UNIT-I

STONES, BRICKS AND TILES

INTRODUCTION:

Building materials have an important role to play in this modern age of technology. Although their most important use is in construction activities, no field of engineering is conceivable without their use. Also, the building materials industry is an important contributor in our national economy as its output governs both the rate and the quality of construction work.

There are certain general factors which affect the choice of materials for a particular scheme. Perhaps the most important of these is the climatic background. Obviously, different materials and forms of construction have developed in different parts of the world as a result of climatic differences. Another factor is the economic aspect of the choice of materials. The rapid advance of constructional methods, the increasing introduction of mechanical tools and plants, and changes in the organization of the building industry may appreciably influence thechoice of materials.

Due to the great diversity in the usage of buildings and installations and the various processes of production, a great variety of requirements are placed upon building materials calling for a very wide range of their properties: strength at low and high temperatures, resistance to ordinary water and sea water, acids and alkalis etc. Also, materials for interior decoration of residential and public buildings, gardens and parks, etc. should be, by their very purpose, pleasant to the eye, durable and strong. Specific properties of building materials serve as a basis for subdividing them into separate groups. For example, mineral binding materials are subdivided into air and hydraulic-setting varieties. The principal properties of building materials predetermine their applications.

PRINCIPAL PROPERTIES OF BUILDING MATERIALS:

For a material to be considered as building material, it should have required engineering properties suitable for construction works.This property of building a material is responsible for its quality and capacity and helps to decide applications of these materials.

Such properties of building materials are categorized as follows.

1. Physical properties
2. Mechanical properties
3. Chemical properties
4. Electrical properties
5. Magnetic properties
6. Thermal properties

PHYSICAL PROPERTIES:

Bulk Density

Bulk density is the ratio of mass to the volume of the material in its natural state that is including voids and pores. It is expressed in kg/m3. Bulk density influences the mechanical properties of materials like strength, heat and conductivity etc.

Bulk density values of some of the engineering materials are given below.

Building material	Bulk density (kg/m3)
Brick	1600-1800
Sand	1450 – 1650
Steel	7850
Heavy concrete	1800 – 2500
Light concrete	500 – 1800
Granite	2500 – 2700

Porosity

Porosity gives the volume of the material occupied by pores. It is the ratio of volume of pores to the volume of material.

Porosity influences many properties like thermal conductivity, strength, bulk density, durability etc.

Durability

The property of a material to withstand against the combined action of atmospheric and other factors is known as durability of material.

If the material is more durable, it will be useful for longer life. Maintenance cost of material is dependent of durability.

Density

Density is the ratio of mass of the material to its volume in homogeneous state.

Almost all the physical properties of materials are influenced by its density values. Density values of some building materials are given below.

Material	Density (kg/m^3)
Steel	7800 – 7900
Brick	2500 -2800
Granite	2600 – 2900
Wood	1500

Bulk density

Bulk density is another important property of building materials. The bulk density is measured in its natural states. So they have the influence of pores and voids.

Bulk density is the mass occupied per unit volume in its natural state.

Specific Gravity

Specific gravity is the ratio of mass of given substance to the mass of water at 4°C for the equal volumes. Specific gravity of some materials is listed below.

Material	Specific gravity
Steel	7.82
Cast iron	7.20
Aluminum	2.72

Fire Resistance

The ability to withstand against fire without changing its shape and other properties. Fire resistance of a material is tested by the combined actions of water and fire. Fireproof materials should provide more safety in case of fire.

Frost Resistance

The ability of a material to resist freezing or thawing is called frost resistance. It is depends upon the density and bulk density of material. Denser materials will have more frost resistance. Moist materials have low frost resistance and they lose their strength in freezing and become brittle.

Weathering Resistance

The property of a material to withstand against all atmospheric actions without losing its strength and shape. Weathering effects the durability of material. For example corrosion occurs in iron due to weathering. To resist this paint layer is provided.

Spalling Resistance

The ability of a material to undergo certain number of cycles of sharp temperature variations without failing is known as spalling resistance. It is the dependent of coefficient of linear expansion.

Water Absorption

The capacity of a material to absorb and retain water in it is known as water absorption. It is expressed in % of weight of dry material. It depends up on the size, shape and number of pores of material.

Water Permeability

The ability of a material to permit water through it is called water permeability. Dense materials like glass metals etc. are called impervious materials which cannot allow water through it.

Refractoriness

The property of a material which cannot melts or lose its shape at prolonged high temperatures (1580°C or more).

Example: fire clay is high refractory material.

MECHANICAL PROPERTIES:

Mechanical properties of the materials are find out by applying external forces on them. These are very important properties which are responsible for behavior of a material in its job. The mechanical properties are,

Strength

The capacity of a material to resist failure caused by loads acting on it is called as strength. The load may be compressive, tensile or bending. It is determined by dividing the ultimate load taken by the material with its cross sectional area. Strength is an important property for any construction materials. So, to provide maximum safety in strength, factor of safety is provided for materials and it is selected depending on nature of work, quality of material, economic conditions etc.

Hardness

The property of materials to resist scratching by a herder body. MOHS scale is used to determine the hardness of materials. Hardness is most important to decide the usage of particular aggregate. It also influences the workability.

Elasticity

The capacity of a material to regain its initial shape and size after removal of load is known as elasticity and the material is called as elastic material. Ideally elastic materials obey Hooke’s law in which stress is directly proportional to strain. This gives modulus of elasticity as the ratio of unit stress to unit deformation. Higher the values of modulus of elasticity lower the deformations.

Plasticity

When the load is applied on the material, if it will undergo permanent deformation without cracking and retain this shape after the removal of load then it is said to be plastic material and this property is called as plasticity. They give resistance against bending, impact etc.
Examples: steel, hot bitumen etc.

Brittleness

When the material is subjected to load, if it fails suddenly without causing any deformation then it is called brittle material and this property is called as brittleness.
Examples: concrete, cast-iron etc.

Fatigue

If a material is subjected to repeated loads, then the failure occurs at some point which is lower than the failure point caused by steady loads. This behavior is known as fatigue.

Impact strength

If a material is subjected to sudden loads and it will undergo some deformation without causing rupture is known as its impact strength. It designates the toughness of material.

Abrasion Resistance
The loss of material due to rubbing of particles while working is called abrasion. The abrasion resistance for a material makes it durable and provided long life.

Creep
Creep the deformation caused by constant loads for long periods. It is time dependent and occurs at very slow rate. It is almost negligible in normal conditions. But at high temperature conditions creep occur rapidly.

CHARACTERISTICS OF GOOD BUILDING STONES

Appearance
For the face work of buildings this property is of extreme importance. From architectural point of view color of the stone should be such as to go well with the surroundings. Lighter shades should be preferred to the darker ones as the latter are less durable, Red and the brown shades of sedimentary rocks are due to the presence of oxide of iron-which, if present in excess, is liable to disfigure the stone with rust stains and to disintegrate it. Stones should be of uniform colour and free from clay holes, bands or spots of color whatsoever.

Structure
Stone, when broken in a direction other than that of cleavage (if it exists), should not give dull appearance. It should show uniformity of texture. It must be either crystalline in structure of homogeneous and close-grained. It should be free from cavities, cracks or patches of soft or loose material. For ornamental carvings it should be fine grained. Stratification (found in sedimen•tary rocks) should not be visible to naked eye except by difference in color. These can be easily split along their planes of stratification known as planes of cleavage, and are, therefore, useful for use in paving’s, flooring’s and roofing’s etc.

Weight
Heavier varieties of stones are more compact, less porous and have greater specific gravities. For constructions in water, like weirs, barrages, dams, docks, harbours and for retaining walls the heavier varieties of stones are to be preferred. For construction of domes and for roof coverings and similar other usages the lighter varieties have to be used.

Strength
In usual constructions the stones used are generally quite strong to withstand the forces likely to be encountered yet in case of construction where unusually bigger forces are likely to come the stone to be used should be tested for its strength. Stones of igneous class are generally stronger than those of the sedimentary class. Stones with compact fine crystalline texture are stronger.

Hardness
It is the resistance of stone to abrasive forces caused by much wear and friction as in floors, pavements and aprons of bridges and weirs in rivers. Stones to be used at such places should be hard.

Toughness

It is a measure of the impact that a stone can with stand. Stones used at places subject to vibrations of machinery and to moving loads should be tough. Stones used in the construction of roads should be hard and tough

Workability

It is the ease with which the stone can be worked upon *i.e.*, cut, dressed, carved and moulded etc., is an important consideration from economy point of view. But this property is opposedto strength, durability and hardness.

Porosity and absorption

More porous building stones are unsuitable for use in construction especially for exposed surfaces of structures. Rain water while coming down carries some acidic gases forming light acids which lodge on the surface of stones and soak in them. Very often it is driven in the pores of stones by the prevailing winds. Acids react with the constituents of stones causing them to crumble. In cold regions water freezes in the pores of stones. This water causes the disintegration of stones because of its increase in volume on freezing.

Stones should as such be tested for porosity and care should be taken to use more porous stones only at places where they are not likely to encounter frost, rain or moisture in any other form.

Seasoning

All freshly quarried stones contain a certain amount of moisture known as quarry sap, which makes them soft and easier to work upon. As such all work such as dressing, carving and moulding etc, should be done as early after quarrying as possible. Stones become considerably harder on seasoning. After quarrying, when all the work has been done upon stones, they should be left to season under sheds having no walls so as to permit free circulation of air. Sheds protect them from rains. A period of 6-12 months is generally enough for proper seasoning. Dressed faces should not be disturbed after seasoning as the crystalline film left by the quarry sap on evaporation weathers much better than the actual face of stone left after removal of that film.

Weathering

It is the extent to which the face of a stone resists the action of weather. The best way of knowing the weathering properties of a particular stone is to inspect ancient buildings made with the same quality of stone possibly in the nearby place or at a place having similar atmospheric conditions. Inspection of an old face of some quarry could also be informative. If sharp edges and corners are preserved on an old building particularly on the faces exposed to rains and prevailing winds and on which sunlight does not play and if the chisel marks on such faces are distinctly visible then that variety of stone has good weathering qualities.

Stones with good weathering properties only should be used in the construction of important buildings.

Resistance to fire.

To be fire-resistant stones should be free from calcium carbonate and oxide of iron and be not composed of minerals with differing co-efficient of thermal expansion.

Specific gravity

The specific gravity of most of the stones lies between 2.3 to 2.5.

CLASSIFICATION OF STONES:

The rocks may be classified on the basis of their geological formation, physical characteristics and chemical composition.

Rocks

↓

Geological	Physical	Chemical
i. Igneous rocks	i. Stratified rocks	i. Argillaceous rocks
ii. Sedimentary rocks	ii. Unstratified rocks	ii. Silicious rocks
iii. Metamorphic rocks	iii. Foliated Rocks	iii. Calcareous rocks

GEOLOGICAL CLASSIFICATION

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

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

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

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

PHYSICAL CLASSIFICATION

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

(i) Stratified rocks
(ii) Unstratified rocks
(iii) Foliated rocks

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

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

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

CHEMICAL CLASSIFICATION

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

(i) Silicious rocks
(ii) Argillaceous rocks and
(iii) Calcareous rocks

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

(ii) Argillaceous rocks: The main constituent of these rocks is clay(Al_2O_3 i.e., clay. These stones are hard and durable but they are brittle. They cannot withstand shock. Slates and laterites are examples of this type of rocks.

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

STONE QUARRYING

Definition: Stones occur in the form of natural rock masses or layers on the surface. The process of extraction of suitable stones from their natural rock beds or layers is commonly called Quarrying of Stones.

SITE SELECTION FOR QUARRYING OF STONES

The quarry should be selected based on some conditions as follows.

1 The site should be near to human living areas where labor and tools are always available, required materials also should be available.
2 At least one of type transportation facilities (road or railway or port or all) should be available.
3 Clean water source should be available near the quarry site.
4 Good quality and quantity of stone should be available.

5 The site should be far from permanent structures like bridges, dams etc. because the vibrations due to blasting in the site may cause harm to them.
6 Non-living area should be available to dump the refuse obtained in quarrying.
7 Proper drainage facility should be available.
8 Geological information of site should be read.

METHODS OF QUARRYING OF STONES

Quarrying can be done by three methods as follows:

1. Hand tools
2. Machine quarrying
3. Blasting

Quarrying of Stones using Hand Tools

In case of soft stones or for smaller works, quarrying is done by using hand tools. There are various ways to quarry using hand tools and they are:

i. Excavating
ii. Heating
iii. Wedging

Excavating

Excavating is preferred in case of soft stone surfaces. Hammers, pick axes, shovels are used to excavate the stones.

Heating

The top surface of rock is heated by placing wood with fuel on it. The fire will be allowed for some hours and the top surface gets heated and separates from the rock. This separated portion is removed by pick axes, crowbars etc.

The stones obtained by heating will be in good shape if the rock formation contains horizontal layers at shallow depth. So, the stone obtained will be directly used for masonry works.

Wedging

This method is applicable when the rock contains cracks or joints in it. Steel wedges or steel points are put in these cracks or fissures and hit them with hammer.

Then the rock portion separates from parent rock. If natural cracks are there, then artificial holes are drilled in the rock and wedging is done.

Machine Quarrying of Stones

Machine quarrying is done by using channelling machines in the site. This type of machine is driven by steam, compressed air or electricity.

A large groove of 24-meter length and 50 to 75 mm width and with a depth about 2 to 3.7 meter can be made using channelling machine. So, larger blocks of stones can be obtained.

Blasting for Quarrying of Stones

In this method explosives are used to separate the stones from parent rock. This process is applied in case of hard stone or hard rock which does not contain any cracks or fissures.

The holes are drilled in the rock and explosives are arranged in the holes and blasted with proper safety measures. The stones obtained through this process are not larger in size.

So, the main purpose of blasting is to obtain small stones which are used as ballast for railway works, aggregate in concrete works etc.

PRECAUTIONS IN BLASTING:

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

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

DRESSING OF STONE

Stones obtained from quarrying do not contain required shapes and sizes. So, they are cut into required sizes and shapes with suitable surfaces. This process is called dressing of stones.

Objectives:

a. To **reduce the size** of the big blocks of stones so that they are converted to easily lift-able pieces. This reduction in size is generally carried out at the quarry itself because that saves a lot of **transportation cost**.
b. To give a **proper shape** to the stone. It is known that stones can be used at different places in the building, e.g., in foundations, in walls, in arches or for flooring, each situation will require a proper shape.
   This can be given at the quarry and also at the site of construction.
c. To obtain an **appealing finish**. In a residential building, stones are used not only because of their extra strength, hardness, and durability but also because of their aesthetic value.

COMPOSITION OF GOOD BRICK EARTH

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

(a) Silica(50-6-%)
(b) Alumina (20-30%)
(c) Lime (10%)
(d) Iron oxide (<7%)
(e) Magnesia (<1%)
(f) Alkalis (<10%)

Silica

Brick earth should contain about 50 to % of silica.

1. It is responsible for preventing cracking, shrinking and warping of raw bricks.
2. It also affects the durability of bricks.
3. If present in excess, then it destroys the cohesion between particles and the brick becomes brittle.

Alumina

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

Lime

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

Iron oxide

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

Magnesia

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

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

Preparation of clay for brick manufacturing:

Preparation of clay for bricks manufacturing is done in six steps:

Unsoiling of claywe 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 called unsoiling.

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 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.

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.

1. Hand molding (for small scale)
2. 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 brick

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,

- Plastic clay machines
- 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 are called pressed bricks and these do not require drying they may directly sent to burning process.

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.

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.

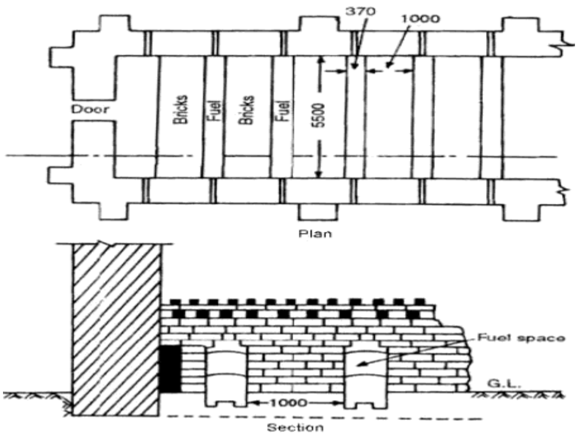
Clamp burning:

A typical clamp is shown in Fig. The bricks and fuel are placed in alternate layers. The amount of fuel is reduced successively in the top layers. Each brick tier consists of 4–5 layers of bricks. Some space is left between bricks for free circulation of hot gasses. After 30 per cent loading of the clamp, the fuel in the lowest layer is fired and the remaining loading of bricks and fuel is carried out hurriedly. The top and sides of the clamp are plastered with mud. Then a coat of cow dung is given, which prevents the escape of heat. The production of bricks is 2–3 lacs and the process is completed in six months. This process yields about 60 per cent first class bricks.

KilnBurning

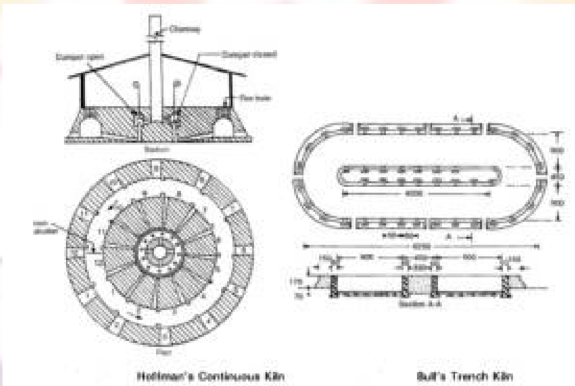
Intermittent Kiln:

The example of this type of an over ground, rectangular kiln is shown in Fig. After loading the kiln, it is fired, cooled and unloaded and then the next loading is done.
Since the walls and sides get cooled during reloading and are to be heated again during next firing, there is wastage of fuel.



Continuous Kiln:

The examples of continuous kiln are Hoffman's kiln and Bull's trench kiln .In a continuous kiln, bricks are stacked in various chambers wherein the bricks undergo different treatments at the same time. When the brick in one of the chambers are fired, the bricks in the next set of chambers are dried and preheated while bricks in the other set of chambers are loaded and in the last are cooled.



AGGREGATES

Aggregates are the important constituents of the concrete which give body to the concrete and also reduce shrinkage. Aggregates occupy 70 to 80 % of total volume of concrete.

Classification of Aggregates Based on Shape

We know that aggregate is derived from naturally occurring rocks by blasting or crushing etc., so, it is difficult to attain required shape of aggregate. But, the shape of aggregate will affect the workability of concrete. So, we should take care about the shape of aggregate. This care is not only applicable to parent rock but also to the crushing machine used.

Aggregates are classified according to shape into the following types

1. Rounded aggregates
2. Irregular or partly rounded aggregates
3. Angular aggregates

Flaky aggregates

4. Elongated aggregates
5. Flaky and elongated aggregates

Rounded Aggregate

The rounded aggregates are completely shaped by attrition and available in the form of seashore gravel. Rounded aggregates result the minimum percentage of voids (32 – 33%) hence gives more workability. They require lesser amount of water-cement ratio. They are not considered for high strength concrete because of poor interlocking behavior and weak bond strength.

Irregular Aggregates

The irregular or partly rounded aggregates are partly shaped by attrition and these are available in the form of pit sands and gravel. Irregular aggregates may result 35- 37% of voids. These will give lesser workability when compared to rounded aggregates. The bond strength is slightly higher than rounded aggregates but not as required for high strength concrete.

Angular Aggregates

The angular aggregates consist well defined edges formed at the intersection of roughly planar surfaces and these are obtained by crushing the rocks. Angular aggregates result maximum percentage of voids (38-45%) hence gives less workability. They give 10-20% more compressive strength due to development of stronger aggregate-mortar bond. So, these are useful in high strength concrete manufacturing.

Flaky Aggregates

When the aggregate thickness is small when compared with width and length of that aggregate it is said to be flaky aggregate. Or in the other, when the least dimension of aggregate is less than the 60% of its mean dimension then it is said to be flaky aggregate.

Elongated Aggregates

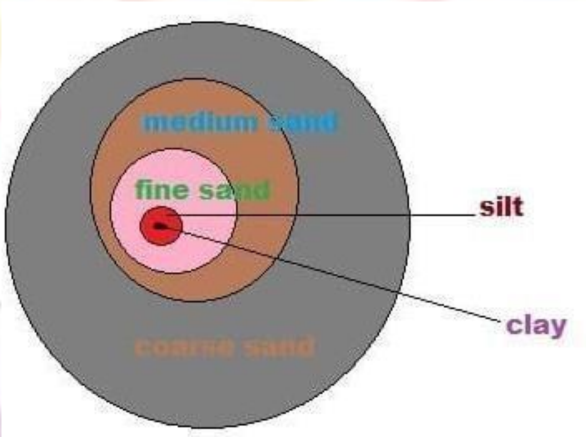
When the length of aggregate is larger than the other two dimensions then it is called elongated aggregate or the length of aggregate is greater than 180% of its mean dimension.

Flaky and Elongated Aggregates

When the aggregate length is larger than its width and width is larger than its thickness then it is said to be flaky and elongated aggregates. The above 3 types of aggregates are not suitable for concrete mixing. These are generally obtained from the poorly crushed rocks.

Classification of Aggregates Based on Size

Aggregates are available in nature in different sizes. The size of aggregate used may be related to the mix proportions, type of work etc. the size distribution of aggregates is called grading of aggregates.



Following are the classification of aggregates based on size:

Aggregates are classified into 2 types according to size

1. Fine aggregate
2. Coarse aggregate

Fine Aggregate

When the aggregate is sieved through 4.75mm sieve, the aggregate passed through it called as fine aggregate. Natural sand is generally used as fine aggregate, silt and clay are also come under this category. The soft deposit consisting of sand, silt and clay is termed as loam. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

Coarse Aggregate

When the aggregate is sieved through 4.75mm sieve, the aggregate retained is called coarse aggregate. Gravel, cobble and boulders come under this category. The maximum size aggregate used may be dependent upon some conditions. In general, 40mm size aggregate used for normal strengths and 20mm size is used for high strength concrete. the size range of various coarse aggregates given below.

Grading of Aggregates

Grading is the particle-size distribution of an aggregate as determined by a sieve analysis using wire mesh sieves with square openings. As per IS:2386(Part-1)

Fine aggregate—6 standard sieves with openings from 150 µm to 4.75 mm.
Coarse aggregate—5 sieves with openings from 4.75mm to 80 mm.

Gradation (grain size analysis)

Grain size distribution for concrete mixes that will provide a dense strong mixture. Ensure that the voids between the larger particles are filled with medium particles. The remaining voids are filled with still smaller particles until the smallest voids are filled with a small amount of

Good Gradation:

Concrete with good gradation will have fewer voids to be filled with cement paste (economical mix) Concrete with good gradation will have fewer voids for water to permeate (durability)

Particle size distribution affects:

1. Workability
2. Mixproportioning

Fine Aggregate effect on concrete:

1. Over sanded (More than requiredsand)
   - Over cohesivemix.
   - Water reducers may be lesseffective.
   - Air entrainment may be moreeffective.
2. Under sanded (deficit ofsand)
   - Prone to bleed andsegregation.
   - May get high levels of waterreduction.
   - Air entrainers may be lesseffective.

Shape and surface texture of aggregates:

- The shape of aggregate is an important characteristic since it affects the workability of concrete.
- It is difficult to measure the shape of irregular shaped aggregates. Not only the type of parent rock but also the type of crusher used also affects the shape of the aggregate produced.
- Good Granite rocks found near Bangalore will yield cuboidal aggregates. Many rocks contain planes of jointing which is characteristics of its formation and hence tend to yield more flaky aggregates.
- The shape of the aggregates produced is also dependent on type of crusher and the reduction ratio of the crusher.
- Quartzite which does not possess cleavage planes tend to produce cubical shape aggregates.
- From the standpoint of economy in cement requirement for a given water cement ratio rounded aggregates are preferable to angular aggregates.
- On the other hand, the additional cement required for angular aggregates is offset to some extent by the higher strengths and some times greater durability as a result of greater Interlocking texture of the hardened concrete.
- Flat particles in concrete will have objectionable influence on the workability of concrete, cement requirement, strength and durability.
- In general excessively flaky aggregates make poor concrete.
- While discussing the shape of the aggregates, the texture of the aggregate also enters the discussion because of its close association with the shape.

Generally round aggregates are smooth textured and angular aggregates are rough textured. Therefore some engineers argue against round aggregates from the point of bond strength between aggregates and cement.

- But the angular aggregates are superior to rounded aggregates from the following two points:
- Angular aggregates exhibit a better interlocking effect in concrete, which property makes it superior in concrete used for road and pavements.
- The total surface area of rough textured angular aggregate is more than smooth rounded aggregates for the given volume.
- By having greater surface area, the angular aggregates may show higher bond strength than rounded aggregates.
- The shape of the aggregates becomes all the more important in case of high strength and high performance concrete where very low water/cement ratio is required to be used . In such cases cubical aggregates are required for better workability.
- Surface texture is the property, the measure of which depends upon the relative degree to which particle surface are polished or dull, smooth or rough.
- Surface texture depends upon hardness, grain size, pore structure, structure of the rock and the degree to which the forces acting on it have smoothened the surface or roughened.
- Experience and laboratory experiments have shown that the adhesion between cement paste and the aggregate is influenced by several complex factors in

Bricks

Bricks are one of the oldest and most popular building materials. The reasons for bricks being very popular
and widely used construction material are,

- They are cheap
- They are durable
- They are easy to handle and work with

Brick can be defined as,
–Bricks are blocks of tampered clay moulded to suitable shapes and sizes while it is still in plastic condition, dried in the sun and burnt, if desired so as to make them more strong, hard and durable.‖
Brick is normally rectangular in shape and size is set so as to make it easy for workers to handle it and is usually available made up of three different materials

- Burnt clay (Most common type in Pakistan)
- Mixture of sand and lime
- Portland cement concrete

The bricks made up of the last two types are usually called blocks and are available in sizes of following proportions,
Length of brick = 2 × width of brick + thickness of mortar

Height of brick = width of brick

Commonly available size is,19 × 9 × 9 cm and 19 × 9 × 4 cm.

Classification of Bricks

First Class Bricks:

- These are thoroughly burnt and are of deep red, cherry or copper colour.
- The surface should be smooth and rectangular, with parallel, sharp and straight edges and square corners.
- These should be free from flaws, cracks and stones.
- These should have uniform texture.
- No impression should be left on the brick when a scratch is made by a finger nail.

- The fractured surface of the brick should not show lumps of lime.
- A metallic or ringing sound should come when two bricks are struck against each other.
- Water absorption should be 12–15% of its dry weight when immersed in cold water for
- The crushing strength of the brick should not be less than 10 N/mm2. This limit varieswith different Government organisations around the country.

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

b. Second Class Bricks:

These are supposed to have the same requirements as the first class ones except that

- Small cracks and distortions are permitted.
- A little higher water absorption of about 16–20% of its dry weight is allowed.
- The crushing strength should not be less than 7.0 N/mm2.

Uses: Second class are recommended for all important or unimportant hidden masonry works and centring of reinforced brick and reinforced cement concrete (RCC) structures.

C. Third Class Bricks:

- These bricks are under burnt.
- They are soft and light-colored.
- They produce a dull sound when struck against each other.
- Water absorption is about 25 per cent of dry weight.

Uses: It is used for building temporary structures.

d. Fourth Class Bricks:

- These bricks are over burnt.
- Badly distorted in size and shape.
- Brittle in nature.

Uses: The ballast of such bricks is used for foundation and floors in lime concrete and road metal.

ON STRENGTH:

On the basis of strength they have been subdivided into the following categories (IS 1077).

Class	*Average compressive strength not less than (N/mm^2)*
35	35.0
30	30.0
25	25.0
20	20.0
17.5	17.5
15	15.0
12.5	12.5
10	10.0
7.5	7.5
5	5.0
3.5	3.5

ON THE BASIS OF USE:

On the basis of use they have been classified into the following three types,

a. Common Bricks:

This is a general multi-purpose unit manufactured economically without special reference to appearance. These may vary greatly in strength and durability and are used for filling, backing and in walls where appearance is of no consequence.

b. Facing Bricks:

These are made primarily with a view to have good appearance, either of colour or texture or both. These are durable under severe exposure and are used in fronts of building walls for which a pleasing appearance is desired.

c. Engineering Bricks:

These are strong, impermeable, smooth, table moulded, hard and conform to defined limits of absorption and strength. These are used for all load bearing structures.

UNIT-II
CEMENT & ADMIXTURES

Babylonians were perhaps the first to use clay as cementing material. In ancient times stones have been invariably used as a construction material with lime as the binder for construction of forts and defense structures.

Egyptians have used lime and gypsum as cementing materials in the famous Pyramids. The calcareous rocks used by the Romans were either composed of limestone's burned in Kilns or mixtures of limestone and puzzolanic materials (volcanic ash, tuff) combining into a hard concrete.

The natural cement is obtained by burning and crushing the stones containing clay, carbonate of lime (CaCO3) and a little quantity of magnesia (CaMgCO3)2. The natural cement is brown in color and is also known as Roman cement.

Ingredient	Oxide / composition	%	Range	Function
Lime	CaO	62	60 – 65	Controls strength and soundness. Its deficiency reduces strength & setting time
Silica	SiO_2	22	17 – 25	Imparts strength. Excess cause slo setting
Alumina	Al_2O_3	5	3 – 8	Responsible for quick setting, if in excess it lowers the strength / weakness the cement
Calcium sulphate	$CaSO_4$	4	3 – 4	A small amount of sulphuris usefulin making sound cement. If it is in excess , it causes cement to become unsound.
Iron oxide	Fe_2O_3	3	0.5 – 6	Gives colour, hardness & strength to the cement
Magnesia	MgO	2	0.5 – 4	Gives color, hardness. If in excess, it causes cracks in mortar.
Alkalies	(Na_2O+K_2O)	1	0.1 – 0.4	These are residues and if in excess cause efflorescence and cracking

USES OF CEMENT

Cement is widely used in construction of various engineering structures. Following are various possible uses of cement:

- Cement mortar for masonryworks
- Cement Concrete for laying floors, roofs, lintels, beams, stairs, pillarsetc
- Construction of important engineering structures such as Bridges, Culverts, Dams, Tunnels, storage Reservoirs; Docksetc
- Making CementPipes
- Manufacture of precast pipes, dust bins, fencing postsetc..

MANUFACTURE OF CEMENT:

Calcareous (limestone, marl, chalk, marine shell)and argillaceous (clay, shale, slate etc) materials are used in the manufacture of Ordinary or Portland cement. From these materials, like silica, iron-oxide, and small quantities of other chemicals such as Na, K, S are obtained during the process of manufacturing of cement. Cement can be manufactured either by dry process or wet process.

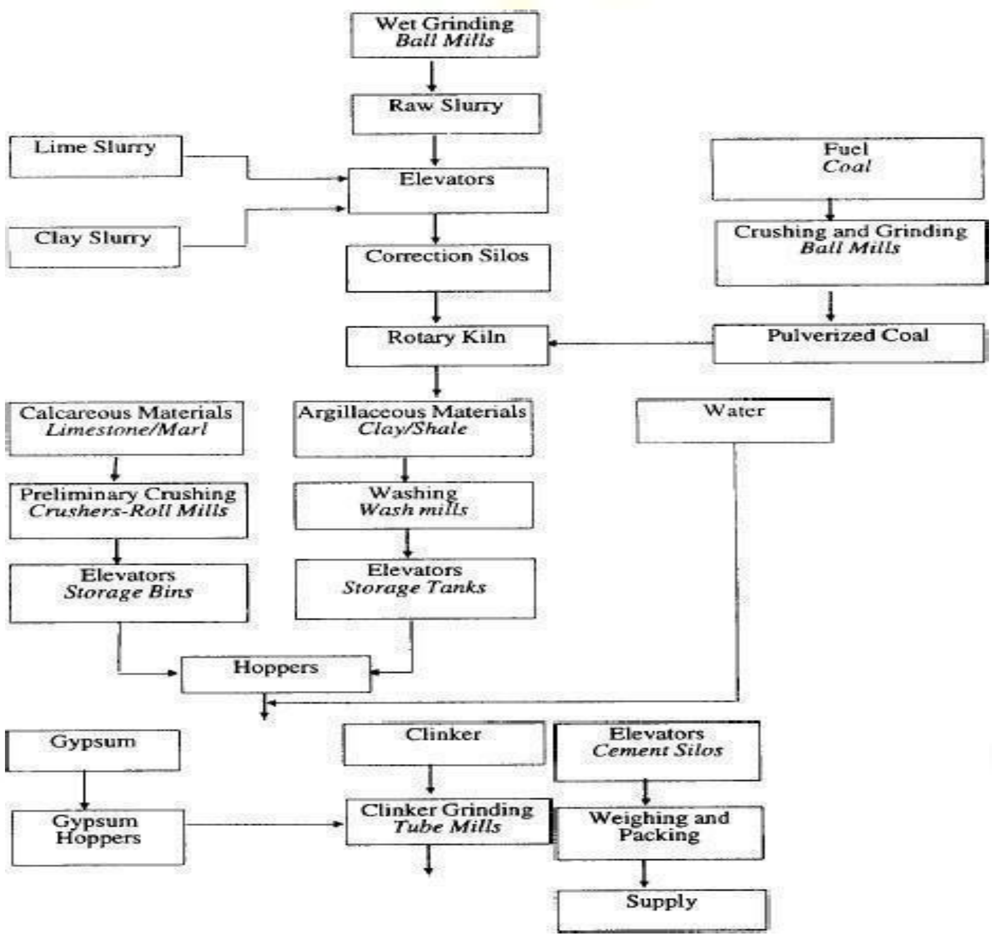
DRY PROCESS :

This process is adopted when the raw materials are quite hard. The raw materials of limestone and clay are first reduced in size of about 25 mm in crushers. A dry air is then passed over these materials. These dried materials are then pulverized into fine powder separately in the ballmills.

Ball mill is a key equipment to grind the crushed materials, and the ball mill is widelyused in powder-making production All these materials are stored in hoppers / bins / silos and they are then mixed in correct proportions.

The clinker is cooled rapidly to preserve the metastable compounds and then ground in Tube Mills where 2 – 3 % of gypsum is added. The purpose of adding gypsum is to retard the setting of cement. Generally, cement is stored in bags of 50 kg. The dry process has been modernized and it is widely used at present because of competition in production; lesser consumption of power; automatic proper temperature; computerization and quality.

Flow diagram of manufacturing of cement



WET PROCESS

Wet process was used for the manufacture of cement started from 1913 onwards and till early 1980. The operations involved in the wet process of cement manufacture are mixing; burning and grinding.

The crushed raw materials are fed into ball mill and a little water is added to make thick paste. Thispaste, usually contain about 14% of moisture is dried and made ready for the feed of rotary kiln where it loses moisture and forms into lumps or nodules.. These are finally burned at 1500 – 1600°C where the nodules change to clinker at this temperature. Clinker is cooled and then ground in tube mills. While grinding the clinker, about 3% of gypsum is added. The cement is then stored in silos from where it is supplied. During the operation of ball mill; the steel balls in it pulverize the raw materials which form a slurry with water. This slurry is passed to silos (storage tanks), where the proportioning of the compounds is adjustedto ensure desired chemical composition.

Why gypsum is to be added during the manufacture of cement?

The gypsum is the hydrated sulphate of calcium and its chemical composition is $CaSO_4$ $2H_2O$. It contains 79.1% calcium sulphate and 20.9% water. When gypsum is added to 205°C, its specific gravity increases from 2.3 to 2.95 due to loss of water. As a binding material, the gypsum quickly sets and hardens. It is soluble in HCl but insoluble inH_2SO_4.

Gypsum has a number of valuable properties like bulk density, incombustibility, good absorbing capacity, good fire resistance, rapid drying etc. Because of all these properties, gypsum is used in the manufacture of cement to increase its setting time.

PLASTER OF PARIS:

Plaster of Paris is a calcium sulfate hemi-hydrate ($CaSO_4$, ½ H_2O) derived from gypsum by firing this mineral at relatively low temperature of 160 – 170°C and then reducing it to powder In ancient times, in Paris, all the walls of wooden houses were covered with plaster as protection against fire. Since then the plaster was named as Plaster of Paris.

POP powder is mixed with water to form a paste which releases heat and then hardens once dried under normal temperature. Unlike mortar and cement, plaster remains quite soft after drying, and can be easily rubbed or scratched with metal tools or even sandpaper. On heating, further upto a temperature of about 20°C, the entire water is driven off and the resulting product is known asthe Gypsum Anhydrite.

FIELD TESTS & LAB TESTS FOR CEMENT:

In engineering construction, the main qualifications of a cement are permanency of structure; strength and a rate of setting. To determine these qualifications, both physical and chemical tests are made, the former on account of importance more often than the other. However, following field tests are to be carried out to ascertain the quality of cement:

The cement should feel smooth when touched in between fingers.

- If it is felt rough, it indicates adulteration withsand.
- If hand is inserted in a bag of cement, one should feel cool and notwarm.
- If a small quantity of cement is thrown in a bucket of water, it should sink and should
- The color of cement should be uniform and the typical cement color is grey.
- The cement should be free from any hard lumps. Such lumps are formed by the absorption of moisture from theatmosphere.

As a result of long experience the physical tests which have come into general use in determining the acceptability of cement are:

- Soundness
- Strength:
- Consistency Testand
- Fineness.

SOUNDNESS

Soundness refers to the ability of a hardened cement paste to retain its volume after setting without delayed destructive expansion. This destructive expansion is caused by excessive amount of CaO or MgO. In other words, the purpose of this test is to detect the presence of uncombined lime in cement. This may happen due to over burning of ingredients of cement in kilns. So it is an important test to assure the quality of cement since an unsound cement produces cracks, disintegration and leading to failure finally.
Soundness of cement may be tested by Le-Chatelier method or by authoclave method.

STRENGTH:

Cement is tested for Compressive and Tensile strength because the cement hydrates when water is added to it. So, the strength of mortar and concrete depends upon the type and nature of cement.

Hydration of cement: The chemical reaction bet cement and water is known as hydration ofcement

Conditions affecting strength:

- Cement is very strong at early stages if a high lime or high alumina content ispresent.
- Gypsum and Plaster of Paris in small percentages also tend to increase the strength slightly but when present in quantities more than 3%, these substances provide

variableeffects.

- The strength of cement is greatly also influenced by the degree of burning, the fineness ofgrinding.
- An under burnt cement is likely to be deficient instrength.

Compressive Strength.:

Compressive Strength is the basic data required for mix design. By this test, the quality and quantity of concrete can be controlled and the degree of **adulteration** is checked.
The compressive strength at the end of 3 days, 7 days and 28 days are given in table and the results are expressed in N/mm^2

Tensile Strength:

Tensile Strength may be determined by Briquette Test method or by Split Tensile Strength Test. The Tensile strength of cement affords quicker indications of defects in the cement. However, the test is also used for the determination of rapid hardening cement. The tensile strength at the end of 3 days and 7 days for OPC is 2.0 N / mm^2 and 2.5 N/ mm^2 respectively. (2.0 N / mm^2 = 20 kg / cm^2) (2.5 N/ mm^2 = 25 Kg / cm^2)

consistency Test

This is a test to estimate the quantity of mixing water to form a paste of normal consistency.

Vicat apparatusis used to determine the consistency test.300 gms of cement is mixed with 25% water. The paste is filled in the mould of Vicat’s apparatus and the surface of the filled paste is smoothened and leveled. A square needle 10 mm x 10 mm attached to the plunger is then lowered gently over the cement paste surface and is released quickly. The plunger pierces the cement paste. The reading on the attached scale is recorded. When the reading is 5 – 7 mm from the bottom of the mould, the amount of water added is considered to be the correct percentage of water for normal consistency

ADMIXTURES

Admixture is defined as a material, other than water, aggregates, cement, that is added to the concrete immediately before or during mixing. Admixtures change properties of the concrete in colour, curing time, temperature range and setting time.

Concrete is being used for wide varieties of purposes to make it suitable in different conditions. Ordinary concrete may fail to exhibit the required quality performance or durability under different conditions. In such cases, admixture is used to modify the properties of ordinary concrete so as to make it more suitable for any situation.

Classification of admixtures as given by MR Rixom is:

- Plasticizers (WaterReducers)
- Super plasticizers (High Range WaterReducers)
- Retarders
- Accelerators
- Air entrainingAdmixtures
- Mineral Admixtures / PuzzolanicAdmixtures
- ChemicalAdmixtures

Plasticizers and Super plasticizers specifically developed in Japan and Germany around 1950 and later on they were made popular in USA, Europe and Middle East. Unfortunately, the use of plasticizers and Super plasticizers have not become popular in India till recently (1985).

Plasticizers (Water Reducers):

Concrete in different situations requires different degree of workability. A high degree of workability is required in case of beams, columns, beam junctions, pumping of concrete for considerable distances. One must remember that addition of excess water, will only improve the fluidity or the consistency but not the workability ofconcrete.

The easy method generally followed at the site in most of the conditions is to use extra water to overcome different situations which is un engineering practice. Today, the use of plasticizers helps the difficult conditions obtaining higher workability without using excess ofwater.

Super plasticizers (High Range Water Reducers):

Super plasticizers constitute a relatively new category and improved version of plasticizer, the use of which was developed in Japan and Germany during 1960 and 1970 respectively.

Use of Super plasticizers permits the reduction of water to the extent up to 30% without reducing the workability. The use of super plasticizer is practiced for the production of high strength and high performance concrete. Super plasticizers can produce same w/c (water cement ratio); same workability; increased strength, homogeneous character etc.

Retarders:

A retarder is an admixture that slows down the chemical process of hydration so that concrete remains plasticity and workable for a longer time. The retarders are used in casting purposes. These are also used in grouting oil wells. Oil wells are sometimes taken upto a depth of about 6000 meter deep where the temperature may be about 200°C.The spacing between the steel tube and the wall of the well are to be sealed with cement grout and to prevent the entry of gas or oil into other rock formations. For all these works cement grout is required to be in mobile condition for about 3 to 4 hours even at that high temperature without gettingset.

Accelerators:

These admixtures are added to increase the rate of strength of concrete and to reduce there required period of curing. In the past one of the commonly used materials as an accelerator was calcium chloride. The recent studies have shown that calcium chloride is harmful for reinforce concrete.

Air entraining Admixtures:

Air entrained concrete is made by mixing a small quantity of air entraining agents. These agents modify the properties of concrete regarding workability, segregation, finishing quality of concrete. Air entraining admixture is used to prevent frost scaling in concrete.

The following types of air entraining agents are used for making concrete:

- Natural woodresins
- Animal or vegetable fats and oils such as olive oil, stearic acid; oleicacid.
- Various wetting agents such as alkalisalts

Miscellaneous materials such as the sodium salts of petroleum sulphonic acids, hydrogen peroxide and aluminiumpowder

The common air entraining agents are Vinsol resin, Darex, Airalon, Orvus, Teepol, Petrosan, Cheecol etc.. Air entrained concrete was used in the construction of Hirakud dam, Koyna dam, etc.

Chemical admixtures:

Chemical admixtures are added to concrete in very small amounts mainly for reduction of water content or control of setting time.

Mineral admixtures:

Mineral admixtures (puzzolanic materials) are usually added to concrete in larger amounts to enhance the workability of fresh concrete; to improve resistance of concrete.

The term Puzzolana is derived from Pozzuoli, a town in Italy. The sand (volcanic dust) around this town, when mixed with hydrated lime was found to possess cementious properties. Puzzolanic materials can be divided into two groups such as:

Natural Puzzolanasviz clay, shales, cherts, volcanic tuff which needs further grinding and sometimes needs calcining to activate them to show puzzolanic properties. Artificial

Puzzolanas include Fly ash, Blast Furnace Slag, Silica fumes.

USES: A proper use of admixtures offers certain beneficial effects to concrete, including improved quality, acceleration or retardation of setting time, enhanced frost and sulphate resistance, control of strength development, improved workability, and enhanced finish ability.

Blast Furnace Slag consisting essentially of silicates and aluminates of calcium. The granulated material when further ground to less than 45 microns will have specific surface of about 400-600 m2/kg. The chemical con of BFS is similar to that of cement clinker.

Concrete

Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. Portland cement is the commonly used type of cement for production of concrete.

In a building construction, concrete is used for the construction of foundations, columns, beams, slabs and other load bearing elements.

There are different types of binding material is used other than cement such as lime for lime concrete and bitumen for asphalt concrete which is used for road construction.

Various types of cements are used for concrete works which have different properties and applications. Some of the type of cement are Portland Pozzolana Cement (PPC), rapid hardening cement, Sulphate resistant cement etc.

Materials are mixed in specific proportions to obtain the required strength. Strength of mix is specified as M5, M10, M15, M20, M25, M30 etc, where M signifies Mix and 5, 10, 15 etc. astheir strength in kN/m^2.

Water cement ratio plays an important role which influences various properties such as workability, strength and durability. Adequate water cement ratio is required for production of workable concrete.

Concrete can be casted in any shape. Since it is a plastic material in fresh state, various shapes and sizes of forms or formworks are used to provide different shapes such as rectangular, circular etc.

Various structural members such as beams, slabs, footings, columns, lintels etc. are constructed with concrete.

There are different types of admixtures which are used to provide certain properties. Admixtures or additives such as pozzolanas or super plasticizers are included in the mixture to improve the physical properties of the wet mix or the finished material.

Various types of concrete are manufactured these days for construction of buildings and structures. These have special properties and features which improve quality of construction as per requirement.

Tests on concrete

Tests on Fresh Concrete

WorkabilityTests

Workability of concrete mixture is measured by, Vee-bee consistometer test, Compaction factor Test, and Slump test.

1. **Concrete Slump Test**

This test is performed to check the consistency of freshly made concrete. The slump test is done to make sure a concrete mix is workable. The measured slump must be within a set range, or tolerance, from the target slump.
Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability. It can also be defined as the relative plasticity of freshly mixed concrete as indicative of its workability.

2. Aircontent

Air content measures the total air content in a sample of fresh concrete but does not indicate what the final in-place air content is, because a certain amount of air is lost in transportation Consolidating, placement, and finishing.

Setting Time

The action of changing mixed cement from a fluid state to a solid state is called –Setting of Cement‖.

Initial Setting Time is defined as the period elapsing between the time when water is added to the cement and the time at which the needle of 1 mm square section fails to pierce the test block to a depth of about 5 mm from the bottom of the mold.

Final Setting Time is defined as the period elapsing between the time when water is added to cement and the time at which the needle of 1 mm square section with 5 mm diameter attachment makes an impression on the test block.

Other tests conducted on fresh concrete are:

1. Segregation resistance
2. Unit weight
3. Wet analysis
4. Temperature
5. Heat generation
6. Bleeding

Tests on Hardened Concrete

Compressive strength

The compressive strength of concrete cube test provides an idea about all the characteristics of concrete

Tensile strength

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures. Moreover, the concrete is very weak in tension due to its brittle nature. Hence.it is not expected to resist the direct tension. So, concrete develops cracks when tensile forces exceed its tensile strength. Therefore, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

Modulus of elasticity

Modulus of elasticity of concrete is the ratio of stress to the strain of the concrete under the application of loads.

Permeability Tests on Concrete

When concrete is permeable it can cause corrosion in reinforcement in presence of oxygen, moisture, CO^2, SO^{3-} and Cl^- etc. This formation of rust due to corrosion becomes nearly 6 times the volume of steel oxide layer, due to which cracking develops in reinforced concrete and spalling of concrete starts.

In situ test on concrete

There are various in-situ test conducted on hardened concrete, both destructive and non-destructive. Some of them are concrete pull out tests, Break off tests, Schmidt Hammer test.

Other quality tests are conducted to test the following

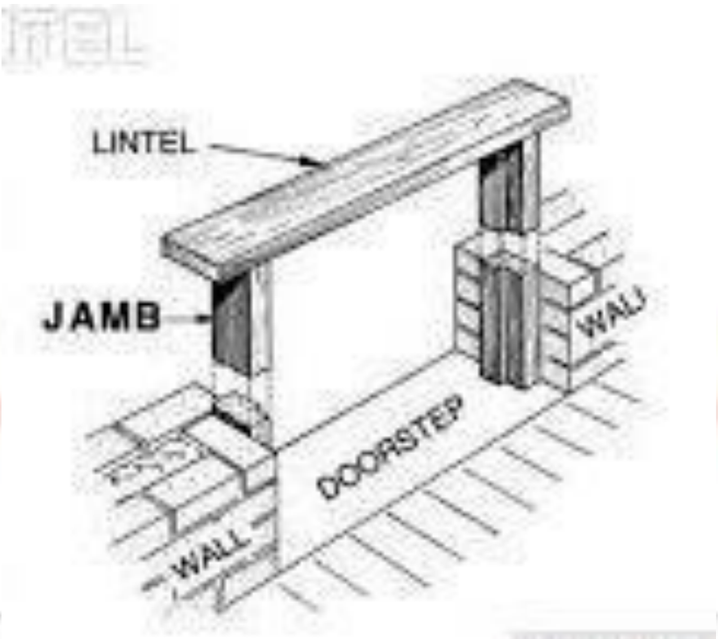
1. Modulus of rupture
2. Density
3. Shrinkage
4. Creep
5. Freeze/thaw resistance
6. Resistance to aggressive chemicals
7. Resistance to abrasion
8. Bond to reinforcement
9. Absorption

UNIT-III

BUILDING COMPONENTS AND BUILDING SERVICES

Lintel

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 are built into the wall. Lintels are classified based on their material of construction.



Bearing of Lintel

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

i. 10 cm
ii. Height of beam
iii. 1/10th to 1/12th of span of the lintel.

Types of Lintel used in Building Construction

Lintels are classified based on the material of construction as:

1. Timber Lintel

In olden days of construction, Timber lintels were mostly used. But now a days they are replaced by several modern techniques, however in hilly areas these are using. The main disadvantages with timber are more cost and less durable and vulnerable to fire.

If the length of opening is more, then it is provided by joining multiple number of wooden pieces with the help of steel bolts In case of wider walls, it is composed of two wooden pieces kept at a distance with the help of packing pieces made of wood. Sometimes, these are strengthened by the provision of mild steel plates at their top and bottom, called as flitched lintels.

Stone Lintel

These are the most common type, especially where stone is abundantly available. The thickness of these are most important factor of its design. These are also provided over the openings in brick walls. Stone lintel is provided in the form of either one single piece or more than one piece.

The depth of this type is kept equal to 10 cm / meter of span, with a minimum value of 15 cm. They are used up to spans of 2 meters. In the structure is subjected to vibratory loads, cracks are formed in the stone lintel because of its weak tensile nature. Hence caution is needed.

Brick Lintel

These are used when the opening is less than 1m and lesser loads are acting. Its depth varies from 10 cm to 20 cm, depending up on the span. Bricks with frogs are more suitable than normal bricks because frogs when filled with mortar gives more shear resistance of end joints which is known as joggled brick lintel.

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.

Steel Lintel

These are used when the superimposed loads are heavy and openings are large. These consist of channel sections or rolled steel joists. We can use one single section or in combinations depending up on the requirement.

When used singly, the steel joist is either embedded in concrete or cladded with stone facing to keep the width same as width of wall. When more than one units are placed side by side, they are kept in position by tube separators.

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.

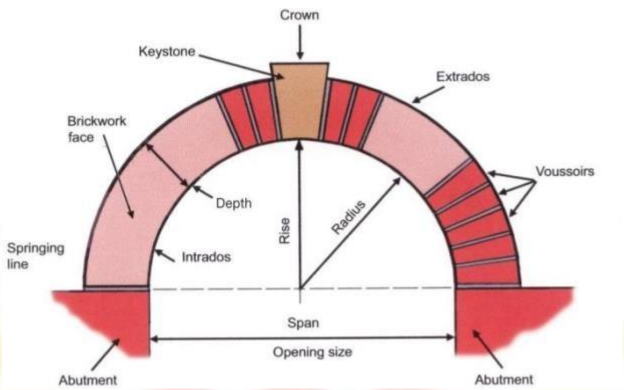
ARCH

An arch is a structure constructed in curved shape with wedge shaped units (either bricks or stones), which are jointed together with mortar, and provided at openings to support the weight of the wall above it along with other superimposed loads.

Because of its shape the loads from above gets distributed to supports (pier or abutment).

Different Components of an Arch

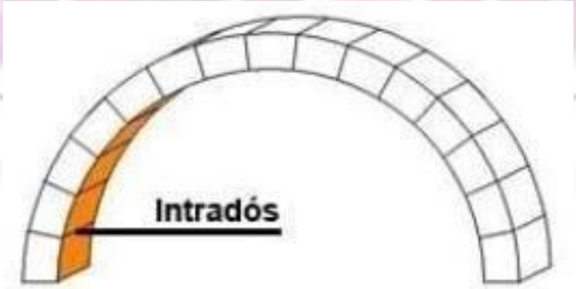
The following are the different components of arches and terms used in arch construction:



Intrados

The curve which bounds the lower edge of the arch OR The inner curve of an arch is called as intrados.

The distinction between soffit and intrados is that the intrados is a line, while the soffit is a surface.



Extrados

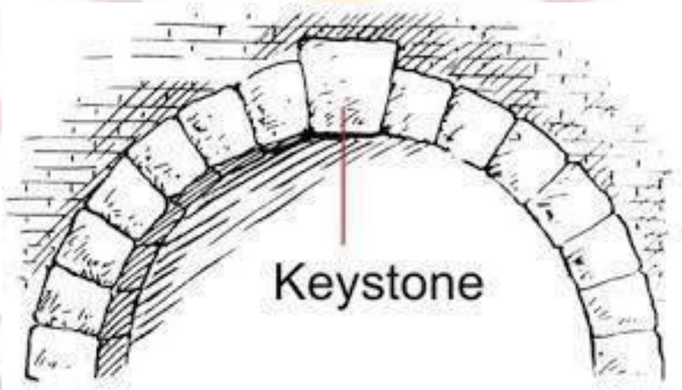
The outer curve of an arch is termed as extrados.

Crown

The apex of the arch's extrados. In symmetrical arches, the crown is at the mid span.

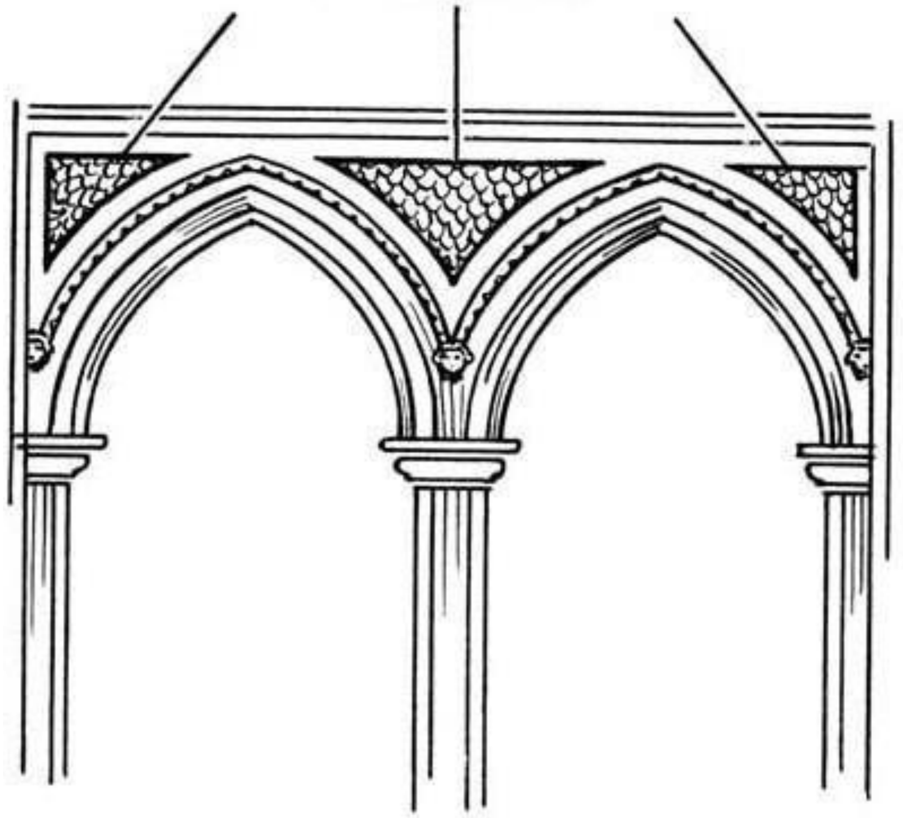
Keystone

The wedge shaped unit which is fixed at the crown of the arch is called keystone.



Spandrel in an Arch

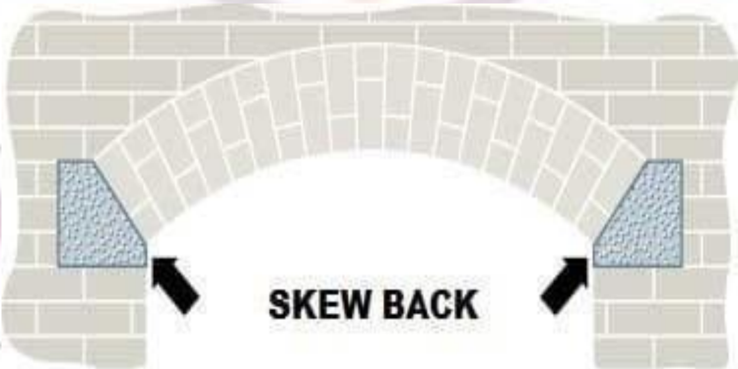
If two arches are constructed side by side, then a curved triangular space is formed between the extrados with the base as horizontal line through the crown. This space is called as spandrel.



Skew Back

The surface on which the arch joins the supporting abutment.

The upper surface of an abutment or pier from which an arch springs; its face is on a line radiating from the center of the arch.



Springing Points

The imaginary points which are responsible for the springing of curve of an arch are called as springing points.

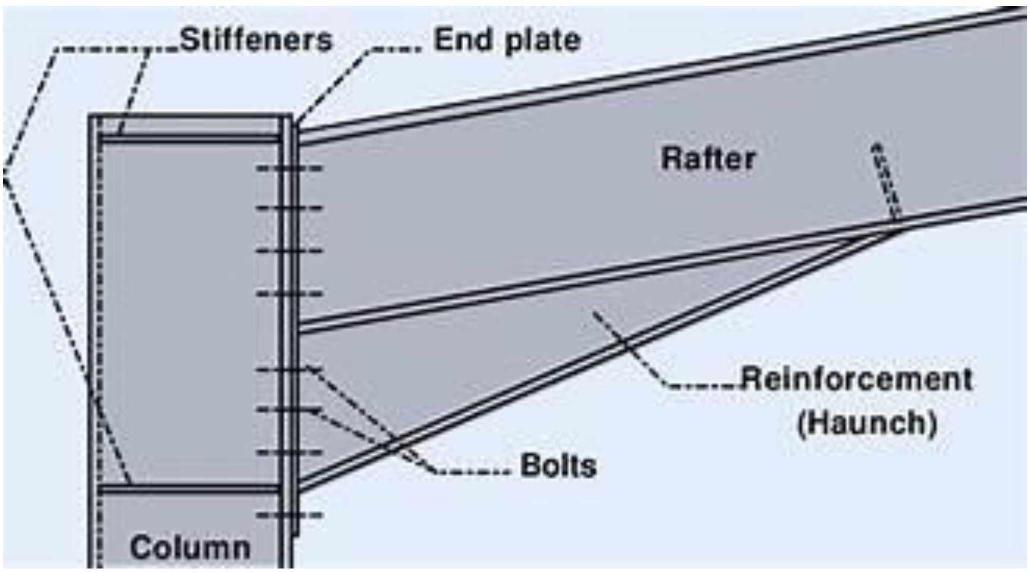
Springing Line

The imaginary line joining the springing points of either ends is called as springing line.

Springer in Arches

The first voussoir at springing level which is immediately adjacent to the skewback is called as springer.

Haunch



The lower half of the arch between the crown and skewback is called haunch. Highlighted area in the below fig is haunch.

Span of an Arch

The clear horizontal distance between the supports or abutments or piers is termed as span of an arch.

Rise of an Arch

The clear vertical distance between the highest point on the intrados and the springing line is called as rise.

Pier and Abutment of an Arch

The intermediate support of an arch is called as pier. The end support of an arch is called as abutment.

Muram or Mud Floors:

The ground floor having its topping consisting of muram or mud is called Muram or Mud Floors

These floors are easily and cheaply repairable Method of Construction:

- The surface of earth filling is properly consolidated
- 20cm thick layer of rubble or broken bats is laid, hand packed, wet and rammed

- 15cm thick layer of muram or good earth is laid
- 2.5cm thick layer of powdery variety of muram earth is uniformly spread
- The whole surface is well watered and rammed until the cream of muram earth rises to the earth surface
- After 12 hours the surface is again rammed for three days.
- The surface is smeared with a thick paste of cow-dung and rammed for two days
- Thin coat of mixture of 4 parts of cow-dung and 1 part of Portland cement is evenly applied The surface is wiped clean by hand.
- For maintaining this type of floor properly, gobri leaping is done once a week

Suitability: These floors are generally used for unimportant building in rural areas

Cement Concrete Floor:

The floor having its topping consisting of cement concrete is called Cement Concrete Floor or Conglomerate Floor Types of Cement Concrete Floor:

According to the method of finishing the topping, Cement Concrete Floor can be classified into the following two types

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

Non-monolithic or bonded floor finish concrete floor:

The type of Cement Concrete Floor in which the topping is not laid monolithically with the base concrete is known as Non-monolithic or bonded floor finish concrete floor.

Method of Construction:

1. The earth is consolidated.
2. 10cm thick layer of clean sand is spread.
3. 10cm thick Lime Concrete (1:4:8) or Lean Cement Concrete (1:8:16) is laid thus forming base concrete
4. The topping {4cm thick Cement Concrete (1:2:4)} is laid on the third day of laying base cement concrete, thus forming Non-monolithic construction.

This type of construction is mostly adopted in the field

The topping is laid by two methods:

I- Topping laid in single layer:
The topping consists of single layer of Cement Concrete (1:2:4), having its thickness 4cm

II- Topping laid two layers:
The topping consists of 1.5cm thick Cement Concrete (1:2:3), which is laid monolithically over 2.5cm thick Cement Concrete (1:3:6)

Monolithic Floor Finish Concrete Floor:

The Cement Concrete Floor in which the topping consisting of 2cm thick Cement Concrete (1:2:4) is laid monolithically with the Base Concrete is known as Monolithic Floor Finish Concrete Floor.

Method of Construction:

1. The surface of muram or earth filling is leveled, well watered and rammed
2. 10cm layer of clean and dry sand is spread over
3. When the sub soil conditions are not favorable and monolithic construction is desired, then, 5cm to 10cm thick hard core of dry brick or rubble filling is laid.
4. 10cm thick layer of Base Concrete consisting of Cement Concrete (1:4:8) or Lean Cement Concrete (1:8:16) is laid.
5. The topping {2cm thick layer of Cement Concrete(1:2:4)} is laid after 45 minutes to 4 hours of laying Base Concrete.

Tile Floor: The floor having its topping consisting of tiles is called tile floor. Method of Construction:

1. The muram or earth filling is properly consolidated.
2. 10cm thick layer of dry clean sand is evenly laid
3. 10cm thick layer of Lime Concrete (1:4:8) or Lean Cement Concrete (1:8:16) is laid, compacted and cured to form a base concrete.
4. A thin layer of lime or cement mortar is spread with the help of screed battens.
5. Then the screed battens are properly leveled and fixed at the correct height.
6. When the surface mortar is harden sufficiently, 6mm thick bed of wet cement (1:5) is laid and then over this the specified tiles are laid.
7. The surplus mortar which comes out of the joints is cleaned off.
8. After 3 days, the joints are well rubbed with a corborundum stone to chip off all the projecting edges.
9. Rubbing should not be done in case of glazed tiles.
10. The surface is polished by rubbing with a softer variety of a corborundum or a pumice stone.
11. The surface is finally washed with soap.

Suitability: This type of floor is suitable for courtyard of buildings. Glazed tiles are used in modern buildings where a high class finish is desired.

Mosaic Floors:

The floors having its topping consisting of mosaic tiles or small regular cubes, square or hexagons, embedded into a cementing mixture is known as Mosaic Floors

Method of Construction:

1. The earth is consolidated.
2. 10cm thick layer of clean sand is spread.
3. 10cm thick Lime Concrete (1:4:8) or Lean Cement Concrete (1:8:16) is laid thus forming base concrete.
4. Over this base course 5cm thick Lime Mortar or Cement Mortar or Lime and Surkhi mortar (1:2) is laid.
5. The mortar is laid in small area so that the mortar may not get dried before finishing the wearing course.
6. 3mm thick cementing mixture is spread.
7. The cementing mixture consists of one part of pozzolana, one part of marble chips and two parts of slacked lime.
8. After nearing 4 hours, patterns are formed on the top of the cementing material.
9. Now the tiles of regular shaped marble cubes are hammered in the mortar along the outline of the pattern.
10. The inner spaces are then filled with colored pieces of marble.
11. A roller 30cm in diameter and 50cm in length is passed gently over the surface.
12. Water is sprinkled to work up the mortar between the marble pieces.
13. The surface is then rubbed with pumice stone fixed to a wooden handle about 1.5m long.
14. The surface is then allowed to dry up for 2 weeks.

Double Flag Stone floor

Two layer of flagstones are used to build this type of floor, this is why it is called double flag stone floor.

Materials used to build this type of floor are –

- Flagstone (about 40 mm thickness)
- Rolled steel joist
- Rolled Steel beam (for span above 4 meter)

Procedure:
For span above 4 meter, a framework is built consist of rolled steel beam and rolled steel joist. To make formwork, beam are place at 10 feet centre to centre distance then joists are placed at right angle to the beam. And then two layers of flagstone are fixed with the joist. One layer is at top flanged of joist and another layer is at bottom flanged of joist. The gap between the two layers of flagstone is filled with earth or concrete before fixing the top layer of flagstone.

Jack arch floor

You'll find the following components/materials in this type of floor –

- Arch (brick arch or concrete arch)
- Rolled steel joist

- Rolled steel beam
- Wall
- Tie rod

Mechanism

Joists are placed on wall or beam and tied together with the tie rod. And then concrete arches or brick arches are constructed and rest on lower flanged of Joists.

Non-Composite Floor

Non composite type of floors are those which are built using one material only. Mostly used material for non-composite floor is timber.

Timber floor can further be divided into 3 types

- Single joist floor
- Double joist floor
- Tripple joist floor,

Floor board: Floor board are fixed at the top of bridging joist. It acts as the wearing of the top surface of the floor.
Floor ceiling: To make the bottom of the floor flat and increasing the aesthetic look floor ceiling is provided. For this purpose plaster board or sheet of asbestors or some other suitable materials are used. Floor ceiling rests on bridging joist. To make the ceiling more durable and strong ceiling joist may be provided at the right angle to the bridging joist.

Single joist floor

In this type of floor single joist is placed below floor board. This joist is supported by wall-plate at both end.

Double joist floor

In this type of floor binders are provided to support the bridging joist. Binders are then rest on the walls at both end.

Triple joist floor

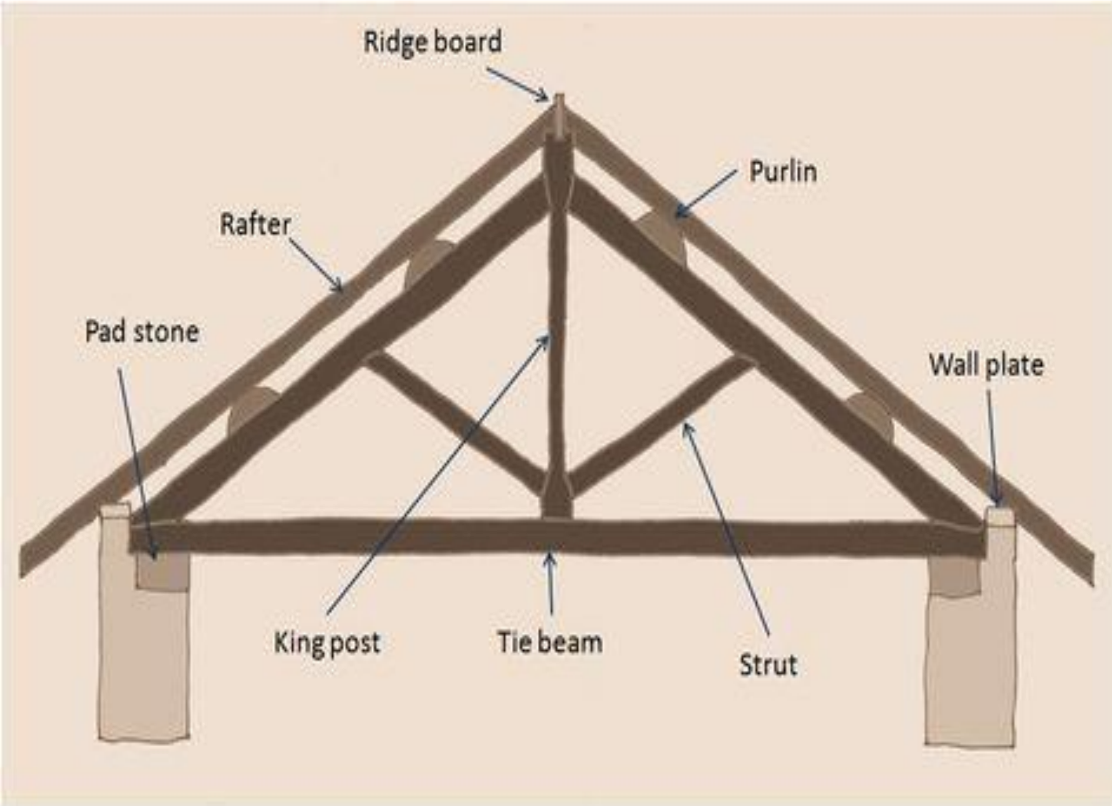
Triple joist floor is also called framed timber floor. In this type of floor another member is added that is girder, which we didn’t use in double joist floor.
These girders are placed on the wall to support the binders. And then joist are placed on the binders.

Roof truss

A roof truss is basically a structure that includes one or multiple triangular units that include straight slender members with their ends connected via nodes.

King Post Truss

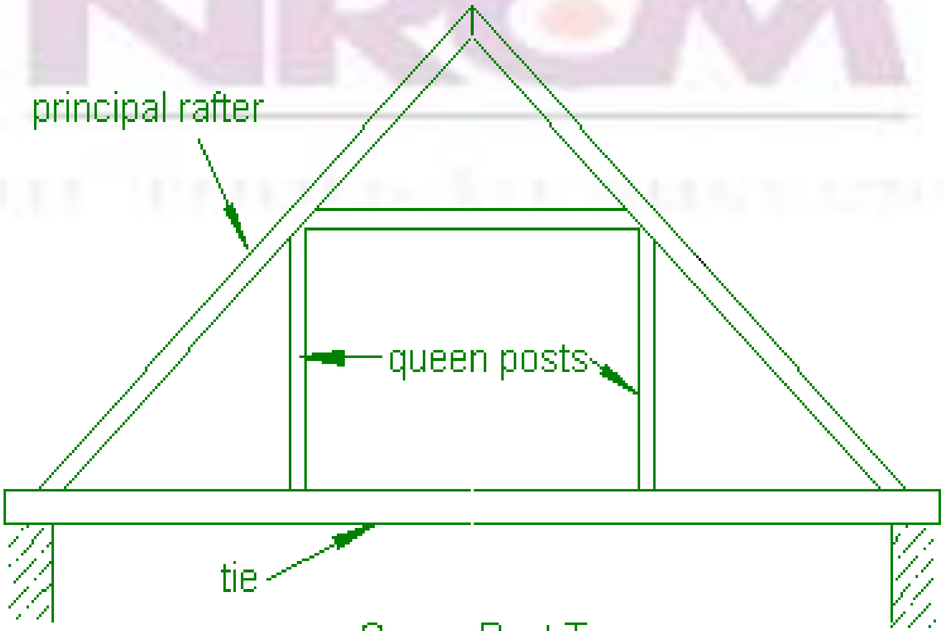
This particular truss is made out of wood most of the time, but it can also be built out of a combination of steel and wood. It all comes down to the architect and the building structure. The King Post Truss spans up to 8m, which makes it perfect for multiple types of houses, especially the smaller one.



Queen Post Truss

The Queen Post Truss is designed to be a very reliable, simple and versatile type of roof truss that you can use at any given time.

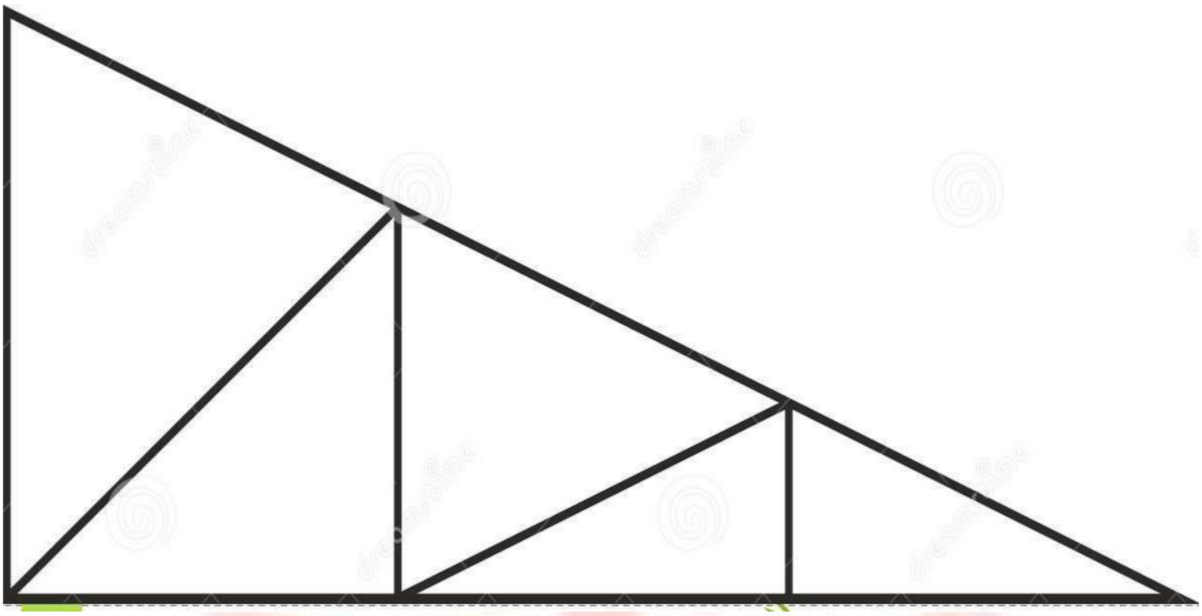
It offers a good span, around 10m, and it has a simple design which makes it perfect for a wide range of establishments.



Queen Post Truss

North Light Roof Truss

The North Light Roof Truss is suitable for the larger spans that go over 20m and get up to 30m. This happens because it's cheaper to add a truss that has a wide, larger set of lattice girders that include support trusses.



This method is one of the oldest, as well as most economical ones that you can find on the market, as it allows you to bring in proper ventilation. Plus, the roof has more resistance too because of that.

If you are looking for types of roof trusses design that bring in durability and versatility, this is a very good one to check out. You can use it for industrial buildings, but this truss also works for drawing rooms and in general those spaces that are very large.

FOUNDATIONS

Foundations are classified as shallow and deep foundations. Types of foundations under shallow and deep foundations for building construction and their uses are discussed.

Types of Foundation and their Uses

Following are different types of foundations used in construction:

1. Shallow foundation
   i. Individual footing or isolated footing
   ii. Combined footing
   iii. Strip foundation
   iv. Raft or mat foundation

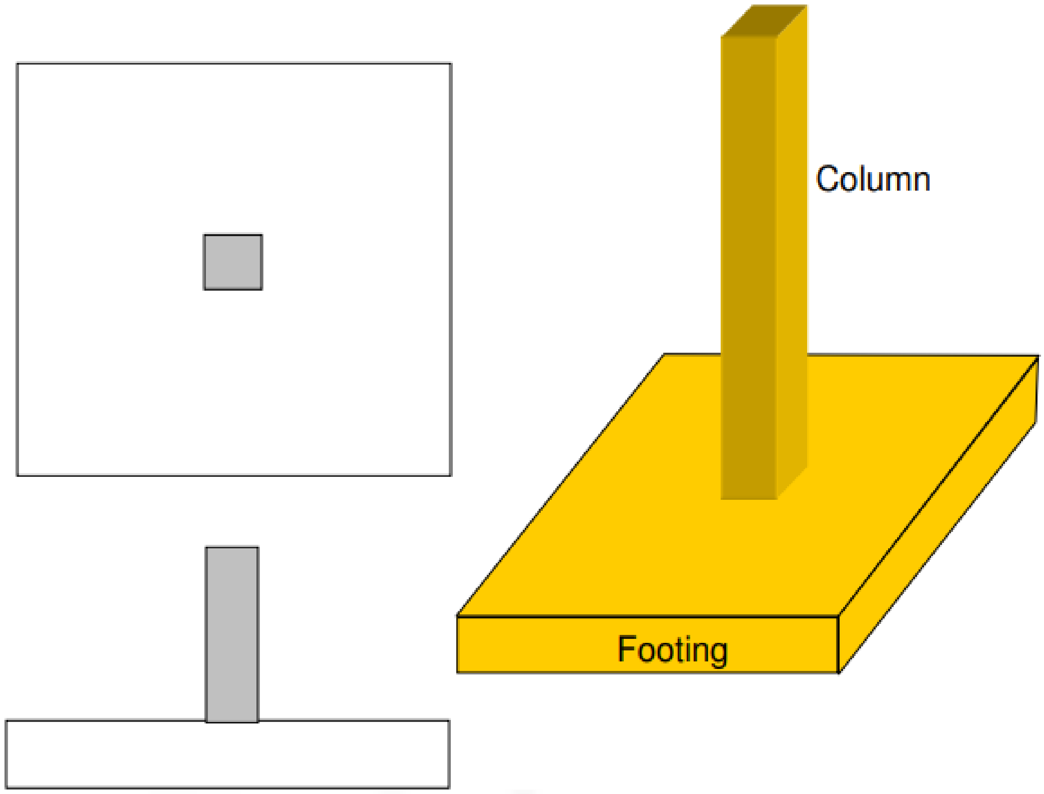
2. Deep Foundation
   i. Pile foundation

ii. Drilled Shafts or caissons

TypesofShallowFoundations

i. Individual Footing or Isolated Footing

Individual footing or an isolated footing is the most common type of foundation used for building construction.
This foundation is constructed for single column and also called as pad foundation.
The shape of individual footing is square or rectangle and is used when loads from structure is carried by the columns.
Size is calculated based on the load on the column and safe bearing capacity of soil.



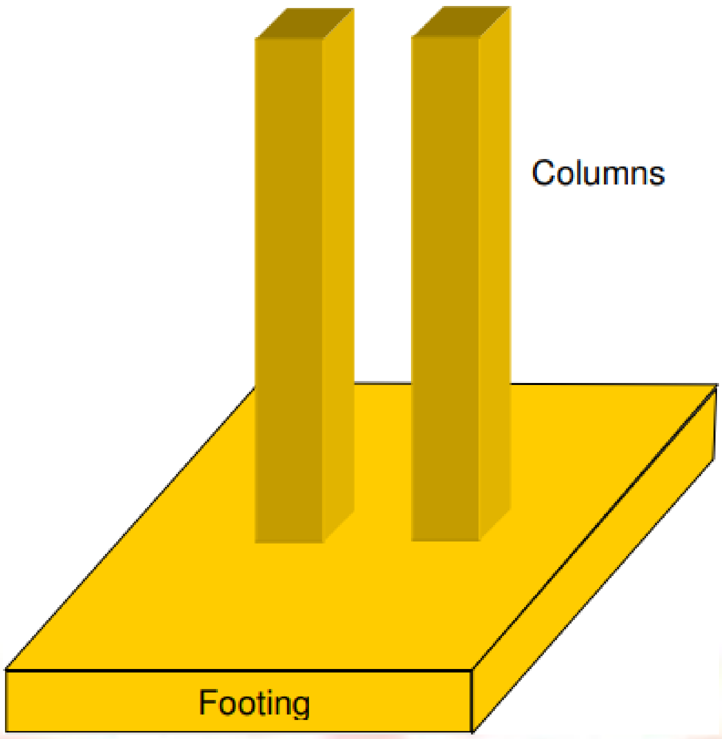
Rectangular isolated footing is selected when the foundation experiences moments due to eccentricity of loads or due to horizontal forces.

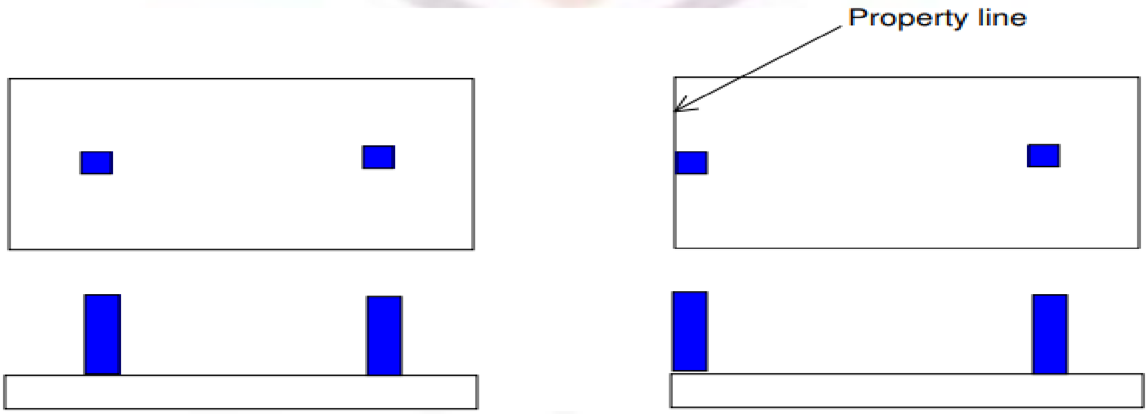
For example, Consider a column with vertical load of 200 kN and safe bearing capacity of 100 kN/m^2 then the area of the footing required will be 200/100 = 2m^2. So, for a square footing, length and width of footing will be 1.414 m x 1.414 m.

2. Combined Footing

Combined footing is constructed when two or more columns are close enough and their isolated footings overlap each other. It is a combination of isolated footings, but their structural design differs.

The shape of this footing is rectangle and is used when loads from structure is carried by the columns.





3. Spread footings or Strip footings and Wall footings

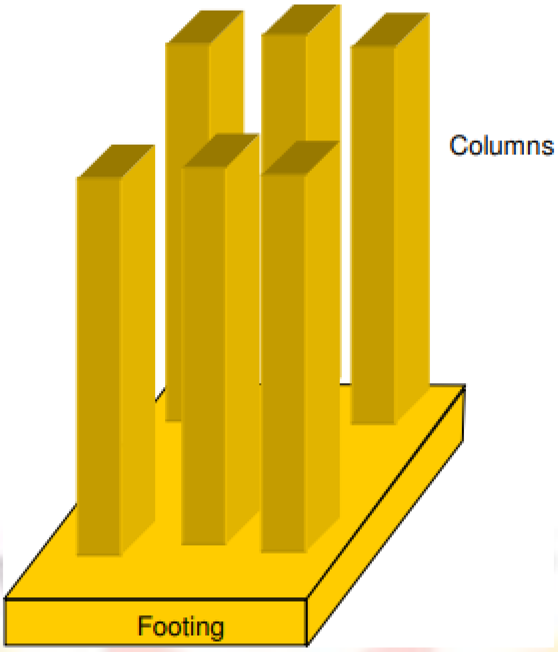
Spread footings are those whose base is more wider than a typical load bearing wall foundations. The wider base of this footing type spreads the weight from the building structure over more area and provides better stability.

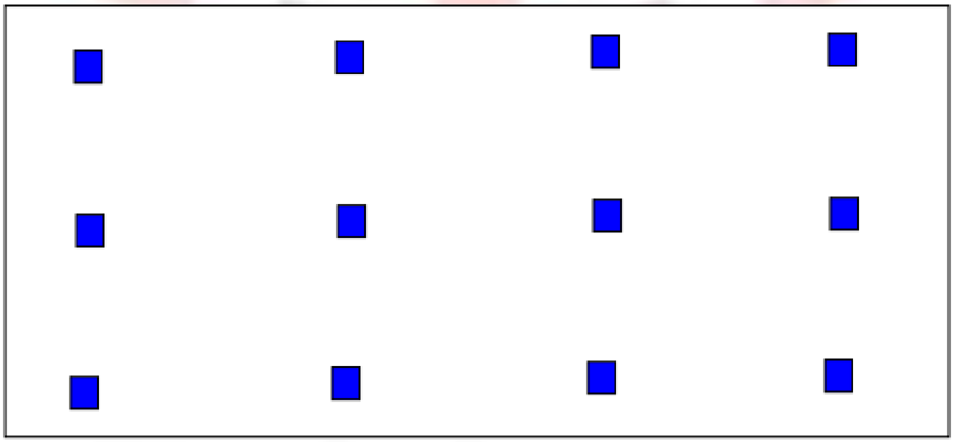
Spread footings and wall footings are used for individual columns, walls and bridge piers where the bearing soil layer is within 3m (10 feet) from the ground surface. Soil bearing capacity must be sufficient to support the weight of the structure over the base area of the structure.

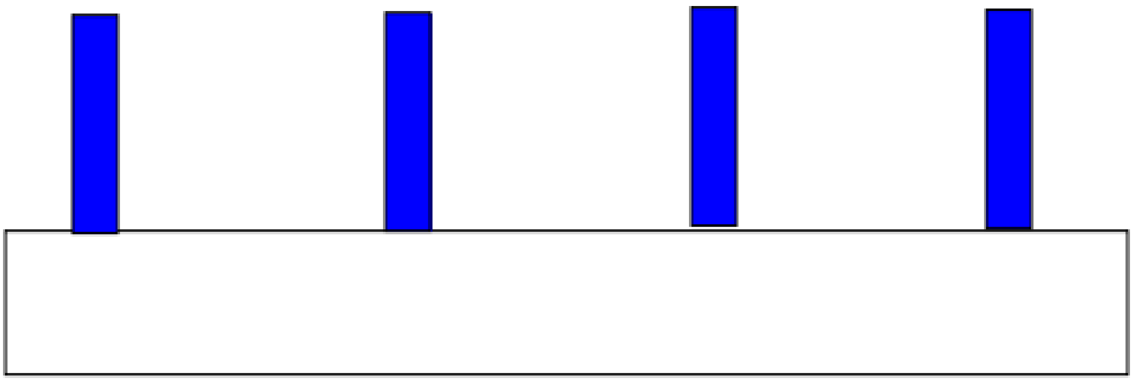
These should not be used on soils where there is any possibility of ground flow of water above bearing layer of soil which may result in scour or liquefaction.

4. Raft or Mat Foundations

Raft or mat foundations are the types of foundation which are spread across the entire area of the building to support heavy structural loads from columns and walls.







The use of mat foundation is for columns and walls foundations where the loads from structure on columns and walls are very high. This is used to prevent differential settlement of individual footings, thus designed as a single mat (or combined footing) of all the load bearing elements of the structure.

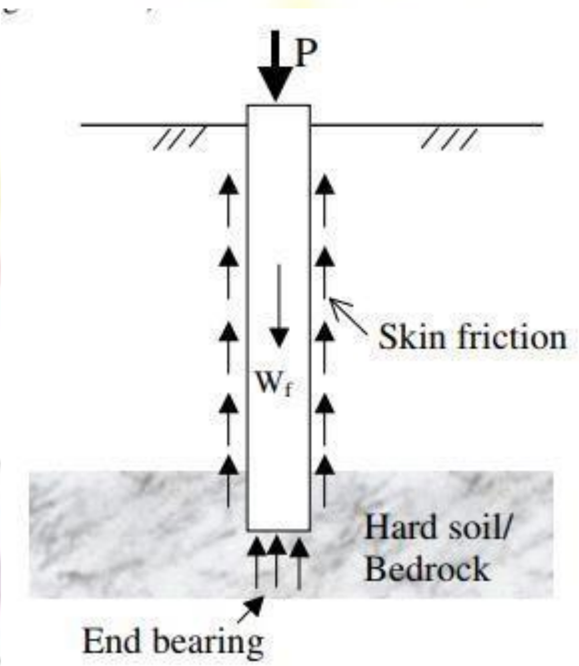
It is suitable for expansive soils whose bearing capacity is less for suitability of spread footings and wall footings. Raft foundation is economical when one-half area of the structure is covered with individual footings and wall footings are provided.

These foundations should not be used where the groundwater table is above the bearing surface of the soil. Use of foundation in such conditions may lead to scour and liquefaction.

Types of Deep Foundation

Pile Foundations

Pile foundation is a type of deep foundation which is used to transfer heavy loads from the structure to a hard rock strata much deep below the ground level.

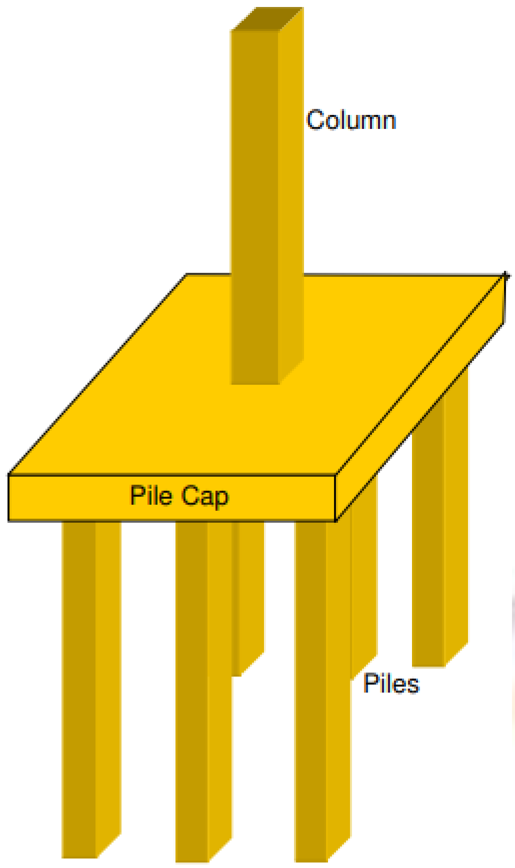


Pile foundations are used to transfer heavy loads of structures through columns to hard soil strata which is much below ground level where shallow foundations such as spread footings and mat footings cannot be used.

This is also used to prevent uplift of structure due to lateral loads such as earthquake and wind forces.

Pile foundations are generally used for soils where soil conditions near the ground surface is not suitable for heavy loads. The depth of hard rock strata may be 5m to 50m (15 feet to 150 feet) deep from the ground surface.

Pile foundation resists the loads from structure by skin friction and by end bearing. Use ofpile foundations also prevents differential settlement of foundations.



Pile Foundation

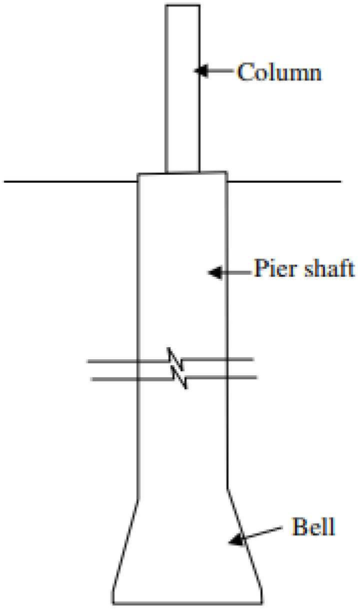
Drilled Shafts or Caisson Foundation

Drilled shafts, also called as caissons, is a type of deep foundation and has action similar to pile foundations discussed above, but are high capacity cast-in-situ foundations.

It resists loads from structure through shaft resistance, toe resistance and / or combination of both of these. The construction of drilled shafts or caissons are done using an auger.

Drilled shafts can transfer column loads larger than pile foundations. It is used where depth of hard strata below ground level is location within 10m to 100m (25 feet to 300 feet).

Drilled shafts or caisson foundation is not suitable when deep deposits of soft clays and loose, water-bearing granular soils exist.
It is also not suitable for soils where caving formations are difficult to stabilize, soils made up of boulders, artesian aquifer exists.



Pier Foundation (Caisson)

UNIT-IV

MORTARS, FINISHERS AND FORMWORK

1. MORTAR

Several different tests are needed to estimate the stability and strength of a structure, from the soil it will stand on to the bricks or concrete that will form it. But what about mortar, the material that binds it all together? There are a variety of ways to perform mortar testing, many of which aresimilar to how you would test aggregates, concrete or cement.

1.1 Types of Mortar:

1. Cement Mortar
2. Lime Mortar
3. Surki Mortar
4. Gauged Mortar
5. Mud Mortar

Cement Mortar

Cement mortar is a type of mortar where **cement** is used as binding material and **sand** is used as fine aggregate. Depending upon the desired strength, the cement to the sand proportion of cement mortar varies from **1:2 to 1:6**.

Lime Mortar

Lime mortar is a type of mortar where **lime** (fat lime or hydraulic lime) is used as binding material and **sand** is used as fine aggregate. The lime to the sand proportion of cement mortar is kept 1:2. The pyramids at Giza are plastered with lime mortar.

Gauged Mortar

Gauged mortar is a type of mortar where **cement and lime** both are used as binding material and **sand** is used as fine aggregate. Basically, it is a **lime mortar** where cement is added to gain higher strength. The process is known as **gauging**. The **cement to the lime** proportion varies from 1:6 to 1:9. **Gauged mortar** is **economical** than cement concrete and also possess **higher strength** than lime mortar.

Surki Mortar

Surkhi is **an artificial pozzolanic material (i.e. Pozzolans** are a broad class of siliceous or siliceous and aluminous materials which, in themselves, possess little or no cementitious value but which will, in finely divided form and in the presence of water, react chemicallywith calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties **(**The **pozzolanic reaction** is the chemical reaction that occurs in portland cement uponthe addition of pozzolans) **made by powdering bricks or burnt clay balls**. Surkhi is used for making waterproof cement mortars and concrete. They also make the concrete more resistant to alkalis and salt solutions. Surkhi is used as a substitute for sand for concrete and mortar, and has almost the same function as of sand but it also imparts some strength and hydraulicity.Surkhi is made by grinding to powder burnt bricks, brick-bats or burnt clay; under-burnt or over- burnt bricks should not be used, nor bricks containing high proportion of sand. When clay is especially burnt for making into surkhi, an addition of 10 to 20 per cent of quick lime will improve its quality; small clay balls are made for burning.

Surki mortar is a type of mortar where **lime** is used as binding material and **surki** is used as fine aggregate. **Surki mortar** is economic.

Mud Mortar

Mud mortar is a type of mortar where **mud** is used as binding material and **sawdust**, **rice husk** or **cow-dung** is used as **fine aggregate**. Mud mortar is useful where lime or cement is not available.

Is Mortar Testing Necessary?

While there are ASTM methods specifically designed for masonry mortar testing, there is not a code requirement for testing mortar. Neither the International Building Code (IBC) nor the Masonry Building Code call for mortar testing on job sites or in labs. Some specifiers will still call for mortar strength testing, so it can be performed on a case-by-case basis. Mortar may only play a small part in contributing to structural capacity, but it's still important to determine whether it meets the physical property requirements of a project, including strength.

1.2 *Types of Mortar Testing*

There are several tests that can be performed on both plastic and hardened mortar to determine ideal mix ratios and strength. The tests listed below are a high-level overview, so be sure to consult ASTM C 780, which outlines the specifics of each, to help you learn more about a mortar sample's physical properties.

1. Air Content

Air content tests are commonly specified for concrete and cement in areas that are prone to frost they can also be specified for mortar. Repetitive tests using pressure meters or "roll-o-meters" help determine if air content levels change due to mixing consistency and mixing time in order tofind the ideal level of air content both in the field and in the lab.

2. Board Life

Board life is an especially crucial form of mortar testing because it describes the time frame of usability for mortar after it's removed from a mixer and placed on a mortarboard. Mortar begins to **lose moisture** and **stiffen** once it's in **open air**, so it needs to be placed quickly to ensure it bonds properly. While time frame determination is important, this test also reveals whether mortar will be acceptable for use once completely hardened — if it's too stiff, it won't work.

3. Compressive Strength

Compressive strength tests are performed on mortar once it has hardened, and can help determine the load a sample will be able to bear. These tests are better suited to a laboratory since field testing may indicate less approximate mortar strengths.

4. Consistency

Consistency testing helps identify variations between batches of mortar mix, both in mix materials and mix time. Mortar testing equipment, like a mortar penetrometer, is generally usedto determine consistency based on the depth it can penetrate into the mortar sample. While inconsistent batches don't indicate that the materials used are improper, they can suggest that poor control was exercised during mortar batching and mixing.

5. Mortar-Aggregate Ratio

This test helps determine whether cement, sand and water are added properly and consistently to each batch of mortar, a bit like the consistency test. But, while the tests might be similar, mortar-aggregate ratio testing is performed solely in a laboratory, after mortar mix samples are obtained from a job site and sent in to be measured.

***6.* Water Retention**

Water retention tests measure the plastic life of mortar. The longer the plastic life, the greater the amount of time a mason has to lay and adjust the mortar/masonry unit before the mortar hardens. These tests are performed in a laboratory.

1. WALL FINISHES:

1.1 PLASTERING:

Definition of Plastering:

plastering is a layer provide over masonry or concrete surface for the purpose of protect wall and other concrete element against the atmospheric effect, and also provide finishing surface.

Purpose of Plastering

1) Plastering is a method that is used to increase the durability of the wall. The purpose of plasteringis to decorate the structures of the walls. Plastering of external walls refers to the process of covering the uneven surface and rough walls with the help of a plastic material named as plaster.

2) The plaster is prepared by mixing sand and lime or cement concrete along with water. There are various requirements of a plaster that must be fulfilled while doing plastering of external walls.

3) To prevent water ingress into brickwork / blockwork, since both bricks and blocks absorb water from outside. This is the reason why most stoneworks are left un-plastered.

4) In case of walls - to make up the issues in underlying brickwork / blockwork - like plumb-outs, diagonal-outs, etc.

5) To prepare a proper base for further painting works (Putty application, paint application, wall paper application, etc.)

Requirement of Good Plaster

-The surface of plaster should be smooth

-The surface of plaster should be non-absorbent

-The plaster surface should not wash by water

-Plaster should not shrink when it dries or freezes

-The shrinkage cracks is not developed in plaster

-The plaster should be firmly attached to the masonry surface

-The fire resistance of plaster should be good

-The plaster should be sound insulated

-The surface of the plaster should be paintable

Methods of Plastering

Plater is applied in the manner mention below. To get uniform 150 x 150 mm and 10 mm thick dots are prepared on the surface at a lower level.

Those dots are transferred on the upper level with a plumb bob, so the dots of the upper level and lower come in one and vertical surface.

In this, any dots are applied on all the surface of the wall at 1500 to 2000 mm. Four dots are covered masonry with the help or screed, and plaster is applied properly. Lime plaster is applied in these coats or in three coats or in two cots. The background is prepared before applying plaster.

Different Layers of plaster:

1) **Three Coat Plaster**
    - Application of Rendering Coat
    - Application of Floating Coat
    - Application of Finishing Coat
2) **Two Coat Plaster**
3) **Cement Plaster and Cement Lime Plaster**
4) **Single Coat Plaster**
5) **Plaster on Lath**
    - Wooden Laths
    - Metal Lath

Three Coat Plaster

The procedure of applying three-coat plaster is similar to two-coat plaster only difference is that an intermediate coat is known as a floating coat. The purpose of this coat is to bring the plaster toan even surface. In the case of 3-coat plaster, the first coat is known id rendering coat, the secondcoat is known as a floating coat, and third coat is known as setting coat or finishing coat. The rendering coat is applied, and scratches are made. The floating coat is applied, and after seven daysfinished coat is applied, after 6 hours of applying a floating coat.

-Application of Rendering Coat

The mortar is applied forcibly on the surface of wall. With masons trowel and pressed well into joints and over the surface. The thickness of the coat should be such as to cover all inequalities of the surface normally this thickness is 12mm.

This coat is allowed to harden slightly a then scratch marks are made on the surface with the helpof trowel ledge. During this period, the surface is curved and then allowed to dry completely

-Application of Floating Coat

The first coat is prepared properly to apply the second coat, i.e., a floating coat. All dirt and dust are cleared. It is wetted properly. 10 cm wide strips or 15 cm x 15 cm patches are applied at a suitable distance. These patches or strips act as a gauge for thickness or floating coat. The mortaris dashed with mason’s trowel, spread, and rubbed to the required plain surface with a wooden float. The floating coat is beaten with floats edge at the close spacing of cm. Then it is allowed todry completely. The thickness or floating coat is 6 to 9 mm.

-Application of Finishing Coat

The third coat is called a finishing coat. In the Case of lime-sand mortar, the finishing coat is applied immediately after the floating coat cream of lime and sand in 4:1 are applied with a steel trowel and rubbed and finished smooth.

1) Two Coat Plaster

The joints are ranked at a depth of 20 mm. The surface is cleaned, and water is sprinkled propertyon it.Before the first coat is applied preliminary coat is applied to make an uneven surface in le. Then, the first coat is applied. The first coat is racked as a rendering coat. The thickness first coatis kept 2 to 3 mm less than a total thickness of plaster. To maintain interim thickness and verticallyof plaster 15 cm * 15 cm dots or are provided, Then a vertical strip of mortar known as the spreadis formed at a distance of 2 m. spacing.Then the spaces between screeds are filled with mortar andproperly finished.Scratches are made on rendering coat to provide mechanical key before ithardens. The rendering coat is watered for 2 days and then dried.

Before applying the final/coat, the rendering coat is damped well. The final coat is applied with wooden floats to a true even surface with steel trowels. The thickness of the final coat may vary from 2 to 3 mm.

Single Coat Plaster

This is used only in interior quality work. It is applied similar to two coat plaster except that the rendering coat as applied fro two-coat plaster is finishing off immediately after it has sufficiently hardened

Cement Plaster and Cement Lime Plaster

For interior work single coat plaster is applied. For good quality works, either two coat or three coat plaster is applied. But two coat plaster is more common sow shall discuss it first.

Plaster on Lath

Thin partition walls and ceilings are plastered using laths. Laths are provided as a foundation to receive plasterwork. Laths may be.

-Wooden laths

-Metal laths

Wooden laths are well seasonal wooden strips 25 mm wide and 1 to 1.2 m long. Wooden laths are used and ceilings.Laths are fixed in a parallel line with a clear spacing of 10 mm and secured to the surface with galvanized iron nails.

Metal laths are available under various patent names. The plain expanded metal lath(exam) is commonly metal laths are fixed to the surface by G.I Staples.In the case of concrete or masonry surfaces, wooden plugs have to be embedded for fixing the lath. After fixing the lath, the surface is plastered, usually, in there coats, cement mortar is usually used.

<u>Plaster Defects and their Solution</u>:

Plaster is a common material used in construction all around the world. Easy to work with and also easier to repair. However, there will be times when your plaster starts to show signs of wear and tear or other problems.If the plaster quality is not good enough it can cause many problems later.**1).**

Blistering of Plastered Surface

Blistering is the formation of small patches of plaster, swelling out beyond the plastered surface, arising due to late slaking (addition of water to lime) of lime particles in the plaster. This defect is usually caused due to the uneven mixing of plaster.

How to prevent it: This can be prevented by ensuring appropriate mixing between cement and its components used to form plaste

Plaster De-bonding

De-bonding occurs when a plaster is separated from the wall. It can be caused by an excessively thick plaster layer, inadequate substrate preparation or may be due to a dusty, oily or dry substrate.

How to prevent it: To prevent de-bonding of plaster, we need to take care of the following things during plastering.

- Remove dust & oil from the substrate before plastering.
- Allow substrate to reach correct moisture content.
- If necessary, you should use bonding chemical.

Cracks on Plastered Surface

One of the most common problems you would have observed in plastering is the crack. Cracks on the plastered surface can be in different forms:

Crazing – It is a network of fine cracks like spider web. They are usually very fine and do not extend through the whole depth of the plaster. It occurs due to presence of excess fine content in the sand or due to dry base on which plaster is applied – when base absorbs the water and fines accumulate on the surface, it leads to crazing.

Separation crack at joints – It usually occurs at joints of two different materials for example at junction of RCC & Brick work. It occurs due to differential thermal movement.

Crack with Hollowness – This crack occurs due to hollowness in plaster. Other reasons could be extra water in the plaster mix or due to poor workmanship.

How to prevent it: Mainly cracks occur due to bad workmanship or expansion and shrinkage in the plaster during drying. Below are few tips to prevent cracks:

- Ensure the addition of water in mortar done is by skilled mason and not by unskilled labour to ensure desired workability in terms of handling and application.
- It can be avoided by proper curing of the plaster in order to slow down any rapid drying.
- Taking care of workmanship and material quality issues will help in preventing cracks.

Efflorescence on Plastered Surface

When a newly constructed wall dries out, the soluble salts are brought to the surface and they appear in the form of a whitish crystalline substance. This is called efflorescence. Efflorescence is formed on plasters when soluble salts are present in plaster making materials as well as building materials such as bricks, sand, cement etc. Even water used in the construction work may contain soluble salts. It seriously affects the adhesion of paint with the wall surface and causes further problems.

How to prevent it:

All Construction materials used for wall should be free from salt.

Ensuring that the surface is moisture-free.

5). Falling Out of Plaster

This defect can happen in two forms – Flaking of plaster and peeling off plaster.

- Flaking of plaster: The formation of a small loose mass on the plastered surface is known as flaking. It is mainly due to bond failure between successive coats of plaster.
- Peeling off plaster: The plaster from some portion of the surface comes off and a patch is

formed. This is termed as peeling. It is also mainly due to bond failure between successive coats of plaster.

How to prevent it: Both defects can be prevented with proper material selection and surface preparation. Imperfect adhesion can be minimized by good workmanship.

6) **Popping of Plaster**

Popping is the formations of conical like holes that break out of the plaster. It is caused due to the presence of contaminant particles such as burnt lime or other organic materials in the mix of mortar.

How to prevent it: To prevent popping in plastering, you need to ensure that no contaminant particles are present in the mortar mix.

7) **Loose Plaster**

When the plaster gets displaced on external impacts like application of material or tapping, etc, itis termed as loose plaster. This is caused mainly due to improper mixture and inadequate curing.

How to prevent it: Good workmanship will help in avoiding this problem.

Apart from the above defects, Uneven or undulation also occurs at plastered surface. The plastered surface should be in perfect plumb and without any undulations. Unevenly plastered surface happens due to poor workmanship2 of the plastering work.

1.2 POINTING:

Definition of pointing: Pointing is the finishing of mortar joints in brick or stone masonry construction. Pointing is the implementing of joints to a depth of 10 mm to 20 mm and filling it with better quality mortar in desired shape. It is done for cement mortar and lime mortar joints.

Purpose of pointing:

Pointing is adopted due to the following purposes.

* For the protection of exposed surface from adverse effects due to atmospheric action like rain, sun, wind, snow etc.
* To hide the interior mortar and inferior quality.

* To develop a decorative impact or to enhance the appearance.

Methods of pointing:

*Mortar joints of the surface (Brick Masonry or Stone Masonry) to be pointed are raked out to a depth of about 13 to 20 mm.

*The raked joints are cleaned from loose mortar and completely wetted. Mortar is taken in smallflat rectangular plates made of iron.

*Pointing should be finished as per the expected finishing with the help of the particular tool.

*Curing should be done on the pointed surface for at least three days in case of lime mortar and ten days in case of cement mortar.

Types of pointing:

Flush Pointing

Flush pointing is the most accessible type of pointing and is generally utilised in brick masonry and stone masonry. In flush pointing, mortar is pushed into the raked joints and joints are made flush with the edge of the stone or brick to provide a uniform appearance.

After that, with the help of a trowel and straight edge, edges are precisely trimmed. This type of pointing doesn’t have a good appearance, but it doesn’t have any space for dust and water which make it long-lasting.

Recessed Pointing

Recessed pointing has a vertical pointing face and provides a better appearance. A recessed pointing mortar is pushed back inside the surface of the wall with a vertical pointing face with the help of a suitable pointing tool.

Beaded Pointing

Beaded pointing is made with the help of a steel or iron rod having a concave edge. Beaded pointing provides a better appearance, but it is susceptible to damage and maintenance is difficult.

Struck Pointing

In struck pointing, have inclined or sloping pointing face as shown in the image. The upper edge of the joint is about 3 to 6 mm pushed back inside from the face of the brick.This joint helps to dispose of water quickly. When the lower edge of the joint is kept inside from the face of brick or stone, it is called overhand struck pointing. But it will not make an adequate joint because water may collect in the joint.

Rubbed, Keyed or Grooved Pointing

In tuck pointing, a channel or groove of 5mm width and 3 mm depth is created at the middle of the mortar joint. Then the groove or track is packed up by white cement putty having a projectionof 3 mm. If the node is made in the mortar, it is known as bastard pointing or half – tuckpointing.

Tuck Pointing

In this case mortar is pressed in the raked joint first and finishing flush with the face.While the pressed mortar is green, groove or narrow channel is cut in the center of groove which is having 5mm width and 3mm depth. This groove is then filled with white cement putty, kept projecting beyond the face of the joint by 3 mm. if projection is done in mortar, it is called bastard pointing or half tuck pointing.

V- Grooved Pointing

This type of point is similar to keyed or grooved pointing except that instead of a normal groove,v groove is formed using a suitable shaped steel rod.

1.3 DISTEMPERING:

Distemper: Distemper is a water based paint in which the binding medium consists essentially of either glue or casein, or similar sizing material. The major constituents of distemper are chalk, lime, water and some coloring agents if necessary. They are also known as cement paint. This is called so because such kind of paint can be applied directly on cement walls without any other coating on them. They are a cheaper option and they stay good for more than 5 years. Distempers are used for both interior and exterior walls usually needing two coatings.

Ingredients of Distemper:

Distemper is composed of base, carrier, colouring pigments and size. For base, the whiting or chalkis used and for carrier, the water is used. Thus it is more or less a paint in which whiting or chalkis used as base instead of white lead and the water is used as carrier instead of linseed oil.

The distempers are available in powder form or paste form. They are to be mixed with hot water before use. The oil-bound distempers are a variety of an oil paint in which the drying oil is so treated that it mixes with water. The emulsifying agent which is commonly used is glue or casein. As the water dries, the oil makes a hard surface which is washable.

It should be remembered that most of the manufacturers of ready-made distempers supply complete directions for use of their products. These directions are to be strictly followed to achieve good results.

Properties of Distempers:

(i) On drying, the film of distemper shrink. Hence it leads to cracking and flaking, if the surface to receive distemper is weak.

(ii) The coatings of distemper are usually thick and they are more brittle than other types of water paints.

(iii) The film developed by distemper is porous in character and it allows water vapour to pass through it. Hence it permits new walls to dry out without damaging the distemper film.

(iv) They are generally light in colour and they provide a good reflective coating.

(v) They are less durable than oil paints.

(vi) They are treated as water paints and they are easy to apply.

(vii) They can be applied on brickwork, cement plastered surface, lime plastered surface, insulating boards, etc.

(viii) They exhibit poor workability.

(ix) They prove to be unsatisfactory in damp locations such as kitchen, bathroom, etc.

Process of Distempering:

The application of distemper is carried out in the following way:

(1) Preparation of Surface:

The surface to receive the distemper is thoroughly rubbed and cleaned.

The important facts to be kept in mind are:

(i) The new plastered surfaces should be kept exposed for a period of two months or so to dry out before distemper is applied on them. The presence of dampness on the surface results in failure ofdistemper coating.

(ii) The surface to receive distemper should be free from any efflorescence patches. These are tobe wiped out by clean cloth.

(iii) The irregularities such as cracks, holes, etc. of the surface are to be filled by lime putty or gypsum and allowed to become hard before distemper is applied on the surface.

(iv) If distemper is to be applied on the existing distempered surfaces, the old distemper should be removed by profuse watering.

(2) Priming Coat:

After preparing the surface to receive the coats of distemper, a priming coat is applied and it is allowed to become dry. For ready-made distempers, the priming coat should be composed of materials as recommended by the makers of distempers. For local made distempers, the milk is used for priming coat. One litre of milk will cover about 10 m2 of the surface.

(3) Coats of Distemper:

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

Following facts are to be remembered:

(i) The distempering should be done in dry weather to achieve better results.

(ii) The oil-bound distemper or washable distemper adheres well to oil- painted walls, wood, corrugated iron, etc. But a priming coat of pure milk should be applied before distempering is done on such surfaces.

(iii) The application of distemper by a spraying pistol is superior to that by brushes. The spraying affords smooth and durable film of distemper.

Defects in Distempering:

The following are the defects which may occur in distempering work.

Blistering: It is the defect caused due to the formation of bubbles under the distempering film.

The bubbles are formed by water vapours trapped behind the surface.

Bloom: In this defect, dull patches are formed on the finished surface. This may be due to the defect in distempering material or bad ventilation.
Crawling or sagging: This defect occurs due to the application of too thick a distempering coat.

Flaking: Flaking is the loosening of some portion of the distempered surface.

Fading: This is the gradual loss of colour of distemper, due to the effect of sunlight.

Flashing: It is the formation of glossy patches on the surface, resulting from bad workmanship.

Grinning: This defect is caused when the final coat does not have sufficient opacity so that background is clearly seen.

1.4 PAINTING:

Paints are coatings of fluid materials which are applied as a final finish to surfaces like walls, ceiling, wood and metal works.

Painting is done to protect the surface from the effects of weathering, to prevent wood from decay and metal from corrosion, to provide a decorative finish and to obtain a clean, hygienic and healthy living atmosphere.

Purpose of painting:

1. Decoration to Interiors and Exteriors of a Building
2. They are used to enhance the interior and exterior of a building by adding pigments, lightness or darkness
3. Reflective surfaces can be also be obtained

4. Now a days textures are also added for different designs Protective Layer
5. Paint are used to protect the outer surfaces of a building or metals to protect them against:
   - Sunlight
   - Dampness
   - Dust
   - Abrasion
   - Weathering
   - Ease of Cleaning
   - To provide easily cleanable surfaces
   - To keep the substrates clean and tidy

Methods and Process of Painting on Different Surfaces

- New wood work
- Repainting Old wood surface
- New iron and steel surfaces
- Repainting of old steel and iron surfaces
- Galvanized iron surface
- Metals
- Plastered surfaces
- Painting on New Wood Work

Following are the steps for painting new wooden surfaces:

- Surface preparation
- Knotting
- Priming
- Stopping

- Under coating
- Finishing

1. Surface Preparation of Wooden Works

The surface should be well cleaned without any dust, spots, greasy matter etc. The nails used in the wood work should be punched up to 3mm below the surface. The wood in wood work shouldbe well seasoned and should not contain more than 15% of moisture content. The surface should be dry.

2. Knotting

Knots present in the wood may eject resins from wood. So, knots are killed or covered in this knotting process. Knotting can be done by two ways as follows: 1. In this first method, two coats of solutions are applied on surface. First coat consists 15g of red lead, 2 liters of water and 225 grams of glue. After adding these three, mixture is heated and applied and left for 10 minutes. After that second coat is applied which consists red lead ground in boiled linseed oil and thinned with turpentine oil. 2. In this method, hot lime coat is applied on surface and left it for 24 hours. After that the layer is scrapped off from the surface.

3. Priming of New Wooden Surface

Priming is nothing but applying prime coat or first coat on surface. In this case, the surface is smoothened with abrasive paper and then first coat of paint is applied to fill all the pores in the surface. The ingredients used in this prime coat is same as subsequent coats but the quantity or composition ratio may vary.

4. Stopping

After filling all the pores of wooden surface in priming, it’s time to fill up nail holes, dents, cracks, etc. Putty is used as the fill material. When putty is dried, then the whole surface is rubbed with glass paper or pumice stone. This process of rubbing sown the wooden surface is called stopping.

5. Under Coating of New Wooden Surface

In general, for good quality works, 4 coats of paints are applied (prime + under coatings + finishing). For inferior quality works 2 to 3 coats can be used. So, under coatings are nothing but second and third coats of good quality works which provides same look or shade as finishing coat. For better results, enough time should be allowed for each coat.

6. Finishing of New Wooden Surface

Finishing is the last coat applied on surface which is generally applied on the under coatings. It should be applied in smooth, uniform manner. It decides the whole final look of surface, so, skilled workers is required for better results.

Repainting of Old Wooden Surface

Old wood work can be repainted but the previous paint work should be removed. The removal is more important which can be done by many ways as follows:

Prepare a solution of 1 kg caustic soda in 5 liters of water and apply on the old painted surface. When this solution is applied on the surface, the old paint gets dissolved and removed easily.

Another method is, prepare a hot solution consisting of soft soap, potash, quicklime in the ratio 1:2:1. This solution is applied on old surface and washed with hot water.

1:1 mixture of washing soda and quick lime is prepared and applied on old paint surface and then washed with water.

After applying any of the three methods described above, the surface is ready for fresh painting. Before that the surface is rubbed with pumice stone or glass paper and then 2 to 3 coats of paints are applied.

Painting of New Iron and Steel Surfaces

Painting of iron and steel surfaces will resist the rust formation due to weathering. Before painting the surface must be cleaned. If there is any rust or scales, should be wiped off using steel brushes etc. stains on surface can be washed with benzene or lime water. Before applying prime coat, the surface should be treated with phosphoric acid to get better adhesive nature. Now prime coat is applied which consists 3kg of red lead in 1 liter of boiled linseed oil. This should be applied using brush. After that, two or more under coats are applied which consist 3 kg of red lead in 5 liters of boiled linseed oil. After drying up, smooth finishing coat of desired paint is applied.

epainting of Old Steel and Iron Surfaces

Repainting of steel and iron surfaces is as same as new surfaces but cleaning of old paint is most important. Oxy acetylene flame is used to burn off the paint surface and then it is scrapped with brushes.

Painting of Galvanized Iron Surface

In general, Galvanized iron surface does not contain adhesive nature with paint. So, it is difficult to apply paint on it without any special action. That special treatment may be applying different solutions on surface. The solutions are 40 grams of copper acetate in one liter of water or 13 grams each of copper chloride, copper nitrate, muriatic acid and ammonium chloride in 1 liter of water.

Any one of these two solutions are mixed in earthen vessel and applied on surface. When the surface turns into black, then prime coat is applied after it dries, finishing coat is applied.

Painting of Plastered Surfaces

Painting of newly plastered surfaces is difficult because of moisture content present in the plaster material. Heat of hydration of cement also causes severe problems for paints especially oil based paints and distempers are liable to alkali attack. To overcome this, alkali resistant primer is used in prime coat. The plastered surface contains pores in it, and whenever the paint is applied, liquidfrom the paint is absorbed by these pores which is called as suction. The suction of surface dependsupon type of paint, prime coat composition, etc. Suction should be uniform throughout the surface.So, the preparation of surface depends upon the type of paint used on the surface. For different paints, different types of pretreatments are adopted on the surface which is described below.

Type of paint	Preparation of surface
Oil paint	A coat of thin primer or prime sealer
Emulsion paint	A coat of paint thinned with water
Dry distemper	Same distemper thinned with water
Size bound distemper	A Coat of clearcole
Cement paint and lime wash	Just wet the surface before applying.

DEFECTS:

The common defects that should be avoided in painting are:

Blistering: These are formed by water vapour trapped inside non-breathing types of paints. **Bloom or Flashing**: These are formation of dull patches usually due to the defect in paint or bad ventilation.

Brush marks: These occur due to defective work.

Cracking: It occurs due to the defect of paint and fast drying. **Crawling or sagging:** It occurs due to application of too thick a paint.**Flaking**: It occurs due to poor adhesion of paint to the surface.

Lack of opacity or body: It happens due to overthinning of paint or inadequate stirring of paint during its application.

Pin holes: These are formed when there are small holes present in the surfaces such as walls even before painting. The air from these holes can burst forth and create holes . Surface should be levelled with putty before painting.

Slow Drying: It can occur due to a moist unhardened undercoat ,bad quality of paint or painting in damp weather on a greasy surface.

Its solutions:

- Employ good surface preparation before the application of paint. Ensure that substrate should be free from sand, dirt or any dust.

- Moisture content on the painting surface should not exceed 6% as it helps to avoid efflorescence.
- Apply adequate primer to seal the surface before going for undercoat and topcoat.
- Use appropriate coating methods and select colours that are more stable to avoid deterioration.
- Use non-yellowing paints, which does not affect by environmental situations. For areas exposed to extreme weather conditions, prefer weather-resistant paints.
- Protect and treat all the metal parts to avoid rust stains or corrosion.
- Avoid details with very rough textures and use algae-resistant paint to prevent algae and fungi growth.

2. VERTICAL COMMUNICATION

2.1 STAIRS: Staircase is an important component of a building providing access to different floors and roof of the building. It consists of a flight of steps and one or more intermediate landing slabs between the floor levels.Stairs can be defined as series of steps suitably arranged for the purpose of connecting different floors of a building. It may also be defined as an arrangement of treads, risers, stringers, newel post, hand rails, and baluster, so designed and constructed as to provide an easy and quick access to the different floors.Stairs can be made of concrete, stone, wood, steel or combination of any of these.

UNIT-V BUILDING PLANNING

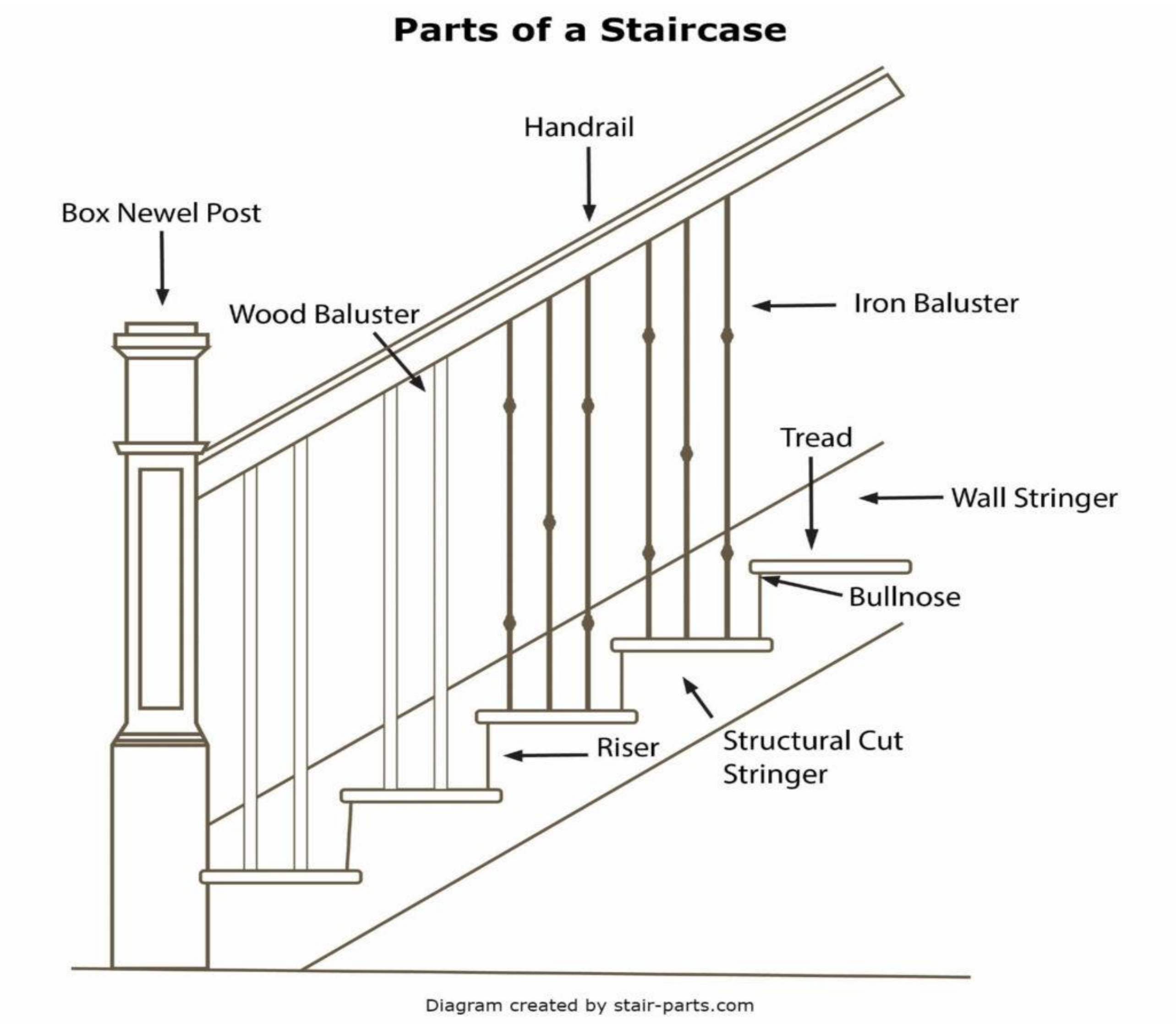
Terminology:

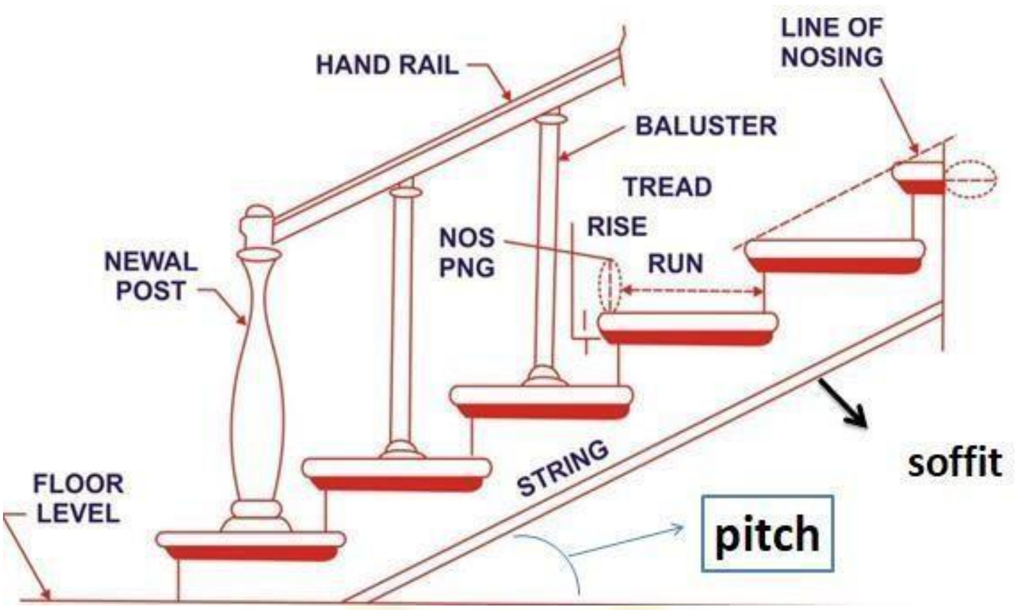
Step

This is a portion of stair which permits ascending or descending from one floor to another. It is composed of a tread and a riser. A stair is composed of a set of steps.

Tread

It is the upper horizontal portion of a step upon which the foot is placed while ascending or descending a stairway.





Flight

The steps between levels including landings.

Landing

An area at the top or part way up the stair that either acts as a resting place, a change of direction or is the end of the stair.

Nosing

The front edge of the step or tread that hangs over the riser.

Going

The measured horizontal distance between nosings.

Riser

The distance between each step. I.e. the vertical space between each step.

Rise

The actual or measured distance between treads.

Total Rise

The total vertical distance from floor to floor.

Total Going

The total horizontal distance of the stair.

PitchLine

An imagined line that stretches from nosing to nosing for the length of the stair.

Pitch

The angle that the flight of stairs is built at.

Headroom

This is the distance from the pitch line to the next surface above it. E.g. the ceiling or soffit above. The normal minimum is two metres.

String

The angled beam or member at each side of the stair that supports the treads.

REQUIREMENTS OF GOOD STAIRS

1. Location

It should preferably be located centrally, ensuring sufficient light and ventilation.

2. Width of Stair

The width of stairs must be uniform.

3. Length

The flight of the stairs should be restricted to a maximum of 12 and minimum of 3 steps.

4. Pitch of Stair

The pitch of long stairs should be made flatter by introducing landing. The slope should not exceed 40 degrees and should not be less than 25 degrees.

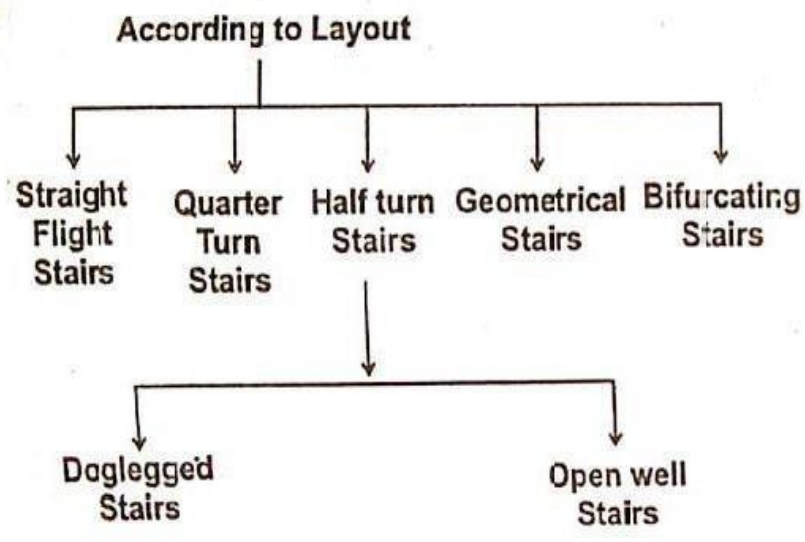
5. Head Room

The distance between the tread and soffit of the flight immediately above it, should not be less than 2.14 to 2.3 m..

6. Materials

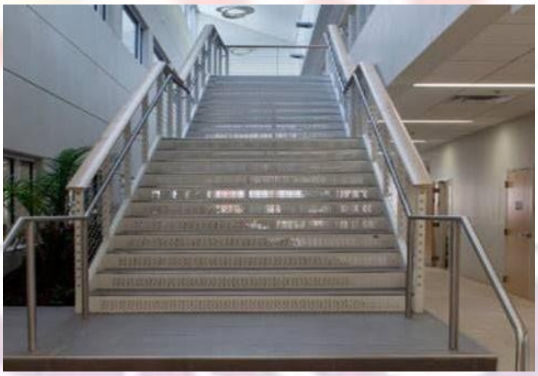
Stairs should be constructed using fire resisting materials. Materials also should have sufficient strength to resist any impact.

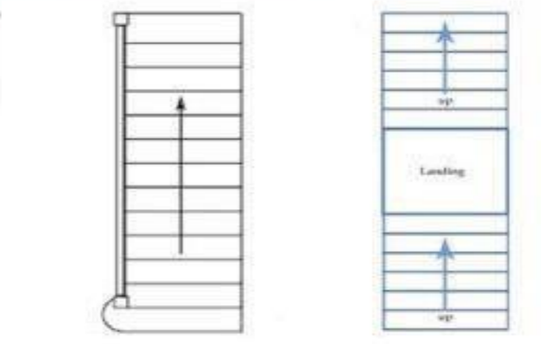
Classification of stairs



Straight flight stairs

In this stair, all the steps are arranged continuously along in one direction. One flight may be split into one or more than one flight by interposing a landing. This stair can be used where narrow and long space is available for a staircase such as entrance, porch etc.

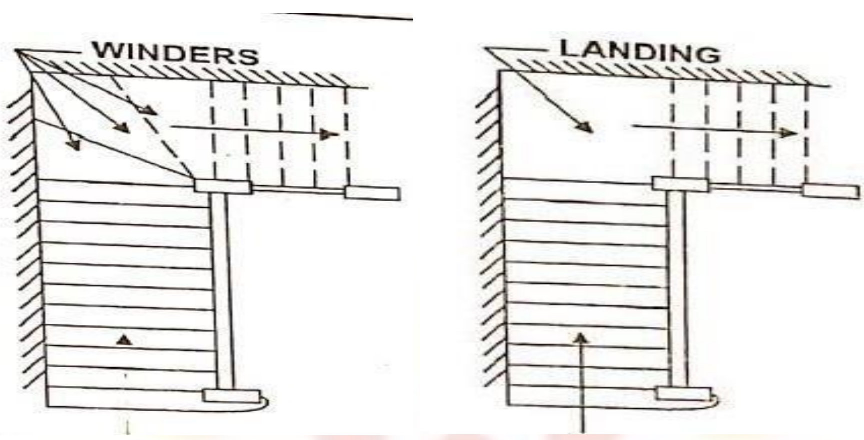




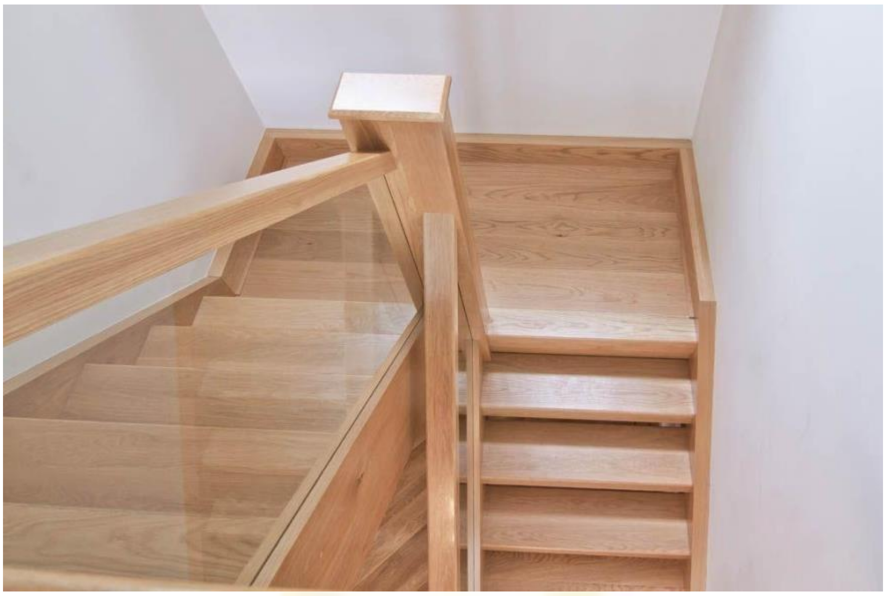
Straight Stair

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.

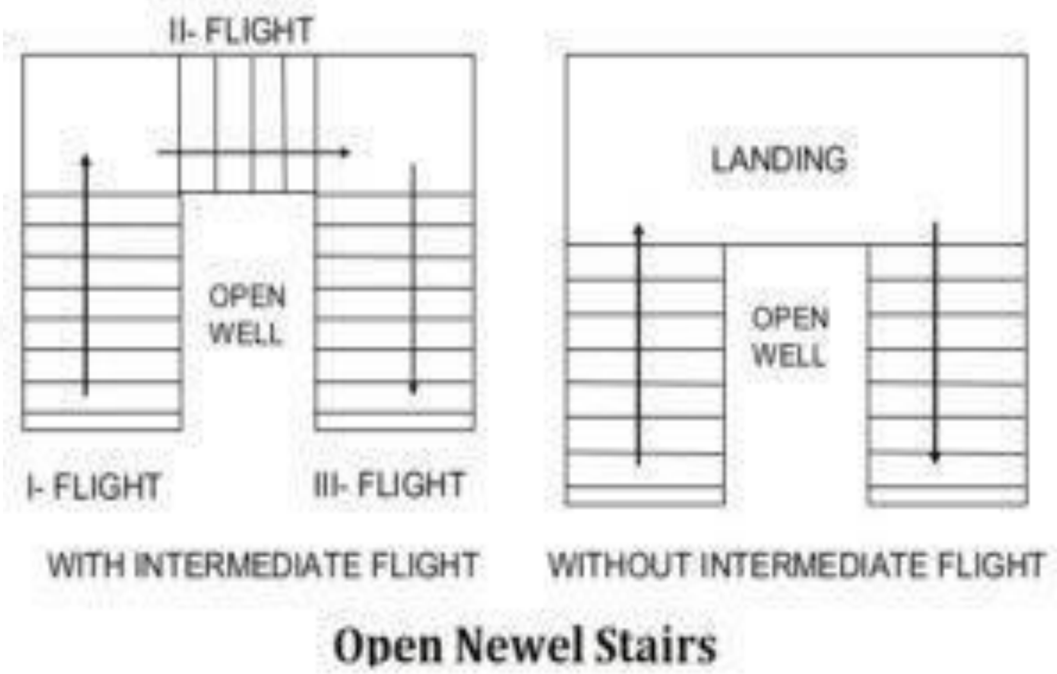


Dog-legged stair



Open well stair

This type of stair consists of two or more flights arranging a well or opening between the backward and forward flights. When all the steps are difficult to arrange in two flights, a short third flight of 3 to 6 steps may be provided along the direction perpendicular to the hall. Open newel stair is mostly adopted in the lift.



Open well stair

Geometrical stair

This is another type of open newel stair where the open well between the forward and the backward flight is curved. This stair may contain different geometrical shape. Here the change in direction is achieved by using winders.

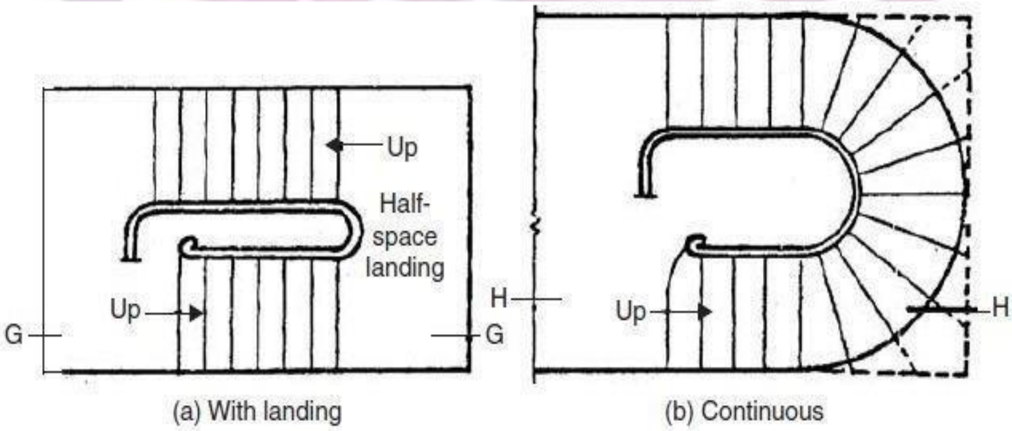
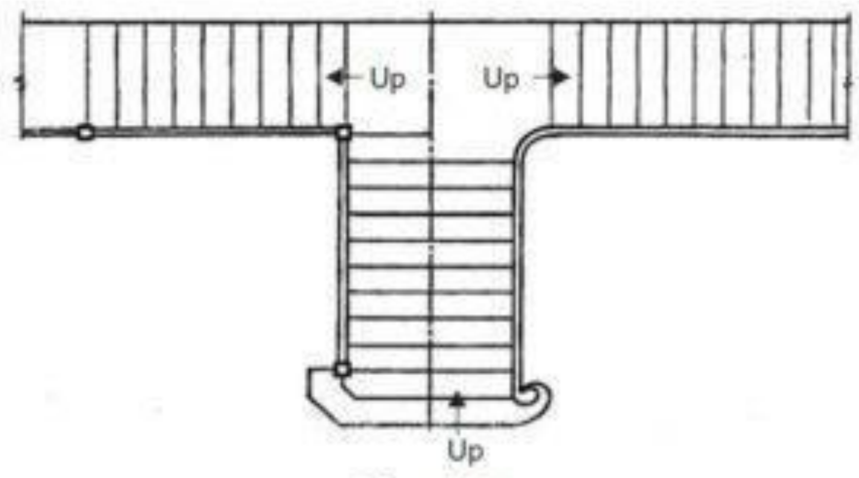


Fig. 8.38. Geometric stairs

Bifurcated stair

This type of stair is provided in modern public buildings as well as residential buildings. In this stair, the flight is so arranged that there is a wide flight at the start which is sub-divided into narrow flights at the mid-landing. The narrow flights start from either side of the mid landing.



Bifrucated Stair

PRINCIPLES OF BUILDING PLANNING

When we first start to plan a new building construction work to begin we definitely need to remember some basic principles of building planning. Some of the basic principles of planning of a building construction are given below.

1. An engineer or architect should prepare the building plan according to the demand, economic status & taste of the owner and also the purpose of the building is to be built whether residential, commercial etc.
2. The design of the building should be compatible with the surrounding structures & the weather.
3. Sufficient air and sunlight should be allowed to the building for healthy building environment.
4. Privacy must be maintained especially in residential buildingplanning.
5. Proper security system should be introduced for safety and reliability.
6. Fire safety alarm and fire fighting materials should be provided within the range of the inhabitants of the proposed building structure.
7. The value of the structure should be maintained in building plans.
8. Follow the associated building codes closely for proper building construction. Example: Civil Engineering Codes.

SELECTION OF SITE

Following factors should be kept in view while making the selection of site for a building:-

- The site should be preferably be situated on an elevated and leveled ground. It should not be located in a flood-prone area.
- The soil at site should not be of black cotton soil and should have good value of bearing capacity.
- The water table of ground at the site should not be high.
- The site should not be irregular in shape or have sharp corners. The site should

preferably be rectangular or a square in shape.

- The site should be in a developed area having facilities like shopping, educational institutions, recreation, hospital, telegraph, telephone, police station, fire station, transport, and utility service like water supply, drainage system, gas supply, electricity etc.
- The site should be located away from quarries, kilns, industrial plants/buildings emitting smoke, steam, noise or other similar environmental pollutants.
- The site should have unobstructed natural light and air and the building on the proposed site should not get overshadowed from adjacent buildings.
- The site should have clear status of the present ownership of the title of the property.

Some important factors to consider for building planning are as follows.

- Aspect
- prospect
- Furniture requirements
- Roominess
- Grouping
- Circulation
- Privacy
- Sanitation
- Elegance
- Economy
- Flexibility
- Practical considerations.

1. Aspect

- Aspect means the peculiarity of the arrangement of doors and windows in the external walls of a building which permits the occupants to enjoy the gifts of nature viz sun, breeze, outside scenery etc. Aspects gains special significance in case of residential buildings.
- This provision is necessary to ensure proper comfort conditions in the room and it also helps in providing hygienic conditions in the room as the sun rays destroy the insects and also impart cheerful living conditions in the room. A room which receives light and air from particular side is termed to have aspect of that direction. Needles to emphasize that different rooms/areas in the dwelling need particular aspect.

2. Prospect

- Prospect is the term used to highlight the architectural treatment given to a building so as to make it aesthetically pleasing from outside and arranging external doors and windows in such a manner that the occupants are able to enjoy the desired outside views from certain rooms.
- Prospect is basically governed by the peculiarities of the selected site. Hence like aspect, prospect of a building also require the deposition of external doors and windows in a building at particular places and in particular manner so as to expose the notable and pleasant features of the openings in the external facade of the building and concealing the undesirable views in a given site. Hence, both aspects as well as prospect demand proper disposition of doors and windows in the external walls at particular places and in particular manner.

3. Grouping

- We know that every apartment in a building has got a definite function and there is some inter-relationship of sequence in between them. Grouping consists in arranging various rooms in the layout plan of the building in such a manner that all the rooms are placed in proper co-relation to their functions and in proximity with each other.
- The basic aim of grouping of the apartments is to maintain the sequence of their function according to their inter-relationship with least interference. For instance in a residential building dinning room should be close to the kitchen. The kitchen on the other hand, should be kept away from drawing room or living room to avoid smoke or smell from kitchen spreading in these rooms.
- The water closet should be located away from the kitchen. Main bedrooms should be so located that there is independent and separate access from each room towards the water closet directly or through other un-important rooms.
- In case of office buildings,hospitals etc., administrative department should be located centrally for convenience and economy in the cost of providing services. Thus the concept of grouping plays a very important role in planning of buildings of all types.

4. Privacy

- Privacy is considered to be one of the most important principle of planning in all buildings specially in residential buildings. Privacy may be one part to another part of the same building or it may be the privacy of all parts of the building from neighboring buildings, public streets or bye ways etc.
- The extent of privacy of a building from the street, bye ways or neighboring buildings depends mainly upon the functions performed in the building.
- Many a time privacy ofonly a part of building is necessary from exterior whereas the remaining building as a whole may be required to be exposed to view. This is achieved by proper layout of streets, approach roads, entrances, provision of trees, creepers etc.
- The privacy within the building means screening interior of one room from other rooms.
- Screening of all the apartments or some of them from entrance, corridors etc., gets covered under the term privacy of part of building from exterior. In case of residential buildings, privacy can be achieved by judicious planning of the building with respect to grouping, disposition of doors and windows, mode of hanging of doors, location of entrance pathways, drives etc.
- Some times, provision of lobbies, corridors, screens. curtains etc., is also made to achieve internal privacy. Importance of privacy requires special consideration in case of bedrooms, toilets, lavatories, water closet, urinals etc.
- All these services should have an independent access from every bedroom without disturbing the others. Doorswith single shutter are desirable for such rooms.

5. Furniture Requirements

- The furniture requirements of a room or an important depends upon the functions required to be performed there in.
- The furniture requirements of a living rooms in a dwelling will be different from that of a class room in a school or an operation theaterin a nursing home/hospital.

- There are no rigid rules which govern the furniture requirements of a particular room in a dwelling. It should be sufficient to accommodate the normal needs of maximum number of persons who can use the room without over crowing. In case of buildings, other than residential, it should be adequate to meet the requirements of the particular functions.
- The space requirements of non-residential building is planned paying regard to the furniture, equipment and other fittings or fixtures which are essential to meet the need of the particular functions required to be performed in the building. In case of residential buildings, normally not much through is given to the furniture requirements.
- It is however, desirable to prepare a sketch plan indicating required furniture as well as its located in different rooms (Viz drawing room, bedroom,kitchen etc.). So as to ensure that doors, windows, cupboards and circulation spaces do not prevent the placement of required number of furniture items in the room.

6. Roominess

- The effect produced by deriving the maximum benefit from the minimum dimensions of a room is termed as roominess. Roominess is the accomplishment of economy of space without cramping of the plan. Particularly in case of residential buildings where considerable storage space is needed for various purpose, adequate provision of wall cupboards, lofts wooden/R.C.C shelves etc., should be made to make maximum use of every nook and corner of the building.
- Following points should be kept in view for creating desirable impression regarding roominess:
  (a) A room square in plan appears relatively smaller than a rectangular room of same area. It is also considered relatively smaller from utility point of view as compared with rectangular room of the same area. Length of beam proportion for a good room is taken as 1.2 to 1.5. If the ratio of length to breadth exceed 1.5 it creates an undesirable effect. A small room having its length more than 2 times its width is objectionable, as it creates tunnel effect.
  (b) A small room with high walls appears relatively smaller than its actual size and as such small rooms should have the maximum permissible height as per bye-laws.
  (c) The location of doors, windows and built in cupboard etc., should be such that they permit easy approach -ability and do not obstruct the placement of furniture etc.
  (d) It requires skill and serious thinking in making best use of the accommodation provided by suitable, arrangement of rooms, by locating doors and passages in such a way that the livability, utility, privacy and exterior appearance are not adversely affected.
  (e) The design of the building should be evolved in such a manner that its floors, walls and ceiling creates a sense of uninterrupted surfaces carried consistently through.

7. Circulation

Circulation means internal through fares or access providing in a room or between rooms on the same floor. Passage, halls and lobbies perform the function of circulation on the same floor. Such provisions are termed as horizontal circulation. On the other hand, stairs, lifts, ramps etc., which serves the purpose of providing means of access between different floors get covered under the category of the term vertical circulation.following aspects should be kept in view to achieve good circulation:
(a) For comfort and convenience, all passages, corridors, halls etc., on each floor

should be short, straight, well ventilated and sufficiently lighted.

(b) The location of entrance passages and staircase which serve as link between various rooms and floors, need careful consideration right at the initial stage of planning.

(c) In a multi-storeyed building, the staircase, which perhaps serve the only unfailing means of vertical circulation, should be planned paying due regard to the size of tread and riser, width of stair and landing, light and ventilation etc. Staircase should be also located that they do not intro-due upon privacy of any room or cause disturbances in the horizontal circulation.

(d) Toilets, should be planned near the staircase block for easy accessibility.

8. Sanitation

- The term sanitation covers not only sanitary convenience like water closet, urinals, bath rooms, wash basins etc., but also proper and adequate lightning ventilation and facilities for general cleaning of the building. From hygienic considerations, all parts of the building should be well ventilated and lighted.
- The lighting of the interior of the building may be done by natural lighting, assisted natural lighting or by artificial lighting. Uniform distribution of light in necessary, specially in offices, schools, factories and other similar buildings where number of persons work in the same premises and each individual has to work at specified place.
- For ensuring sun light for greater length of time it is desirable to provide vertical windows. For proper lighting the area of windows in a room should not be less than 1/10th of the floor area which may be increased to 1/5th for buildings like schools, offices, workshops, factories etc.

9. Elegance

- Elegance is the term used to express the effect produced by the elevation and general layout of the building. Hence for a building to be elegant. It is necessary that its elevation should be evolved that it should be aesthetically pleasing and its layout should fit in well in relation to the site and its environment.

10. Flexibility

- Flexibility means designing certain rooms required for specific purpose in such a manner that they may be used for overlapping functions as and when desired. This concept is particularly important for designing houses where area'scan not be increased from consideration of cost yet the provision of additional facilities is desired during functions or other occasions of social gatherings.
- It is therefore desirable to plan drawing room and dinning room with a removal partition wall or screen in between them so that a large room can be obtained by removing the partition screen to accommodate large gathering.
- 11. Economy
- Economy is one of the very important factor which is required to be kept in view while involving any scheme. Every unit of the built up area is a function of cost and as such the architect has to make sure that the building planned by him can be completed within the funds available for the project. Many a times it becomes necessary to carry out number of alteration in the plans to keep the proposal within the limitation of funds.

Classification of Buildings

The purpose of use or occupancy of a building is a fundamental consideration for the building code. Clients generally share their brainstorming ideas and facility needed and then architect gives shape to reality and grouped the building which is assigned under the code. Buildings are classified into two categories such as based on the occupancy and the type of construction methods.

Building Occupancy Classifications

Every building or portion of land can be classified according to its use or the character of its occupancy as a building of occupancy. They are categorized into the following types.

1. Agricultural buildings
2. Residential buildings
3. Commercial buildings
4. Educational buildings
5. Industrial buildings
6. Government buildings
7. Military buildings
8. Religious buildings
9. Transport buildings
10. Power plants

The classification of buildings by types of construction

Based on the type of construction buildings are classified into five categories.

1. Fire resistive buildings (Type 1A, 1B)
2. Non-Combustible buildings (Type 2A, 2B)
3. Ordinary Buildings (Type 3A, 3B)
4. Heavy timber buildings (Type 4)
5. Wood framed buildings (Type 5A, 5 B)

RESIDENTIAL BUILDINGS:

These buildings include one or two private dwellings, apartment houses (flats), hotels, dormitories etc.

EDUCATIONAL BUILDINGS:

These buildings include any building used for school, college or day care purposes involving assembly for instruction, education or recreation.

INSTITUTIONAL BUILDINGS:

These buildings include any building or part which is used for medical treatment etc. Such as Hospitals, nursing homes, orphanages, sanatoria, jails, prisons, mental hospitals etc.

ASSEMBLY BUILDINGS:

These buildings may include any building or part of a building where a group of people gathers for recreation, amusement, social, religious or such types of purposes such as theaters, assembly halls, exhibition halls, restaurants, museum, club rooms, auditoria etc.

BUSINESS BUILDINGS:

These shall include any building or part of a building which is used for business transactions, keeping records of accounts, town halls, city halls, court houses etc.

Building bye laws:

The rules and regulation framed by town planning authorities covering the requirements of building, ensuring safety of the public through open spaces, minimum size of rooms and height and area limitation, are known as building bye-laws.

Rules and regulations which largely regulate the building activity should be formulated to get disciplined growth of building and the better planned development of towns and cities

Objective of building bye-laws

i. pre-planning of building activity.
ii. allow orderly growth and prevent haphazard development.
iii. Provisions of by-laws usually afford safety against fire, noise, health hazard and structure failure.
iv. Provide proper utilization of space to achieved maximum efficiency in planning.
v. They provide health, safety and comfort to the people who live in building.
vi. Due to these bye-laws, each building will have proper approaches, light, air and ventilation.

Scope of building bye-laws

Aspects of different type of building in building bye-laws:

1. Building frontage line
2. Minimum plot size
3. Built up area of building
4. Height of building
5. Provision of safety, water supply, drainage, proper light and ventilation
6. Requirement for off street parking space
7. Size of structural element