INTERIOR DESIGN STUDIO AND BUILDING SYSTEM TECHNOLOGY- I

BAID32

UNIT-II

An introduction to various construction techniques in interiors. Foundation – Deep and Shallow, Brick bonds -stretcher, header, English and Flemish. Arches, Lintels, flooring, roofing, ceiling.

INTRODUCTION

It is considered that ages ago human beings lived in caves or under trees. Then they would have arranged or removed pebbles to make their entry to the caves easier or would have cut tree branches and arranged the large branches to make roofs for shelter from the rain. They dug the ground with stone tools to make traps for animals. As they learned to grow plants, they would have dug the ground to make water channels and made small bridges by placing logs over the channels.

These actions contain the basics of construction techniques, namely, digging the ground or rock, compacting the ground to make a foundation, transporting materials, processing and assembling various materials to make buildings or structures.

Searching for better living, mankind has refined construction techniques to make it possible. In other words, construction is a history of mankind's making many mistakes and overcoming past failures in the process of conquering the harsh nature.

Thus, the desire for better living was one of the major motivations for humans to develop advanced construction techniques. Development of construction techniques itself was one of the building blocks of civilization.

FOUNDATION

The most important part of a building is its foundation. The safety, stability and soundness of the structure depend upon it. The base of the foundation which comes in direct contact with the ground distributes the load of the structure on a wide area and transmits the same directly to the ground. The soil which is located immediately below the base of the foundation is called the sub-soil or foundation soil.

Foundation is one of the essential parts of the structure. Foundation is the part of a structure on which the building stands. The solid ground on which it rests is known as foundation bed.

DEFINITION

1. The substructure (beneath the ground soil) that transfers the load from the column to the soil is known as Foundation.
2. The bottom most part of the substructure which transmit load of the structure along with its own weight into the soil underneath or surroundings without carrying shear failure or bearing capacity failure and excessive settlement.
3. The lowest artificially prepared part of the structure which is in direct contact with the ground and which transmit the loads of the structure to the ground is called the foundation or substructure.

OBJECTIVES OF FOUNDATION

Foundation should fulfil the following objectives:

1. Distribute the weight of the structure over a large area of soil.
2. Avoid unequal settlement.
3. Prevent the lateral movement of the structure.
4. Increase structural stability.

PURPOSE OF FOUNDATION

Foundations are provided for all load carrying structure for following purposes:

1. Foundation are the main reason behind the stability of any structure. The stronger is the foundation, more stable is the structure.
2. The proper design and construction of foundations provide a proper surface for the development of the substructure in a proper level and over a firm bed.
3. Specially designed foundation helps in avoiding the lateral movement of the supporting material.
4. A proper foundation distributes load on to the surface of the bed uniformly. This uniform transfer helps in avoiding unequal settlement of the building, Differential settlement is an undesirable building effect
5. The foundation serves the purpose of completely distributing the load from the structure over a large base area and then to the soil under beneath. This load transferred to the soil should be within the allowance bearing capacity of the soil.

FUNCTIONS OF FOUNDATION IN CONSTRUCTION

Based on the purposes of foundation in construction, the main functions of the foundation can be enlisted as below:

1. Provide overall lateral stability for the structure
2. Foundation serve the function of providing a level surface for construction of substructure.
3. Load distribution is carried out evenly.
4. The load intensity is reduced to be within the safe bearing capacity of the soil.
5. The soil movement effect is resisted and prevented.
6. Scouring and the undermining issues are solved by the construction of foundation.

REQUIREMENTS OF A GOOD FOUNDATION

The design and the construction of a well performing foundation must possess some basic requirements that must not be ignored. They are

1. The design and the construction of the foundation is done such that it can sustain as well as transmit the dead and the imposed loads to the soil. This transfer has to be

carried out without resulting in any form of settlement that can result in any form of stability issues for the structure.

2. Differential settlements can be avoided by having a rigid base for the foundation. These issues are more pronounced in areas where the superimposed loads are not uniform in nature.
3. Based on soil and area it is recommended to have a deeper foundation so that it can guard any form of damage or distress. These are mainly caused due to the problem of shrinkage and swelling because of temperature changes
4. The location of the foundation chosen must be an area that is not affected or influenced by future works or factors.

TYPES OF FOUNDATION

There are different types of soil, and the bearing capacity of the soil is different for each type of soil. Depending on the soil profile, size, and load of the structure, engineers chose different kinds of foundation.

In general, all foundations are divided into two categories, -

1. Shallow and
2. Deep foundations.

The terms Shallow and Deep Foundation refer to the depth of the soil at which it is placed. Generally, if the width of the foundation is greater than the depth, it is labelled as the "Shallow Foundation".

If the width is smaller than the depth of the foundation it is called as "Deep Foundation." However, deep foundation and shallow foundation can be classified as shown in the following chart.

1. Shallow Foundation
    - Individual footing or isolated footing
    - Combined footing
    - Strip footing
    - Raft or mat foundation
2. Deep Foundation
    - Pile foundation
    - Drilled shafts or Caissons
    - Well foundation

SHALLOW FOUNDATION

a. Shallow foundations are those founded near to the finished ground surface; generally where the founding depth is less than the width of the footing and less than 3m.
b. These are not strict rules, but merely guidelines: basically, if surface loading or other surface conditions will affect the bearing capacity of a foundation it is 'shallow'.
c. Shallow foundations (sometimes called 'spread footings') include pads ('isolated footings'), strip footings and rafts.
d. Shallows foundations are used when surface soils are sufficiently strong and stiff to support the imposed loads; they are generally unsuitable in weak or highly compressible soils, such as poorly-compacted fill, peat, recent lacustrine and alluvial deposits, etc.
e. As the shallow foundation depth is low and it is economical, it is the most popular type of foundation for lightweight structures. Several types of shallow foundations are discussed below.

TYPES OF SHALLOW FOUNDATION

1. INDIVIDUAL FOOTING OR ISOLATED FOOTING

a. Individual footing or an isolated footing is the most common type of foundation used for building construction.
b. This foundation is constructed for a single column and also called a pad foundation.
c. The shape of individual footing is square or rectangle and is used when loads from the structure is carried by the columns.
d. Size is calculated based on the load on the column and the safe bearing capacity of soil.
e. Rectangular isolated footing is selected when the foundation experiences moments due to eccentricity of loads or due to horizontal forces.

2. COMBINED FOOTING

a. Combined footing is constructed when two or more columns are close enough or the bearing capacity of the soil is low and their isolated footing overlap each other.
b. The combined footing is very similar to the isolated footing. It is a combination of isolated footings, but their structural design differs.

c. The shape of this footing is a rectangle and is used when loads from the structure is carried by the columns.
d. There are different types of combined footing, including slab type, slab and beam type, rectangular, raft, and strap beam type. They may be square, tee-shaped, or trapezoidal.
e. The main objective is the uniform distribution of loads under the entire area of footing, for this is necessary to coincide with the centre of gravity of the footing area with the centre of gravity of the total loads.

3. <u>SPREAD FOOTINGS OR STRIP FOOTINGS AND WALL FOOTINGS</u>

a. Spread footings are those base is wider than a typical load bearing wall foundations.
b. The wider base of this footing type spreads the weight from the building structure over more area and provides better stability.
c. Spread footings and wall footings are used for individual columns, walls and bridge piers where bearing soil layer is within 3m (10 feet) from the ground surface.
d. Soil bearing capacity must be sufficient to support the weight of the structure over the base area of the structure.
e. These should not be used on soils where there is any possibility of a ground flow of water above bearing layer of soil which may result in scour or liquefaction.

4. <u>RAFT OR MAT FOUNDATION</u>

a. 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.
b. The use of mat foundation is for columns and walls foundations where the loads from the structure on columns and walls are very high.
c. This is used to prevent differential settlement of individual footings
d. It is suitable for expansive soils whose bearing capacity is less for the suitability of spread footings and wall footings.
e. Raft foundation is economical when one half area of the structure is covered with individual footings and wall footings are provided
f. These foundations should not be used where the groundwater table is above the bearing surface of the soil

ADVANTGES OF SHALLOW FOUNDATION

1. This foundation takes less time for construction as compared to others in the construction work.
2. Shallow foundation reduces our construction time and material.
3. No experienced labour is required to construct a shallow foundation.
4. A shallow foundation is economical and cheaper than other types of foundation.
5. The failure occurs due to earth quack is lesser than any other type of foundation.
6. Shallow foundation is convenient for foundation having depth is equal or less than the foundation width.
7. It is used if bearing capacity of soil is high at shallow depth.
8. For compressive soils, it helps to reduce settlement
9. No piling is required, so it reduces a great cost.

DISADVANTAGES OF SHALLOW FOUNDATION

1. This foundations cannot be used everywhere. The major disadvantages of shallow foundations are given below.
2. If weight of structure is high and load of the structure is distributed unequally.
3. The bearing capacity of top surface soil is less.
4. If sub-soil water level is high and it is uneconomical to pump out the water from the hole or canal.
5. If there is a chance of scouring as the structure is near sea or river shallow foundation cannot be used.

DEEP FOUNDATION

1. The foundations constructed below ground level with some arrangements such as piles, well etc. at their base are called deep foundations.
2. If the depth of footing greater or equal to the Width of footing, it is known as the deep Foundation.
3. Deep Foundation is used Where the bearing capacity of the soil is very low. The load coming from the superstructure is further transmitted vertically to the soil.
4. Deep foundations are usually at depths >3 m below finished ground level.
5. They include piles, piers and caissons or compensated foundations using deep basements and also deep pad or strip foundations.
6. Deep foundations can be used to transfer the loading to a deeper, more competent strata at depth if unsuitable soils are present near the surface.
7. Deep foundations are used when

- The strata of good bearing capacity is not available near the ground
- The space is restricted to allow for spread footings
- In these cases the foundation of the structure has to be taken deep with the purpose of attaining a bearing stratum which is suitable and which ensures stability and durability of a structure.
- The bearing stratum is not the only case. There may be many other cases.

TYPES OF DEEP FOUNDATION

The followings are the types of deep foundation

1. Pile foundation
2. Drilled shafts or Caissons
3. Well foundation

1. PILE FOUNDATION

a. 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.

b. 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.

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

d. Pile foundations are generally used for soils where soil conditions near the ground surface is not suitable for heavy loads.

e. The depth of hard rock strata may be 5m to 50m (15 feet to 150 feet) deep from the ground surface.

f. Pile foundation resists the loads from the structure by skin friction and by end bearing.

g. The use of pile foundations also prevents differential settlement of foundations.

2. DRILLED SHAFTS OR CAISSON FOUNDATION

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

b. It resists loads from structure through shaft resistance, toe resistance and/or combination of both of these.
c. The construction of drilled shafts or caissons are done using an auger.
d. Drilled shafts can transfer column loads larger than pile foundations. It is used where the depth of hard strata below ground level is located within 10m to 100m (25 feet to 300 feet).
e. Drilled shafts or caisson foundation is not suitable when deep deposits of soft clays and loose, water bearing granular soil exist.
f. It is also not suitable for soils where caving formations are difficult to stabilize, soils made up of boulders, artesian aquifer exists.

3. <u>WELL FOUNDATION</u>

a. Well foundation are large diameter foundations adopted in an underwater situation such as bridge foundations in rivers.
b. It is the most common type of foundation in India for both road and railway bridges.
c. Well foundation can be sunk to great depths and can carry very heavy vertical and lateral loads.
d. Well foundations can also be installed in a boulder stratum. It is relatively rigid in its structural behaviour.
e. Well foundations actually belong to one of the types of caissons. Caissons are box type foundations used to support bridges and other heavy structures and sunk into the ground under self-weight with additional weights applied at the top.
f. Three types of caissons are commonly used, which are as follows:
   Open caissons
   Box caissons
   Pneumatic caissons.
g. The following different shapes are used for well foundations, which have their own relative merits and demerits:
   1. Circular.
   2. Twin circular.
   3. Square/Rectangular.
   4. Double D.
   5. Hexagonal/Octagonal.

Well foundations with different shapes of cross section are shown below

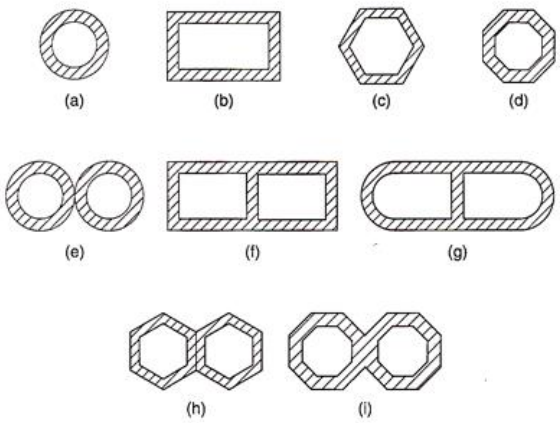


Figure 21.4 Shapes of well foundations: (a) Circular, (b) rectangular, (c) hexagonal, (d) octagonal, (e) twin circular, (f) double rectangular, (g) double D, (h) double hexagonal, and (i) double octagonal.

ADVANTAGES OF DEEP FOUNDATION

1. Piles can be prefabricated off-site which allows efficient installation on the site.
2. The induced piles displace and compact the soil which will increase the bearing capacity of the pile.
3. Piles are durable and will keep the facility safe and strong for many years.
4. Increase overall productivity.
5. A pile quickly damaged by driving through stones and boulders.
6. Piles can be attacked by saltwater marine bits.
7. It is very difficult to know the actual required length in advance.
8. Vibrations are produced when the piles are driving which affects neighbouring structures.

DISADVANTAGES OF DEEP FOUNDATION

1. Piles can undergo corrosion.
2. Daily inspection required.
3. Skilled labour is required to fix the piles.

DIFFERENCE BETWEEN SHALLOW FOUNDATION AND DEEP FOUNDATION

Shallow foundation and deep foundation have several differences. Sources of main differences between deep and shallow footings are definition, depth of foundation, cost, feasibility, mechanism of load transfer, advantages, disadvantages, types, etc.

In the following table the main differences between shallow and deep foundation are given:

S.NO	SOURCES	SHALLOW FOUNDATION	DEEP FOUNDATION
1	**Definition**	Foundation which is placed near the surface of the earth or transfers the loads at shallow depth is called the shallow foundation.	Foundation which is placed at a greater depth or transfers the loads to deep strata is called the deep foundation.
2	**The depth of the foundation**	The depth of shallow foundation is generally about 3 meters or the depth of foundation is less than the footing with.	Greater than the shallow foundation.
3	**Cost**	A shallow foundation is cheaper	Deep foundations are generally more expensive than shallow.
4	**Feasibility**	Shallow foundations are easier to construct.	The construction process of a deep foundation is more complex
5	**Mechanism of load transfer**	Shallow foundations transfer loads mostly by end bearing	Deep foundations rely both on end bearing and skin friction, with few expectations like end bearing pile
6	**Types**	Isolated foundation, strip foundation, Mat foundation, combined foundation etc	Pier foundation, Pile foundation, Caissons etc.

7	**Advantages**	Construction materials are available, less labour is needed, construction procedure is simple at an affordable cost etc.	Foundation can be provided at a greater depth, provides lateral support and resists uplift, can carry huge load etc
8	**Disadvantages**	Possibility of a settlement, usually applicable for light weight structure, weak against lateral loads etc	More expensive, needs skilled labours, complex construction procedures, can be time-consuming and some types of deep foundations are not very flexible, etc

BRICK BONDS

1. A brick bond is a pattern in which bricks are laid. Bond, in masonry, systematic arrangement of bricks or other building units composing a wall or structure in such a way as to ensure its stability and strength. Bonding is the arrangement of bricks in a structure such as a wall or column.
2. The various types of bond may also have a secondary, decorative function. It applies to both brick walls and brick paving for patios and paths, as well as to concrete block and other types of masonry construction. There are many different types of brick bonds and each has its own look, installation challenges, and in the case of walls, structural considerations.

Brick bonding patterns can.,

1. Distribute loads throughout the structure to achieve maximum strength.
2. Ensure stability.
3. Achieve the desired aesthetic.

TYPES OF BRICK BONDS

Types of bond 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.

The most commonly used types of bonds in brick masonry are:

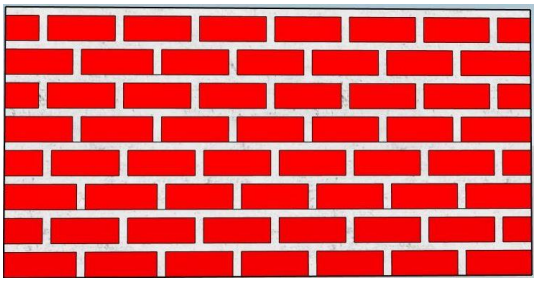
1. Stretcher bond
2. Header bond
3. English bond
4. Flemish bond

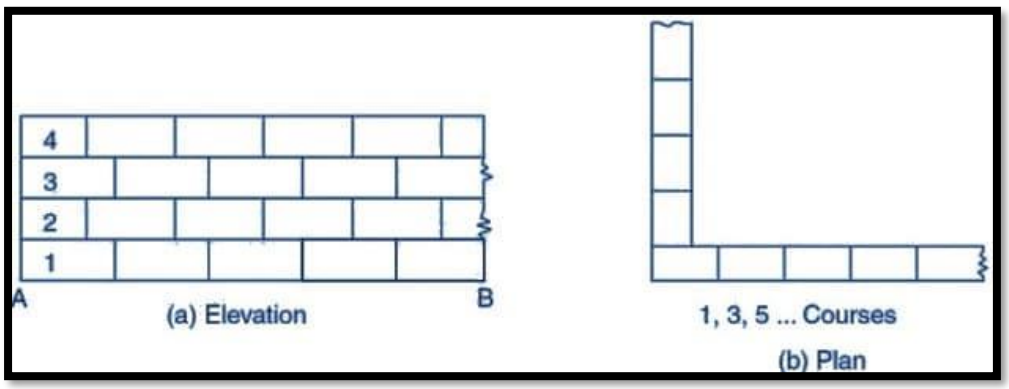
1. STRETCHER BOND

- Longer narrow face of the brick is called as stretcher. Stretcher bond, is also called as running bond.
- It is created when bricks are laid with only their stretches showing 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 of 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 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.

Different types of wall construction done using stretcher type bond are:

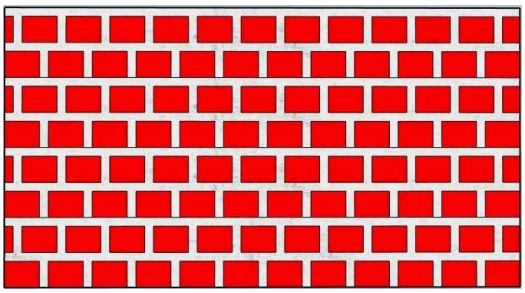
- Sleeper walls
- Boundary walls
- Partition walls
- Division walls (internal dividers)
- Chimney stacks

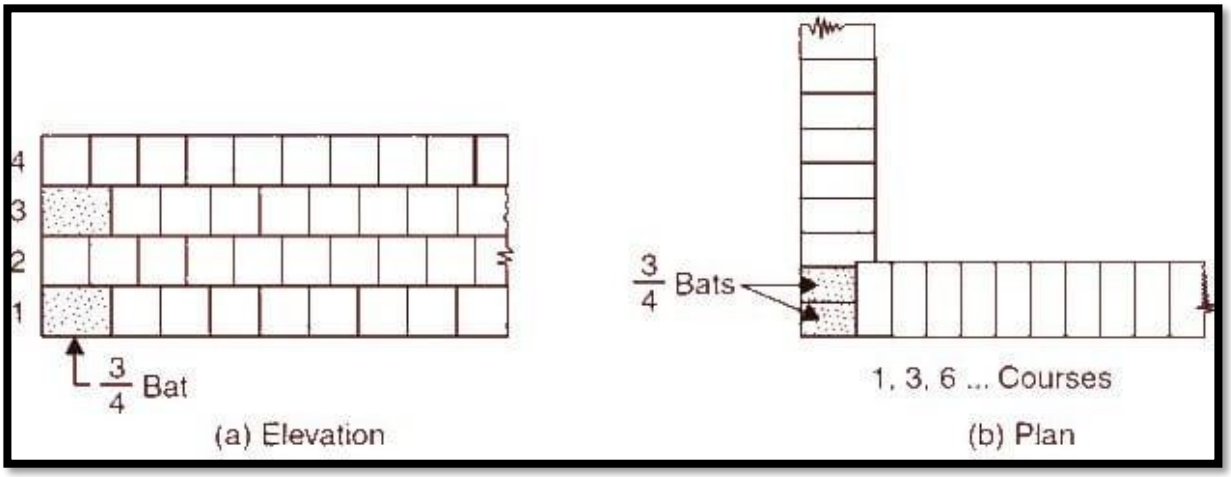




2. HEADER BOND

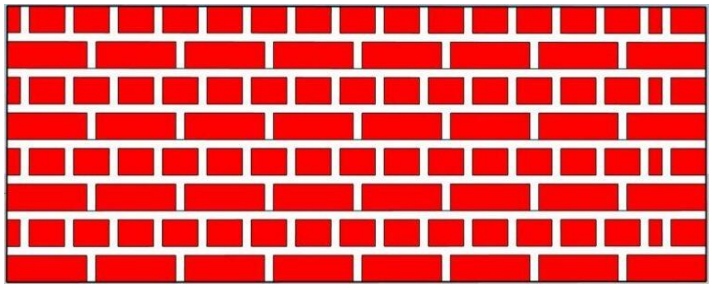
- Header is the shorter square face of the brick which measures 9cm X 9cm.
- Header bond is also known as heading bond.
- In header bonds, all bricks in each course are placed as headers on the faces of the walls.
- While stretcher bond is used for the construction of walls of half brick thickness whereas 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 course as quoins..

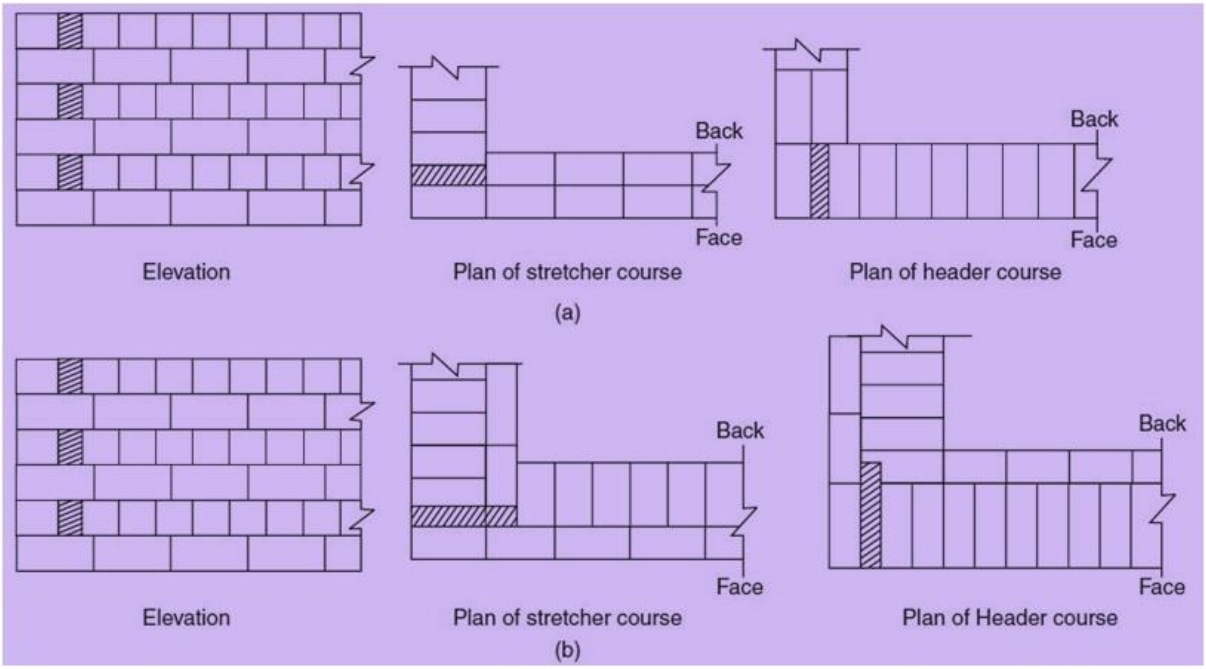




3. ENGLISH BOND

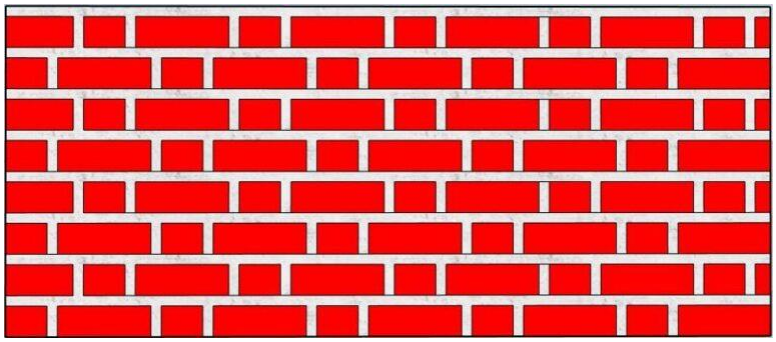
- English bond in brick masonry has one course of stretcher only and a course of header above it, i.e. it has two alternating courses of stretchers and headers.
- Headers are laid centred on the stretchers in course below and each alternate row is vertically aligned.
- To break the continuity of vertical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





4. FLEMISH BOND

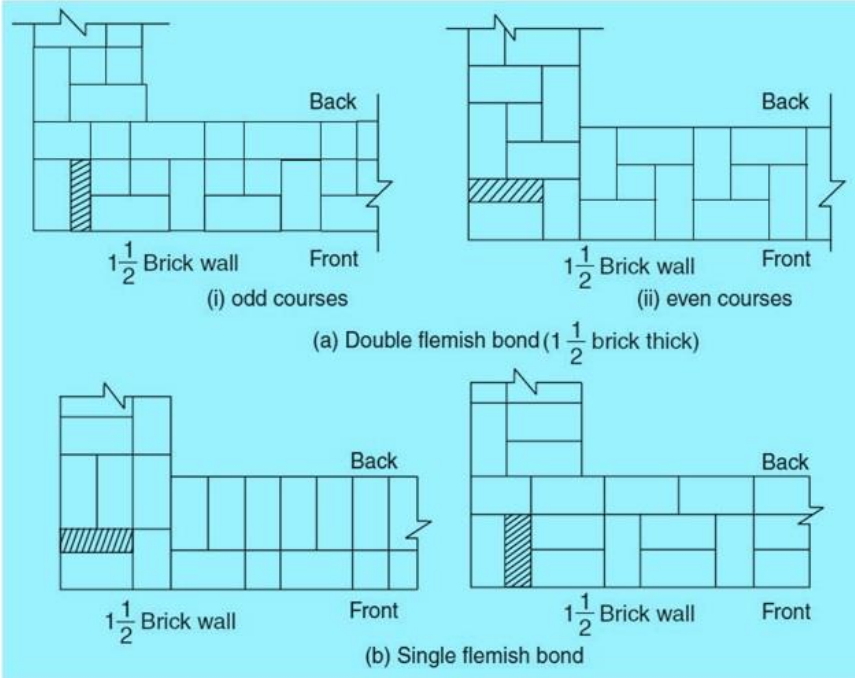
- Flemish bond is one of the strongest types of brick bond for building construction. This type of bond, also famous as Dutch bond, is created by laying alternate headers and stretchers in a single same course.
- The very next course of brick is laid such a way that header lies in the centred of the stretcher in the course below, i.e. the alternate headers of each course are centred on the stretcher of course below. Each and every alternate course of this bond starts with a header at the corner
- The disadvantage of using this bond is that difficult in construction and requires high skill to lay it perfectly as all vertical mortar joints need to be aligned vertically for best and great effects.
- For the breaking of vertical joints in the successive courses, closers are putting in alternate courses next to the quoin header. Bats are used for walls having their thickness equal to an odd number of half bricks.
- Even though Flemish bonds have a better appearance but it is weaker than English bonds for the load-bearing wall construction. So, if the pointing has to be done for brick walls, then Flemish bond can be used for the best aesthetic view but for the walls have to be plastered, then the English bond is more suitable.



TYPES OF FLEMISH BOND

- There are two types of Flemish bond: Single Flemish bond., Double Flemish bond.
- Single Flemish Bond is a combination of English bonds and Flemish Bond, the front exposed surface of the wall is composed of a Flemish bond and back surface of the wall is composed of an English bond in every single 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 takes a similar kind of appearance both in the front as well as the back of elevations, i.e. Each course consists of alternate header and stretcher.
- This type of bonding is comparatively weaker than English bond.

Construction of flemish bond needs greater skill. It gives more pleasing appearance. But it is not as strong as English bond. If only pointing is to be used for finished wall, Flemish bond may be used to get good aesthetic view. If plastering is going to be used, it is better to use English bond.



DIFFFERENCE BETWEEN ENGLISH BOND AND FLEMISH BOND

ENGLISH BOND	**FLEMISH BOND**
Bond pattern with alternate header and stretcher course	Bond pattern with each course having alternate header and stretcher
More strength given for bricks with thickness greater than one and half brick	Less strong and compact compared to English bond
Less pleasing appearance	Appearance is more attractive and pleasing
Expensive	Economical
No strict supervision and skill is demanded	Requires good workmanship and careful supervision

ARCHES

DEFINITION

An arch is a structure constructed in curved shape with wedge shaped units (either bricks or stones), which are joined 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 support (pier or abutment).

MEANING

The brick or stone blocks are formed with circular shapes on the door or window or opening with the purpose of resisting the pressure of the upper load.So, the circular frame that is specifically created by brick or stone blocks is known as the arch. It is arranged both sides support of the opening. The objective of the Arch is to bear its own weight as well as other upper body weight on both side support.

COMPONENTS OF AN ARCH

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

1. Intrados

   The inner curve of an arch is called as intrados
2. Extrados

   The outer curve of an arch is called as extrados
3. Soffit

   The inner surface of an arch is called soffit. Soffit and intrados are used synonymously
4. Voussoirs

   The wedge shaped units of masonry which are forming an arch is called as voussoirs.
5. Crown

   The highest part or peak point of extrados is called crown.
6. Keystone

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

   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.
8. Skew back

   This is an inclined surface or splayed surface on abutment, from which arch curve starts or ends.
9. Springing Points

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

10. Springing Line

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

11. Springer

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

12. Haunch

    The lower half of the arch between the crown and skewback is called haunch.

13. Arcade

    The row of arches in continuation is called arcade.

14. Ring

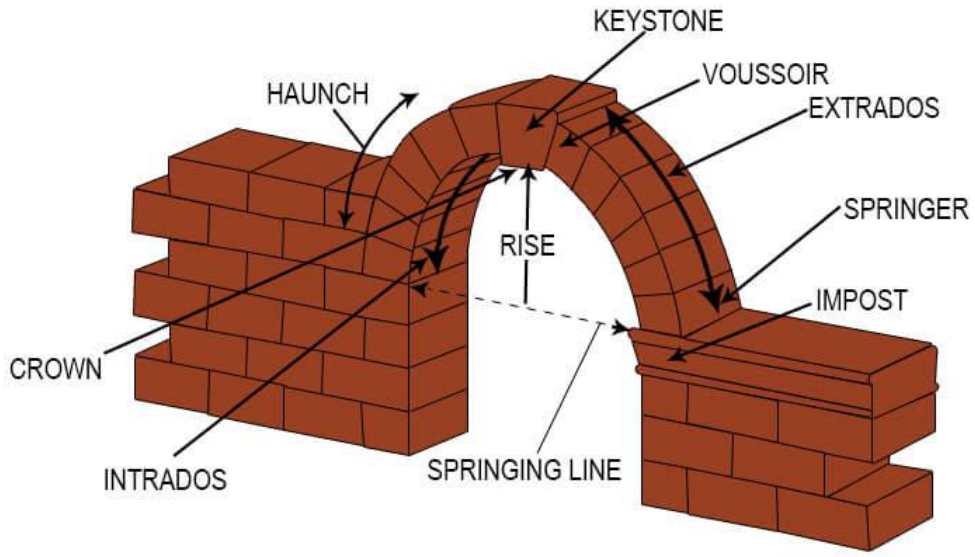
    The circular course forming an arch is called as arch ring. An arch may be formed by one ring or combination of rings

15. Impost

    The projecting course is provided on the upper part of a pier or abutment to stress the springing line. This course is called impost.

16. Pier and Abutment

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



<u>The arch provides the following benefits :-</u>

1. It provides a robust abutment.
2. It is applied in a greater extent.
3. It is most suitable where the weight is bigger.
4. The structure is applied to enhance the look of any construction.

Arches are compressive structures. There are no tensile stresses in these structures due to its basic geometry. They are self-supporting and stabilized by the force of gravity acting on their weight to hold them in compression. This makes them very efficient and stable, capable of larger spans, and supporting greater loads than horizontal beams.

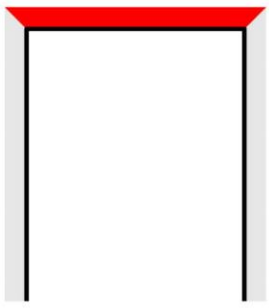
TYPES OF ARCHES

Arches are classified based on:

1. Shape
2. Number of Centre's
3. Workmanship
4. Materials of construction
5. Types of Arches based on shape:

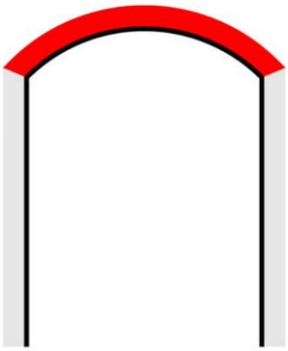
Based on the shape of construction arches are classified into 10 types and they are discussed below.

1. Flat Arch
    - For flat arch, the intrados is apparently flat and it acts as a base of equilateral triangle which was formed by the horizontal angle of 600 by skewbacks.
    - Even though the intrados is flat but it is given that a slight rise of camber of about 10 to 15 mm per meter width of opening is allowed for small settlements.
    - Extrados is also horizontal and flat. These flat arches are generally used for light loads, and for spans up to 1.5m.



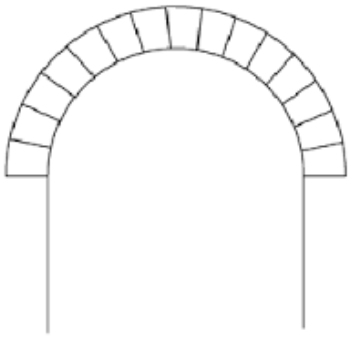
Flat Arch

2. Segmental Arch
    - This is the basic type of arch used for buildings in which Centre of arch lies below the springing line.
    - In segmental arch, the thrust Transferred in inclined direction to the abutment.
    - Considered one of the strongest arches available, it is able to resist thrust.

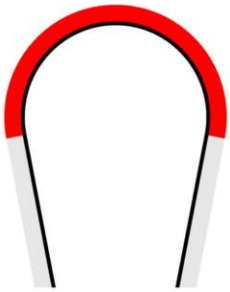


Segmental Arch

3. Semi-Circular Arch
    - The shape of arch curve looks like semi-circle and the thrust transferred to the abutments is perfectly vertical direction since skewback is horizontal.
    - In this type of arch, the Centre lies exactly on the springing line.



4. Horse Shoe Arch
    - Horse Shoe Arch is in the shape of horse shoe which curves more than semi-circle. This is generally considered for architectural provisions.



Horseshoe Arch

5. Pointed Arch

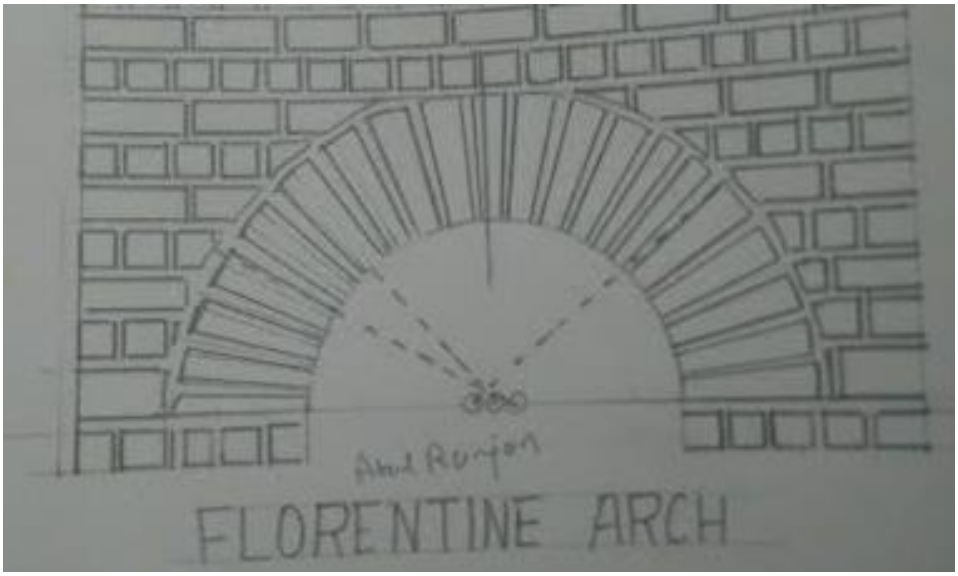
   The other name of pointed arch is Gothic arch. In this type of arch two arcs of circles are met at the apex hence triangle is formed.

6. Venetian Arch

   Venetian arch is also pointed arch but its crown is deeper than springing's. It contains four Centre's, all located on the springing line.

7. Florentine Arch

   Intrados of arch is in the shape of semi-circle and rest of the arch is similar to Venetian arch. It has three Centre's, all located on the springing line.



8. Relieving Arch

   Relieving arch is constructed above flat arch or on a wooden lintel to provide greater strength. In case of relieving arch, we can replace the decayed wooden lintel easily without disturbing the stability of structure. The ends of this arch should be carried sufficiently into the abutments.

9. Stilted Arch

   Stilted Arch consists of a semi-circular arch with two vertical portions at the springing's. The Centre of arch lies on the horizontal line through the tops of vertical portions.

10. Semi-Elliptical Arch

    This is a type of arch of semi-ellipse shape and having three or five Centers.

TYPES OF ARCHES BASED ON NUMBER OF CENTERS

Based on number of centers the arches are classified as:

1. One-centered Arches

   Segmental, semi-circular, flat, horse-shoe arches and stilted arches are one centered arches. In some cases, perfectly circular arch is provided for circular windows which is called as bull's eye arch is also come under these category.

2. Two Centered Arches

   Pointed or gothic or lancet arches are generally come under this type.

3. Three Centered Arches

   Semi elliptical and Florentine arches are generally having three number of centers

4. Four Centered Arches

Venetian arch is a typical example for four-centered arch. Tudor arch is also having four centers.

5. Five centered arches

   A good semi-elliptical shape arch contains five centers.

BASED ON MATERIALS AND WORKMANSHIP

1. **Stone Arches**

   Based on workmanship, these are sub divided into two types. They are,

   Rubble arches

   Rubble arches are very weak and used only for inferior work. These are used up to spans of 1m. These are made of rubble stones which are hammer dressed, roughly to shape and size and fixed in cement mortar.

   Ashlar Arches

   In this type, the stones are cut to proper shape of voussoirs (a wedge-shaped or tapered stone used to construct an arch) and fully dressed, joined with cement mortar. Ashlar stones are also used to make flat arches.

2. **Brick Arches**

   Brick arches are also subdivided into:

   Rough brick arches

   These are constructed with ordinary bricks without cutting to the shape voussoirs. The arch curve is provided by forming wedge shaped joints with greater thickness at extrados and smaller thickness at intrados. So, it looks unattractive. That's why it is not recommended for exposed brick works.

   Axed brick arches

   The bricks are cut into wedge shape with the help of brick axe. So, these are roughly dressed in shape and size. Hence, Arch formed by these axed bricks is not very pleasant.

   Gauged brick arches

   In this type arch, bricks are cut to exact shape and size of required voussoir with the help of wire saw. The bricks are finely dressed and these bricks are joined by lime putty. But, for gauged brick arches only soft bricks are used.

   Purpose made brick arches

   The bricks are manufactured, matching with the exact shape and size of voussoirs, to get a very fine workmanship.

3. Concrete Arches

Concrete arches are of two types:

Precast concrete block arches

In Precast concrete block arches the blocks are cast in molds to the exact shape and size of voussoirs. These will give good appearance because of exact shape and size. Cement concrete of 1:2:4 is used.

Monolithic concrete block arches

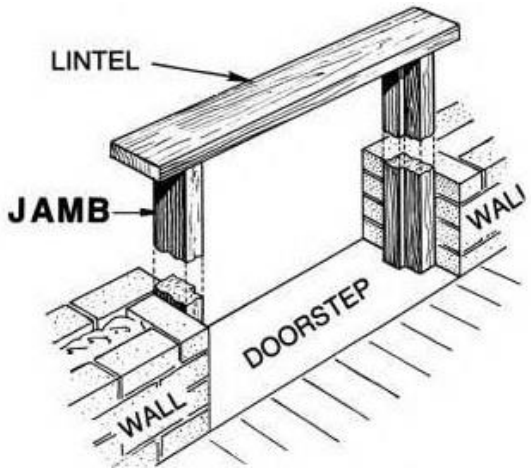
Monolithic concrete block arches are suitable for larger span. These are constructed form cast-in-situ concrete. These may be either plain or reinforced, depending upon the span and magnitude of loading.

LINTELS

A lintel is a pervasive part of buildings. Whenever to create an opening like doors & windows in the building, lintel is used above the opening as a simple solution. lintel construction is simple and it is very commonly used.

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 its built into the wall.

The main function of the lintel is to take loads coming from above wall and transfer its load to the side walls. The lintel beam generally ends in the masonry wall to convey the weight carried by them to the masonry walls, and its width is the same as the wall width. The lintel can likewise be utilized as an enlivening compositional component.



PURPOSE OF LINTEL

Followings are the purposes of lintel beams:

1. To support the walls above the openings like doors, windows, etc.
2. To provide a safeguard of the windows and doors.

3. To withstand the imposed loads coming from above bricks or block including the roofing members.
4. To transfer its load to the side walls.
5. Sometimes lintels are used as a decorative architectural element.

FUNCTIONS OF LINTEL

1. They are provided over an opening to support the proportion of structure above it.
2. Lintels act as a beam.
3. They support the load acting over the openings.
4. They provided openings for doors, windows, ventilators, cupboards, wardrobes, etc.

TYPES OF LINTEL

Lintels may construct of various materials like wood, stone, bricks, R.C.C. and steel. R.C.C. lintels mainly used nowadays.

Lintels are classified based on the material of construction are:

1. Timber lintel
2. Stone lintel
3. Brick lintel
4. Reinforced brick lintel
5. Steel lintel
6. Reinforced cement concrete lintel

TIMBER LINTEL

a. In olden days of construction, timber lintels were mostly used. But now a days they are replaced by several modern techniques, however they are fundamentally used in the hilly areas where timbers are accessible.
b. Wooden or Timber Lintels are the most seasoned sorts of the lintel. But in open areas, uses of timber are constrained as a result of the significant expense and accessibility of present-day materials.
c. If there should be an occurrence of more great dividers, timber lintel is made out of two wooden pieces avoided as much as possible with the assistance of wooden separation pieces.
d. Sometimes, timber lintels are reinforced by the arrangement of mild steel plates at their top and base; such lintels are called flitched lintels.

ADVANTAGES OF TIMBER LINTEL

1. Easy to construct
2. Can be used to temporary structures

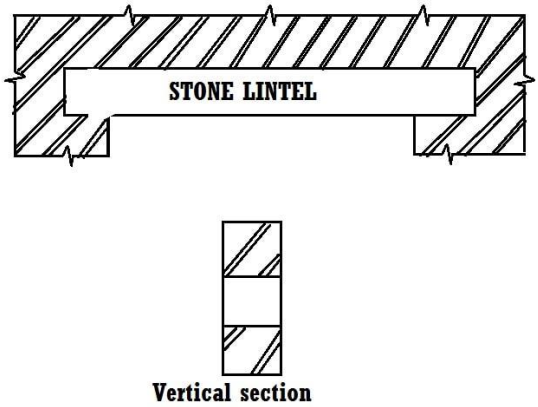
3. No form work is needed
4. No curing period is required

DISADVANTAGES

1. They are not fireproof and they are easily affected by white ants and other insects.
2. They are not using much in permanents structures. Hence these are the weak sections than stone and steel. However, nowadays timbre lintels do not recommend as they are poor in strength and uneconomical.
3. Without appropriate ventilation, timber is obligated to rot.

STONE LINTEL

a. This type of lintel beam is mainly used in such areas where the stone is plentifully accessible and thicknesses of these are the most important factor of its design and also provided over the openings in brick walls.
b. In the form of either one single piece or more than one piece, the stone lintel is provided and the thickness is taken as 4 cm per 30cm length of span and the minimum thickness should be 8 cm as a thumb rule.
c. Stone lintels can found in plenty in old temples, forts, etc. Nowadays the use of stone lintels is rare.
d. These lintels are quite cheap and strong. But they are weak in tension so as cannot be used on large spans.
e. They may crack when subjected to vibrations and are likely to fail under fire.
f. Some lintels can be used up to the span of 3 m if the good stone is available.



Vertical section

ADVANTAGES OF STONE LINTEL

1. It provides a very pleasing sight and an elegant appearance.
2. It is very cheap if the stones are locally available.
3. Ideal for short spans.
4. No need for formworks and curing

DISADVANTAGES OF STONE LINTEL

These lintels have some problems such as;

1. They are not used in buildings where vibratory loads are subjected to the structure due to their weak tensile nature.
2. Its transportation is a very complex task and is difficult to deploy them in cities.
3. Not able to withstand excessive transverse stress.

BRICK LINTEL

a. Brick lintels are uses where construction as mostly done in brickwork. Brick lintels are constructed with hard, well burnt first-class brick.
b. It can be formed as bricks on end, bricks on edge, and coursed bricks laid horizontally over openings.
c. This type of lintel is used when the opening is small (less than 1m) with light loadings. Their depth varies from 10 cm (thickness of one brick) to 20 cm depending upon the span.
d. Depending upon the span their depth varies from 10 cm to 20 cm and at end joints, bricks with frogs filled with mortar give more shear resistance.
e. Bricks with frogs filled with mortar give more shear resistance at end joints than the standard blocks.

ADVANTAGES OF BRICK LINTEL

1. It is the cheapest of all the lintels
2. Ideal for short spans
3. Since both the lintel and masonry are made of the same material, the thermal coefficient of both the members are same. Therefore, cracks due to thermal stresses can be avoided.

DISADVANTAGES OF BRICK LINTEL

1. Bricks are not very strong for acting as a lintel
2. Bricks are weak in tension
3. Only light loads can be taken by brick lintels.
4. It is not suitable for long spans.
5. Formworks are necessary to support the bricks during construction
6. A curing period of minimum 2 to 3 weeks is necessary.

REINFORCED BRICK LINTEL

1. When loads are heavy and span is greater than 1m these lintels are used and depth should be equal to 10 cm or 15 cm.
2. As reinforcement, the bricks are so arranged that 2 cm to 3 cm wide space is left lengthwise between adjacent bricks for the insertion of mild steel bars as reinforcement.
3. Vertical stirrups of 6mm diameter are provided in every 3rd vertical joint.
4. Main reinforcement is provided at t
5. The bottom consists 8 to 10mm diameter bars

STEEL LINTEL

1. When the superimposed loads are heavy and the opening gaps are significant then steel lintels can be suitable and are preferable when the depth of lintel plays an essential role.
2. Steel lintel consists of channel sections and depending upon the requirement, we can use one single section or in combinations.
3. Steel lintels are made using prefabricated GI sheets, rolled I sections or angle sections.
4. In addition to this, the steel sections may be embedded into the concrete to increase the resistance to fire and other environmental conditions like corrosion.
5. Steel lintels are preferable when the depth of lintel plays an essential role because the designer cannot ignore the depth of reinforced concrete lintels due to heavy loads.

ADVANTAGES OF STEEL LINTEL

1. It can be used for long spans.
2. Steel is light thus it is very easy to handle and transport
3. Steel is versatile and can be fabricated to any shape
4. The prefabrication of steel fastens the process of construction
5. No curing or formwork is needed

DISADVANTAGES OF STEEL LINTEL

1. It is vulnerable to corrosion
2. It is susceptible to fire

REINFORCED CEMENT CONCRETE LINTEL

1. At present, reinforced concrete lintels are very common in use. In this type, reinforcement is used to overcome the low malleable issue in concrete. They are developed in present-day structures.
2. They are suitable for heavy loads and larger spans. Their thickness is kept around up to 8 centimeters for every meter.
3. RCC lintels can be either precast or cast-in-situ. Generally, precast reinforced cement concrete lintels are used when the lintel span is smaller.
4. Lintel width should be the same as wall width. The depth of the lintel depends on the length of the span and the loading's magnitude.
3. The reinforced lintels have steel rods provided inside the concrete on bottom to take care of the tension.
4. Sufficient cover is provided to prevent the rusting of the reinforcement.

ADVANTAGES OF REINFORCED CEMENT CONCRETE

a. They are durable, rigid and strong.
b. The reinforced concrete lintel has fire-resisting properties.
c. They are economical and easy in construction.
d. The main advantage of the RC lintels is adaptability to suit any size and shape.

DISADVANTAGES OF REINFORCED CEM ENT CONCRETE

If it is cast in the site,

a. Formworks are necessary to support the concrete during construction.
b. A curing period of minimum of 28 days necessary.

FLOORING

A floor is the bottom surface of a room or vehicle. Flooring is the general term for a permanent covering of a floor, or for the work of installing such a floor covering. A lot of variety exists in flooring and there are different types of floors due to the fact that it is the first thing that catches your eye when you walk into a house, as it spans across the length and breadth of the house. It is also the surface that goes through the most wear and tear, and that's why choosing the right material is of utmost importance.

A floor is the 'lower horizontal surface of any space in a building, including finishes that are laid as part of the permanent construction.'

A floor typically provides:

- Structural support for the contents of the room, its occupants, and the weight of the floor itself.
- Resistance to the passage of moisture, heat and sound.
- A surface finish which may contribute to the look, feel and acoustics of a space.

Very broadly, floor construction tend to be solid floors, built up from the ground, or suspended floors, supported by wall structures. The intended use of the floor, its location, the structure of the rest of the building, and the required floor finish will determine which of the many variations is most suitable for a particular application.

DEFINITION OF FLOORING

- Floors are the horizontal surfaces which carry movable (people and furnishings) and immovable loads. A floor transmits their loads to the beams and columns in a horizontal way Floors are relatively permanent fixtures in interior spaces. They equalize the acoustics, by absorbing and reflecting the noise within a space. Floors are designed with the combination of hard and soft surfaces. (Ching, 2001)
- Floors are the horizontal elements which divide the building into different levels for the purpose of creating more accommodation within a restricted space one above the other and provide support for the occupants, furniture and equipment of a building (B.C. Punmia, I993)

TYPES OF FLOORING

Hard flooring

Hard flooring is a family of flooring materials that includes concrete or cement, ceramic tile, glass tiles, and natural stone products. Ceramic tile are clay products which are formed into thin tiles and fired. Ceramic tiles are set in beds of mortar or mastic with the joints between tiles grouted. (Meehan and Tom, 2002). Varieties of ceramic tiles include quarry tile, porcelain, and terracotta.

- Many different natural stones are cut into a variety of sizes, shapes, and thicknesses for use as flooring. Stone flooring uses a similar installation method to ceramic tile. Slate and marble are popular types of stone flooring that requires polishing and sealing. Stone aggregates, like Terrazzo, can also be used instead of raw cut stone and are available as either preformed tiles or to be constructed in-place using a cement binder (Marta Serrats, 2011).
- Porcelain stoneware can be used instead of natural stone. It is a ceramic material like a tile; however, it is typically 20 mm (0.79 in) thick and often comes in squares of 60 cm (24 in).
- Concrete or cement finished floor is also used for its ability to be treated for different feel and its durability, such as polished concrete. Epoxy resurfacing of concrete flooring is used to update or upgrade concrete floor surfaces in commercial and residential applications.
- Floating tile flooring, also called modular tile flooring, includes a range of porcelain and ceramic tile products that can be installed without adhesive or mortar. Generally, the tile is rectified to precise dimensions, and fused to an interlocking base. Some products require use of a flexible grout and others have an integrated grout strip. The advantages include speed of installation, ease of use, reusability, and low cost relative to using traditional tile installation methods. (Robin Petravic , Catherine Bailey, 2015)
- Resilient flooring
- Resilient flooring is made of materials that have some elasticity, giving the flooring a degree of flexibility called resilience. Performance surfaces used for dance or athletics are usually made of wood or resilient flooring. Resilient flooring includes many different manufactured products including linoleum, sheet vinyl, vinyl composition tile (VCT) [dubious – discuss], cork (sheet or tile), and rubber.
- Linoleum flooring is available in large sheets or pre-cut tiles, the former is resilient. Some come with a pre-applied adhesive for peel-and-stick installation, others require adhesive to be spread on to the substrate. (Germer and Jerry, 2014)
- The two basic categories of linoleum floor tiles are solid linoleum and linoleum composition, and the three basic categories of linoleum sheet flooringare homogeneous, inlaid, and layered composite. These types of linoleum flooring differ in manufacturing process and content, ranging from 11% to 55%. (Armstrong, 2017)

- Resilient flooring products, such as linoleum, PVC and polypropylene are becoming more popular in specialty applications such as trailer flooring and garage flooring. New applications have also emerged for marine flooring. There are important factors to consider in specialty applications, which may not be present in a typical application. For example, certain tires will leave marks on PVC flooring but those marks will be less prevalent on polypropylene products. Adhesives also change based on application.
- Soft Flooring
- Soft Floor Covering, are the material made from textiles, felts, resins, rubber, or other natural or man-made substances applied or fastened to, or laid upon, the level base surface of a room to provide comfort, durability, safety, and decoration. Such materials include both handmade and machine-made carpets and smooth-surfaced floor coverings. Although the word carpet is frequently used interchangeably in reference to textile floor coverings, in modern usage carpets are fastened to the floor and usually cover an entire floor area, and rarely cover the entire floor. Carpets may be classified as handmade or machine-made. Smooth-surfaced coverings generally adhere to a subfloor and are manufactured as sheet goods or tiles. (Ching, 2005)
- Handmade carpets are usually made by knotting a number of pile tufts to a backing structure so that the loose knot ends form the pile. Carpets and rugs may be classified according to the country of manufacture, such as Persian (originating in Iran) or Chinese. (A. Cecil Edwards, 2017)
- Wilton types may have looped (uncut) or cut pile, with designs formed by bringing yarns of the desired colour to the surface and burying the others beneath the surface. (Philips Barty, 2013) Velvet carpeting is made by looping strands that form the pile over wire strips that are removed as each row of loops is completed.

TYPES OF FLOORS

- Apart from giving good finished surface, these floors should have good damp resistance. The ground surface is rammed well and a layer of red earth or sand is placed which is compacted. A layer of broken bricks, stones etc. is provided up to 150 mm below floor finish level and rammed. While ramming the surface is kept moist to get

good compaction. Then 1 : 4 : 8 concrete of 100 to 150 mm thickness is provided as base course. Over this bed floor finish is laid.

The types of flooring used are:

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

MUD AND MURRAM FLOORING

These floorings are used in low cost housing, especially in villages. Over the hard layer of earth filling mud or murram layer is provided. The floor needs a thin wash of cow dung at least once a weak.

Suitability

These floors are not prepared in commercial or professional buildings but only in residential buildings in rural areas where the cheapest and easiest option is selected. The mud flooring is easy to maintain, remains warm in winter and cold in summer and hence it is most suitable for places where the temperature is extreme during these seasons.

BRICK FLOORING

This is also a cheap floor construction. It is commonly used in godowns and factories. Bricks are laid flat or on edges. Bricks of good quality should be used for the construction. Brick layer is provided on sand bed or on lean concrete (1 : 8 : 16) bed. In both cases joints are rendered flush and finished with cement mortar.

Suitability

The floors are suitable for stores, godowns etc.

FLAG STONE FLOORING

Laminated sand stones or slates of 20 mm to 40 mm thick in the form of slabs of 300 mm × 300 mm or 450 mm × 450 mm or in the form of rectangles of size 450 mm × 600 mm are used as floor finishes. The stone slabs are laid on 20 to 25 mm thick mortar spread over concrete bed. The joints are to be finished with rich mortar.

Suitability:

These type of flooring are suitable in go-downs, motor sheds, stores, pavements etc.

Method of construction of Flagstone Floor

For constructing a flagstone floor, the same method is applied as in case of tile floor. The slabs are soaked well in water at least one hour before laying. They should be evenly and firmly bedded in mortar. The thickness of joints should not exceed 4mm and they should be struck off with a trowel while laying.

CEMENT CONCRETE FLOOR

It is modestly cheap and durable floor and hence commonly used in residential, commercial and industrial buildings. It consists of two courses-base course and wearing coat. Base course is laid over well compacted soil. Its thickness is usually 75 mm to 100 mm. It consists of lean cement concrete mix (1 : 4 : 8) or lime concrete containing 40% of 1 : 2 lime mortar and 60% of coarse aggregate of 40 mm size. After base coarse is hardened wearing coat of 40 mm is laid. It consists of panels of 1 m × 1 m, 2 m × 2 m or 1 m × 2 m. Alternate panels are laid with 1 : 2 : 4 concrete using wooden, glass or asbestos strip separators of 1.5 mm to 2.0 mm thickness. To get good bond between base coarse and wearing coat cement slurry wash is given before laying wearing coat panels. After 3–4 days of laying of one set of panel, another alternate panels are laid. Top of these panels are finished by tamping the surface with wooden floats and tapping with trowels, till cement slurry appears on top. It needs curing for 7 to 14 days. To get good appearance many times red-oxide finishing coat is provided.

TERRAZO FLOORING

Terrazo finishing coat is applied over concrete flooring to get pleasing appearance. Terrazo finish consists of 75 to 80% of surface marble chips embedded in cement mortar.

Marble chips are mixed in cement in the proportion 1 : 1.25 to 1 : 2 and about 6 mm terrazo topping is laid. The top is tamped and rolled. Additional marble chips are spread during tamping to get proper distribution of marble chips on the surface. After drying it for 12 to 20 hours, it is cured for 2–3 days.Then grinding is made in the following three steps:

Ist grinding—Using coarse grade (No. 60) carborundum stones.

IInd grinding—Using medium grade (No. 120) carborundum stones.

IIIrd grinding—Using fine grade (No. 320) carborundum stones.

Plenty of water is used during grinding. After each grinding cement grout of cream-like consistency is applied and cured for 6–7 days. After final grinding and curing the floor is washed with plenty of water and then with dilute oxalic acid solution. Then floor is finished with polishing using machines and wax polish.

TILE FLOOR

The floor whose topping is of tiles is called tile floor. The tiles used may be of any desired quality, colour, shape or thickness.

This is an alternative to terrazo flooring, used commonly used in residential, office and commercial buildings. Tiles of clay, cement or terrazo of standard sizes are manufactured in factories under controlled conditions. On the concrete base, 25 mm to 30 mm thick mortar is laid and these tiles are placed and pressed with trowel or wooden mallet. Before placing tiles care is taken to see that, neat cement slurry is applied to bottom side and sides of tiles to get good bond. Next day joints are cleaned of loose mortar and raked up to 5 mm depth. Then that is filled with coloured cement slurry to get uniform colour on the top surface. After curing for 7 days grinding and polishing is made as in the case of terrazo flooring.

Suitability:

These floor are used for paving courtyard of buildings. Glazed tiles floors are used in modern buildings where a high class building 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.

It consists of a finishing coat of small pieces of broken tiles of China glazed or of marble arranged in different patterns set in lime-surkhi or cement mortar. The base coarse is concrete flooring and on it 30 to 40 mm mortar layer is provided. On this mortar layer broken pieces of China glazed or marble are set to get different attractive patterns. After 20 to 24 hours of drying the top is rubbed with carborundum stone to get smooth and polished surface.

TIMBER FLOORING

Timber flooring are used in dancing halls and in auditoriums. Timber plates may be directly placed on concrete bed or may be provided over timber frame work. In latter case it is necessary to provide proper ventilation below the floor. This flooring is costly.

RUBBER FLOORING

Tiles or sheets of rubber with fillers such as cotton fibres, asbestos fibre or granulated cork are manufactured in variety of patterns and colours. These sheets or tiles may be fixed to concrete or timber floors. These floors are attractive and noise proof. However they are costly.

P.V.C. FLOORING

Poly-Vinyl-Chloride (PVC) is a plastic which is available in different colour and shade. Nowadays tiles of this material are used widely. Adhesives are applied on concrete base as well as on bottom of PVC tiles. Then the tile is pressed gently with 5 kg wooden roller till the oozing of adhesive is seen. The oozed out adhesive is wiped and the floor is washed with warm soap water. The floor finish is smooth, attractive and can be easily cleaned. However it is slippery and costly.

MARBLE FLOORING

It is a superior type of flooring, used in residential buildings, temples etc where extra cleanliness is an essential requirement. Marble slabs may be laid in different sizes, usually in rectangular or square shapes.

Marble slabs are cut to get marble tiles of 20 to 25 mm thickness. They are laid on floors similar to other tiles. With power driven machine surface is polished to get even and shining surface. This type of flooring is widely used in hospitals and temples.

FACTORS TO BE CONSIDERED IN SELECTION OF FLOORING MATERIAL

Following factors are to be carefully considered before selecting the material for flooring of a particular building

1. Appearance
2. Cleanliness
1. Cost
2. Damp resistance

3. Durability
4. Fire resistance
5. Hardness
6. Maintenance
7. Thermal Insulation
8. Slipperiness

Appearance: covering should give pleasing appearance; it should produce a desired color effect and architectural beauty. Floorings of terrazzo, mosaic, tiles and marble give good appearance.

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

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

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

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

Fire resistance: This is more important for upper floors. Flooring material should offer sufficient fire resistance so that fire barriers are obtained between different levels of a building.

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

Maintenance: the flooring material should require leapt maintenance. However, whenever repairs are required, it should be such that repairs can be done easily with least possible expenditure.

Thermal insulation: the flooring should offer reasonably good thermal insulation so that comfort is imparted to the residents of the building.

Slipperiness: The surface of floor should be smooth but at the same time, it should not be too slippery.

ROOFING

A roof is defined as the upper most part of a building, provided as a structural covering, to protect the building from weather. The structural elements may be trusses, portals, beams, slabs, shells or domes and the roof coverings may be A.C. sheets, G.I. sheets, wooden shingles, tiles, slates etc.

A roof is a structure forming the upper covering of a building or other shelter. Its primary purpose is generally to provide protection from the elements, but it may also contribute to safety, security, privacy, insulation, and so on.

1. Roofs may have openings or windows within them to allow light into the buildings, as well as providing, access, ventilation, views, and so on. They also frequently include other features such as chimneys, communications infrastructure, building services, drainage, lighting, access routes, and so on.
2. Roofs can be constructed from a wide variety of materials and in a wide variety of shapes depending on the requirements they have to satisfy, the local climate, the availability of materials and skills, the span to be covered, and so on.

CLASSIFICATION OF ROOFS

It can be divided into 3 categories

1. Flat roofs or terraced roofs
2. Pitched or sloping roofs
3. Curved roofs

The choice of the type of roof will depend on the climatic conditions, shape of building, availability of materials, importance of building etc.

FLAT ROOF

1. Flat roof is the one which is either horizontal or practically horizontal with slope less than 10^o so that rain water can be drained off easily and rapidly
2. The construction is same as that of floors except the top surface is made slightly sloping. It may be of RCC, reinforced brick work, precast concrete units etc
3. Flat roofs are considered suitable for buildings in plains or in hot regions, where rainfall is moderate and where snowfall is not there.
4. Efficient water proofing and road drainage is an important requirement of flat roof. In addition insulating material layer is provided for thermal insulation which is known as terracing or grading. Usually 1 in 40 to 1 in 60 slopes is provided for RCC roof slab.

ADVANTAGES OF FLAT ROOF

1. The construction of roof is simple, Maintenance is easier.
2. They can be easily made fire proof, in comparison to sloped roof
3. The roof can be used as terrace for playing, gardening, sleeping and for celebrating functions.
4. In a multi-storeyed building, it is good choice so that construction work of upper floors can be easily started.
5. A flat roof is more stable against high wind.
6. A flat roof is found to be overall economical than a pitched roof.
7. They require lesser areas of roofing material than sloped roof.

SLOPING ROOS/PITCHED ROOFS

A pitched roof is a roof that slopes downwards, typically in two parts at an angle from a central ridge, but sometimes in one part, from one edge to another. The ‘pitch’ of a roof is its vertical rise divided by its horizontal span and is a measure of its steepness. Pitched roofs offer a more classical appearance. They remain the most common and efficient solution in wet and cold weathers to ensure maximum protection.

Types of Pitched Roof

Followings are the type of pitched roof

1. Mono Pitch Roof
2. Couple Roof
3. Closed Couple Roof
4. Collar Roof
5. Purlin Roof
6. Trussed Rafter

Brief descriptions of these pitched roof types are given below.

Mono Pitch Roof

1. Slopes from one side or part of a building to another commonly used to form extensions.
2. Comprises a series of rafters fixed to plates at the top of a wall and the rafter feet are nailed to a wall plate, which distributes the load evenly across the supporting wall.
3. Joists are fitted to form level ceilings and could be raised to give more height.
4. Joists are commonly supported by struts, which precludes rafters from sagging.

Couple Roof

1. The simplest form of the pitched roof, the couple roof comprises two lengths of rafters leaning against each other, tied where they meet at the top.
2. A very limited span of approximately 3.5 m.
3. The downside of this roof is that the weight of it creates natural deflection in the supporting walls by pushing those outwards at the top. Walls could be reinforced but this would require extra brickwork and unnecessary expense.

Closed Couple Roof

1. Ceiling joists are added, a length of timber running horizontally in-between the rafter feet, making the structure much more secure. The joist acts as a tie that prevents the outward deflection of the wall and increases the potential roof-span to approximately 5m.
2. Joists are secured to the rafter feet rather than the wall Plate to negate any potential deflection. A secure connection between the rafter and ceiling joist is therefore critical.

3. The benefit of this form of roof is by using struts, much of the roof space could be utilized for storage and allowed the space to be used for accommodation if needed.

Collar Roof

1. The height of the ceiling joists are raised, such that the roof allowed any upper rooms to be constructed in the roof space, thus the height of the external walls is slightly reduced.
2. The drawback of this method is that lifting the ceiling joist reduces its restraining force, increasing the instability of the supporting walls and decreasing the span to approximately 4 m.
3. For maintaining stability, the height of the ceiling joist could be lifted to a maximum of 1/3 of the height of the roof.

Purlin Roof

1. By introducing purlins roof spans could be increased without compromising wall stability, increasing the size of rafters or attracting extra costs. Purlins allow rafters to get extra support and become lighter and thinner, allowing a potential span of 8 m.
2. The benefit of this form of roof was that by using struts, much of the roof space could be utilized for storage and ultimately allowed the space to be used for accommodation

Trussed Rafter

1. The fink or 'w' truss is the most common form of the trussed rafter in modern house construction. This consists of a rafter comprising W shaped tension and compression members. This trussed rafter is capable of spans up to 12 m and can be designed to accommodate many different pitch angles.
2. The most significant advantage is the off-site assembly of the trussed rafter which speeds up the whole construction process.
3. The only real disadvantage of the trussed rafter is that it requires careful design where a change of direction occurs in the roof.

CEILING

A part of a building which encloses and is exposed overhead in a room, protected shaft or circulation space. (The soffit of a rooflight is included as part of the surface of the ceiling, but not the frame. An upstand below a rooflight would be considered as a wall.)

The ceiling of a building form one of the most important structural elements in terms of functionality as well as creativity which in turn bring good aesthetics to the building interior.

The ceiling gains a definition, " A part of a building which encloses and is exposed overhead in a room, protected shaft or circulation space"

For the purposes of the performance of ceiling linings, a ceiling includes:

1. The surface of glazing;
2. Any part of a wall which slopes at an angle of 70º or less to the horizontal;
3. The underside of a gallery; and
4. The underside of a roof exposed to the room below.

TYPES OF CEILING

Various types of ceiling are used in building construction. Applications, aesthetics, advantages and disadvantages of these types of ceilings are discussed below

1. Exposed ceiling
2. Tightly attached ceiling
3. Interstitial ceilings
4. Acoustical ceilings
5. Radiant chilled ceilings
6. Convective chilled ceilings
7. Suspended ceilings

EXPOSED CEILINGS

This kind of ceiling arrangement would completely expose the structural and mechanical components of the building thus omitting a concept of finished ceiling. This arrangement lacks a discomfort in aesthetics but gains many advantages like the economy, easy

maintenance due to ease of access. This also enables the thermal mass of the building to be exposed.

The disadvantage mentioned before of looks can vanish if well designed and installed roof structures and floor structures properly , leaving it exposed in the space below by means of timber beams or concrete slabs or space trusses. It's true that the mechanical element arrangement at ceiling level in a well systematic manner would create an attractive aesthetic effect.

TIGHTLY ATTACHED CEILING

Ceilings made of gypsum, plasterboard, tongued and grooved timber and so on, may be attached tightly to timber joists or rafters, steel joists or concrete slabs. Careful detailing is required where beams or other obstructions protrude through the plane of the ceiling, such as vents, conduits, pipes, sprinkler heads and so on.

INTERSTITIAL SPACE

Interstitial spaces, such as interstitial ceilings allow for a larger space to be located between regular-use floors. They generally include an access walkway, and have a low height. They are commonly used in buildings such as hospitals and laboratories that have complex services which may include:

1. Air-conditioning ducts.
2. Water and waste pipework.
3. Electrical and communications wiring.
4. Fuel gas lines.
5. Compressed air lines.
6. Oxygen.
7. Chilled water.
8. Vacuum pipework.
9. Chemical waste pipework.

As ducts and pipework can occupy a significant amount of space, often require continual maintenance and are subject to frequent change, interstitial ceilings can allow for

maintenance and updating work to be carried out without interruption of activities in the spaces above and below.

ACOUSTICAL CEILINGS

This ceiling is mainly implemented to control sound reverberation in a hall where there is the possibility of large sound propagation to make the hearing comfort zone. The acoustic ceiling material is made from fibrous materials that would absorb sound energy unlike other materials like plaster or gypsum ceilings.

These materials do not reduce transmission of sound between the spaces. They result in a reduction in the amount of sound that reflects into space. Hence it can be used to bring the modify acoustic character of space.

The performance of the ceiling material in terms of sound absorption can be expressed in terms of noise reduction coefficient (NRC). An NRC of 0.85 means that a ceiling material absorbs 85% o the sound that reaches it, and an almost 15% reflects back to the room.

Most of the acoustical ceilings NRC range from 0.5 to 0.9. This value is found to be 0.10 for plaster and gypsum ceiling board materials.

RADIANT CHILLED CEILINGS

Radiant chilled ceilings include a network of chilled water coils in ceiling panels with insulation above. For some systems, pipework may be incorporated into plaster board. But this is found less efficient as plaster is an insulator.

The ceiling surface then cools the occupied space by both radiation and convection, providing temperatures throughout the space and avoids draught. The space requirement for chilled ceilings is found to be less, which may be installed with a depth of just 100mm. For some, a small-bore cooling coils can be embedded in plaster ceiling.

CONVECTIVE CHILLED CEILINGS

These types of ceilings are a deviation from radiant chilled ceilings, in which the network of chilled water pipes incorporates fins, increasing the proportion of cooling that is provided by convection.

SUSPENDED CEILINGS/FALSE CEILING/DROPPED CEILING

These are secondary ceilings suspended from the structure above (typically a floor or roof slab), creating a void between the underside of the slab and the top of the suspended ceiling. This void can provide a useful space for the sprinklers, distribution of heating, ventilation, and air conditioning (HVAC) services and plumbing and wiring services.

This also provides a display place for the installation of speakers, and smoke detectors, motion detectors, light fittings, wireless, antenna, CCTV, fire and so on. It provides an air 'plenum', in which the void itself forms a pressurized 'duct' to supply air to or extract it from the taken space below.

False ceilings are often secondary ceilings that are hung below the main ceiling with the help of suspension cords or struts. These ceilings are crafted from a wide range of materials such as POP (plaster of Paris), gypsum board, asbestos sheets, particle board, aluminium panel, wood etc. They are also known as dropped ceiling or suspended ceiling.

CLASSIFICATION OF FALSE CEILING

The classification is totally based on 3 criteria:

1. Place of application
2. Ambience needed
3. Economy available

The most commonly used false ceiling materials are as follows:

1. Gypsum Board False Ceiling

Gypsum is the most commonly used false ceiling material. The panels come with either tapered or square edges. Gypsum boards can be easily fixed either by nailing directly to ply or other plain surfaces or placing on a galvanised iron (GI) metal grid. Gypsum board comes in standard sizes of 6 feet X4 feet and 8 feet X 4 feet.

Types Of Gypsum Boards Available In Market

1. Regular Gypsum Board

2. Fire Resistant Gypsum Board
3. Moisture Resistant Gypsum Board
4. Fire and Moisture Resistant Gypsum Boards

Grid False Ceiling

Grid False Ceiling is one of the most common types of false ceilings used in commercial office spaces. These type of ceiling are suitable for large range of applications. They are ideal for concealed wiring. These metal ceiling panels are installed either on steel T- sections or cross sections and then suspended by rods.

Types Of Grid Ceiling Materials

1. Mineral Fiber Grid Ceiling
2. Metal Grid Ceiling

PLASTER OF PARIS (POP) CEILING OR MURGA JAALI CEILING

Plaster of Paris is most commonly used false ceiling material. It is cheapest amongst all the false ceiling materials. POP is mixed with water and is applied to fibreboard or wood base which suspends to form the ceiling. It requires artistic workmanship.

PLYWOOD CEILING

Plywood ceilings are popular for their visually appealing aspects. These type of ceilings are created with strips of ply which are either nailed or glued together.The strips are supported with the help of ply. Plywood ceiling due to its insulating property, it is used in places with cold climate.

PVC False Ceiling

PVC ceiling is also one of the most commonly used ceiling system. It solves the problem of cleaning and maintenance. This type of ceiling is suitable for all types of climate. It also incorporates flush fitting and hidden lighting system. These are one of the most hassle free and easy to install false ceilings.

CONCLUSION

The basic process of construction has remained relatively unchanged since the Middle Ages, however construction technology has changed significantly. Building Technology has become an increasingly important aspect of the construction industry, as buildings have moved from being evolutions of standard types to becoming one-off prototypes, building performance requirements have become more demanding, and the number of products and specialist suppliers has increased.