinary portland cement after 3 days. The use of this cement permits early removal of shuttering thus directly affecting saving in time and money.

It is generally used in road work and bridge construction where the time factor is very important.

Extra rapid hardening cement:

Extra rapid hardening cement is a proper modification of rapid hardening cement. It is manufacture by inter grinding Calcium Chloride with rapid hardening portland cement. Normally, calcium chloride with 2 percentage by weight of rapid hardening cement is mixed. Since Extra rapid hardening cement is very sensitive, concrete should be transported, placed, compacted, and finished within 20 minutes after mixing. After the addition of water, a very huge amount of heat is evolved within a short period of time along with hydration. So, this type of cement is perfect for concreting in cold weather.

Properties of Extra Rapid hardening cement:

- At the age of one or two days strength of Extra rapid hardening cement is 25% more than rapid hardening cement, and only 0-20 % higher at 7 days but at 90 days both cement have nearly the same strength.
- The use of Extra rapid hardening cement in pre-stressed concrete is prohibited.

Portland slag cement

In Portland slag cement a **Blast furnace slag** is a non-metallic product consisting essentially of glass containing silicates and aluminosilicates of lime and other bases and is developed simultaneously with iron in a blast furnace or electric pig iron furnace. Ground granulated slag is obtained by further processing the molten slag by rapidly chilling or quenching it with water or steam and air.

This cement is prepared by intimately grinding Portland cement clinker and ground granulated blast furnace (GGBF) slag with the addition of gypsum and permitted additives. and the proportion of slag should not be less than 25% and not more than 65% of Portland slag cement. The slag contains oxides of lime, alumina, and silica and easily replaces clay or shale used in the manufacture of ordinary Portland cement.

Portland slag cement can be used for all purposes for which ordinary Portland cement is used.

However, the former has certain advantages: it has lower heat evolution and is more durable.

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Hydrophobic cement

Hydrophobic cement is prepared from ordinary Portland cement clinker by adding certain **water repellent chemicals** during the grinding process. A water repellent coating is formed over each particle of cement that prevents water or moisture from the air being absorbed by the cement. This film is broken during the mixing of concrete and the normal hydration process takes place in the same manner as with the ordinary Portland cement.

This cement is ideal for storage for longer periods in extremely wet climatic conditions. The hydrophobic agents can be oleic acid, stearic acid, naphthenic acid, etc. This cement is different from waterproofing cement.

Sulphate Resisting Cement:

Since ordinary Portland cement is susceptible to attack of sulfate, sulfate resisting Cement is developed to use where the soil is infected with sulfates.

Due to the attack of sulphate in O.P.C. cement, there are chances of expansion within the framework of concrete and there are cracks and subsequent disruption.

Many research found that to reduce sulphate attack, cement with low C3A content better results. Sulphates resisting cement has a high silicate content that is with low C3A and low C4AF.

Under the following conditions sulphate resisting cement is used:

- When concreting is done for Marine structure in the zone of tidal variations.
- Where foundation soil is infected with Sulphate.
- In marshy soil or sulphate bearing soil.
- Concrete construction used for sewerage treatment, etc.

Quick setting Cement:

Quick setting cement sets very fast. This cement is used for **aggressive foundation** conditions like where pumping is needed or submersible land area.

In quick setting cement, the quick setting property is achieved by reducing the Gypsum content at the time of clinker grinding. Quick setting cement is also used in some typical **grouting** operations.

High alumina cement

This cement is obtained by grinding high alumina clinker consisting of **monocalcium aluminates**. High alumina cement clinker is obtained by complete or partial fusion of a predetermined mixture of materials mainly containing **alumina (Al2O3)** and **lime**

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(CaO) with a smaller proportion of iron oxides, silica (Si02) and other oxides. High early strength, the high heat of hydration and very high durability against chemical attack are the characteristics of high alumina cement. It is black in colour. Its rapid hardening properties are due to a higher percentage of calcium aluminate in place of calcium silicate as found in ordinary Portland cement.

The rapid development of heat of this cement is of great advantage when concreting is to be done in freezing weather. Its use in hot weather, however, is very limited due to increased porosity, hence reduction in strength.

Supersulphated cement

It is a hydraulic cement having **sulphuric anhydride (SO3)** content less than 5% and made by inter grinding mixture of at least 7% granulated blast furnace slag, calcium sulfate and a little amount of lime or Portland clinker. This cement is used in very serious conditions such as marine works, mass concrete jobs to resist the attack of aggressive waters, reinforced concrete pipes in groundwaters, concrete construction in sulphate bearing soils, and in chemical works exposed to the high concentration of sulphates of weak solutions of mineral acid. It can also be used for the underside of bridges over railways and for sewer pipes.

High alumina cement and super sulphated cement must be used only under special circumstances.

Masonry cement

Masonry cement is obtained by intergrading a mixture of Portland cement clinker with **inert materials (non-pozzolanic)**, such as **limestone**.

Conglomerates, dolomite, limestone and gypsum, and air-entraining plasticizer in suitable proportions. Masonry cement is slow hardening, has high workability and high water retentivity that makes it especially suitable for masonry work.

Oil well cement

Oil-well cement is a special purpose cement for sealing the space between **steel casing and sedimentary rock** strata by pumping slurry in the oil-well which is drilled for the search of oil. This cement prevents the **escape of oil or gas** from the oil-well. This cement also prevents from **sulphur gases** or water containing **dissolved salts**. This all properties of oil-well cement is obtained by adding the compound composition of cement with retarder agents like starches or cellulose products or acids.

At the condition of **high pressure and temperature** in sealing water and gas pockets, and setting casing during the **drilling and repairing** of oil wells Hydraulic cement is suitable to use, often contains retarders to meet the requirements of such use in addition to coarser grinding and/or reduced **tricalcium aluminate (C3A)** content of clinker.

Slurries of such cement have to remain pumpable at **high-temperature and pressures** for a sufficient length of time then harden very rapidly. So this is a very useful type of cement.

Coloured cement:

Coloured cement is made by adding colour carrying **pigment** with a Portland cement clinker. The dose of pigment is **5-10 percentage** of Portland cement. For achieving various colors, either white cement or grey Portland cement is used as a **base materia**l. The white Portland cement is manufactured as same as OPC.

Expansive cement:

Expansive cement is a type of cement that shows **no change in volume on drying**. This type of cement also not shrink while hardening or after that. This type of cement has been developed by using an expansive agent and stabilizer.

Generally, sulphoaluminated clinker is mixed with Portland cement with stabilizer. This cement is used for grouting anchor bolts or grouting **machine foundations, grouting** the **prestressed concrete ducts** where volume change is very sensitive for stability.

Air-Entraining Cement:

Air entraining cement is manufacture by adding an air-entraining agent in power or in liquid form with OPC cement clinker. There are other external materials added are **animal and vegetable fats**, **oil** and another **acid** with a certain wetting agent like **aluminum powder, hydrogen peroxide**, etc. by introducing air-entraining agent frost resisting characteristics of hardened concrete is increased. Workability, segregation, and bleeding property of concrete is improved by using this cement.

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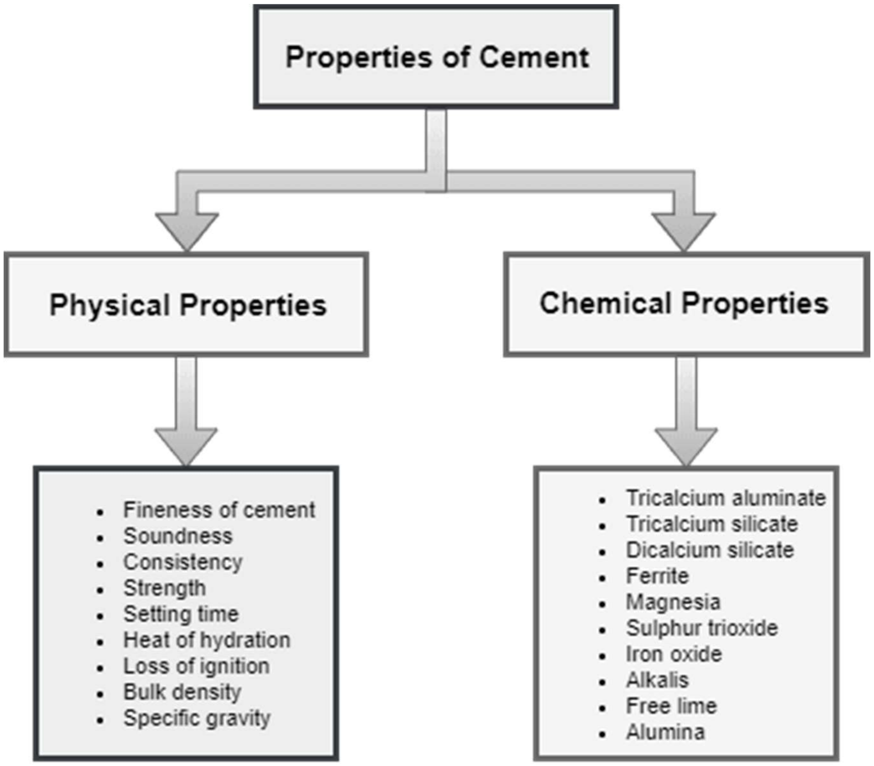

Physical Properties of Cement

Different blends of cement used in construction are characterized by their physical properties. Some key parameters control the quality of cement. The physical properties of good cement are based on:

- Fineness of cement
- Soundness
- Consistency
- Strength
- Setting time
- Heat of hydration
- Loss of ignition
- Bulk density
- Specific gravity (Relative density)

These physical properties are discussed in details in the following segment. Also, you will find the test names associated with these physical properties.

Fineness of Cement

The size of the particles of the cement is its fineness. The required fineness of good cement is achieved through grinding the clinker in the last step of cement production process. As

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hydration rate of cement is directly related to the cement particle size, fineness of cement is very important.

Soundness of Cement

Soundness refers to the ability of cement to not shrink upon hardening. Good quality cement retains its volume after setting without delayed expansion, which is caused by excessive free lime and magnesia.

Tests:

Unsoundness of cement may appear after several years, so tests for ensuring soundness must be able to determine that potential.

- **Le Chatelier Test**
  This method, done by using Le Chatelier Apparatus, tests the expansion of cement due to lime. Cement paste (normal consistency) is taken between glass slides and submerged in water for 24 hours at 20+1°C. It is taken out to measure the distance between the indicators and then returned under water, brought to boil in 25-30 mins and boiled for an hour. After cooling the device, the distance between indicator points is measured again. In a good quality cement, the distance should not exceed 10 mm.
- **Autoclave Test**
  Cement paste (of normal consistency) is placed in an autoclave (high-pressure steam vessel) and slowly brought to 2.03 MPa, and then kept there for 3 hours. The change in length of the specimen (after gradually bringing the autoclave to room temperature and pressure) is measured and expressed in percentage. The requirement for good quality cement is a maximum of 0.80% autoclave expansion. **Standard autoclave test**: AASHTO T 107 and ASTM C 151: Autoclave Expansion of Portland Cement.

Consistency of Cement

The ability of cement paste to flow is consistency.

It is measured by Vicat Test.

> In Vicat Test Cement paste of normal consistency is taken in the Vicat Apparatus. The plunger of the apparatus is brought down to touch the top surface of the cement. The plunger will penetrate the cement up to a certain depth depending on the consistency. A cement is said to have a normal consistency when the plunger penetrates 10±1 mm.

Strength of Cement

Three types of strength of cement are measured – compressive, tensile and flexural. Various factors affect the strength, such as water-cement ratio, cement-fine aggregate ratio, curing conditions, size and shape of a specimen, the manner of molding and mixing, loading conditions and age. While testing the strength, the following should be considered:

- Cement mortar strength and cement concrete strength are not directly related. Cement strength is merely a quality control measure.
- The tests of strength are performed on cement mortar mix, not on cement paste.
- Cement gains strength over time, so the specific time of performing the test should be mentioned.

Compressive Strength

It is the most common strength test. A test specimen (50mm) is taken and subjected to a compressive load until failure. The loading sequence must be within 20 seconds and 80 seconds.

Standard tests:

i. AASHTO T 106 and ASTM C 109: Compressive Strength of Hydraulic Cement Mortars (Using 50-mm or 2-in. Cube Specimens)
ii. ASTM C 349: Compressive Strength of Hydraulic Cement Mortars (Using Portions of Prisms Broken in Flexure)

Tensile strength

Though this test used to be common during the early years of cement production, now it does not offer any useful information about the properties of cement.

Flexural strength

This is actually a measure of tensile strength in bending. The test is performed in a 40 x40 x 160 mm cement mortar beam, which is loaded at its center point until failure.

Standard test:

i. ASTM C 348: Flexural Strength of Hydraulic Cement Mortars

Setting Time of Cement

Cement sets and hardens when water is added. This setting time can vary depending on multiple factors, such as fineness of cement, cement-water ratio, chemical content, and admixtures. Cement used in construction should have an initial setting time that is not too low and a final setting time not too high. Hence, two setting times are measured:

- **Initial set:** When the paste begins to stiffen noticeably (typically occurs within 30-45 minutes)

- **Final set:** When the cement hardens, being able to sustain some load (occurs below 10 hours)

Again, setting time can also be an indicator of hydration rate.

Standard Tests:

i. AASHTO T 131 and ASTM C 191: Time of Setting of Hydraulic Cement by Vicat Needle
ii. AASHTO T 154: Time of Setting of Hydraulic Cement by Gillmore Needles
iii. ASTM C 266: Time of Setting of Hydraulic-Cement Paste by Gillmore Needles

Heat of Hydration

When water is added to cement, the reaction that takes place is called hydration. Hydration generates heat, which can affect the quality of the cement and also be beneficial in maintaining curing temperature during cold weather. On the other hand, when heat generation is high, especially in large structures, it may cause undesired stress. The heat of hydration is affected most by C_3S and C_3A present in cement, and also by water-cement ratio, fineness and curing temperature. The heat of hydration of Portland cement is calculated by determining the difference between the dry and the partially hydrated cement (obtained by comparing these at 7th and 28th days).

Standard Test:

ASTM C 186: Heat of Hydration of Hydraulic Cement

Loss of Ignition

Heating a cement sample at 900 - 1000°C (that is, until a constant weight is obtained) causes weight loss. This loss of weight upon heating is calculated as loss of ignition. Improper and prolonged storage or adulteration during transport or transfer may lead to pre-hydration and carbonation, both of which might be indicated by increased loss of ignition.

Standard Test:

AASHTO T 105 and ASTM C 114: Chemical Analysis of Hydraulic Cement

Bulk density

When cement is mixed with water, the water replaces areas where there would normally be air. Because of that, the bulk density of cement is not very important. Cement has a varying range of density depending on the cement composition percentage. The density of cement may be anywhere from 62 to 78 pounds per cubic foot.

Specific Gravity (Relative Density)

Specific gravity is generally used in mixture proportioning calculations. Portland cement has a specific gravity of 3.15, but other types of cement (for example, portland-blast-furnace-slag and portland-pozzolan cement) may have specific gravities of about 2.90.

Standard Test:

AASHTO T 133 and ASTM C 188: Density of Hydraulic Cement

Chemical Properties of Cement

The raw materials for cement production are limestone (calcium), sand or clay (silicon), bauxite (aluminum) and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate. Chemical analysis of cement raw materials provides insight into the chemical properties of cement.

1. **Tricalcium aluminate (C3A)**
   Low content of C3A makes the cement sulfate-resistant. Gypsum reduces the hydration of C_3A, which liberates a lot of heat in the early stages of hydration. C3A does not provide any more than a little amount of strength.
   Type I cement: contains up to 3.5% SO_3 (in cement having more than 8% C_3A)
   Type II cement: contains up to 3% SO_3 (in cement having less than 8% C_3A)
2. **Tricalcium silicate (C_3S)**
   C3S causes rapid hydration as well as hardening and is responsible for the cement’s early strength gain an initial setting.
3. **Dicalcium silicate (C_2S)**
   As opposed to tricalcium silicate, which helps early strength gain, dicalcium silicate in cement helps the strength gain after one week.
4. **Ferrite (C_4AF)**
   Ferrite is a fluxing agent. It reduces the melting temperature of the raw materials in the kiln from 3,000°F to 2,600°F. Though it hydrates rapidly, it does not contribute much to the strength of the cement.
5. **Magnesia (MgO)**
   The manufacturing process of Portland cement uses magnesia as a raw material in dry process plants. An excess amount of magnesia may make the cement unsound and expansive, but a little amount of it can add strength to the cement. Production of MgO-based cement also causes less CO2 emission. All cement is limited to a content of 6% MgO.
6. **Sulphur trioxide**
   Sulfur trioxide in excess amount can make cement unsound.
7. **Iron oxide/ Ferric oxide**
   Aside from adding strength and hardness, iron oxide or ferric oxide is mainly responsible for the color of the cement.

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8. **Alkalis**
   The amounts of potassium oxide (K_2O) and sodium oxide (Na_2O) determine the alkali content of the cement. Cement containing large amounts of alkali can cause some difficulty in regulating the setting time of cement. Low alkali cement, when used with calcium chloride in concrete, can cause discoloration. In slag-lime cement, ground granulated blast furnace slag is not hydraulic on its own but is "activated" by addition of alkalis. There is an optional limit in total alkali content of 0.60%, calculated by the equation Na_2O + 0.658 K_2O.
9. **Free lime**
   Free lime, which is sometimes present in cement, may cause expansion.
10. **Silica fumes**
    Silica fume is added to cement concrete in order to improve a variety of properties, especially compressive strength, abrasion resistance and bond strength. Though setting time is prolonged by the addition of silica fume, it can grant exceptionally high strength. Hence, Portland cement containing 5-20% silica fume is usually produced for Portland cement projects that require high strength.
11. **Alumina**
    Cement containing high alumina has the ability to withstand frigid temperatures since alumina is chemical-resistant. It also quickens the setting but weakens the cement.

CEMENT MANUFACTURING PROCESS PHASES

Production of cement completes after passing of raw materials from the following six phases. These are;

1. Raw material extraction/ Quarry
2. Grinding, Proportioning and Blending
3. Pre-heater Phase
4. Kiln Phase
5. Cooling and Final Grinding
6. Packing & Shipping

CEMENT MANUFACTURING PROCESS PHASE 1: RAW MATERIAL EXTRACTION

Cement uses raw materials that cover calcium, silicon, iron and aluminum. Such raw materials are limestone, clay and sand. Limestone is for calcium. It is combined with much smaller proportions of sand and clay. Sand & clay fulfill the need of silicon, iron and aluminum.

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Extraction of raw material and crushing of material

Generally cement plants are fixed where the quarry of limestone is near bye. This saves the extra fuel cost and makes cement somehow economical. Raw materials are extracted from the quarry and by means of conveyor belt material is transported to the cement plant.

There are also various other raw materials used for cement manufacturing. For example shale, fly ash, mill scale and bauxite. These raw materials are directly brought from other sources because of small requirements.

Before transportation of raw materials to the cement plant, large size rocks are crushed into smaller size rocks with the help of crusher at quarry. Crusher reduces the size of large rocks to the size of gravels.

CEMENT MANUFACTURING PROCESS PHASE II: PROPORTIONING, BLENDING & GRINDING

The raw materials from quarry are now routed in plant laboratory where, they are analyzed and proper proportioning of limestone and clay are making possible before the beginning of grinding. Generally, limestone is 80% and remaining 20% is the clay.

Proportioning of raw material at cement plant laboratory

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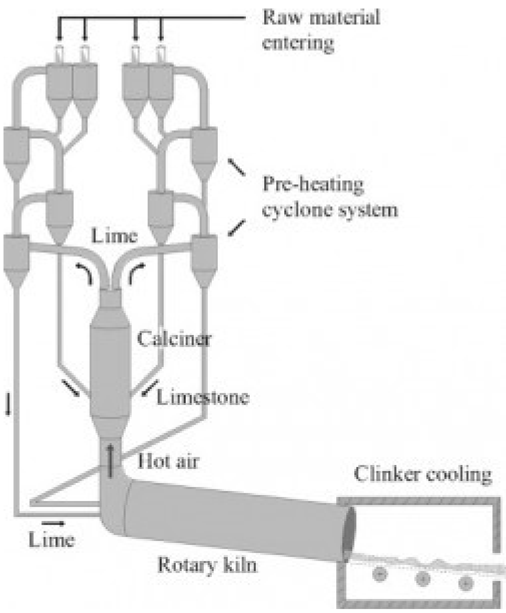
Now cement plant grind the raw mix with the help of heavy wheel type rollers and rotating table. Rotating table rotates continuously under the roller and brought the raw mix in contact with the roller. Roller crushes the material to a fine powder and finishes the job. Raw mix is stored in a pre-homogenization pile after grinding raw mix to fine powder.

CEMENT MANUFACTURING PROCESS PHASE III: PRE-HEATING RAW MATERIAL

After final grinding, the material is ready to face the pre-heating chamber. Pre-heater chamber consists of series of vertical cyclone from where the raw material passes before facing the kiln. Pre-heating chamber utilizes the emitting hot gases from kiln. Pre-heating of the material saves the energy and make plant environmental friendly.



Preheating of raw material | Vertical cyclone

CEMENT MANUFACTURING PROCESS PHASE IV: KILN PHASE

Kiln is a huge rotating furnace also called as the heart of cement making process. Here, raw material is heated up to 1450 ^{0}C. This temperature begins a chemical reaction so called decarbonation. In this reaction material (like limestone) releases the carbon dioxide. High temperature of kiln makes slurry of the material.

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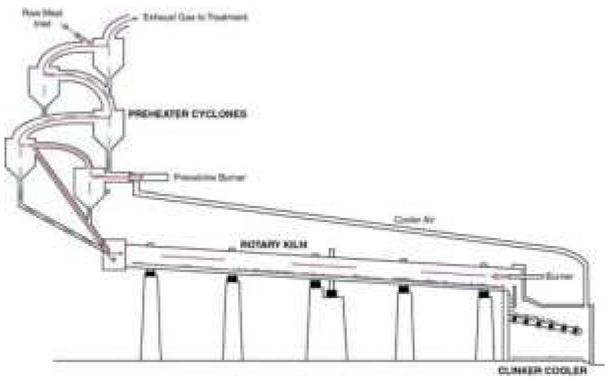

Rotary kiln

The series of chemical reactions between calcium and silicon dioxide compounds form the primary constituents of cement i.e., calcium silicate. Kiln is heating up from the exit side by the use of natural gas and coal. When material reaches the lower part of the kiln, it forms the shape of clinker.

CEMENT MANUFACTURING PROCESS PHASE V: COOLING AND FINAL GRINDING

After passing out from the kiln, clinkers are cooled by mean of forced air. Clinker released the absorb heat and cool down to lower temperature. Released heat by clinker is reused by recirculating it back to the kiln. This too saves energy.

Clinker cooling | Cement making process

Final process of 5th phase is the final grinding. There is a horizontal filled with steel balls. Clinker reach in this rotating drum after cooling. Here, steel balls tumble and crush the clinker into a very fine powder. This fine powder is considered as cement. During grinding gypsum is also added to the mix in small percentage that controls the setting of cement.

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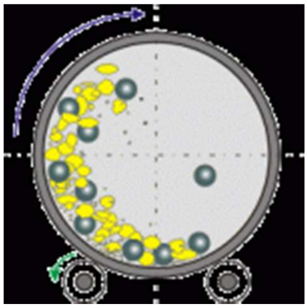

Rotating ball mill

CEMENT MANUFACTURING PROCESS PHASE VI: PACKING AND SHIPPING

Transportation of cement from silos

Material is directly conveyed to the silos (silos are the large storage tanks of cement) from the grinding mills. Further, it is packed to about 20-40 kg bags. Only a small percent of cement is packed in the bags only for those customers whom need is very small. The remaining cement is shipped in bulk quantities by mean of trucks, rails or ships.

CEMENT MANUFACTURING PROCESS FLOW CHART

After explaining the complete process of cement making, flow chart would be like that. flow chart present the summary of whole process as shown below.

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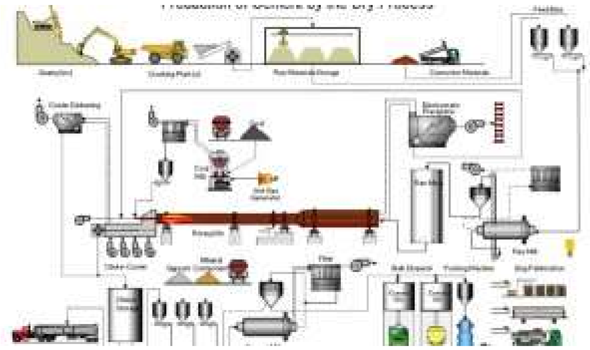

Cement making process flow chart

[8 Types of Tests on Cement to Check the Quality]

Quality Tests on cement are carried out to check the strength and quality of the cement used in construction. It helps to identify the usage of cement for different purposes based on its durability and performance.

The following tests are conducted on cement in the laboratory are as follows:

1. Fineness Test
2. Consistency Test
3. Setting Time Test
4. Strength Test
5. Soundness Test
6. Heat of Hydration Test
7. Tensile Strength Test
8. Chemical Composition Test

Fineness test on cement

The fineness of cement is responsible for the rate of hydration, rate of evolution of heat and the rate of gain of strength. Finer the grains more is the surface area and faster the development of strength.

The fineness of cement can be determined by Sieve Test or Air Permeability test.

Sieve Test: Air-set lumps are broken, and the cement is sieved continuously in a circular and vertical motion for a period of 15 minutes. The residue left on the sieve is weighed, and it should not exceed 10% for ordinary cement. This test is rarely used for fineness.

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Air Permeability Test: Blaine's Air Permeability Test is used to find the specific surface, which is expressed as the total surface area in sq.cm/g. of cement. The surface area is more for finer particles.

Consistency test on cement

This test is conducted to find the setting times of cement using a standard consistency test apparatus, Vicat's apparatus.

Standard consistency of cement paste is defined as that water content which will permit a Vicat plunger of 10 mm diameter and 50 mm length to penetrate depths of 33-35 mm within 3-5 minutes of mixing.

The test has to undergo three times, each time the cement is mixed with water varying from 24 to 27% of the weight of cement.

This test should be conducted at a constant temperature of 25°C or 29°C and at a constant humidity of 20%.

Setting Time of cement

Vicat's apparatus is used to find the setting times of cement i.e., initial setting time and final setting time.

Initial Setting Time: For this test, a needle of 1 mm square size is used. The needle is allowed to penetrate into the paste (a mixture of water and cement as per the consistency test). The time taken to penetrate 33-35 mm depth is recorded as the initial setting time.

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Final Setting Time: After the paste has attained hardness, the needle does not penetrate the paste more than 0.5 mm. The time at which the needle does not penetrate more than 0.5 mm is taken as the final setting time.

Strength test of cement

The strength of cement cannot be defined directly on the cement. Instead the strength of cement is indirectly defined on cement-mortar of 1:3. The compressive strength of this mortar is the strength of cement at a specific period.

Soundness test of cement

This test is conducted in Le Chatelier's apparatus to detect the presence of uncombined lime and magnesia in cement.

Heat of Hydration Test

During the hydration of cement, heat is produced due to chemical reactions. This heat may raise the temperature of concrete to a high temperature of 50°C. To avoid these, in large scale constructions low-heat cement has to be used.

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This test is carried out using a calorimeter adopting the principle of determining heat gain. It is concluded that Low-heat cement should not generate 65 calories per gram of cement in 7 days and 75 calories per gram of cement in 28 days.

Tensile Strength of Cement

This test is carried out using a cement-mortar briquette in a tensile testing machine. A 1:3 cement-sand mortar with the water content of 8% is mixed and moulded into a briquette in the mould.

This mixture is cured for 24 hours at a temperature of 25°C or 29°C and in an atmosphere at 90% relative humidity.

The average strength for six briquettes tested after 3 and 7 days is recorded.

Chemical Composition Test

Different tests are conducted to determine the amount of various constituents of cement. The requirements are based on IS: 269-1998, is as follows:

- The ratio of the percentage of alumina to that of iron oxide should not be less than 0.66.
- Lime Saturation Factor (LSF), i.e., the ratio of the percentage to that of alumina, iron oxide and silica should not be less than 0.66 and not be greater than 1.02.
- Total loss on ignition should not be greater than 4%.
- Total sulphur content should not be greater than 2.75%.
- Weight of insoluble residue should not be greater than 1.50%.

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- Weight of magnesia should not be greater than 5%.

Field Tests of Cement

The following tests should undergo before mixing the cement at construction sites:

Colour Test of Cement

The colour of the cement should not be uneven. It should be a uniform grey colour with a light greenish shade.

Presence of Lumps

The cement should not contain any hard lumps. These lumps are formed by the absorption of moisture content from the atmosphere. The cement bags with lumps should be avoided in construction.

Cement Adulteration Test

The cement should be smooth if you rubbed it between fingers. If not, then it is because of adulteration with sand.

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Float Test

The particles of cement should flow freely in water for sometime before it sinks.

Date of Manufacturing

It is very important to check the manufacturing date because the strength of cement decreases with time. It's better to use cement before 3 months from the date of manufacturing.

Steel, alloy of iron and carbon in which the carbon content ranges up to 2 percent (with a higher carbon content, the material is defined as cast iron). By far the most widely used material for building the world's infrastructure and industries, it is used to fabricate everything from sewing needles to oil tankers. In addition, the tools required to build and manufacture such articles are also made of steel. As an indication of the relative importance of this material, in 2013 the world's raw steel production was about 1.6 billion tons, while production of the next most important engineering metal, aluminum, was about 47 million tons. (For a list of steel production by country, see below World steel production.) The main reasons for the popularity of steel are the relatively low cost of making, forming, and processing it, the abundance of its two raw materials (iron ore and scrap), and its unparalleled range of mechanical properties.

Properties Of Steel

The major component of steel is iron, a metal that in its pure state is not much harder than copper. Omitting very extreme cases, iron in its solid state is, like all other metals, polycrystalline—that is, it consists of many crystals that join one another on their boundaries. A crystal is a well-ordered arrangement of atoms that can best be pictured as spheres touching one another. They are ordered in planes, called lattices, which penetrate one another in specific ways. For iron, the lattice arrangement can best be visualized by a unit cube with eight iron atoms at its corners. Important for the uniqueness of steel is the allotropy of iron—that is, its existence in two crystalline forms. In the body-centred cubic (bcc) arrangement, there is an additional iron atom in the centre of each cube. In

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the face-centred cubic (fcc) arrangement, there is one additional iron atom at the centre of each of the six faces of the unit cube. It is significant that the sides of the face-centred cube, or the distances between neighbouring lattices in the fcc arrangement, are about 25 percent larger than in the bcc arrangement; this means that there is more space in the fcc than in the bcc structure to keep foreign (i.e., alloying) atoms in solid solution.

Iron has its bcc allotropy below 912° C (1,674° F) and from 1,394° C (2,541° F) up to its melting point of 1,538° C (2,800° F). Referred to as ferrite, iron in its bcc formation is also called alpha iron in the lower temperature range and delta iron in the higher temperature zone. Between 912° and 1,394° C iron is in its fcc order, which is called austenite or gamma iron. The allotropic behaviour of iron is retained with few exceptions in steel, even when the alloy contains considerable amounts of other elements.

Effects of carbon

In its pure form, iron is soft and generally not useful as an engineering material; the principal method of strengthening it and converting it into steel is by adding small amounts of carbon. In solid steel, carbon is generally found in two forms. Either it is in solid solution in austenite and ferrite or it is found as a carbide. The carbide form can be iron carbide (Fe_3C, known as cementite), or it can be a carbide of an alloying element such as titanium. (On the other hand, in gray iron, carbon appears as flakes or clusters of graphite, owing to the presence of silicon, which suppresses carbide formation.)

The effects of carbon are best illustrated by an iron-carbon equilibrium diagram. The A-B-C line represents the liquidus points (i.e., the temperatures at which molten iron begins to solidify), and the H-J-E-C line represents the solidus points (at which solidification is completed). The A-B-C line indicates that solidification temperatures decrease as the carbon content of an iron melt is increased. (This explains why gray iron, which contains more than 2 percent carbon, is processed at much lower temperatures than steel.) Molten steel containing, for example, a carbon content of 0.77 percent (shown by the vertical dashed line in the figure) begins to solidify at about 1,475° C (2,660° F) and is completely solid at about 1,400° C (2,550° F). From this point down, the iron crystals are all in an austenitic—i.e., fcc—arrangement and contain all of the carbon in solid solution. Cooling further, a dramatic change takes place at about 727° C (1,341° F) when the austenite crystals transform into a fine lamellar structure consisting of alternating platelets of ferrite and iron carbide. This microstructure is called pearlite, and the change is called the eutectoidic transformation. Pearlite has a diamond pyramid hardness (DPH) of approximately 200 kilograms-force per square millimetre (285,000 pounds per square inch), compared with a DPH of 70 kilograms-force per square millimetre for pure iron. Cooling steel with a lower carbon content (e.g., 0.25 percent) results in a microstructure containing about 50 percent pearlite and 50 percent ferrite; this is softer than pearlite, with a DPH of about 130. Steel with more than 0.77 percent carbon—for instance, 1.05

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percent—contains in its microstructure pearlite and cementite; it is harder than pearlite and may have a DPH of 250.

Effects of heat treating: Adjusting the carbon content is the simplest way to change the mechanical properties of steel. Additional changes are made possible by heat-treating—for instance, by accelerating the rate of cooling through the austenite-to-ferrite transformation point, shown by the P-S-K line in the figure. (This transformation is also called the Ar_1 transformation, r standing for refroidissement, or “cooling.”) Increasing the cooling rate of pearlitic steel (0.77 percent carbon) to about 200° C per minute generates a DPH of about 300, and cooling at 400° C per minute raises the DPH to about 400. The reason for this increasing hardness is the formation of a finer pearlite and ferrite microstructure than can be obtained during slow cooling in ambient air. In principle, when steel cools quickly, there is less time for carbon atoms to move through the lattices and form larger carbides. Cooling even faster—for instance, by quenching the steel at about 1,000° C per minute—results in a complete depression of carbide formation and forces the undercooled ferrite to hold a large amount of carbon atoms in solution for which it actually has no room. This generates a new microstructure, martensite. The DPH of martensite is about 1,000; it is the hardest and most brittle form of steel. Tempering martensitic steel—i.e., raising its temperature to a point such as 400° C and holding it for a time—decreases the hardness and brittleness and produces a strong and tough steel. Quench-and-temper heat treatments are applied at many different cooling rates, holding times, and temperatures; they constitute a very important means of controlling steel’s properties. (See also below Treating of steel: Heat-treating.)

Effects of alloying

A third way to change the properties of steel is by adding alloying elements other than carbon that produce characteristics not achievable in plain carbon steel. Each of the approximately 20 elements used for alloying steel has a distinct influence on microstructure and on the temperature, holding time, and cooling rates at which microstructures change. They alter the transformation points between ferrite and austenite, modify solution and diffusion rates, and compete with other elements in forming intermetallic compounds such as carbides and nitrides. There is a huge amount of empirical information on how alloying affects heat-treatment conditions, microstructures, and properties. In addition, there is a good theoretical understanding of principles, which, with the help of computers, enables engineers to predict the microstructures and properties of steel when alloying, hot-rolling, heat-treating, and cold-forming in any way.

A good example of the effects of alloying is the making of a high-strength steel with good weldability. This cannot be done by using only carbon as a strengthener, because carbon creates brittle zones around the weld, but it can be done by keeping carbon low and adding small amounts of other strengthening elements, such as nickel or manganese. In principle, the strengthening of metals is accomplished by increasing the resistance of lattice structures to the motion of dislocations. Dislocations are failures in the lattices of crystals that make it possible for metals to be formed. When elements such as nickel are kept in solid solution in ferrite, their atoms become embedded in the iron lattices and block the movements of dislocations. This phenomenon is called solution hardening. An even greater increase in strength is achieved by precipitation hardening, in which certain elements (e.g., titanium, niobium, and vanadium) do not stay in solid solution in ferrite during the cooling of steel but instead form finely dispersed, extremely small carbide or nitride crystals, which also effectively restrict the flow of dislocations. In addition, most of these strong carbide or nitride formers generate a small grain size, because their precipitates have a nucleation effect and slow down crystal growth during recrystallization of the cooling metal. Producing a small grain size is another method of strengthening steel, since grain boundaries also restrain the flow of dislocations.

Alloying elements have a strong influence on heat-treating, because they tend to slow the diffusion of atoms through the iron lattices and thereby delay the allotropic transformations. This means, for example, that the extremely hard martensite, which is normally produced by fast quenching, can be produced at lower cooling rates. This results in less internal stress and, most important, a deeper hardened zone in the workpiece. Improved hardenability is achieved by adding such elements as manganese, molybdenum, chromium, nickel, and boron. These alloying agents also permit tempering at higher temperatures, which generates better ductility at the same hardness and strength.

Testing of properties

The testing of steel's properties often begins with checking hardness. This is measured by pressing a diamond pyramid or a hard steel ball into the steel at a specific load. The Vickers Diamond Pyramid Hardness tester, which measures the DPH mentioned above, uses an indenter with an included angle of 136° between opposite faces of a pyramid and usually a load of 10, 30, or 50 kilograms-force. The diagonal of the impression is measured optically, and the hardness expressed as the load in kilograms-force divided by the impressed area of the pyramid in square millimetres. Tensile and yield strength are determined by pulling a standardized machined sample in a special hydraulic press and recording the pulling force at increasing elongations until the sample breaks. The elongation at this point, and the way the fracture looks, are good indications of the steel's ductility. Measuring the pulling force at 0.20 percent elongation and dividing it by the test bar's cross section are a means of calculating the yield strength, a good indicator of cold formability. Impact toughness is determined by hitting a standardized, prismatic, notched sample with a test swing hammer and recording the work required to break it.

This is performed at different temperatures, because brittleness increases as temperature falls.

There are many other tests used in the industry to check a steel's mechanical properties, such as wear tests for rails, drawability tests for sheets, and bending tests for wire. Metallographic laboratories examine the microstructure of polished and etched steel samples, often on computerized and very powerful (up to 80,000× magnification) microscopes. Laboratories also check physical data such as thermal elongation and electromagnetic properties. Chemical composition is often checked by completely automated spectrometers. There are also several nondestructive tests as, for example, the ultrasonic test and magnaflux test used to check for internal and external flaws such as laminations or cracks.

Types Of Steel

There are several thousand steel grades either published, registered, or standardized worldwide, all of which have different chemical compositions, and special numbering systems have been developed in several countries to classify the huge number of alloys. In addition, all the different possible heat treatments, microstructures, cold-forming conditions, shapes, and surface finishes mean that there is an enormous number of options available to the steel user. Fortunately, steels can be classified reasonably well into a few major groups according to their chemical compositions, applications, shapes, and surface conditions.

Chemical composition

On the basis of chemical composition, steels can be grouped into three major classes: carbon steels, low-alloy steels, and high-alloy steels. All steels contain a small amount of incidental elements left over from steelmaking. These include manganese, silicon, or aluminum from the deoxidation process conducted in the ladle, as well as phosphorus and sulfur picked up from ore and fuel in the blast furnace. Copper and other metals, called residuals, are introduced by scrap used in the steelmaking furnace. Because all these elements together normally constitute less than 1 percent of the steel, they are not considered alloys.

Carbon steels are by far the most produced and used, accounting for about 90 percent of the world's steel production. They are usually grouped into high-carbon steels, with carbon above 0.5 percent; medium-carbon steels, with 0.2 to 0.49 percent carbon; low-carbon steels, with 0.05 to 0.19 percent carbon; extra-low-carbon steels, with 0.015 to 0.05 percent carbon; and ultralow-carbon steels, with less than 0.015 percent carbon. Carbon steels are also defined as having less than 1.65 percent manganese, 0.6 percent silicon, and 0.6 percent copper, with the total of these other elements not exceeding 2 percent.

Low-alloy steels have up to 8 percent alloying elements; any higher concentration is considered to constitute a high-alloy steel. There are about 20 alloying elements besides carbon. These are manganese, silicon, aluminum, nickel, chromium, cobalt, molybdenum, vanadium, tungsten, titanium, niobium, zirconium, nitrogen, sulfur, copper, boron, lead, tellurium, and selenium. Several of these are often added simultaneously to achieve specific properties.

Primary Steelmaking

Principles

In principle, steelmaking is a melting, purifying, and alloying process carried out at approximately 1,600° C (2,900° F) in molten conditions. Various chemical reactions are initiated, either in sequence or simultaneously, in order to arrive at specified chemical compositions and temperatures. Indeed, many of the reactions interfere with one another, requiring the use of process models to help in analyzing options, optimizing competing reactions, and designing efficient commercial practices.

Raw materials

The major iron-bearing raw materials for steelmaking are blast-furnace iron, steel scrap, and direct-reduced iron (DRI). Liquid blast-furnace iron typically contains 3.8 to 4.5 percent carbon (C), 0.4 to 1.2 percent silicon (Si), 0.6 to 1.2 percent manganese (Mn), up to 0.2 percent phosphorus (P), and 0.04 percent sulfur (S). Its temperature is usually 1,400° to 1,500° C (2,550° to 2,700° F). The phosphorus content depends on the ore used, since phosphorus is not removed in the blast-furnace process, whereas sulfur is usually picked up during iron making from coke and other fuels. DRI is reduced from iron ore in the solid state by carbon monoxide (CO) and hydrogen (H_2). It frequently contains about 3 percent unreduced iron ore and 4 percent gangue, depending on the ore used. It is normally shipped in briquettes and charged into the steelmaking furnace like scrap. Steel scrap is metallic iron containing residuals, such as copper, tin, and chromium, that vary with its origin. Of the three major steelmaking processes—basic oxygen, open hearth, and electric arc—the first two, with few exceptions, use liquid blast-furnace iron and scrap as raw material and the latter uses a solid charge of scrap and DRI.

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Oxidation reactions

The most important chemical reactions carried out on these materials (especially on blast-furnace iron) are the oxidation of carbon to carbon monoxide, silicon to silica, manganese to manganous oxide, and phosphorus to phosphate, as follows:

$$2C + O_2 \longrightarrow 2CO;$$
$$Si + O_2 \longrightarrow SiO_2;$$
$$2Mn + O_2 \longrightarrow 2MnO;$$
and
$$2P + 2.5O_2 \longrightarrow P_2O_5.$$

Unfortunately, iron is also lost in this series of reactions, as it is oxidized to ferrous oxide:

$$2Fe + O_2 \longrightarrow 2FeO.$$

The FeO, absorbed into the liquid slag, then acts as an oxidizer itself, as in the following reactions:

$$C + FeO \longrightarrow CO + Fe;$$
or
$$2P + 5FeO \longrightarrow P_2O_5 + 5Fe.$$

In the open-hearth furnace, oxidation also takes place when gases containing carbon dioxide (CO_2) contact the melt and react as follows:

$$Fe + CO_2 \longrightarrow FeO + CO;$$
or
$$C + CO_2 \longrightarrow 2CO.$$

The slag

The products of the above reactions, the oxides silica, manganese oxide, phosphate, and ferrous oxide, together with burnt lime (calcium oxide; CaO) added as flux, form the slag. Burnt lime has by itself a high melting point of 2,570° C (4,660° F) and is therefore solid at steelmaking temperatures, but when it is mixed with the other oxides, they all melt together at lower temperatures and thus form the slag. A basic slag contains approximately 55 percent CaO, 15 percent SiO_2, 5 percent MnO, 18 percent FeO, and other oxides plus sulfides and phosphates. The basicity of a slag is often simply expressed by the ratio of CaO to SiO_2, with CaO being the basic and SiO_2 the acidic component. Usually, a basicity above 3.5 provides good absorption and holding capacity for calcium phosphates and calcium sulfides.

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Removing sulfur

The majority of sulfur, present as ferrous sulfide (FeS), is removed from the melt not by oxidation but by the conversion of calcium oxide to calcium sulfide:

$FeS + CaO \rightarrow CaS + FeO$.

According to this equation, desulfurization is successful only when using a slag with plenty of calcium oxide—in other words, with a high basicity. A low iron oxide content is also essential, since oxygen and sulfur compete to combine with the calcium. For this reason, many steel plants desulfurize blast-furnace iron before it is refined into steel, since at that stage it contains practically no dissolved oxygen, owing to its high silicon and carbon content. Nevertheless, sulfur is often introduced by scrap and flux during steelmaking, so that, in order to meet low sulfur specifications (for example, less than 0.008 percent), it is necessary to desulfurize the steel as well.

Removing carbon

A very important chemical reaction during steelmaking is the oxidation of carbon. Its gaseous product, carbon monoxide, goes into the off-gas, but, before it does that, it generates the carbon monoxide boil, a phenomenon common to all steelmaking processes and very important for mixing. Mixing enhances chemical reactions, purges hydrogen and nitrogen, and improves heat transfer. Adjusting the carbon content is important, but it is often oxidized below specified levels, so that carbon powder must be injected to raise the carbon again.

Removing oxygen

As the carbon level is lowered in liquid steel, the level of dissolved oxygen theoretically increases according to the relationship $\%C \times \%O = 0.0025$. This means that, for instance, a steel with 0.1 percent carbon, at equilibrium, contains about 0.025 percent, or 250 parts per million, dissolved oxygen. The level of dissolved oxygen in liquid steel must be lowered because oxygen reacts with carbon during solidification and forms carbon monoxide and blowholes in the cast. This reaction can start earlier, too, resulting in a dangerous carbon monoxide boil in the ladle. In addition, a high oxygen level creates many oxide inclusions that are harmful for most steel products. Therefore, usually at the end of steelmaking during the tapping stage, liquid steel is deoxidized by adding aluminum or silicon. Both elements are strong oxide formers and react with dissolved oxygen to form alumina (Al_2O_3) or silica. These float to the surface of the steel, where they are absorbed by the slag. The

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upward movement of these inclusions is often slow because they are small (e.g., 0.05 millimetre), and combinations of various deoxidizers are sometimes used to form larger inclusions that float more readily. In addition, stirring the melt with argon or an electromagnetic field often serves to give them a lift.

Alloying

Deoxidation is also important before alloying steel with easy oxidizable metals such as chromium, titanium, and vanadium, in order to minimize losses and improve process control. Metals that do not oxidize readily, such as nickel, cobalt, molybdenum, and copper, can be added in the furnace to take advantage of high heating rates. In fact, alloying always has thermal effects on steelmaking—for example, the use of energy to heat and melt the alloying agents, or the heat of reaction or solution when they combine with other elements. Fortunately, there exists a large amount of empirical data, obtained from thousands of thermodynamic experiments, that, when supported by theoretical principles, allows steelmakers to predict such temperature changes.

Most alloys are added in the form of ferroalloys, which are iron-based alloys that are cheaper to produce than the pure metals. Many different grades are available. For example, ferrosilicon is supplied with levels of 50, 75, and 90 percent silicon and with varying levels of carbon and other additions.

Removing hydrogen and nitrogen

Also important for steelmaking is the absorption and removal of the two gases hydrogen and nitrogen. Hydrogen can enter liquid steel from moist air, damp refractories, and wet flux and alloy additions. It causes brittleness of solidified steel—especially in large pieces, such as heavy forgings, that do not permit the gas to diffuse to the surface. Hydrogen can also form blowholes in castings. Nitrogen does not move into and out of liquid steel as easily as hydrogen, but it is well absorbed by liquid steel in the high-temperature zones of an electric arc or oxygen jet, where nitrogen molecules (N_2) are broken up into atoms (N). Like hydrogen, nitrogen substantially decreases the ductility of steel.

Refractory liner

Basic steelmaking takes place in containers lined with basic refractories. These may be bricks or ram material made of highly stable oxides, such as magnesite, alumina, or the double oxides chrome-magnesite and dolomite. It is desirable that the refractories not participate in the steelmaking reactions, but unfortunately they do erode and corrode. Refractory bricks are produced in all shapes and grades by a highly specialized industry.

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Testing

Testing and sampling are an important part of liquid steelmaking. They are carried out by mechanized and often automated facilities, which immerse lances that are equipped with sensors for rapid computation of temperature and dissolved carbon, oxygen, and hydrogen. Test lances also take samples for analysis in laboratories. All results are usually fed automatically into a process-control computer.

Standards

Specifications for steel products as well as testing procedures are normally included in the general standard systems of most industrial countries. Institutions providing these standards are the American Society for Testing and Materials, Philadelphia; British Standards Institute, London; DeutschesInstitutfürNormung, Berlin; Japanese Industrial Standards Committee, Tokyo; ComitéEuropéen de Normalisation, Brussels; and International Organization for Standardization, Geneva.

There are also product manuals published by a number of associations and societies, sometimes for special products only, that are often used as standards in technical specifications and commercial agreements. Organizations that issue these include the American Iron and Steel Institute, Washington, D.C.; Society of Automotive Engineers, Warrendale, Pennsylvania.; American Petroleum Institute, Washington, D.C.; and American Society of Mechanical Engineers, New York City.

Each steel producer publishes lists showing the steel grades and dimensions that it can deliver. Special alloys and coatings are often supplied under a company-owned trademark. There are also publications that provide cross-references for similar steel grades among the various standards and trademarks issued in different countries.

QUARRY DUST: A **quarry** is a type of open-pit mine in which dimension stone, rock, construction aggregate, riprap, sand, gravel, or slate is excavated from the ground. The operation of quarries are regulated in some jurisdictions to reduce their environmental impacts

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Methods of quarrying

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

- 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 and 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.
- 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.

Property	Quarry rock dust	Natural sand	Test method
Specific gravity	2.54-2.60	2.60	IS 2386 (Part III) 1963
Bulk relative density (kg/m3)	1720-1810	1460	IS 2386 (Part III) 1963
Absorption (%)	1.20-1.50	Nil	IS 2386 (Part III) 1963
Moisture content (%)	Nil	1.5	IS 2386 (Part III) 1963
Fine particles less than 0.075mm (%)	12-15	06	IS 2386 (Part I) 1963
Sieve analysis	Zone II	Zone II	IS 383 - 1970

TEST ON QUARRY DUST Silica, SiO_2, is a colorless crystalline compound found mainly as sand, quartz, flint, and many other minerals. Silica is an important element to manufacture to enhance the strength property in a wide variety of materials. It is understood that the SiO_2 is the main chemical component which possess the strength parameters in cement and sand. So, in this regards it is recommended to crusher owners to check chemical property of SiO_2 of their quarries shows higher than 80% may gives the good working results to civil engineering related construction works. Fe_2O_3 nanoparticles with the average diameter of 15 nm were used with four different contents of 0.5%, 0.1%, 1.5% and 2.0% by weight. The results possess that the utilization of Fe_2O_3 particles up to greatest replacement level of 2.0% produces concrete with better split tensile strength. The results also possess that the utilization of Al_2O_3 particles up to utmost replacement level of 2.0% produces concrete with better strength. However, the maximum strength of concrete was attained at 1.0 wt% of cement replacement.

The chemical analysis of sand and quarry dust of crusher samples Chemical Analysis of Sand and Quarry Dust crusher samples The specific gravity of most common minerals found in soils fall within a range of 2.6 to 2.9. The specific gravity of sand, which is mostly made of quartz, may be estimated to be about 2.65, but for soils like clayey and silty may be from 2.6 to 2.9. Soils with porous material and contains organic matter possess below 2 specific gravity, whereas soils with heavy substances may have above 3. These values fall into the average specific value range for most soils.

The specific gravity of quarry dust of crusher samples as shown in Figure no. 2 Figure No. 2: Specific gravity for 40 quarry dust crusher samples It was observed that all the samples of quarry dust are in the range of sand, indicating that soil with high silt content replaced by the quarry dust will reduce the swelling and shrinking of the soil. Here in the Figure no. 3 possess that the most of the quarry dust samples follows the well graded curve. Some of the quarry dust samples are leads to the uniformly graded particle distribution curve. Very less quarry dust samples are in the form of the gap graded type of soil particles distribution curves

Quarry dust, is a result of crushers while doing quarrying activities. Quarry dust was taken from paritala region quarries in Vijayawada. The present research work is planned to study the importance of quarry dust when it is replaced with sand in concrete as partially from various crusher samples. The study mainly involve on compressive strength. The series involves casting and testing cube specimens in each set. The cubes were casted using standard cubes of 150mm X 150mm X 150 mm. Compression testing machine of 2000 KN capacity was used to test the cubes specimens. The two set of series is as follows a)In the first set, M20 grade of concrete with 20, 30 and 40 percentage substitute of quarry dust tested for 3 days, 7 days and 28 days is identified and presented the results. b)In the second set, M30 grade of concrete with 20, 30 and 40 percentage substitute of quarry dust tested for 3 days, 7 days and 28 days is identified and presented the results.

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Compressive Strength.

It is observed that the compressive strength of **quarry dust** waste for controlled brick (0%) is 19.52MPa. For 10% of **quarry dust** waste replacement to the value of compressive strength decreases 18.06MPa and 20% replaced **quarry dust** waste, the value of compressive strength decreases 15.81MPa.

Sand is a granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass.

Sand is a mixture of small grains of rock and granular materials which is mainly defined by size, being finer than gravel and coarser than silt. And ranging in size from **0.06 mm to 2 mm**. Particles which are **larger than 0.0078125 mm** but **smaller than 0.0625 mm are termed silt.**

Sand is made by erosion or broken pebbles and weathering of rocks, which is carried by seas or rivers. And freezing and thawing during the winter break rock up the sand will be made. Sometimes Sand on beaches can also be made by small broken-up pieces of coral, bone, and shell, which are broken up by predators and then battered by the sea, and even tiny pieces of glass from bottles discarded in the sea and other mineral materials or the bones of fishes or other oceanic animals. Sand can be also considered as a textural class of soil or soil type. A sandy soil containing more than 85 percent sand-sized particles by mass.

Composition of Sand

Sand is basically made of unconsolidated granular materials consisting of either rock fragments or mineral particles or oceanic materials. It is mainly made of silicate minerals and silicate rock granular particles.

Typically quartz is the most dominant mineral here as it possesses highly resistant properties to weather. Other common rock-forming minerals like amphiboles and micas also found in sand. Heavy minerals such as tourmaline, zircon, etc can also be present in the sand in smaller concentrations. But from a high level, most sand on the beach is made up of gray or tan quartz and feldspar.

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However, the most common mineral in the sand is quartz–also known as silicon dioxide. This is formed when silicon and oxygen combine. Feldspar is the most found group of minerals on the earth's surface and forms about 65% of the terrestrial rocks. When the wind and sea whip up on the shores, they transport these teeny-tiny granules to the beach and make up the sand with this combination.

Colors of Sand

There are some different colors is found in sand. They are-

1. **White Sand**: It's made of eroded limestone and may contain coral and shell fragments, in addition to other organic or organically derived fragmental material is may find in this color of sand. Magnetite, Chlorite, Glauconite, or Gypsum is also found.
2. **Black Sand**: Black sand is composed of volcanic minerals and lava fragments and Coral deposits.

1. **Pink Sand**: Foraminifera, a microscopic organism that has a reddish-pink shell, is responsible for all this color. Coral, shells, and calcium are also found in this mix.
2. **Red-orange Color**: This color is formed due to the coating of iron oxide.
3. **White-grey Color**: This sand consists of fine rounded grains and It is well graded.
4. **Light-brown Color**: It consists of rounded grains.

Different Types of Sand

It is not possible to classify the sand. Because there is no such thing as an official sand classification. Sand is a highly variable substance and therefore it is possible to make an attempt to classify it into separate categories.

1. **Coral Sand**: Coral sand has several meanings.
2. **Glass Sand**: This type of sand mainly consists of silicon dioxide. and this is the main element in this type of sand.
3. **Immature Sand**: Sand composed of the same minerals that made up its parent rocks.
4. **Gypsum Sand**: This type of same mainly consists of Calcium sulfate dihydrate. ($CaSO_4 \cdot 2H_2O$)
5. **Ooid Sand**: Ooids are rounded pellets, and are also spheroidal coated sedimentary grains. And this type of sand is formed by calcium carbonate.
6. **Silica Sand**: Silica sand is almost pure quartz.
7. **Pit Sand**:

   - Obtained by forming pits into the soil

   - It is sharp, angular, porous and free from harmful salts

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- Clay & other impurities should be washed and screened before using engineering purposes.

- Fine pit sand, when rubbed between fingers, should not leave any stain on it. It indicates the presence of clay.

-Used for the mortars

8. **River Sand**:

   - Found at river beds and banks.

   - Fine, round and polished due to rubbing action of water currents.

   - Has less frictional strength because of roundness.

   - Almost white in color.

   - Grains are smaller than pit sand, and hence more suitable for plastering work.

   - Normally available in pure condition and hence can be used for all kinds of Civil Engineering works.

9. **Sea Sand**:

   - Obtained from seashores.

   - Fine, rounded, and polished due to rubbing action of water.

   - Light brown in color.

   - Worst of the three types of sand because of containing a lot of salts.

   - Salts absorb moisture from the atmosphere and cause permanent dampness and efflorescence in the structure.

   - Sea salt also retards the setting action of cement.

   - Besides, it contains shells and organic matter which decompose in the body of mortar and concrete and hence reduce their life and strength.

   - Sea sand should as far as possible be discarded

10. **Green Sand**: Have some greenish materials.
11. **Desert Sand**: Which is found in the various desert.
12. **Lithic Sand**: Sometimes sand is composed of tiny rocks or comparatively more little, from this its formation its name is lithic sand.
13. **Mixed Carbonate-silicate Sand**: Some sand samples are a mixture of organic and inorganic sand grains.

14. **Biogenic Sand**: Sand may be composed entirely of tiny skeletons — seashells, corals, forams, etc.
15. **Garnet Sand**: Garnet is a common mineral in the sand but sometimes it forms the majority of it.
16. **Olivine Sand**: This type of sand is very unstable. And it is mainly used for steel casting sectors. But, it is a common sand mineral in some area and sometimes makes up a major part of the sand.
17. **Volcanic Sand**: Volcanically affected regions have their own type of dark-colored sand with a different type of characteristics. And sometimes coal is found in that.
18. **Heavy Mineral Sand**: In this type of sand there are some high mass molecule is found and can make a stable structure.
19. **Sands with Hematitic Pigment**: Hematite is the mineral that provides reddish pigment and sandstone.
20. **Continental Sand**: This sand is a common whole over the world for the formation of various structures.
21. **Quartz Sand**: Quartz is the same as silicon sand. Mainly quartz or silicon-dioxide is the main element to form this sand.

Depending on the particle grain size, the sand is divided into four classes:

1. Very coarse
2. Coarse
3. Medium
4. Fine-grained

Classification of Sand According to Size (ASTM)

1. Fine Sand: All the sand particles should pass through No. 16 sieve. This is usually used in plastering works.
2. Moderately Coarse Sand: All the sand particles should pass through No. 8 sieve. This type of sand is generally used for mortar and masonry works.
3. Coarse Sand: All the particles should pass through No. 4 sieve. This type of sand is very suited for concrete work.

Types of Moulding Sand:

According to the use, moulding sand may be classified as below:

1. Green Sand:

The green sand is the natural sand containing sufficient moisture in it. It is mixture of silica and 15 to 30% clay with about 8% water. Clay and water act as a bonding material to give strength. Molds made from this sand are known as green sand mould.

The green sand is used only for simple and rough casting products. It is used for both ferrous and non-ferrous metals.

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2. Dry Sand:

When the moisture is removed from green sand, it is known as dry sand. The mould produced by dry sand has greater strength, rigidity and thermal stability. This sand is used for large and heavy castings.

3. Loam Sand:

Loam sand is a mixture of 50 percent sand and 50 percent clay. Water is added in sufficient amount. It is used for large and heavy moulds e.g., turbine parts, hoppers etc.

4. Facing Sand:

A sand used for facing of the mouldis known as facing sand. It consists of silica sand and clay, without addition of used sand. It is used directly next to the surface of the pattern. Facing sand comes in direct contact with the hot molten metal; therefore it must have high refractoriness and strength. It has very fine grains.

5. Parting Sand:

A pure silica sand employed on the faces of the pattern before mouldingis known as parting sand. When the pattern is withdrawn from the mould, the moulding sand sticks to it.

To avoid sticking, parting sand is sprinkled on the pattern before it is embedded in the moulding sand. Parting sand is also sprinkled on the contact surface of cope, drag and cheek.

6. Backing or Floor Sand:

The backing sand is old and repeatedly used sand of black colour. It is used to back up the facing sand and to fill the whole volume of the box. This sand is accumulated on the floor after casting and hence also known as floor sand.

7. System Sand:

The sand employed in mechanical heavy castings and has high strength, permeability and refractoriness, is known as system sand. It is used for machine moulding to fill the whole flask. In machinemoulding no facing sand is used. The system sand is cleaned and has special additives.

8. Core Sand:

A sand used for making cores is known as core sand. It is silica sand mixed with core oil (linseed oil, resin, mineral oil) and other binding materials (dextrine, corn flour, sodium silicate). It has remarkable compressive strength.

9. Molasses Sand:

A sand which carries molasses as a binder is known as molasses sand. It is used for core making and small castings of intricate shapes.

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Properties of Moulding Sand

Following are the important properties of moulding sand:

1. Porosity:

Porosity also known as permeability is the most important property of the moulding sand. It is the ability of the moulding sand to allow gasses to pass through. Gasses and steam are generated during the pouring of molten metal into the sand cavity. This property depends not only on the shape and size of the particles of the sand but also on the amount of the clay, binding material, and moisture contents in the mixture.

2. Cohesiveness:

Cohesiveness is the property of sand to hold its particles together. It may be defined as the strength of the moulding sand. This property plays a vital role in retaining intricate shapes of the mould.

Insufficient strength may lead to a collapse in the mould particles during handling, turning over, or closing. Clay and bentonite improves the cohesiveness.

3. Adhesiveness:

Adhesiveness is the property of sand due to which the sand particles sticks to the sides of the moulding box. Adhesiveness of sand enables the proper lifting of cope along with the sand.

4. Plasticity:

Plasticity is the property of the moulding sand by virtue of which it flows to all corners around the mould when rammed, thus not providing any possibility of left out spaces, and acquires a predetermined shape under ramming pressure.

5. Flow-Ability:

Flow-ability is the ability of moulding sand to free flow and fill the recesses and the fine details in the pattern. It varies with moisture content.

6. Collapsibility:

Collapsibility is the property of sand due to which the sand mould collapse automatically after the solidification of the casting. The mould should disintegrate into small particles of moulding sand with minimum force after the casting is removed from it.

Aggregate most of which pass through 4.75 mm IS sieve is known as fine aggregate. Fine aggregate shall consists of natural sand, crushed stone sand, crushed gravel sand stone dust or arable dust, fly ash and broken brick (burnt clay).

It shall be hard, durable, chemically inert, clean and free from adherent coatings, organic matter etc. and shall not contain any appreciable amount of clay balls or pellets and harmful impurities e.g. iron pyrites, alkalis, salts, coal, mica, shale or similar laminated materials in such form or in such quantities as to cause corrosion of metal or affect adversely the strength, the durability or the appearance of mortar, plaster or concrete.

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The sum of the percentages of all deleterious material shall not exceed 5%. Fine aggregate must be checked for organic impurities such as decayed vegetation humps, coal dust etc.

Testing of Sand Quality at Construction Site

Following are the tests for sand at construction site:

1. **Organic impurities test** – this test is conducted at the field, for every 20 cum or part thereof.
2. **Silt content test** – this is also a field test and to be conducted for every 20 cum.
3. **Particle size distribution** – this test can be conducted at site or in laboratory for every 40 cum of sand.
4. **Bulking of sand** – this test is conducted at site for every 20 cum of sand. Based on bulking of sand, suitable water cement ratio is calculated for concrete at site.

1. Test for Silt Content Test of Sand

The maximum quantity of silt in sand shall not exceed 8%. Fine aggregate containing more than allowable percentage of silt shall be washed so as to bring the silt content within allowable limits.

2. Test for Grading of sand

On the basis of particle size, fine aggregate is graded into four zones. Where the grading falls outside the limits of any particular grading zone of sieves, other than 600 micron IS sieve, by a total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone.

IS Sieve	**Percentage passing for**			
	Grading Zone I	**Grading Zone II**	**Grading Zone III**	**Grading Zone IV**
10mm	100	100	100	100
4.75mm	90 – 100	90 – 100	90 – 100	90 – 100
2.36mm	60 – 95	75 – 100	85 – 100	95 – 100
1.18 mm	30 – 70	55 – 90	75 – 100	90 – 100

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600 micron	15 – 34	35 – 59	60 – 79	80 – 100
300 microns	5 – 20	8 – 30	12 – 40	15 – 50
150 microns	0 – 10	0 – 10	0 – 10	0 – 15

3. Test for Deleterious materials in sand

Sand shall not contain any harmful impurities such as iron, pyrites, alaklies, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shale in such form or in such quantities as to affect adversely the hardening, strength or durability of the mortar.

The maximum quantities of clay, fine silt, fine dust and organic impurities in the sand / marble dust shall not exceed the following limits:

(a) Clay, fine silt and fine dust when determined in accordance within not more than 5% by mass in IS 2386 (Part-II), natural sand or crushed gravel sand and crushed stone sand.

(b) Organic impurities when determined in colour of the liquid shall be lighter in lighter in accordance with IS 2386 (Part –II) than that specified in the code.

4. Test for Bulking of sand

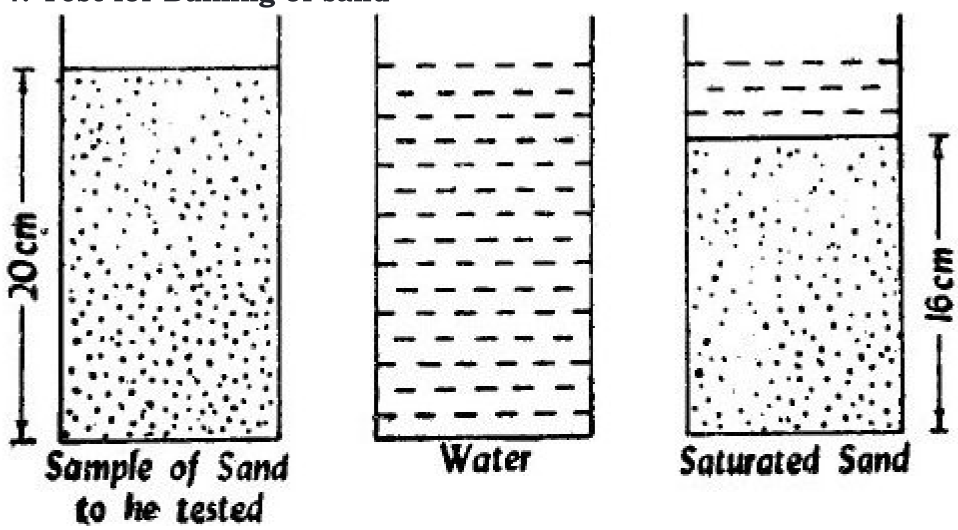

Fig: Bulking of sand test

Fine aggregate, when dry or saturated, has almost the same volume but dampness causes increase in volume. In case fine aggregate is damp at the time of proportioning the ingredients for mortar or concrete, its quantity shall be increased suitably to allow for bulkage.

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Table below gives the relation between moisture content and percentage of bulking for guidance only.

Moisture content (%)	**Bulking percentage (by volume)**
2	15
3	20
4	25
5	30

The Manufacturing Process

The preparation of sand consists of five basic processes: natural decomposition, extraction, sorting, washing, and in some cases crushing. The first process, natural decomposition, usually takes millions of years. The other processes take considerably less time.

The processing plant is located in the immediate vicinity of the natural deposit of material to minimize the costs of transportation. If the plant is located next to a sand dune or beach, the plant may process only sand. If it is located next to a riverbed, it will usually process both sand and gravel because the two materials are often intermixed. Most plants are stationary and may operate in the same location for decades. Some plants are mobile and can be broken into separate components to be towed to the quarry site. Mobile plants are used for remote construction projects, where there are not any stationary plants nearby.

The capacity of the processing plant is measured in tons per hour output of finished product. Stationary plants can produce several thousand tons per hour. Mobile plants are smaller and their output is usually in the range of 50-500 tons (50.8-508 metric tons) per hour.

In many locations, an asphalt production plant or a ready mixed concrete plant operates on the same site as the sand and gravel plant. In those cases, much of the sand and gravel output is conveyed directly into stockpiles for the asphalt and concrete plants.

The following steps are commonly used to process sand and gravel for construction purposes.

Natural decomposition

- 1 Solid rock is broken down into chunks by natural mechanical forces such as the movement of glaciers, the expansion of water in cracks during freezing, and the impacts of rocks falling on each other.
- 2 The chunks of rock are further broken down into grains by the chemical action of vegetation and rain combined with mechanical impacts as the progressively smaller particles are carried and worn by wind and water.
- 3 As the grains of rock are carried into waterways, some are deposited along the bank, while others eventually reach the sea, where they may join with fragments of coral or shells to form beaches. Wind-borne sand may form dunes.

Extraction

- 4 Extraction of sand can be as simple as scooping it up from the riverbank with a rubber-tired vehicle called a front loader. Some sand is excavated from under water using floating dredges. These dredges have a long boom with a rotating cutter head to loosen the sand deposits and a suction pipe to suck up the sand.
- 5 If the sand is extracted with a front loader, it is then dumped into a truck or train, or placed onto a conveyor belt for transportation to the nearby processing plant. If the sand is extracted from underwater with a dredge, the slurry of sand and water is pumped through a pipeline to the plant.

Sorting

- 6 In the processing plant, the incoming material is first mixed with water, if it is not already mixed as part of a slurry, and is discharged through a large perforated screen in the feeder to separate out rocks, lumps of clay, sticks, and other foreign material. If the material is heavily bound together with clay or soil, it may then pass through a blade mill which breaks it up into smaller chunks.
- 7 The material then pass through several / perforated screens or plates with different hole diameters or openings to separate the particles according to size. The screens or plates measure up to 10 ft (3.1 m) wide by up to 28 ft (8.5 m) long and are tilted at an angle of about 20-45 degrees from the horizontal. They are vibrated to allow the trapped material on each level to work its way off the end of the screen and onto separate conveyor belts. The coarsest screen, with the largest holes, is on top, and the screens underneath have progressively smaller holes.

Washing

- 8 The material that comes off the coarsest screen is washed in a log washer before it is further screened. The name for this piece of equipment comes from the early practice of putting short lengths of wood logs inside a rotating drum filled with sand

and gravel to add to the scrubbing action. A modern log washer consists of a slightly inclined horizontal trough with slowly rotating blades attached to a shaft that runs down the axis of the trough. The blades churn through the material as it passes through the trough to strip away any remaining clay or soft soil. The larger gravel particles are separated out and screened into different sizes, while any smaller sand particles that had been attached to the gravel may be carried back and added to the flow of incoming material.

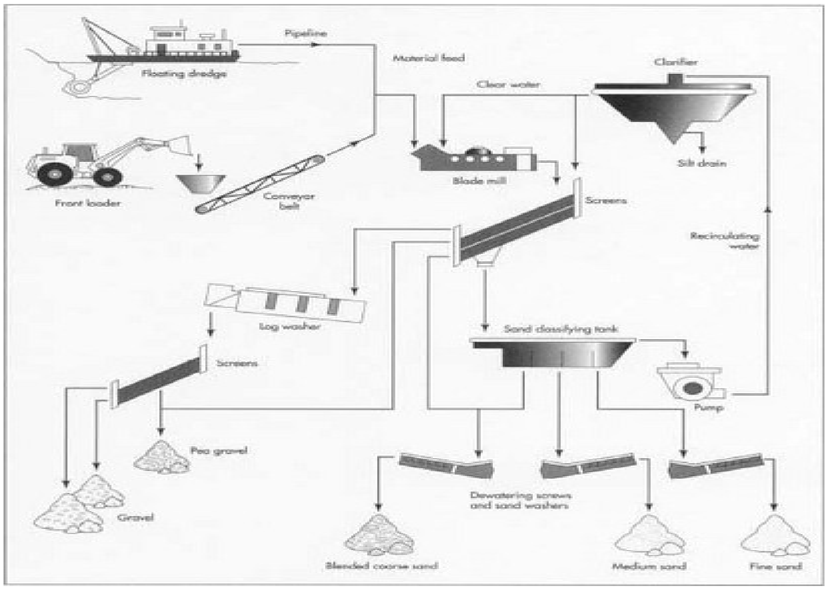
- 9 The material that comes off the intermediate screen(s) may be stored and blended with either the coarser gravel or the finer sand to make various aggregate mixes.
- 10 The water and material that pass through the finest screen is pumped into a horizontal sand classifying tank. As the mixture flows from one end of the tank to the other, the sand sinks to the bottom where it is trapped in a series of bins. The larger, heavier sand particles drop out first, followed by the progressively smaller sand particles, while the lighter silt particles are carried off in the flow of water. The water and silt are then pumped out of the classifying tank and through a clarifier where the silt settles to the bottom and is removed. The clear water is recirculated to the feeder to be used again.
- 11 The sand is removed from the bins in the bottom of the classifying tank with rotating dewatering screws that slowly move the sand up the inside of an inclined cylinder. The differently sized sands are then washed again to remove any remaining silt and are transported by conveyor belts to stockpiles for storage.

Crushing

- 12 Some sand is crushed to produce a specific size or shape that is not available naturally. The crusher may be a rotating cone type in which the sand falls between an upper rotating cone and a lower fixed cone that are separated by a very small distance. Any particles larger than this separation distance are crushed between the heavy metal cones, and the resulting particles fall out the bottom.

Quality Control

Most large aggregate processing plants use a computer to control the flow of materials. The feed rate of incoming material, the vibration rate of the sorting screens, and the flow rate of the water through the sand classifying tank all determine the proportions of the finished products and must be monitored and controlled. Many specifications for asphalt and concrete mixes require a certain distribution of aggregate sizes and shapes, and the aggregate producer must



The preparation of sand consists of five basic processes: natural decomposition, extraction, sorting, washing, and in some cases crushing. Sand is extracted from the location at which it occurs by either a floating dredge or front loader. The dredge delivers a slurry of sand and water to the processing plant via pipeline, while the front loader simply scoops the sand up and into trucks or onto conveyor belts for transporation to the plant. The sand is sorted through a series of screens that separate differently sized particles. The sand is washed, and the smaller particles are sent to the sand classifying tank, where the particles are further separated. Some particles may be crushed if smaller particles are needed.

ensure that the sand and gravel meets those specifications.

Timber is a type of wood which has been processed into beams and planks. It is also known as "lumber" in US and Canada. Basically, timber or Lumber is a wood or firewood of growing trees. Any wood capable of yielding a minimum dimensional size can be termed as a timber or lumber. It is a stage in the process of wood production. Timbers are used for the structural purpose. Those woods which are adapted for building purposes are timbers. Finished timber is supplied in standard sizes for the industry. Timber is used for building houses and making furniture.

There is high demand for timber as a building material. From building construction to furniture making, timbers have numerous uses. These uses have made timber an important building material.

Properties of Timber

The quality of timber must be ensured before using it for a purpose. The quality can be ensured by investigating the properties of timber. Here we have discussed both physical and mechanical properties of timber which affects timber quality.

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Followings are the physical and mechanical properties of timber:

- Colour
- Appearance
- Hardness
- Specific Gravity
- Moisture Content
- Grain
- Shrinkage and Swelling
- Strength
- Density
- Toughness
- Elasticity
- Warping
- Durability
- Defectless
- Workability
- Soundness

Colour

Color is a uniform property by which most trees are characterized as they show variation from tree to tree. Light color indicates weak timber. For example, freshly cut teak, Deodar, and Walnut have a golden yellow, whitish and dark brown shades respectively.

Appearance

Smell is a good property as timbers for few plants as they can be identified by their characteristic aroma. Fresh cut timbers have a good smell. For example resinous smell from pine.

Hardness

For the resistance of any kind of damage, hardness is an obvious property.

Specific Gravity

Variation of timber in specific gravity (0.3-0.9) is found. It depends on pores present inside timber. The specific gravity of this light material is less than that of water (<1). But in case of compact wood where pores are almost absent and become heavier, their specific gravity increases up to 1.5.

Moisture Content

Timbers are hygroscopic and gain water from nature (atmosphere). The absorption of water or dehydration depends on atmospheric humidity. If timbers moisture content is high that means the timber quality is low. Water content is the risk of fungal attack.

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Grain

Several types of grain arrangement found. On the grain structure quality of timber varies. Grains remain closely related.

1. Straight grain: Arrangement of vascular tissue (xylem and phloem) is important which grow parallel to the length of the timber that is termed as straight grain.
2. Coarse grain: vascular tissue and fibre arranged broadly and widely.

1. Interlocked grain: Instead of parallel arrangement twisted, a spiral arrangement may be found.

Shrinkage and Swelling

The percentage of shrinkage and swelling varies from plant to plant. Some give higher percentage after drying. Shrinkage starts when cell walls of timber start to release water. In moisture atmosphere timber swells when cell walls absorb water. Good quality timbers swell less. Timbers having thicker wall swell more than a thinner one.

Strength

Best quality timbers have the highest strength. Strength means capable to bear loads. Anisotropic material like timber has different structure at the different portion. So, the strength of timber is different at different points. Grain structure determines the strength of the timber. Some types of strength are

1. Compressive strength: 500 kg/cm2 to 700 kg/cm2 load is enough to test timbers strength.
2. Tensile strength: When timber is enough strong to the tensile force. If perpendicular force is made then timber is weaker. 500-2000 kg/cm2 is the range of tensile strength load.
3. Transverse strength: Enough bending strength indicates good quality timber.

Density

Timber having higher density have a thicker wall. An important property that quality of timber. Moisture content: Presence of defects: There may be some of the natural and artificial defects in timber such as cross-grain, knots, and shakes, etc. All of them cause a decrease in the strength of the timber.

Toughness

Timber has to have the capability to bear shocks, jerk. Anti-bending and ant splitting characteristic is needed. Old timbers have annual rings which indicate their age is a good indicator.

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Elasticity

Another property elasticity means timber should attain its own shape after use. Because of this quality, it is used in sports bat.

Warping

Environmental change with season can't effect good quality timber.

Durability

A good quality timber has the property to resist the attack the infection of fungus or other insects. This resistance quality makes timber better.

Defectless

This property is gained if the timber is from a sound tree. A defectless tree is free from sap, shakes, and dead knots. To know more about timber defects read: Defects in Timber

Workability

A good timber is always easy to work on it. Easy to drag using saw on good timber. The finishing can be done well.

Soundness

A good quality timber gives good sound.

Texture

The texture of good timber is fine and even.

Free of Abrasion

Timber should not be damaged by the external environment. It has to gain the ability to protect its skin.

Fibre-reinforced plastic (**FRP**) (also called fiber-reinforced polymer, or fiber-reinforced plastic) is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass (in fibreglass), carbon (in carbon fiber reinforced polymer), aramid, or basalt.

Testing timber

Timber can be tested on site for its moisture content. The moisture content is usually expressed as a percentage and calculated as the difference between the weight of the 'wet' timber and the weight of the same sample after drying. For example, the moisture content of a piece of timber weighing 500 g, and containing 250 g of water can be calculated as follows:

(Weight of wet timber - weight of dry timber) / Oven-dry weight x 100

(500 - 250) / 250 x 100 = 100%.

UK national product standards typically recommend that at the time of installation the moisture content should be:

- 18% in covered, generally unheated spaces.
- 15% in covered, generally heated spaces.
- 12% in internal conditions: in continuously heated buildings.
- 20% or more for external timber.

There are two common methods for measuring the moisture content:

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Oven dry testing

This involves drying timber to a relatively constant weight in a ventilated oven at 102-105°C. It is possible to establish a very accurate original moisture content percentage (%MC) by drying a piece of timber in an oven for several hours, and testing it at regular intervals until its weight stops changing.

While this method is accurate, it is a slow process which can, if rushed, burn the timber or render it unusable because of deformations. It is also necessary to have the right kind of ventilated oven, which means it is impractical in many instances.

Using a moisture meter

Moisture meters for timber come in a variety of types but can be divided into two general categories by the method of measurement:

- Pin-type meters: These use two or more electrodes to measure the moisture content using electrical resistance. The more resistance to the electrical current the drier the timber, since water is a conductor and timber is a natural insulator.
- Pinless moisture meters: These pass an electromagnetic wave through a sample using a specialised scanning plate. It creates a reading of the average moisture content in the scanning area.

Classification of timber(IS:399)

The terms timber and wood are often used synonymously, but they have distinct meaning in the building industry. Wood is the hard,fibrous material that makes up the tree under the bark,whereas timber may be defined as a wood which retains its natural physical structure and chemical composition and is suitable for various engineering works.Folowing is the classification of timber as pre IS: 399,except the classification of timber based on grading which is given in IS:6534.

On the basic of its Postion

Standing timber implies a living tree.

Rough timber forms a part of the felled tree.

Converted timber or Lumber are long of timber sawn into planks,posts,etc.

On the Basic of Grading (IS :6534)

All grading specifications are clearly distinguished between structural or stress grading, and commercial or utility grading based on Indian Standard classification.

Structural grading is also known as stress grading.However,there is a small distinction between the two.Structural grading refers to the principle by which the material is graded on the basic of visible defects which have known effects on the strength properties of the material.Stress grading refers to the principle by which the material is graded by consideration of structural grading is further divided as:

1.Grading based on known effect of defect and estimating accumulative value.

2.Machine grading.

Commercial grading also known as yard grading or utility grading refers to the principle by which the material is graded by consideration of usefulness of the material and price factors.

Commercial grading is further divided in the following classes:

Grade A: This classification is based on dimensions and general appearance.The dimensions of lengths,widths and thicknesses of converted materials are measured.This system is prevalent is Kerala and Mysore.

Grade B: This classfiaction is based on the best ultimate use of the material.Such a system is mostly in Andhra Pradesh and some parts of Tamil Nadu.Here,each grade is further divided into A,B and C classes to indicate occurrence of defect.Only two lengths are recognized,long(L) which is 5m and above,and short(S) that is under 5m.Each log is stamped such as BAL(Beam,A-class,long),PBS(Plank,B-class,short),etc.Some times another letter is also added indicating the species e.g.T for teak.

Grade C: This classification is based on qualitative evaluation of defects and rough estimate of out-turn of utilizable material.It is prevalent in Madhya Pradesh.

Grade D: This classification is based on evaluation of units of defect and fixing the permissible number of standard volume of area or the material in each grade.This system is prevalent in number of standard volume of area or the material in each grade.This system is prevalent in Bombay region and is increasingly adopted in Indian Standards and is recognized internationally.

Fibre-reinforced plastic (**FRP**) (also called fiber-reinforced polymer, or fiber-reinforced plastic) is a composite material made of a polymer matrix reinforced with fibres. The

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fibresare usually glass (in fibreglass), carbon (in carbon fiber reinforced polymer), aramid, or basalt.

Classification of Fibre Reinforced Polymer (FRP)

1. Glass Fibre Reinforced Polymer (GFRP)

Glass fibresare basically made by mixing silica sand, limestone, folic acid and other minor ingredients. The mix is heated until it melts at about 1260°C.

The molten glass is then allowed to flow through fine holes in a platinum plate. The glass strands are cooled, gathered and wound. The fibresare drawn to increase directional strength. The fibresare then woven into various forms for use in composites.

Based on an aluminium lime borosilicate composition, glass produced fibres are considered as the predominant reinforcement for polymer matrix composites due to their high electrical insulating properties, low susceptibility to moisture and high mechanical properties.

Glass is generally a good impact resistant fibre but weighs more than carbon or aramid. Glass fibres have excellent characteristics equal to or better than steel in certain forms.

Fig. 3: Glass Fibre Reinforced Polymer Bars

2. Carbon Fibre Reinforced Polymer (CFRP)

Carbon fibres have a high modulus of elasticity, 200-800 GPa. The ultimate elongation is 0.3-2.5 % where the lower elongation corresponds to the higher stiffness and vice versa.

Carbon fibres do not absorb water and are resistant to many chemical solutions. They withstand fatigue excellently and neither corrode nor show any creep or relaxation.

Fig. 4: Carbon Fibre Reinforced Polymer Bars

3. Aramid Fibre Reinforced Polymer (AFRP)

Aramid is the short form for aromatic polyamide. A well-known trademark of aramid fibres is Kevlar but there does exist other brands as well such as Twaron, Technora and SVM.

The modulii of the fibres are 70-200 GPa with an ultimate elongation of 1.5-5% depending on the quality. Aramid has a high fracture energy and is therefore used for helmets and bullet-proof garments.

They are sensitive to elevated temperatures, moisture and ultraviolet radiation and therefore not widely used in civil engineering applications. Finally, Aramid fibres do have problems with relaxation and stress corrosion.

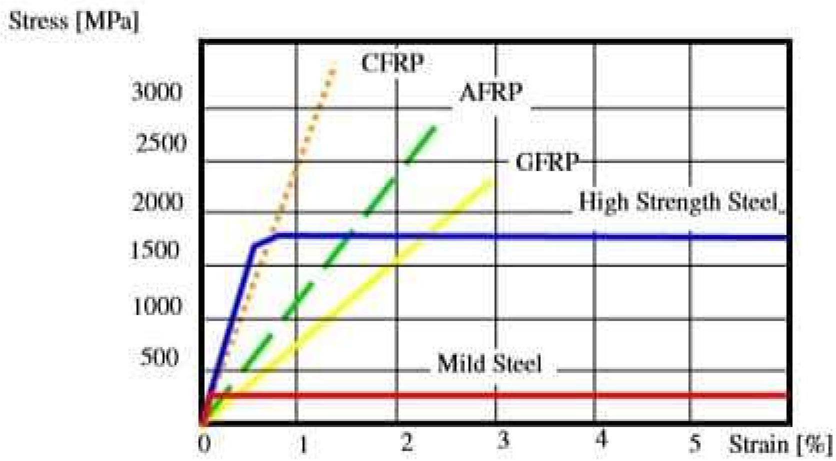

Fig. 5: Properties of Different Types of FRP Compared with Steel

Applications of FRP

1. Carbon FRPs are used in prestressed concrete for applications where high resistance to corrosion and electromagnetic transparency of CFRP are important.
2. CFRP composites are employed for underwater piping and structural parts of offshore platform. Added to that, FRP declines the risk of fire.
3. Carbon fibre reinforced polymers are used to manufacture underwater pipes for great depth because it provides a significantly increased buoyancy (due to its low density) compared to steel.
4. The stairways and walkways are also made of composites for weight saving and corrosion resistance.
5. It is used in high-performance hybrid structures.
6. FRP bars are used as internal reinforcement for concrete structures.
7. FRP bars, sheets, and strips are used for strengthening of various structures constructed from concrete, masonry, timber, and even steel.
8. FRPs are employed for seismic retrofitting.
9. Fibre reinforced polymers are used in the construction of special structures requiring electrical neutrality.
10. The high energy absorption of aramid fibre reinforced polymer (AFRP) composites makes them suitable for strengthening engineering structures subjected to dynamic and impact loading.

Properties of FRP:

High Strength-to-Weight Ratio– FRP are lightweight and strong; they posses a vast range of mechanical properties, including tensile, flexural, impact and compressive strengths. When compared to most other metals they can deliver more strength per unit of weight then most metals. Their light weight also lends itself well to logistics—it's easier to ship and install.

Customizable- Every industry has unique problems to solve. With FRP engineers have the ability to tailor or modify the design of their FRP to meet their specific requirements. For example, consider the benefits of altering resin, glass content to optimize your corrosion and or abrasion resistance—you can't do this with metal.

Anisotropic- Engineers can maximize the performance and efficiency of the structure when they take advantage of the inherent anisotropic properties of FRP. Because the maximum strength is in the direction of the fiber reinforcements engineers can optimize the design to optimize the materials and the overall performance of the structure.

High Tensile Strength with Low Modulus of Elasticity-FRP have high tensile strength due to its composite properties. Engineers can specify unique resin, fiber-reinforcement compositions when working with FRP manufactures. The design control inherent to FRP will enhance performance and can only be realized when working with composites, not metals.

Ability to Form Complex Shapes- Engineers can harness ultimate design flexibility when using FRP—an advantage over traditional materials such as metal, concrete, and wood. When you integrate FRP design into your project into your project also consider the added benefits of part consolidation, noise reduction and streamlined design.

A **composite material** (also called a **composition material** or shortened to **composite**, which is the common name) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions.[1][2]

The new material may be preferred for many reasons. Common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

Typical engineered composite materials include:

- Reinforced concrete and masonry
- Composite wood such as plywood
- Reinforced plastics, such as fibre-reinforced polymer or fiberglass
- Ceramic matrix composites (composite ceramic and metal matrices)
- Metal matrix composites
- and other Advanced composite materials

Types of Composites in Construction

Composites are classified into two distinct levels; based on matrix constituents and their forms.

Composite Types Based on Matrix Constituents

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There are three major types of composites based on matrix constituents. In each of these systems, the matrix is typically a continuous phase throughout the component.

1. Polymer Matrix Composite (PMCs)

It consists of various short or continuous fibers which are bound together by an organic polymer matrix. Polymer matrix composite's main function is to transfer the loads between fibers through the matrix.

Lightweight, high stiffness, high strength along the direction of their reinforcements, abrasion resistance, and corrosion resistance are some properties of polymer matrix composite.

2. Metal Matrix Composite (MMCs)

Metal matrix composites are usually made up of aluminum to give it enough strength as it is less dense than iron, and hence is preferred in the aerospace industry. It is a material in which continuous carbon, silicon carbide, or ceramic fibers are embedded in a metallic matrix material.

Most common metal matrix composites are aluminum matrix composites. Major advantages of aluminum matrix composites are increased specific strength, specific stiffness, and elevated temperature strength in addition to improved wear resistance, lower density, and good corrosion resistance.

3. Ceramic Matrix Composite (CMCs)

These are materials consisting of a ceramic or carbon fiber surrounded by a ceramic matrix such as silicon carbide.

Composite Types Based on Matrix Constituents Forms

1. Particulate Reinforced Composites

Particulate reinforced composites are composed of hard particle constituents which are scattered in a softer matrix in an arbitrary manner. Metallic particle dispersed in metallic, polymeric or ceramic matrices is an example of particulate composite. A widely used particulate composite is concrete in which gravel is embedded in the cement paste.

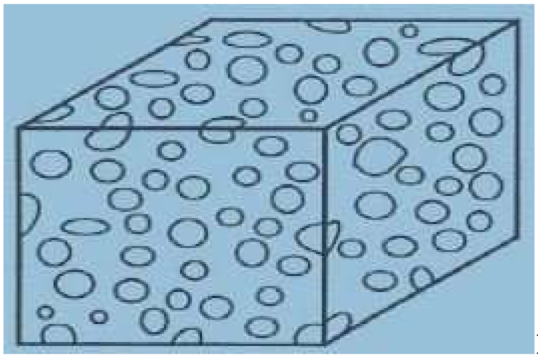
Fig. 3: Particulate Composite

2. Flake composites

This type of composite is produced by blending matrix material and thin flakes. Despite the fact that flakes dispersion in the matrix is random, the flakes can be made to align with one another forming a more orderly structure compared to particulate composites.

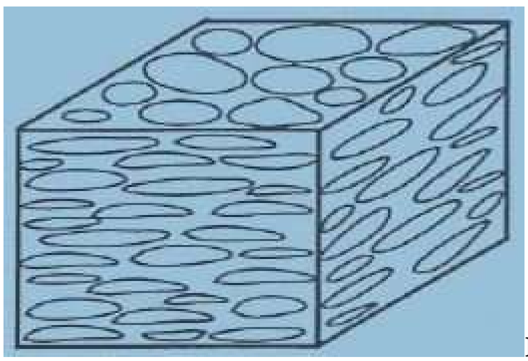
Fig. 4: Flake Composite

3. Fiber Reinforced Composites (Fibrous Composites)

It is composed of strong and stiff fibers which are held together by a matrix. Fibers act as primary load-carrying constituent due to their strong characteristics. The matrix serves as an agent to redistribute the loads from a broken fiber to the adjacent fibers in the material when fibers start failing under excessive loads.

This property of the matrix constituent contributes to one of the most important characteristics of fibrous composites, namely improved strength compared to the individual constituents.

Reinforcement composites are usually glass fibers, carbon fibers and aramid fibers. Fibers are usually high strength, low-density materials that possess good resistance to heat and corrosion and are easy to handle.

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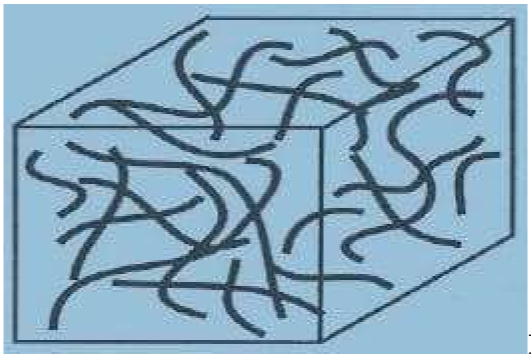
Fig. 5: Fiber Reinforced Composite

4. Laminated Composites

Laminated composites are made from completely bonded thin elementary layers. These layers can be composites themselves; for instance, fibrous composite layer. This type of composite is the most commonly encountered laminated composite material used in high-performance structures.

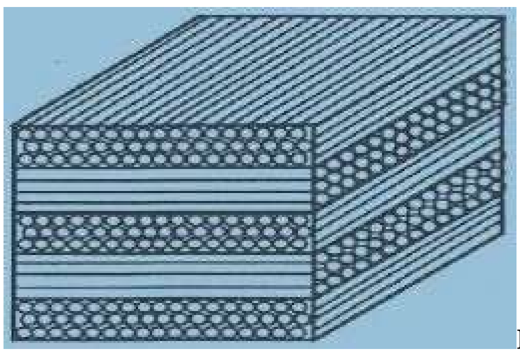
Fig. 6: Laminated Composite

IS Standards And Specifications For Use In Construction As Per SP 21:1983:

GENERAL 1.1 Materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for use in the work. Materials shall also be stored to protect against atmospheric agencies, fire and other hazards. 1.2 Materials like timber, coal, paints, etc, shall be stored in such a way that there may not be any fire hazards. Inflammable materials like kerosene, petrol, etc, shall be stored in accordance ~with the relevant rules and regulations in force prescribed by the Authority, so as to ensure safety during storage (see also IS 7969 : 1975). Explosives like detonators shall be stored in accordance with the rules and regulations in force. Materials which are likely to be affected by subsidence of soil, like precast elements, large size timber sections, etc, shall be provided with unyielding supports. In areas, likely to be affected by floods, the materials shall be suitably stow cd to prevent their being washed away or damaged by floods. During construction, stairways, passageways and gangways shall not be obstructed due to storage of materials, tools or rubbish.

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CEMENT Cement shall be stored at the work site in a building or shed which is dry, leakproof and as moisture proof as possible. The building shall have minimum number of windows and close fitting doors which shall be kept closed as far as possible. Cement stored in bags shall be stacked and shall be kept free from the possibility of any dampness or moisture coming in contact with the bags. Cement bags shall be stored/stacked off the floor on wooden planks in such a way as to be clear above the floor by 1 SO mm to 200 mm and a space of 450 mm minimum alround between the bags and external walls. In the stacks, cement bags shall be kept close together to reduce circulation of air as much as possible. Owing to pressure on the bottom layer of bags 'warehouse pack' is developed in these bags. This can be removed easily by rolling the bags when the cement is taken for use. The height of the stack shall be not more than 15 bags to~prevent the possibility of lumping up under pressure. The width of the stack shall not be more than four bags length or 3 m. In stacks more than 8 bags high, the cement bags shall be arranged alternately lengthwise and crosswise so as to tie the stacks together and minimize the danger of toppling over. Cement bags shall be stacked in a manner to facilitate their removal and use in the order in which they are received. During the monsoon orwhen it is expected to be stored for a long period, the stack shall be completely enclosed by a waterproofing membrane, such as, polyethylene sheet. Care shall be taken to see that the membrane is not damaged any time during use. Different types of cements shall be stored separately. Cement stored in drums may be arranged vertically with closures on top. After partial use of cement in drums when it occurs, the closure should be firmly fastened to prevent ingress of moisture. A maximum of 3 drums can be stacked in height.

LIME Quick lime deteriorates rapidly on exposure by taking up moisture and carbon dioxide from atmosphere. Therefore, it should be stacked as soon as possible before deterioration sets in. If unavoidable, quicklime may be stored in compact heaps having only minimum of exposed area. The heaps shall be stored on a suitable platform and covered to avoid direct contact with moisture/rain or being blown away by wind. In case it is stored in a covered shed, a minimum space of 300 mm should be provided alround the heaps to avoid bulging of walls.. Hydrated lime is generally supplied in containers such as jute bags, lined polyethelene or HDPE woven bags lined with polyethylene or craft paper bags. It should be stored in a building to protect lime from dampness and to minimize warehouse deterioration. Dry slaked lime should be stored on a platform suitably covered from rain and wind if it is to be used within a few days. If required to be stored for longer periods not exceeding 2 months it may be kept in a dry and closed godown.

BRICKS Bricksshall not be dumped at site. They should be stacked in regular tiers as and when they are unloaded to minimize breakage and defacement of bricks. In case of bricks made -from clay containing lime kanknrthe bricks in stack should be thoroughly soaked in water to prevent lime bursting. Bricks shall be placed close to the site of work so that least effort is required to unload and transport the bricks again by loading on pallets or barrows. Building bricks shall -be loaded a pair at a lime unless palletized. Unloading of building bricks or handling in any other way likely to damage the corners or edges or other parts of bricks shall not be permitted. Bricks shall be stacked on firm ground. For proper inspection of quality and ease in counting, the stacks SP 62 (S & T) : 1997 shall be 50 bricks long and 10 bricks high, the bricks being placed onedge. The width of each stack shall be 6 to 8 bricks. Clear distance between adjacent stacks shall not be less than 0.8 m. Bricks of different types and class shall be stacked separately.

TIMBER Timber shall be stored in stacks upon well treated and even surfaced beams, sleepers or brick pillars as to be above the ground level by at least 150 mm. The various members shall preferably be stored separately n different lengths, and material of equal lengths shall be piled together in layers with wooden battens, called crossers, separating one layer from another. The crossers shall be of sound wood, straight and uniform in thickness. In any layer, air space of about 25 mm shall be provided between adjacent members. The larger pieces shall be placed in the bottom layers and the shorter pieces in the upper layers, but one end of the stock including crossers shall be in true vertical alignment. The most suitable width and height of a stack are recommended to. be about 1.5 m and 2 m. Distance between adjacent stacks is shown in Fig. 1.1. The stacks shall be protected from hot dry winds or direct sun and rain. Heavy weights, such as metal rails

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Unit 2 Substructure:

Introduction – Types Of Soils – Classification Of Soils As Per IS Standards –Cohesion And Adhesion Of Soil – Bearing Capacity Of Soil – Methods Of Assessing Bearing Capacity Of Soil – Types Of Foundations – Shallow Foundation – Deep Foundation - Special Types Of Foundations For Shore And Offshore Structures – Foundations With Rock Anchors.

Substructure. The **substructure** is the lower part of a **building** which is constructed below the ground level. The function of **substructure** is the transfer of loads from the superstructure to the underlying soil. ... An experienced structural engineer should generate plans and works for the **substructure** of a **building** project.

The basic **components** of a building **substructure** are the foundation and plinth beam.

Foundation

The foundation is the structure below the ground level that has direct contact with the superstructure. This component transfers dead loads, live loads and all other loads coming over it to the underlying soil.

Foundation is constructed in such a way that the soil over which it is lying is stressed within its safe bearing capacity. Any failure of foundation results in the failure of the building structure. Hence, different building structure demands different types of foundations like shallow or deep foundations.

Plinth Beam

Plinth beam is a beam constructed in the plinth level between the wall and the foundation. This is a reinforced concrete beam constructed to prevent the propagation of cracks from the foundation to the walls.

Fig.2.Plinth Beam; Image Courtesy: www.dreamstime.com

A plinth beam helps to transfer and distribute the load evenly from the walls to the foundation. These are mandatory for construction projects planned in earthquake-prone areas.

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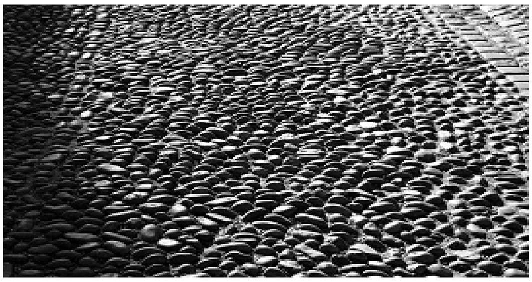
Classification of Soils As Per IS Standards

Very coarse

Boulders

- Particle sizes: Anything above 200 mm.
- Particle shape: Angular, subangular, rounded, flat, elongated.
- Texture: Rough, smooth, or polished.
- Compactness: Loose.
- Strength field test: By inspection of voids and particle packing.
- Structure: Homogenous, inter-stratified, heterogeneous, or weathered.

Cobbles



- Particle sizes: 60-200 mm.
- Particle shape: Angular, sub-angular, rounded, flat, elongated.
- Texture: Rough, smooth, or polished.
- Compactness: Dense.
- Strength field test: By inspection of voids and particle packing.
- Structure: Homogenous, inter-stratified, heterogeneous, or weathered.

Coarse soils

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Gravels

Coarse gravels:

- Particle sizes: 20-60 mm. Easily visible to the naked eye meaning that grading can be described. Well graded means there is a wide range of grain sizes; poorly graded means there is a limited range.
- Particle shape: Angular, subangular, rounded, flat, elongated.
- Texture: Rough, smooth, or polished.
- Composite soil types: Clay or silt content of under 5%. Classified as 'slightly clayey' or 'slightly silty'.
- Structure: Homogenous, inter-stratified, heterogeneous, or weathered.

Medium gravels:

- Particle sizes: 6-20 mm. Easily visible to the naked eye meaning that grading can be described. Well graded means there is a wide range of grain sizes; poorly graded means there is a limited range.
- Particle shape: Angular, subangular, rounded, flat, elongated.
- Texture: Rough, smooth, or polished.
- Composite soil types: Clay or silt content of 5-15%. Classified as 'clayey' or 'silty'.
- Compactness: Loose.
- Strength field test: Can be excavated with a spade; 50 mm wooden peg can be easily driven.
- Structure: Homogenous, inter-stratified, heterogeneous, or weathered.

Fine gravels:

- Particle sizes: 2-6 mm. Easily visible to the naked eye meaning that grading can be described. Well graded means there is a wide range of grain sizes; poorly graded means there is a limited range.
- Particle shape: Angular, subangular, rounded, flat, elongated.
- Texture: Rough, smooth, or polished.
- Composite soil types: Clay or silt content of 15-35%. Classified as 'very clayey' or 'very silty'.
- Compactness: Dense.
- Strength field test: Excavation requires a pick; 50 mm wooden peg is difficult to drive.

- Structure: Homogenous, inter-stratified, heterogeneous, or weathered.

For more information see: Gravel

Sands

Coarse sands:

- Particle sizes: 0.6-2 mm. Visible to the naked eye. When dry there is little to no cohesion. Grading can be described.
- Particle shape: Angular, subangular, rounded, flat, elongated.
- Texture: Rough, smooth, or polished.
- Composite soil types: Classified as 'sandy gravel' or 'gravelly sand'. Clayey composites are described as plastic or cohesive. Silty composites are described as non-plastic or of low plasticity.
- Compactness: Slightly cemented.
- Strength field test: Visual examination; pick removes soil in lumps.
- Structure: Homogenous, inter-stratified, heterogeneous, or weathered.

Medium sands:

- Particle sizes: 0.2-0.6 mm. Visible to the naked eye. When dry there is little to no cohesion. Grading can be described.
- Particle shape: Angular, subangular, rounded, flat, elongated.
- Texture: Rough, smooth, or polished.
- Composite soil types: Classified as 'sandy gravel' or 'gravelly sand'. Clayey composites are described a plastic or cohesive. Silty composites are described as non-plastic or of low plasticity.
- Structure: Homogenous, inter-stratified, heterogeneous, or weathered.

Fine sands:

- Particle sizes: 0.06-0.2 mm. Visible to the naked eye. When dry there is little to no cohesion. Grading can be described.
- Particle shape: Angular, subangular, rounded, flat, elongated.
- Texture: Rough, smooth, or polished.

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- Composite soil types: Classified as ‘sandy gravel’ or ‘gravelly sand’.
  Clayey composites are described a plastic or cohesive. Silty composites are described as non-plastic or of low plasticity.
- Structure: Homogenous, inter-stratified, heterogeneous, or weathered.

NB Continuously graded means: ‘A soil or aggregate with a balanced mix of particle sizes with significant proportions of all fractions from the maximum nominal size down.’ Ref The SuDS Manual published by CIRIA in 2015.

For more information see: Sand

Fine soils

Silts

Coarse silts:

- Particle sizes: 0.02-0.06 mm. Barely visible to the naked eye.
- Particle nature: Non-plastic or of low plasticity.
- Compactness: Soft or loose.
- Strength field test: Easily moulded or powdered between fingers.
- Structure: Fissured, intact, homogeneous, inter-stratified, or weathered.

Medium silts:

- Particle sizes: 0.006-0.02 mm. Not visible to the naked eye.
- Particle nature: Non-plastic or of low plasticity.
- Compactness: Firm or dense.
- Strength field test: Can be moulded or powdered between fingers with strong pressure.
- Structure: Fissured, intact, homogeneous, inter-stratified, or weathered.

Fine silts:

- Particle sizes: 0.002-0.006 mm. Not visible to the naked eye.
- Particle nature: Non-plastic or of low plasticity.
- Composite soil types: Sand or gravel content of 35-65%. Classified as ‘sandy’ or ‘gravelly’.

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- Compactness: Very soft.
- Strength field test: Exudes between fingers when squeezed in hand.
- Structure: Fissured, intact, homogeneous, inter-stratified, or weathered.

Clays

- Dry lumps can be broken but not powdered between fingers; smooth to the touch; shrinks on drying which usually leaves cracks.
- Particle nature: Intermediate plasticity through to high plasticity.
- Composite soil types: Sand or gravel content of less than 35%.
- Compactness: Soft.
- Strength field test: Soft (moulded by light finger pressure), firm (moulded by strong finger pressure), stiff (can be indented by thumb), very stiff (can be indented by thumb nail).
- Structure: Fissured, intact, homogeneous, inter-stratified, or weathered.

For more information see: Clay

Organic soils

Organic clay, silt or sand

- Particle sizes: Varies.
- Visual identification: Contains substantial amounts of organic vegetable matter.
- Composite soil types: Sand or gravel content of 35-65%. Classified as ‘sandy’ or ‘gravelly’.
- Compactness: Firm.
- Strength field test: Fibres already compressed together.
- Structure: Fibrous (plant remains recognisable and retains some strength); amorphous (recognisable plant absent).

Peats

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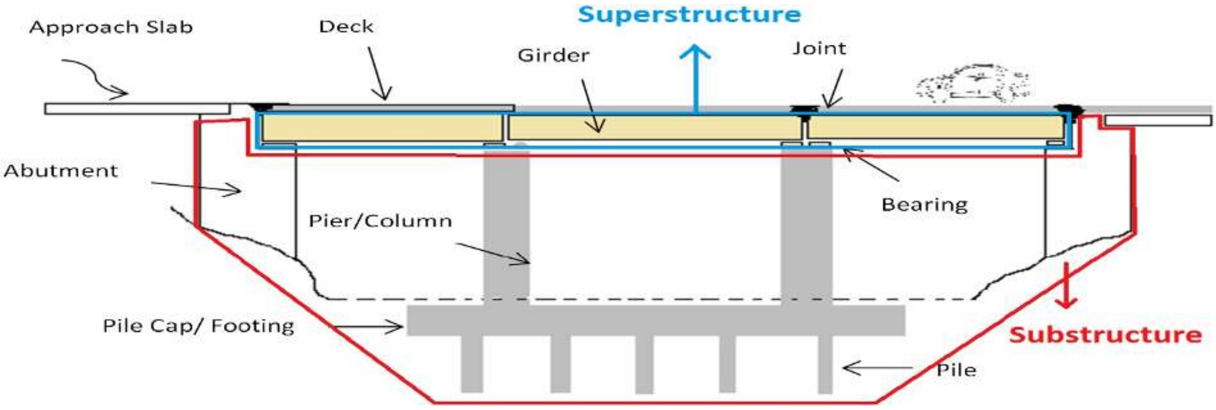
- Particle sizes: Varies.
- Visual identification: Predominantly plant material which remains dark brown or black, usually with a distinctive smell and low-bulk density.
- Compactness: Spongy, plastic.
- Strength field test: Very compressible and open structure; can be moulded by hand.
- Structure: Fibrous (plant remains recognisable and retains some strength); amorphous (recognisable plant absent).

Alluvial deposits

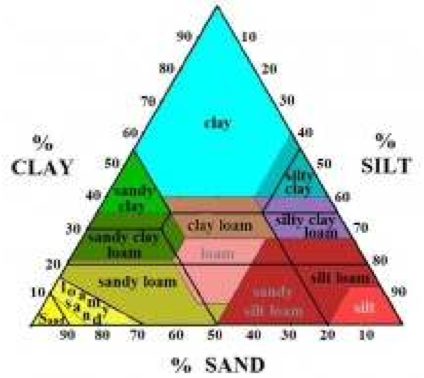
Natural materials deposited within and adjacent to rivers. For more information see: Alluvium.



Types of soil: Every house has a foundation, and every foundation must be constructed efficiently, safely and correctly, so it will last. The materials that make up the building block and the process of building it are equally important; however, one thing that's often overlooked is the soil supporting them because even foundations need a solid foundation. Each type of soil has different properties that affect foundations differently. Generally, soil will be more stable the more rock and compacted sand/gravel it contains.

A diagram showing the different soil levels.

A soil textural triangle showing the subtle differences between the USDA (colours) and UK- ADAS (black lines) soil classes



The Types of Soils

1. **Peat** – Peaty soil is usually dark brown or black and is easily compressible because of how much water it can hold. However, during the summer it becomes extremely dry and can even be a fire hazard. It is very poor subsoil and not ideal for support, as foundations are most stable on soil that does not shift or change structure.
2. **Clay** – Clay is made up of tiny particles so it stores water well, but because of its tight grasp on water it expands greatly when moist and shrinks significantly when dry. When clay is moist, it is very pliable, and can easily be moved and manipulated. These extreme changes put a great deal of pressure on foundations, causing them to move up and down, and eventually crack, making clay a poor soil for support.
3. **Silt** – Silty soil can be smooth to the touch and retains water longer because of its smaller particles. However, because of its tendency to retain moisture it is cold and drains poorly. This causes the silty soil to expand, pushing against a foundation and weakening it, making it not ideal for support.
4. **Sand/Gravel** – Sand/gravel has the largest particles of the different soil types. It is dry and gritty to the touch and does not hold moisture because of the large openings, but drains easily. When compacted and moist it holds together fairly well, and if compacted these make for good soils to support a foundation because of their non-water-retaining properties. However, when moist, the particles will lose their friction and can be washed away, which can leave gaps beneath the foundation.
5. **Loam** – Loam is the ideal soil type: typically it's a combination of sand, silt and clay. It is dark in color and soft, dry and crumbly to the touch. Loam is great for supporting foundations because of its evenly balanced properties, especially how it maintains water at a balanced rate. Loam is a good soil for supporting a foundation, as long as no miscellaneous soils find their way onto the surface.
6. **Rock** – Types such as bedrock, limestone, sandstone, shale and hard chalk have high bearing capacities. These are very strong and good for supporting foundations because of their stability and depth. As long as the rock is level the foundation will be well supported.

The bearing capacity of soil is defined as the capacity of the soil to bear the loads coming from the foundation. The pressure which the soil can easily withstand against load is called allowable bearing pressure.

Cohesion Force: Because of **cohesion** forces, water molecules are attracted to one another. **Cohesion** causes water molecules to stick to one another and form water droplets. **Adhesion** Force: This force is responsible for the attraction between water and solid surfaces.

Cohesive soils are clay type soils. Cohesion is the force that holds together molecules or like particles within a soil.

Cohesion, **c**, is usually determined in the laboratory from the *Direct Shear Test.* Unconfined Compressive Strength, $\mathbf{S_{uc}}$, can be determined in the laboratory using the *Triaxial Test* or the *Unconfined Compressive Strength Test.* There are also correlations for $\mathbf{S_{uc}}$ with shear strength as estimated from the field

Cohesive strength (c) for some materials

Material	Cohesive strength in kPa	Cohesive strength i
Rock	10000	1450
Silt	75	10
Clay	10 to 20	1.5 to 3
Very soft clay	0 to 48	0 to 7
Soft clay	48 to 96	7 to 14
Medium clay	96 to 192	14 to 28

using *Vane Shear Tests.*

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Stiff clay	192 to 384	28 to 56
Very stiff clay	384 to 766	28 to 110
Hard clay	> 766	> 110

c = $S_{uc}/2$

Where:

c = cohesion, kN/m^2 (lb/ft^2), and
S_{uc} = unconfined compressive strength, kN/m^2 (lb/ft^2).

Adhesion of Soil
When performing the analysis in the total stress state for active or passive earth pressure it is necessary to consider the total (undrained) shear strength of soil c_u and the adhesion a of soil to the structure face. The value of adhesion a is usually considered as a fraction of the soil cohesion c. The typical values of a for a given range of the cohesion c are listed in the following table.

Common values of the adhesion of soil a

Soil	Cohesion c [kPa]	Adhesion a [kPa]
Soft and very soft cohesive soil	0 - 12	0 - 12
Cohesive soil with medium consistency	12 - 24	12 - 24
Stiff cohesive soil	24 - 48	24 - 36
Hard cohesive soil	48 - 96	36 - 46

Adhesion vs. Cohesion

Adhesion is the mutual attraction between unlike molecules that causes them to cling to one another. The word can be used in a more general sense to refer to any clinging property (for example, glues and tapes can be called adhesives). The defining feature is that adhesion occurs between two different substances. For example, the adhesion of

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water molecules to the plastic beaker causes them to cling at a higher level around the edges.

Cohesion is the mutual attraction between like molecules that causes them to stick together. The word can also be used in a more general sense to indicate that something, such as a story or a lecture, remains the same throughout. The defining feature of cohesion is that it occurs between two like substances.
Adhesion is responsible for a meniscus when water is observed in a glass container, because the water clings to the glass around the edges. Cohesion is responsible for surface tension, such as droplets of water beading together on waxed paper.

Bearing capacity: **bearing capacity** is the capacity of soil to support the loads applied to the ground. The bearing capacity of soil is the maximum average contact pressure between the foundation and the soil which should not produce shear failure in the soil. *Ultimate bearing capacity* is the theoretical maximum pressure which can be supported without failure; *allowable bearing capacity* is the ultimate bearing capacity divided by a factor of safety. Sometimes, on soft soil sites, large settlements may occur under loaded foundations without actual shear failure occurring; in such cases, the allowable bearing capacity is based on the maximum allowable settlement.

There are three modes of failure that limit bearing capacity: general shear failure, local shear failure, and punching shear failure. It depends upon the shear strength of soil as well as shape, size, depth and type of foundation.

Types of Bearing Capacity of Soil
Following are some types of bearing capacity of soil:
1. Ultimate bearing capacity (q_u)
The gross pressure at the base of the foundation at which soil fails is called ultimate bearing capacity.

2. Net ultimate bearing capacity (q_{nu})
By neglecting the overburden pressure from ultimate bearing capacity we will get net ultimate bearing capacity.

$$q_{nu} = q_u - \Upsilon D_f$$

Where Υ = unit weight of soil, $\mathbf{D_f}$ = depth of foundation
3. Net safe bearing capacity (q_{ns})
By considering only shear failure, net ultimate bearing capacity is divided by certain factor of safety will give the net safe bearing capacity.

$$\mathbf{q_{ns} = q_{nu} / F}$$

Where F = factor of safety = 3 (usual value)

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4. Gross safe bearing capacity (q_s)

When ultimate bearing capacity is divided by factor of safety it will give gross safe bearing capacity.

$$q_s = q_u/F$$

5. Net safe settlement pressure (q_{np})

The pressure with which the soil can carry without exceeding the allowable settlement is called net safe settlement pressure.

6. Net allowable bearing pressure (q_{na})

This is the pressure we can used for the design of foundations. This is equal to net safe bearing pressure if $q_{np} > q_{ns}$. In the reverse case it is equal to net safe settlement pressure.

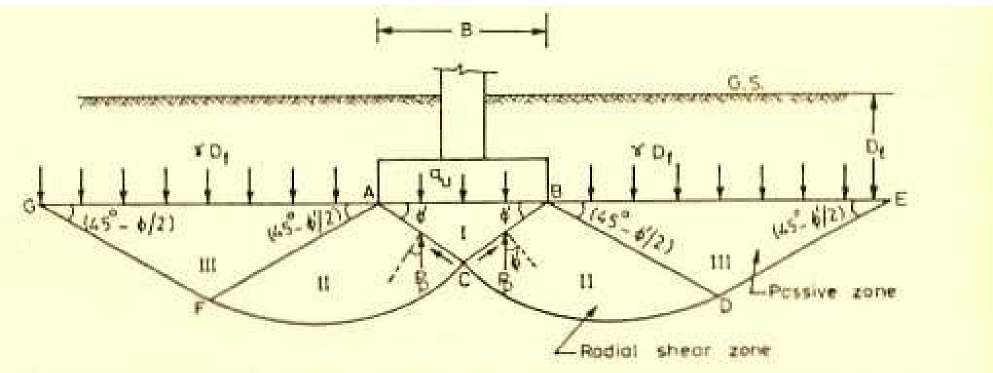
Methods of assessing Bearing Capacity of soil

For the calculation of bearing capacity of soil, there are so many theories. But all the theories are superseded by Terzaghi's bearing capacity theory.

1. Terzaghi's bearing capacity theory

Terzaghi's bearing capacity theory is useful to determine the bearing capacity of soils under a strip footing. This theory is only applicable to shallow foundations. He considered some assumptions which are as follows.

1. The base of the strip footing is rough.
2. The depth of footing is less than or equal to its breadth i.e., shallow footing.
3. He neglected the shear strength of soil above the base of footing and replaced it with uniform surcharge. (γD_f)
4. The load acting on the footing is uniformly distributed and is acting in vertical direction.
5. He assumed that the length of the footing is infinite.
6. He considered Mohr-coulomb equation as a governing factor for the shear strength of soil.



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As shown in above figure, AB is base of the footing. He divided the shear zones into 3 categories. Zone -1 (ABC) which is under the base is acts as if it were a part of the footing itself. Zone -2 (CAF and CBD) acts as radial shear zones which is bear by the sloping edges AC and BC. Zone -3 (AFG and BDE) is named as Rankine's passive zones which are taking surcharge (y D_f) coming from its top layer of soil.
From the equation of equilibrium,

Downward forces = upward forces

Load from footing x weight of wedge = passive pressure + cohesion x CB sinϕ

$$q_u \times B + \left(\frac{1}{4} \Upsilon B^2 \sin\phi\right) = 2P_p + 2c' \times \left(\frac{B}{2\cos\phi} . \sin\phi\right)$$

Where P_p = resultant passive pressure = $(P_p)_y$ + $(P_p)_c$ + $(P_p)_q$
$(P_p)_y$ is derived by considering weight of wedge BCDE and by making cohesion and surcharge zero.
$(P_p)_c$ is derived by considering cohesion and by neglecting weight and surcharge.
$(P_p)_q$ is derived by considering surcharge and by neglecting weight and cohesion.
Therefore,

$$q_u \times B = 2((P_p)_y + (P_p)_c + (P_p)_q) + \left(\frac{Bc'}{\cos\phi} . \sin\phi\right) - \left(\frac{1}{4} \Upsilon B^2 \sin\phi\right)$$

By substituting,

$$2(P_p)_y - \frac{1}{4} \Upsilon B^2 \sin\phi = B \times 0.5 \Upsilon B N_y$$

$$2(P_p)_y + Bc' \tan\phi = B c' N_c$$

$$2(P_p)_q = B \Upsilon D_f N_q$$

So, finally we get $\mathbf{q_u = c'N_c + y D_f N_q + 0.5 y B N_y}$
The above equation is called as Terzaghi's bearing capacity equation. Where q_u is the ultimate bearing capacity and N_c, N_q, N_y are the Terzaghi's bearing capacity factors. These dimensionless factors are dependents of angle of shearing resistance ().
Equations to find the bearing capacity factors are:

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$$N_c = \cot\phi\left[\frac{a^2}{2\cos^2(45+\phi/2)} - 1\right]$$

$$N_q = \left[\frac{a^2}{2\cos^2(45+\phi/2)}\right] \text{ and}$$

$$N_\gamma = 0.5\tan\phi\left[\frac{Kp}{\cos^2\phi} - 1\right]$$

Where

$$a = e^{\left(\frac{3\pi}{4} - \frac{\phi}{2}\right)\tan\phi}$$

Kp = coefficient of passive earth pressure.

For different values of ϕ , bearing capacity factors under general shear failure are arranged in the below table.

ϕ	Nc	Nq	Ny
0	5.7	1	0
5	7.3	1.6	0.5
10	9.6	2.7	1.2
15	12.9	4.4	2.5
20	17.7	7.4	5
25	25.1	12.7	9.7
30	37.2	22.5	19.7

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35	57.8	41.4	42.4
40	95.7	81.3	100.4
45	172.3	173.3	297.5
50	347.5	415.1	1153.2

Finally, to determine bearing capacity under strip footing we can use

$$q_u = c'N_c + \gamma D_f N_q + 0.5 \gamma B N_y$$

By the modification of above equation, equations for square and circular footings are also given and they are.

For square footing

$$q_u = 1.2 c'N_c + \gamma D_f N_q + 0.4 \gamma B N_y$$

For circular footing

$$q_u = 1.2 c'N_c + \gamma D_f N_q + 0.3 \gamma B N_y$$

2. Hansen's bearing capacity theory

For cohesive soils, Values obtained by Terzaghi's bearing capacity theory are more than the experimental values. But however it is showing same values for cohesionless soils. So Hansen modified the equation by considering shape, depth and inclination factors.

According to Hansen's

$$q_u = c'N_c Sc\ dc\ ic + \gamma D_f N_q Sq\ dq\ iq + 0.5 \gamma B N_y Sy\ dy\ iy$$

Where Nc, Nq, Ny = Hansen's bearing capacity factors

Sc, Sq, Sy = shape factors

dc, dq, dy = depth factors

ic, iq, iy = inclination factors

Bearing capacity factors are calculated by following equations.

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$$N_q = \tan^2(45+\phi)\,(e^{\pi \tan\phi})$$

$$N_c = (N_q - 1)\cot\phi$$

$$N_\gamma = 1.8(N_q - 1)\tan\phi$$

For different values of ϕ Hansen bearing capacity factors are calculated in the below table.

ϕ	**Nc**	**Nq**	**Ny**
0	5.14	1	0
5	6.48	1.57	0.09
10	8.34	2.47	0.09
15	10.97	3.94	1.42
20	14.83	6.4	3.54
25	20.72	10.66	8.11
30	30.14	18.40	18.08
35	46.13	33.29	40.69
40	75.32	64.18	95.41
45	133.89	134.85	240.85
50	266.89	318.96	681.84

Shape factors for different shapes of footing are given in below table.

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Shape of footing	**Sc**	**Sq**	**Sy**
Continuous	1	1	1
Rectangular	1+0.2B/L	1+0.2B/L	1-0.4B/L
Square	1.3	1.2	0.8
Circular	1.3	1.2	0.6

Depth factors are considered according to the following table.

Depth factors	**Values**
dc	1+0.35(D/B)
dq	1+0.35(D/B)
dy	1.0

Similarly inclination factors are considered from below table.

Inclination factors	**Values**
ic	1 – [H/(2 c B L)]
iq	1 – 1.5 (H/V)
iy	$(iq)^2$

Where H = horizontal component of inclined load

B = width of footing

L = length of footing.

10 Different Types of footings used in construction, where to use? and when to use?

Introduction to Foundations:-

Foundation is an important part of the structure which transfers the load of the structure to the foundation soil. The foundation distributes the load over a large area. So that pressure on the soil does not exceed its **allowable bearing capacity** and restricts the settlement of the structure within the permissible limits. Foundation increases the stability of the structure. The settlement of the structure should be as uniform as possible and it should be within the tolerable limits.

Why we provide Foundations or Footings?

In simple words, Consider $1m^3$ of concrete weight i.e., 2400 Kgs to 2600 Kgs depending on mix. Think for a Two storeyed building how much concrete needed? How much quantity of bars needed? to construct a building. Foundation is to be strong enough to bear that all loads without any settlement, So for spreading the vertical load to large area footings are constructed.

Main Functions of foundations:-

1. **Distribution of loads**
2. Stability against sliding & overturning
3. Minimize differential settlement
4. Safe against undermining
5. Provide level surface
6. Minimize distress against soil movement

Depending on **Soil bearing capacity** of a particular location. Different Types of Footings are selected and constructed.

Different types of Foundations:-

Foundations are mainly classified into two types:

1. Shallow Foundations
2. Deep foundations

If depth of the footing is equal to or greater than its width, it is called **deep footing**, otherwise it is called **shallow footing.**

Difference between footings and foundations:

Footing is a part of foundation which is constructed with concrete or brickwork masonry and acts as a base to the floor columns and floor walls. The main function of footing is to transfer the vertical loads directly to the soil. The term footing is used in conjunction with Shallow foundation commonly.

Where We Provide Shallow foundation and Deep foundation?

Foundations may be shallow or deep foundations depending upon the load and type of foundation soil. If the load to be supported is very high and soil is of low bearing capacity, Deep foundations are provided. If the soil has adequate **bearing capacity** at reasonable depth then shallow footings are provided.

Below we have discussed about the different types of house foundations which we usually use for construction. Deep foundations and Shallow foundations are further classified into following types:-

Contents [show]

Shallow Foundations or Spread Foundations:-

Spread foundations are used when the soil has sufficient strength within a short depth below the ground level. Shallow foundations need enough area to transfer the **heavy loads** to the base soil. As mentioned above, we chose shallow foundations when the soil has adequate **Soil bearing capacity**. Footings in Shallow foundations may be of Masonry, Plain concrete or reinforced concrete. The depth of shallow foundations are generally less than its width.

Different types of Shallow foundations are further divided into two types, depending on the soil bearing capacity:-

Category	Range	Footings
Type-I	If Soil bearing capacity is greater than 24 KN/m^3	Plain footing, Step footing, shoe footing, Isolated footing, Plain combined footing, Combined isolated footing
Type-2	If soil bearing capacity is less than 24 KN/m^3	Raft footing

I. Isolated footing:-

Footings which are provided under each column independently are called as Isolated footings. They are usually square, rectangular or circular in section. Footing is laid on PCC. Before laying PCC, termite control liquid is sprayed on top face of PCC to restrict the termites to damage the footing. Isolated footings are provided where the soil bearing capacity is generally high and it comprises of a thick slab which may be flat or stepped or sloped. This type of footings are most economical when compared with the other kind of footings.

Advantages of Isolated Footing:-

1. Economical when columns are placed at longer distances.
2. Workmen with little or no knowledge can easily construct.
3. Ease of Constructability:- Excavation, Form-work, Reinforcement placement and placing of Concrete is at ease.

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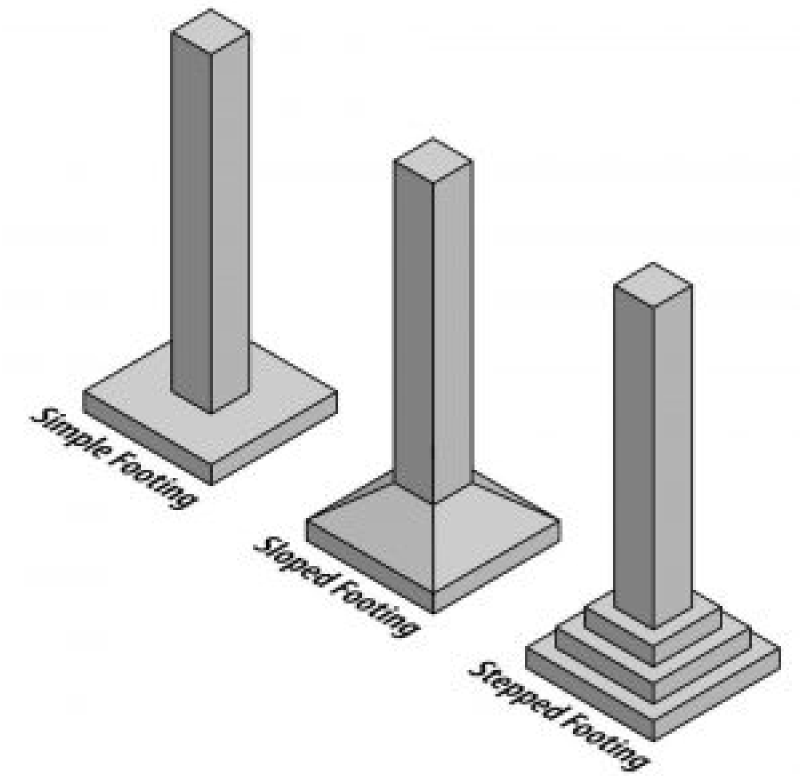
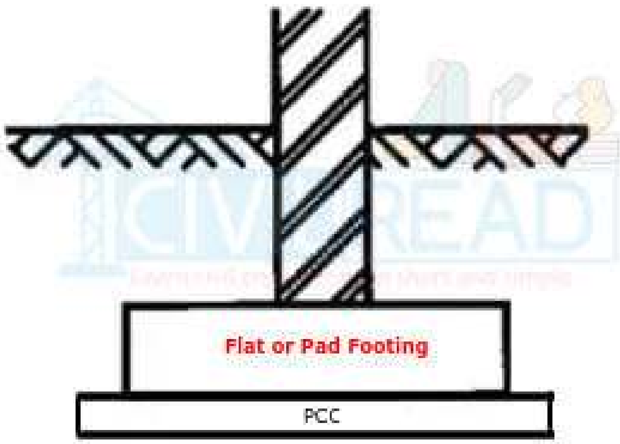


(i) Flat or Pad or Plain footing:-

These kind of footings are generally square or rectangular or circular in shape which are provided under each **column** independently. Flat or Pad Footing is one of the Shallow Foundations. It is circular, square or rectangular slab of uniform thickness.



(ii) Stepped footing:-

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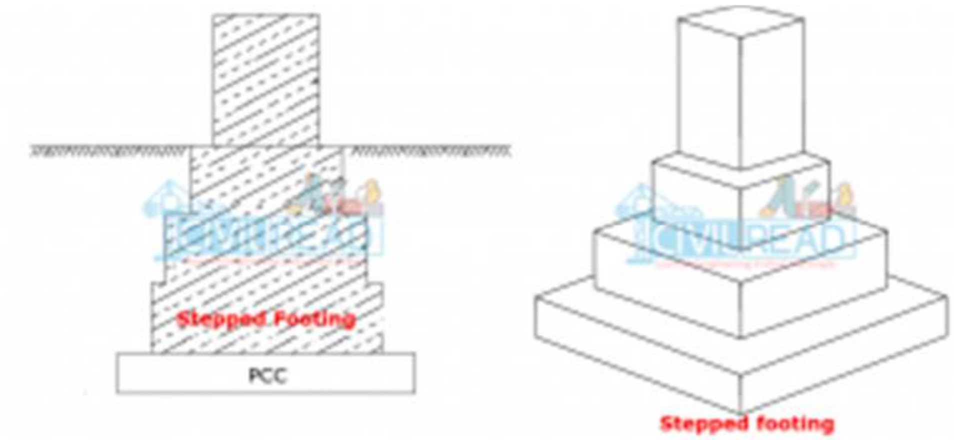
These types of footings are constructed in olden days now they are outdated. As from the name its resembling that, footings are stacked upon one another as steps. Three concrete cross sections are stacked upon each other and forms as a steps. This type of footings are also called as a Step foundation. Stepped footing is used generally in residential buildings.



(iii) Sloped Footing:-

Sloped footings are trapezoidal footings. They are designed and constructed with great care to see that the top slope of 45 degree is maintained from all sides. When compared the trapezoidal footing with the flat footing, the usage of concrete is less. Thus, it reduces the cost of footing in concrete as well as reinforcement.

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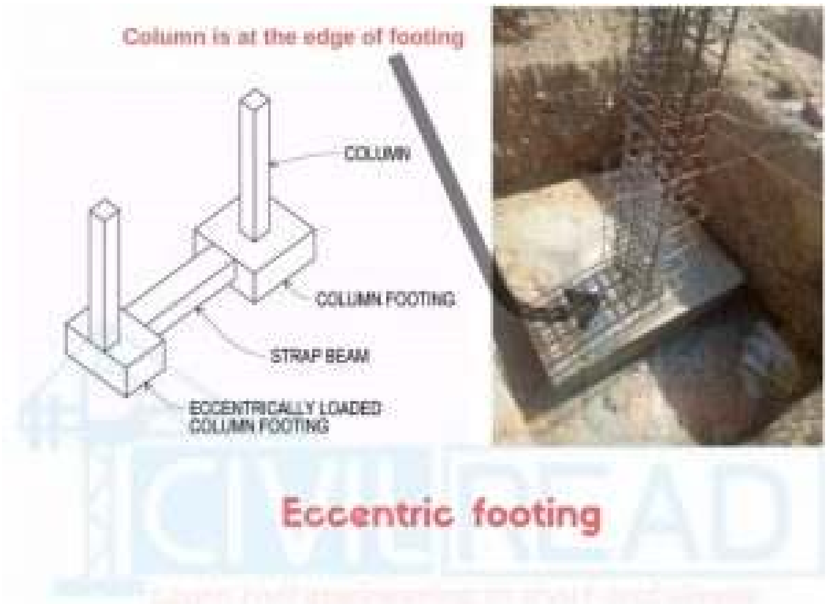
(iv) Shoe or eccentric footing –

Shoe footing is the half cut-out from the original footing and it has a shape of shoe. They are constructed on property boundary, where there is no provision of setback area. It is constructed at the corner of the plot when the exterior column is close to the boundary or property line and hence there is no scope to project footing much beyond the column face.. Column is provided or loaded at the edges of shoe footing. Shoe footings are constructed when the soil bearing capacity is $24KN/m^2$



(v) Combined footing:-

A footing which has more than one column is called as combined footing. This kind of footing is adopted when there is a limited space. Due to lack of space we cannot cast

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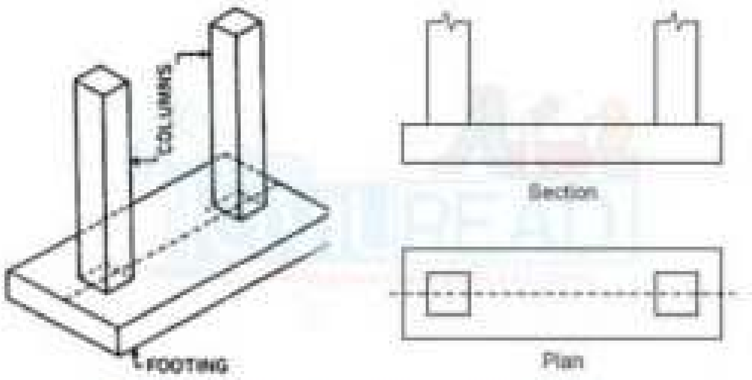
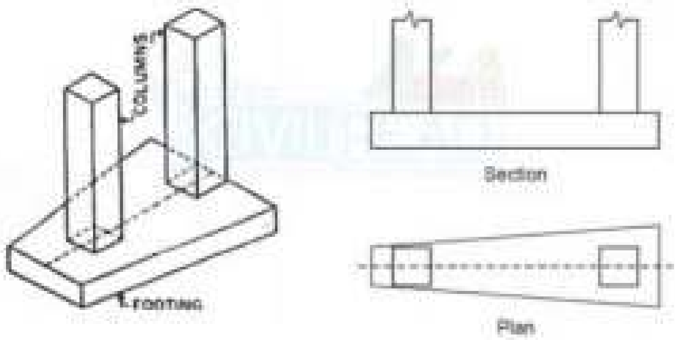
individual footing, Therefore footings are combined in one footing. They are classified into two types based on their shape:

1. *Rectangular combined footing.*



Combined Rectangular Footing

2. *Trapezoidal combined footing.*



Combined Trapezoidal footing

II. Raft or Mat Foundation or footing:-

When the **column loads** are heavy or when the safe bearing capacity of soil is very low, The required footing area become very large. As mentioned this footing is in shallow foundation.

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So in order to spread the load over large area with less depth then we have to increase the footing area. If we increase footing area the footings are overlapped each other, instead of providing each footing on each column all columns are placed in common footing. A raft foundation is a solid reinforced concrete slab covering entire area beneath the structure and supporting all the columns. Such foundation due to its own rigidity minimizes differential settlements.
It is provided in a places like seashore area, coastal area area where the water table is very high and soil bearing capacity is very weak.

When number of column in more than one row, provided with a combined footing, the footing is called mat or raft foundation.

How to decide which footing is to be adopted Isolated footing or Raft footing:-

1. If the bearing capacity of the soil is very good and the super structural load is very small.. The use of isolated foundation is recommended.
2. If the bearing capacity of the soil is very low, like less than 100 kpa(this isnt an exact number but it could be used as a boundary)
3. If the super structural load to be transferred to the foundation is very high that the area of the isolated footing to be used is more than half the area covered by the building (this is recommended by Joseph.E Bowles)
4. When we provide elevator in the building a separate raft may be provided on the elevator shaft.
5. When the soil contains lenses (or weak zones) that should be bridged then raft might be used.

Raft footing does not have Neck column, they start directly From the ground surface but reinforcement of neck column starts from Raft.

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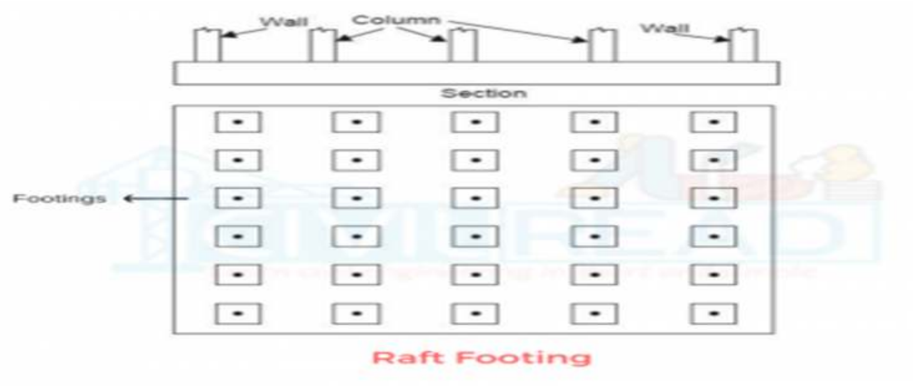
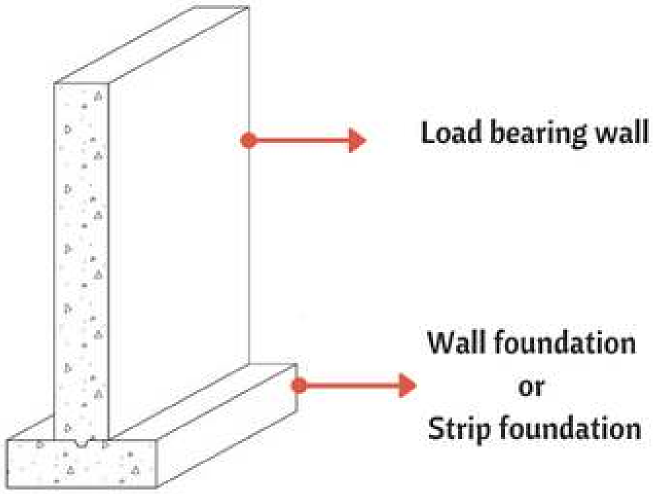


III. Strip foundation:

Strip foundation is also called as **Wall footing.** As name itself showcasing that, it is a strip type footing which follows the path of Superstructure Wall. This type of footing is constructed for Load bearing walls. It is a continuous **strip** of concrete that serves to spread the weight of a load-bearing wall across an area of soil. The strip footing foundation width is decided by considering bearing capacity of soil. Greater the bearing capacity of soil lesser is the width of the Strip footing.



Advantages of Strip Footing:

1. It doesn't require expensive tools to construct.
2. Easy to build
3. Not required skilled labour to construct.

Disadvantages of Strip footing:

1. Less durable when compared with other types of footings
2. This type of footing is not suitable for specific types of soils

Deep foundations or Pile Foundations:-

If the depth of a foundation is greater than its width, the foundation laid is known as **deep foundation.** In deep foundation, the depth to width ratio is usually greater than 4 to 5. Deep foundations as compare to Shallow foundations distribute the load of the super structure vertically rather than laterally. Deep foundations are provided when the expected loads from superstructure cannot be supported on shallow foundations.

Pile footings:-

A pile is a long **vertical load** transferring member made of timber, steel or concrete. In pile foundations, a number of piles are driven in the base of the structure.

They are constructed where excessive settlement is to be eliminated and where the load is to be transferred through soft soil stratum, where the Soil bearing capacity is sufficient. These types of footings are provided when the Soil bearing capacity of soil is very weak and the Ground water table (level) is high. These types of the footings are generally designed on sea shore areas, **bridges to construct pillars**, etc.

The main objective of providing piles under the footing is to prevent structure from settlement. If we don't provide pile under the footing, then the building will have settlement. Piles are hammered in to the ground till hard strata (in compressible) layer of earth is found.

Pile foundations are divided into two types they are:-

1. Pre cast Piles.
2. Cast-in-situ piles.

1. Precast Piles:

Precast piles are casted at factory and transported to the site. This kind of piles are readymade and used where there is less place to cast pile. Precast piles are not economical and requires more money to transport piles to the site.

The Pre-cast concrete piles are usually reinforced or Pre-stressed concrete piles. These piles occupies more space for casting and storage, and takes more time to set and cure. The precast concrete piles are generally used for a maximum design load of about 800 kN except for large Pre-stressed piles. The length of precast concrete piles varies from 4. 5 m to 30m. The Pre-stressed concrete piles as compared to Pre-cast and reinforced concrete piles are lesser in weight & easy to handle having high load carrying capacity and are extremely durable.

Advantages of Precast Piles:-

- Reinforcement provided in Precast piles are not liable to change it place and disturbed.
- The cost of Precast piles manufacturing is less because large number of precast piles are manufactured at a time.
- The defects in pile can be easily identified after the removal of **formwork**, and these defects (such as presence of cavity or hole) can be repaired before driving the pile in site.

Disadvantages of Precast Piles:-

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- These pile are heavy so it requires special equipment to carry and transport the pile to site.
- Sufficient care must be taken at the time of transportation, otherwise piles may break.
- For embedding these piles in field, heavy pile driving equipment is required.
- These piles are costly as extra reinforcement is required to bear handling and driving stresses.
- Post insertion of pile in ground it is not possible to increase the depth of pile. As the length of the pile is restricted.

2. Cast-in-situ piles.

The piles which are casted on site. And don't require any transportation is called cast-in-situ piles. The cast-In-situ concrete piles are casted in position inside the ground and need not to be reinforced in ordinary cases. These piles are not subjected to handling or driving stresses. The cast- in-situ concrete piles are generally used for a maximum design load of 750 kN.

CAST- IN- SITU PILES

Rock anchors are used commonly as part of retaining walls, and as part of a system to resist movement of a foundation. Most rock anchors consist of a pre drilled hole that is filled with grout material. A threaded steel anchor bar that is sheathed and is then inserted into the grouted hole and is tensioned to the appropriate specifications of the particular job. There are many sizes and weight capacities of rock anchors depending on whether they are for small house foundation type jobs or for retaining large structures such as bridges. Either way the use and installation are largely the same.

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purpose of Rock Anchoring?

The main purpose of rock anchoring is to stabilize the foundation of the construction and avoid its movement. Several factors such as hydrostatic pressure, wind loads, seismic activities among others, can induce an uplifting force on the foundation. It can endanger the constructional integrity of the structure. Apart from the rock anchors are also installed to keep in check the tilting of Piles in situations like shoring systems for resisting active and passive earth pressure.

Step 1 - Drill Your Hole
Use the appropriate size and type of drill for the material you are drilling into and the size of rock anchors that you will be using. You may need to drill through old, loose and unstable materials and into solid materials to install your rock anchor firmly in place. Oftentimes some sort of casing may be used in the instance of unstable materials or crumbling foundations.

Step 2 - Inject Grout
When injecting your grout it is important to first clear the drilled hole of as much debris as possible. Filling the drilled hole with grout from the bottom up through the top will also help assist in clearing the hole of debris. To avoid mess leave an estimated amount of space at the top of your drilled out anchor hole free of grout to account for expansion when your actual rock anchors are inserted.

Step 3 - Insert Threaded Sheathed Rock Anchors
Before grout sets, Insert your sheathed, threaded anchor down into the grouted anchor hole to a depth that leaves the amount you want to work with sticking out of the hole. The sheath is to keep the threaded anchor from bonding with the grout material as it dries therefore making it nearly impossible to turn or tension. Once the grout has set up, remove the sheath.

Step 4 - Install Bearing Plate
Once your grout has set up and your rock anchors are properly installed it is time to attach the steel bearing plate to the outside surface of the anchored material. This plate will be square and will have a hole in the center for your threaded rock anchors to fit through. Once placed over the anchors and bolted in place there will also be a retaining nut that will screw down onto the threads of your rock anchors. Together with the bearing plate this not will allow you to tension the rock anchor once installed.

Step 5 - Tension the Anchor Appropriately
At this point you can pull the anchor to a prescribed tension with your retaining nut and then lock in place appropriately to avoid future movement. This will provide rock anchors that are incredibly strong and able to withstand great amounts of tension and weight.

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Unit 3 Superstructure

Introduction – Masonry – Types Of Masonry – Reinforced Cement Concrete (RCC) Works Like Footings, Columns, Plinth Beams, Lintels, Sill Slab, Sunshades, Roof Beams And Roof Slabs – Fabrication Of Steel, Bar Bending As Per IS Standards (SP 34: 1987), Cover Blocks, Placing Of Bars In Form Work - Types Of Roofing Systems – Types Of Stairs – Types Of Doors – Windows And Ventilators – Methods Of Termite Proofing – Methods Of Damp Proofing.

A **superstructure** is an upward extension of an existing structure above a baseline called Ground Level in general and it usually serves the purpose of the structure's intended use. ... The **superstructure** of a **building** is the part that is entirely above its foundation or basement.

Masonry is the building of structures from individual units, which are often laid in and bound together by mortar; the term masonry can also refer to the units themselves. The common materials of masonry construction are brick, building stone such as marble, granite, and limestone, cast stone, concrete block, glass block, and adobe. Masonry is generally a highly durable form of construction. However, the materials used, the quality of the mortar and workmanship, and the pattern in which the units are assembled can substantially affect the durability of the overall masonry construction. A person who constructs masonry is called a mason or bricklayer. These are both classified as construction trades.

Types of Masonry Walls in Building Construction
Based on the type of individual units used for masonry walls and their functions, the types of masonry walls are:

1. Load Bearing Masonry Walls
Load bearing masonry walls are constructed with bricks, stones or concrete blocks. These walls directly transfer loads from the roof to the foundation. These walls can be exterior as well as interior walls. The construction system with load bearing walls are economicalthan the system with framed structures.

Fig: Load Bearing Masonry Wall

The thickness of load bearing walls is based on the quantity of load from roof it has to bear. For example a load bearing wall with just a ground floor can have its outer walls of 230mm, while with one or more floors above it, based on occupancy type, its thickness may be increased.The load bearing walls can be reinforced or unreinforced masonry walls.

2. Reinforced Masonry Walls
Reinforced masonry walls can be load bearing walls or non-load bearing walls. The use of reinforcement in walls helps it to withstand tension forces and heavy compressive loads.

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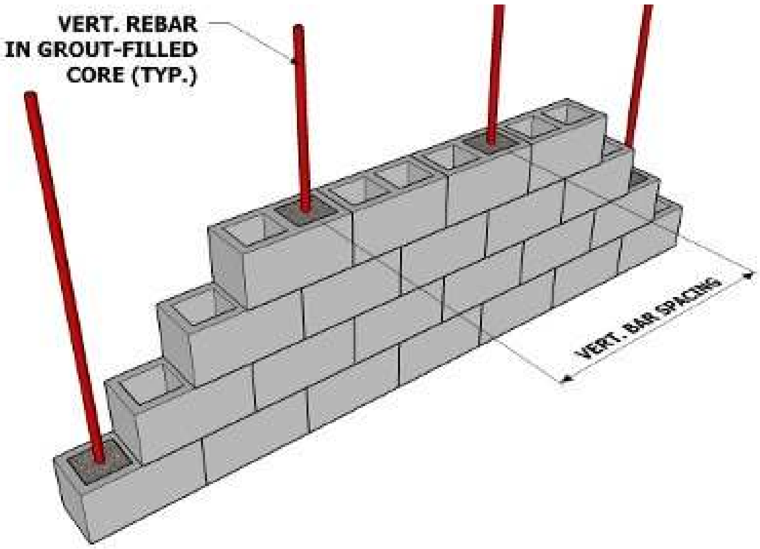
The un-reinforced masonry walls are prone to cracks and failure under heavy compressive loads and during earthquakes. They have little ability to withstand lateral forces during heavy rain and wind. Cracks also develop in un-reinforced masonry walls due to earth pressure or differential settlement of foundations.



To overcome such problems, reinforced masonry walls are used. Reinforcement in walls are at required intervals both horizontally and vertically is used. The size of reinforcement, their quantity and spacing are determined based on the loads on the walls and structural conditions.

3. Hollow Masonry Walls

Hollow or Cavity masonry walls are used to prevent moisture reaching the interior of the building by providing hollow space between outside and inside face of the wall. These walls also helps in temperature control inside the building from outside wall as the hollow space restricts heat to pass through the wall.

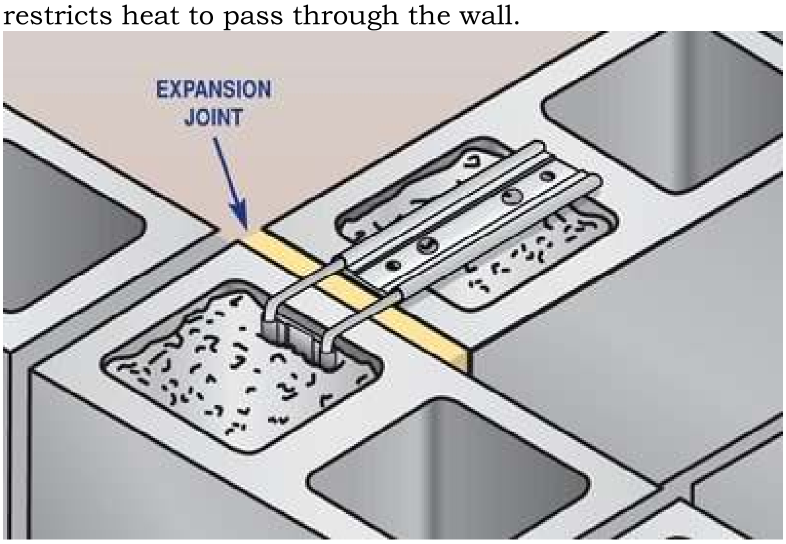


Fig: Hollow Masonry Wall

When the wall is exposed to moisture for a sustained period and penetrates through the outer face, the water reaches the cavity or the hollow space and flows down. Then they are drained through the weep holes to the exterior of the building. These hollow spaces may be coated with water repellent coating or damp-proofing to further reduce the ingress of moisture.

4. Composite Masonry Walls

These walls are constructed with two or more units such as stones or bricks and hollow bricks. This type of masonry wall construction is done for better appearance with economy.

In composite masonry walls, two wythes of masonry units are constructed bonding with each other. While one wythe can be brick or stone masonry while the other can be hollow bricks. A wythe is a continuous vertical section of masonry one unit in thickness.

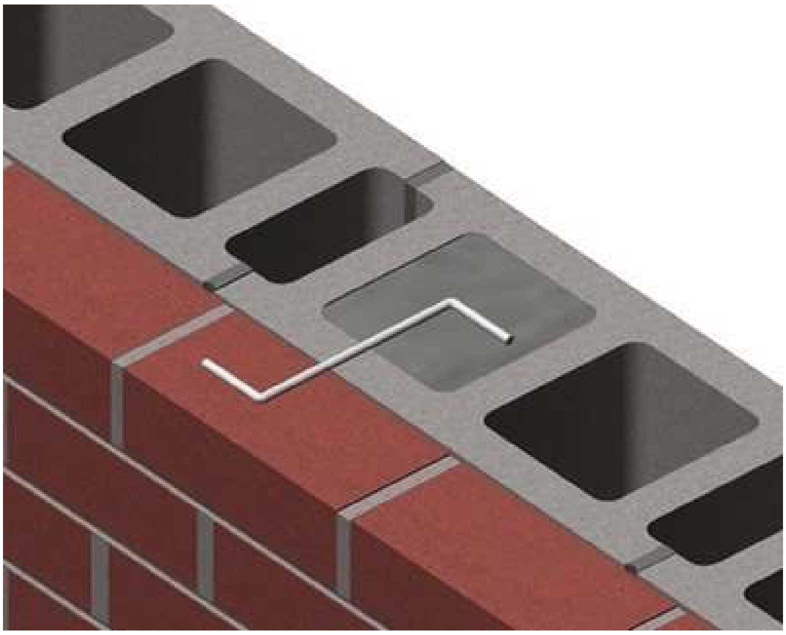


Fig: Composite Masonry Wall

These wythes are interconnected either by horizontal joint reinforcement or by using steel ties.

5. Post-tensioned Masonry Walls

Post-tensioned masonry walls are constructed to strengthen the masonry walls against the forces that may induce tension in the wall such as earthquake forces or wind forces.

These walls are constructed from the foundation level and post-tensioning rods are anchored into the foundation. These rods are run vertically between the wythes or in the core of concrete masonry units.

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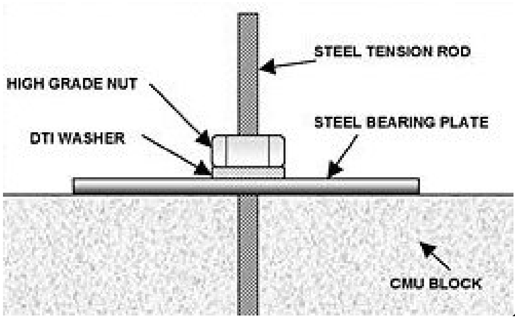


After the masonry wall construction is completed and cured, these rods are tensioned and anchored on the steel place at the top of the wall. **Reinforced concrete** (RC) (also called **reinforced cement concrete** or RCC) is a composite material in which **concrete**'s relatively low tensile strength and ductility are counteracted by the inclusion of **reinforcement** having higher tensile strength or ductility.

RCC foundation - Reinforced Cement Concrete- concrete **Foundation** or **footing** of superstructure using concrete and reinforcement steel bars. These are like a base of the structure above to distribute the load evenly from the superstructure.
There are mainly two types of R.C.C. footings:
1. One way reinforced footings.
2. Two way reinforced footings.
1. **One Way Reinforced Footing**: These footings are for the walls. In these footings main reinforcements are in the transverse direction of wall. In longitudinal directions there will be only nominal reinforcement.
2. **Two Way Reinforced Footings**: For columns two way reinforced footings are provided.
TYPES OF FOOTING:
Footings can be of the following types.

- Spread or isolated or pad footing.
- Strap footing.
- Combined footing.
- Strip or continuous footing.
- Mat or raft footing.

How to Calculate Footing Size

1. Determine the width and length of the cement slab in inches.
2. Divide the width by 12 to convert it to feet. ...
3. Divide the length by 12 to convert it to feet. ...
4. Determine the depth or thickness that is required for the footing in inches. ...
5. Multiply the width by the length and then by the depth.

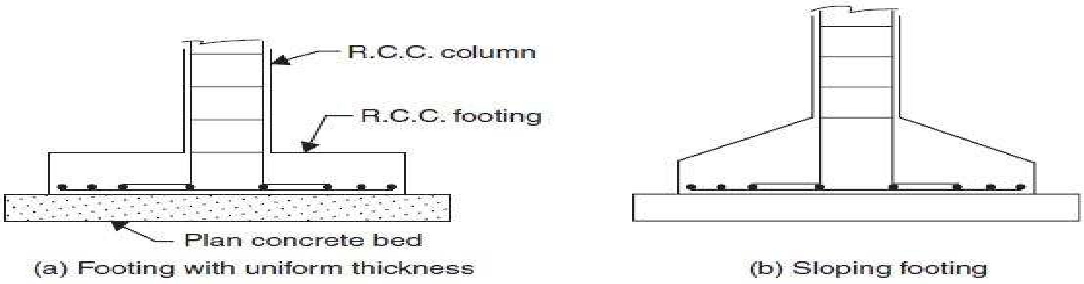
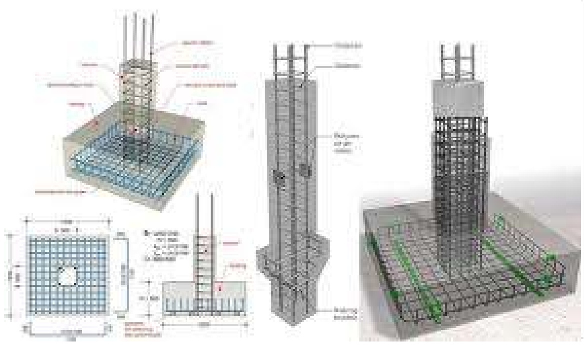


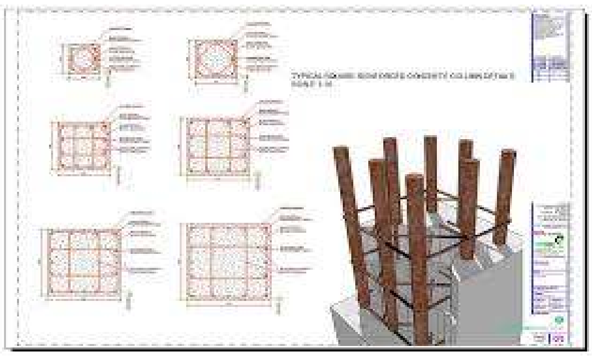
Fig. 7.3. Isolated R.C.C. footing

Reinforced concrete (**RC**) (also called **reinforced cement concrete** or RCC) is a composite material in which **concrete**'s relatively low tensile strength and ductility are counteracted by the inclusion of **reinforcement** having higher tensile strength or ductility. There are various types of RCC Column based on its shape, length and forces. Function and construction methods are discussed here for these types of column. Column is a vertical member which takes complete load of the beam, slabs and the entire structure and the floor and other area of the building is adjusted as per the requirement of the client or owner. The size of the columns, quantity of cement sand and aggregate to be mixed, the number of steel bars to be placed, spacing between the stirrups is all mentioned in the structural drawing which is designed by structural designer as per the actual load on the column and considering the factor of safety.

A column is a vertical member which effectively takes load by compression. Basically column is a compression member as load acts along its longitudinal axis. Bending moment may occur due to wind earthquake or accidental loads.

Column transfers the load of the structure of slabs beams above to below, and finally load is transferred to the soil. Position of the columns should be so that there are no tensile stresses developed at the cross section of the columns. Columns location should be such that it hides in the walls partially or fully.





Types of RCC Column
Types of RCC Column based on Shapes

- Circular for exposed outside for good architecture view
- Square or rectangular traditional for any structure

Types of RCC Column based on length

- Short column – if L/B<=12

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- Long column – if L/B > 12

Where L is the height of the column, B is width

Generally, floor height is approximately 3 m or 10 feet, L/B ratio will be less than 12, so in maximum cases short column is placed. In case where height of floor is more than 3 m or 10 feet, we need to check L/B ratio so result may be long or short column. Generally, on long column there are more forces generated so should be designed carefully.

Types of RCC Column based on moments

- Biaxial column: Designed for axial load and moment in 2 directions
- Uniaxial columns: Designed for axial load and moment in 1 direction

Generally, in a building corner most columns are biaxial columns and side column is uniaxial column and internal columns can be any of these.

Construction Methods of RCC Columns
Construction of RCC columns involve following four steps:

- Column layouts
- Column reinforcement work
- Column formwork
- Pouring of concrete

Layout of Columns
Column layouts are done by laying rope in the grid lines and mark the location of columns

Column Reinforcement
Column reinforcement works needs following checklist on site:

- Check the numbers and diameter of vertical bars
- Spacing between vertical bars
- Check Development length which depends on diameter of bar
- Lapping in alternate bars should come at same height.
- Lapping should not come inside beam or slab.
- Lapping should be at l/3 or 2l/3 of column as per structural notes
- Spacing between stirrups is as per the drawing
- Hook should be bend properly at right angles.
- Check the stirrups corner. Vertical bar should come at right angle edge of stirrup properly bound with binding wire.

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Column Reinforcement and Layout

Column Formwork

Columns carry the load of structure and hence they are critical. It is important to align them for verticality so that load is transmitted properly. The column shuttering should be strong enough to take the pressure of fresh concrete and remain in position during concreting.

Some Guidelines on column shuttering

- To hold the concrete shuttering firmly in place and for proper alignment a concrete pad called starter is cast before fixing the shuttering. The thickness is about 45 mm to 60 mm and dimensions are precisely the same as the dimensions of proposed column. The starter should be cured for a day or 2 so that it is hard enough to fix the shuttering around it.
- Column box or shuttering for columns is made of plywood sheets or steel sheets fabricated with adequate stiffeners.
- A thin films of oil or grease should be applied to inner surface of the shuttering to enable easy removal of the column after the concrete hardens.
- Shuttering should be properly aligned to its verticality and diagonals to be checked to ensure accuracy in dimensions.
- Formwork has to be thoroughly supported with props size before pouring the concrete so that it does not moves horizontally or vertically during concreting.
- The gaps near the shuttered joints should be sealed with plaster or a piece of wood to prevent any leakage of slurry.
- Appropriate space is to be provided in the inner face of the shutter and reinforcement by fixing cover blocks of about 40mm.
- It is preferable to remove shutters after 24 hrs. of casting and if they need to be removed earlier, it should not be removed within sixteen hours.
- The removal of shutters has to be done gently without jerks so that edges of columns are not damaged.

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- Care should be taken regarding fixing and supports of column shuttering to prevent it from movement during concreting.
- Diagonals of the shuttering to be checked to ensure dimensional accuracy.

Concreting of RCC Column

Concreting of an RCC column can be done

- Manually
- With the help of machine or pump

Manual Concreting of RCC Column

Concreting of RCC Column using Pump

Following points to be followed during and after concreting:

- For less quantity machine mix concrete is done and for larger quantity ready mix concrete (RMC) is ordered.
- Approval of placing concrete whether by pump or manually has to be taken from client.
- Concrete should be poured up to slab bottom; the remaining column gets concreted during pouring of slab & beam.
- Mechanical vibrator to be compulsorily used in the column but excess vibration can cause segregation. Each layer should be thoroughly compacted.
- Target slump to be 160 mm.
- Height of pouring concrete should not exceed 1.5 m.
- Construction joint should be avoided in the column.
- Proper cover as per structural drawings to be maintained.

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- Temperature should be below 30 degree while pouring concrete.
- After the pouring of concrete and vibrating it with the help of a vibrator the horizontality and verticality of column to be checked

Plinth beam is a **reinforced concrete beam** constructed between the wall and its foundation. **Plinth beam** is provided to prevent the extension or propagation of cracks from the foundation into the wall above when the foundation suffers from settlement.

Applications of Plinth Beam

- It is mandatory to provide plinth beam in areas that prone to earthquake.
- Construction of plinth beam above the natural ground is another application of this type of beam.

Concrete Strength Suitable for Plinth Beam Construction
Strength of plinth beam concrete shall not be smaller than 20MPa. If concrete is mixed manually, then an extra of 20% cement need to be added to the mixture. Figure 3 show plinth beam concrete preparation placement.

Minimum Dimension of a Plinth Beam

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A minimum depth of plinth beam is 20cm whereas its width should match the width of final course of the foundation.

Formwork for Plinth Beam

Formwork used for plinth beam construction should be properly installed and adequately secured prior to concrete placement as shown in Figure-4. The concrete needs to be compacted sufficiently to prevent steel bars from aggressive elements.

Fig.4: Plinth beam shuttering is completed

Steel Bars Used for Plinth Beam

It is recommended to provide two bars with minimum diameter of 12mm at the bottom of the beam. Similarly, two bars with minimum diameter of 10mm shall be provided at the top of the plinth beam.

Reinforcement bars should be protected by 25mm concrete cover. As far as stirrups are concerned, stirrup diameter should be at least 6mm and a spacing of 15cm should be sufficient.

Fig.5: Reinforcement installation for plinth beams are completed

Reinforced cement concrete is the most suitable and commonly used material for **lintels**. It is resistant to fire, insects, temperature stresses and atmospheric agents. It possesses excellent resistance to tensile stresses with minimum size and is best suited for long spans and heavy loading conditions.

What is Lintel?

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A lintel is a beam placed across the openings like doors, windows etc. in buildings to support the load from the structure above. The width of lintel beam is equal to the width of wall, and the ends of it is built into the wall. Lintels are classified based on their material of construction.

Horizontal lintels are easy to construct as compared to arches.

Bearing of Lintel

The bearing provided should be the minimum of following 3 cases.

1. 10 cm
2. Height of beam
3. 1/10th to 1/12th of span of the lintel.

1. Reinforced Brick Lintel

These are used when loads are heavy and span is greater than 1m. The depth of reinforced brick lintel should be equal to 10 cm or 15 cm or multiple of 10 cm. the bricks are so arranged that 2 to 3 cm wide space is left length wise between adjacent bricks for the insertion of mild steel bars as reinforcement. 1:3 cement mortar is used to fill up the gaps.

Vertical stirrups of 6 mm diameter are provided in every 3rd vertical joint. Main reinforcement is provided at the bottom consists 8 to 10 mm diameter bars, which are cranked up at the ends.

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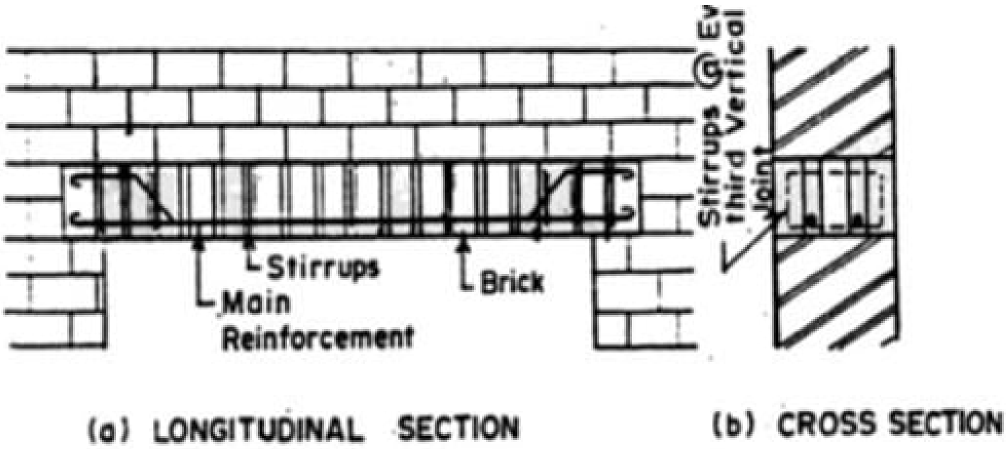
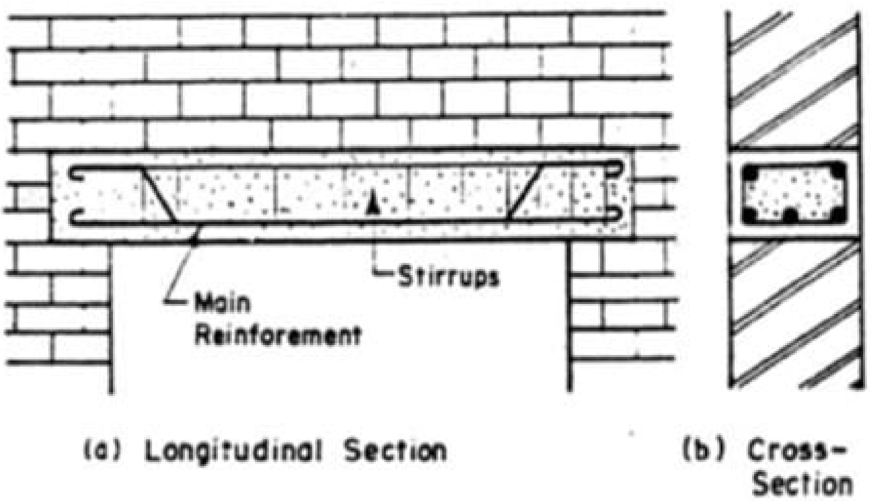


2. Reinforced Cement Concrete Lintel
At present, the lintel made of reinforced concrete are widely used to span the openings for doors, windows, etc. in a structure because of their strength, rigidity, fire resistance, economy and ease in construction. These are suitable for all the loads and for any span. The width is equal to width of wall and depth depends on length of span and magnitude of loading.

Main reinforcement is provided at the bottom and half of these bars are cranked at the ends. Shear stirrups are provided to resist transverse shear as shown in fig.



R.C.C lintel over a window with projection is displayed in below fig.

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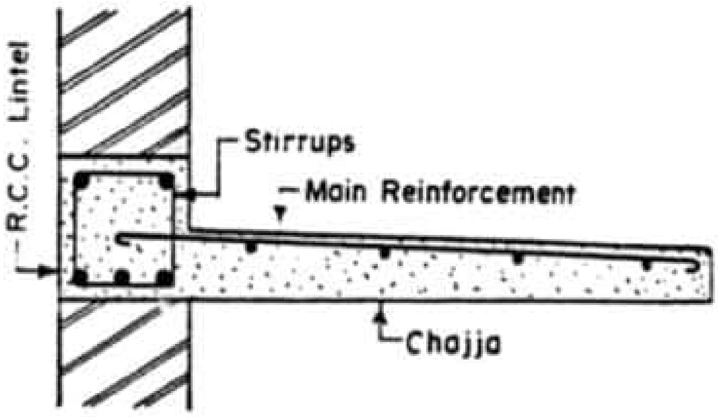
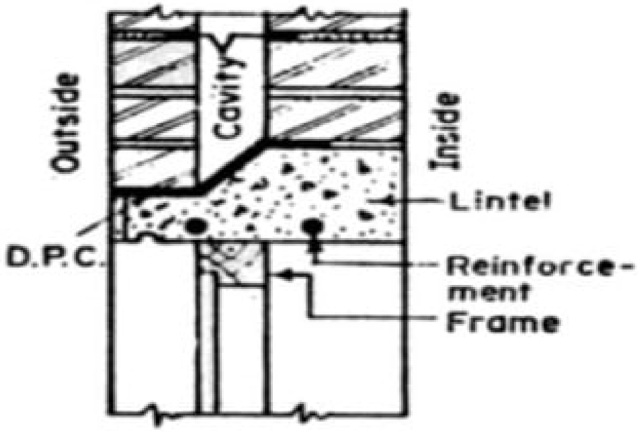


R.C.C boot lintels are provided over cavity walls. These will give good appearance and economical. A flexible D.P.C is provided above as shown in fig.



Sill slab:
An important structural and aesthetic element of any building, a precast **concrete** window **sill** keeps rainwater away from the window frame and offers support to the window itself. ... Bespoke **sills** can also be precast for one off dwellings or renovation projects.

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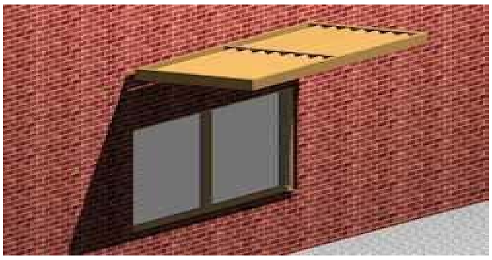
SUN SHADE: Control the Sun with **Sunshades**. The primary purpose of a **sunshade** is to control the amount of direct sunlight through your building's windows. The benefits can be found in so many articles that we will not go into them here.



Roof beam

A **roof beam** is a load-bearing member that is integral to the strength of the building. It supports the floor or **roof** above, while adding integrity to walls. It also supports joists, trusses and other **roofing** elements. A **roof beam** will be the thickest and most important element of a **roof** or levels within a property.

Beams

beam is a horizontal structural element that withstand vertical loads, shear forces and bending moments. The loads applied to the beam result in reaction forces at the support points of the beam.

The total effect of all the forces acting on the beam is to produce shear forces and bending moment within the beam, that in turn induce internal stresses, strains and deflections of the beam.

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Fig. 5: Reinforced concrete beam

Types of Loads on Beams

1. Self-weight of the beam
2. Dead load includes point load for instance column constructed on beam, distributed load for example setting slabs on a beam.
3. Live load
4. Torsional load

Load Transfer Mechanism in Beams

They transfer loads imposed along their length to their end points where the loads are transferred to columns or any other supporting structural elements.

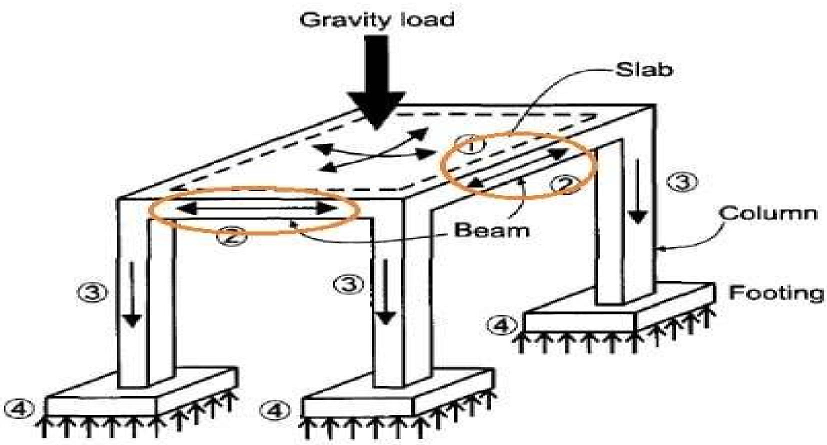

Fig. 6: Transfer loads from beams to column

Slabs

Slab is an important structural element which is constructed to create flat and useful surfaces such as floors, roofs, and ceilings. It is a horizontal structural component, with top and bottom surfaces parallel or near so.

Commonly, slabs are supported by beams, columns (concrete or steel), walls, or the ground. The depth of a concrete slab floor is very small compared to its span.

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Fig. 1: Reinforced concrete slab

Types of Loads on a Slab

Types of loads acting on a slab include:

1. Dead load of the slab
2. Live load
3. Floor finish load
4. Snow load in the case of roof slab
5. Earthquake loads

Load Transfer Mechanism in Slabs

The forces transfer from slab to beams occur either in one way or in two ways. The total system completely counts on the geometrical dimensions of the slab. Slabs may be supported by columns only, in this case two way action will prevail. If the ratio Long side / short side < 2 it is considered as 2-way slab, and if Longer side to shorter side greater than 2 then it is considered as 1-way slab.

The load transfer mechanism from floor slab to supporting elements for one way slab and two way slab are shown in Fig. 2 and Fig. 3. Lastly, Fig. 4 illustrate the transfer of loads from slabs to different types of supporting elements.

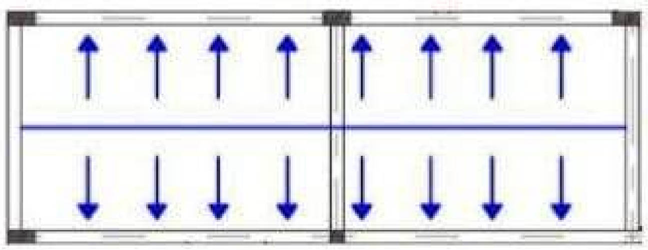

Fig. 2: Load distribution mechanism from one way slab to supporting member

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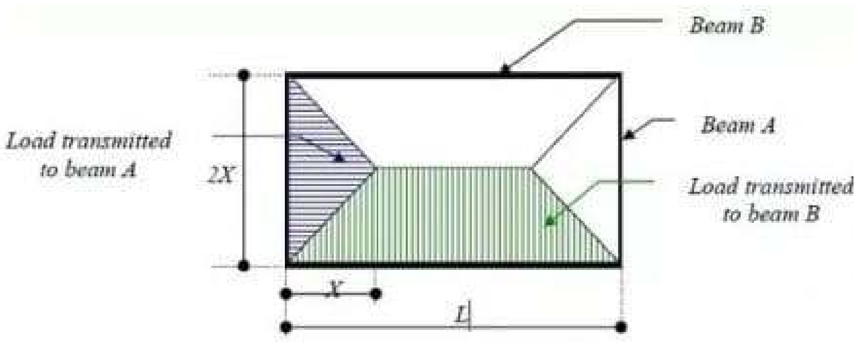

Fig. 3: Load distribution mechanism from slab to beams or other supporting elements

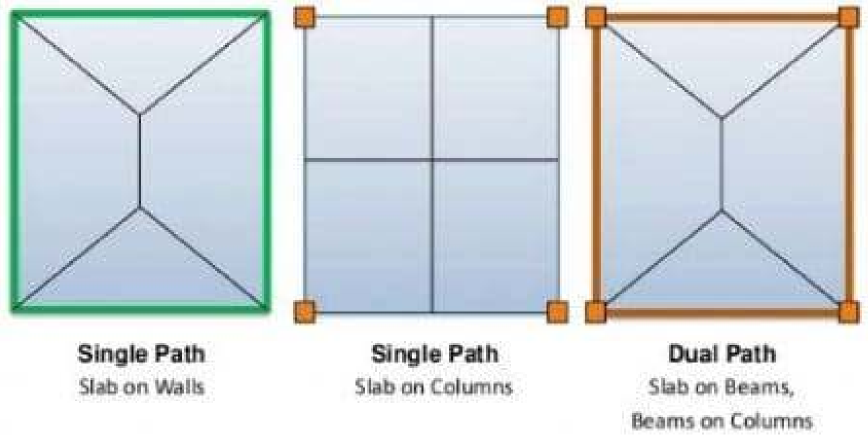

Fig. 4: Transfer of loads from slab to different types of supporting Members

What Is Steel Fabrication?

Steel fabrication involves taking raw materials and shaping them to their desired form. The raw materials are melted down and mixed into steel before being constructed into the desired shape. The process requires a skilled technician who has the experience in taking raw components and transforming them into marketable items, and there is often very little room for error. Industrial facilities use steel fabrication to create everything from vehicular parts to household appliances.

The basic methods of fabricating include cutting or burning, forming, machining, or welding. Here is a brief overview of how each of these tactics work:

- **Machining:** This process involves using a specialized piece of equipment to shave away parts of the metal to make it into the shape that is needed. Some of the tools that are involved include lathes, mills and drills.
- **Cutting:** We utilize water jet cutting, an abrasive process that uses high pressure water to cut virtually any material with a high level of precision and no distortion. Check out the benefits of water jet cutting here.
- **Welding:** This is a common form of steel fabrication. Welding is used to bend or combine pieces to make them one piece. Check out this blog post on the differences

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between MIG and TIG welding. As a CT welding contractor, we specialize in MIG & TIG welding of Steel, Stainless Steel and Aluminum and use Pulsed welding machines to help control the heat put into a part, minimize distortion, and improve the quality of the parts we produce.

Machinists who are tasked with steel fabrication would first have to gauge the original shape of the raw material which might exist in the form of a flat plate, reshaped channels, pipes or many other starting forms. Once the steel has been processed, the next step to be taken by the fabricator entails determining its shape. There are two factors which govern this outcome, namely the software package and the equipment available in the machine shop. In this regard, most of the metal fabrication companies prefer using cutting-edge technology to keep track of the operation and maintain the proficiency of the process.of straight bar from which the actual shatx will be bent or for a straight bar. the length of that bar. This length will be equal-to the sum of individual overall lengths of the straight portions of each shape 5.2.2 A schedule shall be supplemented with diagrams and sketches wherever necessary. Where bars of different dimensions are used, the exact arrangement of the reinforcement shall be shown by means of clear diagrams. No abbreviation or symbol shall be used in a schedule without proper explanation. 5.2.3 For small structures detailed on a single sheet, the schedule may be placed in the upper left corner of the drawing. For larger structures requiring more than one drawing, the complete schedule may appear on the last sheet of the details, or if the size of the strucutre warrants

Bar Bending As Per IS Standards (SP 34: 1987): please download (sp 34 : 1987) and read it. Bar bending schedules are very important out of detailing and should give the following information:

a) Identification of the structural member(s),

b) Position of the bars in the structure,

c) The bar mark, The diameter or size of bar,

d) The number of bars of one type in each structural member,

e) The total number of bars of each type,

f) The total straight length of the bar,

g) The shape and bending dimensions of the bar,

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h) The details of bar chairs can also be included, and Remarks, if any.

- **Prepare bar schedule (important considerations)**
  Reinforcement Bar Schedule
  Reinforcement Bar Schedule is prepared in a standard manner. The bar bending schedule should be prepared and it should be submitted to the steel bar steel yard to cut and to bend the bars for purposes, because bar bending schedule is the simplest of details what is in the drawings which can easy to under stand for bar benders. It contains all the details needed for fabrication of steel.Those details are bar mark, bar type and size, number of units, length of a bar, shape code, distance between stirrups (column, plinth, beam) etc.

  Advantages of the Bar Schedule:

- By preparing a bar schedule, and arranging them according to the lengths, it will lead to an economical bar cutting, reduce the bar cutting wastages.
- It is easy to manage the reinforcement stock required for identified time duration.
- It will help to fabrication of R/F with structure.
  Calculating weight of the steel
  While prepared the bar schedule, we used the unit weight of reinforcement bar.

Nominal Diameter of the bar (mm)	Unit weight (kg/m)
R6	0.222
R10	0.610
T10	0.617
T12	0.888
T16	1.580
T20	2.469
T25	3.858
T32	6.313

Table- Unit weight of the bar

It is necessary to be careful about length when preparing bar schedules. In case of bending, bar length will increased at the bending positions.

- **Minimization of bar cutting wastage**
  In the site several steps were adopted for that purpose. Those are, Use of 12m long r/f bars rather than using shorter bars. For example 6m bars off cuts of 12m bars were used to prepare stools, separators etc.
- Off cuts of larger diameter (25mm) bars-for spacer bars
- Off cuts of smaller diameter (10mm) bars-for stools
- **Lapping**
  Lapping is required when a bar isn't long enough or a joint is required. Bars may be deliberately left short for constructability and transportation concerns. The preferred

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method of lapping where the two bars overlap each other for some minimum distance. This distance is called Lap length. These two bars are in physical contact and wired together. It does not represent an actual bend in the bar.

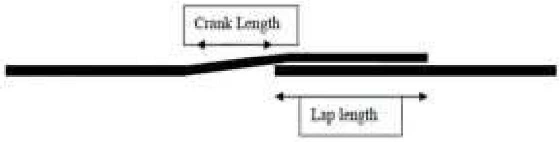

Fig 2: Lapping and cranking detail

- **Other material used In Reinforcement Works**
  Binding Wires
  R/f bars are jointed with using wires which is called “binding wires”. Hackers are used to bind these wires.

cover block: A **cover block** is essentially a spacer that is used to lift the rebar matrix off the ground so that concrete may flow underneath the rebar. In order to prevent corrosion of the rebar, it needs to be fully encased in concrete. By code, it usually needs about 2 to 3 inches of coverage on all sides.

Cover block and uses of cover block

Introduction: RCC members like footing, column, Beam and Roof slab must have clear cover. Clear cover is nothing but a gap between outer edge of concrete surface and outer edge of Reinforcement. Clear cover is not constant for all RCC members.

For Roof slab, it must be 20 mm

For Beam, column and footing, it must be 40 mm.

Clear cover must be greater if section area of particular RCC member is larger and less if section area is small.

If we don’t follow clear cover, Failure at surface of the concrete may occur. So that, so many cracks will form.

Some examples of failure of roof slab those not using cover block:

no cover block causing damage at early stage

no cover block causing severe damage

In order to maintain a gap between outer edge of concrete surface and edge of Reinforcement, we should place a small block called cover block.

Below the image of cover block for your reference.

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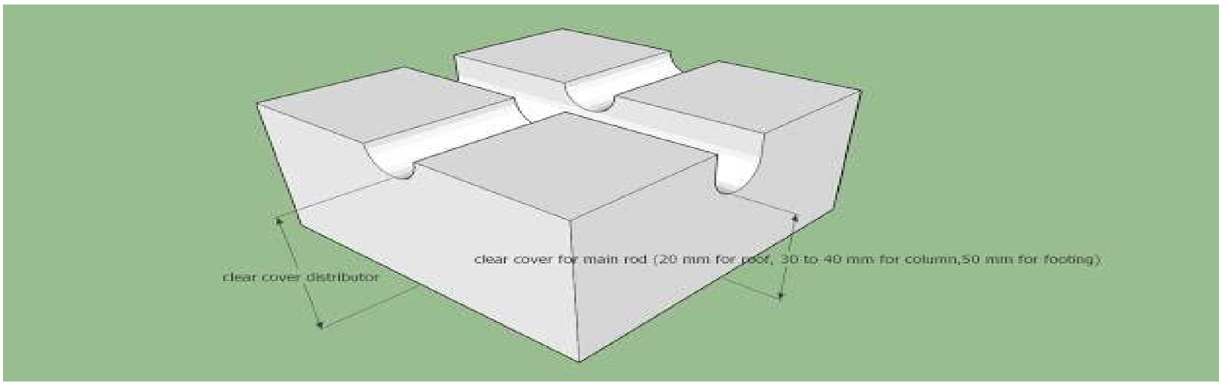


dimension of cover block

Cover block is a small block made of plain cement concrete. it may be vary in size according to types of RCC member(Roof, beam. column. Footing).

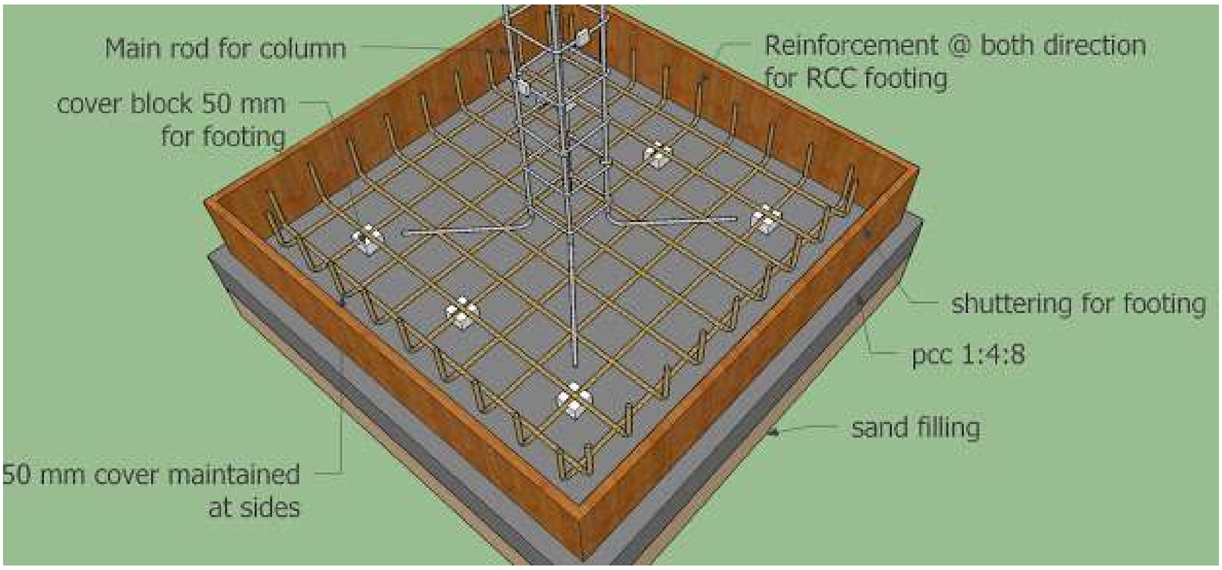
It has two straight semi circular hollows at top of the cover block. One is for main rod and other one for distributor in order to don't allow them to move from placed position.

How to use cover block?:

Simply place it below the main rod of Rcc members.

Here I have given some images to describe how to place cover block for various structure.

cover block effectively used at RCC footing.



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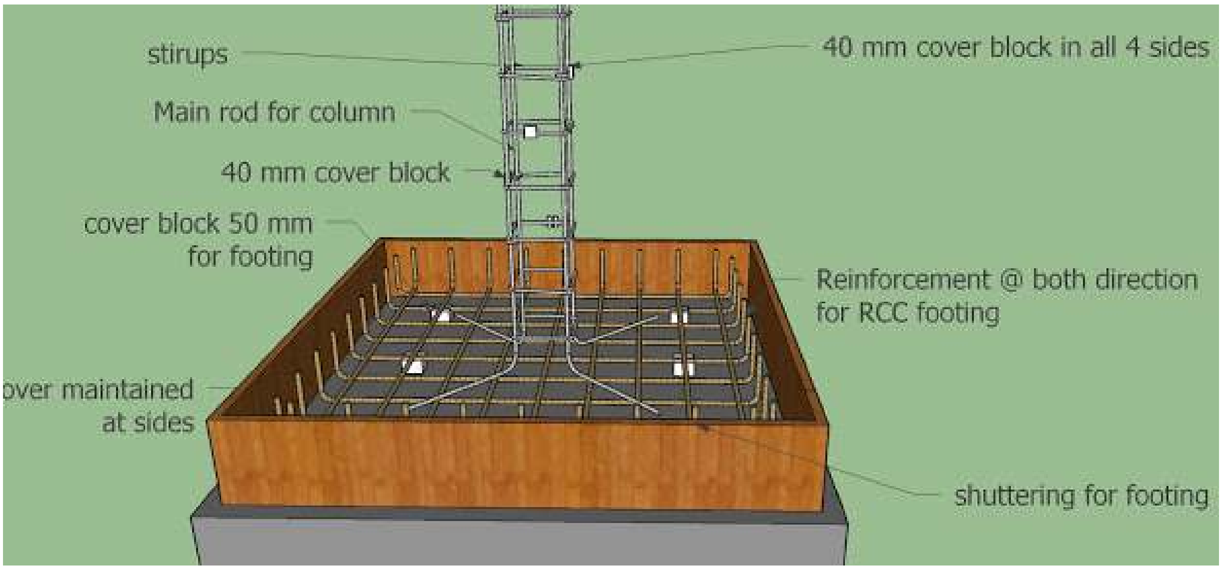
cover block used for RCC footing

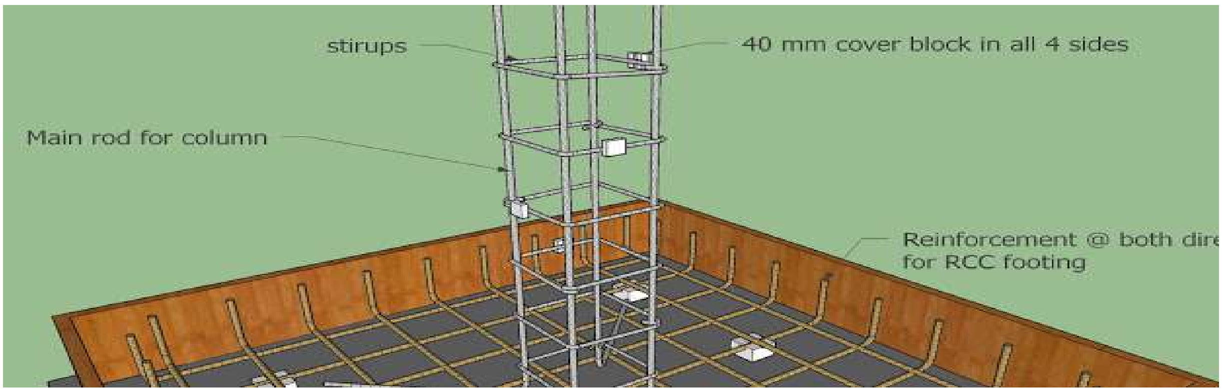


cover block used for RCC footing

In the above image, you can notice some important points.

- Always place cover block of size 40 to 50 mm at bottom of the footing.
- At side of footing leave a space of at least 50 mm to avoid corrosion of steel .Otherwise reinforcement affected by damping earth and corrosion will occur.
- Complete the shuttering work and place the concrete.

cover block effectively used at RCC column.



cover block for column

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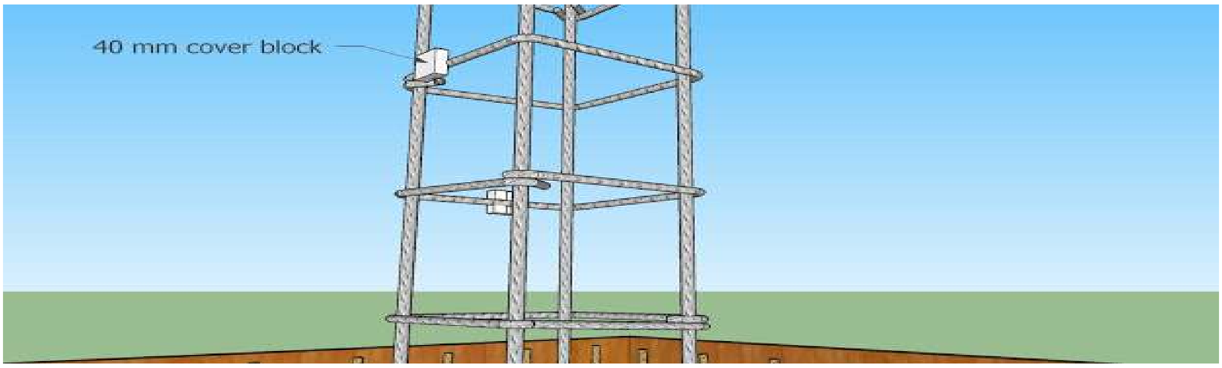


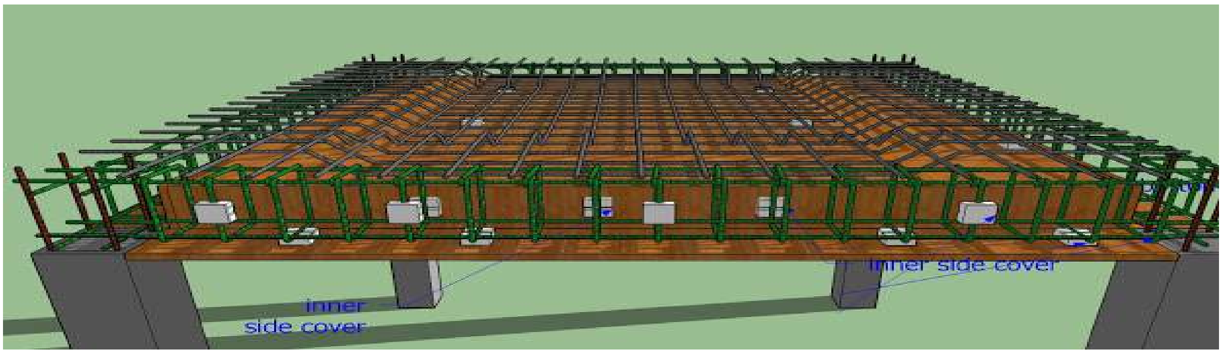
cover block for column

In the above image, you can understand some important points.

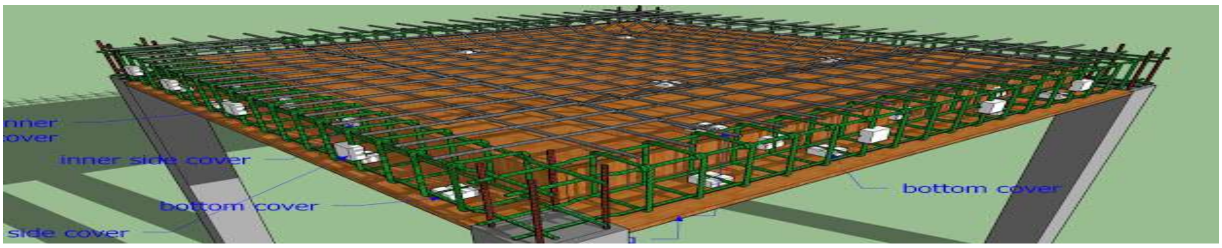
- Place the cover block at the all 4 sides of the column.Then only you can save the column from failure.

- Place the cover block at the rings and bind it with binding wire.
- After placing the cover block,complete the shuttering work and place concrete.

  cover block effectively used at RCC beam and Roof slab:



front view of cover block at beam and roof



perspective view of beam and roof having cover block placed

From the above two image, some points should be followed.

Always place cover block for all 3 sides (bottom, 2 sides)of a beam. leave top side without placing cover block. but place the concrete for extra height as rings plus clear cover.

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Place the cover block for roof slab bottom randomly as sufficient as possible.

To protect the top reinforcement at nearer to support, place the chair rod.

Here are some things to remember about placing rebar:

- Bar supports are not intended as support for construction equipment such as concrete pumps, buggies, or laser screeds.
- Spacing of bar supports depends upon the size of the reinforcing bar being supported. For example, for a one-way solid slab with #5 temperature-shrinkage bars, high chairs are used at 4 feet on center; for #4 bars, high chairs would be placed 3 feet on center.
- Placing reinforcement onto layers of fresh concrete or adjusting the position of bars or welded wire reinforcement during concrete placement should not be permitted. The ill-advised practice in slab construction of placing reinforcement on the subgrade and pulling it up during concrete placement is called “hooking.”
- Spacers for vertical concrete (wall construction) have traditionally been optional. Side form spacers include double-headed nails, precast concrete blocks (dobies), and proprietary all-plastic shapes.
- The ironworker, ironworker foreman, contractor, and inspector all have the responsibility to see that the reinforcing bars in concrete construction are properly placed.
- Deviation from specified location: In slabs and walls, other than stirrups and ties ±3 in. Stirrups: depth of beam in inches divided by 12. Ties: width of column in inches divided by 12.
- Placing of rebar:
  - Rebar cages are either pre-fabricated or constructed on site using hydraulic benders and shears. Site labourers known as steel fixers place the rebar and ensure adequate concrete cover and embedment. Rebar cages are connected either by spot welding, tying steel wire or with mechanical connections. Mechanical connections, also known as ‘couplers’ or ‘splices’, are an effective means of reducing rebar congestion in highly-reinforced areas for cast-in-place concrete construction.
  - Rectangular stirrups are placed at regular intervals on the outer part along a column or beam to prevent shear failure.
  - For safety purposes while being stored on site, protruding ends of rebar should be bent over or guarded by using coloured plastic ‘mushroom caps’.
  - Although rebar has ribs that bind it mechanically to the concrete, high stresses can still pull the rebar out of the concrete, which may lead to structural instability and ultimately failure. To prevent this, rebar must be deeply embedded into adjacent structural members (40-60 times the diameter), which increases the friction locking the bar into place. Alternatively, rebar can be bent and hooked at the ends to lock it around the concrete and other rebar sections, which makes use of the concrete’s high compressive strength.
  - Steel rebar can also be susceptible to corrosion if insufficient cover is provided which can cause the concrete to spall away from the steel, and render it less efficient in terms of fire resistance. As a general rule, the minimum cover should not be less than the maximum size of the aggregate in the concrete, or the largest reinforcement bar size (whichever is largest).
  - NB In November 2019, The British Association of Reinforcement (BAR) issued a warning to clients and contractors to check prefabricated reinforcement was welded by workers certified to do the job. CARES is the Certification Authority for Reinforcing Steels.

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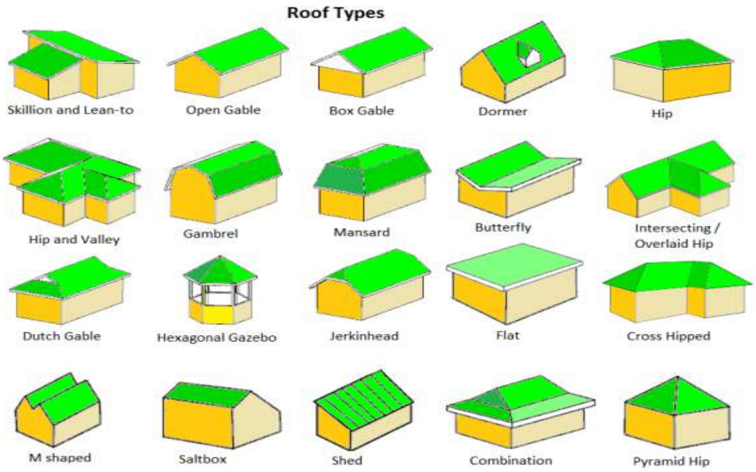
Types of roofing system:

1.Gable
2. Hip
3. Mansard
4. Gambrel
5. Flat
6. Skillion
7. Jerkinhead
8. Butterfly



9. Bonnet
10. Saltbox
11. Sawtooth
12. Curved
13. Pyramid
14. Dome
15. Combination

Types of stairs: A stair is a set of steps leading from one floor of a building to another, typically inside the building. The room or enclosure of the building, in which the stair is located is known as staircase. The opening or space occupied by the stair is known as a stairway.

Types of Stairs – Classification of stairs:
Stairs can be broadly classified into three types:

1. Straight stairs
2. Turning stairs
3. Continuous stairs

1. Straight stairs
Generally for small houses, available width is very retractable. So, this type of straight stairs are used in such conditions which runs straight between two floors. This stair may consists of either one single flight or more than one flight with a landing.

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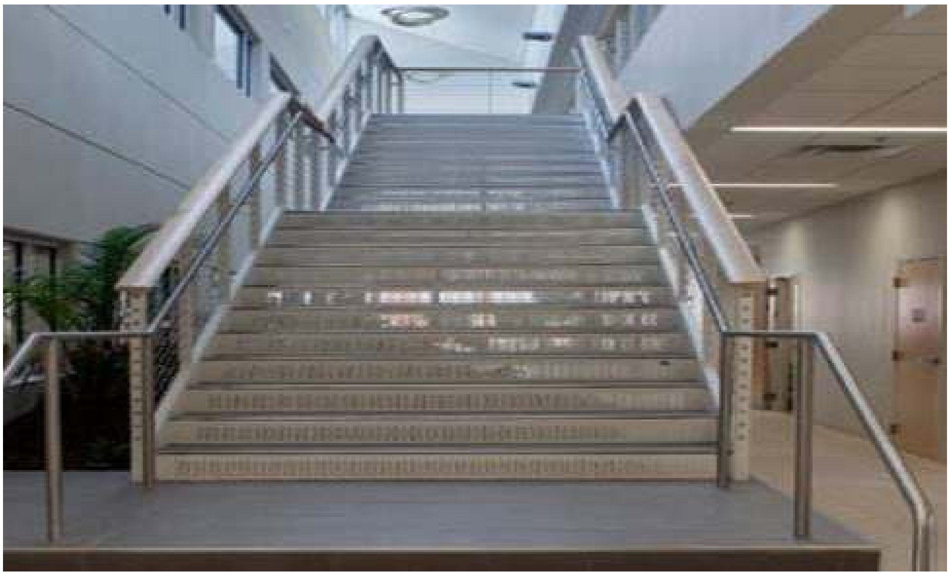
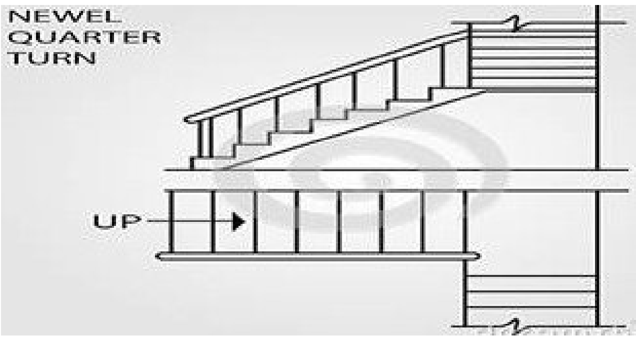


2. Turning stairs
Turning stairs are sub classified as:

1. Quarter turn stairs
2. Half turn stairs (dog legged stairs)
3. Three – quarter turn stairs
4. Bifurcated stairs

3. Quarter turn stairs
A quarter turn stair is the one which changes its direction either to the right or to the left but where the turn being affected either by introducing a quarter space landing or by providing winders. In these type of stairs the flight of stair turns 90 degrees art landing as it rises to connect two different levels. So it is also called as L-stair. Again these quarter turn stairs are two types.

3.1. Newel quarter turn stairs
These type of stairs have clearly visible newel posts at the beginning of flight as well as at the end. At the quarter turn, there may either be quarter space landing or there may be winders.



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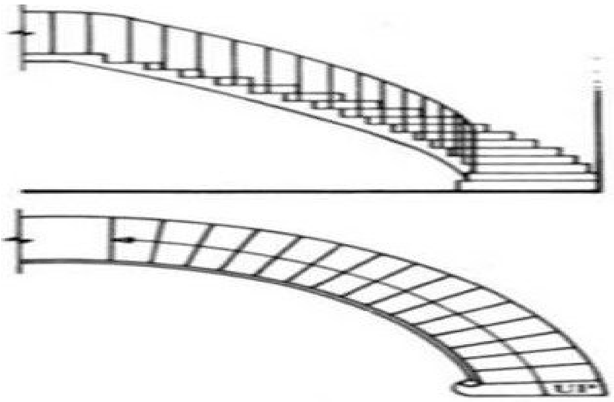
3.2. Geometrical quarter turn stairs

In geometrical stairs, the stringer as well as the handrail is continuous without any newel post at the landing area.

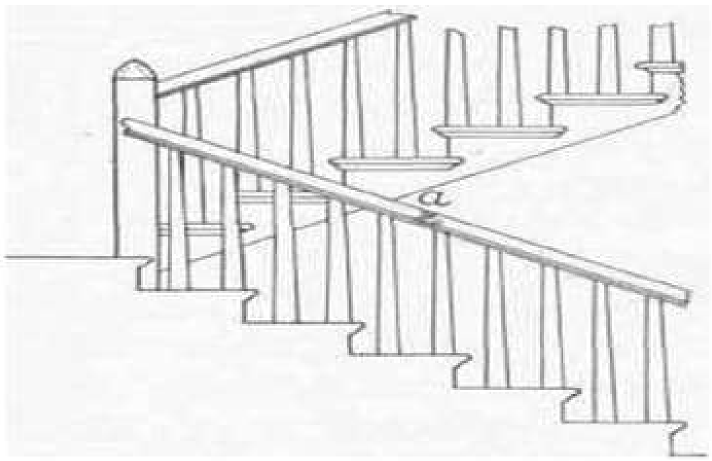


4. Half turn stairs

In case of half turn stairs its direction reversed, or changed for 180^o. Such stairs are quite common. Again these are three types.

4.1. Dog-legged stairs

Because of its appearance in sectional elevation this name is given. It comes under the category of newel stairs in which newel posts are provided at the beginning and end of each flight.



4.2. Open newel half turn stair

In this type of open newel half turn stairs, stair has a space or well between the outer strings. This is the only aspect in which it differs from the doglegged stair.

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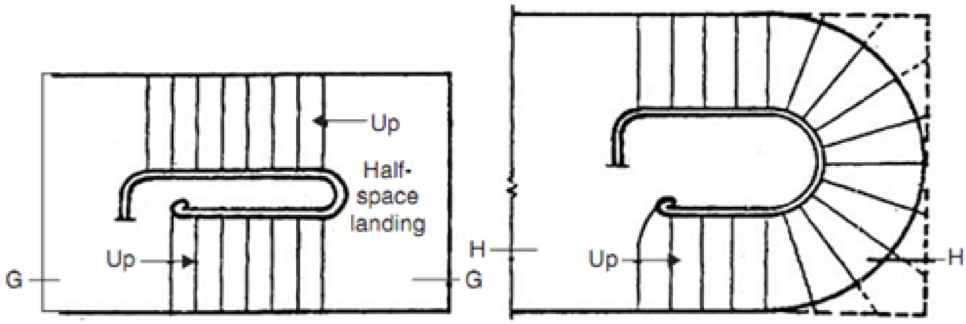
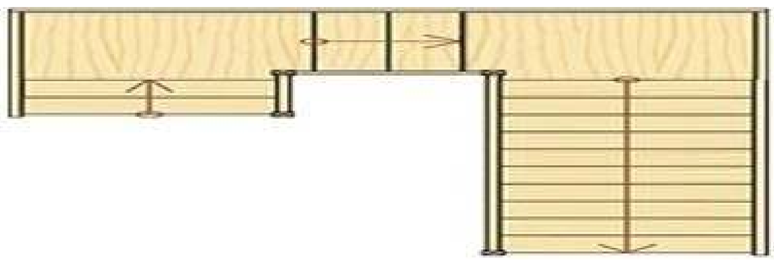
4.3. Geometrical half turn stairs
In case of geometrical half turn stairs the stringers and the hand rails are continuous, without any intervening newel post. These stairs may contains either with half space landing or without landing.



5. Three quarter turn stairs
The direction of stairs changed three times with its upper flight crossing the bottom one in the case of three quarter turn stairs. These stairs are may either be newel or open newel type. This type stairs are generally used when the vertical distance between two floors is more and as well as length of the stair room is limited.



6. Bifurcated stairs
Bifurcated stairs are commonly used in public building at their entrance hall. This has a wider flight at the bottom, which bifurcates into two narrower flights, one turning to the

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left and other to the right, at landing.it may be either of newel type with a newel post or of geometrical type with continuous stringer and hand rails.

7. Continuous stairs

This type of stairs neither have any landing nor any intermediate newel post. They are geometric in shape. These are may be of following types.

- Circular stairs
- Spiral stairs
- Helical stairs

Circular stairs or spiral stairs are usually made either of R.C.C or metal, and is placed at a location where there are space limitations. Sometimes these are also used as emergency stairs, and are provided at the back side of a building. These are not comfortable because of all the steps are winders and provides discomfort.

A helical stair looks very fine but its structural design and construction is very complicated. It is made of R.C.C in which a large portion of steel is required to resist bending, shear and torsion.

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Read More: Components or Parts of Staircase and their Details
A window is a vented barrier provided in a wall opening to admit light and air into the structure and also to give outside view. Windows also increases the beauty appearance of the building.

Selection Criteria for Windows

The selection of suitable windows in a particular place should be dependent on the following factors.

- Location of room
- Size of room
- Direction of wind
- Climatic conditions
- Utility of room
- Architectural point of view

Based on the above factors we can select a suitable window for our structures.

Types of Windows used in Buildings

There are so many types of windows are available based on their positions, materials, and functioning. Windows are classified as follows.

1. Fixed windows
2. Sliding windows
3. Pivoted windows
4. Double-hung windows
5. Louvered windows
6. Casement windows
7. Metal windows
8. Sash windows
9. Corner windows
10. Bay windows
11. Dormer windows
12. Clerestory windows
13. Lantern windows
14. Gable windows

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15. Ventilators
16. Skylights

1. Fixed Windows

Fixed windows are fixed to the wall without any closing or opening operation. In general, they are provided to transmit the light into the room. Fully glazed shutters are fixed to the window frame. The shutters provided are generally weatherproof.

2. Sliding Windows

In this case, window shutters are movable in the frame. The movement may be horizontal or vertical based on our requirements. The movement of shutters is done by the provision of roller bearings. Generally, this type of window is provided in buses, bank counters, shops, etc..

3. Pivoted Windows

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In this type of windows, pivots are provided to window frames. Pivot is a shaft which helps to oscillate the shutter. No rebates are required for the frame. The swinging may either horizontal or vertical based on the position of pivots.

4. Double Hung Windows
Double hung windows consist of pair of shutters attached to one frame. The shutters are arranged one above the other. These two shutters can slide vertically with in the frame. So, we can open the windows on top or at bottom to our required level.

To operate the double hung windows, a chain or cord consisting metal weights is metal provided which is connected over pulleys. So, by pulling the weights of cord the shutters can move vertically. Then we can fix the windows at our required position of ventilation or light etc..

5. Louvered Windows
Louvered windows are similar to louvered doors which are provided for the ventilation without any outside vision. The louvers may be made of wood, glass or metal. Louvers can also be folded by provision of cord over pulleys. We can maintain the slope of louvers by tilting cord and lifting cord.

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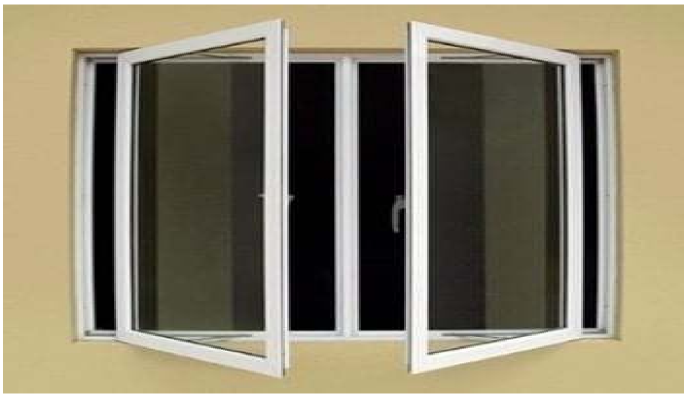
Recommended angle of inclination of louvers is about 45^o. The sloping of louvers is downward to the outside to run-off the rain water. Generally, they are provided for bathrooms, toilets and privacy places etc..

6. Casement Windows

Casement windows are the widely used and common windows nowadays. The shutters are attached to frame and these can be opened and closed like door shutters. Rebates are provided to the frame to receive the shutters. The panels of shutters may be single or multiple. Sometimes wired mesh is provided to stop entering of fly's.



7. Metal Windows

Metal windows, generally mild steel is used for making metal windows. These are very cheap and have more strength. So, now days these are widely using especially for public buildings, private building etc.

Some other metals like aluminum, bronze, stainless steel etc. also used to make windows. But they are costly compared to mild steel windows. For normal casement windows also, metal shutters are provided to give strong support to the panels.

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8. Sash Windows

Sash window is type of casement window, but in this case panels are fully glazed. It consists top, bottom and intermediate rails. The space between the rails is divided into small panels by mean of small timber members called sash bars or glazing bars.

9. Corner Windows

As in the name itself corner windows are provided at the corners of room. That means corner windows has two faces in perpendicular directions. By providing this type of windows, light or air can be entered into room in two different directions.

To provide this type of window special lintel is provided in the wall. Corner windows will give aesthetic appearance to the building.

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10. Bay Windows
Bay windows are projected windows form wall which are provided to increase the area of opening, which enables more ventilation and light form outside. The projection of bay windows are of different shapes. It may be triangular or rectangular or polygonal etc. They give beautiful appearance to the structure.

11. Dormer Windows
Dormer windows are provided for sloped roofs. These are projected from the sloping surface as shown in below image. They provide ventilation as well as lighting to the room. They also enhance aesthetic sense of room.

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12. Clerestory Windows
If the rooms in a building are of different ceiling heights, clerestory windows are provided for the room which has greater ceiling height than the other rooms. The shutters able to swing with the help of cord over pulleys. These also enhances the beauty of building.

13. Lantern Windows
Lantern windows are provided for over the flat roofs. The main purpose of this window is to provide the more light and air circulation to the interior rooms. Generally, they are projected from the roof surface so, we can close the roof surface when we required.

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14. Gable Windows
Gable windows are provided for sloped roof buildings. These windows are provided at the gable end of sloped roof so; they are called as gable windows. They also improve the appearance of building.

15. Ventilators
Ventilators are provided for the purpose of ventilation in the room. They are provided at greater height than windows nearer to roof level. It is in very small size. Horizontally pivoted shutters are provided for ventilators. Sometimes shutter is replaced by wired mesh, in this case sunshade is provided to prevent against rain water.

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16. Skylights
Skylights or generally provided on the top of sloped roofs. To admit light into the rooms, sky lights are provided. It is provided parallel to the sloping surface. Sky lights can be opened when we required. Lead gutters are arranged to frame to make it as waterproof.

Types of Doors Used in Building Construction
Based on the arrangement of door components, the doors are classified as following,

1. Battened and Ledged Doors

- Battens are vertical bonds which are having grooves are attached together by horizontal supports called ledges as shown in below figure.
- General Dimensions of batten are 100-150mm width and 20-30mm thick.
- General dimension of ledges are 100-200mm width and 25-30mm thick.
- This type of battened and ledged doors suitable for narrow openings.

2. Battened, Ledged and Braced Doors

- To make more rigid, braces are provided diagonally in additional to battens and ledges as shown in figure.
- Braces are having 100-150mm width and 25-30mm thickness are preferable.
- Braces should place upwards from handing side, then they acts as struts and take compression.
- These type of doors can be used for wider openings.

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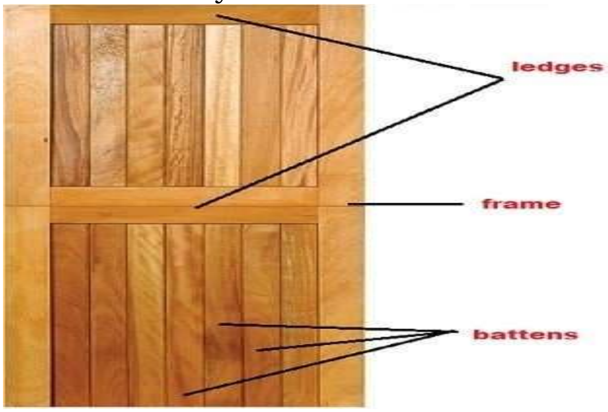
3. Battened, Ledged and Framed Doors

- For the simple battened and ledged door, frame work is provided in the form of two verticals, known as stiles.
- Stiles are generally 100mm wide and as far as thickness is concerned, the thickness of stile should be equal to the combined thickness of ledge and batten. Preferably 40 mm.



4. Battened, Ledged, Braced and Framed Doors

- In this type, the door made up of battens, ledges, stiles and braces. So, it is more rigid.

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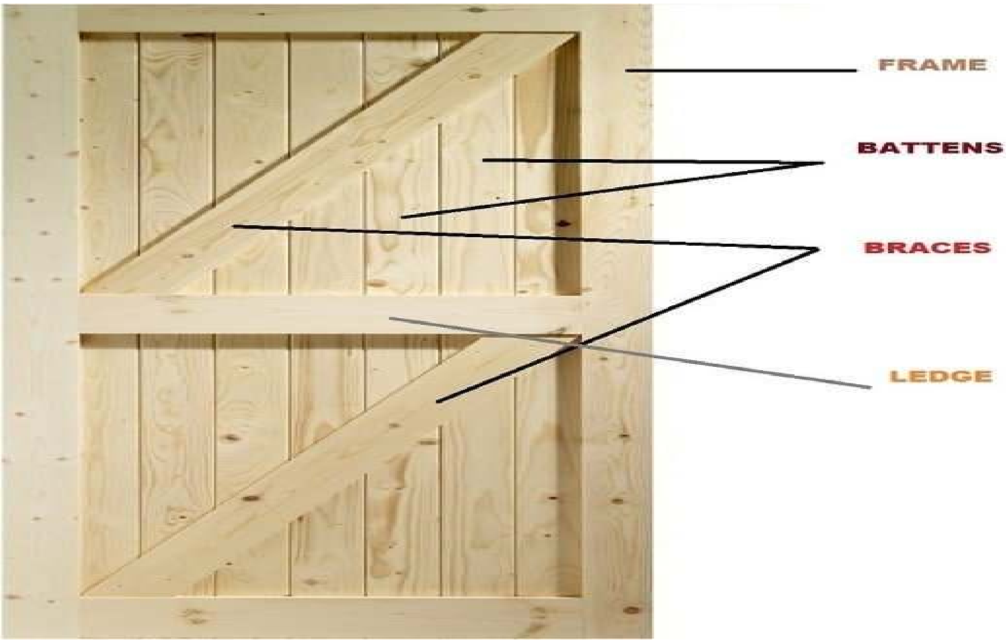
- The braces are connected diagonally between the ledges, at about 40mm from the stiles.



Types of Doors based on Method of Construction:
Based on the method of construction, the doors are again classified into 5 types and they are:

5. Framed and Panelled Doors

- These are very strong and will give good appearance when compared to battened doors. These are the widely used doors in almost all types of buildings.
- Stiles, vertical members and rails, horizontal members are grooved along the inner edges of frame to receive the panels.
- The panels are made up of timber or plywood or A.C. sheets or glass.
- These doors may be single leaf for narrow openings and double leaf for wider openings.
- Minimum width of stile should be 100mm and minimum width of bottom and locked rail should be 150mm.

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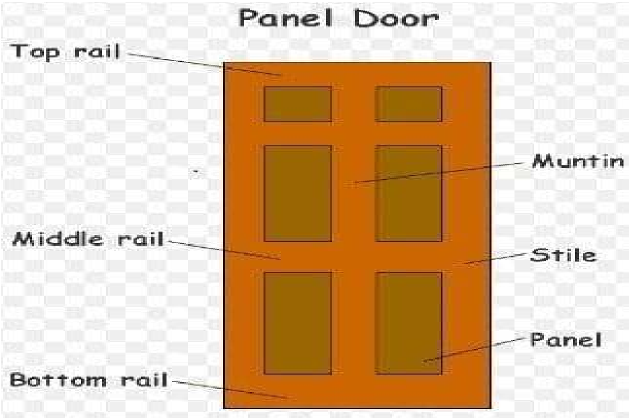

6. Glazed Doors

- Glazed doors are generally provided in interior wall openings or in hospitals, colleges etc.
- The interior of room is visible through glazed doors and light also passes through glazed portion of the door.
- These may be fully glazed or partly glazed and partly panelled. Glass panels are provided for glazed doors.

7. Flush Doors
In flush doors, a solid or semi-solid or core portion is covered on both sides with plywood or face veneer. Now a days these type of doors are widely used because of good appearance, economic, ease of construction and greater durability.

There are two types of Flushed doors:
Solid Core or Laminated Core Flush Door

- The core part in solid core flush door consists of core strips of timber which are glued under high pressure condition. Similarly in the laminated core, battens of 25mm width are glued under high pressure.
- These doors consists of wooden frame with stiles and rails for holding the core.
- Finally plywood sheets or face veneer and cross-bands are glued under pressure on both side of doors.

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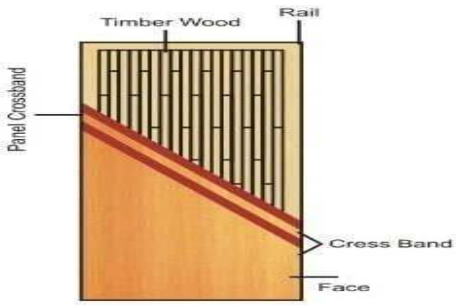
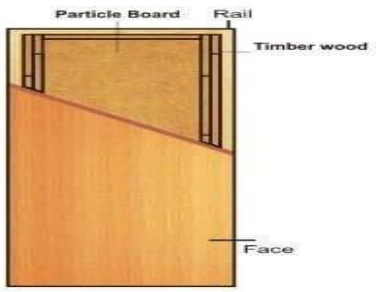
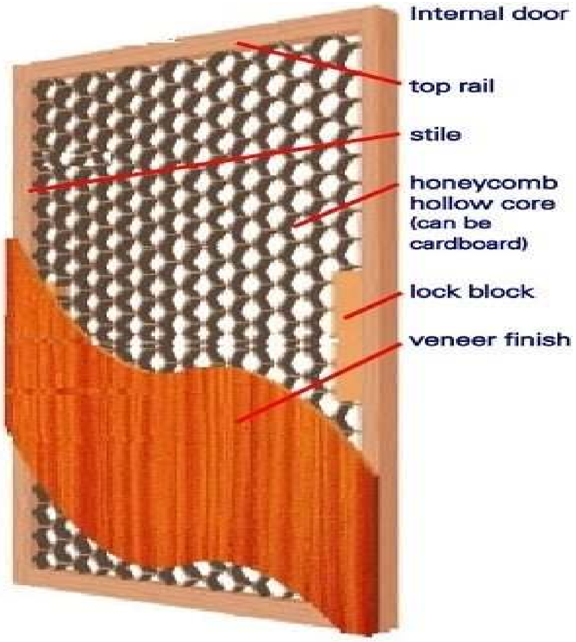




Hollow core and cellular core flush door

- In this case also stiles and rails are provided for frame. But, a minimum of two intermediate rails should be provided.
- The inner space of door consists of equally space battens of width 25mm each. Other space is called void space which does not exceed 40% of the area of door.
- Here also face veneer and cross-bands are glued under high pressure.



8. Louvered Doors

- The louvers permit natural ventilation when the door is closed and also provide privacy in the room.
- These are generally used for toilets of residential and public buildings.
- The door may be fully louvered are partly louvered.
- Louvers are made up of timber or glass or plywood and these may be either fixed or movable.

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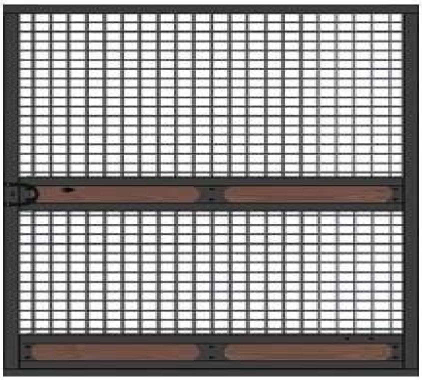
9. Wire Gauged Doors
Wire gaged doors permits natural ventilation and restrict the entry of flies, mosquitoes, insects etc.. These doors are commonly used in hotels, restaurants and for cup boards containing eatables.

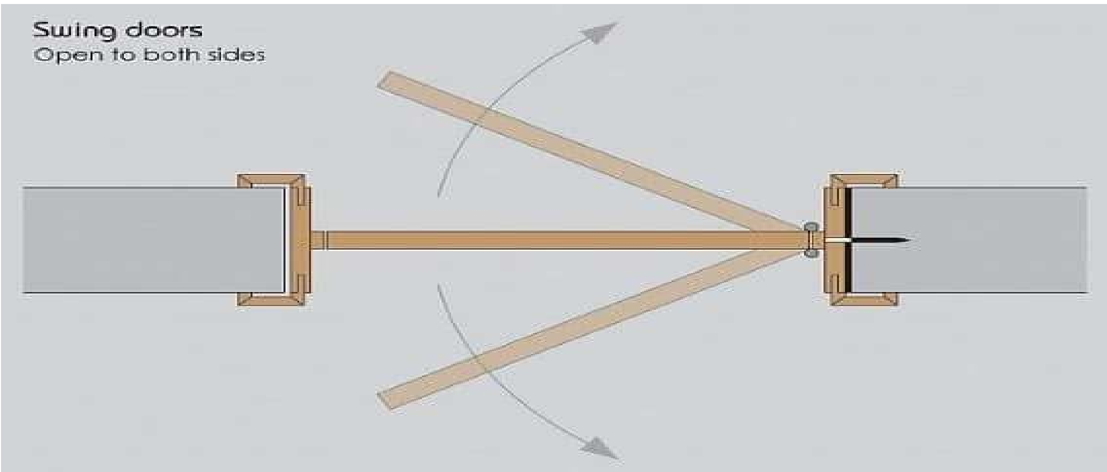


Types of Doors based on Working Operations
The doors are classified on the basis of working operations as:

10. Revolving Doors
Revolving doors are only provided in public buildings like museums, banks, libraries etc., because of constant visitors. It consists mullion at its centre to which four radiating shutters are attached.

11. Sliding Doors
In this type, with the help of runners and guide rails the door slides to the sides. The door may have one or more sliding shutter depending up on the opening available.

12. Swing Doors
In this case, the shutter is attached to frame by double action spring which helps the shutter to move inwards as well as outwards.



13. Collapsible Steel Doors
Collapsible steel doors are generally used for workshops, sheds, warehouses etc.. It acts like a steel curtain which will opened or closed by horizontal pull or push. Vertical double channel units of (20x10x2 mm) are spaced at 100 to 120 mm thick and are braced flat iron diagonals 10 to 20mm wide and 5mm thick.

14. Rolling Steel Shutter Doors
Rolling steel shutter doors are commonly used for warehouses, garages, shops etc.. These are very strong and offer proper safety to the property. The door consists frame, drum and a shutter of thin steel plate inter locked together. A horizontal shaft is provided in the drum which helps to open or close the shutter.

Types of Doors based on Materials:
Doors are made up of wood, glass, metals. Wood doors are already discussed in the 1t classification and glass doors are nothing but glazed doors. Types of Metals doors are described below.

15. Mild Steel Sheet Doors

- The door frame is made up of angle or T-sections.
- Shutter is made up of frame of angle of iron, having 2 verticals at least 3 horizontal.
- Mild steel plates are welded to the shutter frame.

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16. Corrugated Steel Sheet Doors
These are same as mild steel sheet doors, but in place of mild steel sheet corrugated steel sheet is welded.

17. Hollow Metal Doors
Hollow steel sections are used to make these doors. The rails and stiles etc., are strengthened by welding small T or I sections inside.

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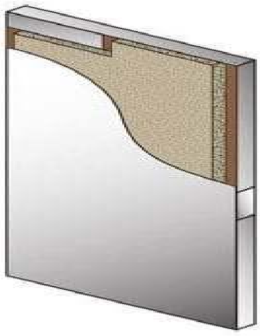
18. Metal Covered Plywood Doors

- This type of door is a composite construction of hollow metal door and wood door.
- The door is encased in tight fitting sheet metal, having tightly folded joints to exclude air so that the core of the door does not ignite. So, it acts as fire proof.



Methods of Preventing Dampness in Buildings
Following methods are generally adopted to prevent the defect of dampness in a structure:

1. Membrane damp proofing
2. Integral damp proofing
3. Surface treatment
4. Guniting
5. Cavity wall construction

1. Membrane Damp Proofing
This consists in providing layers of membrane of water repellant material between the source of dampness and the part of the structure adjacent to it. This type of layer is commonly known **as damp proof course (DPC)** and it may comprise of materials like bituminous felts, mastic, asphalt, plastic or polythene sheets, cement concrete, etc. Depending upon the source of dampness, DPC may be provided horizontally or vertically in floors, walls, etc. Provision of DPC in basement is normally termed as tanking.

General principles to be observed while laying damp proof course are:

1. The DPC should cover full thickness of walls excluding rendering.
2. The mortar bed upon which the DPC is to be laid should be made level, even and free from projections. Uneven base is likely to cause damage to DPC.
3. When a horizontal DPC is to be continued up a vertical face a cement concrete fillet 75mm in radius should be provided at the junction prior to the treatment.
4. Each DPC should be placed in correct relation to other DPC so as to ensure complete and continuous barrier to the passage of water from floors, walls or roof.

2. Integral Damp Proofing
This consists in adding certain water proofing compounds with the concrete mix to increase its impermeability. Such compounds are available in market in powdered as well as in liquid forms.

The compounds made from clay, sand or lime (chalk, fuller's earth, etc) help to fill the voids in concrete and make it waterproof.

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Another form of compounds like alkaline silicates, aluminium sulfate, calcium chlorides, etc react chemically when mixed with concrete to produce water proof concrete.

Pudlo, Imperno, Siks, etc. are some of the many commercially made preparation of water proofing compounds commonly used. The quantity of water proofing compounds to be added to cement depends upon manufacturers' recommendations.

In general, one kg of water proofing compound is added with one bag of cement to render the mortar or concrete waterproof.

3. Surface Treatment
As described earlier, the moisture finds its way through the pores of materials used in finishing. In order to check the entry of the moisture into the pores, they must be filled up.

Surface treatment consists in filling up the pores of the surfaces subjected to dampness. The use of water repellant metallic soaps such as calcium and aluminium oleates and stearates is such effective in protecting the building against the ravages of heavy rain. **Bituminous solution, cement coating, transparent coatings, paints, varnishes** fall under this category.
In addition to other surface treatment given to walls, the one economically used is lime cement plaster. The walls plastered with cement, lime and sand in proportion of 1:3:6 is found to serve the purpose of preventing dampness in wall due to rain effectively.

4. Guniting
This consists in depositing an impervious layer of rich cement mortar over the surface to be waterproofed. The operation is carried out by use of a machine known as **cement gun**. The assembly broadly consists of a machine having arrangements for mixing materials and a compressor for forcing the mixture under pressure through a 50mm diameter flexible hose pipe. The hose pipe has nozzle at its free end to which water is supplied under pressure through a separate connection.

The surface to be treated is first thoroughly cleaned of dirt, dust, grease or loose particles and wetted properly. Cement and sand (or fine aggregates) usually taken in proportion of 1:3 to 1:4 are then fed into the machine. This mixture is finally shot on the prepared surface under a pressure of 2 to 3 kg per square cm by holding the nozzle of the cement gun at the distance of 75 to 90 cm from the working surface.

The quantity of water in the mix can be controlled by means of regulating valve provided in the water supply hose attachment. Since the material is applied under pressure, it ensures dense compaction and better adhesion of the rich cement mortar and hence treated surface becomes waterproof.

5. Cavity Wall Construction

This consists in shielding the main wall of the building by an outer skin wall leaving a cavity in between the two. The cavity prevents the moisture from traveling from the outer to the inner wall

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TOP THREE TERMITE TREATMENT METHODS

Termites can cause irreparable damage to homes and can affect the integrity and structure of your house. If you discover termites or suspect you have termites, it's important to contact a professional pest control company immediately. A professional pest control company will be able to assess the situation, and recommend and administer the appropriate termite treatment. There are three standard **methods of treatment for termites**:

1. Soil Treatment: Since subterranean termites live in the soil, **termite treatments** are used on the surrounding soil to act as a treatment barrier. First, a trench is dug around the foundation, and the soil is treated with a termiticide. The trench is then refilled. This type of treatment helps prevent future termite infestations, and kills any termites in the house as they to return to the soil to nest.

2. Wood Treatment: Pest control professionals can use a variety of different wood treatments to help kill any existing termite colonies and prevent future ones from spouting up. Wood treatments include surface sprays, injected sprays and foams, and Borate treated wood. Pest control professionals use borate wood treatments to prevent termite infestations and eliminate any existing termites in homes. Wood treatments include surface applications during the construction phase of home building and wood injections and foams after a home is built.

3. Bait Systems: Bait termite treatment systems are an effective way of destroying termite colonies. A pest control professional will install bait stations around the perimeter of the home and monitor the stations on a set frequency ensuring a home is protected from future and any current infestations. This termite infestation treatment effectively eliminates termites.

These are just a few ways of effectively protecting your home from termites and preventing further damage to your home's structure. For more information on the different types of termite treatments, or if you think you may have a termite problem, **contact HomeTeam Pest Defense** today to schedule an assessment of your home.

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Unit 4 Finishing Of Superstructure:

Types of floor finishes – mud flooring, cement flooring, ceramic tile flooring, marble and granite flooring, wooden flooring, flooring with puffed panels – plastering (interior and exterior) – pointing for walls and floors using grouts – white washing, color washing with different color shades available in the markets – painting – types of painting for interior and exterior application. Form work (shuttering or scaffolding) – types of formwork – use of shoring and underpinning.

FLOOR FINISHES. A **floor finish** is a liquid which is applied to a resilient tile **floor** and dries to a hard, durable and smooth film. This film is about the thickness of waxed paper and is expected to protect and extend the life of the **floor** while providing an attractive appearance and slip resistant surface.

CRITERIA FOR SELECTION OF FLOORING

- It should be durable
- It should be easy to clean
- Noiseless
- Have Good Appearance
- Free from dampness
- Fire Resistant
- Low Maintenance cost

Types of floor finishes :

1) **Natural stone floor finishes**

   a) slate

   b) Limestone and Sandstone

   c) Granite

   d) Marble

   e) Mosaic

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Slate

- Slate is another form of metamorphic rock that consists of silica alumina and iron oxide.
  - It is easily split into layers that provide a rugged rustic look.
  - It has good abrasion resistance and high durability if it has been correctly cut.
  - It is impervious to water, cold hard and noisy under foot and can be slippery.
  - A non-slip variety is available.
  - It is difficult to lay as the product is quite brittle and heavy.
  - It is usually laid into a bed of cement over concrete.

Limestone and Sandstone

- These are derived from sedimentary rocks; deposits of sediment being laid down under water or air formed these.
- Sandstone comes from deposited sand grains i.e. quartz, pressed and held together by silica, calcium carbonate or other cements.
- Limestone comes from deposited organic origin materials i.e. bones shells and consists mainly of calcium carbonate.
- Limestone is rarely used for floors today as it becomes slippery when it is worn and not all products are hardwearing.
- It is grey or beige in color.
- Sandstone - is used more in outdoor paving than indoor, but looks great in an area that flows to the outdoors such as a conservatory.
- Its irregular natural pattern is its best feature and can range from a grainy timber look to stripes and speckles.
- It is beige, brown, reddish brown, in color and some stones are hardwearing.

Granite

Granite used for steps to a commercial building entry.

- Granite is a form of Igneous Rock, created by the cooling of molten magma.
- It is made up of feldspar quartz and mica.
- This is a luxury floor covering and one that needs careful consideration before specification, as it is an expensive product.
- The floor structure needs consideration, as it is very heavy.
- Once laid, it will last for a very long time, as it is hardwearing and resistant to chemicals.
- It has a timeless look.
- If highly polished it is slippery, but a honed finish provides a more manageable finish.
- It comes in limited colors - black, red, green, grey, blue, pink.
- It is supplied in a slab form and is cold and noisy underfoot. But it looks great!

Marble

- This is a form of metamorphic rock, a combination of igneous and sedimentary rocks undergoing a major change due to extreme influences of heat or pressure.
- It is made up of calcium carbonate; it comes in numerous colors, white, grey, green, ochre, beige and is usually veined.
- It is a hardwearing beautiful product, expensive to purchase and lay as it is heavy and comes in slab form.
- It is cold and noisy underfoot.
- From a designers point of view like granite it has a timeless quality.

Marble used of floor and walls of a hotel bathroom, very stylish.

2) Artificial semi hard floor finishes

a) Linoleum

b) Rubber

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c) Cork

d) Flexible vinyl

Linoleum

Linoleum is made up from natural ingredients, linseed oil, ground cork, resin, fillers and pigments. These are baked slowly at high temperatures and pressed onto a jute or Hessian backing.

It is a misunderstood product as in its early form it was thin and brittle but with new production methods and design development it is fast becoming a popular flexible flooring choice. It is available in numerous color combinations and can be plain, patterned or in a marbleized look.

It is warm and quiet underfoot. It requires sealing with a polish as if water penetrates under the surface it will lift. It comes in sheet or tile form and is fixed to the floor with an adhesive.

Rubber

Rubber is made from natural or synthetic rubber, fillers and pigments. It is available in single colors with relief patterns or marbled. It comes in sheet form or tiles cut from sheets. The sheet form is available with foam rubber backing which provides a form of sound insulation. It has good wear properties, is resilient and tough, warm and quiet underfoot. It can be loose laid on concrete.

Cork

Cork is a natural product that comes from the bark of the evergreen oak. It is most commonly available in tiles. These are cut from blocks of granulated cork that has been compressed with binders Cork is a natural product that comes from the bark of the evergreen oak. It is most commonly available in tiles. These are cut from blocks of granulated cork that has been compressed with binders

3) Artificial hard floor finishes

a) Cement Resin

b) Terrazzo

c) Concrete Screeds

d) Epoxy Resin

e) Polyester Resin

f) Polyurethane Resin

Cement Resin This comprises of cement polyester resin and an aggregate (crushed stone or sand). It can be laid over concrete or a timber base. It provides a hardwearing non-slip surface, which has a slight texture.

Terrazzo

This is a composite material made up of cement and marble aggregate, it is then mixed and poured in situ onto a concrete base. It is then ground waxed and polished. It has a mosaic look. It can also be premade and is available in slabs or tiles. It is very hard wearing, if it is polished or wet it is very slippery. It is a suitable product to be used with under floor heating.

Terrazzo flooring in a mall situation.

It is very useful in commercial situations i.e. malls and shopping centers as it is very durable and easy to clean.

Over large expanses control joints are required to reduce the risk of cracking. It is expensive but worth it in these situations. It can be used to great effect in design work, using brass strips to define the edges with the use of different colored terrazzo between can be very effective.

Concrete Screeds

These are usually used as a base for other floor finishes. There are many forms, monolithic, laid over the concrete base within a few hours of the base being laid. Bonded - existing concrete base with aggregate exposed has a cement screed laid over it. Unbounded - a cement screed is laid over a plain existing concrete base. Floating - is laid over thermal or sound insulation materials.

Colored Concrete Screed in a mall situation.

Epoxy Resin

Produced by combining epoxide resin, fillers, aggregate and hardener. It can be laid over a cement screed, plywood or other surfaces. It provides a thin hardwearing layer available in numerous colors and textures. It can be made non-slip if required.

Polyester Resin

Produced by combining polyester resin, aggregates, fillers, glass fibers pigments and catalyst. It can be laid over a cement screed or plywood. It is a hardwearing product with a wide color range.

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Polyurethane Resin

Produced by combining polyurethane resin and fillers. It can be laid over a cement screed or plywood. It provides a hardwearing non-slip surface available in numerous textures and colors.

All the hard flooring examples above are joint less liquid floor finishes. They start as a liquid form then harden to form the desired finish. Terrazzo and cement screed floors are required to be laid in bays with control joints to reduce the possibility of cracking and shrinkage. The majority of these products are best suited for commercial industrial and institutional applications.

4) FALSE FLOORING :

A FALSE FLOORING IS also called raised floor (also raised flooring) is a type of floor used in office buildings with a high requirement for servicing, such as IT data centers, to carry cables, wiring, electrical supply and sometimes air conditioning or chilled water pipes. Additional structural support and lighting are often provided when a floor is raised enough for a person to crawl or even walk beneath.

This type of floor consists of a gridded metal framework or understructure of adjustable-height legs called pedestals, that provide support for individual floor panels which are usually 2×2 feet or 60×60cm in size. The height of the legs/pedestals is dictated by the volume of cables and other services provided beneath, but typically arranged for a clearance of at least six inches or 15cm.

FIXING FALSE FLOORING :

- STEPS FOR EXECUTING FALSE FLOORING :
  - Identify the area where FALSE FLOORING is required to execute.
  - Clean the area by removing all loose,liatences etc..

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- Floor to be coated with epoxy paint for reducing friction for airflow.
- Floor to be insulated in the case of higher floors since the floor is likely to be very cold and can cause sweating on the ceiling of lower floor causing damage to their false ceiling etc.
- Complete the services works like data cable,Wiring,lighting etc.. Before false flooring work.
- Fix the frame work of false flooring like pedestals etc..
- Fix the panels by using nut and bolts of suitable size.
- Make provision for opens and fix these opens with openable panels provided with hinges.
- Mark the ducts for repairs and maintenance of wires, cables inside the false flooring.
- Before closing the false flooring, prepare a diagram showing the rooting of the cables to enable for quick searching of cable. Wires etc..in case of failures

5) Concrete Floor Finishes

Chemical Staining - Special stains are formulated to chemically react with the concrete's lime content. They lightly etch and bond color into the concrete surface. This method can be used on new or old concrete slabs. However, the results are not always predictable due to lime leaching, weathering, surface texture, or exposure to other chemicals, and results may vary widely from project to project. Mottling that occurs in the stain process can create rich tones and complex, almost translucent textures to mimic granite, marble, or to highlight natural variegations in the concrete. Patches or cracks in existing slabs will not be concealed, but may add character and uniqueness. Skilled artisans can create a wide range of effects using, brushes, mops, sprayers, etc., or by creating patterns with leaves, sawdust, rags, or other inert materials. The full depth of color may not become apparent until waxes or sealers are applied to the surface. This is the most versatile and creative method of coloring concrete.

Scoring - Shallow-cuts can be made in existing concrete surfaces to suggest tile grout lines or simply create geometric designs and patterns to separate colors. Standard circular saws with abrasive masonry blades are used to make cuts no more than 1/8" deep. With tile patterns, borders are incorporated into the design a few inches from walls or other vertical surfaces that would prevent the saw from scoring lines all the way to the edge.

Integrally Colored Concrete - Colorant added to concrete during the mixing process produces uniform tinting throughout the slab and consistent results from batch to batch. The colorant may be in liquid or powder form. For small projects, home centers or concrete-product retailers may carry bottles of liquid colorant which can be added to bags of ready-mix. For larger flatwork projects like foundation slabs, walkways, patios, or driveways, bags of powdered water-reducing color admixtures can be ordered at the mixing plant. Admixtures are used to improve plasticity, workability, and to control set time. When pattern stamps are used, a longer period of workability may be needed to complete the process in large areas. Some manufacturers offer their products in pre-measured disintegrating bags designed to treat particular amounts of concrete. The unopened bags are simply tossed into the mixer with water and aggregate prior to adding cement and sand. When pattern stamping is planned, integral colorants may serve as a base tone that can be modified by color hardeners and release agents to achieve a more mottled natural look.

Colored hardeners - Hardening agents in powder form consist of colored, finely-ground, cementitious aggregates that are sprinkled (or "broadcast") onto freshly placed concrete. Moisture seeps from concrete into the powder to activate and monolithically bond it, creating a denser, harder finished surface. Surface strength may be increased up to 7,500 PSI compared to 3,000 to 4,000 PSI for standard 4" concrete. Because the colorant is concentrated into the top layer, hues can be more intense than integrally colored concrete. For improved surface durability, use of colored hardeners is recommended prior to pattern stamping, or in conjunction with chemical staining to produce brighter or deeper finished colors, but the results may vary slightly from batch to batch.

Colored release agents - Pigmented powder or liquid agents are used with pattern stamps to reduce friction and facilitate their removal from fresh concrete surfaces. Applicators may choose release agent colors that contrast or compliment hardener colors to produce a mottled patina or "antique" look on the patterned surface. Unlike the other methods described here, these pigments do not penetrate the concrete surface and must be protected by sealers or wax finishes.

Sealers and Waxes - Colored materials are available to seal and waterproof concrete surfaces, the final step in any finishing process. Manufacturers offer a broad range of products for different applications, ranging from buffing waxes for interior floors to industrial sealers for high traffic exterior settings. Choosing a matching color wax or sealer for integrally-colored concrete can intensify the hue and add gloss. Clear coatings can bring out the depth and luster of antiquing patinas or variegations from chemical staining. Depending on the how heavily the floor is used, sealers or waxes may need to be periodically renewed or reapplied, but maintenance might be as simple as occasionally mopping with floor wax.

wood floor finishes:

1. Oil-modified urethane **is generally the most common surface finish and is easy to apply. It is a petroleum base with a blend of synthetic resins, plasticizers and other film forming ingredients that produces a durable surface that is moisture-resistant. It is a solvent-base polyurethane that dries in about eight hours. This type of finish ambers with age and comes in different sheen levels.**
2. Moisture-cured urethane **is a solvent-base polyurethane that is more durable and more moisture resistant than other surface finishes. Moisture-cure urethane comes in non-yellowing and in ambering types and is generally available in satin or gloss. These finishes are extremely difficult to apply, have a strong odor and are best left to the professional. Curing of this type of finish is by absorbing minute quantities of moisture vapor from the air, which causes them to dry and harden. The curing process is very dependant on relative humidity.**
3. Water-based urethane **is a water-borne urethane with a blend of synthetic**

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resins, plasticizers and other film forming ingredients that produces a durable surface that is moisture-resistant. These finishes are clear and non-yellowing and are different sheen levels. They have a milder odor than oil-modified finishes have and they dry in about two to three hours. Water-based urethanes are generally more expensive.

4. Converstion-Varnish Sealers**-(Swedish Finishes)- A two-component acid-curing, alcohol-based sealers. Because of their origin (country), conversion varnish sealers are often referred to as Swedish finishes5. Penetrating Sealers - These sealers are spread on the floor and allowed to penetrate and are solvent based. The excess sealer is removed with rags or buffed in with synthetic or steel wool pads. This type of finish often have a color and can be used to stain and seal the wood floor. Penetrating Oil Sealers are made from tung or linseed oil, with additives improve drying and hardness.**

6. Paste Wax**- The oldest, and in some ways the best. Wax is the easiest to apply, least expensive, fastest drying, easiest to repair, and with proper care will survive forever. Wax over a penetrating stain, and the system is in the wood so you wear the wood, not the finish. Wax is spread in thin coats for a surface protection after the stain and/or sealer is applied, then buffed to the desired sheen.**

7. Varnish**- Vinyl-alkyd varnishes have superseded natural varnish made from vegetable oils. This product was commonly used before urethane finishes where introduced.**

8. Lacquer **- The flammability and incompatibility of this floor finish is NOT a recommended by many manufacturers. This finish should avoided.**

9. Shellac **- This product (natural shellac) contains wax and is not widely used for top coating in today's wood flooring market. Dewaxed shellac is becoming used more and more for a wood floor sealer.**

Mud flooring: Flooring is actually the process which is often misunderstood with some element. It is the process of providing clean, smooth, durable and impervious levelled surface to the occupants of the house. “To understand the reasons, you must first look at the origins” said Anthony T. Hincks. Among all the flooring materials mud flooring is the ancient flooring material and hence knowing about mud flooring will acknowledge you with the basic things a flooring material should have. Once you know the basic things about flooring material, you will have ample of options for flooring material.

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If flooring is nicely done, it increases the aesthetic view of house. The mud flooring is a natural type of flooring. Mud has been the easiest form of material available for construction of building. The method of constructing a mud floor is quite simple.

- Good quality and clean mud is first selected.
- Then small quantities of chopped straw are mixed in it along with water to make a consistent paste.
  Chopped Straws are mixed to prevent the mud floor from cracks during drying.

- Then about 25cm (10”) thickness of this paste is applied on already prepared floor bed.
- After that, the floor is rammed properly to get a compacted, even and level surface of about 15cm (6”) thickness.No water should be used during the process of ramming.
- Mud floors have to be maintained at least once or twice a week.
  Sometimes, cow-dung is also mixed with earth and a thin layer of this mix is spread over the compacted layer to give texture.

- Mud floor is maintained by giving a thin cement cow-dung wash (1:2 to 1:3) once or twice a week.
  Mud flooring is one type of flooring that is most commonly used in rural areas even today. It has following advantages:

- Mud flooring is cheap and hard.
- Easy to construct.It does not require skilled labour.
- It has good thermal insulation property. It remains cool in summers and warm in winters.
- It is environmentally friendly flooring.
- It is fire resistant.
- It is noiseless.
  The only disadvantage of mud flooring is that it is not moisture resistant.

Advantages:

- The main advantage of mud flooring is; it is eco-friendly.
- Mud flooring is a very cheap option compared to PVC flooring or any other type of flooring.
- There is no health concern in case of mud flooring whereas PVC flooring emits high VOC compound which is not good for health.
- Mud flooring has ability to control the temperature variations. During summer it stays cool and vice a versa during winter time. It can provide fairly warm atmosphere.
- It is a fire resistant compared to PVC flooring.
- Skilled labours not required to do the mud flooring.

Disadvantages:

- It is not durable as compared PVC flooring.
- Mud flooring requires frequent maintenance, once or twice in a week.
- The surface of the mud flooring is not smooth as compared PVC flooring.
- Mud flooring gets weathered due to certain activities i.e. walking, moving of furniture, etc.
- It is not moisture resistant therefore there are chances of the growth of bacteria which is unhygienic.
- It dost not resist heavy load as the floor gets dent.
- Mud flooring has low resistance to stain as it has high porosity.
- Its life is limited.

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Cement concrete flooring is one of the most common types of **flooring** used in both in residential as well as public buildings owing to its non-absorbent nature and thus it is very useful for water stores, durability, smooth and pleasing in appearance, good wearing properties, easy maintenance and is economical

Cement Concrete Flooring

Cement Concrete Flooring is commonly used both in residential as well as public buildings.

The method of laying **cement concrete flooring** on ground floor of a building can be broadly divided in the following steps.

(i) Preparation of sub-base:

The earth filling in plinth is consolidated thoroughly so as to ensure that no loose pockets are left in the whole area. A 10 to 15 cm. thick layer of clean coarse sand is then spread over the whole area. The sand layer a consolidated and dressed to the required level and slope.

(ii) Laying of base concrete:

The base concrete used under floors may be cement concrete or lime concrete laid to a thickness varying from 75 to 10 cm. In case of **cement concrete**, the mix commonly used is 1:5:10 (1 cement: 5 sand : 10 stone or over burnt brick aggregates 40 mm. nominal size). Lime concrete, if used, should be made up out of 40 mm. nominal size stone/over burnt brick aggregate and 40% mortar comprising of 1 lime : 2 sand/surkhi or 1 lime : 1 surkhi/ash : 1 sand. The base concrete layer is deposited over the whole area, thoroughly lamped and levelled to a rough surface.

Cement Concrete Flooring

(iii) Laying the topping:

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When the base concrete layer has fully set and hardened, its surface is thoroughly cleaned and the entire area is divided into rectangular or square panels by use of 4 mm, thick glass strips or 5 mm, thick plain asbestos strips. The size of panel is basically governed by the location of floor (exposed or indoor), temperature and other climatic conditions, thickness of topping and proportions of ingredients in concrete mix. etc. In general, the area of one such panel should not preferably be more than 2 sq. m. The surface of base concrete should be made damp and applied with a coat of neat cement slurry prior to laying the topping., The rough finished surface of base concrete coated with cement slurry ensures adequate bond between the base and the topping. The cement concrete topping, normally consisting of 1:2:4 (1 cement :2 sand : 4 stone aggregate) is then laid in required thickness in one operation in the panels. The concrete is spread evenly by using a straight edge and the surface is thoroughly tamped and floated with wooden floates till the cream of the mortar comes at top. The surface is then smoothened and finally finished by means of steel trowels. In case glass or plain asbestos strips are not required, the panels are formed by use of wooden or angle iron battens. The battens should have depth equivalent to that of concrete topping. The surface of the battens which is to come in contact with concrete, is coated with raw linseed oil before concreting. Concrete for the topping is then laid in alternate panels and finished as described above. The battens used for forming panels are removed next day and the topping concrete laid in the alternate panels.

In case the **cement concrete flooring** is to be laid over R.C.C. slab, it is usual to allow the slab concrete to harden and then lay the flooring. Prior to laying, the slab top is cleaned of all dirt, dust, loose particles, mortar droppings and debris etc. and the flooring laid as described under the sub-head 'laying of topping' above.

In order to prevent the tendency of separation of the. cement concrete flooring from the R.C.C. slab, a 20 mm. thick cushioning layer of lime mortar (1 lime : 2 sand/surkhi or/lime : 1 surkhi/sand) or 50 to 75 mm. thick lime concrete is sometimes provided between the R.C.C. slab and the **cement concrete flooring**.

If the working conditions permit, the flooring can also be laid monolithically over the R.C.C. slab while the slab concrete is still green. In this case, the slab concrete is roughened with wire brushes so as to ensure a good bond between the base and the flooring layer. Prior to laying of flooring, the slab surface is cleaned and a coat of cement slurry is applied over it. In this case, any slope required for the floor is given in structural concrete itself.

The flooring should be cured for 10 days before use.

Merits of cement concrete flooring:

- It is non-absorbent and thus it is very useful for water stores.
- It is durable and hence it is commonly used in kitchens, bathrooms, schools, hospitals, drawing rooms etc.
- **cement concrete flooring** smooth and pleasing in appearance.

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- It is economical and has the advantages of costlier types of floors.
- It possesses good wearing properties and can be easily maintained clean.

Demerits of cement concrete flooring:

- Detects in carelessly made floor cannot be rectified, and as such, it requires proper attention while laying.
- **Cement concrete flooring**cannot be satisfactorily repaired by patch work.

advantages of concrete floors:

1. They are hard & Durable.
2. Provide a smooth & non absorbent surface.
3. They are more fire resistant.
4. They provide more sanitary surface as they can be cleaned & washed easily.
5. They are economical as they require negligible maintenance cost.
6. They can be finished with a pleasing appearance.

Ceramic tile may be the only flooring material that truly works in any room of the house. It's most often used in kitchens and bathrooms as well as foyers, mudrooms, and other high-traffic areas. But many homes, especially in warm climates, use tile to great effect in living areas and bedrooms, too. In other words, you really can't go wrong with tile. If there are any drawbacks to this durable, elegant flooring, it is that it can be hard and cold, and is somewhat tricky for DIYers to install.

Ceramic tiles have a hard, solid surface, that does not attract or hold onto dirt, dust, pollen, or other allergens. When these small particles do land on a ceramic floor, they stand out against the surface, making it easy to wipe them away with a mop or sponge. This helps to keep the air free of irritating materials that can be harmful to asthma and allergy sufferers.

Ceramic Tile Cost

Ceramic tile can be one of the more affordable flooring materials, starting at well below $5 per square foot for budget tile and DIY installation. However, as you move into better-looking tile and professional installation, tile flooring can easily cost as much or more than quality hardwood flooring. National industry statistics show that ceramic tile flooring installed professionally can range from a low of about $15 per square foot to a high of more than $60 per square foot. It all depends on the quality of the tile and the difficulty of the installation.

Maintenance and Repair

Ceramic flooring is fairly easy to care for—especially glazed tiles, which have a hard protective top layer that makes them impervious to water and most stains. This is the main reason why tile is preferred for wet areas like bathrooms, kitchens, and laundry rooms. Dirt, stains, and liquids rest on the surface, allowing you to easily wipe or mop them away.

Routine maintenance consists of little more than sweeping or vacuuming with a soft brush attachment to keep the floor free of dirt and loose debris. If set-in stains do occur, you can use almost any heavy-duty cleaner without having to worry about damaging the material.

While most ceramic floor tile is glazed, there are unglazed ceramic tiles, such as traditional Saltillo tile. These must be sealed to protect their surface from liquids and stains. And with all types of tile, the grout in between the tiles is susceptible to moisture and stains and should be sealed regularly for protection.

Ceramic flooring is extremely tough and difficult to crack. A quality installation can last for hundreds of years if the floor is well-maintained. If a single tile does crack due to a severe impact, the process for replacing a tile is relatively simple.

ADVANTAGES OF CERAMIC FLOORING TILES

There are many added benefits that go along with installing ceramic flooring tiles in your custom home.

WATER RESISTANCE

When you choose glazed ceramic flooring tiles, you are getting the added bonus of a protective layer that sits on the material, which will make it impenetrable to water and stains. Glazed tiles are also resistant to high humidity conditions, something that is especially beneficial to homebuyers in Florida. These properties make glazed ceramic tiles ideal for moist environments, such as bathrooms and kitchens.

If you choose unglazed ceramic flooring tiles, be advised that they need to be sealed if you want to protect its surface from liquids. As luxury home builders Clearwater, we also recommend that you seal the grout lines as well to keep out any moisture that can lead to potential mold.

DURABLE

Ceramic flooring is very tough, and the tiles are difficult to crack. If installed properly, ceramic flooring can last 10-20 years and longer if maintained. However, if a single tile does crack due to a heavy impact, it’s simple to replace.

EASY MAINTENANCE

Caring for ceramic flooring is fairly easy. As custom home builders Clearwater, we know that dirt, stains, and liquids rest on just the surface of the ceramic tile, which will allow you to easily wipe them up. There is some regular maintenance required like sweeping or vacuuming.

NO ALLERGY CONCERNS

Due to the hard surface of ceramic tiles, it tends to not attract any dirt, dust, animal hair, or pollens. This helps keep the air free of irritating materials to those that suffer from allergies.

DISADVANTAGES OF CERAMIC FLOORING TILES

Along with advantages come a few disadvantages of ceramic flooring tiles.

HARDER SURFACE

Like we mentioned before, ceramic flooring is extremely hard. While this makes it easier to clean and maintain, it can also make it uncomfortable to stand on. This material, unlike resilient floors, can’t be softened using padded underlayments, which means it might not be a suitable choice for some. However, the hardness of ceramic can be offset by using throw rugs or area rugs in places people tend to stand for a lengthy period of time, such as in front of the kitchen sink.

CERAMIC IS A COLD MATERIAL

Ceramic flooring, unfortunately, does not hold on to heat very well. When it gets chillier in the winter, it can be uncomfortable to walk on. Also, on a hot summer day the flooring will be warmer than usual.

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HEAVIER WEIGHT
Ceramic tiles can be very heavy, which means that in some cases, it might not be an appropriate choice for upper story installations. If you do choose to install ceramic flooring on the second or third story, we recommend having a qualified professional check the integrity of the structure to make that you are not putting extra stress on it.
Marble flooring: Marble is very evergreen, timeless and royal flooring. The advent of new technology and new materials has not been able to take away the charm of marble flooring.

Marble is the embodiment of luxury, however, surprisingly, it is one of the most affordable natural stones used for decorating and facing living spaces. Prior to choosing marble facing in your home, let us consider all the advantages and disadvantages of this natural material.

Advantages and Disadvantages of Marble Flooring

However there are certain advantages and disadvantages of marble.

Advantages of Marble

- Marble creates a very magnificent aesthetic impact on the interiors especially Italian marble.
- Marble flooring is very durable and can last for ages. It is a heavy stone and can take heavy loads on it.
- Marble flooring is scratch resistant.
- Natural stone – marble can be grey, and white, beige, pink or even green, but in terms of its visual characteristics it is the most easily recognizable natural stone, which, with its smooth lines, beautiful veins, smooth surface, is ideal not only for kitchen countertops but also for flooring, as well as for the bathrooms. In any room, marble will be noticeable due to its natural appearance, giving elegance and luxury to the interior.
- Elegant and refined, marble stone is the best suited for decorating not only the living spaces but also the office foyers that usually serve as the corporate identity of the company. At first glance, any marbled interior creates a striking effect of luxury, elegance, and reliability. Surprisingly, marble, in comparison with other natural stones, is quite an affordable option, which makes it more attractive today for use as construction or facing material.

Disadvantages of Marble

-
    - Marble requires proper care and maintenance. Acid should never be used on marble as it shall loose its shine. Marble should be regularly polished over a

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period of time to give it a new look. If proper precautions are not taken the marble becomes yellowish in colour.

  - Italian marble is usually very soft and prone to cracks. Proper resins have to be used to make the surface strong and solid and avoid further cracks.
  - Proper sealants should be used in marble flooring as the marble is highly porous and prone to staining. It absorbs stains very quickly especially kitchen stains hence are not appropriate for kitchen counter tops.
  - Marble is very heavy and lot of labour is required in lifting the stone. Only very professional contractors can work with marble flooring and insert design infill's in the floor.
  - Marble flooring becomes very cold in winters.

- Softer than other natural stones, marble, compared to other stones, has a soft and porous surface that makes it more susceptible to coloration, surface stripping by products with a high acid content, and staining by any spilled liquids.
- Marble requires certain maintenance and care with the use of special means to protect the surface from bacteria and any damage. Moreover, marble kitchen countertops are not intended for products to be cut on them, and cannot be used as a hot pad. To prevent scratches and other damages, cutting boards and hot pads should be used. Of course, marble requires certain attention, but subject to the proper care, the magnificence and beauty of its elegant, incomparable appearance will be a delight for the eye for a long time.
- 
- What is the Granite Stone?
- **Granite** Stone is a very hard and tough stone, it has very high compressive strength and its color variety is high compared to other stones.
- Its void fractions are few and this has caused it to also have low water absorption. The texture of granite stone has a uniform and flat appearance.
- The inside of granite has clearly visible black grains in its texture. Granite is the most well known igneous rock.

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- Many people are familiar with granite because it's the most common type of stone found in the earth's surface and it is used for creation of objects used in everyday life.

- Granite Use Cases
- Cabinets and kitchen countertops, floor covering, cobblestones, curbstones, stairs, and building external façade are some of the parts in which granite stones are used. You can see the presence of granite in many parts of the house.

- Granite Stone Advantages
- According to experts, one of the distinguishing features of granite stones is their durability and strength. These stones are also very resistant to erosion and can be used as floor covering.

- Due to its high toughness, this stone can withstand difficult weather conditions. Granite stone has a very elegant appearance which is why it is being used in building façade and floor covering.

- This igneous stone also has a good resistance against impacts and cannot be broken easily.

- The Disadvantages of Granite
- Despite the many merits of granite stones, they also suffer from some disadvantages and problems.

- One of the biggest problems with granite stones is its high price and high cost of installation, which is very high compared to other products.

- The speed of implementing granite is low due to behind the stone mortaring operation and time-consuming mortar adhesion and takes a long time.

- One of the unique features of granite is radiation of radioactive waves. These waves can increase in environments which have x-ray or gamma radiations or magnetic fields.

- For this reason, the use of these stones in laboratory environments and hospitals was banned in the early twenty-first century since granite radiations can be carcinogenic.

- Granite Stones in Kitchen Countertops
- According to experts granite stones are mostly used in kitchens. Granite stones can be used as countertop surfaces, cabinet surfaces or even floor covering.

- Granite in Bathrooms
- As we pointed out in the paragraphs above, granite stones are impervious to water. Therefore, they can be used in internal decoration of bathrooms.

- These stones can be used as the surface that wash-basins gets mounted on and also as bathroom wall decorations.

- Granite Stones in Internal Decoration Design
- Granite stones can also be used in decoration of environments like living rooms and dining rooms since their distinct and attractive appearance can attract the attention of anyone

Wooden Flooring Advantages and Disadvantages: Making the Right Choice

Is it time to replace the flooring of your home in Allen TX? Perhaps it's covered in stubborn stains due to dirty shoes or scratches from furniture and pets. Was it damaged by the flood? If so, this is also a good reason to replace flooring.

If you landed on this guide, we're guessing that you are interested to know what your options are for your replacement material. There's carpet, linoleum, stone, laminate, and more. But out of the many choices available, wood flooring stands out.

For many homeowners in Allen TX and the rest of the US, wood flooring is a dream come true. It's a popular choice as it offers many benefits. But wood flooring also has its share of disadvantages.

In today's article, we'll tackle everything you need to know. Let's dive into the following topics:

- Wooden flooring advantages and disadvantages
- Other types of flooring materials

StormPros is here to help you make the right choice.

Wooden Flooring Advantages and Disadvantages

Benefits of Wooden Flooring

1. Contributes to a healthier indoor air

Unlike carpets, wooden floors don't accumulate allergens.

What is the benefit of wooden flooring? One of the biggest reasons why you should choose it is that it ensures better indoor air. If you have family members who suffer from allergies,

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you'll be glad to know that hardwood floors don't absorb particles such as dust and pollutants. Carpets are known to harbor these particles, including parasites. So if your main purpose is to avoid allergens at all costs, go for wood material.

2. Boosts your home interior

When it comes to wooden flooring advantages and disadvantages, people think about appearance first. Hardwood looks brilliant and gives your home a feel of elegance and warmth for many years to come. Other flooring materials tend to fade over time, but not hardwood. This is especially true if you choose a contractor that installs high-quality wood flooring.

Speaking of aesthetic appeal, wooden flooring also matches any piece of interior decor. Modern or rustic — it doesn't matter.

3. Makes maintenance a breeze

Perhaps you heard rumors that wood flooring is hard to maintain. This is simply not true. We're here to tell you that caring for hardwood flooring to maintain its beauty and cleanliness is simple. Sweep it to remove dust and particles. If you spill water or colored drinks on the surface, wipe them dry with a clean cloth immediately. Use a proven floor cleaner to bring back its luster. Easy peasy, right?

4. Increases the value of your home

"Why is hardwood good in terms of your home's value?" Well, hardwood definitely helps you achieve a higher return on investment. You get to sell your home faster and for a better price. An article on Time magazine states that hardwood flooring is one of the features that buyers are willing to pay for. This is why many homeowners replace their old carpets if they plan to sell their properties anytime soon.

5. Available in a variety of types

Ask your local contractor about natural wood species for your flooring.

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Getting started with wooden flooring is an exciting experience since there are tons of options to choose from. You can have your contractors get you a unique plank size, specific shade, or wood type. When it comes to the wood material itself, here are some beautiful selections:

- Oak
- Mahogany
- Hickory
- Pine
- Cherry
- Walnut
- Cypress

The abovementioned list of species will vary in terms of color, ease of installation, and susceptibility to scratches.

6. Can be restored easily

Wooden flooring advantages and disadvantages… when it comes to restoration, you'll find hardwood easy to deal with. To make it look like new, replace damaged areas and apply a layer of fresh coat. You can do this with the help of a contractor like us, StormPros.

Disadvantages of Hardwood

1. Cost of the materials and installation service

Is wooden flooring expensive? Yes, it costs more than most materials because of the material quality and workmanship. Installing hardwood floors require expertise from experienced professionals. According to HomeAdvisor, a homeowner can expect to spend around $4,396 for installation. The most expensive wood types such as cypress and walnut costs around $8 to $14 per square foot.

Despite this high price tag, still, people continue to get wood flooring because of its long-term value.

2. Prone to water damage

Be sure to clean wood flooring right away to prevent damage from moisture.

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Since wood is a natural material, it is susceptible to water damage. Failure to dry your floors immediately will result in discoloration, raised edges, and buckling. All these consequences of water damage lead to an early replacement. Be sure to get in touch with a water damage restoration specialist if your wooden floors get soaked in flood water.

If there is no flooding, you can simply dry out the floors by vacuuming and setting your fans on full-blast. The only downside is that the process can be time-consuming. It may take an entire day depending on the area that requires drying.

3. Gets scratched easily

Scratches… they're one of the worst enemies of wooden flooring. Scratches immediately reduce its beauty. Some wooden floors are more vulnerable to scratches. You can deal with light and minor scratches by applying protective coatings or wax filler. Deeper scratches prompt you to ask for professional help.

Advantages of puffed panels:

1. Can withstand wind velocity upto 300kms per hour.
2. Can withstand heavy snowfall/rainfall.
3. It can withstand extreme temperature from -50 degree celcius to +120 degree celcius.
4. PUF having a thermal conductivity of 0.018 k cal prevents cross heat flow between room & outside ambience.
5. The shelter can be installed at any place in less than a day.
6. These shelters are called mobile shelter as they can be moved from one place to another.
7. These shelters are very light in weight, compact and have high structural strength thereby making it possible to create suitable size.
8. No air or water can penetrate through the panels of the shelter.

Plastering: **Plastering** is a process of covering the walls and ceiling with a smooth finish by any type of **plaster** materials (Cement, POP etc). The below **plastering work** checklist and for any type **plastering work**.

Gypsum plaster

Gypsum plaster, or 'plaster of Paris' (POP), is the most common form of plaster for interior walls. It is produced by heating gypsum to around 150°C (300 °F). When mixed with water, the dry plaster powder re-forms into gypsum. Unmodified plaster starts to set about 10 minutes after mixing, but it will not be fully set until 72 hours have elapsed. Gypsum plaster has good fire-resistant qualities.

Lime plaster

Lime plaster is a composite of calcium hydroxide (lime) and sand (or other inert fillers). It may sometimes be strengthened with animal hair to preventing cracking and reduce shrinkage. The plaster sets through contact with carbon dioxide in the atmosphere which transforms the calcium hydroxide into calcium carbonate (limestone). It is typically more flexible and breathable than gypsum and cement plasters, and is most commonly used on older properties.

Cement plaster

Cement plaster is a mixture of sand, cement and water. It is normally applied to masonry interiors and exteriors. While it is capable of achieving a smooth surface, interiors will sometimes require an additional finishing layer of gypsum plaster. Cement plaster offers greater moisture resistance than gypsum plaster.

Clay plaster

Clay plaster is considered to be a more sustainable alternative to modern plasters, with a lower embodied energy than gypsum, cement or lime based plasters. It is available with fibre additives to increase its strength, and in a range of 'natural' colours. It is breathable and does not need to be painted.

Interior plaster work: Interior plasterwork is designed according to the type of lathing to which it is applied and the number of applications that are necessary. Ornamental plaster

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for ceilings and cornices is usually applied with a metal molding tool that has the reverse of the desired profile. Some elements may be formed by hand, while others are precast and stuck in place with plaster of paris. Stucco may be applied directly to concrete, brick, tile, or a supporting metal lath base. Various types of finish, including colours and textures, may be incorporated in the finish coat. Splatter dash and pebble dash are textured surfaces resulting from throwing mortar or pebble with some force on the finish coat while it is still soft.

plastering of external walls:

There are various requirements of a plaster that must be fulfilled while doing plastering of external walls. So you need to consider these requirements to get a perfect plastering on your wall. These requirements are given below:

- The plaster should be economical.
- The durability of the plaster should be high and it should be hard in nature.
- The plaster must adhere during all the changes occurred in climate.
- The plaster is prepared wisely in such a way that it can be applied during all the weather conditions
- The workability possessed by plaster must be good

Method of plastering of external wall:

For **plastering of external walls,** you need to follow a series of steps that are mentioned below:

- First of all, the alignment and fixing of level pegs on the wall should be done with the help of surveying instruments.
- After completing the level pegs on walls, projections on the wall surface will be clipped off and cleaned.
- After this, the first coat mortar filing is applied which is required up to 15mm on the surface.
- To improve the bonding of plaster to the concrete surface, cement paste on concrete surfaces will be applied.
- After plastering the wall surface, a width of a groove between beams and walls will be formed by cutting with the help of grinders which is filled with weather sealant.

pointing for walls : **Pointing** is the term given to the 'finish' that is between the bricks or stone used to build your house. ... The function of the mortar in the **wall** is to act as a bedding between stones and varies from fine joints in ashlar stonework to larger joints in rubble masonry **walls**. 

Press a pointing trowel into the joint. Once the mortar is sufficiently dry, push your narrow pointing trowel firmly into the mortar that you've just applied. If you don't have a pointing trowel, or would prefer for the finished mortar to have a concave curve to it, you can use a 6-inch (15-cm) section of rubber hose instead.[13]

- If you don't have either a pointing tool or a length of rubber hose, you can even use a bucket handle to point the mortar in a joint.

Drag the pointing trowel along the joint. Keep applying pressure as you slide your trowel or rubber hose along the mortar in the joints. This will compact the mortar (making it more weather resistant) and give it a concave shape. If you've added mortar to both vertical and horizontal joints, be sure to point the cross joints first and the bed joints second.[14]

- The outer surface of the joint should be indented from the surface of the bricks. You don't want the mortar from the joint to protrude out past the brick face.[

Use a "weather struck" bed joint for exposed walls. If your wall is in an exposed area where it will receive a lot of wind, rain, or snow, you can use a weather struck joint. To make a weather struck bed joint, press your pointing trowel at an angle, so that the top edge is indented into the mortar and the lower edge is away from the wall. Then run the trowel along the mortar and press the joint into shape.[16]

- A weather struck joint will protect your brick wall from absorbing water. The angle of the joint will deflect moisture and force rainwater to run down the surface of the bricks, rather than soaking into the mortar.
- Weather struck joints are only used on bed joints. There is no corresponding pointing angle for vertical joints.
- For a professional finish, smooth out the joint and surrounding area with a medium-soft mason brush when it's about halfway dry.
- Wait for the mortar to fully dry after this step. Give it at least another 30 minutes.

Brush over the entire wall. Once the mortar has dried, you're ready for the final step. To finish the pointing process, take your wire brush and rub it over the entire area you've pointed. This will remove any excess mortar that may have gotten onto the bricks, and will even out the texture of the mortar in the joint.[17]

- Be careful when you're using the wire brush. If there's moisture still in the mortar, the wire brush may pull the mortar out.

Method1

Choosing and Mixing Grout

Remove the old grout. If you're re-grouting an old tile surface, remove the old grout. You can remove the old grouting compound with a grout saw or a grout removal bit in a rotary tool.[1] Make sure this is fully removed before proceeding.

- Make sure that the joints are free of any dirt, dust, or debris before you start as well.

Pick a color of grout. The color of the grout will affect whether people notice the beauty of the individual tiles, or the overall pattern of the tiles. Light grout tends to accentuate the

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individual tiles by blending in, becoming "invisible," while dark grout tends to accentuate the pattern of the tiles, their overall structure on the floor.[2]

- Choose a color that matches the tile if you want the floor to have a continuous appearance. If you installed the tile yourself and the grout lines aren't perfectly straight, a matching color of grout can help conceal these imperfections.
- Choose a color of grout that contrasts the tile color if you want the individual tiles to stand out. If you installed tiles with an irregular edge, a contrasting color of grout will enhance this feature of the tile.
- Choose a dark color for high traffic areas. White or light-colored grout will be difficult to keep clean.

Choose between sanded or unsanded grout. Sanded grout is stronger than unsanded grout. Sanded grout is needed when the grout lines are greater than 1/8-inch (3-mm) wide to add strength. Unsanded grout is liable to crack on wider joints

Wait for the thinset mortar to cure. Thinset is used to adhere the tiles to the floor during installation. The exact drying time varies by brand, so read and follow the thinset packaging carefully.[4] You usually have to wait at least a day to grout a tile floor.

Mix the grout according to the package directions. You only want to mix as much as you can apply in about a half hour, as it will begin to dry out.[5]

- Dump the powder into a large bucket, and add only 3/4 of the recommended water, mixing thoroughly with a trowel. Afterwards, mix in the remaining 1/4 of water and mix again. It should be the consistency of thick batter or slightly looser than smooth peanut butter; too much water will prevent it from spreading and hardening properly.

Method2

Applying the Grout

Scoop some grout onto the tile floor with a trowel. Begin in the corner farthest from the doorway and work backwards.

Spread the grout over a small joint. Hold a grout float at a 45-degree angle to the floor to press the grout into the joint. Move the grout float at a diagonal angle to the grout lines for a smooth finish. If you wipe parallel to the lines, the edge of the grout float can end up gouging out the grout.

Remove excess grout. Your floor is full of muddy grout, which isn't a lovely sight. After applying, wait about 15 to 30 minutes for the grout in the joints to set. Then start cleaning:

- Fill two buckets with the water.

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- Dip a large grout sponge with rounded corners into the first water bucket and wring it out.
- Wipe in a circular motion or at a diagonal to the grout lines to remove excess grout from the surface of the tiles.
- Rinse the sponge in the second bucket and repeat until all grout is removed from the surface of the tile.
- Wait three hours before repeating the process again. However, don’t wait too long or you have a harder time buffing out the grout haze.
- Make a final pass along the grout lines with the damp sponge to make sure the grout lines are smooth.
- Don't worry if the excess grout has dried. You can remove it with some basic tools, such as a plastic chisel or putty knife.

Verify the grout color is what you want. Use a hairdryer to quickly dry this small area of grout, so you see how the color looks against the installed tile. Now is the time to make a last-minute change, as grout is nearly impossible to remove once it's dried.

Continue with grouting if you are satisfied with the color. Keep working in small areas at a time, so you can remove the excess grout before it has a chance to dry. If you have a helper, one can grout and the other can remove the excess.

Clean up the grout haze once everything is dry. No matter how effectively you cleaned the excess grout from the tiles, you're likely to have a "grout haze" covering your tiles after your job is done. To clean up the grout haze:

- Use a sponge and a bucket of clean water. Rinse the sponge often.[6]
- Take a dry towel or used rag and wipe at the haze until it begins to cake off. An old sock will work well: you can wear the sock on your hand while you scrub.
- Brush up the residue with a broom.

Wait for the grout to cure before sealing it. Read the manufacturer's directions to determine how many days to wait. To seal grout:

- Crack the windows to get good ventilation in your room.
- Pour a small amount of sealant on the grout and work it in with a sponge, using small, circular motions.
- Wipe the sealant off after about 5 to 10 minutes, although the time may vary. Check the sealant label to be sure.
- Re-seal the grout every six months to a year if possible.

whitewashing : Whitewashing is the process of covering a wall with a very thin coat of thin plaster made with water, lime and other ingredients. Whitewashing is used to color fences, wood, and most commonly, walls. Whitewashing is a fairly historic process, and most individuals choose to treat their walls and fences with more modern paints and finishes. Whitewashing walls is a fairly easy process, and is a project that can be completed in less than a day.

Create a paste by mixing 2 parts calcium hydroxide, also know as hydrated lime, to 1 part water. Mix the 2 ingredients together until the paste is creamy. Let the mixture sit overnight

Create a salt water solution by mixing 2 parts salt with 1 part water. Remove any excess water from the calcium and water mixture in the morning. Stir the mixture again until it becomes a thick paste-like consistency.

Add the salt water mix to your paste. Stir well until the mixture is completely blended and has a similar consistency to cake or brownie batter. Continue stirring the mixture, adding extra water if you feel it is too thick. It's easier to fix a solution that is too thick than too thin, so only add small amounts of water at a time.

Test your paste mixture by painting it on top of a piece of paper. Watch it dry, if it dries looking coarse and bumpy, the solution is too thick and more water needs to be added.

Add pigments to your whitewash solution, if you want to have your whitewash colored. Add pigments, purchased from a local hardware store, that can be safely added to any paint or plaster mixture.

Cover your floors with plastic and clean your walls prior to whitewashing and remove any scuffs or stains. These stains can show through after whitewashing.

Wet the walls by applying water with a paintbrush to your walls. This will help the whitewash spread once you apply the whitewash.

Use a wide paintbrush to apply a thick coat of whitewash to the wet walls. It is easiest to apply the whitewash to the tips of the brush and lightly apply it to the wall. You should be aware that whitewash is thicker than paint and doesn't go on as smoothly as interior paint does.

Color washing: Color washing is an easy and forgiving form of faux finishing often used by beginners, but perfected by professional finishers. It was historically created with oil-based products because of the long drying time, but today's environmental and health conscious companies are producing user-friendly water based glazes. Color washing can be done in any color of paint and is generally applied with brushes over a solid paint color, using long sweeping strokes to meld the glaze colors together.

Paint is a liquid or mastic material that can be applied to surfaces to colour, protect and provide texture. They are usually stored as a liquid and dry into a thin film after application. **Paints** be categorised decorative, are applied on site, or industrial, applied in factories as part of the manufacturing process.

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Quality Paint Plays in Building Painting Services Toronto:

1. Painting protects the surface of the building from all the adverse effects of atmospheric action
2. Painting offers an attractive appearance to the building surface
3. Painting helps to keep the building surface safe and clean

Different Types of Paint Used in the Construction Services are:

Oil paint: Oil paints are mainly applied in the interior walls of the residential buildings. These paints are usually applied in three coats, namely primer, undercoat, and finished coat. Oil paints are mainly available in two variations, glossy and matt. Glossy oil paint is applied on the smooth surfaces. On the other hand, matt paint is applied to the surface, which has undulations, which can't be covered by putty. The best thing about oil paint is that it offers more durability.

Enamel Paint: This is another popular painting option for building interior due to the wide range of availability. Besides, in many cases, enamel paint is also used in **building painting services toronto** designs. Apart from that, enamel paint is used widely in the doors, trims, patios, and porches and it can be used in the surfaces like masonry, wicker, plaster, concrete, metal, ceramic and glass. The best thing about enamel paint is that it is available both in alkyd and oil-based variations. Another great thing about enamel paint is that it can be dried and cleaned easily.

Bituminous Paint: This paint is mostly used for painting surfaces like metal sheets. This type of paint is mainly used to waterproof the foundations of concrete, waterproofing wooden surfaces, preparing rust resistant surface for cisterns and metals, priming the substrates before installing bituminous membranes.

Cement Paint: This type of paint material is used widely for painting rough brick walls. And therefore, this paint plays an important role in the exterior painting services Toronto. This paint is available in the form of a powder that needs to be mixed with water before application. Being durable and waterproof, cement paint is widely used for painting rough surfaces in the exterior of buildings. Besides, with two coats of application of cement paints, it is possible to paint surfaces that are prone to dampness.

Plastic Paint: This type of paint material includes different types of plastics as the base and water as thinner. Due to the availability of a wide range of colors and the attractive look and feel offered, this type of paint is mostly used in painting the interior of modern households. Besides, this type of paint is often used for painting interiors of the commercial spaces like showrooms, auditoriums etc.

Formwork is temporary or permanent molds into which concrete or similar materials are poured. In the context of concrete construction, the falsework supports the **shuttering** molds.

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Formwork comes in several types:

1. Traditional timber formwork. The formwork is built on site out of timber and plywood or moisture-resistant particleboard. It is easy to produce but time-consuming for larger structures, and the plywood facing has a relatively short lifespan. It is still used extensively where the labour costs are lower than the costs for procuring reusable formwork. It is also the most flexible type of formwork, so even where other systems are in use, complicated sections may use it.
2. Engineered Formwork System. This formwork is built out of prefabricated modules with a metal frame (usually steel or aluminium) and covered on the application (concrete) side with material having the wanted surface structure (steel, aluminum, timber, etc.). The two major advantages of formwork systems, compared to traditional timber formwork, are speed of construction (modular systems pin, clip, or screw together quickly) and lower life-cycle costs (barring major force, the frame is almost indestructible, while the covering if made of wood; may have to be replaced after a few - or a few dozen - uses, but if the covering is made with steel or aluminium the form can achieve up to two thousand uses depending on care and the applications). Metal formwork systems are better protected against rot and fire than traditional timber formwork.
3. Re-usable plastic formwork. These interlocking and modular systems are used to build widely variable, but relatively simple, concrete structures. The panels are lightweight and very robust. They are especially suited for similar structure projects and low-cost, mass housing schemes. To get an added layer of protection against destructive weather, galvanized roofs will help by eliminating the risk of corrosion and rust. These types of modular enclosures can have load-bearing roofs to maximize space by stacking on top of one another. They can either be mounted on an existing roof, or constructed without a floor and lifted onto existing enclosures using a crane.[citation needed]
4. Permanent Insulated Formwork. This formwork is assembled on site, usually out of insulating concrete forms (ICF). The formwork stays in place after the concrete has cured, and may provide advantages in terms of speed, strength, superior thermal and acoustic insulation, space to run utilities within the EPS layer, and integrated furring strip for cladding finishes.
5. Stay-In-Place structural formwork systems. This formwork is assembled on site, usually out of prefabricated fiber-reinforced plastic forms. These are in the shape of hollow tubes, and are usually used for columns and piers. The formwork stays in place after the concrete has cured and acts as axial and shear reinforcement, as well as serving to confine the concrete and prevent against environmental effects, such as corrosion and freeze-thaw cycles.
6. Flexible formwork. In contrast to the rigid moulds described above, flexible formwork is a system that uses lightweight, high strength sheets of fabric to take advantage of the fluidity of concrete and create highly optimised, architecturally interesting, building forms. Using flexible formwork it is possible to cast optimised structures

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that use significantly less concrete than an equivalent strength prismatic section,[1] thereby offering the potential for significant embodied energy savings in new concrete structures.

What is shoring?

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.

Fig. shoring and underpining.

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.

What is underpinning?

Underpinning is the process of strengthening and stabilizing the foundation of an existing building or other structure.

Underpinning in Building Construction

Underpinning may be necessary for a variety of reasons:

- The original foundation is simply not strong or stable enough, e.g. due to decay of wooden piles under the foundation.
- The usage of the structure has changed.
- The properties of the soil supporting the foundation may have changed (possibly through subsidence) or were mischaracterized during planning.
- The construction of nearby structures necessitates the excavation of soil supporting existing foundations.
- It is more economical, due to land price or otherwise, to work on the present structure's foundation than to build a new one.

Underpinning is accomplished by extending the foundation in depth or in breadth so it either rests on a stronger soil stratum or distributes its load across a greater area. Use of micropiles and jet grouting are common methods in underpinning.

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An alternative to underpinning is the strengthening of the soil by the introduction of a grout. All of these processes are generally expensive and elaborate.

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UNIT 5: SPECIAL MATERIALS AND REPAIRS:

INTRODUCTION – GLASS – CERAMICS – PVC – UPVC – REFRACTORY – ALUMINIUM – LIGHT WEIGHT CONCRETE BLOCKS – POLY CARBONTE SHEETS – INSULATED PUFFED SHEETS – SEALANT JOINTS – USES IN VONSTRUCTION. CRACKS IN BUILDING- CAUSES – METHODS OF REPAIRS – EQUIPMENT USED FOR REPAIR WORKS**.**

Glass is now being **used** in the **building industry** as insulation material, structural component, external glazing material, cladding material; it is **used** to make delicate looking fenestrations on facades as well as conventional windows.

Engineering Properties of Glass

1. Transparency
2. Strength
3. Workability
4. Transmittance
5. U value
6. Recycling property

1. Transparency of Glass

Transparency is the main property of glass which allows the vision of the outside world through it. The transparency of glass can be from both sides or from one side only. In one side transparency, glass behaves like a mirror from the other side.

2. Strength of Glass

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

3. Workability of Glass

A glass can be molded into any shape, or it can be blown during melting. So, workability of glass is a superior property.

4. Transmittance

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

5. U value of Glass

U value represents the amount of heat transferred through glass. If a glass is said to be insulated unit then it should have lower u value.

6. Recycle Property of Glass

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

Types of Glass and their Uses

The types of glass used in construction are:

1. Float glass
2. Shatterproof glass

3. Laminated glass
4. Extra clean glass
5. Chromatic glass
6. Tinted glass
7. Toughened glass
8. Glass blocks
9. Glass wool
10. Insulated glazed units

1. Float Glass

Float glass manufactured from sodium silicate and calcium silicate so, it is also called as soda-lime glass. It is clear and flat, so it causes glare. Thickness of the float glass is available from 2mm to 20mm, and its weight range from 6 to 36 kg/m^2. The application of float glass includes shop fronts, public places, etc.

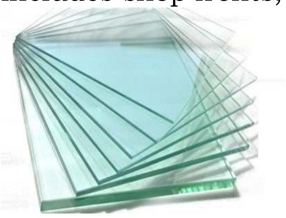

Fig. 2 Laminated Glass

2. Shatterproof Glass

Shatterproof glass is used for windows, skylights, floors, etc. Some type of plastic polyvinyl butyral is added in its making process. So, it cannot form sharp-edged pieces when it breaks.

Fig. 3: Shatterproof Glass

3. Laminated Glass

Laminated glass is the combination of layers of ordinary glass. So, it has more weight than a normal glass. It has more thickness and is UV proof and soundproof. These are used for aquariums, bridges, etc.

Fig. 4: Laminated Glass Used in Building Construction

4. Extra Clean Glass

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Extra clean glass has two unique properties, photocatalytic and hydrophilic. Because of these properties, it acts as stain proof and gives a beautiful appearance. Maintenance is also easy.


Fig. 5: Extra Clean Glass

5. Chromatic Glass
Chromatic glass is used in ICU's, meeting rooms etc. it can control the transparent efficiency of glass and protects the interior from daylight. The chromatic glass may be photochromic which has light sensitive lamination, thermos-chromatic which has heat sensitive lamination and electrochromic which has electric lamination over it.

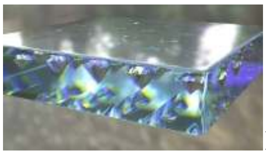
Fig. 6: Chromatic Glass

6. Tinted Glass
Tinted glass is nothing but colored glass. A color producing ingredients is mixed to the normal glass mix to produce colored glass which does not affect other properties of glass. Different color-producing ingredients are tabulated below:

Table 1: Different Types of Ions Used to Produce Various Colors in Glasses

Coloring ion	**Color**
Iron oxide	Green
Sulphur	Blue
Manganese dioxide	Black
Cobalt	Blue
Chromium	Dark green
Titanium	Yellowish brown

Uranium	Yellow


Fig. 7: Tinted Glass

7. Toughened Glass

Toughened glass is a durable glass that has low visibility. It is available in all thicknesses, and when it is broken it forms small granular chunks that are dangerous. This is also called as tempered glass. This type of glass is used for fire-resistant doors, mobile screen protectors, etc.

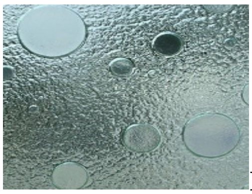
Fig. 8: Toughened Glass

8. Glass Blocks

Glass block or glass bricks are manufactured from two different halves and they are pressed and annealed together while melting process of glass. These are used as architectural purpose in the construction of walls, skylights etc. They provide aesthetic appearance when light is passed through it.


Fig. 9: Glass Block

9. Glass Wool

Glass wool is made of fibers of glass and acts as an insulating filler. It is fire-resistant glass.

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Fig. 10: Glass Wool

10. Insulated Glazed Units

Insulated glazed glass units contains a glass is separated into two or three layers by air or vacuum. They cannot allow heat through it because of air between the layers and acts as good insulators. These are also called as double glazed units.

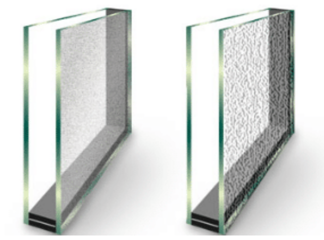
Fig. 11: Insulated Glazed Glass Unit

Use of ceramics in construction

Ceramics are a material often used in construction, made from a mixture of minerals, typically silica sand, with a clay binder and some impurities, and up to 30% water. They are fired at a higher temperature than bricks, so that the silica re-crystallises to form a glassy material that has greater density, strength, hardness, resistance to chemicals and frost and a greater dimensional stability.

Fire clays and shales

These products include ordinary bricks, clay roof tiles, flooring quarries and pavers.

Terracotta

This is literally 'burnt earth'. It is made from yellow to brownish-red clays with a uniformity and fineness between brick and vitrified wall tiles. Terracotta is often used for unglazed chimney pots, air bricks, copings and planters.

For more information, see Terracotta.

Faience

This is a glazed form of terra-cotta or stoneware. The base material may be fired to the 'biscuit' stage before glazing and re-firing, or a 'once-fired' process may be used. The latter improves resistance of the glaze to crazing (the spread of lines or cracks on the glazed surface), but reduces the range of colours available.

Fireclay

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This contains a high proportion of clay resistant to high temperatures (kaolin). It is used for chimney flue linings and firebacks.

Stoneware

This is similar in composition to fireclay, but is fired at a higher temperature than fireclay and contains a higher proportion of glass. As a result it is harder and less absorbent. Modern manufacturing processes mean that stoneware no longer has to be glazed for use in drainage pipes.

Earthenware

The raw materials are blended and may contain a considerable proportion of limestone. It is a finer product than stoneware and is used as the body for glazed wall tiles and table 'china'. Water absorption may be up to 15%, however, making it less suitable for sanitaryware than vitreous china.

Vitreous china

This has a higher glass content than earthenware, and its water absorption is only about 0.5%, which makes it suitable for sanitary fittings. It is stronger than earthenware.

Porcelain

Porcelain is very similar to vitreous china, but is often made from purer materials under more strictly controlled conditions. It is used for special uses, such as electrical insulators.

New ceramics

These are also called 'technical' or 'engineering' ceramics. Their purity is far higher than traditional ceramics, not using raw clay mined directly from the ground. Powders are formed which are then cast, pressed, extruded or moulded into shape. The powders may be set in organic binders. The combination of pure materials and exacting production techniques ensures the very high strength of these materials.

PVC FOR BUILDING AND CONSTRUCTION



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PVC has been used extensively in a wide range of construction products for over half a century. PVC's strong, lightweight, durable and versatile characteristics make it ideal for many applications as outlined below.

Pipes

PVC pipes have been in use for over 60 years. When compared with traditional pipe materials, PVC offers valuable energy savings during production, low cost distribution and a safe, maintenance-free lifetime of service. PVC pipes will not degrade to damage the environment and suffer fewer breaks / leaks than other alternatives.

PVC is widely specified for pipeline systems for water, waste and drainage due to its a theoretical service life of hundreds of years for buried pipes. PVC pipes suffer no build-up, pitting, scaling or corrosion and provide smooth surfaces reducing energy requirements for pumping.

Windows

PVC has been used for fabricating window frames since the 1960s. The UK has seen dramatic growth over the past 15 years with over 85% of new and replacement window projects now using PVC.

PVC windows are tough and durable with a typical life span greater than 35 years (as assesed by the Building Research Establishment, BRE).

PVC-U Windows have many different benefits and advantages over other window

Flooring

Vinyl flooring has been in use for over 50 years providing highly effectively flooring solutions in both public and private buildings whether large and small ideal for both domestic and durable applications.

Major benefits of PVC flooring:

- Durable
- Freedom of aesthetic effects – available in a wide range of colours and patterns
- Ease of installation, easy to clean
- Easily recyclable
- Variable thickness

PVC flooring is used extensively in housing, hospitals and hotels around the world.

Roofing

Reinforced PVC roofing is easy to install, has low maintanence requirments and lasts for over 30 years. Can be used to create 'web-like' ultra-light weight structures.

PVC tensile fabric is often used for 'signature' projects such at the Mount Canopy Stand at Lords Cricket

Inflatable structures

PVC can be made sufficiently strong and flexible to allow large inflatable structures to be made.
"PVC is simply the most versatile plastic" - Nick Crosbie, Designer

Lighter structures

"Let's not forget that the mass of a building per sq. metre has been divided by 50 since Roman times. With the latest textile architecture, it's even now possible to construct web-like structures capable of withstanding identical constraints. Being lighter, their hold on the ground and their impact on the environment are reduced. The current trend towards lighter building structures is for me a major source of inspiration." - Jacques Pierlot, Architect, A&A Associates

Benefits of PVC over other materials

PVC is replacing traditional building materials such as wood, metal, concrete and clay in many applications.
Versatility, cost effectiveness and an excellent record of use mean it is the most important polymer for the construction sector, which accounted for 60 per cent of European PVC production in 2006.

Polyvinyl chloride, PVC, is one of the most popular plastics used in building and construction. It is used in drinking water and waste water pipes, window frames, flooring and roofing foils, wall coverings, cables and many other applications as it provides a modern alternative to traditional materials such as wood, metal, rubber and glass. These products are often lighter , less expensive and offer many performance advantages.

Bay windows

Strong and lightweight
PVC's abrasion resistance, light weight, good mechanical strength and toughness are key technical advantages for its use in building and construction applications.

Easy to install
PVC can be cut, shaped, welded and joined easily in a variety of styles. Its light weight reduces manual handling difficulties.

Durable
PVC is resistant to weathering, chemical rotting, corrosion, shock and abrasion. It is therefore the preferred choice for many different long-life and outdoor products. In fact, medium and long-term applications account for some 85 per cent of PVC production in the building and construction sector.

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For example, it is estimated that more than 75 per cent of PVC pipes will have a lifetime in excess of 40 years with potential in-service lives of up to 100 years. In other applications such as window profiles and cable insulation, studies indicate that over 60 per cent of them will also have working lives of over 40 years.

Cost-effective

PVC has been a popular material for construction applications for decades due to its physical and technical properties which provide excellent cost-performance advantages. As a material it is very competitive in terms of price, this value is also enhanced by the properties such as its durability, lifespan and low maintenance.

Safe material

PVC is non-toxic. It is a safe material and a socially valuable resource that has been used for more than half a century. It is also the world's

PVC Gym Mats

most researched and thoroughly tested plastic. It meets all international standards for safety and health for both the products and applications for which it is used.

The study 'A discussion of some of the scientific issues concerning the use of PVC' (1) by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia concluded in 2000 that PVC in its building and construction applications has no more effect on the environment that its alternatives.

Substitution of PVC by other materials on environmental grounds with no additional research or proven technical benefits will also result in higher costs. For example, as part of a housing renovation project at Bielefeld in Germany , it has been estimated that the replacement of PVC by other materials would lead to a cost increase of approximately 2,250 euro for an average sized apartment.

Restrictions on PVC use in construction applications would not only have negative economic consequences but also have wider social impacts, such as in the availability of affordable housing.

Fire resistant

Like all other organic materials used in buildings, including other plastics, wood, textiles etc., PVC products will burn when exposed to a fire. PVC products however are self-extinguishing, i.e. if the ignition source is withdrawn they will stop burning. Because of its high chlorine content PVC products have fire safety characteristics, which are quite favourable as. they are difficult to ignite, heat production is comparatively low and they tend to char rather than generate flaming droplets.

But if there is a bigger fire in a building, PVC products will burn and will emit toxic substances like all other organic products.
The most important toxicant emitted during fires is carbon monoxide (CO), which is responsible for 90 to 95 % of deaths from fires. CO is a sneaky killer, since we cannot smell it and most people die in fires while sleeping. And of course CO is emitted by all organic materials, be it wood, textile or plastics.

PVC as well as some other materials also emits acids. These emissions can be smelled and are irritating, making people try to run away from the fire. A specific acid, hydrochloric acid (HCL), is connected with burning PVC . To the best of our knowledge, no fire victim has ever been proven scientifically to have suffered HCl poisoning.

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Some years ago no big fire was discussed without dioxins playing a major role both in communication and measuring programmes. Today we know that dioxins emitted in fires do not have an impact on people following the results of several studies on fire exposed people: The dioxin levels measured were never elevated against background levels. This very important fact has been recognised by official reports and we know that many other carcinogens are emitted in all fires, such as polycyclic aromatic hydrocarbons (PAH) and fine particles, which present a much higher hazard than dioxins.

So there are very good reasons to use PVC products in buildings, since they perform well technically, have good environmental and very good economic properties, and compare well with other materials in terms of fire safety.

Cabling

Good insulator

PVC does not conduct electricity and is therefore an excellent material to use for electrical applications such as insulation sheathing for cables.

Versatile

The physical properties of PVC allow designers a high degree of freedom when designing new products and developing solutions where PVC acts as a replacement or refurbishment material.

PVC has been the preferred material for scaffolding billboards, interior design articles, window frames, fresh and waste water systems, cable insulation and many more applications.

What is UPVC?

It is Unplasticized Polyvinyl Chloride and this material is based on the plastic powder which is heated up and injected into a mould so that it gets into a particular shape. Once it cools through different methods, the UPVC is cut and is made to be assembled in a double glazed window together with other components.

The use of uPVC windows has become popular these days. They add value to our homes and installing them is one of the best choices you will make for your home. It improves the functionality and overall usability of the house.

But, each choice you make has its pros and cons. So, as you opt-in for uPVC windows, there are some advantages and disadvantages as well.

UPVC Window: Advantages and Disadvantages

Let's look at the advantages:

- **Easy to maintain:**

UPVC windows don't need much maintenance thus, saving on your time and money. Unlike wooden windows that are prone to rotting, fading, and flaking. One more advantage of uPVC

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windows is they are weatherproof and rigid. They can be cleaned easily and need to be wiped only occasionally.

You can oil them frequently to maintain the locking mechanism. But, that's all you need to do. It's the most hassle-free choice for windows.

- **They secure your home and are hazard resistant:**

  UPVC windows can give a better level of security as compared to traditional wooden windows. They are made secure with galvanized steel thus, making them tough to be broken. So, no one can really force into your home if you use uPVC windows.

  It's a stable material thus making it sea-water resistant, chemical proof and pollution resistant. It is flame retardant as well.

- **Insulated and environmentally friendly**

  It's known for a high level of insulation and it keeps the rooms warm during winter. It is soundproof and doesn't let too much of noise levels enter the rooms. This goes a long way in reducing the stress levels especially in a world that is extremely stressful.

  As it keeps out cold and warms up the rooms you need lesser electricity thus, creating a positive impact on energy and reducing your energy bills. They are more environmentally friendly as compared to wooden and aluminium windows.

- **Durable and strong:**

  One of the major positive points of uPVC windows is that they are stronger and are durable due to the material used as compared to traditional wooden doors. Thus, they are long-lasting and resilient. You don't need to change them for years. UPVC is a durable material and the windows will stand the test of time. They won't even lose their shape like the wooden ones.

- **Pricing:**

  UPVC is far cheaper than wooden and aluminium windows. Thus, it is economical and light on your pocket.

  If do you want to buy & Sell UPVC Windows. Visit our website or Click below link

  UPVC Windows

- **Maintenance:**

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UPVC doors never rot, flakes, rusts, fades, pits, peels or corrodes. It needs only a light soapy wash and a check of the seals for maintenance. UPVC requires virtually no maintenance making it very convenient and time-saving.

- **Fire Test:**

  Fire tests have shown that UPVC materials, being naturally flame retardant throughout their product life, will not cause, support or enhance the development of accidental fire and are in fact self-extinguishing.

Disadvantages:

- **Lack of the aesthetically superior look:**

  Wooden windows give a suave and sophisticated look. It gives a rustic look that cannot be obtained with the use of uPVC. Aesthetically wooden doors look appealing and add charm to your home. UPVC lack that aesthetically superior look and can look out of place in traditional homes.

- **Customized:**

  Despite modern technology leading to different kinds of textures and colours uPVC windows aren't a great choice if you want varied colours and want to customize windows according to your choice. Wood and aluminium allow the use of paint and varnish in any colour. This gives an elegant look to your house and it blends with your home, its style and décor.

- **Structure:**

  Despite the robustness, uPVC windows can sag and sash due to lightweight and also as they are structurally not strong. Too much heat might rupture the frames.

- UPVC doors are unsuitable to be used as the front door as due to their lightweight.
- They are not weatherproof enough like wooden or aluminium doors.
- It doesn't appear to be attractive due to its simple plastic look. However, they are available in a wide range of colours.

Refractory : A **refractory material** or **refractory** is a material that is resistant to decomposition by heat, pressure, or chemical attack, and retains strength and form at high temperatures.[1] Refractories are inorganic, nonmetallic, porous, and heterogeneous. They are typically composed of oxides of the following materials: silicon, aluminium, magnesium, calcium, and zirconium.

Refractory materials are used in furnaces, kilns, incinerators, and reactors. Refractories are also used to make crucibles and moulds for casting glass and metals and for surfacing flame deflector systems for rocket launch structures.[4] Today, the iron- and steel-industry and metal casting sectors use approximately 70% of all refractories produced.

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Refractory materials

Refractory materials must be chemically and physically stable at high temperatures. Depending on the operating environment, they must be resistant to thermal shock, be chemically inert, and/or have specific ranges of thermal conductivity and of the coefficient of thermal expansion.

The oxides of aluminium (alumina), silicon (silica) and magnesium (magnesia) are the most important materials used in the manufacturing of refractories. Another oxide usually found in refractories is the oxide of calcium (lime).[6] Fire clays are also widely used in the manufacture of refractories.

Refractories must be chosen according to the conditions they face. Some applications require special refractory materials.[7] Zirconia is used when the material must withstand extremely high temperatures.[8] Silicon carbide and carbon (graphite) are two other refractory materials used in some very severe temperature conditions, but they cannot be used in contact with oxygen, as they would oxidize and burn.

Binary compounds such as tungsten carbide or boron nitride can be very refractory. Hafnium carbide is the most refractory binary compound known, with a melting point of 3890 °C.[9][10] The ternary compound tantalum hafnium carbide has one of the highest melting points of all known compounds (4215 °C)

Uses

Refractory materials are useful for the following functions:[13][2]

1. Serving as a thermal barrier between a hot medium and the wall of a containing vessel
2. Withstanding physical stresses and preventing erosion of vessel walls due to the hot medium
3. Protecting against corrosion
4. Providing thermal insulation

Refractories have multiple useful applications. In the metallurgy industry, refractories are used for lining furnaces, kilns, reactors, and other vessels which hold and transport hot mediums such as metal and slag. Refractories have other high temperature applications such as fired heaters, hydrogen reformers, ammonia primary and secondary reformers, cracking furnaces, utility boilers, catalytic cracking units, air heaters, and sulfur furnaces.

purpose of refractory:
The main **purpose of refractory** material that is used inside a marine boiler is to contain the heat generated by burning of the fuel in the furnace and to minimise heat losses from the furnace. It is therefore important that these materials have insulating properties and are able to withstand high temperatures.
types of refractory:
The main criterion on the basis of which the **refractories** and **refractory** materials are classified is **their** chemical behavior, mostly by **their** reactions to the **type** of slag. Accordingly we have three **types of Refractories**: Acid, Basic & Neutral.

Aluminium : Aluminium makes up more than 8% of the Earth's core mass and is the most widespread metal. It is also the third most common chemical element after oxygen and silicon. It is the 13 element on the Periodic Table and has a silvery-white appearance.

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Pure aluminium does not occur in nature because it binds very easily with other elements. It is because of this that aluminium was only discovered in the 19th century when scientists were able to break down chemical compounds into their elements.

Because of the high costs of the extraction process, it wasn't until the late 19th century that it was possible to produce aluminium on an industrial scale for use in construction and other industries.

Properties of aluminium

Today, aluminium is the second most used metal in buildings after steel.

Because of its ductility, aluminium can be formed into many shapes and profiles. Aluminium wall cladding systems are commonly used for building exteriors, with large wall panels requiring fewer joints, resulting in time-efficient installation.

One of the main reasons for aluminium's widespread application is its combination of properties:

- Lightweight: Almost three times lighter than iron.
- Durable: Almost as durable as steel.
- Ductile: Extremely flexible and easily processed using pressure when hot or cold.
- Corrosion-resistant: Its surface is protected by an extremely thin yet very strong layer of aluminium oxide.
- Non-magnetic.
- Excellent conductivity.
- Fire-resistant.
- Non-toxic.
- Bonds with other elements relatively easily, enabling the formation of a wide variety of aluminium alloys.
- Re-usable: Aluminium and its alloys can be melted down and reused without any impact on their mechanical properties. Estimates suggest that around 75% of all aluminium produced is still in use in some form.

Aluminium in construction

Some of the most common applications for aluminium are:

- Long-span roof systems covering large areas such as halls and auditoriums.
- Structures located in inaccessible places where the economy of transport and ease of installation are important, such as electrical transmission towers.
- Structures in corrosive or humid environments, such as swimming pools, bridges, hydraulic structures, offshore superstructures, and so on.
- Structures with moving sections, such as moving bridges.
- Structures to which access for maintenance is limited, such as masts, lighting towers, antenna towers, and so on.
  - **Strength versus weight**
    One of Aluminium's primary appeals to specifiers is its exceptional strength to weight

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ratio. At 2.7g/cm², Aluminium is 66% lighter than steel. It is also far less susceptible to brittle fractures. Indeed, when aluminium and steel structures are compared, Aluminium's greater modulus of elasticity means that weight ratios of 1:2 are easily attained.

- While Aluminium has a relatively high co-efficient of linear expansion, at 24 X 10-6/'C – in its pure form, the material's low modulus of elasticity (65,500N/mm² for 6063 alloy) enables temperature induced stresses to be accommodated. Indeed, these are generally far lower than in a comparable steel structure (M of E = 210,000N/mm²). This is graphically illustrated by Aluminium's load-deflection curve, which is continuous, without a yield point.
- Advertisements
- Aluminium sections are generally thinner and deeper than equivalent steel sections to achieve the required strength and rigidity since, Aluminium is not affected bymoisture and aluminium windows do not warp, stick or rot. In door construction, typically using hollow-section extrusions, sight lines are improved because multi-point locks and other door furniture can be fitted within the frame. This is in addition to the intrinsic lightness, strength and rigidity of Aluminium frames
- **2.2 Low maintenance – low cost-in-use** While Aluminium has a natural, built-in durability (it forms a protective layer of oxide as soon as it is exposed to air), most Aluminium construction products are treated or coated. One way in which the oxidization process can be enhanced is anodization; an electrolytic process which increases the thickness of the natural oxide layer from 0.00001mm to between 0.005 and 0.025mm (25 Microns). This enhances the ability of Aluminium to withstand attack in aggressive environments. Natural anodizing results in a similar silvery finish to oxidized Aluminium, but it can also introduce a range of colours.
- This is because, after anodizing, the surface film remains porous, allowing it to accept colouring agents, such as organic dies, pigments, electrolytes or metallic. Attractive gold, bronze, gray, black and even blue finishes are commonly achieved in this way. For a wider choice of colours, most specifiers opt for an electrostatically sprayed polyester powder coating. This is a common finish for curtain walling, rainwater goods and cladding panels, where the powder coating is used to provide resistance to the acidity of rainwater. In this process, charged paint particles are blown onto the extrusion (which has undergone a twelve-stage pre-treatment process) and then stove, at between 200 and 210'C, for 10 to 12 minutes. This provides a high quality surface with excellent adhesion, accurate colouration and very even film thickness.
- **2.3 Fabricated for the fast track** One of the principal reasons for Aluminium's enduring and growing popularity is its compatibility with today's fast track construction techniques and just-in-time ordering. Nowhere is this seen more clearly than in curtain walling, where the accuracy of factory-finished sections allows rapid erection on site and, in him, allows internal finishing to proceed more quickly. The end result is earlier building occupancy and greater profit margins for the ultimate customer. Aluminium shop fronts, window systems and door assemblies offer comparable on-site benefits, which are now being enhanced by fabricators' computer-controlled machining rigs which can drill, miter, grind and countersink to exact tolerances enabling the easiest possible installation of ironmongery, glazing beads and other secondary components.
- **2.4 Guaranteed performance through quality control** Although basic material costs will always be important to specifiers, they should be balanced against the cost of fabrication and subsequent service performance. This is

an area where Aluminium, being ideally suited to highly automate manufacturing procedures to exact tolerances, offers many benefits. Aluminium extrusions, for instance, are subjected to a rigorous quality regime, from hardness testing of the raw extrusion to conical bends, sawing, scratching, gouging, hammering and weight drops to guarantee coating performance. It is this combination of quality control, excellent cost in use and systems technology that has helped develop new markets for Aluminium systems companies in the health, education, leisure and transport sectors where changes in the funding of building procurement, such as PFI and fund-holding schools has changed the emphasis from lowest capital cost to lowest cost in use. Specifiers are increasingly looking for effective systems solutions by involving system suppliers early in the design process to ensure the most elegantly engineered solution at the lowest cost.

- **2.5 Aluminum recyclable at end of building's life**
  The ability to recycle aluminum building products is also becoming more important as more building owners decide to deconstruct rather than demolish older buildings. Instead of simply going in with a wrecking ball, owners are now much more deliberate about how they take down a building in order to extract as much recyclable material as possible. By doing so, they not only retain the scrap value of a material such as aluminum but also eliminate the environmental impact and cost of dumping it in a landfill.
- Aluminum recycling also reduces energy consumption. To produce aluminum from recycled material, for example, requires only 5% of the energy required to produce aluminum from bauxite. In addition, every ton of recycled aluminum saves four tons of bauxite.

Lightweight Concrete: A **lightweight concrete block** is an engineering control that may help reduce heavy lifting and carrying. ... **Lightweight** or ultra **lightweight** may also be applied to a different technology known as aerated autoclaved **cement** (AAC) **block**

Uses of Lightweight Concrete

1. Screeds and thickening for general purposes especially when such screeds or thickening and weight to floors roofs and other structural members.
2. Screeds and walls where timber has to be attached by nailing.
3. Casting structural steel to protect its against fire and corrosion or as a covering for architectural purposes.
4. Heat insulation on roofs.
5. Insulating water pipes.
6. Construction of partition walls and panel walls in frame structures.
7. Fixing bricks to receive nails from joinery, principally in domestic or domestic type construction.
8. General insulation of walls.
9. Surface rendered for external walls of small houses.
10. It is also being used for reinforced concrete.

Advantages of Lightweight Concrete

1. Reduced dead load of wet concrete allows longer span to be poured un-propped. This save both labor and circle time for each floor.

2. Reduction of dead load, faster building rates and lower haulage and handling costs. The eight of the building in term of the loads transmitted by the foundations is an important factor in design, particular for the case of tall buildings.
3. The use of LWC has sometimes made its possible to proceed with the design which otherwise would have been abandoned because of excessive weight. In frame structures, considerable savings in cost can be brought about by using LWC for the construction floors, partition and external cladding.
4. Most building materials such as clay bricks the haulage load is limited not by volume but by weight. With suitable design containers much larger volumes of LWC can haul economically.
5. A less obvious but nonetheless important characteristics of LWC is its relatively low thermal conductivity, a property which improves with decreasing density in recent years, with the increasing cost and scarcity of energy sources, more attention has been given the formerly to the need for reducing fuel consumption while maintaining, and indeed improving, comfort conditions buildings. The point is illustrated by fact that a 125 mm thick solid wall of aerated concrete will give thermal insulation about four times greater than that of a 230 mm clay brick wall.

Durability of Lightweight Concrete

Durability is defined ass the ability of a material to withstand the effect of its environment. In a building material as chemical attack, physical stress, and mechanical assault:-

Chemical attack is as aggregate ground-water particularly sulfate, polluted air, and spillage of reactive liquids LWC has no special resistant to these agencies: indeed, it is generally move porous than the ordinary Portland cement. It is not recommended for use below damp-course. A chemical aspects of durability is the stability of the material itself, particularly at the presence of moisture.

Physical stresses to which LWC is exposed are principally frost action and shrinkage and temperature stresses. Stressing may be due to the drying shrinkage of the concrete or to differential thermal movements between dissimilar materials or to other phenomena of a similar nature. Drying shrinkage commonly causes cracking of LWC if suitable precautions are not taken.

Mechanical damage can result from abrasion or impact excessive loading of flexural members. The lightest grades of LWC are relatively soft so that they subject to some abrasion were they not for other reasons protected by rendering.

Sealant JOINT: Sealant is a material which is used to seal the joints between materials such as concrete, glass, aluminum, masonry wall etc. In general joints are provided in the structures to prevent the damage produced by stresses.

Properties of Good Sealant

Different types of sealants with good properties are available. The basic properties of a good sealant should be as follows.

- The sealant should have good bond with building materials.
- The sealant should be soft.
- It should be flexible.
- It should not affected by the weather changes.

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- It should strong against stress and stress relief cycle.

Types of Sealants Used for Joints in Buildings – Properties and Uses

There are several types of sealants are:

- Silicone based sealants
- Urethane based sealants
- Acrylic based sealants
- Polysulphide based sealants

Out of the above sealants, Polysulphide sealants are more popular in construction world.

Uses of Polysulphide based Sealants

Polysulphide based sealants are used in different areas of constructions as follows:

1. Building structures joints like basements, glazing frames, ceiling joints, floors, roofs, external walls, cladding, retaining walls etc.
2. Water retaining structures joints such as dams, reservoirs, canal linings, culverts etc.
3. Joints in bridges, roads, aerodromes etc.

There are various causes for various types of cracks in masonry buildings such as in walls, foundations, slabs, columns. Repair methods of such cracks in masonry buildings is discussed.

There are certain problems in structures that arise suddenly. Some problems like crack formation or settlement of foundation won't give a caution before it appears. Most of these problems arise due to improper construction method and carelessness during initial construction. So, care during initial stages can help avoid such problems that require huge maintenance.

Polycarbonate in Building and Construction

Polycarbonate is a high-performing thermoplastic that is widely used in building and construction products, from windows and skylights to wall panels and roof domes to exterior elements for LED lighting. Polycarbonate has a number of qualities that make it useful in these applications – it is lightweight and durable, with high optical clarity, high-impact and high-heat resistance, as well as excellent flammability resistance.

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Polycarbonate sheets are those that have replaced glass and acrylic in various applications because of their numerous benefits today. These sheets are available in a variety of qualities and thicknesses. When compared to glass, they are much lighter in weight, yet durable, and resistant to breakage and cracks. These are only few of the reasons why polycarbonates are today so popular among the users for constructional purposes.

Earlier this material was used only in commercial structures as these sheets were very expensive to purchase. A **polycarbonate roof** was seen only in high profile restaurants, cafes, lounges and offices. But with the growing realization of its benefits, people starting opting for this material more and more. This led to high demand of the material, thus lowering costs. Today, it is so affordable that it is being used in a wide range of residential constructional purposes. Polycarbonate is used for doors and windows, instead of glass. To enhance modern home decors, these sheets are also used for showers and swimming pool enclosures. Other areas where these sheets are used in residential projects include balconies, patios and decks. In the commercial sector, they are highly used in greenhouses, sports stadiums, railway stations, carports and office buildings.

It is the multiple advantages that polycarbonate has that makes it so widely used today. Some of the most important benefits are listed below.

Ease of construction

Polycarbonates are so light weight yet durable. This makes them very easy to install. They can be easily handled and can be fixed with the help of screws and support rods, or can be easily welded. Also, these sheets can be easily cut with the help of sharp-edged scissors and circular saws without the need of any additional tools and machinery.

Lowered costs

The light weightiness of polycarbonate makes it easier to handle, transport and carry. Therefore, the costs involved with the labour and transportation are highly cut down. This makes polycarbonates even more affordable even after purchase.

Versatility

Polycarbonate, being so strong and flexible, helps the structures it is used in to be more creatively designed. Unlike glass, the structures that use polycarbonate can be shaped like domes, igloos and many other fancy shapes that add a design feature to the building.

Property of resistance

Polycarbonates are resistant to impact and any kind of damage. Therefore, these sheets can be used in areas that are prone to stone, hail, rain, wind, storm and snow. Even in the worst case of breakage, these sheets do not produce harmful shards like glass. Also, these sheets are highly resistant to flame and do not cause toxic gases when on fire. So, they can also be conveniently used in areas prone to fire.

Sound barrier

The ultimate property of polycarbonate to block sound makes it a popular material used in areas that require privacy like conference rooms, office cabins, etc.

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Ultraviolet protection

One of the most beneficial features of polycarbonate is that it lets in maximum sunlight while keeping out the harmful UV radiations. Therefore, it is the ideal choice when you want maximum light to come in without being harmful. This property makes it the most widely used in greenhouses to help the plants within to grow well while keeping them protected against burning.

There are many other areas where polycarbonates are used, other than constructional purposes. They are also used in the advertising industry, for police equipment, automobile parts, DVDs, lenses and many other applications. Whatever your area of usage, you must get in touch with Tuflite Polymers to get your hands on the best quality **polycarbonate sheets** available in a variety of qualities, types, colours and designs.

Below are some of the many building applications that take advantage of the high performance of polycarbonate:

- Polycarbonate can be used in place of glass in a variety of **window and skylight applications**. Polycarbonate panels and sheets allow natural light to enter a building, and they can also be tinted, reducing the sunlight that reflects inside a building and helping to minimize interior cooling costs in the summer. Depending on the gauge, a typical window- and roof-glazing application using solar-control IR multi-wall polycarbonate sheet can help to reduce interior heat, resulting in energy savings in a temperature-controlled environment.

- From opaque cladding panels to canopies, barrel vaults, skylights, translucent walls and signage, roof domes and louvers, **polycarbonate sheet products** are designed and available in a wide range of thicknesses, structural strengths and configurations that also meet LEED® requirements Polycarbonate can be formed into a variety of complex shapes using thermoforming, a heat-based thermoplastic shaping technique. Polycarbonate sheet also can be cold-line bent similar to metal. A variety of processes to shape polycarbonate facilitate many building features, from stressed curves for arches to simple paneling.

- **Light-emitting diode (LED) lighting** is a top choice for illuminating homes and businesses, offering energy efficiency, durability and long life. As an exterior element for LED lighting, polycarbonate plastic is sturdy, and its crystal-like clarity holds up over many years. Other benefits of polycarbonate plastic in LED lighting include heat resistance, transparency, impact resistance, low flammability, and increased energy efficiency.

- Polycarbonate is used in **security glazing**—strengthening prisons, guard booths, bank teller shields, convenience stores, hurricane shutters, hockey rink surrounds and more. Specifically, polycarbonate's impact strength makes it an excellent choice for security applications, including blast and bullet-resistant glazing. Clear as glass, it also presents an advantage over alternatives such as wire glass and metal screens. When used in a multi-wall format, polycarbonate provides significant insulation, with resulting energy efficiency benefits. When treated with solar control technology, polycarbonate also provides protection from IR radiation and can also increase energy efficiency.

- Polycarbonate is used extensively in **sports stadium roofs** to protect fans from bad weather – and let the game go on – while allowing in natural light and saving energy at the same time.

PUF materials are suitable for temperature range between -200°C to +110°C. PIR Slabs & Pipe Sections are suitable for use between -200°C to +145°C. It has low thermal conductivity value of maximum 0.021 w/mk at 10°C. It is not easily ignitable and has negligible water permeability. It is suitable for cold / chilled pipelines, building roof & wall insulation, equipment insulation and horton sphere insulation.

PIR is suitable for LNG pipe insulation.

CFC Free

PUF / PIR is the only CFC Free product, designed within the guidelines of the Montreal Protocol, 1987, for the protection of the Ozone layer.

Better Extreme temperature performance

Unlike most thermoplastics, PUF / PIR has low smoke emission and will not melt or drip in a fire,
Being rigid Polyisocyanurate foam, it also has a higher hot surface performance of 150°C compared with only 110°C of normal Polyurethane Foam. This makes it ideal for use directly over steam or electrical tracing.

Its fire classification meets even the stringent requirements of the British Board of Trade for shipboard insulation as per BS 5608, the Indian Navy, and those of the US Bureau of Mines.

Better Cost-effectiveness

With PUF / PIR, insulation thickness can be reduced by 50% compared with cork, 44 compared with expanded polystyrene or fiberglass. It exposes lower surface area, reducing area or expensive vapour barrier and outer cladding per running meter of piping.

So insulation parameters can be upgraded without increasing pipe rack spacing.

Ease of application

Resistant to almost all solvents, PUF / PIR is compatible with cold applied adhesives, sealants and vapour-barrier mastics.

PUF / PIR is available in boards, pipe sections, radiused and beveled lags, with or without factory laminated facings.

Cast-Insitu Applicationn

Material Applied at site & suitable for large dia pipelines, underground pipelines & storage tanks.

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The use of Polyurethane and PUF panels

Among the several uses of polyurethane, rigid foam is one, which can unique insulation capabilities. This makes PUF panels ideal for building walls and roofs. Also, PUF panels can be used while remodelling homes. The insulation capability of PUF panels can save huge electricity costs, maintaining uniform temperature inside the building. The quality of insulation offered by PUF panels allows construction companies to make the walls thinner, yet maintain adequate temperature inside, thereby also allowing more space for people and equipments. Rigid foam can also save homeowners money, both in reduced construction costs and lower utility bills.

When polyurethane foam is sprayed, it acts as weatherproof sealant, forming a continuous layer of insulation, fills out the gaps and seams during application. It also covers areas that are difficult to insulate. The closed cell spray PUF also forms an air and moisture barrier. This in turn lessens the drafts thereby creating stronger and quieter buildings. PUF panels are also self-supporting structures which can be used in a wide range of applications.

Polyurethane, when combines with other materials also form an excellent insulation from extreme weather conditions. High performance PUF panels are therefore one of the most in demand sandwich panels used around the world.

PUF panels increase aesthetics of a building

Polyurethane building materials add design flexibility to new-home and remodeling projects. Foam-core panels offer a wide variety of colors and profiles for walls and roofs, while foam-cored entry doors and garage doors are available in different finishes and styles.

Buildings that are made of PUF panels are alto high on aesthetics. PUF panels offer design flexibility which can be leveraged to obtain aesthetically appealing buildings and structures. There are multiple colour options, that can be applied on walls and roofs. The doors and windows are available in different styles and finishing touches.

Structural insulated panels also have a polysio or PU core insulation, which can be used independently as structures within a building. Sandwich panels like PUF improve the design and functionality of a building. It also enables quick construction and helps reduce the amount of excessive other things that are required to spruce up the building. The final product is reusable and thus saves time and cost.

Causes and Types of Cracks in Masonry Buildings and their Repair Methods

The cracks appear in the masonry structure, at a certain period of time. Most commonly caused cracks with their respective causes and precaution, are explained below:

Cracks in Brick Mortar Joints

Vertical or horizontal cracks are seen at the brick mortar joints. One of the main reason is the sulfate attack, that weakens the mortar. These cracks mainly appear after 2 to 3 years of construction. These cracks can be avoided by:

- Checking the sulfate content of bricks used in construction
- The damping of brick wall has to avoided, as these are more prone to sulfate attack when it is damp

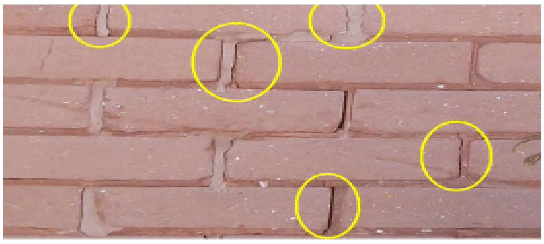

Fig.1: Cracks Formed in the Brick Mortar Joints

Crack Formation Below the Load Bearing Walls

Cracks are observed below the load bearing walls, mainly those that supports R.C.C slabs. Now the temperature variation makes the reinforced concrete slab to expand or contract, but both in the horizontal direction.

These are observed in the Top most story that is more exposed to the temperature changes. There no smooth contact between the wall and the slab.

Hence the frictional forces are developed at the contact place of the wall and the slab. This creates cracking in the walls.

The precaution that can be suggested is to provide a bearing plaster over the brick wall, which helps in having a smooth contact with the floor over it. If required a bituminous coating can be applied over the plaster applied.

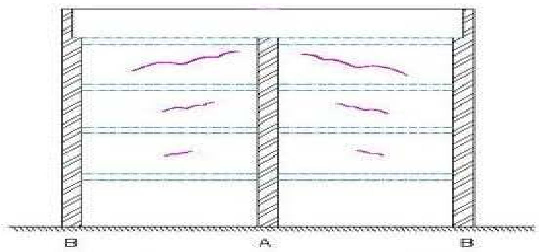

Fig.2: Cracks in Masonry Walls of Multi-Storey Building at Higher Floors

Main Wall and Cross Walls Joint Cracks

Improper bonding between the cross wall and the main wall creates cracks between the joints. This suggests us to have proper and quality bonding between the two walls. These are properly done by toothing.

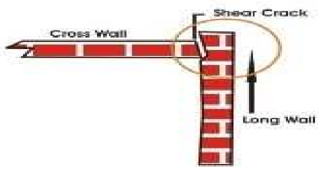

Fig.3: Shear Cracks between Cross Wall and the Main Long Wall of Masonry Building

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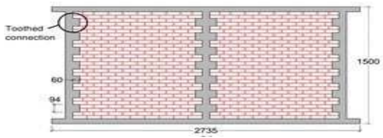

Fig.4: Tooth connection between the Walls

Cracks Found in R.C.C Columns and Masonry

One of the main reason behind this is the differential movement of the columns and the masonry because of temperature variation. This variation can be either expansion or contraction depending upon the temperature.

These cracks can be hidden by making a groove in the reinforced concrete column and masonry junction. The provision of chicken wire alternatively at the plaster between the junction of columns and masonry can also help in this variation.

The Horizontal cracks between R.C.C slab and the brick parapet

The non-projecting slab is mainly subjected to such cracks. This too is due to the temperature variation and the drying shrinkage. Small micro cracks formed he propagated with the increase in expansion or contraction.

These cracks can be hidden by making a groove at the masonry junction will help in hiding the cracks. The provision of chicken wire alternatively at the plaster junction can also help.

Cracks in Roof Slab The exposure of roof slab to higher temperature variation cause cracks numerously. This can be reduced by providing a weather proof course. New treatment methods and compounds are available as weather course, that is applied over the terrace.

Repair Methods for Cracks in Masonry Building Structural Members

Measures to be followed for already appeared cracks are:

1. Application of grouting or uniting for cracks that are appeared in the main structural members, that cannot be compromised at any cost. The material mainly used for this is either cement or epoxy mixture. The epoxy has the ability to fill even small and thin cracks, say as fine as 0.1mm. These epoxy gain high strength and adhesion.
2. The flexible sealant can be used for cracks that are appeared on the non-structural members. This helps in having a control over the differential movement (expansion or contraction) of the member under temperature changes.
3. Epoxy putty, polymer filler or lime cement mortar can be used for filling the cracks seen in plain cement concrete.

Methods for Correcting the Concrete Cracks:

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1. Cracks in R.C.C. Member
2. Cracks due to Excessive Shear
3. Cracks in Slab
4. Pressure Grouting
5. Cracks in Foundation due to Settlement
6. Load-Relieving Techniques
7. Modifying the Structural System

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Method # 1. Cracks in R.C.C. Member:
Cracks in R.C.C. member may appear due to excessive bending moment. These cracks appear in the tensile zone of the member and goes on increasing till the member fails.

To correct this defect the member shall be released of load causing bending moment as far as possible, then strengthening the member by adding reinforcing steel with proper key and bonding with the old member is done.

Method # 2. Cracks due to Excessive Shear:
These cracks are at 45° to the axis of the member they are wider at the lower fibre and appear in the compressive zone. These may be corrected by adding diagonal shear reinforcement in the form of stitching dowels.

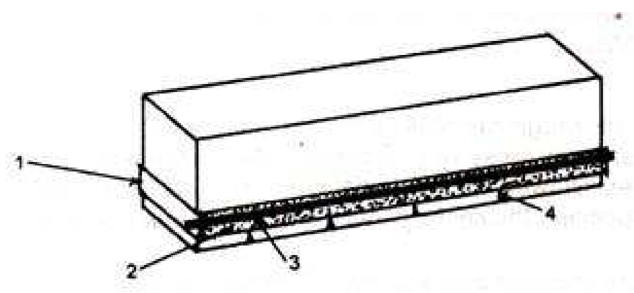

Fig. 4.5 Cracks in R.C.C. member
1. Anchoring lug 2. Filling the chase 3. Additional bars in the chase 4. Tensile crack.

Method # 3. Cracks in Slab:
These cracks are generally at the support or at the mid-span bottom and develop due to provision of insufficient steel or displacement of steel. These may be corrected by addition of steel as required. The ends of the added steel bars are bent at 90° and inserted in the slab by drilling in it.

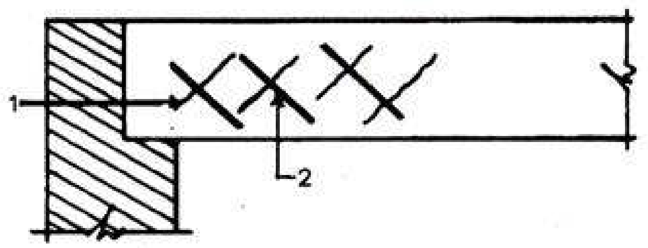

Fig. 4.6 Shear cracks in R.C.C. member
1. Shear crack 2. Diagonal shear bar.

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Method # 4. Pressure Grouting:
This method is adopted when the concrete has become porous, but has not decayed. It is estimated that, in course of time, moisture would find entrance through the porosity and corrode the steel.

To improve the concrete, the method adopted is as below:
Drills are made on the surface of the concrete member. Diameter and depth of the drills are fixed as per requirement according to the thickness of the member and the quality of the concrete to be treated. Cement slurry or chemicals are grouted under pressure and forced in the pores of the concrete. The pores get filled and the quality of the concrete is improved.

Method # 5. Cracks in Foundation due to Settlement:
These, when detected, may be beyond repair. The foundation may have to be replaced. In such case, either the foundation would have to be redesigned with wider base and/or the foundation may have to be taken down on soil having adequate bearing capacity.

The safe bearing capacity of the soil may be increased by chemical grouting or cement slurry grouting for stabilisation of the soil and thereby increasing the safe bearing capacity of the soil.

Method # 6. Load-Relieving Techniques:
The member may be pre-stressed externally by placing pre-stressing wires outside on both sides of the member and then stressing the wires by portable appliances.

Method # 7. Modifying the Structural System:
The structure may be redesigned and the stresses in the damaged member may be reduced while redesigning.

Some important construction tools and their uses are listed below:

- Bolster.
- Boning rod.
- Brick hammer.
- Bump cutter/screed.
- Chisel.
- Circular saw.
- Concrete mixer.
- Cordless drill.

How to Repair Wide Concrete Cracks

The secret to fixing wide concrete cracks is to undercut the sides of the crack to give it an inverted "V" shape. This helps the repair material to "key" into the crack, creating a mechanical bond in addition to the chemical bond between the patch material and the concrete.

1. Chisel the crack with a hammer and masonry chisel to widen the base of the crack and to dislodge any loose material from the old concrete.

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2. Remove all debris from the crack, using a wire brush. If desired, clean the crack with a pressure washer or a garden hose and spray nozzle.
3. Remove all water and debris from the crack with a wet/dry shop vacuum or a brush. Work carefully to remove all dust and grit from the crack. It's OK if the surfaces are wet, but there should be no pools of water.
4. Mix the concrete patching compound, following the manufacturer's directions.
5. Trowel the compound into the crack. Stab the trowel into the compound to remove air pockets and help work the patching material deep into the crack. Fill the crack up to the surrounding concrete surface.
6. Smooth the surface of the patch with the trowel, feathering the compound into the surrounding concrete.
7. Brush the surface of the patching compound with a dry paintbrush to texture the surface, if desired.
8. Let the compound cure as directed.
9. Paint or seal the surface of the patch and surrounding area, if desired.

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