DOOR

A **door** is a moveable barrier secured in a wall opening.

Functions:

- They admit ventilation and light.
- Controls the physical atmosphere within a space by enclosing it, excluding air drafts, so that interiors may be more effectively heated or cooled.
- They act as a barrier to noise.
- Used to screen areas of a building for aesthetic purposes, keeping formal and utility areas separate.

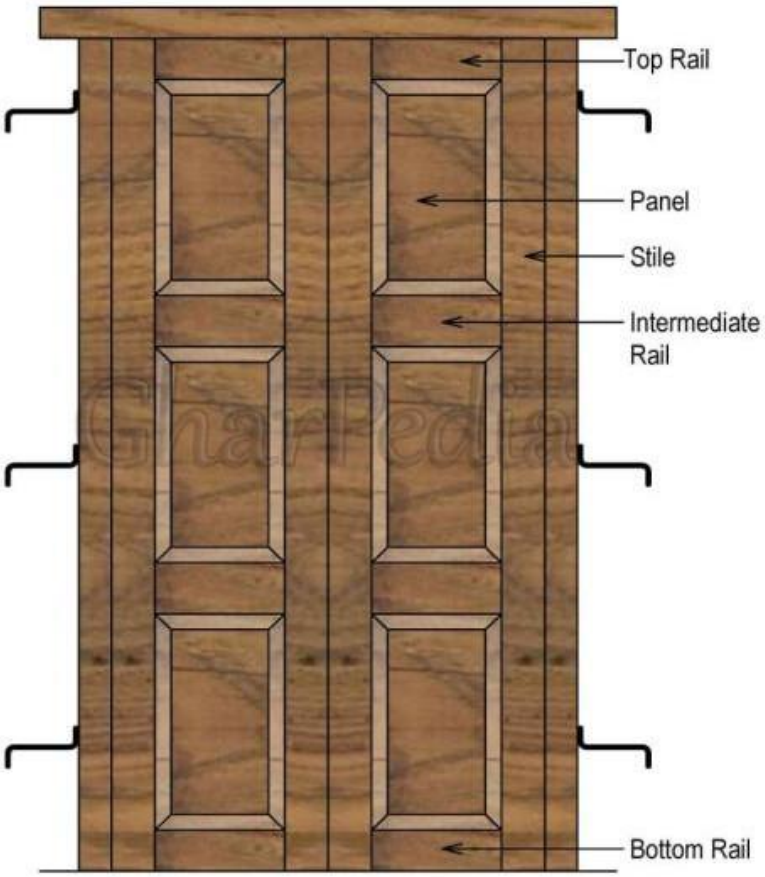
Location of door in a building

- The number should be kept as minimum.
- It should meet the functional requirement.
- It should preferably be located at the corner of the room, nearly 20 cm from corner.
- If in a room, more than 2 doors are there, they shall be located facing each other.

Components of a door:
a) Door frame b) Door shutter

Door frame

Door Shutter



Frame : It is an assembly of horizontal and vertical members, forming an enclosure, to which the shutters are fixed
Shutters : These are the openable parts of a door or window.
Head : This is the top or uppermost horizontal part of frame
Horn : These are the horizontal projections of the head of a frame to facilitate the fixing of a frame on the walls opening. The length of horns is kept about 10 to 15cm
Style : It is the vertical outside member of shutter
Top Rail : This is the top most horizontal member of a shutter
Bottom Rail : This is the lower most horizontal member of a shutter
Lock Rail : This is the middle horizontal rail where locking arrangement is fixed
Intermediate or Cross Rail: Additional horizontal rails fixed between top and bottom rail of a shutter
Panel : This is area of the shutter enclosed between the adjacent rails
Holdfasts : These are mild steel flats to fix or hold the frame to the opening
Rebate : It is the depression or recess made inside the door frame, to receive the door shutter

SIZES OF DOORS

The common width-height relations used:

- Width = 0.4 – 0.6 Height
- Height = (width +1.2)m

General sizes used:

a) Residential

External door – 1.0 x 2.0 to 1.1 x 2.0 m
Internal door – 0.9 x 2.0 to 1.0 x 2.0 m
Bath & WC – 0.7 X 2.0 to 0.8 x 2.0 m
Garages for cars – 2.25 x 2.25 m to 2.40 x 2.25 m

b) Public

1.2 x 2.0 m **or** 1.2 x 2.1 m **or** 1.2 x 2.25 m

DOOR FRAMES

Materials used for door frames

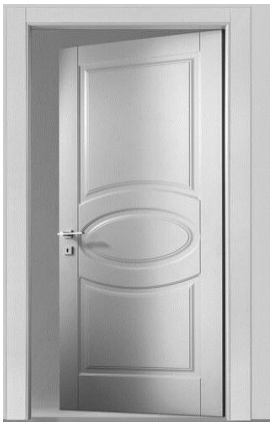
- Timber
- Steel
- Aluminium
- Concrete
- Stone

Timber door frame
General specifications:

- Timber is sawn in the direction of grains.
- All members of frames are of same species of timber and be straight without any warp.
- The frames are smooth, well planned surfaces except the surface touching wall lintel sill etc.
- The thickness of rebate is 15 mm and the width is equal to the thickness of shutter.
- Nominal size of door frame for single shutter is 75 X100 mm and for double shutter 75 X 125 mm.
- The back portion of door frame which in contact with walls, lintels sill etc. is painted with bitumen or any anti-termite chemical.
- To protect door frame during construction priming coat is done before fixing.
- A minimum of 3 holdfasts shall be fixed on each side, one at the centre and the other two at 300 mm from top and bottom of the frame.
- Holdfasts and other parts, which go into the masonry wall and thus not accessible for maintenance, shall be protected against moisture and decay, with a coating of coal tar or other suitable protective material.

TYPES OF DOORS

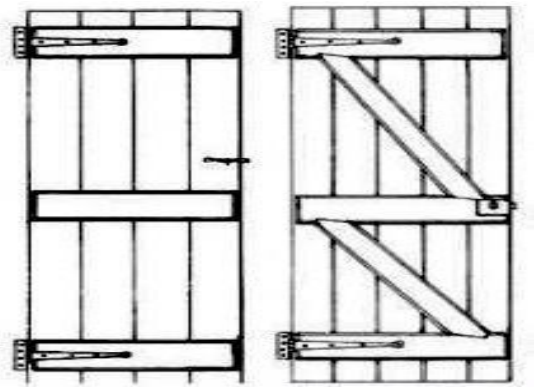
Hinged doors



- Most doors are hinged along one side to allow the door to pivot away from the doorway in one direction but not in the other. The axis of rotation is usually vertical.
- The most common door type. It is a simple & rigid.
- The panel swings, opens and closes, on hinges.
- Hinged doors require a minimum amount of maintenance and cleaning, they are not expensive, and have an excellent insulating ability.
- However, they take up precious room space to swing in.

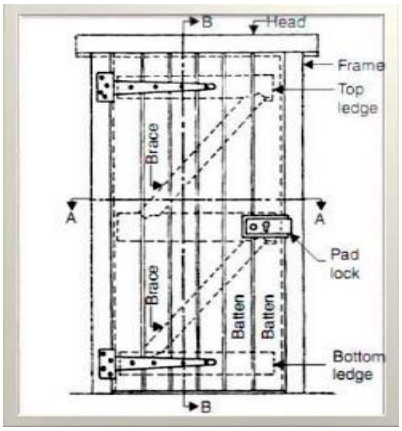
Battened and ledged door

- The door consists of vertical boards i.e. battens and three or four horizontal ledges. The vertical boards are tongue and grooved to stop draughts and the edges chamfered to relieve the plain appearance.
- Battens : 100-150 mm wide and 20-30 mm thick
- Ledges : 200 mm wide and 25 – 30 mm thick
- The door is hung to the frame by T-hinges of iron.
- The door is commonly used for narrow openings for internal use where it is not subject to hard use, or where economy is of main consideration than the appearance.



Battened Door **Ledged Door**

Battened, Ledged and braced door



- Normally constructed using a Z-shaped frame with tongue-and-groove interlocking boards attached they can be quite heavy in weight but this can depend on the thickness of boards used.
- Due to their construction they are normally very strong and hardwearing and can also be planed and shaped to fit pretty much any door way.
- Such doors are used for wider openings.
- The braces incline down towards the hinged side.

Framed and Paneled door

- These types of doors are widely used in all types of buildings since they are strong and give better appearance than battened doors.
- Panel doors consist of vertical members called stiles and horizontal members called rails.
- Stiles and rails form the framework into which panels are inserted.
- Panels may be solid wood, plywood, particleboard or louvered or have glass inserts.
- Additional vertical members called mullions are used to divide the door into any number of panels.



Glazed or sash door

- This type is used in residential and public buildings.
- They supplement the natural lighting provided by windows or to make the interior of the room visible from adjoining rooms.
- They can be made fully glazed or partly glazed.
- Fully glazed doors are recommended where sufficient light is required through the door openings like in shopping malls, entrance halls etc.
- In case of partly glazed, the bottom 1/3rd part is usually paneled and upper 2/3rd part is glazed.



Flush Door

- Flush doors are simply doors with a completely flat surface on both sides.
- Flush doors can come in solid format which is a door made of solid wood or hollow format which is lightweight and comprised of two layers of thin timber separated, usually, by a lightweight honeycomb core. The core is covered with either hardboard or plywood on both sides.
- Solid flush doors are usually used as fire-check doors.
- Flush doors are lighter and cheaper than other types.
- The flush door shutters are manufactured in
- Standard thickness of 25, 30, 35 and 40 mm.

Louvered doors

- A louvered door has fixed or movable wooden louvers which permit open ventilation while preserving privacy and preventing the passage of light to the interior.
- They are most commonly used for bath and W.C. In residential and public buildings, where good ventilation is desired.
- The door may be louvered to its full height or may be partly louvered and partly paneled.
- The louvers are arranged in inclined fashion thus obstructs the vision but permits entry of air.
- Louvers may be fixed or movable.
- Louvers may be of timber, plywood or glass.
- However, they are difficult to clean.

Revolving doors

- Such types are provided in public buildings, like banks, museums, hotels, offices etc.
- A revolving door normally has four wings/leaves that hang on a center shaft and rotate one way about a vertical axis within a round enclosure.
- The central shaft is fitted with ball bearing arrangement at the bottom, which allows the shutters to move without any jerk and making noise.
- The radiating shutters may be fully paneled, fully glazed or partly glazed. The glass doors allow people to see and anticipate each other while walking through.
- People can walk out of and into the building at the same time.

Sliding doors

- In these doors, the shutter slide horizontally along tracks with the help of runners and rails. often for space or
- Sliding glass doors are common in places where there is no space to swing the door.
- Such doors are very popular for use for the entrances to commercial structures and also in residential buildings for aesthetic considerations.
- Sliding doors consist of either one, two or three doors that slide by each other on a track depending upon the size of opening and space available for sliding.
- They are pretty easily cleaned and maintained.
- These doors sound insulation is pretty poor usually, and they must be of high quality and fitted exactly in their tracks or else they may slide out of them.
- When fully open these doors will allow half the space of the opening in double sliding doors, or one third if triple.
- Sliding doors move along metal, wood, or vinyl tracks fitted into their frames at the top and bottom. To ease their movement, sliding doors often have plastic rollers attached to the top and bottom or to the bottom only.
- The door is hung by two trolley hangers at the top of the door running in a concealed track while at the bottom, rollers are provided to slide the shutter in a channel track.

Swing doors

- The shutter is fitted to its frame by special double action hinges.
- The hinges permits the shutter to move both ways, inward as well as outward.
- The doors are not rebated at the meeting styles.
- To open the door, a slight push is made and the spring action brings the shutter in closed position.
- The return of the shutter is with force and thus, the door shall be either fully glazed Or provided with a peep hole at eye level, to avoid accidents.

Folded doors

- Made of many narrow vertical strips or creases that fold back to back into a compact bundle when doors are pushed open, these strips or creases will be hanged from the top, and run on a track.
- They save space as they do not swing out of the door opening, though their sound and weather isolation is poor. Folding doors are usually pretty noisy, and considered not so durable

Collapsible Door

- Such doors are used in garages, workshops, public buildings etc. to provide increased safety and protection to property.

- The doors do not require hinges to close or open the shutter nor the frame to hang them.
- It acts like a steel curtain.
- The door is made up from vertical double channels
- (20x10x2 mm), jointed together with the hollows on the inside to create a vertical gap.
- These channels are spaced at 100-120 mm apart and braced with diagonal iron flats.
- These diagonals allow the shutter to open or closed.
- The shutter operate between two rails, one fixed to the floor and other to the lintel.
- Rollers are mounted at the top and bottom.

Rolling shutter

- These are commonly used for shops, godowns, stores etc.
- The door shutter acts like a curtain and thus provides adequate protection and safety against fire and thefts. The shutter is made up of thin steel slabs called laths or slates about 1.25 mm thick interlocked to each other and coiled upon specially designed pipe shaft called drum mounted at the top.
- The shutter moves in two vertical steel guide channels installed at their ends.
- The channel is made up of steel sheets and deep enough to accommodate the shutter and to keep it in position.
- A horizontal shaft and spring in the drum which allow the shutter to coiled in or out.
- These may be manually operated for smaller openings (upto 10 sq.m.). Above 10 sq. m., they may be operated manually.

WINDOWS

A window is comprised of two parts: (i) Window Frame, and (ii) Sashes or shutter frame.

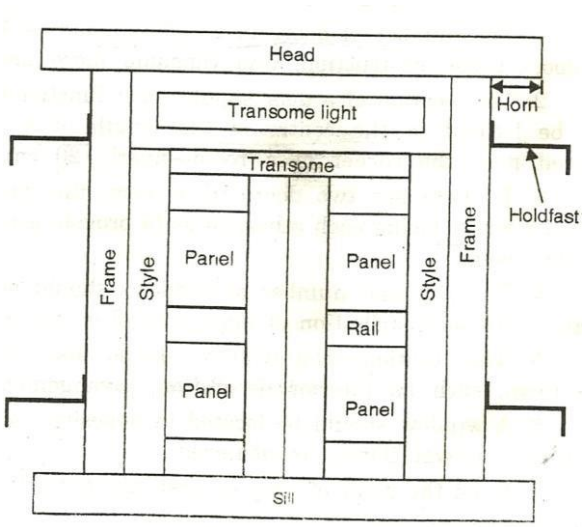
Window frames are fixed to the opening in the wall, by means of suitable holdfasts. The sashes or shutter are fixed to the window frames by means of suitable hinges.

The function of the window is to admit light and air to the room to give a view to the outside. It should also provide insulation against heat loss and in some cases, against sound

The selection of size, shape, location and number of windows in a room depends upon the following factors

(i). Size of the room
(ii). Location of the room
(iii). Utility of the room
(iv). Direction of wall
(v). Direction of wind
(vi). Climatic conditions such as humidity, temperature etc.
(vii). Requirements of exterior view
(viii). Architectural treatment to the exterior of the building

WINDOW PARTS



Frame : It is an assembly of horizontal and vertical members, forming an enclosure, to which the shutters are fixed

Shutters : These are the openable parts of a door or window.

Head : This is the top or uppermost horizontal part of frame

Sill : This is the lowermost or bottom horizontal part of a window

Horn : These are the horizontal projections of the head of a frame to facilitate the fixing of a frame on the walls opening. The length of horns is kept about 10 to 15cm

Style : It is the vertical outside member of shutter

Top Rail : This is the top most horizontal member of a shutter

Bottom Rail : This is the lower most horizontal member of a shutter

Intermediate or Cross Rail: Additional horizontal rails fixed between top and bottom rail of a shutter

Panel : This is area of the shutter enclosed between the adjacent rails

Mullion : This is a vertical member of a frame, which is employed to sub-divide a window opening

Holdfasts : These are mild steel flats to fix or hold the frame to the opening

Rebate : It is the depression or recess made inside the door frame, to receive the door shutter

TYPES OF WINDOWS

Fixed windows

- In this type, the glass pane is permanently fixed in the opening of the wall.
- The shutter can't be opened or closed.
- The function is limited to allowing light and or permit vision in the room.
- No rebates are provided to the frame.
- The shutters are fully glazed.
- In homes they are generally decorative windows near doors, stairwells and high-places or are used in combination with other styles.
-

Pivoted windows

- In this type of window, the shutter is capable of rotating about a pivot fixed to window frame.
- The frame has no rebate.
- The shutter can swing horizontally or vertically.

Double-hung windows

- Special frames called boxed or cased frame is used, which consists of two vertical members spaced apart to create a groove to slide the shutter.
- A parting bead is provided in the groove of the frame to keep the two shutters apart.
- Only the bottom sash slides upward in a single-hung window. In single-hung windows the top sash is fixed and can't be moved.
- It has two panes, top and bottom that slide up and down in tracks called stiles.
- The most common used windows today. When open, these windows allow air flow through half of its size.
- The two parts are not necessarily the same size.
- Traditionally, each shutter is provided with a pair of counterweights connected by cord or chain over pulleys.
- When the weights are pulled, the shutters open to required level.
- It is possible to have controlled ventilation.
- Sash windows may be fitted with simplex hinges which allow the window to be locked into hinges on one side, while the rope on the other side is detached, allowing the window to be opened for escape or cleaning.
- Nowadays, most new double-hung sash windows use spring balances to support the sashes.

Sliding Window or Slider:

- Has two or more sashes that overlap slightly but slide horizontally within the frame.
- Suitable openings or grooves are left in the frame or wall to accommodate the shutters when are shutters are opened.

Casement windows

- Casement windows are hinged at the sides.
- When fully opened, offer the maximum amount of ventilation.
- Operates like a hinged door, except that it opens and closes with a lever inside the window.
- The shutter consists of styles, top rail, bottom rail and intermediate rail.
- Depending upon the design, the frame can have additional vertical and horizontal members i.e. mullion and transom respectively.
- The panels may be either glazed, unglazed or partly glazed and are fixed in the grooves made in rails and styles.

Glazed window

- This is a type of casement window where panels are fully glazed.
- The frame has styles, top rail and a bottom rail.
- The space between top and bottom rail is divided into number of panels with small timber members called, sash bars or glazing bars.
- The glass panels are cut 1.5-3.0 mm smaller in size than the panel size to permit movement of sash bars.
- Glass panes are fixed to sash bars by putty or by timber beads.

Louvered window

- They are provided for the sole function of ventilation and not for the vision outside.
- The styles are grooved to receive a series of louvers which may be of glass or wood slates.
- The louvers re usually fixed at 450 inclination sloping downward to the outside to run-off the rain water.
- The windows provide light and ventilation even if closed.
- Such windows are recommended for bath, WC, workshops etc., where privacy is more important.
- Venetian shutters uses louvers which can be opened or closed. The louvers are pivoted at both ends in the frame and in addition each blade is connected to a vertical batten by hinge.

Metal Windows

- These are very popular in public buildings and can be made up of mild steel, stainless steel, aluminium, bronze etc.
- Mils steel being cheapest of all, they are widely used. The windows can be fabricated for the required size using light rolled steel sections.
- They can be fixed directly to the wall opening in a wooden frame or in the steel frame.
- While fixing, care has to be taken that the members of the frame are not subjected to any structural loads to prevent damage.

- Thus, the size of the window opening is kept slightly more than the frame size so as to allow some clearance between the two.
- The window is fixed into the opening only after masonry and lintel work is over and fully set.

- *Advantages:*
  - They are more stronger and durable as compared to wooden windows.
  - They are not subjected to expansion and contraction of joints.
  - They are rot-proof, termite proof.
  - Highly fire resistant.
  - Presents better elegance and smooth finishing.
  - Provide more area for light and ventilation.
  - The cost of maintenance is negligible and thus proves economical.

Bay window

- The window projecting outward from the external walls.
- Wide and decoratively impressive allow for 180° view.
- A multi-panel window, with at least three panels set at different angles to create an extension from the wall line.
- it is commonly used in cold country where snow often falls.
- They may be triangular, circular, rectangular or polygonal in plan.

Corner window

- These are provided at the corner of the room.
- Light and air is admitted from two directions.
- The jamb post at the corner is made of heavy section.

Dormer window

- Dormer window is a vertical window provided on the sloping roof
- Provides ventilation and lighting to enclosed space below the roof
- Very good appearance

Gable window

- It is a vertical window provided in the gable end of a pitched roof.

Skylight

- These are fixed windows on the sloping roofs.
- Admit natural light and help distribute light more evenly throughout the room. Considered an energy saver feature.
- In addition to reducing the need to use electric lights, it can deliver warmth in the winter and cooling in the summer, minimizing the need for fuel-based heating and air conditioning. On winter days, the sun's radiant energy can shine through a south- or west-facing skylight to warm interior surfaces. And in the summer, a ventilating skylight can promote air circulation by releasing the warm air that naturally rises.
- The opening for the window is made by cutting common rafters. The framework consist of trimming pieces, curb frames, bottom rail and top rail. The opening is treated with lead flashings to ensure water proofing.
- Skylights may be plastic or glass, fixed or operable, and made in any number of sizes and styles.
- Ventilator: It is a narrow window of small height fitted near the roof of a room for ventilation. The construction is similar to the fanlights. They are horizontally pivoted.

Ventilators

- Ventilators are small windows, fixed at a greater height than the window,
- Generally about 30 to 50 cm below roof level.
- The shatter can be opened or closed by means of two cords, one attached to the bottom rail and other one with top rail
- Top edge opens inside and bottom edge opens outside, so that rain water excluded

Fanlights

- The small window or ventilator fitted above the door or window frame separated by transom. The function is to ensure cross ventilation in the room even if the door or windows are closed. They also assist in admitting natural light.

PLASTERING

It is the process of covering rough walls and uneven surfaces in the constructions of houses and other structures with a plaster or mortar.

Objectives of Plastering

- It is to provide an even, smooth, regular clean and durable finished surface
- To improve the appearance of the surface
- In order to protect the surfaces free from the effects of atmospheric agencies, plastering is required.
- To conceal the defective workmanship.
- To cover up the use of inferior quality and porous materials of masonry work.
- To provide a satisfactory base for white washing, colour washing, painting or distempering.

Types of Plastering

There are basically four types of plastering. They are:

1. Lime plastering
2. Cement plastering
3. Mud plastering
4. Water proof plastering

Lime plaster - It is an intimate mixture of equal proportions of lime and sand, ground in a mortar mill to form a paste of required consistency. Sand to be used in the mortar should not pass a 100 mesh sieve for more than 5% or a 50 mesh sieve for more than 20% water and sand used should be clean and free from all deleterious materials

Cement plasters - It is an intimate mixture of Portland cement and sand with required amount of water to make a plaster mass. The proportion of cement and sand depends upon the nature of work. The ingredients are first mixed in a dry state and water is added to make a paste. This plaster should be used within 30 minutes since starts setting after 30 minutes.

Mud plasters - It is prepared with equal volumes of clay or brick earth and of chooped straw, hay, loose soil or cowdung and hemp. The ingredients are mixed and left for 7 days with large quantity of water. Then, it is again mixed till it reaches the required consistency before using. Mud plasters made of sand and clay can also be used.

Water proof plaster - This plaster consists of 1 part of cement, 2 parts of sand and pulverized alum at the rate of 12 Kg/m^3 of sand. In order to make this to be water proof, soap water containing about 75 gm soap/liter of water is added.

Requirements of a good plaster

- It should not shrink while drying which results in cracking of the surface.
- It should adhere firmly to the surface and resist the effects of atmospheric agencies.
- It should provide the surface a decorative appearance and should durable.
- It should provide a smooth, non absorbent and washable surface.
- It should be economical with locally available materials.
- It should be highly workable.
- It should be possible to apply during all weather condition.
- It should be water tight or impermeable.

Tools for plastering

Trowel

Float

Floating Rule

Spirit Level

Plumb bob

Gauging trowel

- Used for applying mortar on walls, mouldings, corners etc.

Float

- Used to spread mortar on surface and also for finishing
- Made of thin tampered steel or wood

Floating rule

- To check the level of plastered surface

Plumb bob

- To ascertain verticality of plastered surface.

Miscellaneous tools

- Brushes, spirit level, set squares, straight edges etc.

Methods of Plastering

Plaster is usually applied in a single coat or double coat. Double coat plaster is applied where thickness of plaster is required to be more than 15 mm or when it is required to get a very fine finish. The process of applying a double coat cement plaster on wall surface consists of the following steps.

Step-1-Preparation of surface for plastering
Step-2-Ground work for plaster
Step-3-Applying first coat (or under coat or rendering coat)
Step-4-Applying second coat (or finishing coat or fine coat)

Step-1 (Preparation of Surface for Plastering)

- Keep all the mortar joints of wall rough, so as to give a good bonding to hold plaster.
- Clean all the joints and surfaces of the wall with a wire brush, there should be no oil or grease etc. left on wall surface.
- If the surface is smooth or the wall to be plastered is old one, then rake out the mortar joint to a depth of at least 12 mm to give a better bonding to the plaster.
- If the projection on the wall surface is more than 12 mm, then knock it off, so as to obtain a uniform surface of wall. This will reduce the consumption of plaster.
- If there is any cavities or holes on the surface, then fill it in advance with appropriate material.
- Roughen the entire wall to be plastered.
- Wash the mortar joints and entire wall to be plastered, and keep it wet for at least 6 hours before applying cement plaster.

Step-2 (Ground Work for Plaster)

- In order to get uniform thickness of plastering throughout the wall surface, first fix dots on the wall. A dot means patch of plaster of size 15 mm * 15 mm and having thickness of about 10 mm.
- Dots are fixed on the wall first horizontally and then vertically at a distance of about 2 meters covering the entire wall surface.
- Check the verticality of dots, one over the other, by means of plumb-bob.
- After fixing dots, the vertical strips of plaster, known as screeds, are formed in between the dots. These screeds serve as the gauges for maintaining even thickness of plastering being applied.

Step-3 (Applying First Coat or Under Coat or Rendering Coat)

- In case of brick masonry the thickness of first coat plaster is in general12 mm and in case of concrete masonry this thickness varies from 9 to 15 mm.
- The ratio of cement and sand for first coat plaster varies from 1:3 to 1:6.
- Apply the first coat of plaster between the spaces formed by the screeds on the wall surface. This is done by means of trowel.
- Level the surface by means of flat wooden floats and wooden straight edges.
- After leveling, left the first coat to set but not to dry and then roughen it with a scratching tool to form a key to the second coat of plaster.

Step-4 (Applying Second Coat or Finishing Coat or Fine Coat)

- The thickness of second coat or finishing coat may vary between 2 to 3 mm.
- The ratio of cement and sand for second coat plaster varies from 1:4 to 1:6.
- Before applying the second coat, damp the first coat evenly.
- Apply the finishing coat with wooden floats to a true even surface and using a steel trowel, give it a finishing touch.
- As far as possible, the finishing coat should be applied starting from top towards bottom and completed in one operation to eliminate joining marks.

After completion of the plastering work, it is kept wet by sprinkling water for at least 7 days in order to develop strength and hardness.

Simple steps

1. All mortar joints of the wall are kept rough.
2. Clean the surface with a wire brush and made sure it is free from harmful substances like oil, grease etc.
3. Projections more than 12mm knocked off to obtain uniform surface.

4. All holes and cavities are filled in advance and all woodwork surfaces to be plastered are roughened.
5. The mortar joints and surfaces are washed and wetted and kept for 6 hours before plastering.
6. To achieve uniform thickness for plastering, vertical strips formed on the wall surface by fixing dots.
7. First coat of plastering is done.
8. If second coat is needed, it is done after 2 days curing of first coat.

POINTING

Final treatment with cement or lime mortar made to the joints of the masonry to provide neat appearance is termed as pointing. The joint on the face of stone or brick masonry are roughly filled in while the walls are being raised. They are after wards neatly finished off to make them water tight. The joints thus finished, give a better appearance to surface and prevent rain water from entering the interior of the masonry.

Purpose

- To prevent the moisture and the rain water from entering the interior of masonry through joints.
- To make them durable.
  - To improve the appearance of the structure.

Suitability

Pointing is preferred to plastering under following conditions.

1. When a smooth and even surface is not essentially required.
2. Where it is desirable to exhibit to view the natural beauty of the materials (bricks or stones) used in construction.
3. When the workmen ship is neat and good.

Types of pointing

The selection of particular type of pointing depends upon the types of bricks or stone used and the appearance required.

1. Flat or flush pointing

In this pointing, the mortar is pressed tightly and the joints are filled up and made flush with the face of the wall. This is the simplest type of pointing and is provided extensively. It is economical because it requires less labor than all other pointing. It does not give good appearance, but it is durable as it does not provide any space for accumulation of dust, water etc

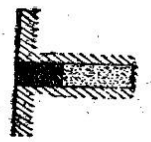


Fig. 14-1. Flush Pointing

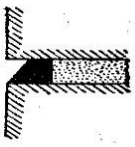


Fig. 14-2. Struck Pointing

2. Struck pointing

In this pointing the face of the mortar joint instead of keeping it vertical, its upper side is kept about 12 mm inside the face of the masonry and the bottom is kept flush with the face of the wall. This pointing has a better effect of throwing rain water. This is also known as ruled pointing. This pointing is the best in ordinary circumstances.

3. Recessed pointing

In this pointing the face of the mortar joint is pressed inside by means of a suitable tool and is left vertical instead of being made inclined. This pointing is provided when face work of good textured bricks with good quality mortar is used. Recessed joints are not suitable for buildings in exposed situations because they do not readily shed water. Only bricks with good frost resistance should be used with recessed joints. It Gives good appearance.

4. V-pointing

This type of pointing is provided by forming a v-shaped groove inside the mortar of the joint with a special tool (steel or iron jointer). This pointing is commonly recommended for brick work in case of governmental buildings.

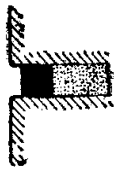


Fig. 14-3. Recessed Pointing

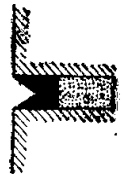


Fig. 14-4. V-Pointing

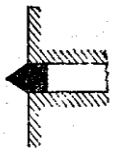


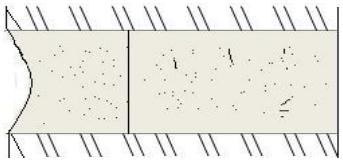
Fig. 14-5. Weather Pointing

Fig. 14-6. Keyed Pointing

5. Weather pointing

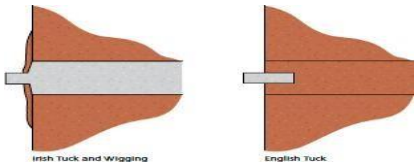
This is similar to V-Pointing but in this case instead of pressing a v shaped groove inside, it is provided by forming a v shaped projection outside the wall's surface. This pointing is generally recommended for superior brick work.

6. Keyed or grooved pointing



In this case, the joints are first filled up flush, and then a circular piece of steel or iron is pressed in and rubbed in the middle of joints. Grooved pointing has a big groove in the face than keyed. Keyed pointing gives an attractive appearance to the structure and is generally used for superior work.

7. Tuck pointing



In this pointing, the mortar joints are filled with the face of the wall. Then 6 mm wide and 3 mm deep groove is immediately and carefully formed in the centre of the joint and the groove is filled with or tucked in with white lime putty. The lime putty is given a maximum projection of 6 mm. Tuck pointing has a neat attractive appearance. But the lime putty is not durable and in due course of time becomes defective.

Method of pointing

- Raking of mortar joints at least 20mm depth
- Dust removed by brushes
- Surface washed out with clean water and kept wet for a few hours
- Mortar placed in these joints in desired shape using trowel
- Finished surface well-watered for at least 3 days for lime mortar and 10 days for cement mortar

FLOORS AND FLOOR COVERING

Floors arc the horizontal elements of a building which divide building into different levels for the purpose of creating more accommodation one above other within the limited space. Floor just above the ground level-is called **ground floor** and the floors above ground level are upper floors. These are known as first floor, second floor etc. with reference to ground floor. Floors below the natural ground are called as **basement floor**. An intermediate floor between two floors of any storey forming an integral part of floor below is called **mezzanine floor**. A floor consist or two main components.

a) **A sub-floor (or base course or sub grade**) that provides proper support to the floor covering and all loads carried on it. It imparts strength and stability to floor.

b) **A floor covering (or flooring or paving)** is a covering over subfloor which provides a smooth, clean, impervious and durable surface .

TYPES OF FLOORS

It is divided into **Ground floor & Upper floor**

1. Ground Floor

It rests directly on ground. 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.

Materials used for ground floor construction are

- **i.** Bricks
- **ii.** Stones
- **iii.** Timber
- **iv.** Concrete

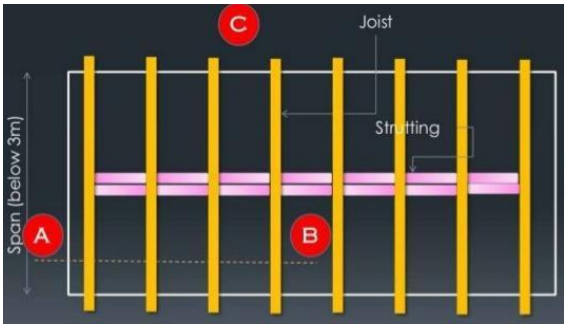
Bricks, stones and concrete are laid above ground to desired height and over that suitable floor covering is done. Timber joists are laid above the concrete layer and the gap between floor and concrete is filled with sand to form timber floor.

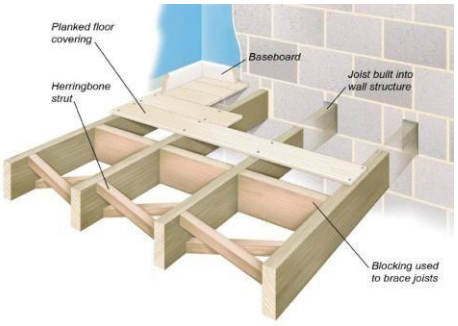
2. UPPER FLOOR

They are classified on the arrangement of beams and girders or the frame work for supporting the flooring. They are

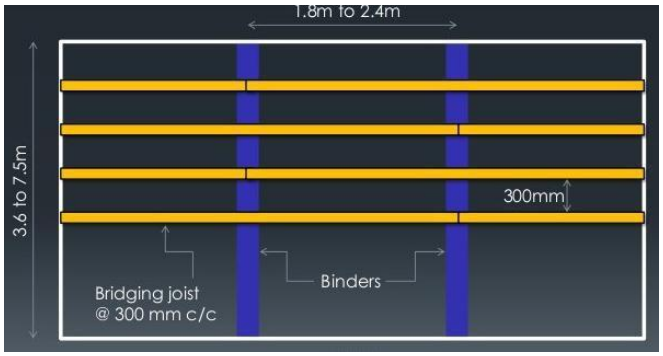
i. Timber floors

Single joist floor: joists are placed 30 cm center to center supporting on wall plates. Corbels are also requires to support joists, if the width of wall is less. Wooden planks of thickness 4 cm thick are placed over joists. These are easy to construct and requires less initial cost. Distribution of loads on the wall is more uniform as the joists are spaced closely. But the joists may slag and hence cracks will develop in ceilings. They are not sound proof.



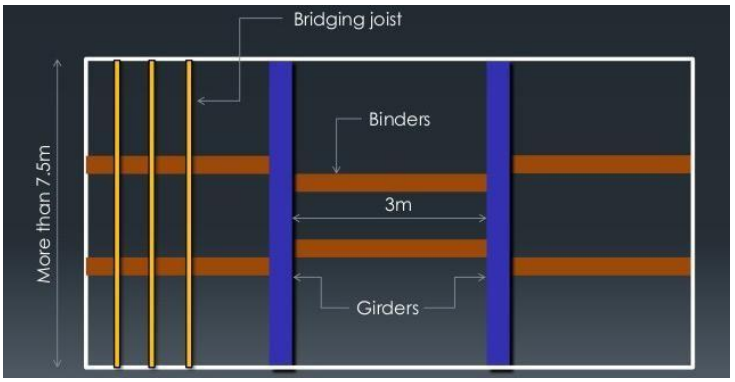


Double joist timber floors: They are used for longer spans of 3.6- 7.5 and prevent the travel of sound waves to a great extent. Intermediate supports called binders are placed to support joists. Binders are placed at a centre-to- centre distance of about 2 m. The ends of binders are kept on or stone blocks and they are not embedded in the masonry wall.



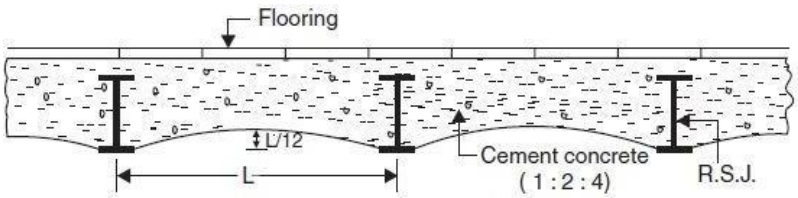
This is a more rigid type of flooring and, hence, there is less chance of developing cracks in the plastered ceiling. It is more soundproof. Often wall plates maybe avoided by the use of binders. The depth of the floor is considerably increased and thus the head room is reduced.

Framed timber floors: This type of timber floor is used for spans of more than 7 m. Girders arc placed between the walls and binders are put on the girders and the bridging joists rest on the binders. The spacing between girders depends on size of binders. Girders are supported on stones or templates on the walls.



ii. Jack Arch Floor

In this, brick or concrete arches are provided between the lower flanges of rolled steel Joists with spacing not more than 1.5m. Steel bars are provided at end spans. The rise of the arch is normally kept one-fifth of span. These are rigidly fixed on walls; the side filling is done with lime concrete etc. Pl; ceiling is not obtained when jack arch floors are used.



iii. Filler Joist Floor

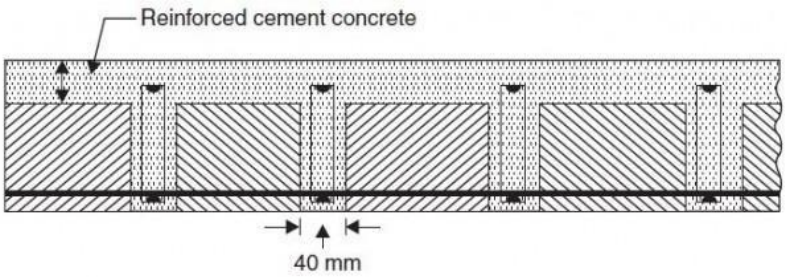
Rolled steel joists encased in the concrete arc used in this type of floor. The joists are supported on walls or on side beams. Then the spaces between joists are filled with cement concrete.

iv. Steel Joist and Flagstone Floor

In this, rolled steel joists are placed are places at suitable intervals supporting on walls or edge beams. Flag stones of 40 mm are placed on · top flange and bottom flange of the joist and the empty space is filled with selected earth or concrete. Precast concrete slabs also may be used instead of flag stones.

v. RCC Floor

Reinforced Cement Concrete (RCC) floors are the most popular t: of floor construction in the modern era. The slabs are directly cast over beams or wall supports. Continuous floor is cast on frame work of beams in a framed type building constructions. A suitable thickness of l0 cm to 25mm is normally adopted based on the design. Beams are cast monolithically with slabs to form a combined structure in the case of framed structure. Suitable floor covering is adopted over the slabs.

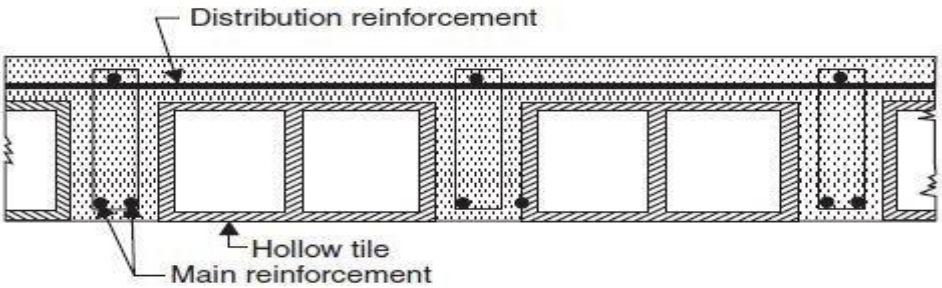


vi. Flat Slab Floor

In this system of floors, beams are avoided and slabs are directly supported by columns. Column heads or drops are constructed at column top. this is very advantageous because of less form work required for floor construction compared to normal beam-slab construction. False ceiling is not required in this type of floors. More head room is also available in flat slab constructions. Also it gives more aesthetic appearance.

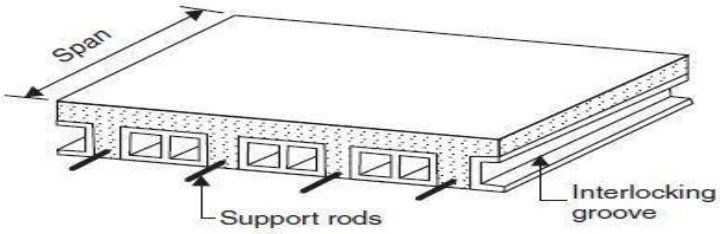
vii. RCC or Hollow Brick-ribbed Floor

These floors are used when to reduce the weight of the floor. Hollow blocks or tiles with clay or cement are placed in the gaps of steel reinforcement m slab. Then the empty spaces are filled up concrete. The floor acts as RCC floor but with light weight. This floor is economical, fire resistant, sound proof and damp roof.



viii. Pre-cast Concrete Floor

With the advancement of concrete technology and construction methods, it is now possible to cast suitable elements of floors with concrete and place it over the walls or beams. Precast units are jointed and grouted with cement mortar at site. Suitable floor covering is adopted over the floor. No formwork is required for this type of construction; this saves both time and money.



SELECTION OF FLOORINGS

Every flooring has its own merits and demerits that there is not even a single type which can be suitably provided under all circumstances. Floors have to serve different purposes in different types of building. The following actors govern the selection of floorings.

(1) **Initial Cost:** The cost of construction is an important factor in the election of the type of floor. Floor covering of marbles, granite, vitrified tiles, etc. is considered to be very expensive whereas cork, slate, vinyl, tile, etc. are moderately expensive. Concrete and brick floors are cheapest type of floor construction. The cost of both floor covering and sub-floor has to be accounted while comparison.

(2) **Appearance:** Flooring should achieve the desired colour effect and architectural beauty according to the use in the building. Generally flooring of terrazzo, mosaic, tiles, marble and cement concrete provides a good appearance whereas asphalt covering and mud flooring etc. give an ugly appearance.

(3) **Durability:** The flooring material should offer sufficient resistance to wear and tear, temperature, chemical action, etc. So as to provide long life. From the durability point of view, flooring of marble, terrazzo, tiles and concrete is considered to be good. Flooring of other materials such as linoleum, rubber, cork, bricks, timber etc. can be used where heavy floor use is not anticipated.

(4) **Cleanliness:** A Floor should be non-absorbent and could be easily effectively cleaned. All joints in flooring should be watertight. Moreover, greasy and oily substances should neither spoil the appearance nor have destroying effect on the flooring materials. Floorings with terrazzo, marble, tiles and slates arc generally found suitable for cleanliness.

(5) **Sound Insulation:** According to modern building concepts, a floor should neither create noise nor transmit noise. For buildings like hospitals, libraries: libraries, studios etc.it is required that any movement on the top floors should not disturb the persons working on the other floors. Suitable flooring is provided in such situations. Cork tile and rubber floorings have excellent sound insulation properties. Timber and linoleum flooring has poor sound insulation.

(6) **Dump-resistance:** All the floors, especially ground floors, should be damp - resistant to ensure a healthy environment. Normally, floors of clay tiles, terrazzo, concrete, bricks, etc. are preferred for use where the floors are subjected to dampness. Floorings with wood, rubber, linoleum, cork etc. arc easily vulnerable to dampness.

(7) **Thermal Insulation:** Flooring materials play an important role in maintaining the temperature inside the building even the temperature changes outside. This reduces the cost of demand for heating in winter and refrigerating in summer. The floors with wood, cork etc. are best suited for this purpose

(8) **Hardness:** It is desirable to have good resistance against scratches, impressions and imprints when used for either supporting the loads or moving the loads over floors. Normally the hard surfaces rendered by concrete, marble, stone, etc. do not exhibit any impressions whereas the coverings like asphalt, cork, plastic, etc. get scratched when used.

(9) **Smoothness:** The floor covering should have smooth and even surface However, at the same time, it should not be too slippery which will cause unsafe movements over it, particularly by old people and children. Floor coverings with terrazzo, concrete, tiles are suitable in this aspect. Antiskid tiles are also available in various trade names in the market.

(10) **Fire Resistance:** This is also another important factor in selection of upper floors. These floors are to act as highly resistant fire barriers on which rescue operations take place. Hence flooring materials should have sufficient fire resistance. All combustible flooring materials like wood, cork, plastic etc. should be used over fire resistant base only.

(11) **Maintenance:** It is always expected that maintenance cost should be as low as possible. Generally a covering of tiles, marble, terrazzo or concrete requires less maintenance cost as compared to the floors of wood blocks, cork etc.

FLOOR COVERINGS

Floor coverings or floor finishes are provided above the floors to improve the appearance, cleanliness, sound proofing and damp proofing. A variety of materials are used for floor coverings. These are selected based on the requirements and uses of the floors. Various types are briefly explained below.

1. Mud and Mooram flooring

Mud flooring is usually used in villages for their huts and other unimportant buildings. These are cheap and easy to construct and maintain. Mud floor is hard, impervious and has good thermal insulation capacity. For mud floor construction, 25-30 cm thick layer of selected moist earth is spread over a bed and it rammed well to get a thickness of 15-20cm. Chopped straw is also mixed in the earth to prevent drying cracks on the floor. When mooram (disintegrated rocks, especially Laterite) is used for making mud flooring instead of earth, it is called mooram flooring.

2. Stone floor covering

Square or rectangular slabs of suitable stones like granite, sand stone or marble are used for this type of flooring. Normally 20-40 mm thick stones of sizes of30 cm x 30 cm, 45 cm x45 cm, 60 cm x 60 cm, 45 cm x 60 cm etc. are used. The stones used should be hard, durable, tough and good quality, the earthen base is levelled, compacted and watered. Over this a layer of 10-15 cm thick concrete is placed and properly rammed. Over this concrete a thin layer of mortar is laid. Before fixing the stone slabs in position, their edges and the joints are finished with cement. The stone surface maybe rough or polished. A slope of l in 40 is provided in such type of floor covering for proper drainage.

3. Brick floor covering

Brick floors are used for cheap constructions like go-downs, barracks stores etc. These are commonly used in alluvial places where brick earth is available in plenty and stones are scare. First of all, a well compacted and levelled ground is prepared. Then a lean mix of concrete of 1:3:6 or so is placed over for a thickness of 15cm. Then the bricks are laid in parallel set in cement. The joints are then pointed for better appearance and durability. This flooring is non-slippery, hard and durable. The initial cost is less compared to cement concrete. But this flooring is water absorbent.

4. Concrete floor covering

The most popular type of flooring used in these days is concrete flooring in all types of buildings. It has two parts namely

a. A base course or the sub grade and
b. A wearing course or floor finish

The concrete flooring consists of a topping of cement concrete 2.5- 4 cm thick laid on a 10'-15 cm base of either lime or cement concrete. A flushing coat with rich cement slurry mixed with red or black colour pigment is also applied over this for better appearance. The actual construction operation consists of the following steps.

a. Ground preparation
b. formation of base course
c. Laying of topping concrete
d. Laying of wearing coat
e. Grinding and polishing and
f. Curing

Concrete flooring is non-absorbent and hence offers sufficient resistance to dampness. It possesses high durability and, hence, is employed for floors in kitchens, toilets, schools, hospitals, etc. It provides a smooth, hard, even and pleasing surface and can be cleaned easily. Concrete flooring fire-resistant and can be used for fire resistant purposes in the buildings.

But defects once developed in concrete floors, whether due to poor workmanship or materials, cannot be easily rectified. The concrete flooring is difficult to repair by patchwork satisfactorily. It possesses poor insulation properties against sound and heat.

5. Mosaic floor covering

This type of floor finish is commonly used in operation theatres, temples, brooms, etc. For this construction, first a concrete base is constructed for laying the floor covering. Over this, while it is still wet, lime or cement mortar is placed to a depth of about 2 cm and it is levelled up. A layer of cementing material about 3 mm in thickness is spread. The cementing material consists two parts of slaked lime, one part of powdered marble and one part of powdered marble and pozzolana. After 4-5 hours of laying this cementing material, a mixture of coloured cement and small pieces of broken glazed tiles (popularly known as mosaic chips) are laid. This is compacted with a light roller. This surface is for 24 hours and then it is rubbed with pumice stone or mechanical grinders to get a smooth and polished surface. The polished surface is left for about 2 weeks before use.

6. Terrazzo floor covering

Terrazzo is a special type of concrete with cement and marble chips as aggregates. Flooring laid with this concrete is polished with carborundum stone to obtain a smooth finish at the top. Any desired colour is obtained by adding marble chips of different colour or using colored cements. The base for this e of floor covering is concrete and is laid in the ordinary method. Over the 3 mm concrete base, a thin layer of sand is sprinkled evenly and it is covered tar paper. A layer of rich mortar is spread over it and then terrazzo mixture is placed over it evenly. Marble chips of 3-6 mm are mixed with white or cured cement in the proportion 1 2 or I :3 to get the terrazzo mixture. Dividing strips of metal, 20 gauges thick, (sometimes glass strips) are inserted into mortar base to form the desired patterns. Terrazzo mixture is laid in the formed between the metal strips. The terrazzo is levelled in position trowel.

When the terrazzo has hardened, the surface is rubbed by coarse fine carborundum stones, respectively to get a smooth finished surface is kept wet with water while rubbing. The surface is cleaned with soap sol and then wax polish is applied to the surface. This type of floor covering costly and is used to obtain a clean, attractive and durable surface in public buildings, hospitals bathrooms, etc. It requires more time to finish terrazzo flooring.

7. Timber floor covering

Timber floor covering is the oldest type, but nowadays it is used for some special-purpose floors such as theatres, dancing halls, carpentry rooms and hospitals. It is preferred in hill places because of its good thermal insulation properties. It possesses natural beauty and has enough resistance to wear. But prevention from dampness is very important in the case of timber flooring. Timber floor covering may be carried out in the following types:

a. Strip floor covering: This is made up of narrow and thin strips timber which are joined to each other by tongue and groove joints.
b. Planked floor covering: In this type of construction, wider planks are employed and these are joined by tongue and groove joints.
c. Wood block floor covering: It consists of wooden blocks are laid in suitable designs over a concrete base. The thickness of a block20-40 mm and its size varies from 20 X 8 to 30 X 8 cm. The blocks properly joined together with the ends of the grains exposed.
d. Parquet floor covering: This is the same type of wood block floor where thin blocks (max. I0 mm) are used instead of thicker ones.

8. Tiled floor covering

Tiled flooring has become the most popular one now a days and extensively used in all types of buildings including public, semi-public, residential, commercial and industrial buildings. The prime advantages of this flooring shorter time of installation, pleasing appearance and durability. Tiles are directly on the concrete or other hard base with a thin layer of mortar. Adhesives are also available to paste these on surfaces. Flooring tiles are available sizes from 20cm x 20cm to 120 x 120 and also in any shades and designs.

For laying tiles on ground or basement, first the ground for receiving is level lied, well watered and rammed. Then a sub grade of I0 to 15 cm thick lime or cement concrete is placed. Then a layer of 1:3 cement mortars is spread over it and levelled it. After it hardened for few hours, neat cement slurry is poured over it. Then tiles are placed over it with utmost care using cement paste applied on its sides. After 2-3 days, joints are rubbed off and cleaned. For upper floors, normally on RCC floors, sub grade with cement concrete is not required.

Tiled flooring provides a non-absorbent, decorative and durable surface. Installation is fast and possible to repair in patches. These are generally costly compared to other floorings. Terracotta (earthen ware) tiles, ceramic tiles, vitrified tiles, glazed tiles, cement concrete tiles and terrazzo are the important varieties of tiles used in tiled flooring.

9. Marble floor covering

Naturally available marble slabs are directly laid over a sub grade set in cement mortar. Then it is polished with carborandum stones. Though s costly, it has the properties of hardness, durability and aesthetic appearance. is flooring is adopted in superior type of constructions and places where sanitation and cleanliness are important like hospitals, theatres, places of worships and toilets etc .

10. Granite floor covering

Granite slabs arc also naturally available in different colours and textures. These are laid in the similar way of marble and possess better qualities than marble.

11. Rubber floor covering

These are used in public and industrial buildings because of their good wearing qualities. It has good elasticity and noise insulation properties. It is made of pure rubber mixed with cotton fibre, granulated cork or asbestos, fibre and the desired colouring pigments. The thickness of rubber sheets or tiles varies from 3 to 10 mm and it is available in many designs and patterns .The tiles or sheets and can be cemented over the dry base of concrete or wood by means of special adhesives. The rubber floor coverings arc expensive t provide a durable wearing surface.

12. Linoleum floor covering

Linoleum is the floor covering which is generally laid over wooden or concrete floors. It is the fabricated form of a mixture of resins, linseed oil, gums, pigments, wood flour, and cork dust and filler materials. It is available in market in rolls of width about 2-4 m. The thickness varies from 2 to 6mm. These tiles are also manufactured in various sizes, shapes and patterns. This can be laid over the floors or pasted with adhesives on the floors. Also linoleum coverings are prepared over wooden bases and nailed over the timber floor bases.

This flooring provides an attractive, resilient durable and economical surface. It offers a surface that can be easily washed and cleaned. Being moderately warm with cushioning effect, linoleum provides comfortable living and working conditions. It offers adequate insulation against noise and heat. But it is subjected to rotting when kept wet for enough time and its use is not suitable for basements. It has poor resistance against fire, being combustible in nature. This covering when applied over a wooden base get them under excessive sub-floor traffic.

13. Glass floor covering

It is used when it is desired to allow light to the floor below. Structural glass is available in the form slabs or tiles of thickness 10 to 30 mm. They are fitted within frames of different types. The members of the frame are designed in such a way that the glass floor covering can take up superimposed loads without breaking. This type of floor covering is not common**.**

14. Plastic or PVC floor covering

The plastic tiles are made of PVC (Poly Vinyl Chloride). Plastic or thermoplastic tiles can be economically used as floor covering on the concrete floor base. It is not preferred over wooden floor base as the preparation of the wooden surface for receiving the tiles is very costly. Plastic floor covering are used in all types of buildings like offices, hospitals, shops, schools.

15. Magnesite floor covering

Magnesite flooring is known as composition flooring or joint less flooring. It is composed ofa dry mixture of magnesium oxide, a pigment and inert filler materials, e.g., wood flour, asbestos or sawdust. Liquid magnesium chloride added to this powder and a plastic material is obtained at site. This plastic material is spread over the floor and the surface is levelled with a trowel can be directly laid over stone, concrete or wooden floor base. It is economical and is used as floor covering for office buildings, schools, factories, etc.

ROOFING

Roof is the uppermost part of the building provided as structural covering, to protect the build mg from weathering agencies like sun, rain, wind etc. The roof, as a structural element supports the roof covering. Structural element may be truss, beam, slab, shell or dome. The roof covering may be of corrugated sheets, tiles, slates or slab.

REQUIREMENTS OF AN IDEAL ROOF

1. It should protect the building from weathering agencies like sun, rain, wind etc.
2. It should be durable.
3. Roof should be water proof with good drainage arrangements.
4. It should be fire resistant.
5. Should have adequate strength and stability.
6. It should have thermal and sound insulation properties.

TYPES OF ROOFS

Generally roofs can be classified into the following categories based on its geometry.

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

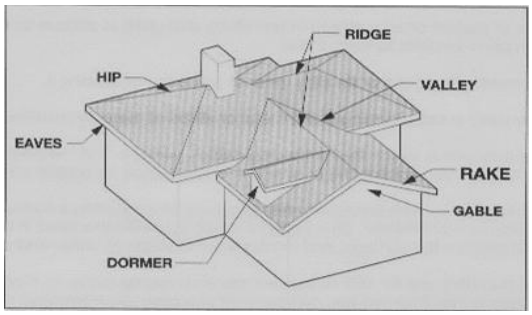
Pitched or sloping roofs

Pitched roofs are sloped roofs. The slope is given towards different sides. Since the top surface is sloped, the drainage is excellent in these roofs. Buildings with irregular shapes cannot have pitched roofs effectively. In the areas of heavy rain falls and snow fall sloping roof are used. The slope of roof shall be more than 10°. They may have slopes as much as 45° to 60° also. The sloping roofs are preferred in large spanned structures like workshops, factory buildings and ware houses.

Terms:

1. *Span*: It is the clear distance between the supports of roof.
2. *Rise*: It is the vertical distance between the top of the ridge and wall plate
3. *Pitch*: It is the slope of the roof. It is obtained as the ratio of rise to span.
4. *Ridge*: It is the apex line of the sloping roof.
5. *Eaves*: The lower edge of the inclined roof surface is called eaves.
6. *Hip*: Itis the ridge formed by joining of two sloping surfaces; external angle is greater than 180.
7. *Valley*: It is a reverse of a hip.It is formed by the intersection of two roof surfaces, making an external angle less than 180.
8. *Principal rafter*: This is the inclined member running from the ridge to the eaves.
9. *Purlins*: These are horizontal wooden or steel members, used to support roofing material of a roof. Purlins are supported on trusses or walls.
10. *Wall plates*: These are long wooden members, which are provided on the top of stone or brick wall, for the purpose of fixing the feet of principal rafters.
11. *Battens*: These are thin strips of wood, called scantlings, which are nailed to the rafters for lying roof materials above.
12. *Cleats*. These are short sections of wood or steel, which are fixed on the principal rafters of trusses to support the purlins.

13. *Truss*: A roof truss is a framework, usually of well-fanned triangles designed to support the roof covering or ceiling over rooms.

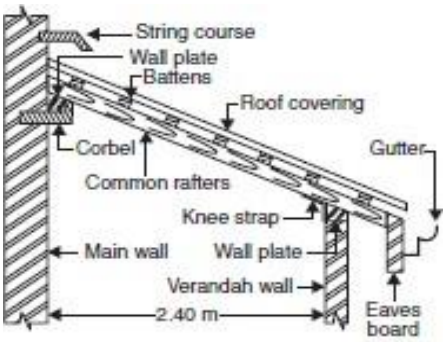


Types of Pitched roofs

A. Single Roof

1. Lean to roof

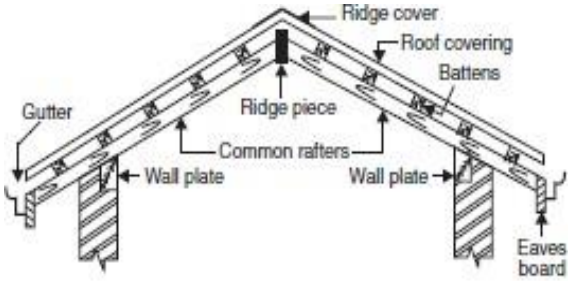
It is used to cover veranda. It has span upto 2.5 m. The rafters are suitably secured on the wall-plates and eaves boards, battens and roof covering is provided. It is generally used for sheds, out-houses attached to main buildings, verandahs, etc.



(a) Lean to roof

2. Couple roof

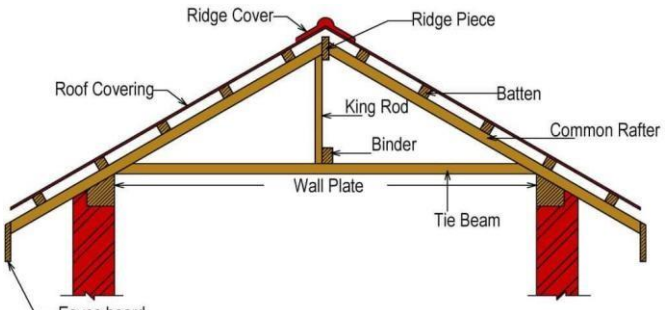
In this type of roof, the common rafters slope upwards from the opposite walls and they meet on a ridge piece in the middle. The common rafters are firmly secured in position at both the ends, one end being on the ridge piece and the other on the wall plate. This type of roof is used for span up to about 3.60 m



(b) Coupled roof

3. Couple close roof

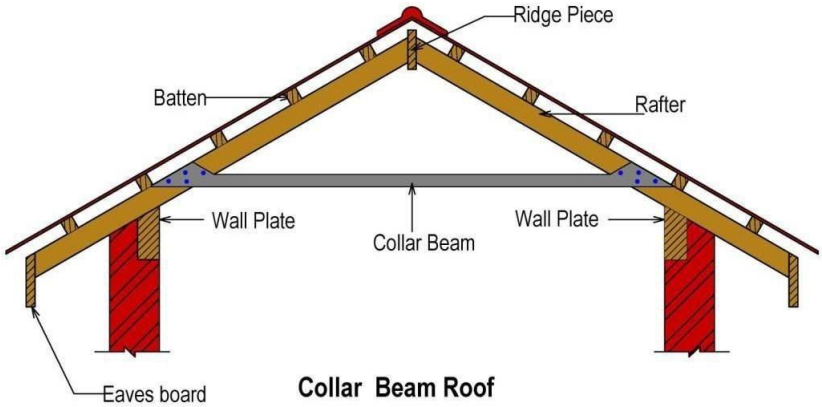
This roof is similar to couple roof except that the legs of common rafter is connected by a tie, preventing the spread out and overturning of walls. This type of roofs are adopted economically up to a span of 4.20 m



Couple Close Roof

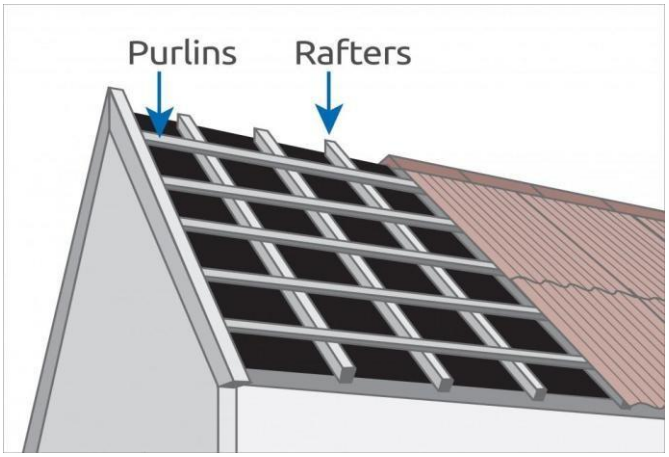
4. Collar tie roof

This roof is variation of couple close roof. The tie beam is raised and placed at a higher level. The tie beam is the known as a collar or a collar beam. A collar beam is adopted to economize the space and to increase the height of room. The collar beam is usually fixed at one-third to one-half the vertical height from the ridge. The roof can be adopted up to a maximum span of 4.80m.



B. Double or Purlin Roofs

- These roofs have two basic elements: (i) rafters and (ii) purlins.
- Purlin gives intermediate support to the rafters which in turn reducesthe size of the rafters to the economical range.
- It is also known as rafter and purlin roof.
- Used when span exceeds 5m.
- The rafters are provided at 20 to 40 cm c/c spacing.
- Each rafter is supported at three points: ridge, purlin and wall plate.
- For larger roofs, two or more purlins may be provided to support each rafter.



C. Triple Membered/Trussed Roofs

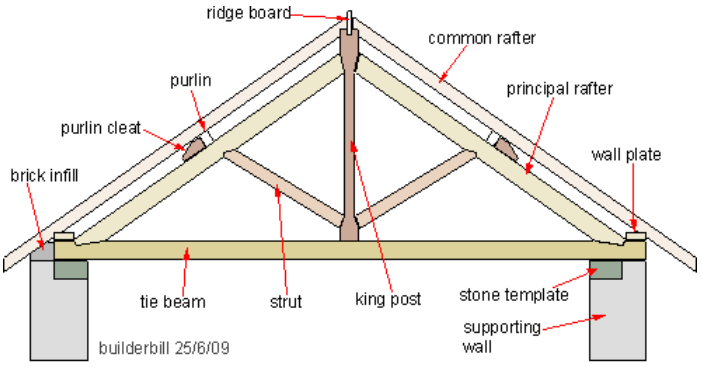
- In this system, the roof consists of 3 elements:

a) Rafters to support the roofing material
b) Purlins to provide intermediate support to rafters
c) Trusses to provide support to the ends of purlins.

- A trussed roof is provided when
  - The span of the room is greater than 5 meters
  - When the length of the room is large i.e., (where there are no internal walls or partitions to support the purlins)

1. King post truss

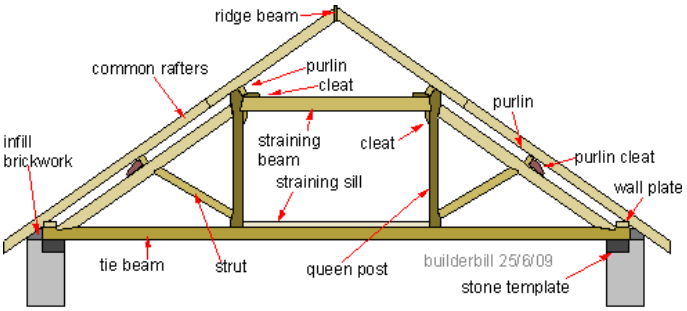
A king post truss has two principal rafters, a tie beam, and a central vertical king post. It is suitable for spans of 6 to 9m.



Traditional King Post Roof Truss

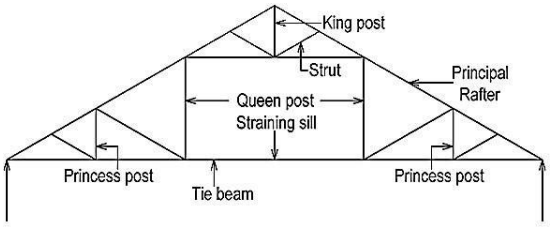
2. **Queen post truss**

It consists of two queen posts and s straining beam. Here straining beam and strut are under compression .Queen post and tie beams are under tension. It is suitable for spans upto 13.5 m.



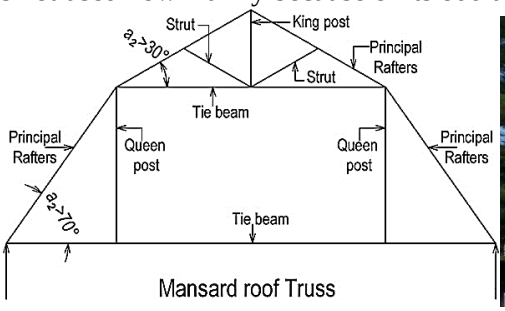
Traditional Queen Post Roof Truss

3. **Combination of King-Post and Queen-Post trusses**
   - For greater spans, the queen post truss can be strengthened by one
   - more upright member, called princess-post to each side
   - Suitable upto 18m span



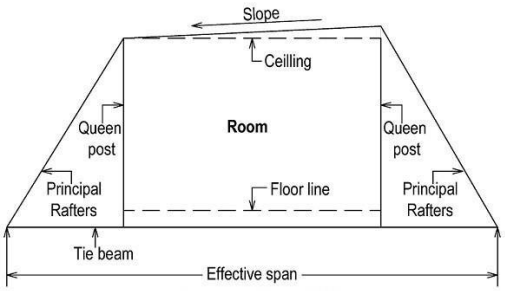
King & Queen Post Roof

4. **Mansard roof truss**
   - Is a 2 storey truss with upper portion consisting of the king-post truss and the lower portion of queen-post truss.
   - It is thus a combination of king-post and queen-post trusses
   - Mansard truss has 2 pitches. The upper pitch(King-Post truss) varies from 30 degrees to 40 degrees and lower pitch(Queen-Post truss) varies from 60 degrees to 70 degrees
   - A room may be provided in the roof between the two queen-posts
   - Is not used now mainly because of its odd and ugly appearance



Mansard roof Truss

5. **Truncated roof Truss**
   - Similar to Mansard roof truss except that the top portion is finished flat with a gentle slope to one side.
   - Used when it is required to provide a room in the roof



Truncated Roof Truss

Flat roofs

These roofs are nearly flat. However slight slope (not more than 10°) is given to drain out the rain water. Flat roofs are suitable for places where rainfall is moderate, where there is no snowfall.

The *advantages* of flat roofs are:

- The roof can be used as a terrace for playing and celebrating functions.
- At any latter stage the roof can be converted as a floor by adding another storey.
- They can suit to any shape of the building.
- Over-head water tanks and other services can be located easily.
- They can be made fire proof easily compared to pitched roof.

The *disadvantages* of flat roofs are:

- They cannot cover large column free areas.
- Leakage problem may occur at latter date also due to development of cracks. Once leakage problem starts, it needs costly treatments.
- The dead weight of flat roofs is more.
- In places of snow fall flat roofs are to be avoided to reduce snow load.
- The initial cost of construction is more.
- Speed of construction of flat roofs is less.

Curved roofs

Curved roofs have the top surface curved. This is done with shells and domes. These are adopted when large column free areas are required. *Shell roof* may be defined as a curved surface, the thickness of which is small compared to the other dimensions. In these roofs lot of load is transferred by membrane compression instead of by bending as in the case of conventional slab and beam constructions. Caves are having natural shell roofs.

Advantages of shell roofs are:

- Good from aesthetic point of view
- Material consumption is quite less
- Form work can be removed early
- Large column free areas can be covered.

Disadvantages are:

- Top surface is curved and hence advantage of terrace is lost.
- Form work is costly.

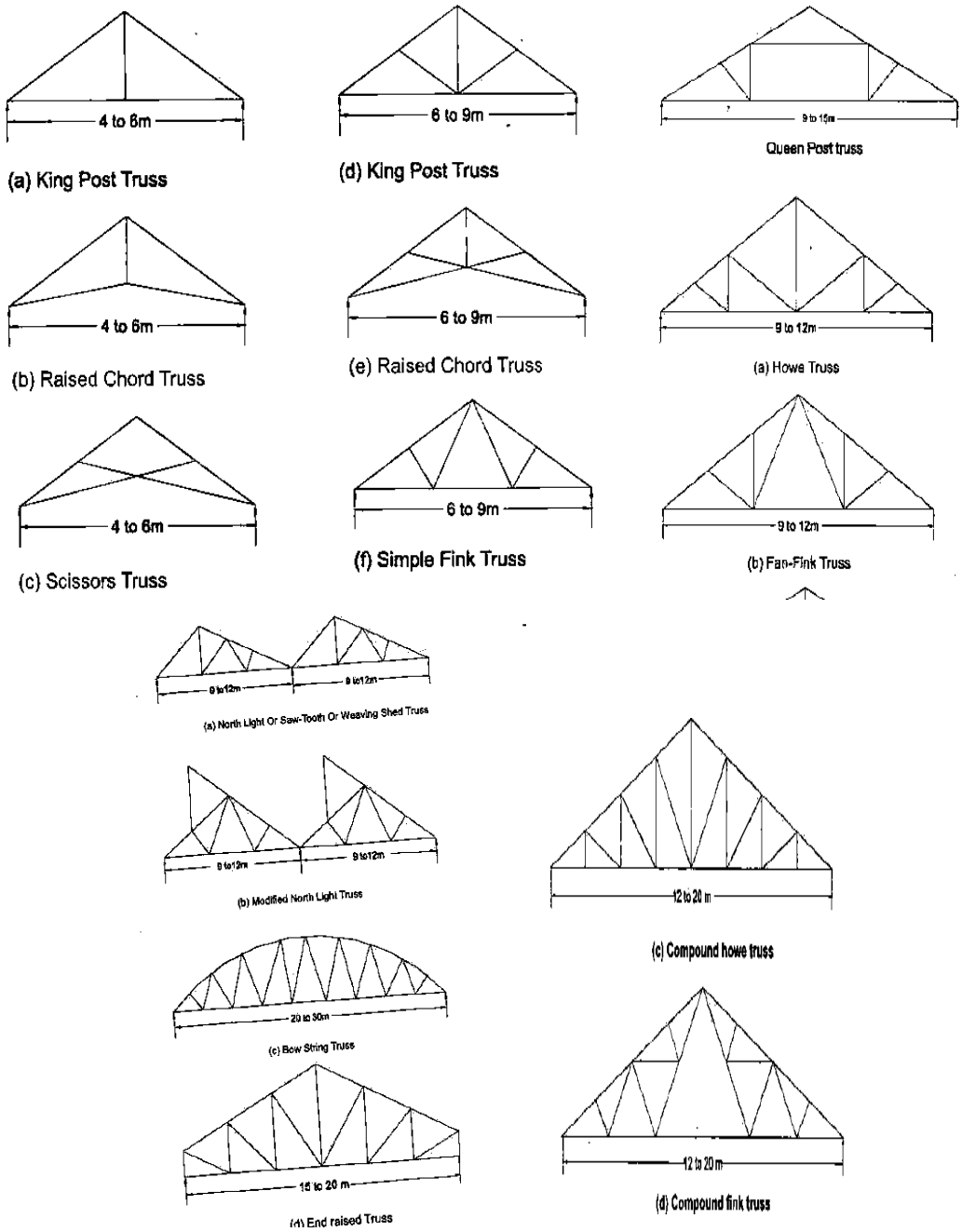
STEEL ROOF TRUSSES

Steel trusses are suitable for large column free buildings like factories, auditoriums, cinema halls, stadia etc. The situations where steel trusses are adopted:

- When large column free area required.
- When the span of the roof is more than 10 m.
- When the height of the roof is more compared to the ordinary buildings. -
- Where other roofs proved to be uneconomical.
- For speedy construction.

Steel trusses are fabricated from structural steel sections. Normally angle, channel, plate, T and tube sections are used for fabrication of trusses. Various configurations are adopted for the trusses based on its span.

The various configurations of truss are shown below. The suitable configuration is selected according to the span of the truss.



Steel Roof Trusses

DETAILS OF STEEL ROOF TRUSS

Generally steel roof trusses are fabricated from angle sections and plates. But channel sections, T-sections and tubular can also be used. The roof trusses are so designed that the members carry only direct stress (i.e. either compression or tension) and no bending stress is induced· This is achieved by allowing loads to be applied only at joints of the trusses. The principal rafters (the top member) as well as the main tie (the bottom member) are generally made of built up sections like two angle sections placed side-by-side etc. The inclined members are generally made of single angle sections.

The members are jointed together using a gusset plate either through rivet or by welding. At least two rivets should be used at each joint. Gusset plate should not be less than 6 mm, though its thickness is designed on the basis of forces carried by members to be jointed are connected to the bearing plate. The bearing plate is jointed to-concrete bed through bolts. At the apex, suitable ridge section is fitted.

Advantages of steel trusses

- They are economical compared to R.C.C. roofs
- Easy to construct and erect.
- Fire proof and resists termite attack.
- These are rigid and light.
- Maintenance is easy.

RCC ROOFS

- Made up of concrete and steel
- Two types of roof slab-one way slab and 2 way slab
- In one way slab, main reinforcement is laid in the shorter span
- In 2 way slab, main reinforcement runs parallel to both sides of the room
- Easy to construct and it provides smooth finish
- Thickness of roof slab depends on type of concrete used, span, floor loads etC

ROOF COVERING

Different materials are used for covering the steel trusses. Corrugated sheets made up of various materials are suitable for steel trusses. The types of sheets are:

1. Asbestos cement sheets (A.C. sheets)
2. Galvanized iron corrugated sheets (G.l.) sheets
3. Aluminium sheets
4. FRP sheets (Fibre glass sheets)
5. Powder coated sheets
6. Roof tiles
7. Asphalt Shingles

A.C. sheets and G.I. sheets covering materials used for industrial buildings

1. A.C. sheets

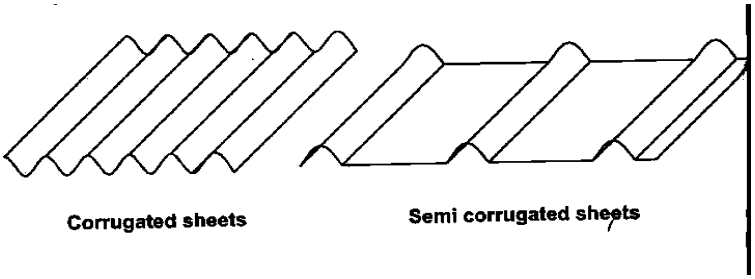
These are widely used sheets for industrial buildings, factories, shed· cinema halls, auditoriums etc.

A.C. sheets are manufactured from asbestos which is a silky fibrous material, found in veins of metamorphized volcanic rocks. It is mixed with Portland cement and these sheets are made. The advantages of asbestos sheets are:

- They are cheap, light in weight and durable.
- Water tight, fire resisting and termite resistant.
- These are available in larger size, which makes the laying fast.
- A.C. sheets do not require any protective paints etc.
- Maintenance is also less

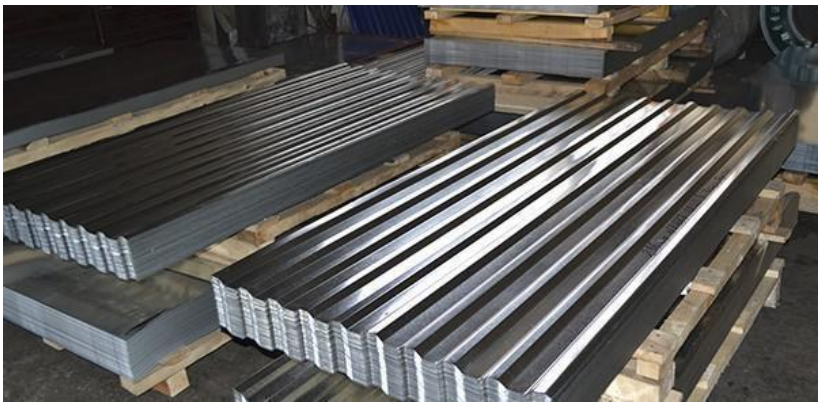
These sheets are available in three forms

- Corrugated sheets
- Semi-corrugated sheets
- Plain sheets



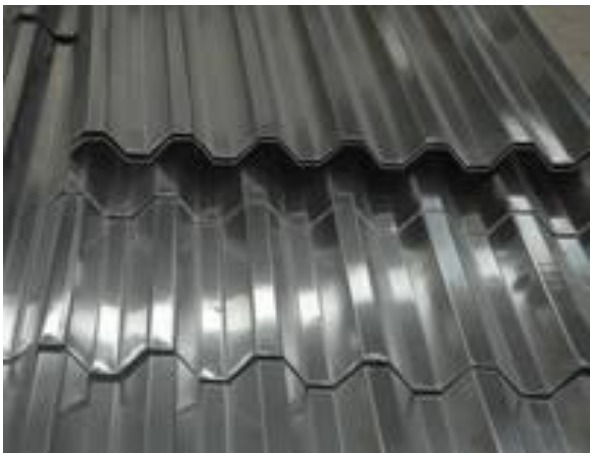
2. GI. sheets

Galvanized Iron sheet are also used for steel trusses. They are stronger than A C sheet. But these sheets are costly. These are iron sheets galvanized with zinc to prevent rusting. These sheets are not suitable for flatter slopes. These are mainly used in warehousing sheds, shelters. Security cabins, garages, site cabins, bus stations. Ticket counters, parcel offices, shade-shelters. These sheets are water proof with better impact strength and tire resistance. These are light in weight yet strong and free from problems of cracking, warping and buckling.



3. Aluminium sheets

Another variety of roof sheet is aluminium sheets. These are long lasting, economical than PVC, steel and cement sheets and make inside atmosphere cool. The most important advantage is that it is corrosion free. This has almost zero maintenance and eco healthy. No side effects on human body. It has very good scrap value. It is light in weight and with better appearance. These are used for sheds, industrial buildings and temporary constructions.



4. FRP sheets

Fibre Reinforced Polymer (FRP) sheets are made with glass or any suitable fibre with a suitable resin. It is popularly known as fibre glass sheets. It is available in different colours and shapes. The advantages are:

- UV Protected
- Does not warp or wilt.
- Non-combustible material of construction
- Can be easily cut, tooled, and handled at site with conventional tools.
- Resists tire corrosive action of chemicals and acidic vapours
- Rustproof.
- Lightweight
- High durability
- Does not absorb dust, grim, moss, or mildew.
- Virtually maintenance free
- High flexibility
- Can be bent perpendicular or parallel to the corrugation
- High thermal insulation

These sheets arc used for types of buildings and structures now a days because of its advantages over other type of roofing materials.

5. Powder Coated Sheets

Conventional GI or Aluminium sheets are enhanced by applying powder coating on the surface. This increases the life and improved the appearance. They are two types.

– Powder coated GI sheets

The GI Sheets arc coated with different coloured epoxy resins. These have excellent chemical resistance and good mechanical properties. It minimizes the rusting of the GI sheets. It also gives good appearance. It is also available in all patterns like corrugated, plain, traffored etc.

– Powder coated aluminium sheets

When aluminium sheets arc coated with epoxy resins, they are called powder coated aluminium sheets. It improves the appearance and life. Different patterns are available viz. plain, corrugated, trafford and etc. Unitiled coated aluminium sheets are another pattern which are very commonly used now. This gives the appearance of a tiled roof building.

6. Roof tiles

- Roof tiles are thin members used for covering roofs made out of clay or concrete. They are of different shapes and sizes.
- Manufactured from clay
- Fire resistant, cheap and durable
- Tiles are better non-conductor of heat and cold
- Tiles are hung to the battens with projection which are already marked in tiles. They kept in position by a sort of interlocking action due to their self-weight
- Pitch of roof should be less than 40 degree

7. Reinforced concrete roofs

The RCC slabs are classified into one way and as two way slab. When length of the slab more than twice the width of the slab, it is called one-way slab and otherwise it is two way slab.

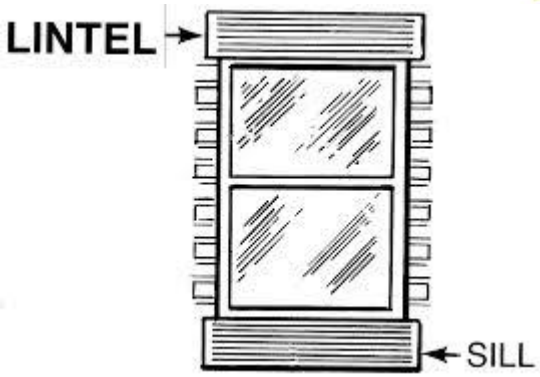
8. Asphalt Shingles

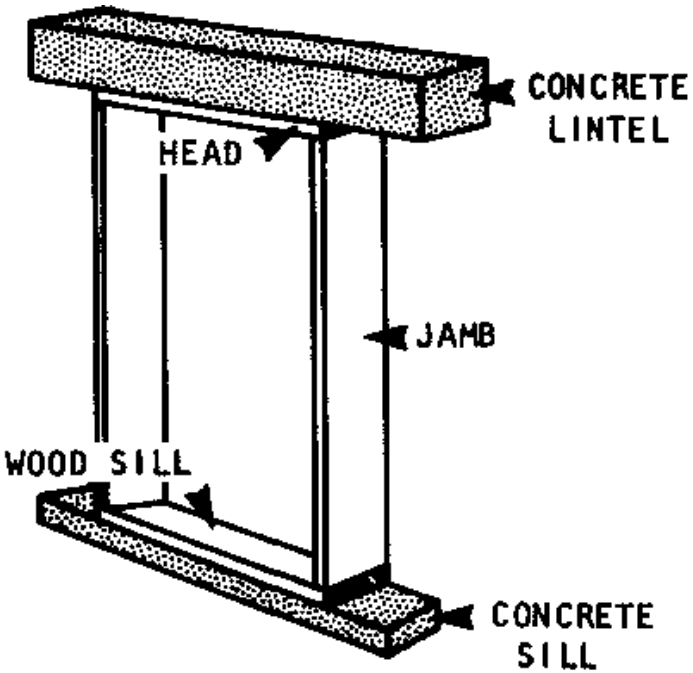
- Available in different colours
- They are easy to install, relatively affordable, last 20 to50 years
- Asphalt shingles do not do particularly well in climates that change drastically

TOPIC 1: LINTELS AND ARCHES

Lintels

- A lintel is a horizontal member which is placed across the opening.
- A lintel is thus a sort of beam, the width of which is equal to the width of wall, and thus ends of which is built inside a wall





Classification of Lintels

- Based on the material of construction:

1. Timber lintels
2. Stone lintels
3. Brick lintels
4. Steel lintels
5. Reinforced Brick lintels
6. Reinforced Concrete lintels

Timber Lintels

- Oldest type of lintel.
- Not commonly used nowadays except in hilly areas.
- Relatively costlier
- Structurally weak and vulnerable to fire.

Timber lintels are strengthened by the provision of mild steel plates at their top and bottom, called as Flitched lintels.

Timber Lintels

Stone Lintels

- These are the most common types of lintels especially where stone is abundantly available
- These are also provided over the openings in brick walls.
- Stone lintels are 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.

Stone Lintels

Brick Lintels

- When the opening is less than 1m and lesser loads are acting, brick lintels are used.
- The depth of brick lintel 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. Such lintel is known as joggled brick lintel.

Brick Lintels

Steel Lintels

- If the superimposed loads are heavy and openings are large then we can go for steel lintels.
- These lintels 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.

Steel Lintels

Reinforced Brick Lintels

- If loads are heavy and span is greater than 1m, then reinforced brick lintels are useful.
- 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 vertical joint.
- Main reinforcement is provided at the bottom consists 8 to 10 mm diameter bars, which are cranked up at the ends.

Reinforced Brick Lintels

Reinforced Concrete Lintels

- At present, the lintels of R.C.C 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.
- R.C.C lintels are suitable for all the loads and for any span.
- The width of lintel is equal to width of wall. Depth of lintel is dependent of 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

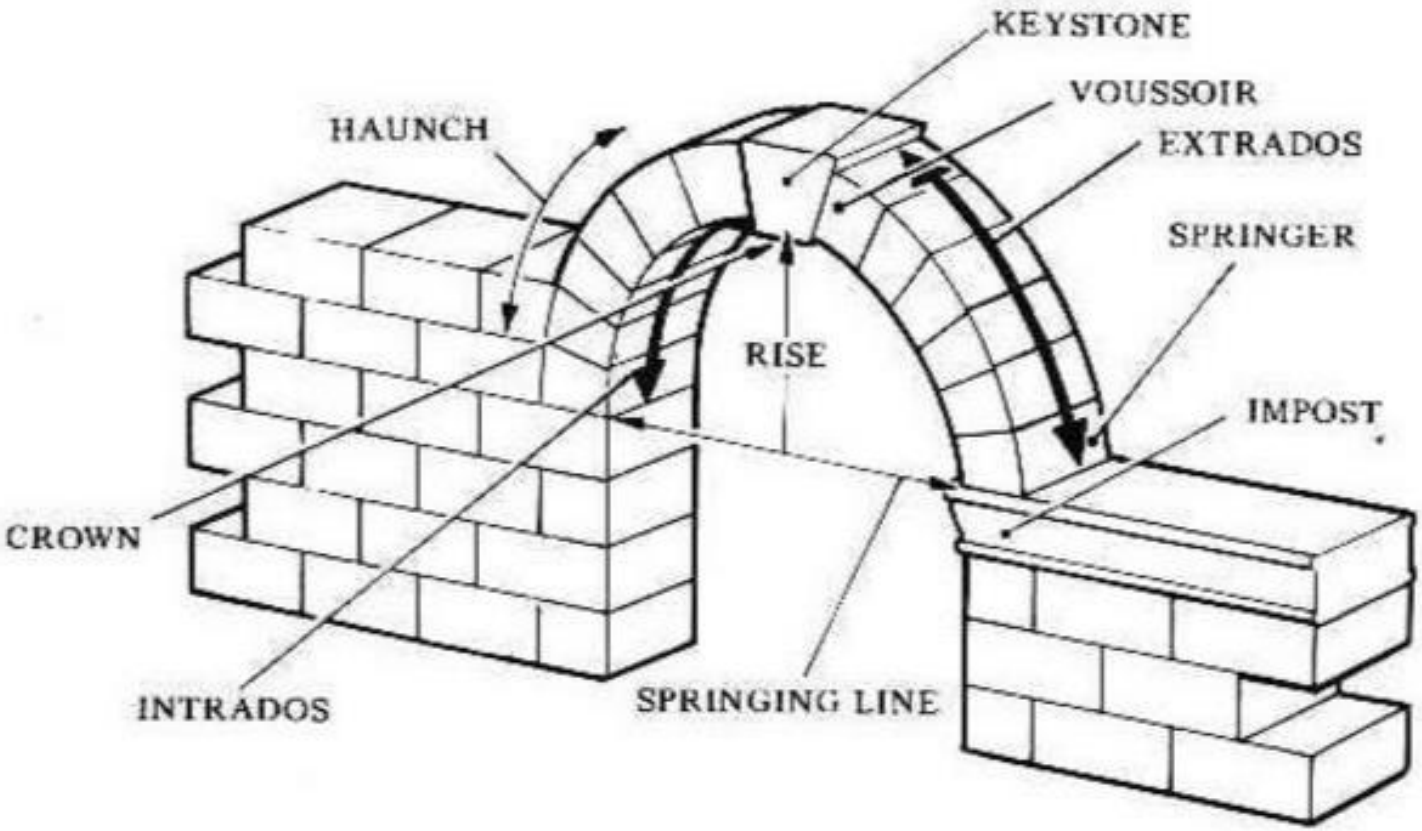
Reinforced Concrete Lintels

ARCHES

Arches

- An arch is constructed in curved shape due to which loads from above is distributed to supports (pier or abutment).
- An arch is a structure which is constructed to span across an opening.
- It generally consists of small wedge shaped units which are joined together with mortar.
- However the arches made of steel and RCC are built in single units.

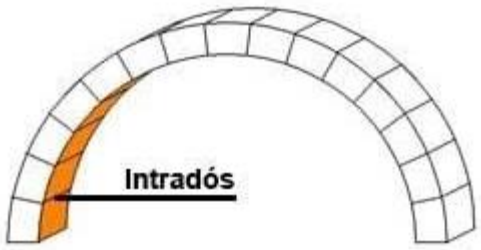
Arches: Technical terms



Arches: Technical terms

Intrados

The inner curve of an arch is called intrados.



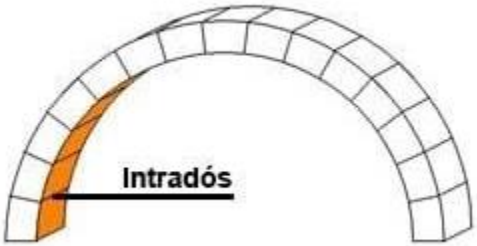
Extrados

The outer curve of an arch is called as extrados.

Arches: Technical terms

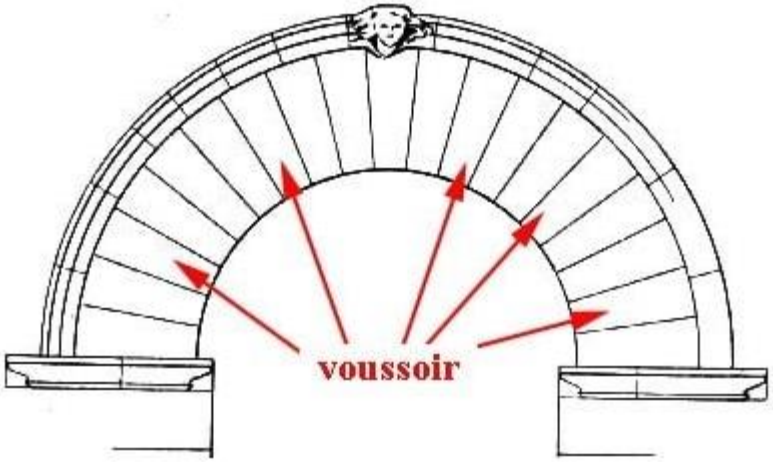
Soffit in an Arch:

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



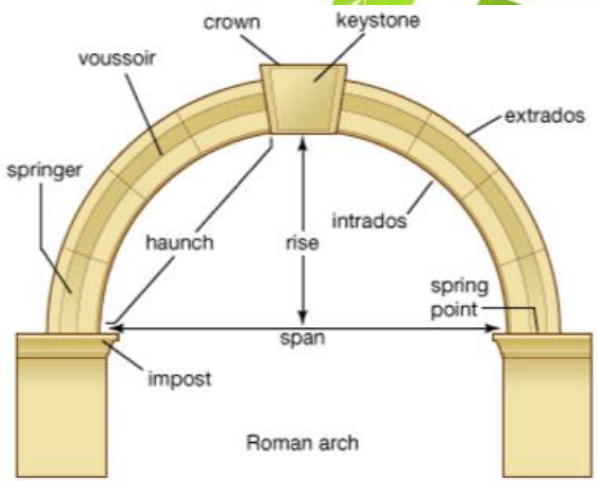
Voussoirs

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

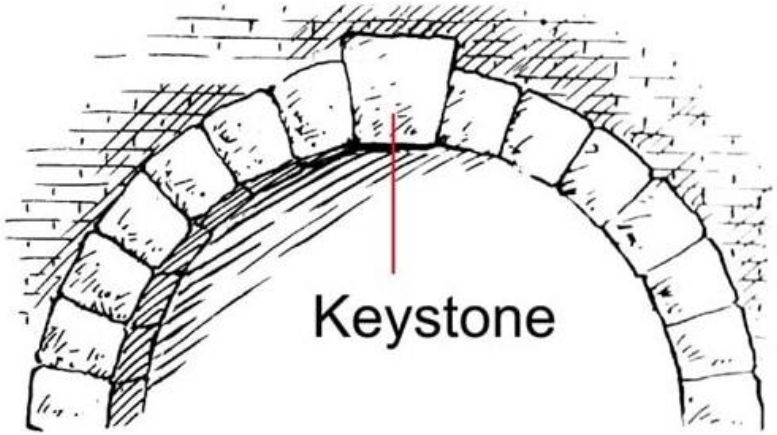


Arches: Technical terms

Crown of an Arch:
The highest part are peak point of extrados is called crown.



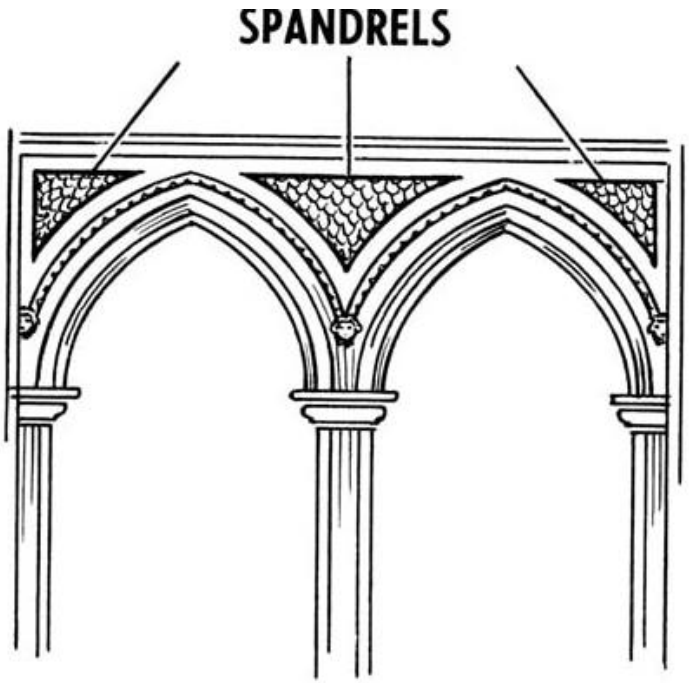
Keystone
The wedge shaped unit which is fixed at the crown of the arch is called keystone.



Arches: Technical terms

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.



Arches: Technical terms

Skew Back

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

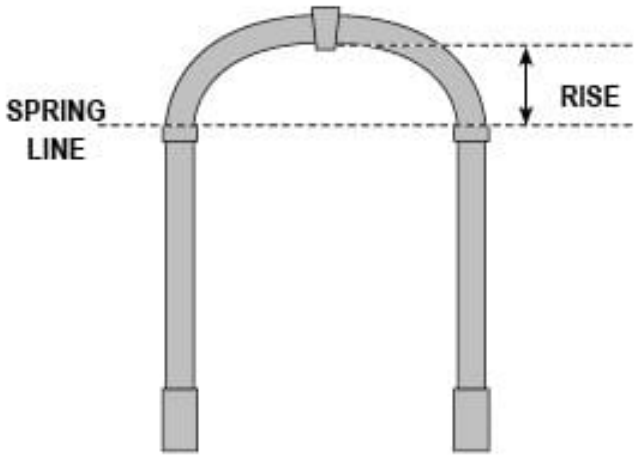
Springing Points

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

Arches: Technical terms

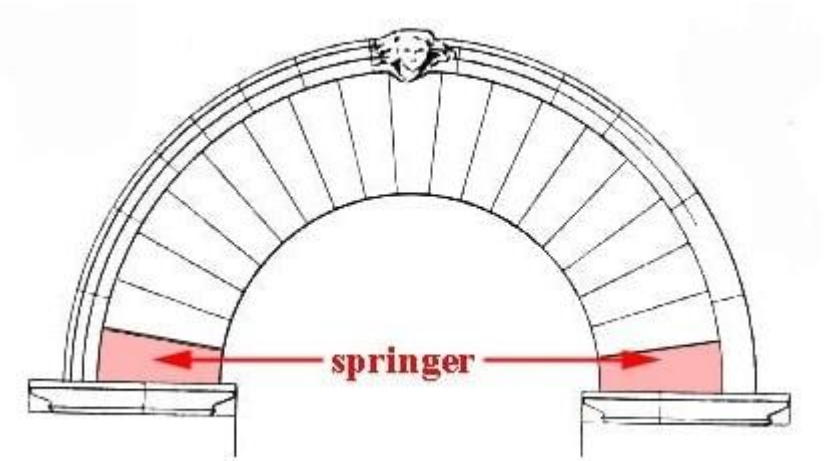
Springing Line

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.



Arches: Technical terms

Haunch

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

Arcade

The row of arches in continuation is called arcade.

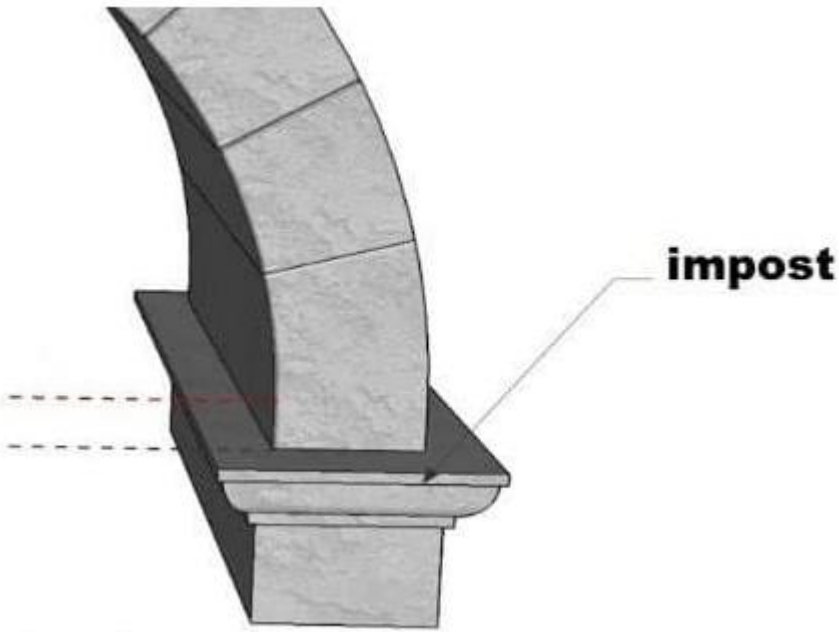
Arches: Technical terms

Ring

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

Impost

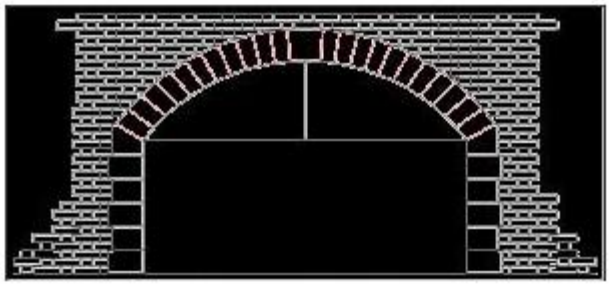
The projecting course is provided on the upper part of a pier or abutment to stress the springing line. This course is called impost.



Arches: Technical terms

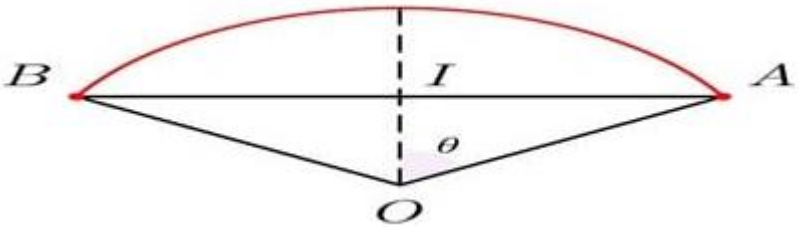
Bed Joints

The joints between the voussoirs are called bed joints. These bed joints are radiate from center of arch. The red color lines in the below figure are bed joints.



Center of an Arch

The geometrical point based on which the arcs forming intrados of arch, extrados of arch and arch rings are described is the center or striking point.



Arches: Technical terms

Span of an Arch

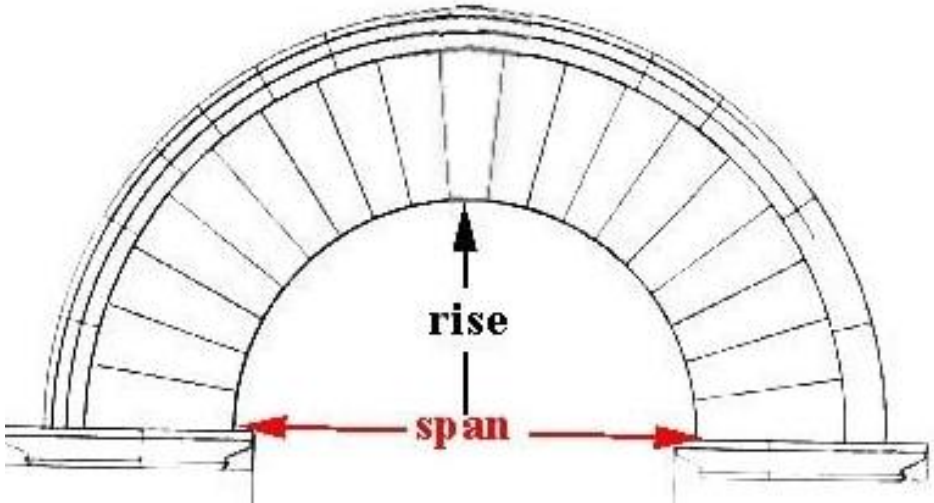
The clear horizontal distance between the supports or abutments or piers is termed as span of an arch.

Rise of an Arch

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

Depth or Height of an Arch

The perpendicular distance between the intrados of arch to the extrados of arch is called depth of an arch or height of an arch.



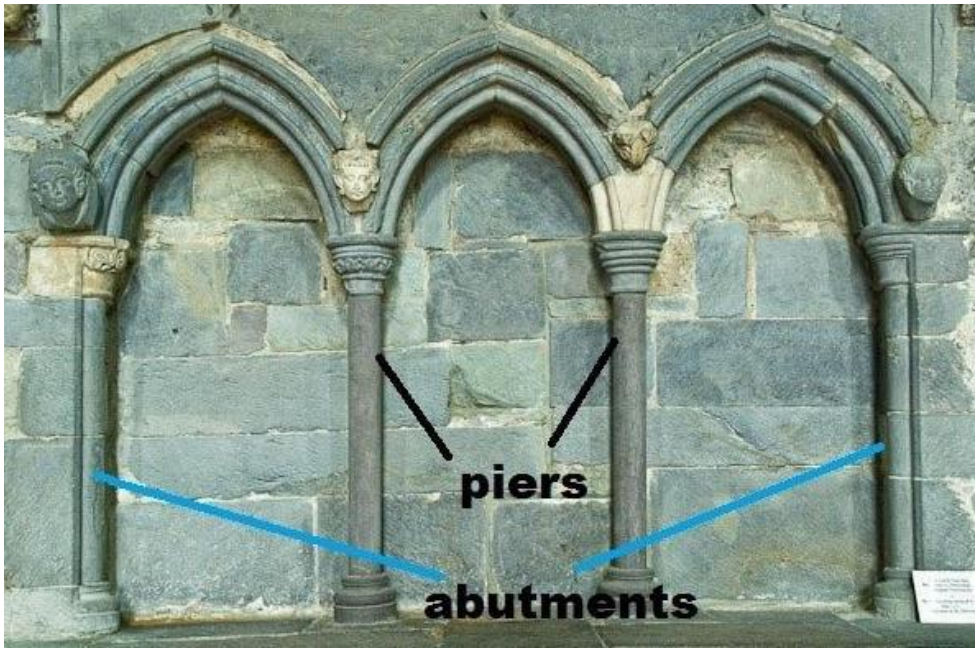
Arches: Technical terms

Thickness of an Arch

This is the breadth of soffit which is measured perpendicular to the front and back faces of an arch. Colored area in the below figure is the thickness of an arch.

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.



Stability of an arch

- An arch transmits the super-imposed load to the side walls through friction between the surfaces of voussoirs and cohesion of mortar.
- Every element in arch remain in compression.
- It has also to bear transverse shear
- An arch may fail in following ways

1. Crushing of masonry
2. Sliding of voussoir
3. Rotation of some joint about edge and
4. Uneven settlement of abutmet/pier

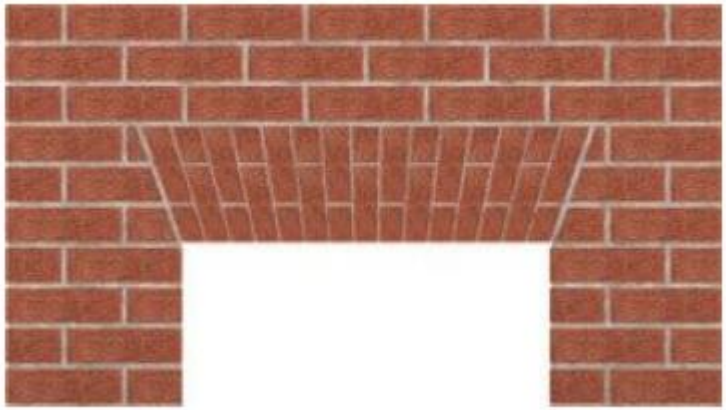
Types of arches

- Arches are classified based on:

1. Shape: 10 types
2. Number of Centre’s: 5 types
3. Workmanship
4. Materials of construction: 3 types

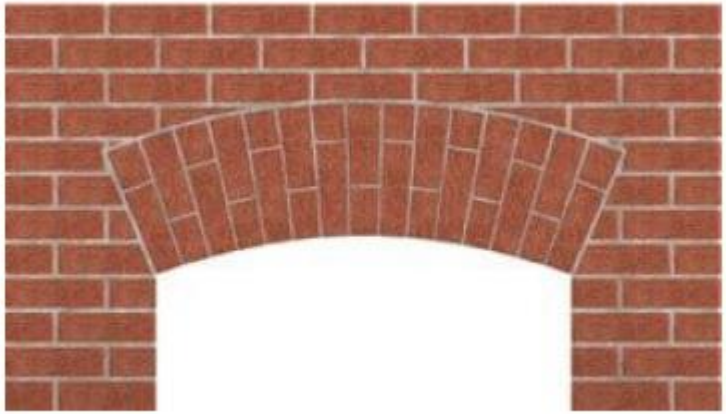
1.Flat arches

- 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 forlight loads, and for spans up to 1.5m.



2.Segmental arches

- 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.



3.Semi circular arches

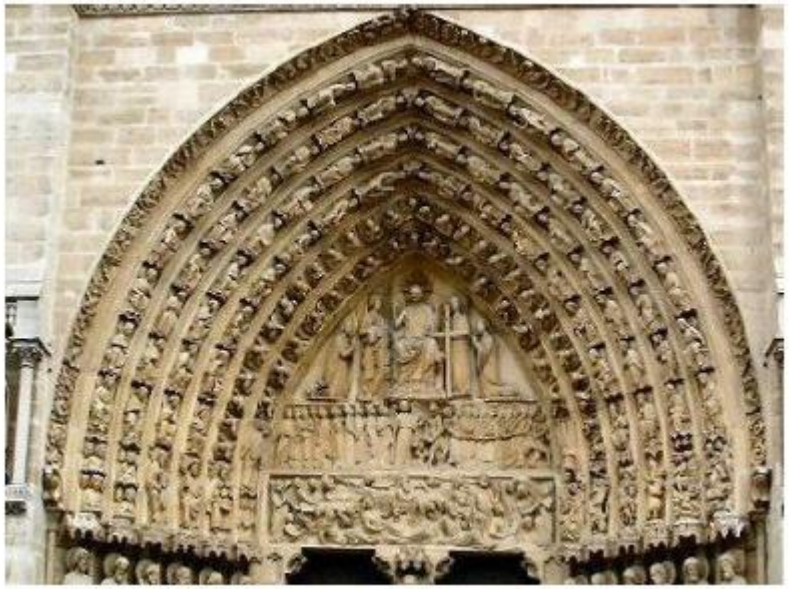
- The shape of arch curve looks like semi-circle and the thrust transferred to the abutments is perfectly vertical direction since skewback is horizontal.
- In this type of arch, the Centre lies exactly on the springing line.

4.Horse shoe arches

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

5.Pointed arches

- 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. This may be either isosceles or equilateral.



6.Venetian arches

- 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 arches

- 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 arches

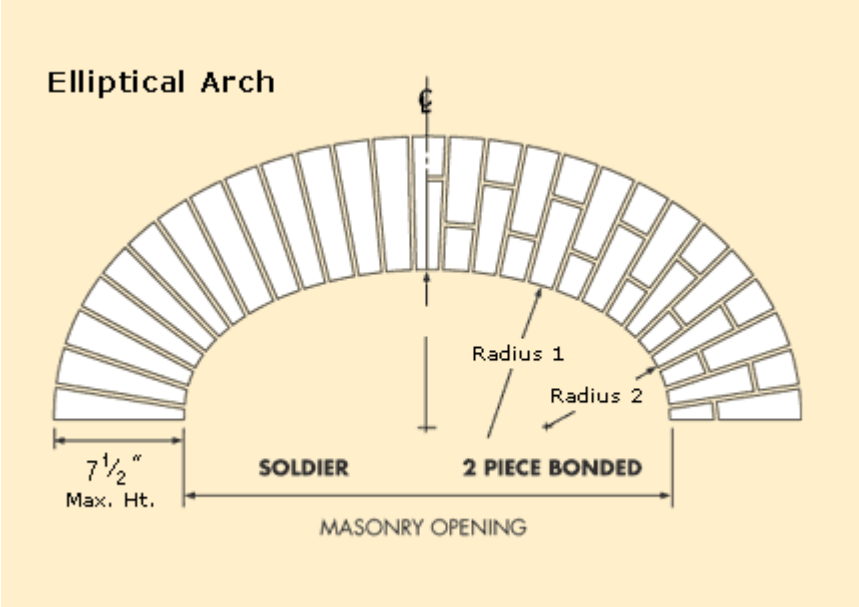
- Relieving arch is constructed above flat arch or on a wooden lintel to provide greater strength.
- In case of relieving arch, we can replace the decayed wooden lintel easily without disturbing the stability of structure.
- The ends of this arch should be carried sufficiently into the abutments.

9.Stiled arches

- 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.

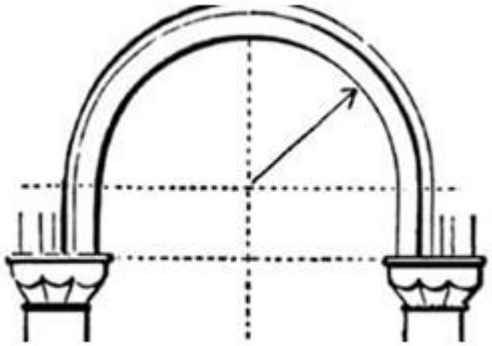
10.Semi- elliptical arches

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



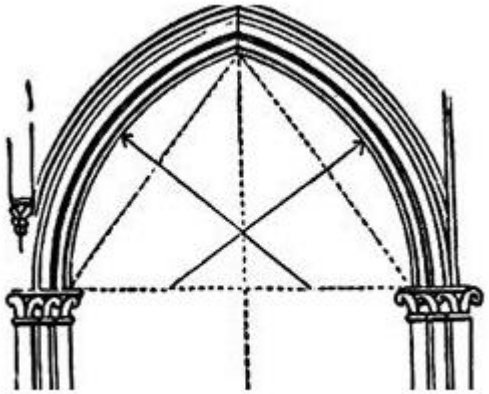
1. One-centered Arches

- 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.



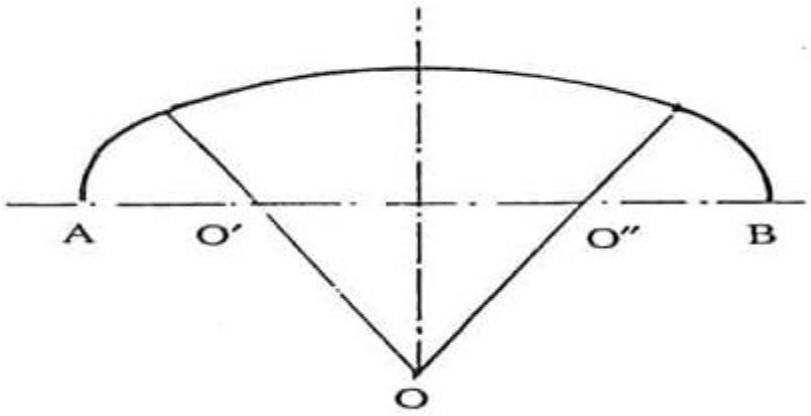
2. Two Centered Arches

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



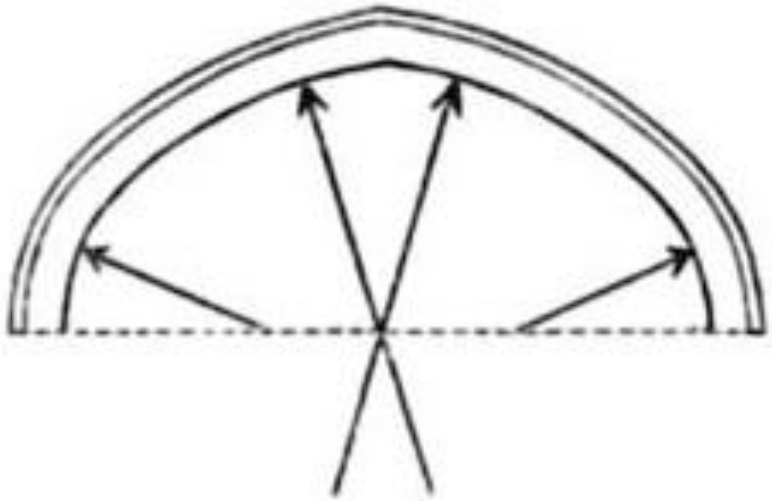
3.Three centered arches

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



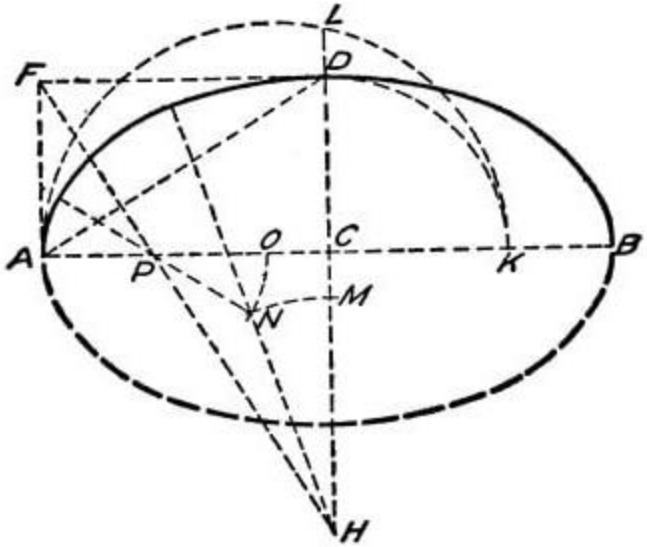
4.4 centered arches

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



5.5 centered arches

- A good semi-elliptical shape arch contains five centers.



1 Stone arches

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

  Rubble arches

  Ashlar arches

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.
- Sometimes these are also used as relieving arches up to a depth of 37.5cm, but these are constructed in one ring.
- If the depth is more, we can go for two rings in alternate course of headers and stretchers.

Rubble arches

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

  Axed brick arches

  Gauged brick arches

  Purpose made brick arches

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.

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

  Monolithic concrete block arches

Precast concrete block arches

- In Precast concrete block arches the blocks are cast in molds to the exact shape and size of voussoirs.
- For key stone and skewbacks special molds are prepared. 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.

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.

Construction of Arches

1. Installation of centring
2. Laying of arch
3. Decentring

Installation of centering

- The centering for smaller spans is made with mud masonry and is plastered with mud mortar or with lean cement problem.
- For arches of medium span wooden centering are used.
- Steel centring is preferred for larger spans and repeated used.
- A pair of wedges are provided between the centering and staging to allow centering to be tightened and loosened

Laying of arches

- Skewbacks of exact size and shape are carefully laid on both sides of arch.
- Then the construction of arch starts from both sides and proceeds towards crown.
- The joints of 5-15 mm thickness are made with mortar.
- Finally a keystone is inserted and the arch is locked.

Decentring

- After curing period of about 4 weeks centering is to be removed.
- Two days before removal, the centering is eased to see that the blocks close in and compress the mortar.
- The centering is to be removed without any shock.
- To achieve this centering are provided with wedges or they are built on sand boxes.
- Providing sand box to facilitate decentering is the best method

LINTELS AND ARCHES

TOPICS TO BE COVERED

LINTELS

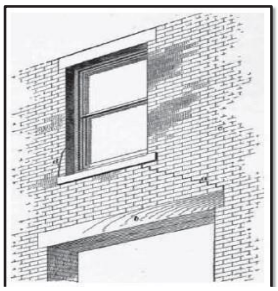
- Introduction
- Classification of lintels

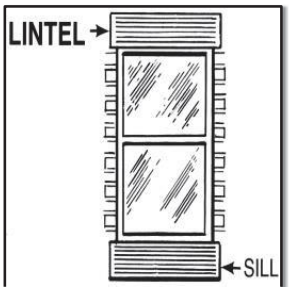
ARCHES

- Arches : Terms to be used
- Stability of an arch
- Classification of an arches

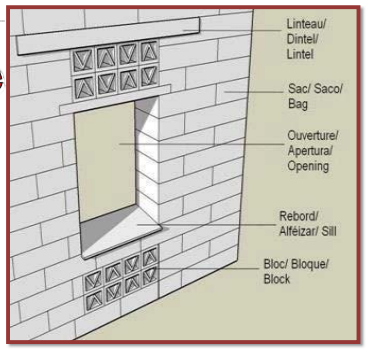
Introduction

❖ A lintel is defined as a horizontal structural member which is placed across the opening.





Structure of lintel



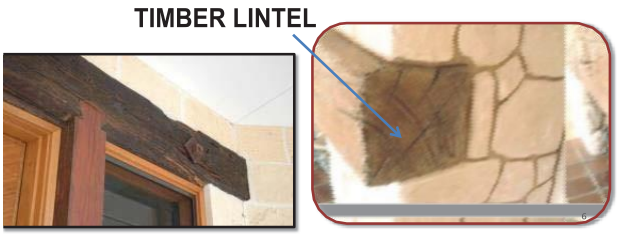
Classification of lintel

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

❖ [1] Timber lintels
❖ [2] Stone lintels
❖ [3] Brick lintels
❖ [4] Reinforced Brick lintels
❖ [5] Steel lintels
❖ [6] Reinforced cement concrete lintels

Timber lintels

❖ Easily available in hilly area.
❖ Relatively costly, structurally weak and valnerable to fire.
❖ Easily decay, if not properly taken care.

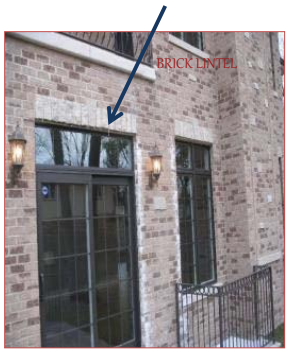


Stone lintels

- Used , where stones are easily available.
- Consists of a simple stone slab of greater thickness.
- Due to high cost and its inability to with stand the vibratory load.

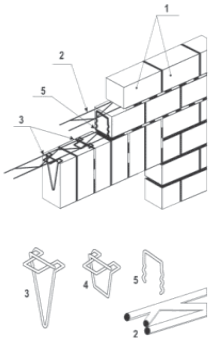
Brick lintels

- The brick are hard, well burnt, first class bricks
- Not structurally strong
- Suitable for small span.
- The bricks having frogs are more suitable.



Reinforced Brick lintels

- For large spans and heavy loads .
- They are reinforced with mild steel bars.
- Very common due to durability, strength and fire resisting properties.
- Joints are filled with cement concrete.



Steel lintels

- Provided at large opening and where the super-imposed loads are heavy.
- It consists of rolled steel joists .
- Either used singly or in combination of two or three units.
- Joint with bolts.

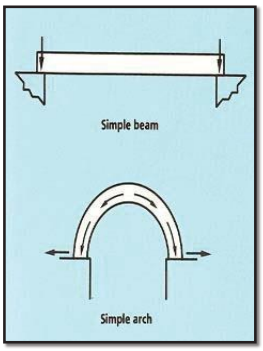
REINFORCED CEMENT CONCRETE LINTEL

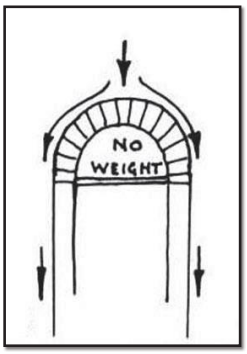
- Common in used.
- They may be pre-cast .
- For smaller span, the pre-cast concrete lintels are used.
- Depth of lintel depend on span.

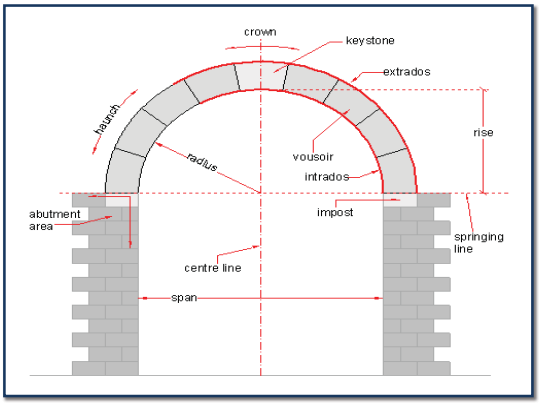
ARCHES

ARCHES

- The structure constructed of wedge shaped block of stones or bricks ,jointed together with mortar and provided across the opening to carry the weight of the structure above the opening.







ELEMENTS OF ARCHES

TECHNICAL TERMS

The various technical terms used in arches are as follows:-

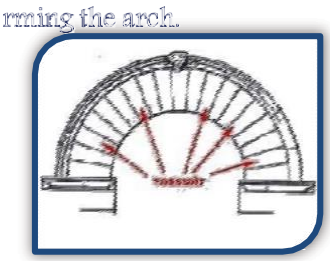
1) **Abutment**:-This is the end support of an arches.

2) **Pier**:-This is support an intermediate of an arch.

3) **Intrados** :-This is the inner curve or surface of an arch.

4) **Extrados** :-This is the outer curve or surface of the arches.

5) **Voussoirs** :-The voussoirs or arch stones are the wedge shaped units forming the arch.



6) **Springing stone**:-The springing stone or springer is the first voussoir at springing level on either side of the arches.

7) **Springing line**:-This is an imaginary line joining the two springing points.

8) **Crown**:-This is the highest point of extrados or it is the highest part of an arches.

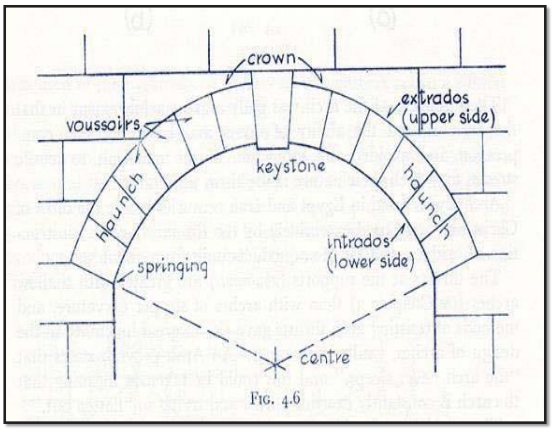
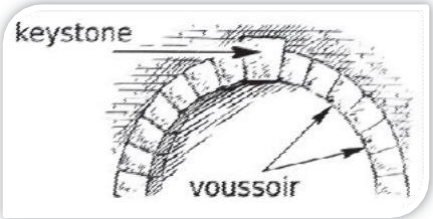


FIG. 4.6

9) **Keystone**:-This is the highest central wedge shaped block of an arch.



10) **Skew back**:-This the surface of the abutment on which the arch rests.

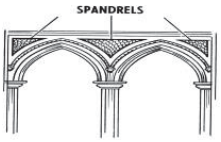
11) **Span**:-This is the clear horizontal distance between the two supports.

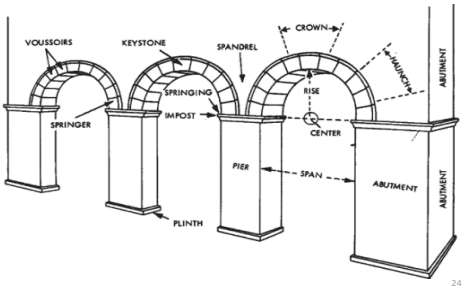
12) **Rise**:-this is the vertical distance between the two supports.

13) **Depth of arch**:-This is the perpendicular distance between the intrados and extrados.

14) **Haunch of an arch**:-This is the portion of arch situated centrally between the key and skew backs.

15) **Spandril**:-This is the triangular walling enclosed by the extrados of the arch, a horizontal line from the crown of the arch and perpendicular line from the springing of the outer curves.





FAILURE OF AN ARCH

- EVERY ELEMENT OF ARCH REMAINS IN COMPRESSION.
- An arches fail due to:-

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

CLASSIFICATION OF ARCHES

Classification of arches

An arch may be classified according to their:

1) Material of construction and workmanship
2) Shape of curve formed by their soffit or intrados
3) Number of centers.

CLASSIFICATION BASED ON MATERIAL AND WORKMANSHIP

- BRICK ARCHES

*Rough brick arches
*Axed brick arches
*Gauged brick arches

- STONE ARCHES

*Rubble arches
*Ashlar arches

- GAUGED ARCHES

*Precast concrete block arches
*Monolithic concrete arches

ROUGH BRICK ARCHES

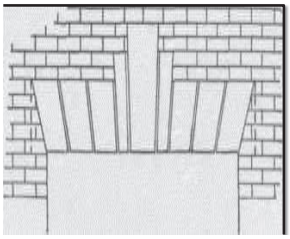
- These arches are built with ordinary bricks, which are not in wedge shape .
- Also known as "RELIEVING ARCHES".
- Made up of rectangular brick that are not cut into wedge shape. Curvature are obtained by mortar.

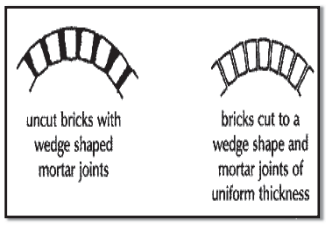
AXED BRICK ARCHES

- Bricks are cut to wedge-shape.
- Joints of arches are of uniform thickness.
- Not dress finely so it does not give much attractive appearance.

GAUGED BRICK ARCHES

- Accurately prepared to wedge shape.
- Specially shaped bricks known as "RUBBER BRICKS" are used .(soft bricks)
- The lime putty is used for binding the blocks.



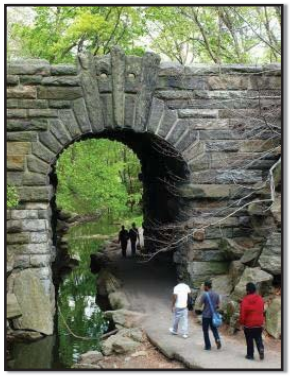


RUBBLE ARCHES

- Made of rubble stones, which are hammer dressed, roughly to the shape and size of voussoirs of the arch and fixed in cement mortar.
- These arches are used for small span upto 1 m.

ASHLAR ARCHES

- Stones are cut to proper shape of voussoirs and are fully dressed, properly joint with cement or lime.
- The voussoirs made of full thickness of the arch.



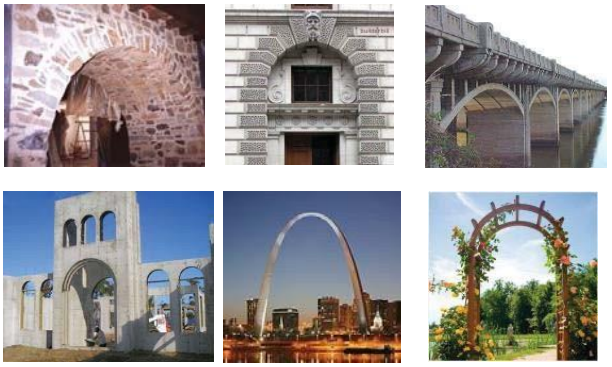
PRECAST CONCRETE BLOCK ARCHES

- Used for small openings in building.
- The voussoirs, in the form of cement concrete blocks are prepared in special moulds .
- Generally , the concrete blocks are used without reinforcement.

MONOLITHIC CONCRETE ARCHES

- Constructed from cast-in-situ concrete,either plain or reinforced , depending upon the span and magnitude of loading.
- Quit suitable for larger span (3.0 m).
- The curing is done 2 to 4 weeks.

Types Of Arches on Material of Construction



Classification according to shape

- Flat arch
- Segmental arch
- Semi-circular arch
- Relieving arch
- Dutch or French arch

FLAT ARCH

- Acts like a lintel, when it provided over the opening .
- Joints radiated to center.
- Used only for light loads only.
- Span up to 1.50 m.

SEGMENTAL ARCH

- Segmental in shape and provided over the openings .
- Joints radiate from a center of arch, which lies below the springing line.

SEMI-CIRCULAR ARCH

- The shape of the curve given to the arch soffit is semi-circular.
- The center of the arch lies on the springing line.

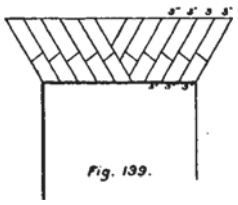
SEMI-CIRCULAR ARCH

RELIEVING ARCH

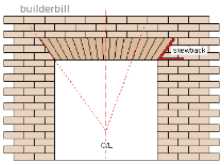
- When wooden lintel is provided over the wider opening, a brick relieving arch is constructed above the lintel.
- Relieving the load of masonry over lintel.

Dutch or French arch

- A flat arch in brick; most of the bricks slope ou tward from the middle of the arch (at the sam e angle on both sides of the centerline)



Types of Arches on Geometry



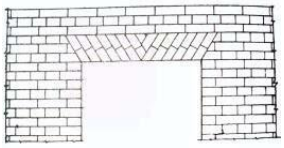
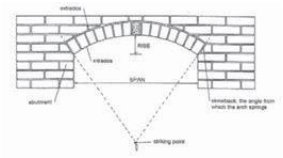
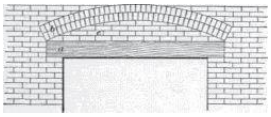
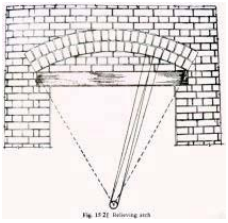


Fig. 15.22 Dutch or French arch







CLASSIFICATION BASED ON NUMBER OF CENTRES

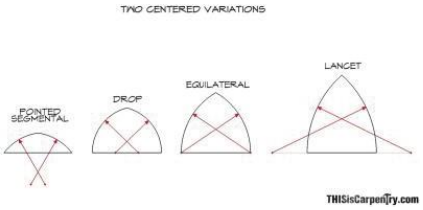
- **One centred arch.**
- **Two centred arch.**
- **Three centred arch.**
- **Four centred arch.**
- **Five centred arch.**

ONE CENTRED ARCH

- **Segmental, semi circular, flat arches come under this category.**
- **Sometime , a perfectly circular arch known as bull's eye arch ,provided for circular window.**

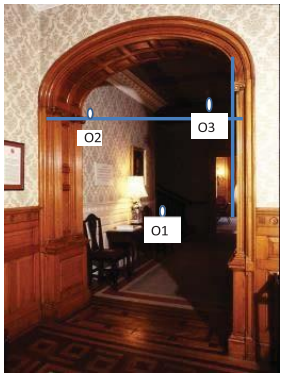
TWO CENTRED ARCH

- **Pointed, semi-elliptical arches come under this category.**

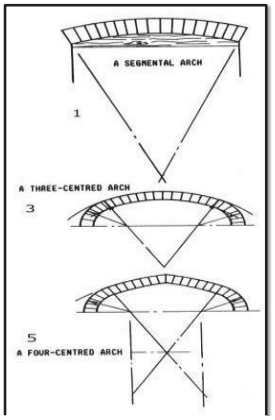


THREE CENTRED ARCH

- Elliptical arches come under this category.
- O1,O2 and O3 are the center.



FOUR CENTRED ARCH

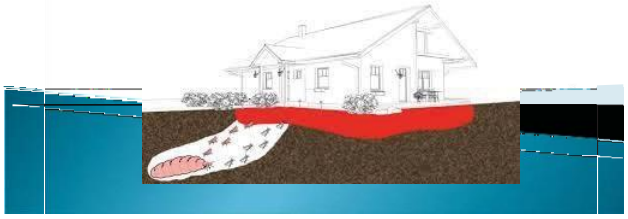


- It has four center.
- Venetian arch is typical example of this type.

FIVE CENTRED ARCH

- This type of arch ,having five centre's ,gives good semi-elliptical shape.

Presentation on Termite Treatment in Buildings



➢ Introduction

- Termite control in building is very important as the damage likely to be caused by the termite is huge.
- Termites damages the cellulosic materials (Like wood) at faster rate because cellulose forms their nutrients .
- Termites also known to damage non cellulosic material in their search for food .

➢ Classification Of Termites

According to their habits, termites are classified into two well defined groups :-

Subterranean

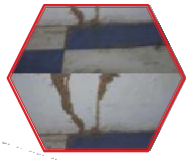
Termites which builds their nests in the soil.

Non Subterranean (dry wood)

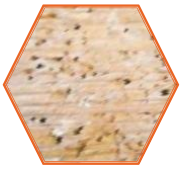
These type of termites are wood nesting ,which live in wood with no contact to soil.

➢ Damages By Termites

Termite damage indoors on walls



Termite nest on walls



Termite holes on wood

Termite destruction of wooden Doors

➢ Prevention

- Pre-construction anti-termite treatment is considered as most effective way to prevent termite invasion in buildings or homes.
- In this soil under the foundation is treated with chemicals. A chemical barrier is formed between ground and brickwork of the foundation to avoid termites access to the building.

- Post construction anti-termite treatment is conducted after the completion of the construction of the building. This normally consists of re-using termiticides to the soil around the foundation. Also treat the floors of the rooms by making holes under floors and fill them with chemicals for Termite Control.

➢ Anti termite treatment

1. Pre construction
2. Post construction

1. Pre construction

- The various operation involved in this treatment are as follows

I. Site preparation
II. Soil treatment
III. Structure barriers

i. Site preparation

- The site preparation consist of removing the stumps, roots, logs, waste woods etc from the site where the building is to be constructed.
- If the termite mounds are detected within the plinth area of the building they should be destroyed by the use of **insecticide solution.**

ii. Soil treatment

To make the soil treatment effective the chemical water emulation is applied in required dosage on entire area of ground covered by the building.

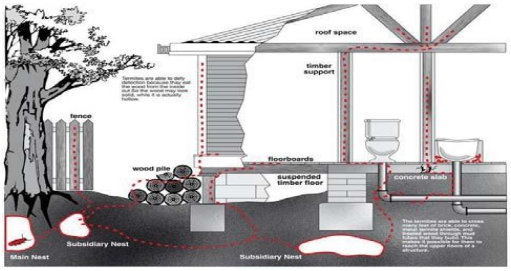
The watering can or and operated compressed air sprayer can be used to ensure distribution of the chemical emulsion.

ii. Soil treatment

CHEMICAL	CONCENTRATION BY WEIGHT
Aldrin	0.5%
Heptachlor	0.5%
Chlordane	1%

STRUCTURE BARRIERS

- The structure barriars may be provided continually at plinth level to prevent entries of termites through walls.
- The cement concrete layer 5 to 7.5 cm thick may be provided projecting 5 to 7.5 cm on both the side.
- The metal barriers consist of non corrodible sheets of copper or galvanized iron of 0.8 mm thick may be provided on both the side.



POST CONSTRUCTION

- This teeatment is applied to exsting bulidings
- This treatment is applied to which are already Attacked by termites
- The termites even after their entries in the building they maintain regularly contact with their nest in the ground.
- In case of sever attack the soil around and beneath the building is treated with chemical emulsion.
- The wood work which is badly damaged by termites may be replaced by new timber brushed with oil or kerosene based chemical emulsion.
- The wood work which is not attack by termites may be sprayed over with chemical emulsion to prevent the possible attack .

PAINTING

Paint is a fluid that spreads over a solid surface and forms a film when it dries. It is usually applied on a surface in layers like primary coat, first coat, second coat etc.

Paints are applied on the surfaces of timber, metals and plastered surfaces as a protective layer and at the same time to get pleasant appearance. Paints are applied in liquid form and after sometime the volatile constituent evaporate and hardened coating acts as a protective layer.

Purpose

- Prevent decay in wood
- Prevent corrosion in metal
- Provides clean ,smooth and colored surface
- Protect the surface of wood, metal and all structures from atmospheric influences.

CONSTITUENTS OF PAINT

The essential constituents of paints are:

1. Base
2. A vehicle
3. A pigment
4. A drier and
5. A thinner.

1. Bases: It is a principal constituent of paint. It also possesses the binding properties. It forms an opaque coating. Commonly used bases for paints are *white lead, red lead, zinc oxide, iron oxide, titanium white, aluminum powder and lithopone*. A lead paint is suitable for painting iron and steel works, as it sticks to them well. However it is affected by atmosphere action and hence should not be used as final coat. While zinc forms good base but is costly. Lithophone, which is a mixture of zinc sulphate and barytes, is cheap. It gives good appearance but is affected by day light. Hence it is used for interior works only.

2. ***Vehicles:*** The vehicles are the liquid substances which hold the ingredients of paint in liquid suspension and allow them to be applied evenly and uniformly on the surface to be painted. It provides a binder for the ingredients of paint so that they may stick or adhere to the surface. Linseed oil, Tung oil and Nut oil are used as vehicles in paints. Of the above four oils, linseed oil is very commonly used vehicles. Boiling makes the oil thicker and darker. Linseed oil reacts with oxygen and hardens by forming a thin film.

3.Pigment: Pigments give required colour for paints. They are fine particles and have a reinforcing effect on thin film of the paint. The common pigments for different colours are:

Black—Lamp black, suit and charcoal black.

Red—venedion red, red lead and Indian red.

Brown—burned timber, raw and burned sienna

Green—chrome green, copper sulphate.

Blue—prussian blue and ultra marine

Yellow—ochre and chrome yellow.

4. The Drier: These are the compounds of metal like lead, manganese, cobalt. The function of a drier is to absorb oxygen from the air and supply it to the vehicle for hardening. The drier should not be added until the paint is about to be used. The excess drier is harmful because it destroys elasticity and causes flaking.

5. The Thinner: It is known as solvent also. It makes paint thinner and hence increases the coverage. It helps in spreading paint uniformly over the surface Turpentine and naphtha are commonly used thinners. After paint applied, thinner evaporates and paint dries.

PROPERTIES OF AN IDEAL PAINT

1. It should be possible to apply easily and freely.
2. It should dry in reasonable time.
3. It should form hard and durable surface.
4. It should not be harmful to the health of workers.
5. It should not be easily affected by atmosphere.
6. It should possess attractive and pleasing appearance.
7. It should form a thin film of uniform nature i.e., it should not crack.
8. It should possess good spreading power.
9. It should be cheap.

TYPES OF PAINTS

Depending upon their constituents there are various types of paints. Brief descriptions of some of them which are commonly used are given below:

1. Oil Paint: These paints are applied in three coats-primer, undercoat and finishing coat. The presence of dampness while applying the primer adversely affects the life of oil paint. This paint is cheap and easy to apply. It possesses good opacity and low gloss.

2. Enamel Paint: It contains white lead, oil, petroleum spirit and resinous material. The surface provided by it resists acids, alkalies and water very well. It is desirable to apply a coat of titanium white before the coat of enamel is applied. It can be used both for external and internal walls. It Dries slowly and forms a hard durable surface. It is not affected by gases, acids, alkalies, hot water and cold water, steam and temperature. It is available in different colours.

3. Emulsion Paint: It contains binding materials such as polyvinyl acetate, synthetic resins etc. It dries in 1 to 2 hours and it is easy to apply.

The advantages of emulsion are:

1. This paint is easy to apply and dry within 2 hrs.
2. Possess good weather resistance and alkali resistance
3. Long lasting paint with no change in colour
4. It is possible to clean the painted surface with water

For long life of painting two coats of emulsion is applied. While applying emulsion paint on plastered surface, apply a coat of cement paint to smoothen the plastered surface before applying emulsion paint directly

4. Cement Paint: It is available in powder form. It consists of white cement, pigment and other additives. It is durable and exhibits excellent decorative appearance. It should be applied on rough surfaces rather than on smooth surfaces. It is applied in two coats. First coat is applied on wet surface but free from excess water and allowed to dry for 24 hours. The second coat is then applied which gives good appearance.

5. Bituminous Paints: This type of paint is manufactured by dissolving asphalt or vegetable bitumen in oil or petroleum. It is black in colour. It is used for painting iron works under water.

6. Synthetic Rubber Paint: This paint is prepared from resins. It dries quickly and is little affected by weather and sunlight. It resists chemical attack well. This paint may be applied even on fresh concrete. Its cost is moderate and it can be applied easily**.**

7. Aluminium Paint: It contains finely ground aluminium in spirit or oil varnish. It is visible in darkness also. The surfaces of iron and steel are protected well with this paint. It is widely used for painting gas

tanks, water pipes and oil tanks.

8. Anti-corrossive Paint: It consists essentially of oil, a strong dier, lead or zinc chrome and finely ground sand. It is cheap and resists corrossion well. It is black in colour.

PROCESS OF PAINTING DIFFERENT SURFACES:

1. Painting on new wood work

The process of painting on new wood work can be divided into the following stages:

1. **Preparation of surface**: the surface of wood work is prepared to receive the paint. For satisfactory working the woodwork should be sufficiently seasoned and the Moisture content of timber must be less than 15% of their dry weight. The surface of woodwork should be thoroughly cleaned and heads of nails are punched to a depth of 3mm below the surface.
2. **Knotting**
3. **Priming**: Pores get filled and opaque covering formed over the whole surface.
4. **Stopping**: Surface is rubbed with pumic stone
5. **Surface coats or under coatings**
6. **Finishing coat**

Each coat applied only after previous coat has dried completely

2. Repainting on old wood work

Old paint should be completely removed

Removing old paint

1. Equal parts of washing soda and quick lime- mixture is brought to a paste form by adding water
2. It is applied on the surface and kept for one hour, then washed off with water
3. After, wood surface is painted as that for new wood work.

3. Painting new iron and steel work

- Clean the surface by scrapping/brushing with steel wire brushes
- Phosphoric acid is used to remove the scale deposit on surface.
- Prime coat is applied using brush
- Two or more coats with a brush /spray gun
- Each coat applied only after previous coat has dried completely

4. Repainting old iron and steel work

- Before repainting, it should be thoroughly washed with soap water
- If grease is present it may be removed by lime water.
- Remove old paint by flat oxy-acetylene flame over the metal and then scrapped the surface with wire brush.
- Washed with solution of caustic soda and slaked lime.

5. Painting plastered surface

- For newly plastered wall, there is considerable amount of moisture.
- For applying paint wait for at least 3to 6 months.
- Defects in plastered surfaces are to be removed.
- Coats of alkali resistant primer paint should then be applied on the surface.
- Usual paints:- cement paint, silicate paint, emulsion paint

WHITEWASHING

Whitewash or lime paint is a low-cost type of paint made from slaked lime (calcium hydroxide, Ca(OH)2) and chalk (calcium carbonate, (CaCO3), sometimes known as "whiting".

Preparation of White Wash

White wash is prepared from fat lime. The lime is slaked at the site and mixed and stirred with about five liters of water for 1 kg of unslaked lime to make a thin cream. This should be allowed to stand for a period of 24 hours, and then should be screened through a clean coarse cloth. One kg of gum is dissolved in hot water may also be added for every 10 kg of lime. Sometimes, rice is used in the place of gum. The application of sodium chloride (common salt) to lime-wash helps in quick carbonation of calcium hydroxide making the coating hard and rub-resistant. Small quantity of ultra-marine blue (up to 3 gm per kg of lime) may be added to the last two coats of white wash solution.

Preparation of Surface

The new surface should be thoroughly cleaned off all dirt, dust, mortar drops and other foreign matter before white wash is to be applied. Old surfaces already white-washed or colour-washed should be broomed to remove all dust and dirt. All loose scales of lime wash and other foreign matter should be removed. Where heavy scaling has taken place, the entire surface should be scraped clean, any growth of moulds moss should be removed by scrapping with steel scraper and ammonical copper solution consisting of 15 gm of copper carbonate dissolved in 60 ml of liquor ammonia in 500 ml of water, should be applied to the surface and allowed to dry thoroughly before applying white or colour wash.

Application of White Wash

White wash is applied with brush, to the specified number of coats (generally three). The operation in each coat should consist of a stroke of the brush given from top down-wards, another from the bottom upwards over the first before it dries. Each coat should be allowed to dry before the next coat is applied. The white washing on ceiling should be down prior to that on walls.

The lime is toxic for germs. It reflects light and thus it increases the brightness of the surface. The whitewashing therefore is extensively used for interior wall surfaces and ceilings of houses.

The process of whitewashing is sometimes used for exterior wall surfaces also. A satisfactory work gives an opaque smooth surface with uniform white colour and does not readily come off on the hand, when rubbed.

COLOUR WASHING

Colour washing is prepared by adding colouring pigment to the screened white wash. Generally used pigments are yellow earth red ocher and blue vitriol. These are crushed to powder, before mixing. The colour wash is applied in the same fashion as the white wash. For colour washing on new surface, the first primary coat should be of white wash and the subsequent coats should be of colour wash. A satisfactory work does not give out powder when the finished surface is rubbed with the fingers.The process of colour washing imparts cleanliness and pleasant appearance of the surfaces which are treated.

DISTEMPERING

Distempers are also called as water paints. It is prepared by mixing chalk and glue boiled in water. Earthly pigments like ochre, umber, Indian red and lamb black also added to give colour shade to this paint. They are also available in powder or paste form in that case to be mixed with water to form a viscous fluid. Distempers are cheaper than paint and varnish. These paints are used for painting interior walls. The main use of applying distemper to plastered surface is to give a smooth outer surface in low cost. Distemper is porous. It Allows water vapor to escape. It is less durable.

The main object of applying distemper to the plastered surfaces is to create a smooth surface. The distempers are available in the market under different trade names. They are cheaper than paints and varnishes and they a present a neat appearance. They are available in a variety of colours.

Properties of distempers:

Following are the properties of distempers:

- On drying, the film of distemper shrinks. Hence it leads to cracking and flaking, if the surface to receive distemper is weak.
- The coatings of distemper are usually thick and they are more brittle than other types of water paints.
- The film developed by distemper is porous in character and it allows water vapour to pass through it. Hence it permits new walls to dry out without damaging the distemper film.
- They are generally light I colour and they provide a good reflective coating.
- They are less durable than oil paints.
- They are treated as water paints and they are easy to apply.
- They can be applied on brickwork, cement plastered surface, lime plastered surface, insulating boards, etc.
- They exhibit poor workability.

- They prove to be unsatisfactory n damp locations such as kitchen, bathroom, etc.

Ingredients of a distemper:

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

The distempers are available I powder form or paste form. They are to be mixed with hot water before use. The oil-bound distempers are a variety of an oil paint in which the drying oil is so treated that it mixes with water. The emulsifying agent which is commonly used is glue or casein. As the water dries, the oil makes a hard surface which is washable. It should be remembered that most of the manufacturers of readymade distempers supply completely directions for use of their products. These directions are to be strictly followed to achieve good results.

Process of distempering:

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

Preparation of surface: The surface to receive the distemper is thoroughly rubbed and cleaned

Preparation of New Surface

- Newly plastered surfaces are allowed to dry for at least two months before the application of distemper.
- The surface is brushed thoroughly to make it free from mortar droppings.
- Then the sand paper is rubbed to make the surface smooth.

Preparation of Old Surface

- All loose pieces and scales are removed by sand papering.
- The surface is cleaned of all grease, dirt, etc
- Holes in plaster are filled in with Plaster of Paris mixed with color.
- Then the surface is rubbed down again with fine grade sand paper to make it smooth.
- A coat of distemper is applied on patches.
- The patched surface is allowed to dry thoroughly before applying regular coat of distemper.

Priming Coat

A priming coat of approved primer is applied over prepared surface in case of new work. No white washing coat is used as priming coat for distemper. The treated surface is allowed to dry before applying distemper coat.

Application on New Construction

After the application of primary coat two or more coat of distemper should be applied till the surface shows an even color.

Application on Old Work

One or more coats of distemper should be applied on the surface till the surface attains an even color.

Procedure of Application

- The entire surface should be coated with proper distemper brushes in horizontal strokes uniformly followed by vertical ones immediately.
- The subsequent coats should be applied only after the previous coats are dried.
- The finished surface should be even and uniform showing no brush marks.
- Enough distemper should be mixed to finish one room at a time.
- After a days work the brushes should be washed in hot water and hung down to dry.
- Old and dirty brushes with distemper should not be used.

Precautions during Distempering

- Doors, windows, floors and electrical items should be protected from the splashes of distemper.
- If any drops of distemper fall on any articles, these should be cleaned immediately.
- After distempering care should be taken that the surface is not destroyed by touching with any dirty materials.

DAMP PROOF COURSE (DPC)

Properties of Materials for DPC

An effective damp proofing material should have the following properties;

- It should be impervious.
- It should be strong and durable, and should be capable of withstanding both dead as well as live loads without damage.
- It should be dimensionally stable.
- It should be free from deliquescent salts like sulphates, chlorides and nitrates.

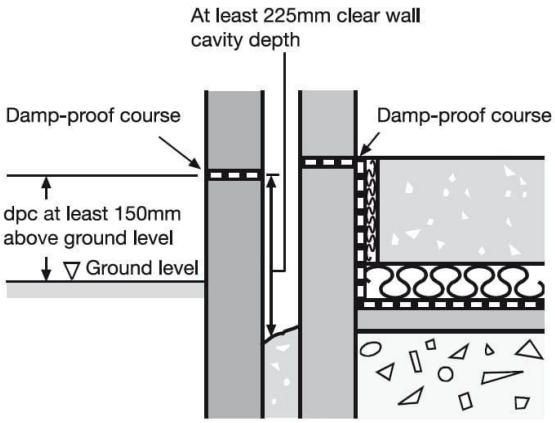
Types of Materials for Damp Proof Course

The materials commonly used to check dampness can be divided into the following three categories:

- Flexible Materials: Materials like bitumen felts (which may be hessian based or fiber/glass fiber based), plastic sheeting (polythene sheets) etc.
- Semi-rigid Materials: Materials like mastic, asphalt, or combination of materials or layers.
- Rigid Materials: Materials like first class bricks, stones, slate, cement concrete etc.

Selection of Materials for Damp Proof Course in Buildings

The choice of material to function as an effective damp proof course requires a judicious selection. It depends upon the climate and atmospheric conditions, nature of structure and the situation where DPC is to be provided



The points to be kept in view while making selection of DPC materials are briefly discussed below:

1. DPC above ground level

For DPC above ground level with wall thickness generally not exceeding 40 cm, any one of the type of materials mentioned above may be used. Cement concrete is however commonly adopted material for DPC at plinth level, 38 to 50mm thick layer of cement concrete M15 (1:2:4 mix) serves the purpose under normal conditions.

In case of damp and humid atmosphere, richer mix of concrete should be used. The concrete is further made dense by adding water proofing materials like Pudlo, Impermo, Waterlock etc. in its ingredients during the process of mixing. It is used to apply two coats of hot bitumen over the third surface of the

concrete DPC.

2. DPC Material for floors, roofs etc.

For greater wall thickness or where DPC is to be laid over large areas such as floors, roofs, etc., the choice is limited to flexible materials which provide lesser number of joints like mastic, asphalt, bitumen felts, plastic sheets etc.

The felts when used should be properly bonded to the surface with bitumen and laid with joints properly lapped and sealed.

3. DPC Material for situations where differential thermal movements occur

In parapet walls and other such situations, materials like mastic, asphalt, bitumen felts and metal (copper or lead) are recommended.

It is important to ensure that the DPC material is flexible so as to avoid any damage or puncture of the material due to differential thermal movement between the material of the roof and the parapet.

4. DPC material for Cavity Walls

In cavity wall construction, like cavity over the door or window should be bridged by flexible material like bitumen felt, strips or lead etc.

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

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

METHODS OF PROVIDING DPC

1. Membrane damp proofing

In this method of damp proofing a water repellent membrane or damp proof course(D.P.C.) is introduced in between the source of dampness and the part of building adjacent to it. Damp proofing course may consist of flexible materials such as bitumen, mastic asphalt, bituminous felts, plastic or polythene sheets, metal sheets, cement concrete. Damp proofing course may be provided either horizontally or vertically in floors, walls etc. Provision of Damp Proofing Course in basement is normally termed as 'Tanking'. The general principles to be followed while providing damp proof course are:

- The damp proofing course should cover the full thickness of walls, excluding rendering.
- The mortar bed supporting damp proof course should be leveled and even, and should be free from projections, so that damp proof course is not damaged.
- Damp proof course should be laid in such a way that a continuous projection is provided.
- At junctions and corners of walls, the horizontal damp proof course should be laid continuous.
- When a horizontal damp proof course (i.e. that of a floor) is continued to a vertical face, a cement concrete fillet of 7.5 cm radius should be provided at the junction.
- Each damp proof course should be placed in correct relation to other damp proof course, so as to ensure a complete and continuous barrier to the passage of water from floors, walls or roof.
- Damp proof course should not be kept exposed on the wall surface otherwise it may get damaged during finishing work.

2.* Integral damp *proofing

In the integral damp proofing method certain water proofing compounds are added to the concrete mix, so that it becomes impermeable. The common water proofing compounds may be in the following three forms.

- Compounds made from chalk, talc, fullers earth, which may fill the voids of concrete under the mechanical action principle.
- Compounds like alkaline silicates, aluminum sulphate, calcium chlorides, etc. which react chemically with concrete to produce water proof concrete.
- Compounds like soap, petroleum, oils, fatty acid compounds such as stearates of calcium, sodium, ammonia etc. work on water repulsion principle. When these are mixed with concrete, the concrete becomes water repellent.
- Commercially available compounds like Publo, Permo, and Silka etc.

The quantity of water proofing compound to be added to cement depends upon the manufacturer's

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

***3.* Surface treatment**

Moisture finds its way through the pores of material used in finishing. In order to check the entry of the moisture into the pores, they must be filled up. In the surface treatment method a layer of water repellent substances or compounds are applied on these surfaces through which moisture enters. The use of water repellent metallic soaps such as calcium and aluminum oletes and stearates are much effective against rain water penetration. Pointing and plastering of the exposed surfaces must be done carefully, using water proofing agents like sodium or potassium silicates, aluminum or zinc sulphates, barium hydroxide and magnesium sulphates etc. Surface treatment is effective only when the moisture is superficial and is not under pressure. Sometimes, exposed stone or brick wall face may be sprayed with water repellent solutions. The walls plastered with cement, lime and sand mixed in proportions of 1:1:6 is found to serve the purpose of preventing dampness in wall due to rain effectively.

***4.* Cavity wall construction**

Cavity wall construction is an effective method of damp prevention. In this method the main wall of a building is shielded by an outer skin wall, leaving a cavity between the two. The cavity prevents the moisture from travelling from the outer to the inner wall

5. GUNITING

In this method of damp proofing, an impervious layer of rich cement mortar is deposited under pressure over the exposed surfaces for water proofing or over pipes, cisterns etc. for resisting the water pressure. The operation is carried out by use of a machine known as cement gun. The cement gun consists of a machine having arrangements for mixing materials and a compressor for forcing the mixture under pressure through a 50 mm dia flexible hose pipe. The hose pipe has nozzle at its free end to which water is supplied under pressure through a separate connection.The surface to be treated is first thoroughly cleaned of dirt, dust, grease or loose particles and wetted properly. Cement mortar consists of 1: 3 cement sand mix, is shot on the cleaned surface with the help of a cement gun, under a pressure of 2 to 3 kg/cm2. The nozzle of the machine is kept at a distance about 75 to 90 cm from the surface to be gunited. The mortar mix of desired consistency and thickness can be deposited to get an impervious layer. The layer should be properly cured at least for 10 days. Since the material is applied under pressure, it ensures dense compaction and better adhesion of the rich cement mortar and hence the treated surface becomes water proof.

6 .Pressure grouting

This consists of forcing cement grout under pressure, into cracks, voids, fissures and so on present in the structural components of the building, or in the ground. Thus the structural components and the foundations which are liable to moisture penetration are consolidated and are thus made water- penetration-resistant. This method is quite effective in checking the seepage of raised ground water through foundations and sub-structure of a building:

MODULE 1

CONSTRUCTION MATERIALS

1. STONES

Stone is a 'naturally available building material' which has been used from the early age of civilization. It is available in the form of rocks, which is cut to required size and shape and used as building block. It has been used to construct small residential buildings to large palaces and temples all over the world. Red Fort, Taj Mahal, Vidhan Sabha at Bangalore and several palaces of medieval age all over India are the famous stone buildings.

1.1 TYPE OF STONES

Stones used for civil engineering works may be classified in the following three ways:

1. **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.

(*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, mudstones, shale, kankar, chalk 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 greisses, trap and basalt change to schist and laterite, lime stone changes to marble, sand stone becomes quartzite and mud stone becomes slate.

2. **Physical Classification**

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

(*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.

3. **Chemical Classification**

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

(*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 argil *i.e.*, clay. These stones are hard and durable but they are brittle. They cannot withstand shock. Slates and laterites are examples of this type of rocks.

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

1.2 QUALITIES OF GOOD BUILDING STONES

In selecting a stone for engineering work .the following characteristics should be looked into.

(*i*) **Strength:** The stone should be able to resist the load coming on it. Ordinarily this is not of primary concern since all stones are having good strength. But stones of sedimentary origin have low strength. However in case of large structure, it may be necessary to check the strength. It should have a minimum crushing (compressive) strength of 100 N/mm^2. It should be remain unaffected by smoke and atmospheric acids.

(*ii*) **Durability:** Stones selected should be capable of resisting adverse effects of natural forces like wind, rain and heat and should be durable. Stones which have their natural bed perpendicular to direction of pressure are durable. They are acid resistant and have negligible

water absorption.

(*iii*) **Fire resistance:** Stones must be fire resistant and capable of retaining shape when exposed to fire. Limestone resist heat upto 800^0 C. Sandstones also resist fire in a good way. Argillaceous stones highly resist fire ev4en though they are poor in strength.

(*iv*)**Hardness:** The stone used in floors and pavements should be able to resist abrasive forces caused by movement of men and materials over them (scratching).

(*v*) **Toughness:** Building stones should be tough enough to sustain stresses developed due to vibrations (hammering). The vibrations may be due to the machinery mounted over them or due to the loads moving over them. The stone aggregates used in the road constructions should be tough to resist wear and tear.

*(vi)***Weight:** To resist higher compressive force, stones should have high weight. Heavy stones possess compactness and less porosity.

(*vii*) **Specific Gravity:** Heavier variety of stones should be used for the construction of dams, retaining walls, docks and harbours. The specific gravity of good building stone should be greater than 2.7.

(*viii*) **Porosity and Absorption:** Building stone should not be porous. If it is porous rain water enters into the pour and reacts with stone and crumbles it. In higher altitudes, the freezing of water in pores takes place and it results into the disintegration of the stone. It should not absorb more than 0.60 percent of its weight of water after 24 hours of immersion.

(*ix*) **Dressing:** Giving required shape to the stone is called dressing. It should be easy to dress so that the cost of dressing is reduced. However care should be taken that, this is not at the cost of required strength and the durability.

(*x*) **Colour and Appearance:** In case of the stones to be used for face works, where appearance is a primary requirement, its colour and ability to receive polish is an important factor. The surface of a freshly broken stone should be sharp, clean and bright with uniformity of colour and texture. It should have pleasing uniform colour and fine grained compact texture Light coloured stones are preferred as they resist weathering action in a better way. Stones possessing iron oxide should be avoided as it disfigures the stones and brings about disintegration. It should be free from cracks cavities, flaws, decay or patches of soft material.

*(xi)***Compactness:** It should have compact, fine, crystalline and homogeneous structure. Compact stones are able to withstand adverse effects of external agencies effectively.

*(xii)***Seasoning:** It should be seasoned. Good stones should be free from the quarry sap. Laterite stones should not be used for 6 to 12 months after quarrying. They are allowed to get

rid of quarry sap by the action of nature. This process of removing quarry sap is called seasoning.

*(xiii)***Cost:** Cost is an important consideration in selecting a building material. It should be easily obtainable and economical. Proximity of the quarry to building site brings down the cost of transportation and hence the cost of stones comes down. However it may be noted that not a single stone can satisfy all the requirements of a good building stones, since one requirement may contradict another. For example, strength and durability requirement contradicts ease of dressing requirement. Hence it is necessary that site engineer looks into the properties required for the intended work and selects the stone.

1.3 USES OF STONES

Stones are used in the following civil engineering constructions:

1. Stone masonry is used for the construction of foundations, walls, columns and arches.
2. Stones are used for flooring.
3. Stone slabs are used as damp proof courses, lintels and even as roofing materials.
4. Stones with good appearance are used for the face works of buildings and for ornamental works in buildings in the form of mouldings with large projections. Polished marbles and granite are commonly used for face works.
5. Stones are used for paving of roads, footpaths and open spaces round the buildings.
6. Stones are also used in the constructions of piers and abutments of bridges, dams and retaining walls.
7. Crushed stones with graved are used to provide base course for roads. When mixed with tar they form finishing coat.
8. Crushed stones are used in the following works also:
   (a) As a basic inert material in concrete
   (b) For making artificial stones and building blocks
   (c) As railway ballast.

1.4 QUARRYING OF STONES

The process of taking out stones from natural bed is known as *quarrying*. It is the art of extracting stones for engineering purposes from natural rock. The place where exposed surface of good quality natural rocks are abundantly available is known as *quarry.*

1.4.1 Selection of site for quarry:

Following are the point to be kept in mind while selecting site for quarry:

1. Availability or tools, power, materials and labour for the easy and efficient working of quarry.

2. Availability of site for dumping of refuse.
3. Distance of quarry from roads, railways, sea coast etc. for transportation.
4. Drainage of quarry pit
5. Economy in quarrying
6. Facility of carrying and conveying stones from quarry.
7. For quarrying by blasting, absence of permanent structures in the nearby area.
8. Geological data regarding rock forming at the site.
9. Quality of stone available from quarry.
10. Quantity of stone likely to be obtained from quarry.
11. Space availability for installation of machinery, storing of stones and other materials.
12. Enough provision for drainage of rain water.

1.4.2 Methods of quarrying:

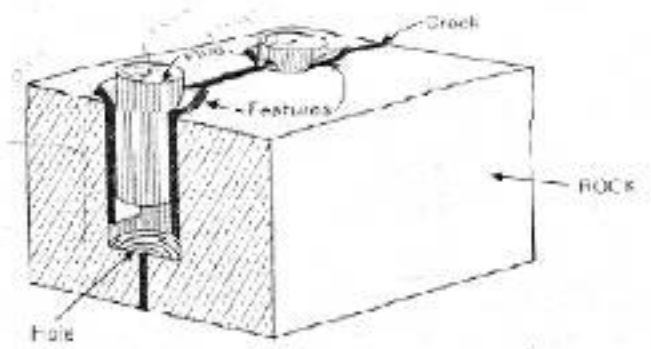
Depending upon the nature of rock and the purpose for which stone is to be used, the process of quarrying can be performed by the following methods.

1. Quarrying by hand tools
2. Quarrying by channelling machine
3. Quarrying by blasting

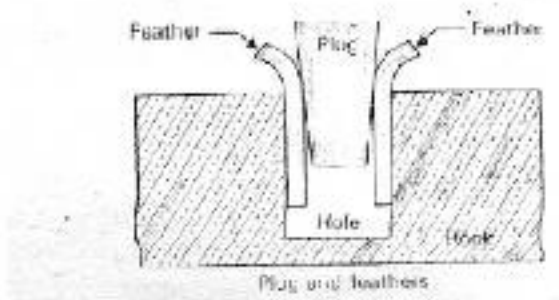
1. Quarrying by digging using hand tools

a. Quarrying by digging/excavating:

In this method, the stones are excavated with the help of pick axes, hammers, showels, chisels etc. This method is useful when soft stones are lying below earth.



b. Quarrying by wedging



In quarrying by wedging, steel wedges or feather and plugs are inserted into natural cracks and driven by hammers. If natural cracks are not available, holes are driven and cracks are made artificially. A number of holes first drilled on the surface of rock in a straight line. The holes are usually 12mm diameter, 15 to 20cm deep and are spaced at 10 to 15cm apart. Steel wedges or feather and plugs are then inserted in each hole. Tops of the plugs are then simultaneously

driven by hammer till the rock cracks along the line of holes. The blocks of stones are shifted by crowbars. This method of quarrying is suitable for sedimentary and soft rocks.

c. **Quarrying by heating**

The top surface of rock is heated continuously for few hours by using firewood or any other fuel. Due to unequal expansion, the upper layer of rock cracks and separates out with bursting sound. The detached portion, of rock is then removed by pick axes, crow bars etc. This method is suitable for rocks formed with horizontal layers. Stones for getting road metals, ballast for railways and aggregate for concrete can be obtained by this method.

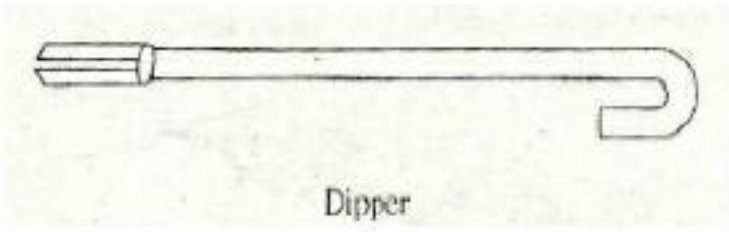
2. **Quarrying by channelling machine**

In this method, channelling machines driven by steam, compressed air or electricity are used. With the help of channelling machines vertical or oblique grooves or channel can be cut to a depth of 2.4 to 3.7m. After the channels are cut around the stone block which is be removed from the rock mass, horizontal holes are drilled beneath the block and the block is then broken loose from its bed by driving wedge in the holes. This method is suitable for quarrying marbles, lime stones, soft sand stones

3. **Quarrying by blasting**

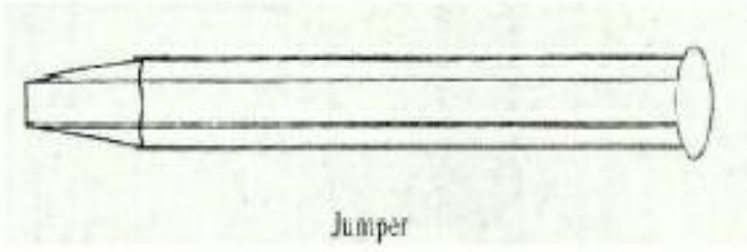
This method is suitable for quarrying hard stone and compact rocks having no cracks or fissures. Blasting consists of splitting, separating or loosening a portion of rock from its mass by use of explosives. This method is also used for splitting larger blocks of stones into stones of smaller sizes. Explosives are kept in holes driven in rocks. Dynamite and gun powder are generally used explosives. The remaining portion of holes above explosives is filled with specially prepared sand. Then a fuse is inserted into hole and other end projecting out for about 15 to 20 cm. Then fuse is fired. Then the stones explode into pieces.

Tools for blasting:



Dipper: It is used to drill a hole to the required depth.

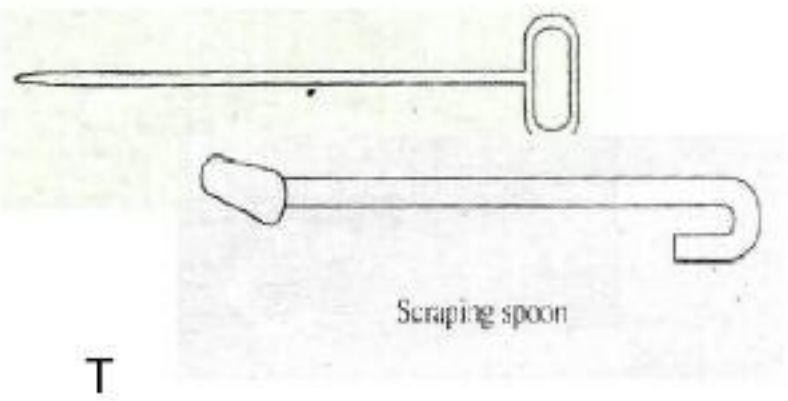
Jumper: It is used to make blast holes.



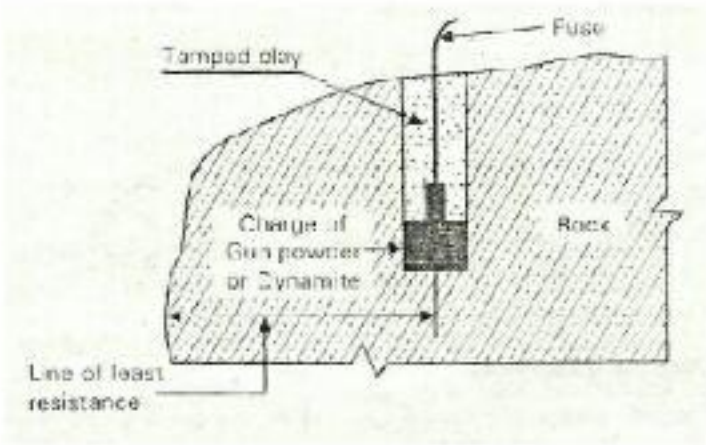
Priming needle: It is in the form or thin copper rod. Used for making a passage for the insertion of fuse to cause explosion in the hole.

Scrapping spoon: It is used to scrap or remove dust of crushed stones from blast holes.

Tamping bar: It is used to tamp the material while refilling blast holes.



1.5 DRESSING OF STONES



The stones after quarrying have rough surface and irregular shape. The process of cutting and converting the stones to regular size and shape and required smooth finish is known as dressing of stones. This may be done at the quarry or the construction site. Stones are dressed for proper bedding, thin joints and speed construction. The stones should be cut and dressed as soon after quarrying as possible because stones when freshly quarried contain some moisture "quarry sap" and in this state they are softer and can be easily dressed.

1.5.1 Advantages of dressing

The following are the advantages of dressing

1. Dressed stones can be transported easily & economically.
2. Dressed stones can be used for stone masonry works, ornamental works.
3. Dressing of stones at quarry site reduces the cost of labour (as it is possible to get cheap labour at quarry site).
4. Dressed stones suit the requirements of stone masonry.

1.5.2Types of dressing

The different types of surface dressing or surface finish of stones are discussed below:

1. **Scabbling dressing**

The dressing in which irregular projections of the stone are removed by means of a scabbling hammer is called scabbling dressing. This is usually done at quarry. The stones thus dressed roughly are called scabbled stones, and the surface finish provided in this way is termed as scabbling finish.

2. **Hammer dressing**

The dressing in which the stones are made roughly square or rectangular by means of a mason's hammer is called hammer dressing. The stone blocks are simply made square to enable the mason to provide proper joints in the masonry work. This has no sharp or irregular

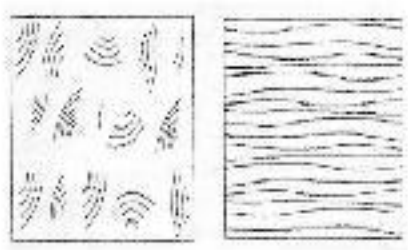
corners.

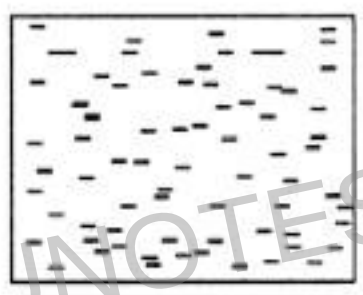
3. **Rough tooled dressing**

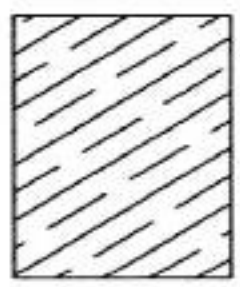
The dressing in which projections from the surface of stone block are removed by means of chisels until no portion of the dressed surface is more than 10mm from a straight edge placed on it is called rough tooled dressing or one line dressing. The stones thus dressed are called rough tooled or one line dressed stones and the surface finish provided in this way is known as rough tooled finish. This type of dressed stones generally used for coursed rubble masonry.

4. **Tooled dressing**

The dressing in which all the projections from the surface of stone blocks are removed by means of chisels until no portion of the surface is more than 3 mm from a straight edge placed on it, is called tooled dressing. Parallel continuous marks either horizontal or inclined or vertical are left on surface. This type of dressed stones used for superior type of coursed rubble masonry.







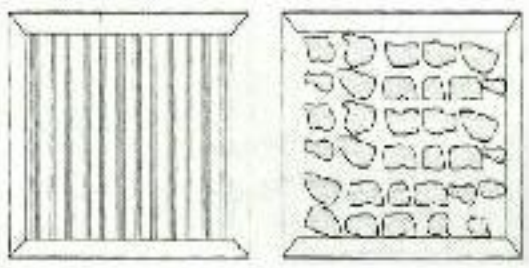
(a)Hammer dressed (b) Tooled (c) Fine tooled (d) rough tooled surface

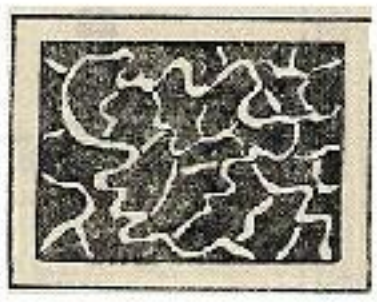
5. **Furrowed finish**

The surface of the exposed face is finished by making a number of vertical and horizontal grooves about 10 mm wide on central portion. 2 cm wide margin is also made around the edges or the exposed face. And central portion is made to project about 15 mm.

6. **Reticulated finish**

In this finishing 2 cm wide margin, chamfered at 45° is marked on the edges and irregular depressions are developed on the enclosed space of the exposed face. A margin of about 10 mm is provided around irregularly shaped sinking, having a depth of about 5 mm. This finish looks like a net- like appearance. A pointed tool is used to put the marks.





Furrowed Reticulated finish Vermiculated finish

7. **Vermiculated finish**

This finish appears just like worm eaten surface. It is similar to reticulated finish except that depressions in this surfacing are more curved and good looking in appearance.

8. **Finely punched dressing**

The dressing in which all the projections from the surface of a stone block are removed by means of pointed tools or a punch giving a clotted appearance is called finely punched dressing. This type of dressing is usually specified to give architectural appearance to the masonry work.

9. **Cut stone dressing**

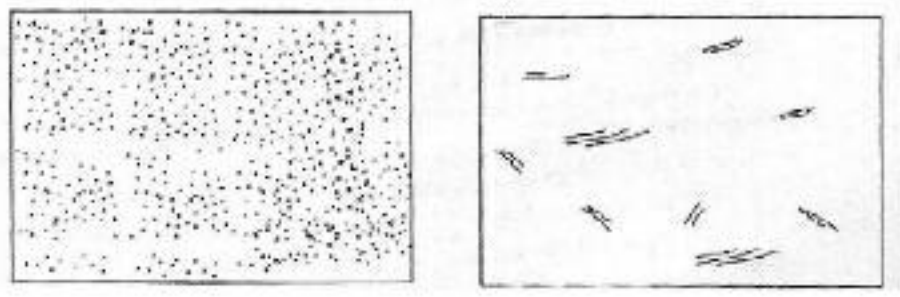
The dressing in which all the projections from all the faces or a stone block are removed by means of a sharp chisel, rend ring the surface free of chisel marks is called cut stone dressing. This type of dressed stones used for ashlar masonry.

10. **Rubbed dressing**

The dressing in which a perfectly smooth surface finish is obtained by grinding or rubbing a cut stone by hand or by machine is called rubbed dressing. This type of dressed stone used for ashlar masonry. Rubbing is accelerated by addition of water and sand.

11. **Polished dressing**

The dressing in which the rubbed stone surfaces are polished by manual labour, using sand and water pumice stone etc. or by means of a rubbing machine is called polished dressing. It is preferred in marbles or granites.



Punched and Polished surface

12. **Plain dressing**

Surface of stone is made approximately smooth using a saw or chisel.

13. **Axed dressing**

Surface of hard stones like granite are dressed by axe.

14. **Boasted finish**

It is also called droved finish. Non continuous parallel marks on stone surface is made using a boaster

15. **Dragged finish**

It is also called combed finish. A piece of steel with a number of teeth called drag or comb is rubbed on surface of stone in all directions. It can be done in soft stones only.

16. **Circular finish**

Surface of stone is made circular is round as in case of column.

1.6 TESTS ON STONES

To determine various engineering properties of stones, the following tests can be conducted:

1.6.1 Field tests

i. Water absorption test

It is a simple test conducted on all stones. It consists of keeping a dry cube of 0.5N (W1) immersed in water for 24 hours. Then remove specimen, wipe off surface water with damp cloth and weigh specimen (W2) to find the absorbed water (W2 −W1). This % should not be more than 0.6 %. This test is also known as electrical resistance test.

Water absorption= [(wet weight-dry weight)/dry weight] x 100

ii. Smith's test

This test is performed to find out the presence of soluble matter in a sample stone. The few pieces of stones are taken and then they are placed in a glass tube filled with water and then stir briskly after an hour. Stone will not be durable if the water becomes dirty.

iii. Toughness test

It is a rough test without any rigid procedure. A stone is hit by a hammer to assess the toughness of the stone. The force required to break the stone reflects the toughness of stone.

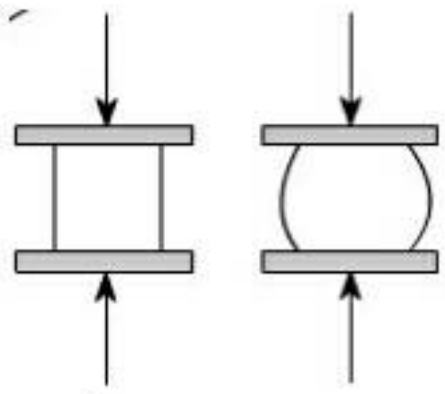
iv. Field hardness test

It is also called Moh's scale of roughness test. It is a simple test in which hardness of test is based on hardness of surface. Surface of stone is scratched with penknife. Hardness is

graded based on relative abrasiveness of minerals. Moh has divided stones to ten scales based on this, the soft being talc and hardest diamond.

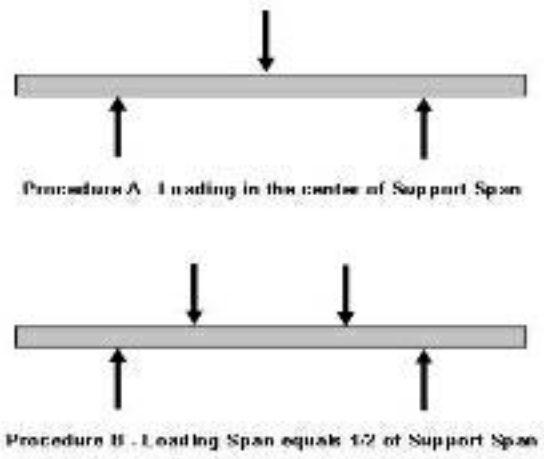
1.6.2 Laboratory tests

(i) Compressive/ Crushing strength test



For conducting this test, specimen of size 40 × 40 × 40 mm is prepared from parent stone. Then the sides are finely dressed and placed in water for 3 days. The saturated specimen is provided with a layer of plaster of Paris on its top and bottom surfaces to get even surface so that load applied is distributed uniformly. Uniform load distribution can be obtained satisfactorily by providing a pair of 5 mm thick plywood instead of using plaster of Paris layer also. The specimen so placed in the compression testing machine is loaded at the rate of 13.72 N/mm^2 per minute. The crushing load or load at breaking is noted. Then crushing strength is equal to the crushing load divided by the area over which the load is applied. At least three specimens should be tested and the average should be taken as crushing strength.

(ii) Flexural strength test



Rectangular test specimens of 20x5x5 cm are cut or drilled out from sample rock. Specimen is placed over two bearers and load is applied through the third bearer placed over test specimen. Load may be applied by a compression testing machine. Load at time of breaking is recorded and transverse strength is obtained using formula. The test is conducted for saturated and dry condition.

(iii)Split tensile strength test

The cylinder test specimens of minimum 50 mm diameter and 100 mm height are cut or drilled out from parent rock. Test is done as split tensile test. Specimen is placed horizontally between the two steel plates top and bottom. Then load is applied on top plate placed on specimen. Load at time of breaking is recorded and split tensile strength is obtained using formula. The test is conducted for saturated and dry condition

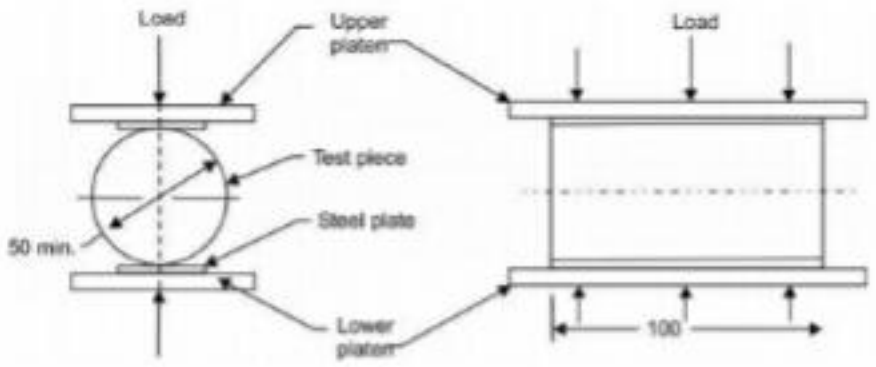
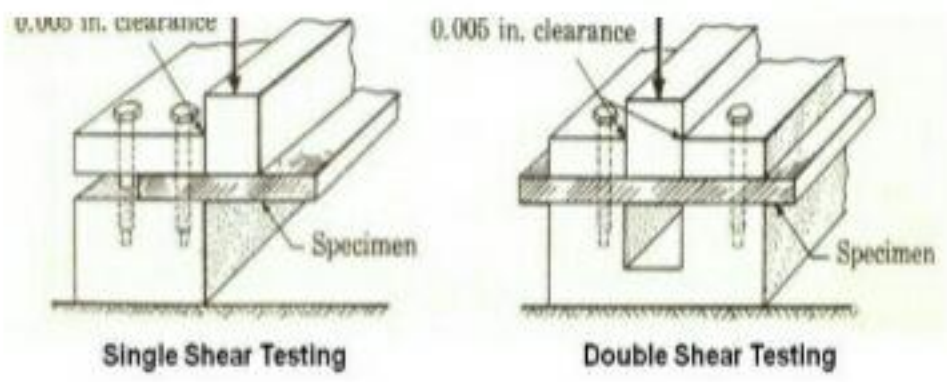


Fig. 2 General Arrangement for Testing Tensile Strength of Building Stone



(iv)Shear strength test

For finding shear strength, rectangular test specimen of minimum 50x50 mm cross section and 180 mm length are cut or drilled out from sample rock. Test is done using Johnsons shear tool. Maximum load is found out and shear strength is obtained by dividing maximum load by two times cross sectional area.

(v) Impact test

The resistance of stones to impact (toughness) is found by conducting tests in impact testing machine. A stone specimen of 25 mm diameter and 25 mm height is placed in the machine. A steel hammer weighing 2 kg is allowed to freely fall on the cylinder from 1 cm height for first blow, 2 cm for second blow and so on. The blow at which specimen breaks is noted, which is the toughness index of stone.

(vi)Attrition test

This test is carried out on stones which are used as aggregates for road construction. The test result indicates the suitability of stones against the grinding action under traffic. Any one of the following test may be conducted to find out the suitability of aggregates (i) Los Angeles abrasion test (ii) Deval abrasion test (iii) Dorry's abrasion test.

a. Los Angeles abrasion

This test is preferred since these test results are having good correlation with the performance of the pavements. The Los Angeles apparatus consists of a hollow cylinder 0.7 m inside diameter and 0.5 m long with both ends closed. It is mounted on a frame so that it can be rotated about horizontal axis. IS code has standardised the test procedure for different gradation of specimen. Along with specified weight of specimen a specified number of cast iron balls of 48 mm diameter are placed in the cylinder. Then the cylinder is rotated at a speed of 30 to 33 rpm for specified number of times (500 to 1000). Then the aggregate is removed and sieved on 1.7 mm. IS sieve. The weight of aggregate passing is found. Percentage weight is the ratio of loss in weight to the initial weight which is expressed in percentage.

Sl. No.	Type of Pavement	Max. permissible abrasion value in %
1	Water bound macadam sub base course	60
2	WBM base course with bituminous surfacing	50
3	Bituminous bound macadam	50

4	WBM surfacing course	40
5	Bituminous penetration macadam	40
6	Bituminous surface dressing, cement concrete surface course	35
7	Bituminous concrete surface course	30

b) Dorry's abrasion test

The Dorry's testing machine is used to determine hardness of stone. A cylindrical stone specimen of diameter 25mrn and height 25mmis taken and placed in machine at pressure of 1.25 kg/mm^2 and machine is rotated in speed of 28rpm. After1000 revolutions, the specimen is taken out and weighed.

Coefficient of hardness =

If coefficient of hardness is greater than 17, it is said to be hard stone. If it is between 14 to 17, the stone is said to be of medium hardness & if it is less than 14 the stone is said to be of poor hardness.

c) Deval's attrition test

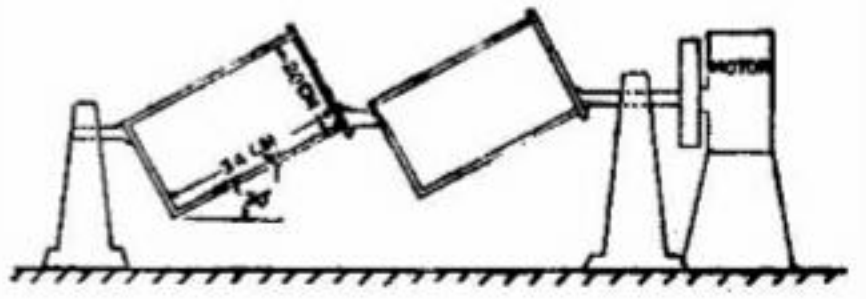


Fig. 6.17 Deval Abrasion Testing Machine

An attrition test is a test is carried out to measure the resistance of a granular material to wear. The machine consists of a rotating frame to support two steel cylinders complete with covers and locking device. These cylinders are mounted on a shaft at an angle of 30 degrees with the axis of rotations of shaft. The shaft rotates at 30 – 33 rpm through a reduction gear operated by motor. The test sample consists of clean aggregates dried in oven at 105° – 110°C. Place the aggregates on the cylinders and fix the cover. Rotate the machine at a speed of 30 – 33 revolutions per minute. The number of revolutions is 10000. The machine is stopped after the desired number of revolutions and material is discharged to a tray. The entire stone dust is sieved on 1.70 mm IS sieve. The material coarser than 1.7mm size is weighed correct to one gram. The weight of aggregate passing is found. Percentage weight is the ratio of loss in weight to the initial weight which is expressed in percentage.

(vii) Acid test

This test is normally carried out on sand stones to check the presence of alkaline or lime (calcium carbonate), which weakens the weather resisting quality. In this test, a sample of stone weighing about 50 to 100 gm is taken and kept in a solution of 1% hydrochloric acid for seven days. The solution is agitated at intervals. A good building stone maintains its sharp edges and keeps its surface intact. If edges are broken and powder is formed on the surface, it indicates the presence of calcium carbonate. Such stones will have poor weather

resistance.

(viii) Crystallization test

This test is performed for assessing the resistance of stone against action of atmospheric agencies like sun, rain, wind, etc. This test is also known as weathering test or brad's test. In this test three 4cmx4cmx4cm size cubes are weighed and then immersed in a 14% solution of sodium sulphate at room temperature and then dried at 100^0C.The dried stone is weighed and the difference in the two weights is recorded. This process or weighing of sample and immersing them in sodium sulphate solution is repeated for about 10 to 15 times. Each time difference in weight is noted. The difference in two readings i.e. initial weight and weight after immersion gives the amount of stone particles which get disintegrated by the action of salt. Presence of visible defects and loss in weight should be minimal for high durability and good weather resistance.

(ix)Freezing and Thawing test

This test is performed to ascertain the frost resisting properties of a stone. In this test, specimen samples of stone are kept immersed in freezing mixture at -12^0C for a Period of 24 hours. The specimen is taken out and kept at ordinary temperature. The visible changes on the surface are then carefully observed. A stone showing no appreciable change even after-being testing, is considered to be durable.

(x) Microscopic test

This test consists in examining thin slice of a stone with a petro logical microscope.

This test is performed to examine

a. The nature of binding material.
b. Average grain size,
c. Nature and kind of mineral present.
d. Sources of weakness, defect
e. Presence of pores, fissures and veins.

1.7 SPECIFICATIONS

Indian Standard specifications for stones are

1. IS 1128- 1974 – Specifications for lime stone slabs.

2. IS 1130- 1969 – Specifications for marble (blocks, slabs and tiles)

1.8 USE OF COMMON BUILDING STONES

The following are some of commonly used stones. Their qualities and uses are explained below:

i. Granite (Igneous rock)

Granites are also igneous rocks. It consists of quartz, felspar and mica. The colour varies from light gray to pink. The structure is crystalline, fine to coarse grained. They take polish well. They are hard durable and highly resistant to natural forces. Specific gravity is from 2.6 to 2.7 and compressive strength is 100 to 250 N/mm^2.Its weight varies from 26 to 27 kN/m.

Uses: They are used primarily for bridge piers, river walls, and for dams. They are used as kerbs and pedestals. The use of granite for monumental and institutional buildings is common. Polished granites are used as table tops, cladding for columns and wall. They are used as coarse aggregates in concrete and as road metal. It is also used in steps, sills, facing work, etc.

ii. Basalt and Trap:

These are igneous rocks which are heavier, darker and stronger than granites. It consists of felspar, augite, olivine and titanic iron. The structure is medium to fine grained and compact. Their colour varies from dark gray to black. Fractures and joints are common. Their weight varies from 18 kN/m3to 29 kN/m3. The compressive strength varies from 200 to 350 N/mm2.

Uses: They are used as road metals, aggregates for concrete and for foundation work. They are also used for rubble masonry works for bridge piers, river walls and dams. They are used as pavement.

iii. Sand stone:

These are sedimentary rocks, and hence stratified. They consist of quartz and feldspar. They are found in various colours like white, grey, red, buff, brown, yellow and even dark gray. The specific gravity varies from 1.85 to 2.7 and compressive strength varies from 20 to 170 N/mm2.Its porosity varies from 5 to 25 per cent. Weathering of rocks renders it unsuitable as building stone.

Uses: It is desirable to use sand stones with silica cement for heavy structures, if necessary. They are used for steps, facing work, columns, flooring, walls, road metal, ornamental carvings, etc.

iv. Slate:

These are metamorphic rocks. They are composed of quartz, mica and clay minerals. The structure is fine grained, hard tough, durable and gives metallic sound when struck. They split along the planes of original bedding easily. The colour varies from dark gray, greenish gray, purple gray to black. They are non-absorbent. The specific gravity is 2.6 to 2.7. Compressive strength varies from 100 to 200 N/mm2.

Uses: They are used as roofing tiles, damp proof courses, insulating material, sills, slabs, pavements etc.

v. Laterite:

It is a sedimentary rock. It consists of sandy clay stone containing high percentage of iron oxide. It is having porous and sponge's structure. Its colour may be brownish, red, yellow, brown and grey. Its specific gravity is 1.85 and compressive strength varies from 1.9 to 2.3 N/mm2. It can be easily quarried in blocks. With seasoning it gains strength. When used as building stone, its outer surface should be plastered

Uses: Building stone, road metal, rough stone masonry work and sometimes used in place of bricks for masonry bonds etc.

vi. Gneiss:

It is a metamorphic rock. It is having fine to coarse grains. Alternative dark and white bands are common. Light grey, pink, purple, greenish gray and dark grey coloured varieties are available. These stones are not preferred because of deleterious constituents present in it. The specific gravity varies from 2.5 to 3.0 and crushing strength varies from 50 to 200 N/mm2.

Uses: They may be used in minor constructions. However, hard varieties may be used for buildings. It is used in street paving, rough masonry work etc.

vii. Quartzite:

Quartzites are metamorphic rocks. It is essentially siliceous sand stone, which has been subjected to metamorphic action. The structure is fine to coarse grained and often granular and branded. They are available in different colours like white, gray, yellowish. Quartz is the chief constituent with feldspar and mica in small quantities. The specific gravity varies from 2.55 to 2.65. Crushing strength varies from 50 to 300 N/mm2.

Uses: They are used as building blocks and slabs. They are also used as aggregates for concrete, retaining walls, road metal, concrete aggregates, pitching, rubble masonry, facing of buildings.

viii. Limestone:

It is a sedimentary rock composed mainly of calcium carbonate. They are not useful as building stones.

Uses: They are used in construction of floors, steps, walls, road metal, manufacture of cement and lime, etc.

ix. **Marble:**

This is a metamorphic rock. It consists of crystallised lime store. It can take good polish. It is available in different pleasing colours like white and pink. It can easily be sawn and carved. Its specific gravity is 2.65 and compressive strength is 70–75 N/mm2.

Uses: It is used for facing and ornamental works. It is used for columns, flooring, steps etc.

x. **Kankar:**

It is a sedimentary rock and is a form of impure limestone.

Uses: It is used as road metal, for manufacture of hydraulic lime etc.

xi. **Murum:**

This is a metamorphic rock. It is a form of decomposed laterite and is deep brown and red in colour. It is a soft rock.

Uses: It is used for fancy paths and garden walls.

2. TIMBER

Timber is one of the oldest materials used in construction. It is not only used in construction, but also it caters other needs of human beings. The timber is used in the raw form in ancient days, but it is treated, converted, preserved and used now. Timber is obtained from trees. Trees are classified into two types. They are,

1. **Exogenous trees:** These trees grow outwards and increase in bulk by forming concentric rings from the centre. These are used for engineering construction. E.g.: Teak, deodar and sal.

These are further classified into

a) **Conifers (soft wood):** Conifers are evergreen trees. These are soft, light and weak.
b) **Deciduous (hardwood):** Deciduous are broad leaf trees. They are hard, heavy, dark colored and durable.