LECTURE NOTES

ON

BUILDING MATERIALS, CONSTRUCTION AND PLANNING

B.Tech III Sem (IARE-R18)

PREPARED BY

Mr. K. ANAND GOUD

ASSISTANT PROFESSOR

Mr. K. TARUN KUMAR

ASSISTANT PROFESSOR

Department of Civil Engineering

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal – 500 043, Hyderabad

MODULE-I
STONES, BRICKS AND AGGREGATES

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 the choice 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. Only a comprehensive knowledge of the properties of materials allows a rational choice of materials for specific service conditions.

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^oC 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^oC 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

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 opposed to 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

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

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

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

CHEMICAL CLASSIFICATION

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

(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 groove is made using this machine around the rock and the horizontal holes are drilled underneath the block. Hence, the block gets separated from its bed.

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 using this method.

Marbles, lime stones, etc. are quarried using machine quarrying.

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 bricks

Ground molded bricks

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

Table molded bricks

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

Machine molding of bricks

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

- 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:

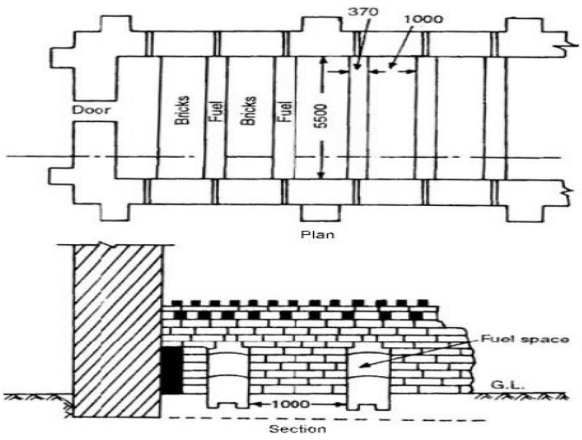
A typical clamp is shown in Fig. The bricks and fuel are placed in alternate layers. The amount of fuel is reduced successively in the top layers. Each brick tier consists of 4–5 layers of bricks. Some space is left between bricks for free circulation of hot gasses. After 30 per cent loading of the clamp, 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.

Kiln Burning

Intermittent Kiln:

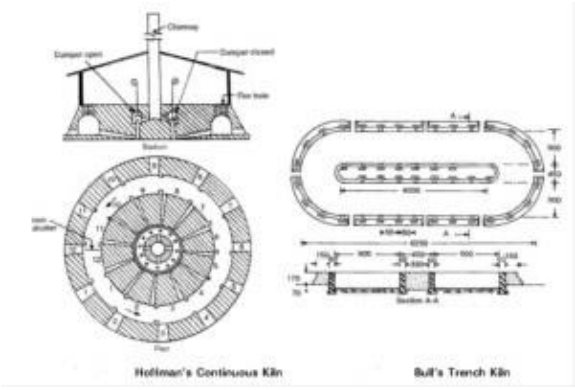
The example of this type of an over ground, rectangular kiln is shown in Fig. After loading the kiln, it is fired, cooled and unloaded and then the next loading is done.

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

4. Flaky aggregates
5. Elongated aggregates
6. 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

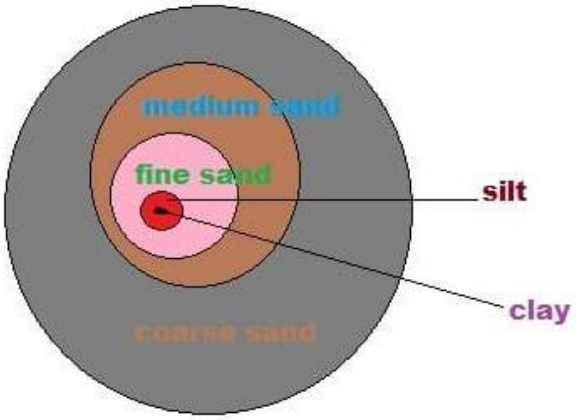
When the length of aggregate is larger than the other two dimensions then it is called elongated aggregate or the length of aggregate is greater than 180% of its mean dimension.

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 fines.

Ensure maximum density and strength using a maximum density curve

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 24 hours.

- The crushing strength of the brick should not be less than 10 N/mm2. This limit varies with 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.

MODULE-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 :

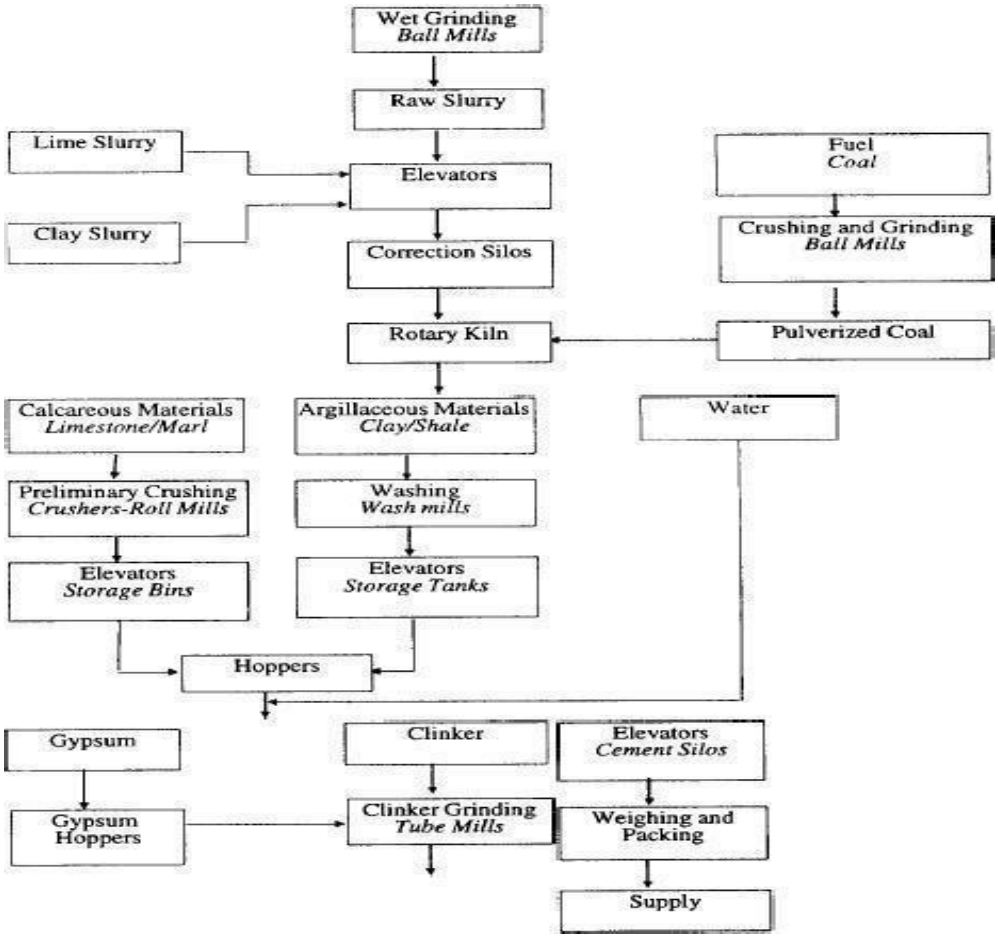
This process is adopted when the raw materials are quite hard. The raw materials of limestone and clay are first reduced in size of about 25 mm in crushers. A dry air is then passed over

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. This paste, 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^{o}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 adjusted to 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 CaSO4 2H2O. It contains 79.1% calcium sulphate and 20.9% water. When gypsum is added to 205^{o}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 inH2SO4.

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 (CaSO4, ½ H2O) derived from gypsum by firing this mineral at relatively low temperature of 160 – 170^{o}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^{o}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 not float on the surface.

- The color of cement should be uniform and the typical cement color isgrey.
- 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 of cement

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^{o}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. as their 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.

3. 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.

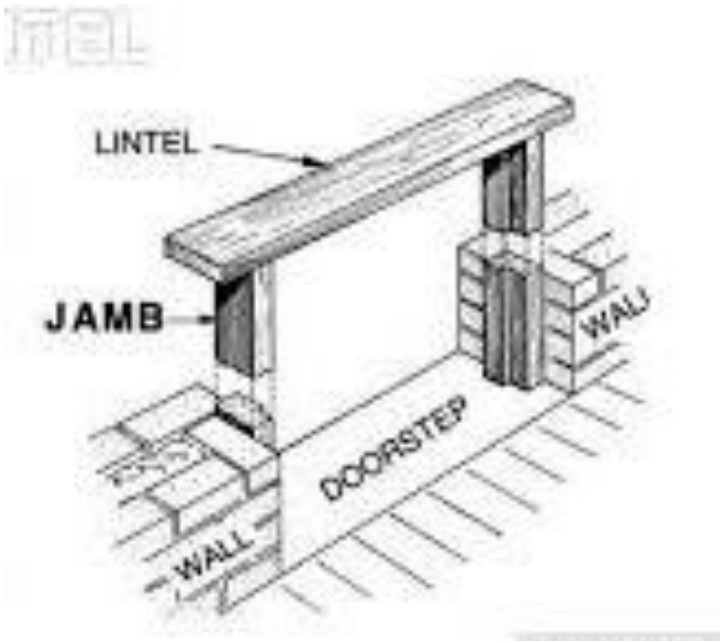
Other quality tests are conducted to test the following

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

MODULE-III
BUILDING COMPONENTS AND FOUNDATIONS

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 3^{rd} 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.

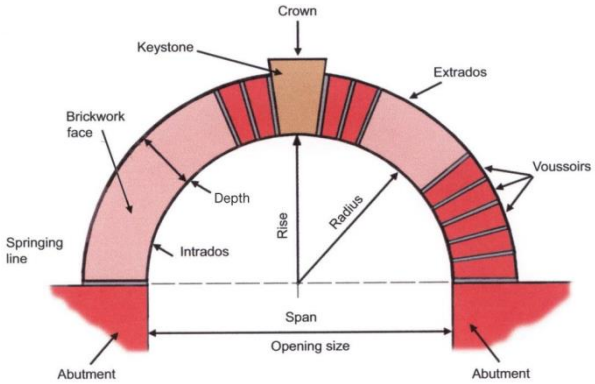
ARCH

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

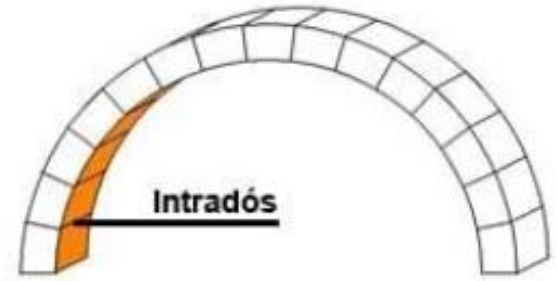
The following are the different components of arches and terms used in arch construction:



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.



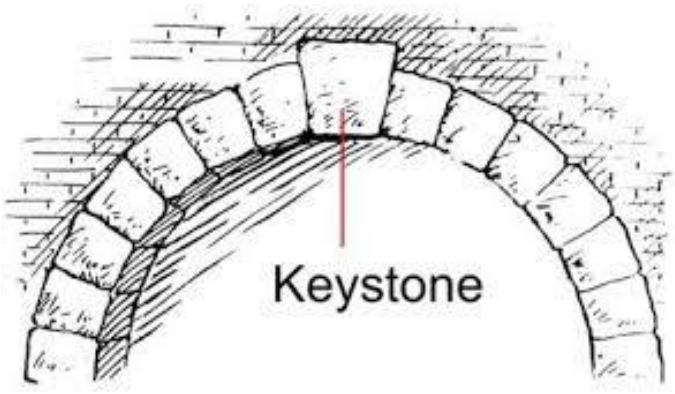
Extrados

The outer curve of an arch is termed as extrados.

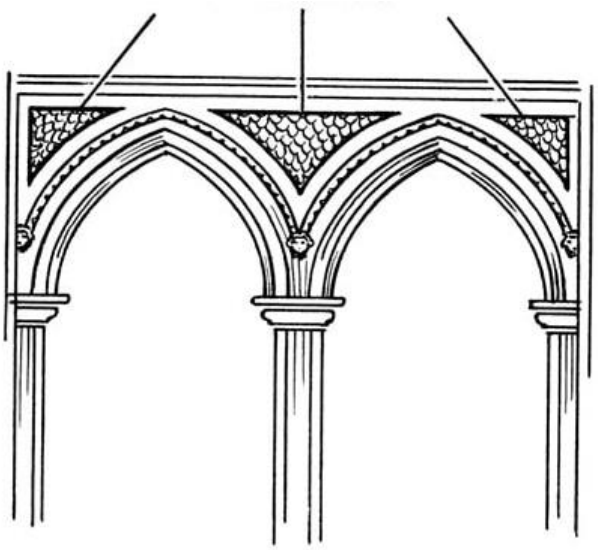
Crown
The apex of the arch's extrados. In symmetrical arches, the crown is at the mid span.

Keystone

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

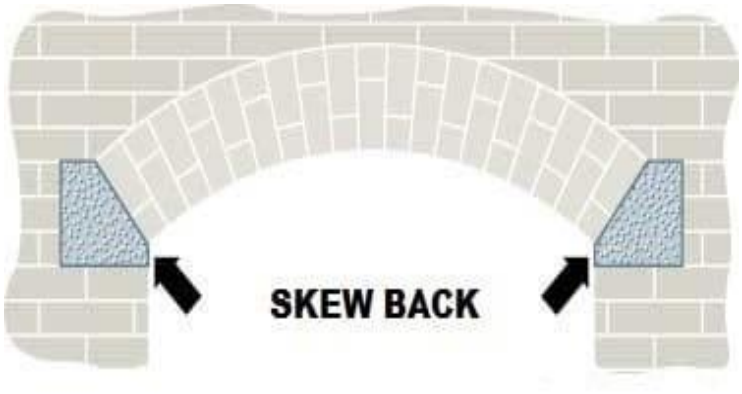


Spandrel in an Arch
If two arches are constructed side by side, then a curved triangular space is formed between the extrados with the base as horizontal line through the crown. This space is called as spandrel.



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.

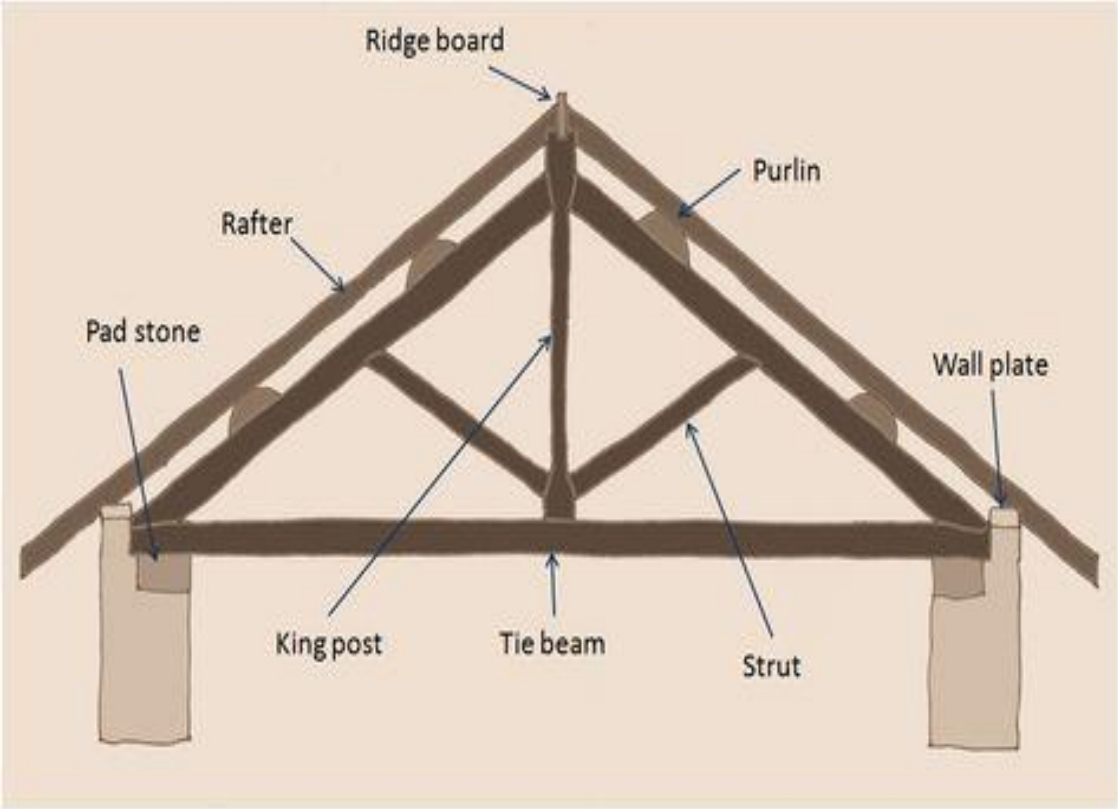
In this post, I did not include floors which are built on ground as a type of floor. Because, I think, it does not need serious mechanism to build a floor on ground. Because there is a ground itself to support the floor.

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

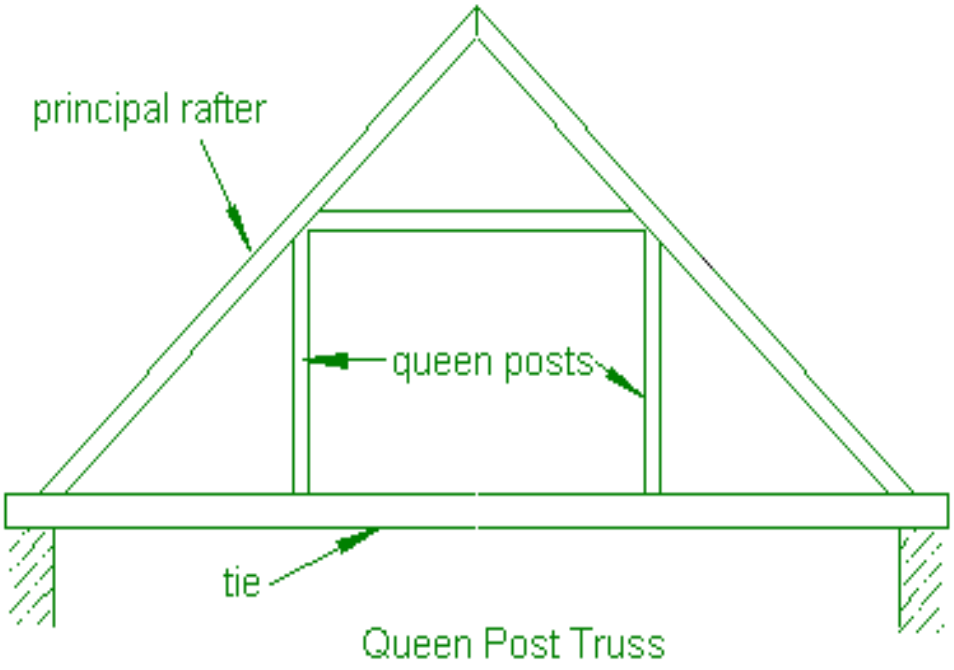
This particular truss is made out of wood most of the time, but it can also be built out of a combination of steel and wood. It all comes down to the architect and the building structure. The King Post Truss spans up to 8m, which makes it perfect for multiple types of houses, especially the smaller ones.



Queen Post Truss

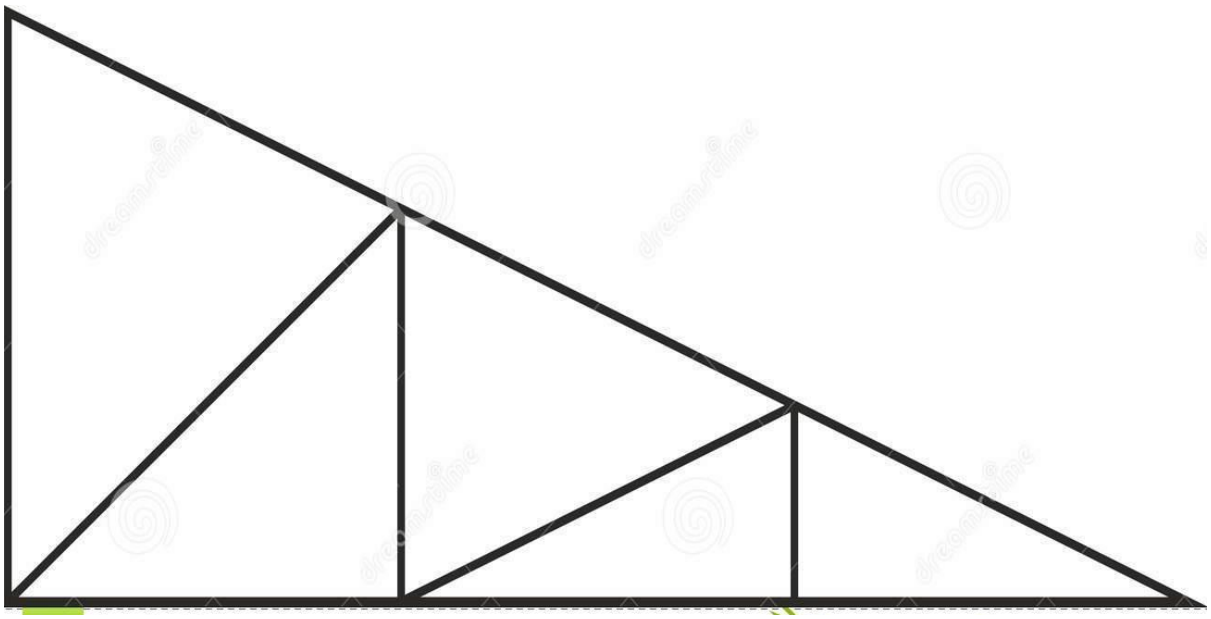
The Queen Post Truss is designed to be a very reliable, simple and versatile type of roof truss that you can use at any given time.

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



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

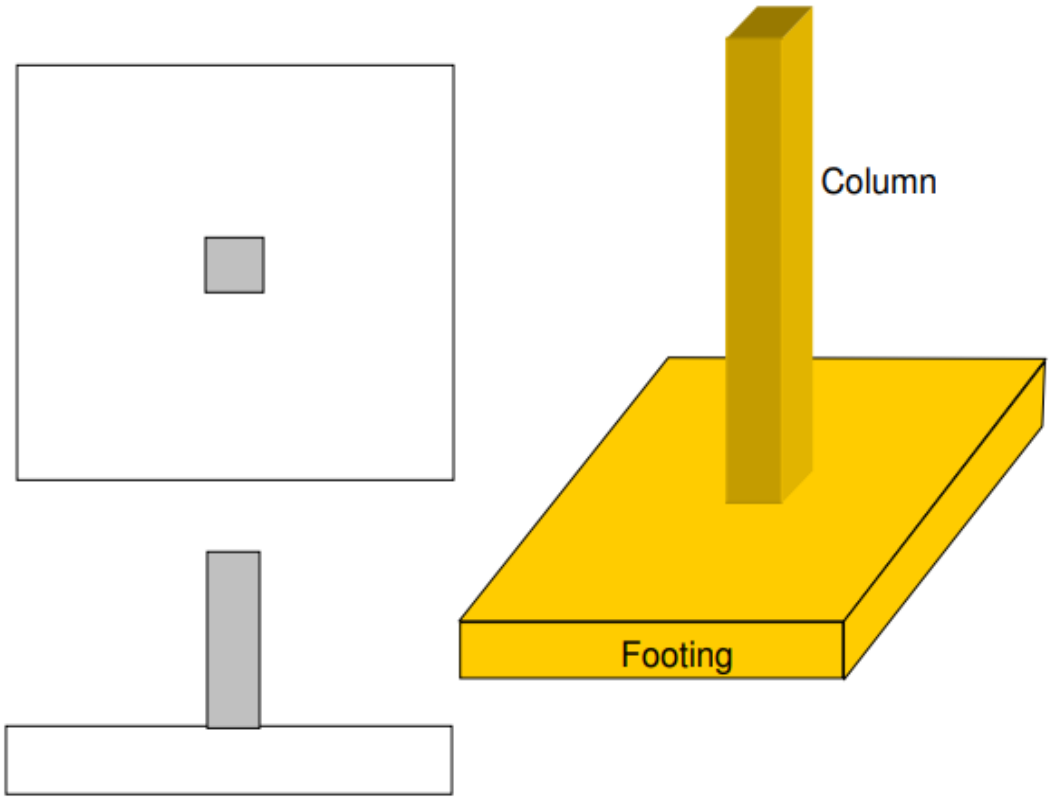
2. Deep Foundation
    i. Pile foundation

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.



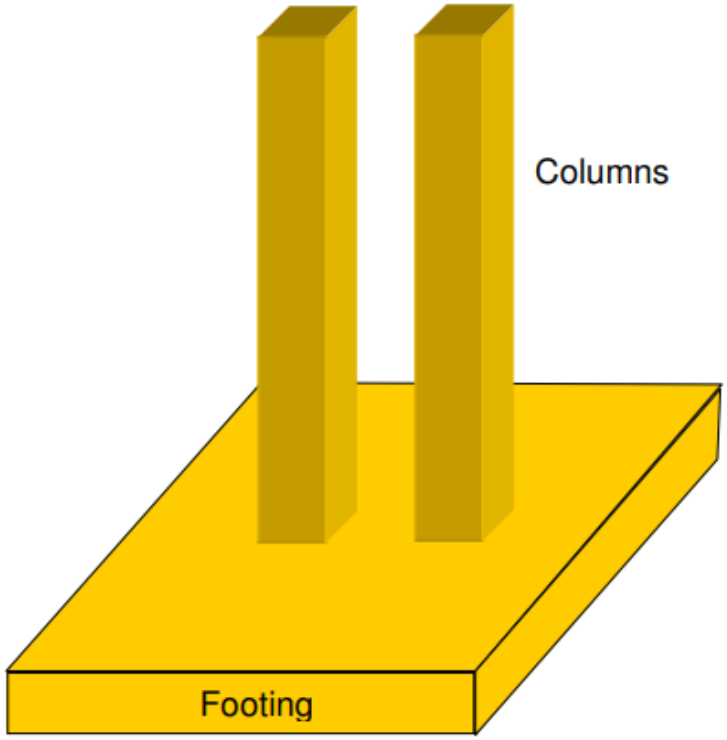
Rectangular isolated footing is selected when the foundation experiences moments due to eccentricity of loads or due to horizontal forces.

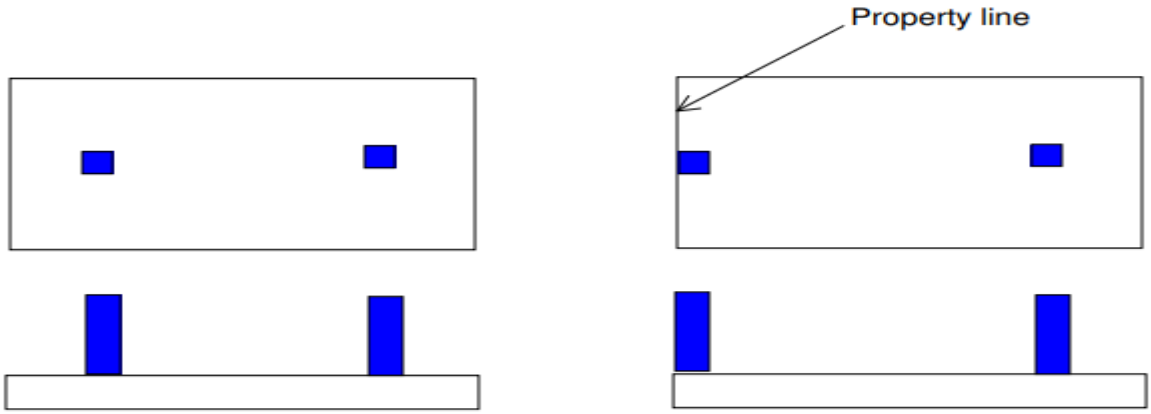
For example, Consider a column with vertical load of 200 kN and safe bearing capacity of 100 kN/m^2 then the area of the footing required will be 200/100 = 2m^2. So, for a square footing, length and width of footing will be 1.414 m x 1.414 m.

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

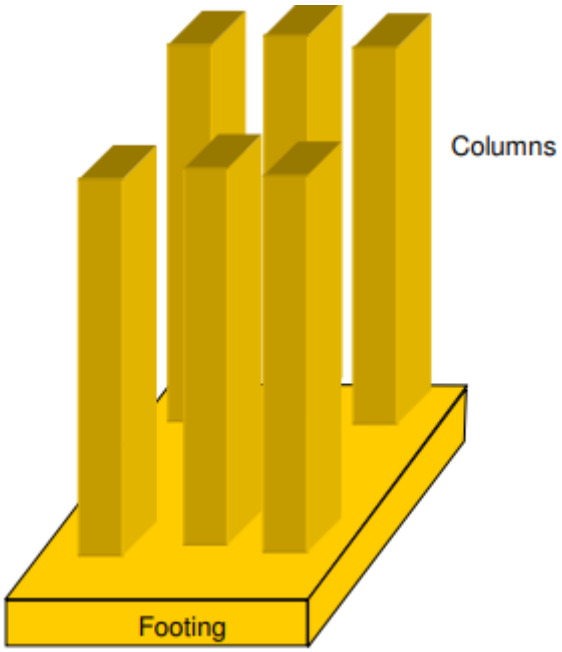
Spread footings are those whose base is more wider than a typical load bearing wall foundations. The wider base of this footing type spreads the weight from the building structure over more area and provides better stability.

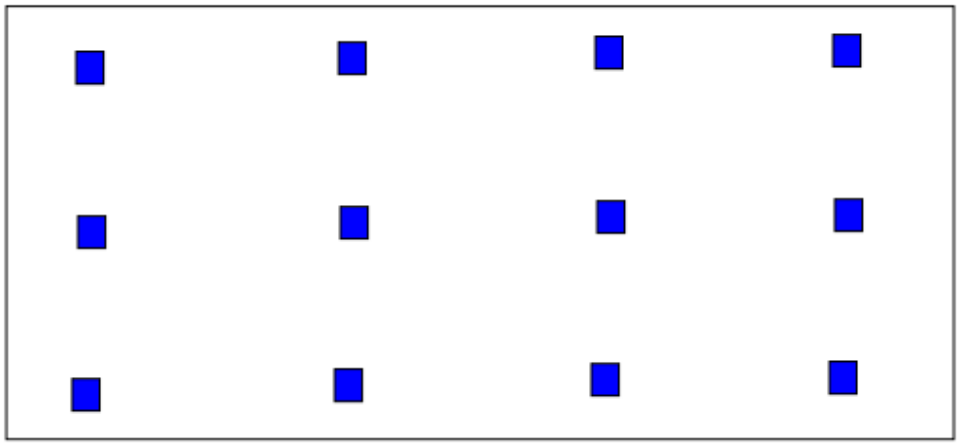
Spread footings and wall footings are used for individual columns, walls and bridge piers where the bearing soil layer is within 3m (10 feet) from the ground surface. Soil bearing capacity must be sufficient to support the weight of the structure over the base area of the structure.

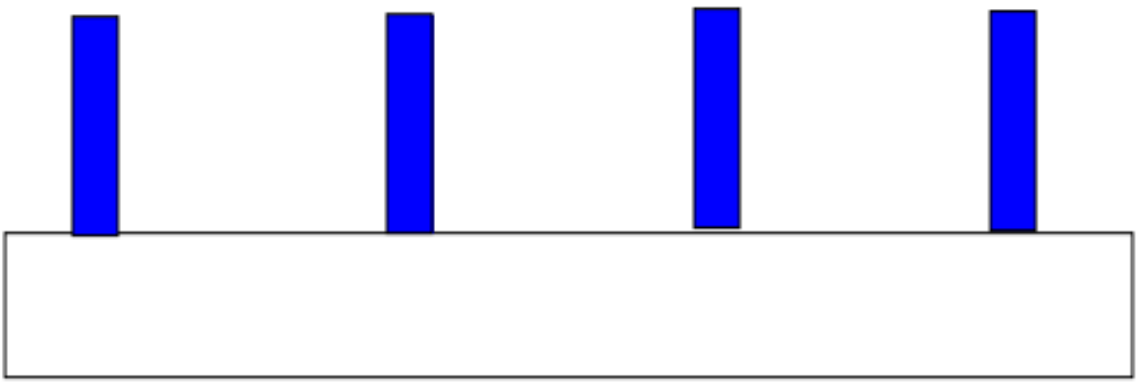
These should not be used on soils where there is any possibility of ground flow of water above bearing layer of soil which may result in scour or liquefaction.

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.

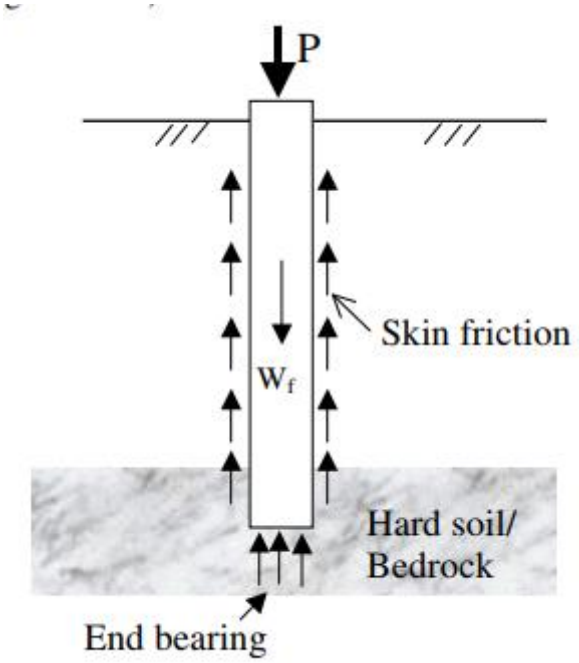
It is suitable for expansive soils whose bearing capacity is less for suitability of spread footings and wall footings. Raft foundation is economical when one-half area of the structure is covered with individual footings and wall footings are provided.

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.

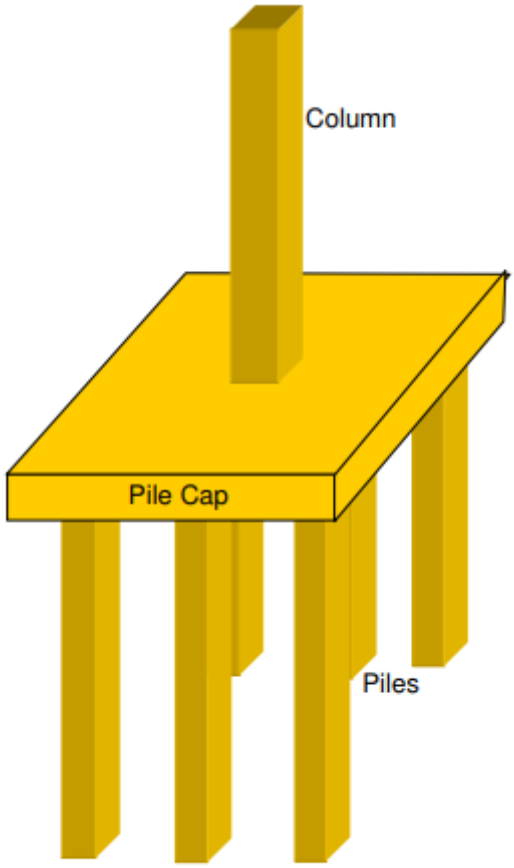


Pile foundations are used to transfer heavy loads of structures through columns to hard soil strata which is much below ground level where shallow foundations such as spread footings and mat footings cannot be used.

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 of pile foundations also prevents differential settlement of foundations.



Pile Foundation

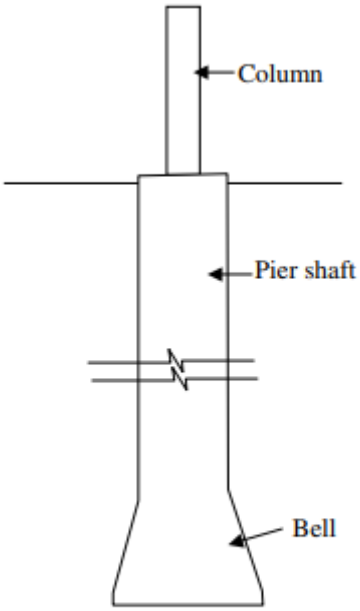
Drilled Shafts or Caisson Foundation

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)

MOULE-IV
WOOD, ALUMINUM AND GLASS

Wood

Wood is one of the most used natural building materials in the world. A number of valuable properties such as low heat conductivity, small bulk density, relatively high strength, amenability to mechanical working etc. makes wood as famous building material.

Types of Trees

The trees are classified into following types based on their mode of growth.

1. Exogenous
2. Endogenous

1. Exogenous

Exogenous trees are outward growing trees. Horizontal section of such tree contains several rings which are nothing but annual rings. These rings can be used to predict the age of tree. Most of the exogenous trees are useful for many engineering purposes.

Exogenous trees are sub classified into following types.

- Conifers
- Deciduous

Conifers

Conifers are nothing but soft wood producing trees which are also called as ever green trees. The timber of these trees is light colored, light in weight, low dense and poor against fire.

Examples: Pine, Fir, redwood, spruce, deodar, cedar etc.

Deciduous

Deciduous trees are hard wood producing trees. The leaves of this type of trees are generally broad in size and they fall in autumn and grow in spring. Deciduous trees are most suitable for constructional purposes. Timber of deciduous trees is dark colored, dense, heaviest and good against fire.

Examples: Maple, Mahogany, Oak, teak, walnut, babul etc.

2. Endogenous

Endogenous trees are inward growing trees which contains fibrous mass in their longitudinal section. The timber from these trees is useful in some limited engineering purposes.

Examples: bamboo, palm, cane etc.

Structure of a Tree

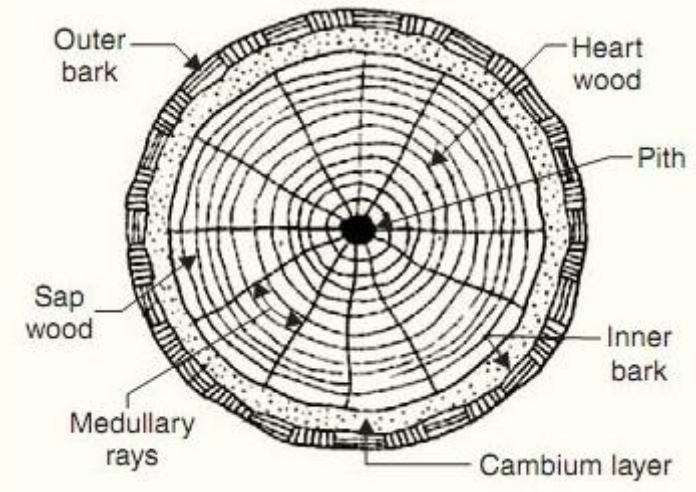
The structure of tree can be divided in to two categories as follows

1. Macrostructure
2. Microstructure

1. Macrostructure

The structure of a tree which is visible to the naked eye is called macro structure of tree. Macrostructure of tree contains following components

- Pith
- Heart wood
- Sap wood
- Cambium Layer
- Inner bark
- Outer bark
- Medullary rays



Pith

The core part or innermost part of the tree is called as pith. It contains cellulose tissues which are helpful for the growth of plant during its young age.

Heart wood

Heart wood is the portion around the pith which is dark in color and contain some annual rings in it. It is very hard and provides rigidity to the tree. Heart wood is used for several engineering purposes because of its strength and durability.

Sap wood

Sap wood contain outer annual rings. This indicates the recent growth of tree and is light in color. It contains sap which helps in the growth of tress.

Cambium Layer

Cambium layer contains sap which will turn into sap wood after some time. It should not exposed to atmosphere otherwise the tree may dead.

Inner bark

The protecting layer of cambium layer is known as inner bark.

Outer bark

The outermost layer of the tree section is called outer bark or cortex. It contains cells of wood fiber.

Medullary rays

The rays extending from pith to cambium layer are known as medullary rays. These rays hold the annual rings of sap wood and heart wood together.

Characteristics of good timber

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

1. Narrow annual rings, closer the rings greater is the strength.
2. Compact medullary rays.
3. Dark colour.
4. Uniform texture.
5. Sweet smell and a shining fresh cut surface.
6. When struck sonorous sound is produced.
7. Free from the defects in timber.
8. Heavy weight.
9. No woolliness at fresh cut surface.

Seasoning of timber

Seasoning of timber is the process by which moisture content in the timber is reduced to required level. By reducing moisture content, the strength, elasticity and durability properties are developed. A well-seasoned timber has 15% moisture content in it.

Methods of Seasoning of Timber

There are two methods of Seasoning of timber which are explained below

1. Natural seasoning
2. Artificial seasoning

Natural or air Seasoning of Timber

Natural seasoning is the process in which timber is seasoned by subjecting it to the natural elements such as air or water. Natural seasoning may be water seasoning or air seasoning.

Natural or Air Seasoning

In the process of air seasoning timber logs are arranged in layers in a shed. The arrangement is done by maintaining some gap with the ground. So, platform is built on ground at 300mm height from ground. The logs are arranged in such a way that air is circulated freely between logs. By the movement of air, the moisture content in timber slowly reduces and seasoning occurs. Even though it is a slow process it will produce well-seasoned timber.

Artificial Seasoning of Timber

Natural seasoning gives good results but takes more time. By artificial seasoning, timber is seasoned with in 4-5 days. Here also different methods of artificial seasoning are there and they are as follows.

- Water Seasoning
- Seasoning by Boiling
- Chemical seasoning
- Kiln seasoning
- Electrical seasoning

Water Seasoning

Water seasoning is the process in which timber is immersed in water flow which helps to remove the sap present in the timber. It will take 2 to 4 weeks of time and after that the timber is allowed to dry.

Seasoning by Boiling

Seasoning of timber is also achieved by boiling it in water for 3 to 4 hours. After boiling timber is allowed to drying. For large quantity of timber boiling is difficult so, sometimes hot steam is passed through timber logs in enclosed room. It also gives good results. The boiling or steaming process develops the strength and elasticity of timber but economically it is of heavier cost.

Chemical Seasoning

In case of chemical seasoning, timber is stored in suitable salt solution for some time. The salt solution used has the tendency to absorb water from the timber. So, the moisture content is removed and then timber is allowed to drying. It affects the strength of the timber.

Kiln Seasoning

In this method timber is subjected to hot air in air tight chamber. The hot air circulates in between the timber logs and reduces the moisture content. The temperature inside the chamber is raised with the help of heating coils. When the required temperature is obtained moisture content and relative humidity gets reduced and timber gets seasoned. Even though it is costly process it will give good results strength wise.

Electrical Seasoning

In the method of electrical seasoning timber is subjected to high frequency alternating currents. The resistance of timber against electricity is measured at every interval of time.

When the required resistance is reached seasoning, process is stopped because resistance of timber increases by reducing moisture content in it. It is also called as rapid seasoning and it is uneconomical.

Kiln seasoning

In this method, the drying of timber is carried out inside airtight chambers or even, The process is as follows

1. The timber is arranged inside the chamber, such that spaces are left in free circulation of air.

2. The air saturated with moisture and heated to a temperature of about 35 ° C to 38 ° C is then forced into the chamber by suitable arrangements

3. This forced air is allowed to circulate round the timber pieces. as air is Fully saturated with moisture, the evaporation from the surfaces of timber pieces is prevented, The heat Gradually reaches inside timber pieces.

4. The relative humidity is now gradually reduced. Then the temperature is raised and maintained till the desired degree of moisture content is attained,

Depending upon mode of construction and operation, the kilns are of two types.

They are

1. Stationary Kilns and

2. Progressive Kilns.

1. Stationary kiln

It is also known as a **compartment** kiln. In it the process of seasoning is carried in single compartment only. In it the drying operations are adjusted as drying proceeds. This kiln is adopted for seasoning of timber which required a close control of humidity and temperature. It gives better result.

2. progressive kiln

In it, the carriage with timber sections travels slowly from one end to other end of kiln. In doing so, it gets seasoned. The hot air is supplied from the discharging end, so that the temperature is less at the charging end and it increases at towards the discharging end. It is used for seasoning timber on a large scale. If it is not properly attended, the drying in the kiln prove to be unsatisfactory.

Note; The kiln seasoning though costly gives well seasoned timber as it controls, circulation of air, temperature and relative humidity.

Classification of timber

On the basic of its Postion
Standing timber implies a living tree.

Rough timber forms a part of the felled tree.

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

On the Basic of Grading (IS :6534)
All grading specifications are clearly distinguished between structural or stress grading, and commercial or utility grading based on Indian Standard classification.

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

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

2.Machine grading.

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

Commercial grading is further divided in the following classes:

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

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

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

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

based on durability
The Forest Research Institute of India conducts durability tests on specimens of size 600 × 50 × 50 mm by burying them in the ground upto half their length and observing them over several
years.
On the basis of durability it classifies trees into the following three classes:

1. High durability: If the average life is more than 10 years.
2. Moderate durability: If the average life is 5-10 years.
3. Low durability: If the average life is less than 5 years.

Classification Based on Grading
Based on permissible stresses, defects and so on, IS:12326-1976 classifies timber into three grades: Special Grade, Grade-I and Grade-II.

Classification Based on Availability
Based on availability, IS: 339-1963 classifies timber as:
X – Most common, 1415 m^3 or more per year.
Y – Common, 335 m^3 to 1415 m^3 per years.
Z – Less common, less than 335 m^3 per year.

DEFECTS IN TIMBER:

There are various types of defects in timber as a construction material. These defects in timber can be due to natural forces, fungi, insects and during seasoning and conversion. Types of these defects in timber is discussed in detail.

Shakes in Timber
Shakes are nothing but cracks which separates the wood fibers partly or completely. Different shakes are formed in different conditions as follows:

- **Cup shakes** are formed due to non-uniform growth of a tree or excessive bending by cyclones or winds. In this case, the shake develop between annual rings and separates them partly.
- **Heart shakes**, the other type of shakes which develop in maturity approaching trees whose inner part is under shrinkage. The shake spread from pith to sap wood following the directions of medullary rays.
- **Ring shakes** are similar to cup shakes, but they completely separate the annual rings.
- **Star shakes** are formed due to extreme heat or severe frost action. They develop wider cracks on the outside of timber from bark to the sap wood.
- **Radial shakes** are developed radially from pith to the bark.

Twisted Fibers in Timbers
When the tree in its younger age is exposed to high speed winds, the fibers of wood gets twisted. This type of wood is not suitable for sawing. So, this can be used for making poles, posts etc.

Upsets
Upsets, a defect of timber in which the fibers of wood are crushed and compressed by fast blowing winds or inappropriate chopping of tree.

Rind Galls
Rind galls are curved swellings of trees which are formed at a point where a branch of the tress is improperly removed or fell down.

Knots in Timber
The central part or stem of a tree is majorly used in the conversion of timber. Branches from the stem are removed and whole rounded stem is taken. But the base of branches forms a mark on the stem which results dark colored stains on the surface after conversion. These dark colored stains are due to the continuity of wood fibers. These dark colored rings are known as knots.

Glass

Glass is an inorganic product of fusion, which has been cooled to a solid state condition without crystallizing.

slow cooling process leads to formation of crystal nuclei and crystallization takes place.

If the cooling rate is fast, leaving no time to the formation of crystal nuclei, structure of super cooled liquid state turns to rigid and forms a glass.

Properties

1. Hard and brittle
2. appearance
3. glass can absorb, refracts or transmits light.
4. Glass transmits up to 80% of available natural day light in both directions
5. The glass is fully weather resistance
6. Melting point 1400 to 1500 degree c.

Classification

1. Soda-lime glass.
2. Potash-lime glass.
3. Potash – Lead glass.
4. Common glass.

Uses

1. Soda lime glass: It is used in the manufacture of glass tubes, laboratory apparatus, plate glass, window glass etc.
2. Potash lime glass: It is used in the manufacture of glass articles, which have to with stand high temperatures.
3. Potash – Lead glass: It is used in the manufacture of artificial gems, electric bulbs, lenses, prisms etc.
4. Common Glass: It is mainly used in the manufacture of medicine bottles.

Commercial forms or special types of glass

- Fibre glass
- Float glass
- Ground glass
- Laminated glass
- Wired glass
- Optical glass

Manufacture of glass

1. Batching of fret mixing
2. Furnace melting
   a. Initial stage
   b. Second stage
   c. Third stage
3. Drawing
4. Annealing
5. Cutting

Stone Masonry and brick stone masonry:

Definition:

The art of building a structure in stone with any suitable masonry is called stone masonry.

Basic Types of Stone Masonry

There are two types of stone masonry namely

1. Ashlar Masonry
2. Rubble Masonry

Ashlar Masonry

Ashlar are those stones that are finely dressed in a square or rectangular shape i.e. free from any irregularity or defects. Care must be taken while dressing the stone so their sizes and dimensions must be in accordance with the thickness of wall and a height of course.

The joints in this type of masonry are finely made with thickness of around 3 mm or so. In most of the cases the ashlar masonry is carried out in cement mortar or in some cases lime mortar.

This type of stone masonry is costly and time taking as it involves extensive dressing work and only expert masons having experience of ashlar masonry must be hired. So for most of the cases we can find the application of Ashlar Masonry only in building that are large and important like fortresses, palaces etc.

Types of Ashlar Masonry

When naming any type of ashlar masonry, it is related to the quality or specification of the face finish of the stones used.

Ashlar Rough Tooled

Keeping in view of the above stated rule, we can relate that ashlar rough tooled is that type of ashlar masonry in which the face of the stones is rough tooled. So Ashlar rough tooled types of ashlar masonry is the one in which sides and the bed is dressed properly with fine chisel tool thereby drafting all the corners. The height of the stones in each course may not be kept same but it is selected keeping in view the symmetry along with structural integrity of the wall.

It had a well-made joint with reasonable thickness i.e. usually less than 6 mm. The corners of the stone around the periphery are finely dressed by drafting.

Ashlar fine Masonry

In Ashlar fine type of stone masonry, unlike the ashlar rough masonry, the faces along with the bed and joints are also dressed finely true to the requirement of finish. One other difference of ashlar fine type from ashlar rough tooled is that the courses in the earlier one are well formed with uniform height of around 30 cm or so. This is the most expensive type of stone masonry and it involves a lot of wastage in material while dressing.

The bond between each stone is well formed with uniform thickness of joint. One last thing, in this type of stone masonry, the stones are laid alternatively as header and stretcher in the course.

AshlarChamfered

As the name suggests, in this type the faces, that are obviously finely dressed, are chamfered or beveled at the periphery edges at an angle of 45 degrees with the help of chisel. The depth of chamfered strip is about a depth of 1 inch.

Ashlar Rock Quarry Faced

It is also known by the name rustic faced ashlar masonry. In this type of stone masonry, the face of the stone is only chiseled around the periphery making a projection of about 3 inches or less while the remaining face of the stone is left as it is received from the quarry.

So you might be thinking that this type is similar to that of rough tooled ashlar masonry, but there is a difference between the two. In rough tooled, the space between finely dressed strip around periphery is not left untouched but it is roughly dressed but in case of rock or rustic faced the area between the finely dressed strip is left untouched.

Ashlar Facing

I have already explained that ashlar masonry is very expensive and is only recommended in areas of importance. But it is always a good idea to build only the facing of the masonry with ashlar while fill in the rubble or other type in the core of the wall. Such a composite type of ashlar masonry is named as ashlar facing masonry. The backing of such a wall can be concrete or brick whatever recommended but the facing stones should not be less than 20 cm.

Ashlar Block in Course

Ashlar block in course type of masonry is same as that of roughly tooled ashlar masonry with only difference that in this case the height of the course is much less but not less than 20 cm.

Rubble Masonry

Unlike ashlar masonry, this types of stone masonry involves laying of rough undressed stones irregularly i.e. the courses in rubble masonry are not defined and the size of shape is also not uniform.

This type of stone masonry is very cheap and is useful for areas of low income for constructing traditional huts and mud houses especially in villages. But sometimes, the architect, in order to render some traditional look of the building, prefer to use rubble wall look.

Although the sizes of stones are not defined, but even than it must be considered that the width of the stone face must not be less than the height. And in addition to that, the orientation for placement of stone should be such that the mortar joints should not be excessively wide. The rubble masonry stones can be laid in cement mortar or lime mortar as per the specification of the project.

Types of Rubble Masonry

Following are the types of rubble masonry :

Dry Rubble Masonry

Dry Rubble Masonry is the most common type of rubble masonry in which the rough undressed stones are laid in irregular horizontal courses without mortar hence named dry. You might have seen this type of masonry on the slopes of canals for erosion protection. This type is also used in villages for construction of retaining walls or as stone pitching of earthen dams.

These are used to render non-load bearing walls with height less than 6 meters and are the cheapest of all the types.

Un-coursed Rubble Masonry

The stones taken from the quarry are used as it is without any dressing or cutting in irregular courses. The orientation of stone is decided to allow maximum load distribution and thickness of mortar joint should be less than 13 mm. While lying the stones, there must be intermediate stones on the line of vertical joints to avoid long vertical joints.

Un-coursed Random Rubble Masonry

This type of stone masonry is slightly superior than the previous one in the manner that soft corners and edges are dressed with a hand hammer but the shape of the stone is still irregular and undefined. In this type the face of the stone to be used must be of uniform color and orientation must be in similar fashion. In between the bigger stones, boulders and small stones must be used to ensure efficient packing inside and on the face of the wall.

Un-coursed Squared Rubble Masonry

In this type, the stones obtained from quarry are dressed from all edges to obtain a regular square shape but their orientation are such that they are not placed in well-defined courses although the thickness of joints is uniform.

Coursed Random Rubble

In all the coursed rubble masonry this the cheapest of all, it involves slightly dressed irregular shape and size stones placed in well-defined courses where height is uniformly adjusted.

Brick masonry

Types of bonds

Types of bonds in brick masonry wall construction are classified based on laying and bonding style of bricks in walls. The bonds in brick masonry is developed by the mortar filling between layers of bricks and in grooves when bricks are laid adjacent to each other and in layers in walls.

Mostly used material for bonds in brick masonry is cement mortar. Lime mortar and mud mortar are also used.

Types of Bonds in Brick Masonry

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

Other Types of bonds are:

1. Facing bond
2. Dutch bond

3. English cross bond
4. Brick on edge bond
5. Raking bond
6. Zigzag bond
7. Garden wall bond

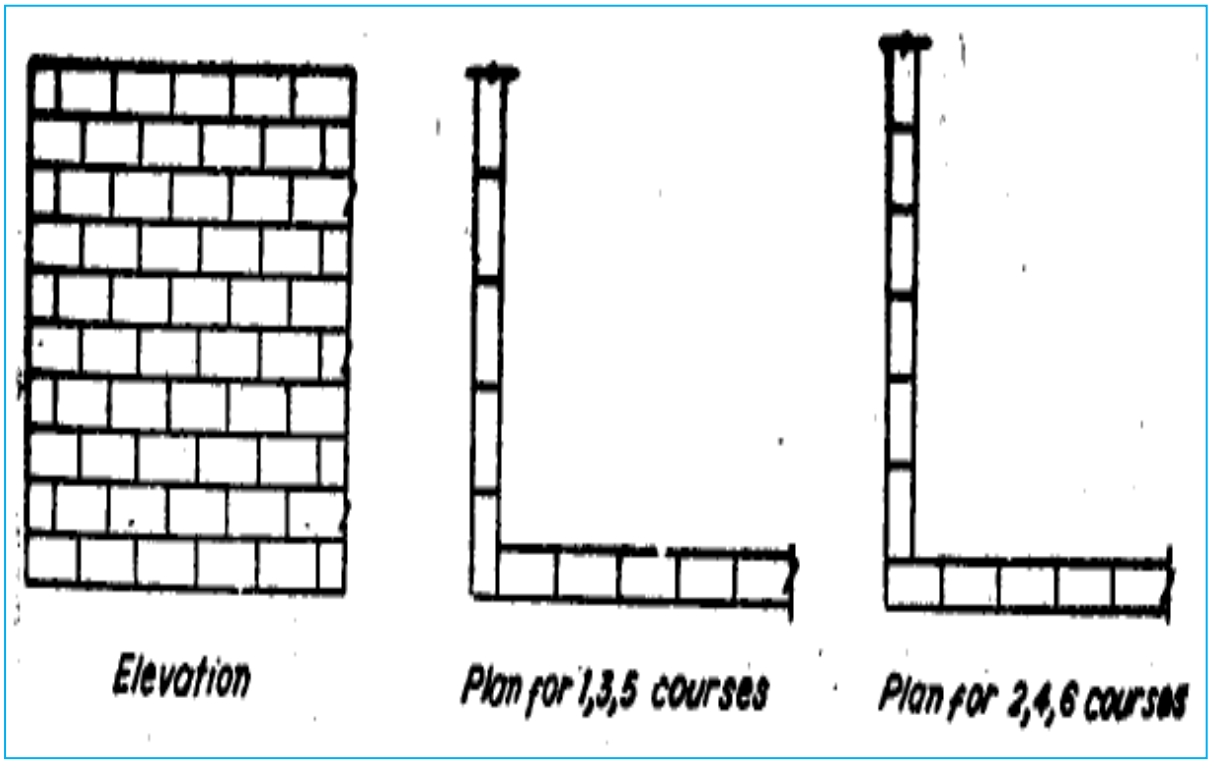
1. Stretcher bond

Longer narrow face of the brick is called as stretcher as shown in the elevation of figure below. Stretcher bond, also called as running bond, is created when bricks are laid with only their stretchers showing, overlapping midway with the courses of bricks below and above.

Stretcher bond in the brick is the simplest repeating pattern. But the limitation of stretcher bond is that it cannot make effective bonding with adjacent bricks in full width thick brick walls. They are suitably used only for one-half brick thick walls such as for the construction half brick thick partition wall.

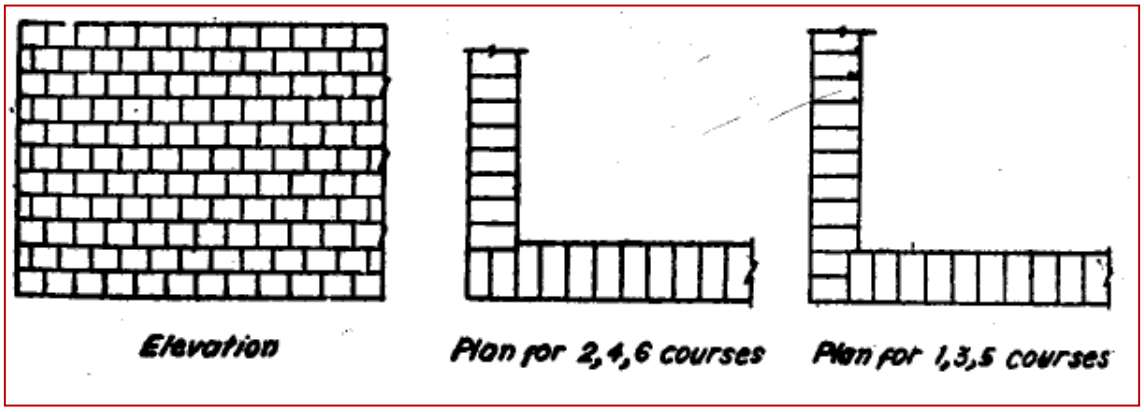
Walls constructed with stretcher bonds are not stable enough to stand alone in case of longer span and height. Thus they Then need supporting structure such as brick masonry columns at regular intervals.

Stretcher bonds are commonly used in the steel or reinforced concrete framed structures as the outer facing. These are also used as the outer facing of cavity walls. Other common applications of such walls are the boundary walls, gardens etc.



2. Header bond

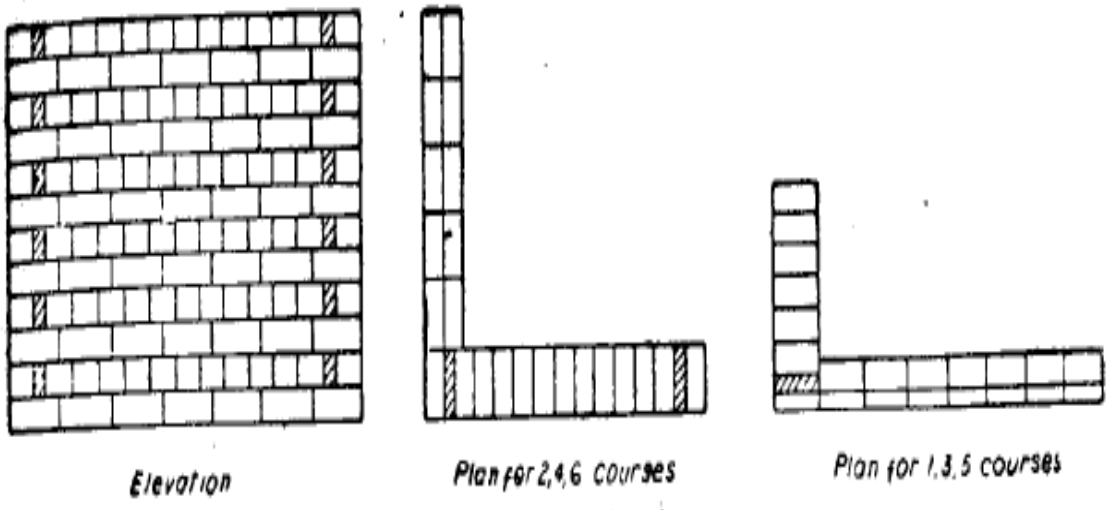
Header is the shorter square face of the brick which measures 9cm x 9cm. Header bond is also known as heading bond. In header bonds, all bricks in each course are placed as headers on the faces of the walls. While Stretcher bond is used for the construction of walls of half brick thickness whereas header bond is used for the construction of walls with full brick thickness which measures 18cm. In header bonds, the overlap is kept equal to half width of the brick. To achieve this, three quarter brick bats are used in alternate courses as quoins.



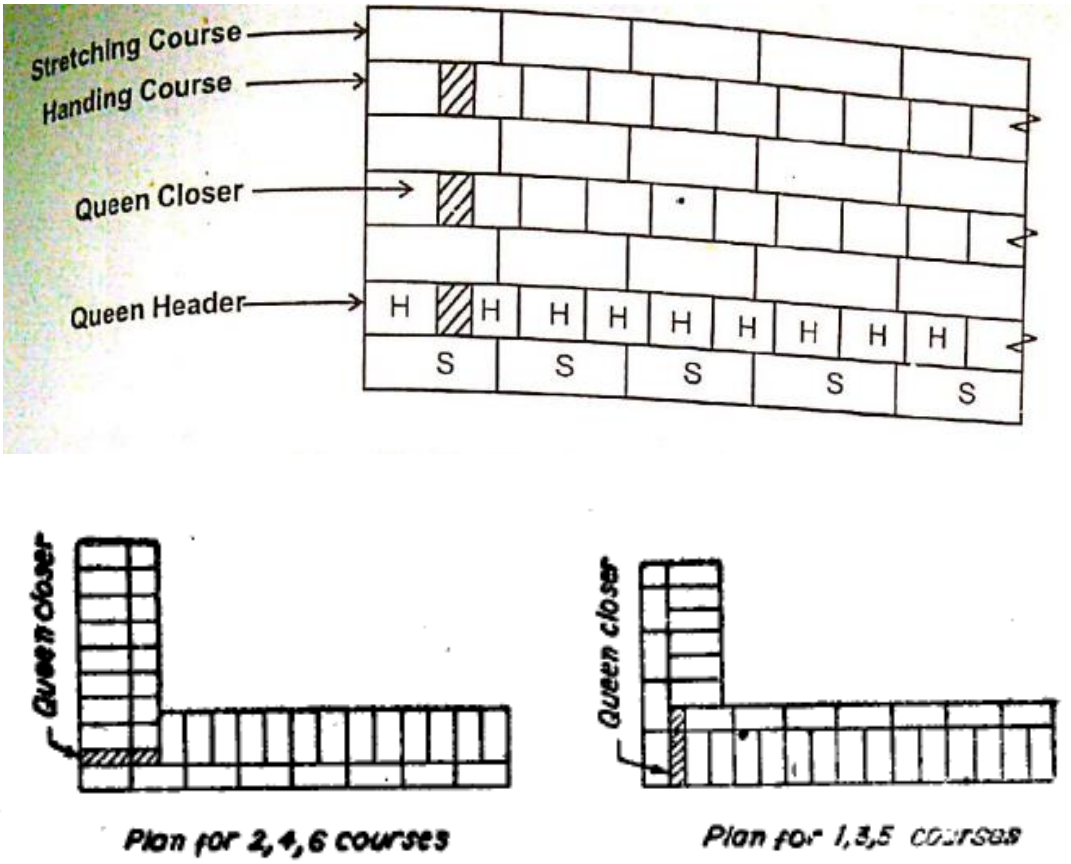
3. English Bond

English bond in brick masonry has one course of stretcher only and a course of header above it, i.e. it has two alternating courses of stretchers and headers. Headers are laid centered on the stretchers in course below and each alternate row is vertically aligned.

To break the continuity of vertical joints, quoin closer is used in the beginning and end of a wall after first header. A quoin close is a brick cut lengthwise into two halves and used at corners in brick walls.



One-brick wall English bond



One-and-a-half-bricks wall English bond.

4. Flemish Bond

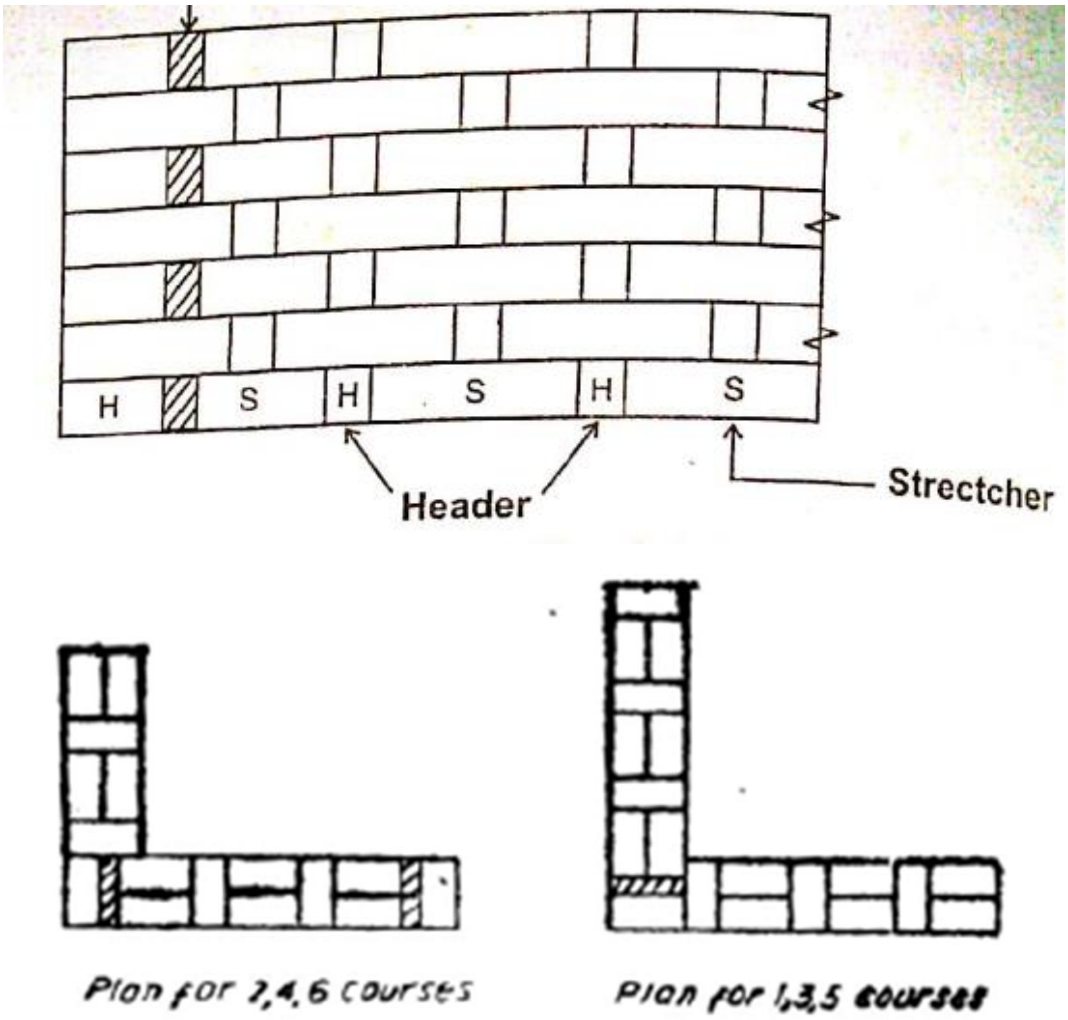
For the breaking of vertical joints in the successive courses, closers are inserted in alternate courses next to the quoin header. In walls having their thickness equal to odd number of half bricks, bats are essentially used to achieve the bond.

Flemish bond, also known as Dutch bond, is created by laying alternate headers and stretchers in a single course. The next course of brick is laid such that header lies in the middle of the stretcher in the course below, i.e. the alternate headers of each course are centered on the stretcher of course below. Every alternate course of Flemish bond starts with header at the corner.

The thickness of Flemish bond is minimum one full brick. The disadvantage of using Flemish bond is that construction of Flemish bond is difficult and requires greater skill to lay it properly as all vertical mortar joints need to be aligned vertically for best effects. For the breaking of vertical joints in the successive courses, closers are inserted in alternate courses next to the quoin header. In walls having their thickness equal to odd number of half bricks, bats are used to achieve the bond.

Flemish bonds have better appearance but are weaker than English bonds for load bearing wall construction. Thus, if the pointing has to be done for brick masonry walls, then Flemish

bond may be used for better aesthetic view. If the walls have to be plastered, then it is better to use English bond.



Flemish bonds are classified as:

- Single Flemish Bond
- Double Flemish Bond

Single Flemish bond is a combination of English bond and Flemish bond. In this type of construction, the front exposed surface of wall consists of Flemish bond and the back surface of the wall consists of English bond in each course. Minimum thickness required for single Flemish bond is one and a half brick thickness. The main purpose of using single Flemish bond is to provide greater aesthetic appearance on the front surface with required strength in the brickwork with English bond.

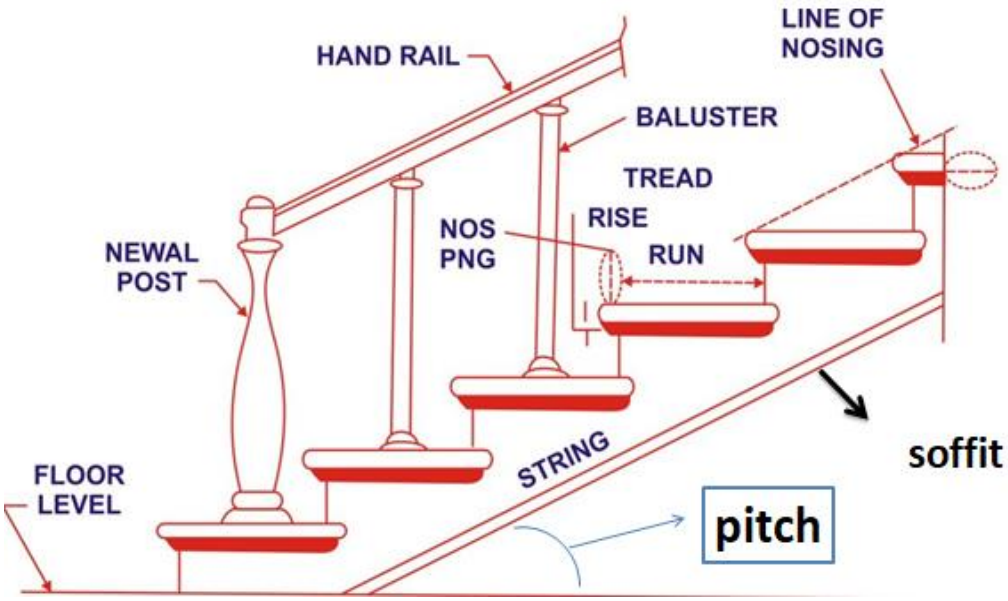
Double Flemish Bond has the same appearance both in the front and back elevations, i.e. each course consists of alternate header and stretcher. This type of bonding is comparatively weaker than English bond.

MODULE-V
STAIRS AND STAIR CASES

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.

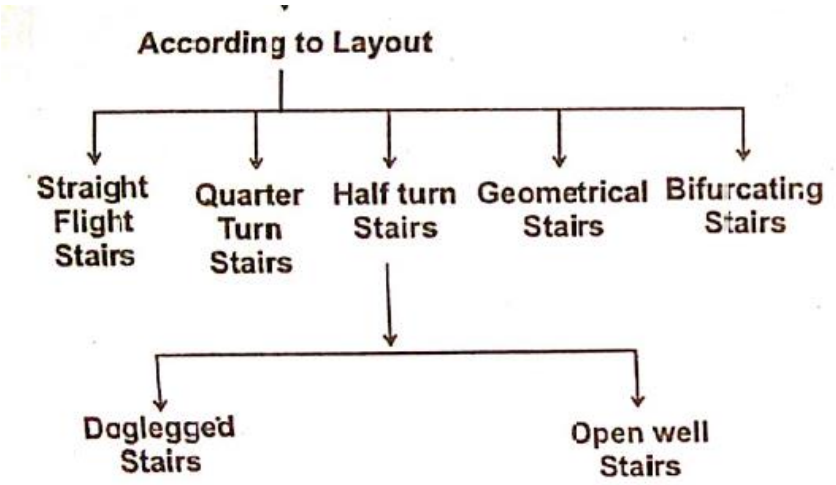
3. Length
The flight of the stairs should be restricted to a maximum of 12 and minimum of 3 steps.

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..

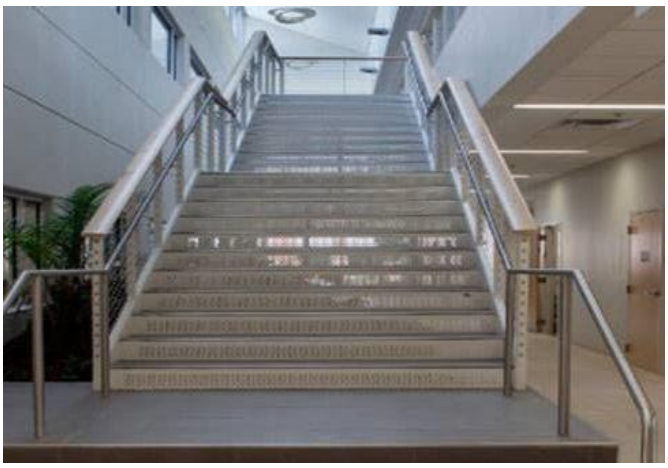
6. Materials
Stairs should be constructed using fire resisting materials. Materials also should have sufficient strength to resist any impact.

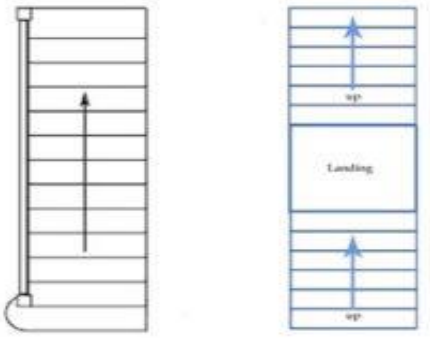
Classification of stairs



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.

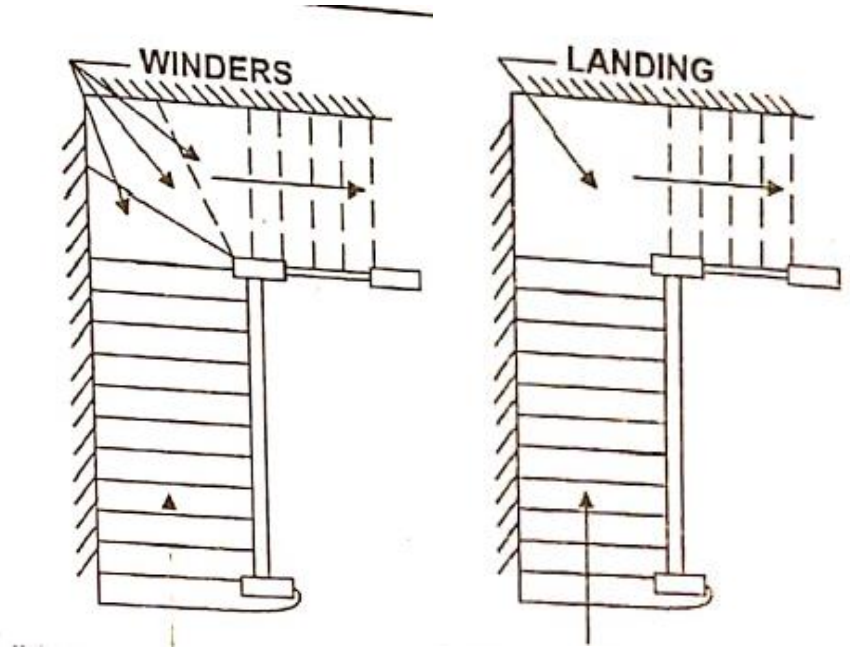




Straight Stair

Quarter turn stairs

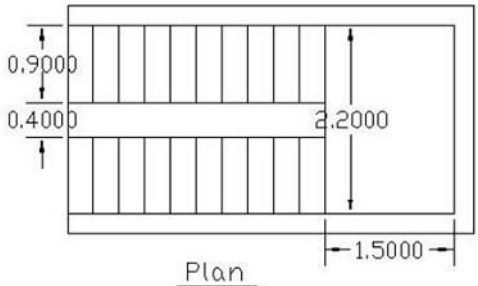
A quarter turn stair is the one which changes its direction either to the right or to the left but where the turn being affected either by introducing a quarter space landing or by providing winders. In these type of stairs the flight of stair turns 90 degrees art landing as it rises to connect two different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



Half turn stairs

Half turn stairs are those which reverse direction or change direction to 180°.

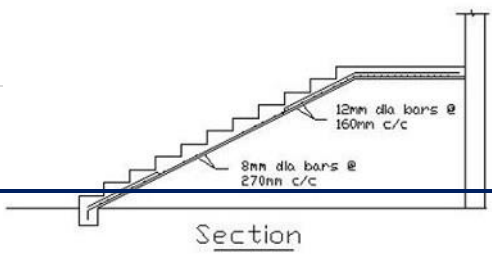
1. Dogged-legged Stair
2. Open well Stair



Plan

Dogged-legged Stair

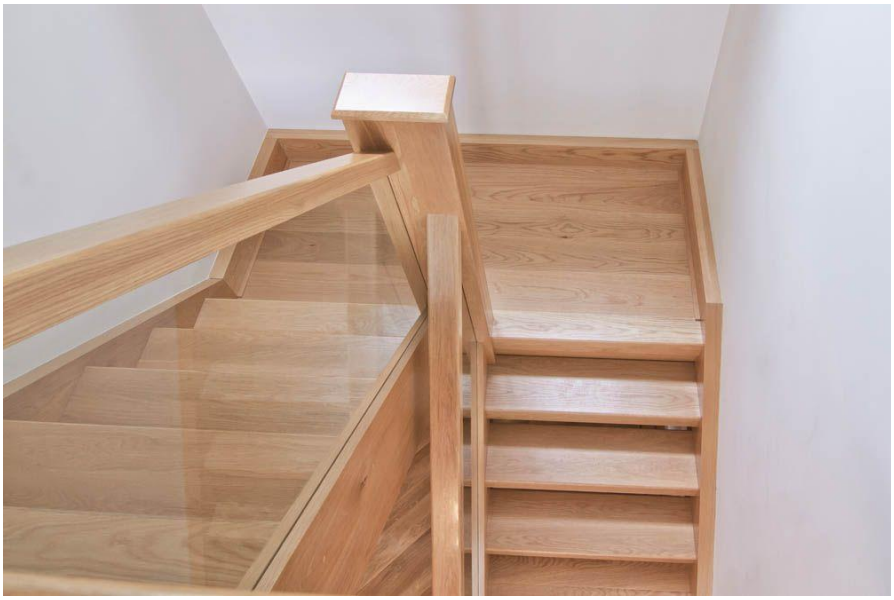
Dog-legged or newel half turn stairs the name is



Section

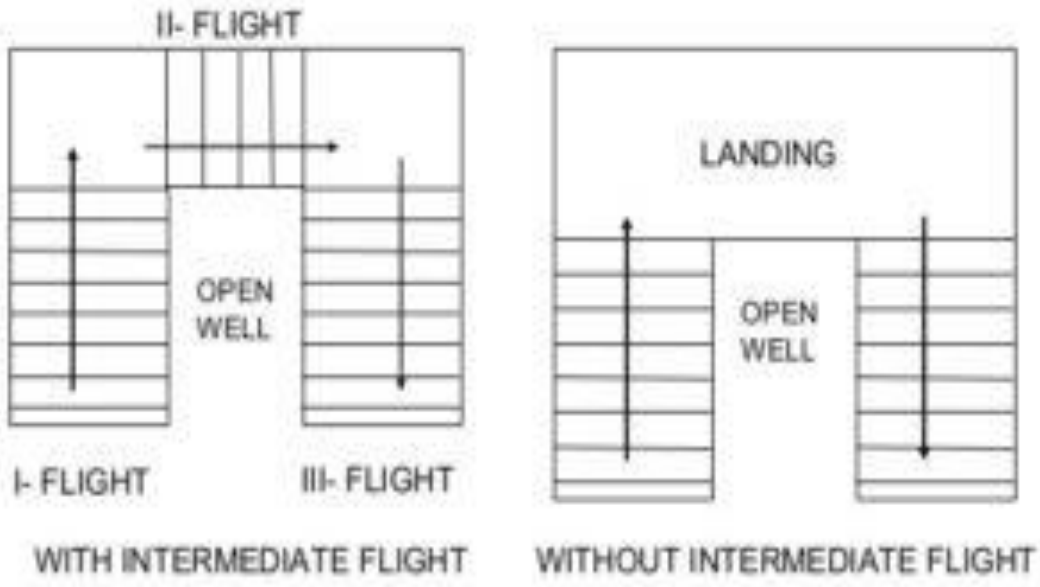
due to its sectional appearance. The newel posts are provided at the beginning and end of each flight.

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 Newel Stairs

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.

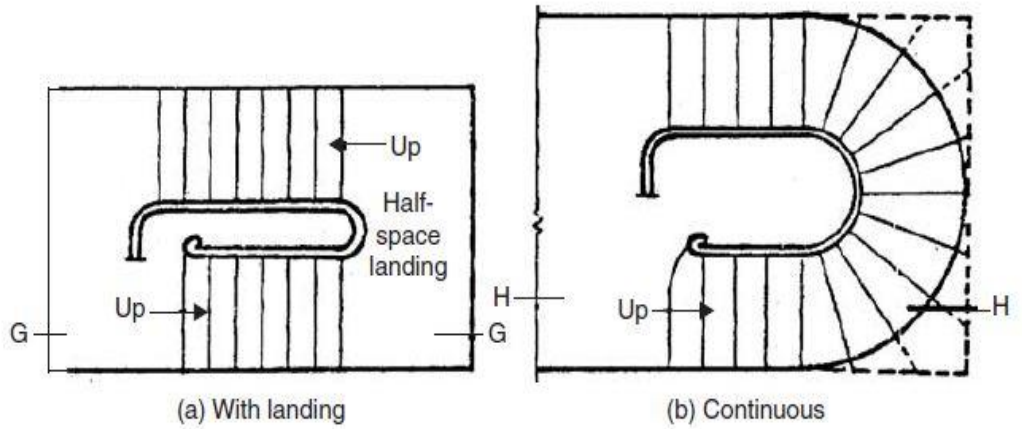
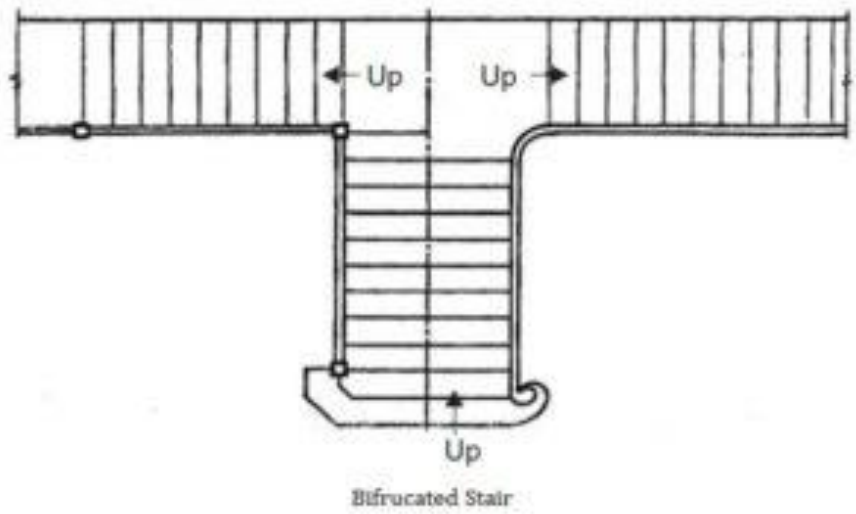


Fig. 8.38. Geometric stairs

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 of only 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. Doors with 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 theater in 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