FOUNDATIONS

“A **foundation** is the lowest and supporting layer of a structure”

- It transfer the structural load of building safely into the ground.

FUNCTIONS OF FOUNDATION

1. Distribution of load

- Loads of walls and columns are distributed over a large area of soil such that soil takes that intensity of load safely.

2. Minimising unequal settlement

- Load is distributed uniformly so that foundation settles uniformly.

3. Provides stability

- Foundations provide stability against the action of lateral forces.

4. Provides level surface

- To build plinth and superstructure.

5. Safety

- Safety against undermining by floods or burrowing by animals.

6. Prevention of soil movement

- Prevents movement of soil under building due to water flow or due to expansion of soil.

DEFINITIONS

1. Bearing Capacity of soil

➢It is the ability of soil to support superimposed load without failure or deformation.

2. Ultimate bearing capacity of soil

➢Gross pressure intensity at which soil fails.

3. Safe bearing capacity of soil

➢Maximum pressure which soil can carry without the risk of shear failure.

4. Factor of safety (F.S)

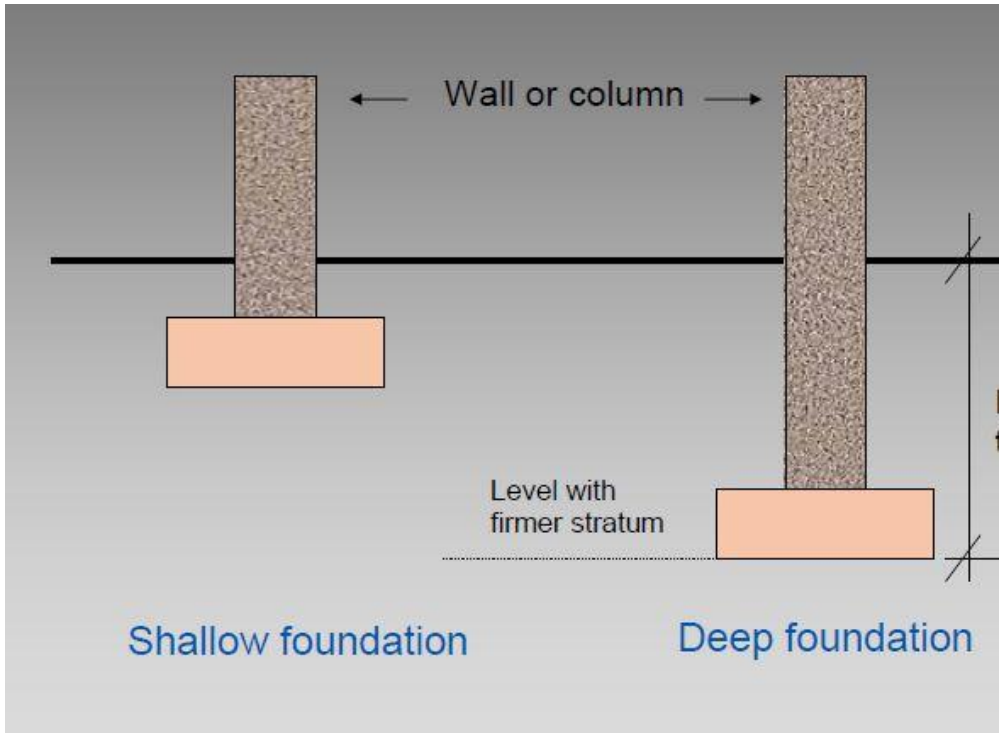
➢It is the ratio of ultimate bearing capacity by safe bearing capacity.

F.S. = Ultimate bearing capacity/Safe bearing capacity

CLASSIFICATION

The foundation can be broadly classified into:

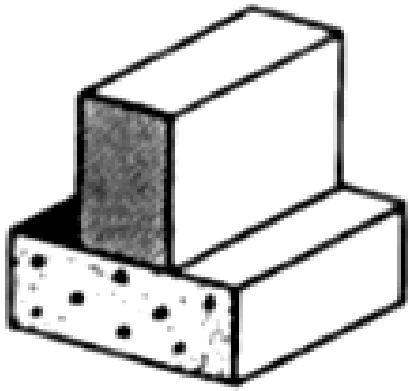
- Shallow foundations - Depth of foundation (D) is less than or equal to width of foundation.(B)
- Deep foundations - Depth of foundation is greater than width of foundation.



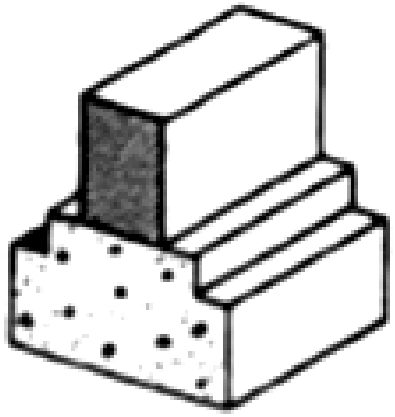
TYPES OF SHALLOW FOUNDATION

1. Wall footing or strip footing

- Footing provided under wall.
- It can be a simple footing or stepped footing.
- Simple footing is provided for light load and have only one foundation block.
- Stepped footing is provided for heavy load and have two or three foundation block.



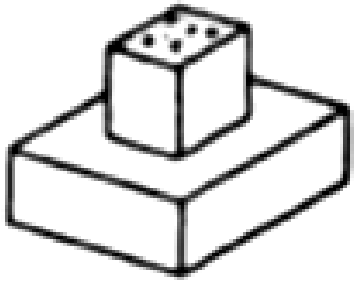
SIMPLE WALL FOOTING



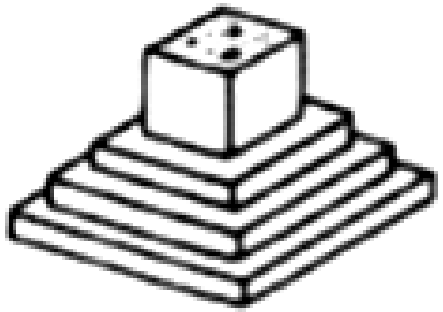
STEPPED WALL FOOTING

2. Isolated or column footing

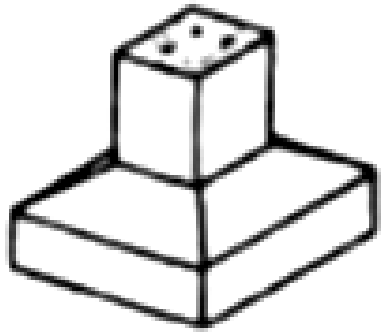
- Used to support isolated column.
- Can be either stepped or sloped footing.
- Reinforced cement concrete footing is provided when column carry heavy load otherwise use plain concrete.
- Thickness depends upon load acting on the column and width of footing.
- If size is very large, stepped footing or sloped footing is provided to reduce the cost of foundation.



SIMPLE COLUMN FOOTING



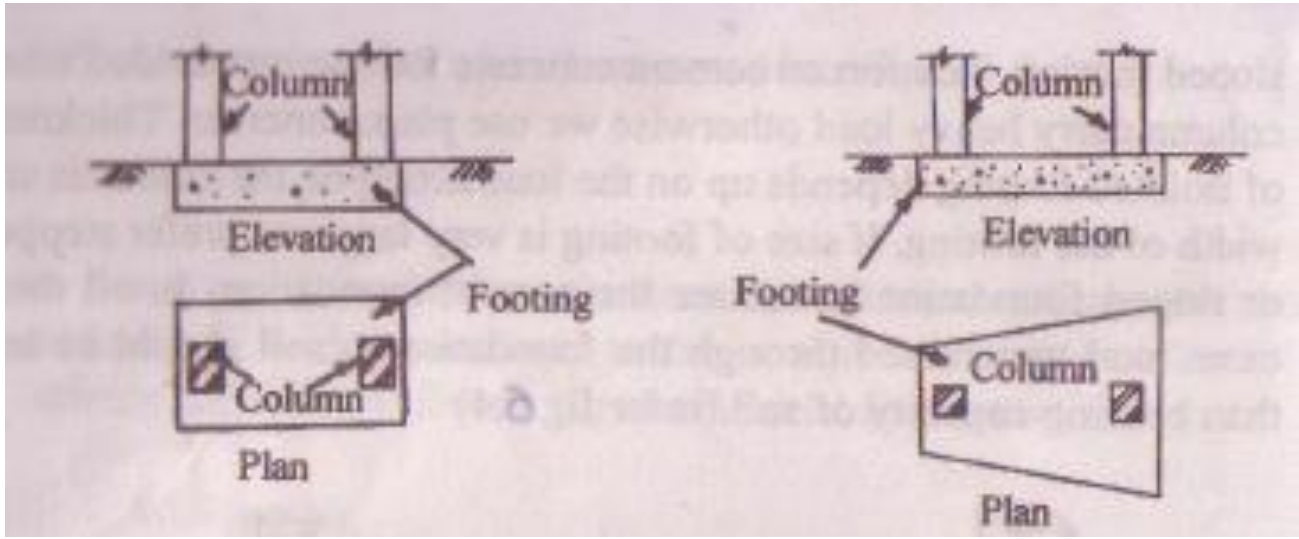
STEPPED COLUMN FOOTING



SLOPED COLUMN FOOTING

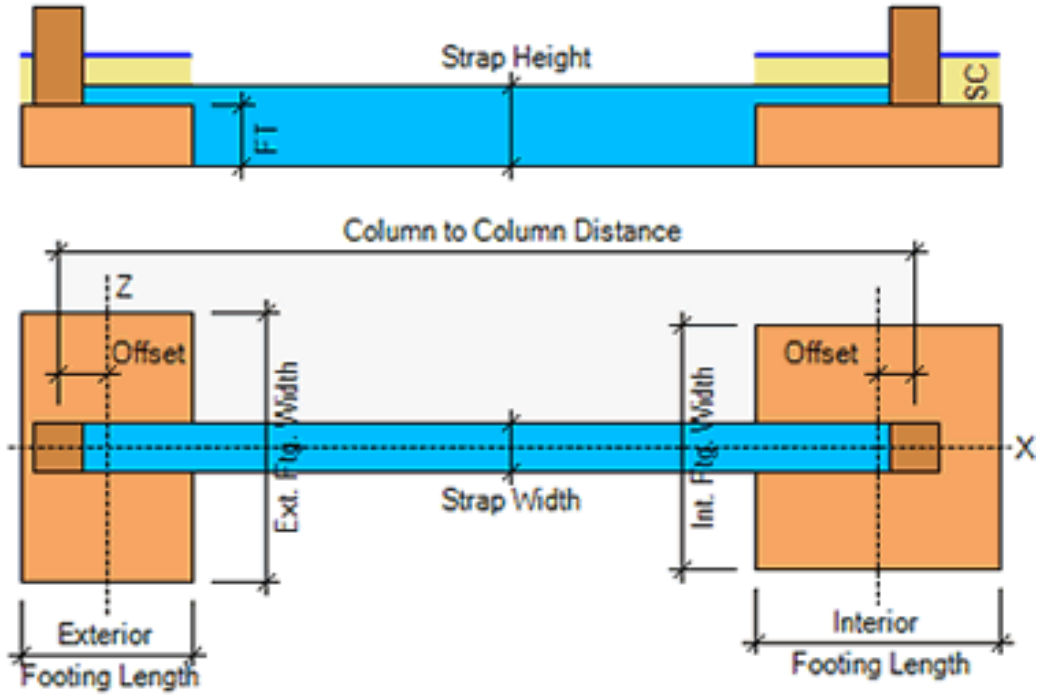
3. Combined footing

- Common footing constructed for two or more column.
- Provided when isolated footings of individual column overlaps or when external column is situated near the boundary.
- Can be rectangular or trapezoidal.
- Rectangular is provided when load acing on columns are almost equal.
- Trapezoidal is provided when 1) Load acting on one of the column is high 2)when one of the column is close to boundary.
- Centre of gravity of footing should coincide with centre of gravity of loads to prevent overturning.



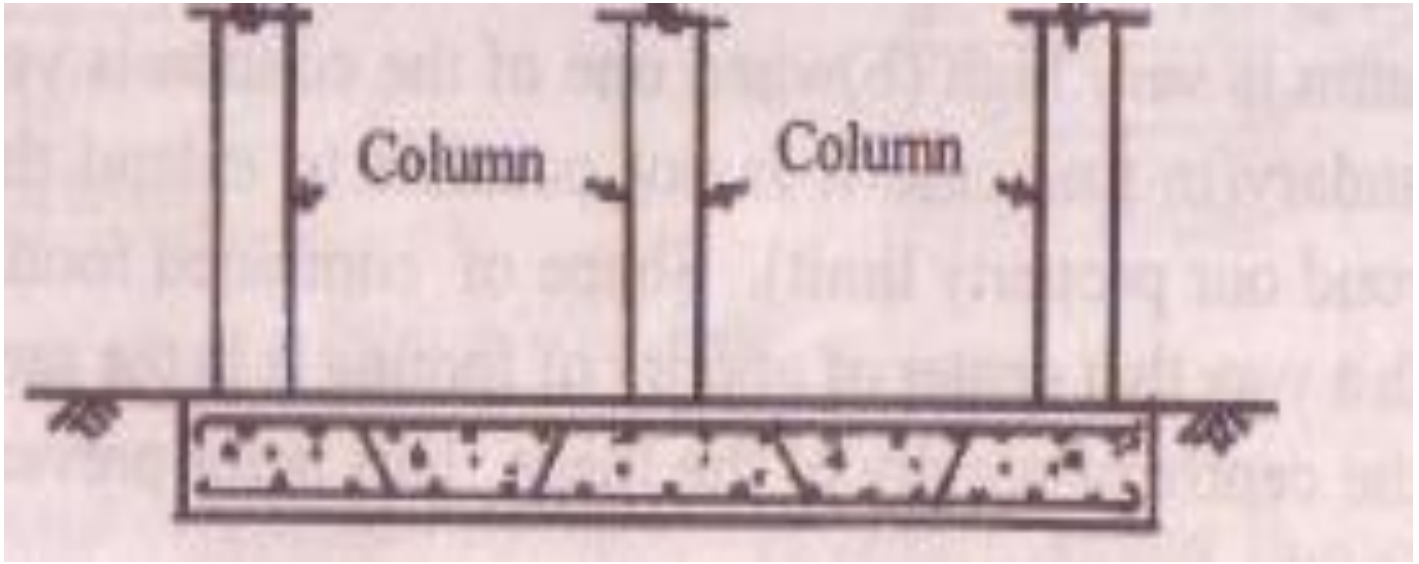
4. Cantilever footing or strap footing

- Used when it is impossible to place a footing directly beneath column due to limitations of land, adjacent building or due to eccentric loading.
- Columns are connected by a cantilever beam or strap beam.
- Load from exterior column is transferred to interior by a strap beam.



5. Continuous footing

- Single continuous reinforced cement concrete slab that acts as a foundation for two or more columns.
- Used when there are two or more columns in one row and footings of individual column overlap.
- It is safe against differential settlement and earthquake.



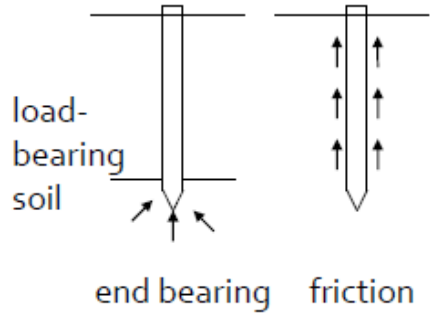
PILE FOUNDATION

- Deep foundation.
- Pile is a long vertical member made up of timber, steel, concrete or R.C.C or a combination of any of these that is used to transfer load.
- Used if heavy load has to be transferred to a soil strata of low bearing capacity

CLASSIFICATION

1) Based on load carrying capacity

- Load bearing pile- carries load
  - End bearing pile
  - Frictional pile



- Non load bearing pile- does not carry load
- If the load bearing pile rests on a hard strata and transfer load to that strata, it is called end bearing pile.
- When loose soil extend to a great depth, piles are driven up to such a depth that friction between pile and surrounding soil will resist the load, such piles are called friction piles.

2) Based on material used

a. Wooden pile
b. Concrete pile → Pre cast concrete piles
c. Steel pile → Cast in situ piles
d. Prestressed concrete pile

Precast concrete piles

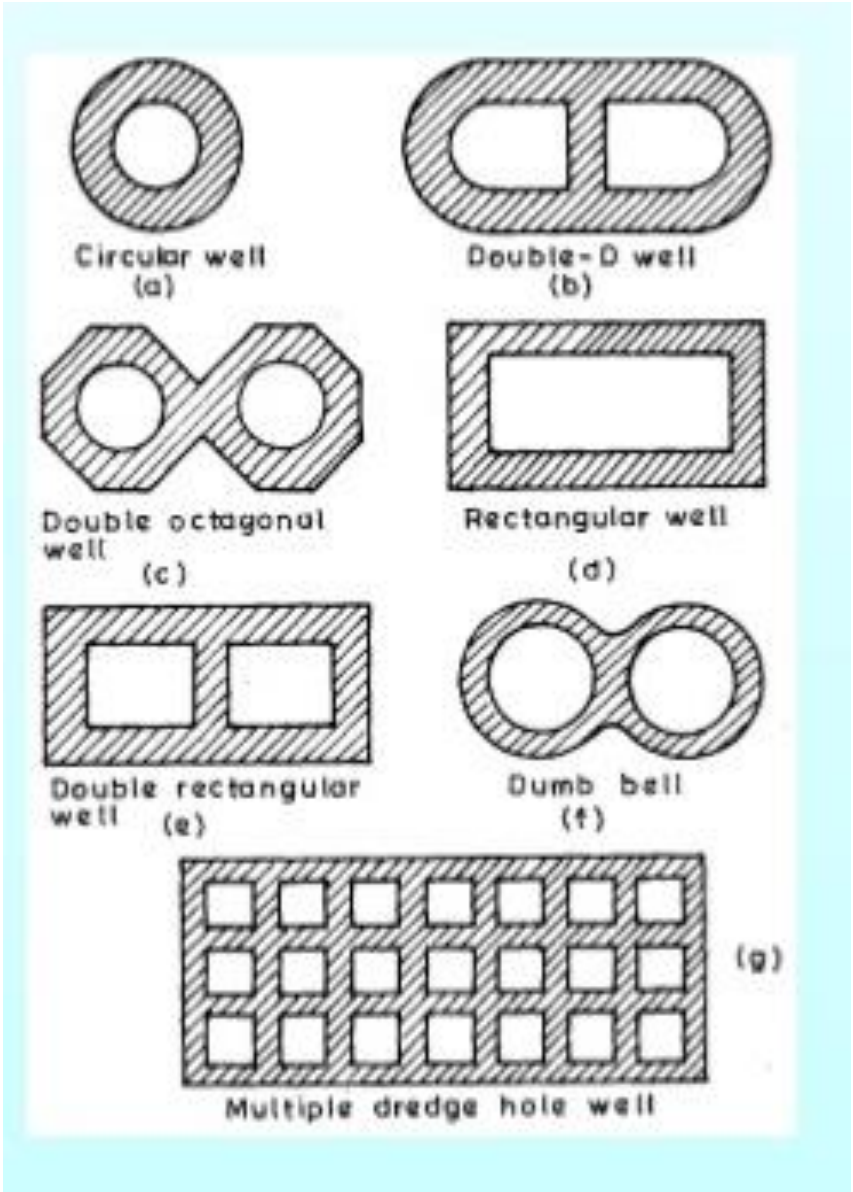
- Cast in a yard, cured and then driven into ground.
- Commonly of square section with chamfered corners.
- Concrete mix generally used is 1:2:4 or 1:1½:3
- Diameter varies from 25 cm to 60 cm.
- Length of pile varies from 3 m to 30 m.
- For driving piles, cast iron or mild steel shoes are provided at lower end.

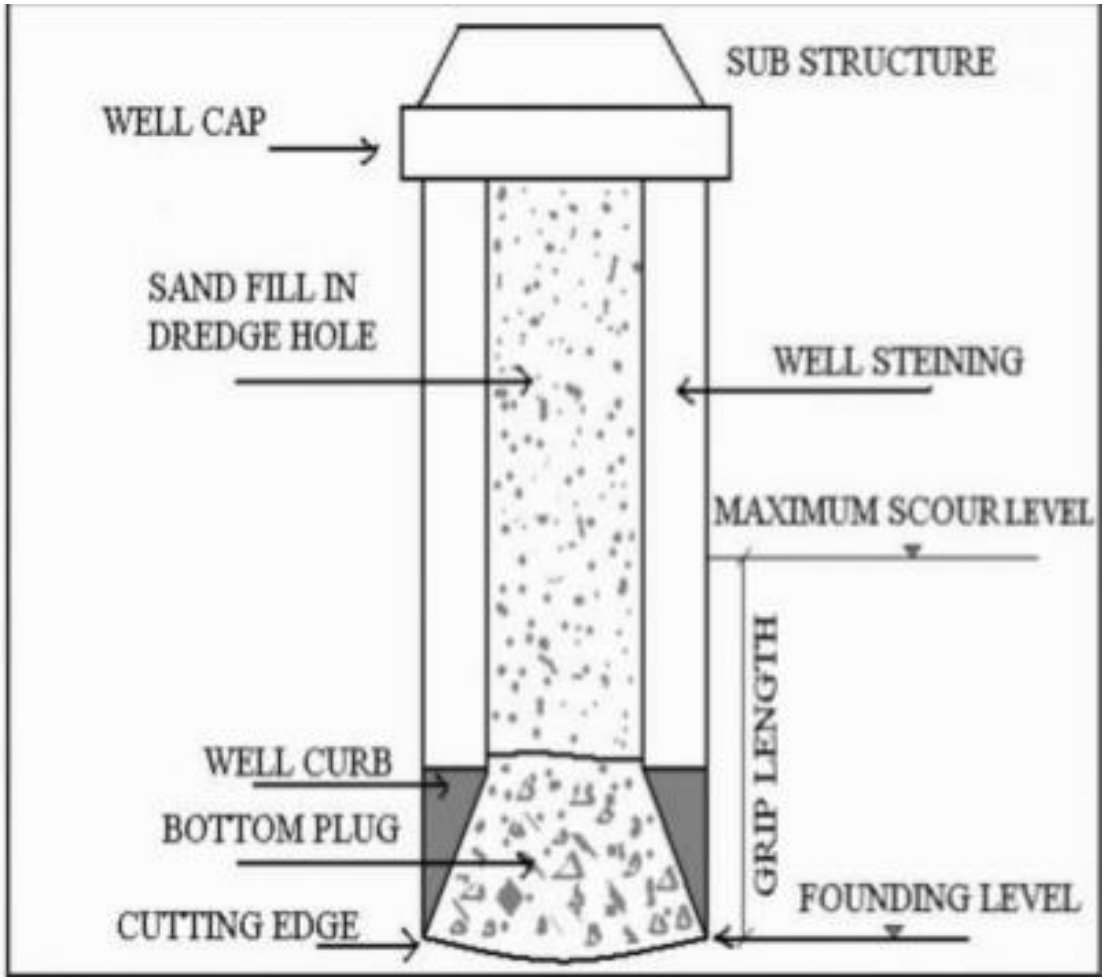
Cast in situ piles

- Cast at the place where they have to function by driving a casing into an excavated hole and filling up this casing with concrete.
- If the casing is kept in position after placing the concrete, it is called cased cast in situ piles.
- If the casing is withdrawn after placing concrete, it is called uncased cast in situ piles.

WELL FOUNDATION

- It is a deep foundation.
- Used to transfer heavy load to deep strata in river or sea bed for bridges, transmission towers and harbour structures.
- Well have different shapes and accordingly they are classified as circular wells, dumb bell, double-D well, double octagonal well, single and double rectangular well and multiple dredged hole well.


Circular well
(a)
Double-D well
(b)
Double octagonal well
(c)
Rectangular well
(d)
Double rectangular well
(e)
Dumb bell
(f)
(g)
Multiple dredge hole well


SUB STRUCTURE
WELL CAP
SAND FILL IN DREDGE HOLE
WELL STEINING
MAXIMUM SCOUR LEVEL
GRIP LENGTH
WELL CURB
BOTTOM PLUG
CUTTING EDGE
FOUNDING LEVEL

Components of well foundation are

1. Well cap

- It is an R.C.C. slab laid on top of well steining and it is cast monolithically with steining.
- It transmits load of superstructure to steining.

2. Steining

- It is the main body of well which transfers load to sub soil.
- Provides weight for sinking of structure.

3. Curb

- Lower wedge shaped portion of well steining.
- Facilitates the process of sinking.

4. Cutting edge

- Lower most portion of well curb.
- It cuts into soil during sinking.

5. Bottom plug

- After the well is sunk to the required depth, base of the well is plugged with concrete, which is called bottom plug.
- Transmits load to sub soil.

6. Dredge hole

- Well is sunk by excavating soil from within the well. Hole formed due to excavation is called dredge hole, which is later filled with sand.
- This helps in distributing load of superstructure to bottom plug.

Based on method of load transfer, buildings are divided into load bearing masonry and framed buildings.

Load bearing masonry	Framed building
Load from roof and floors is transferred to foundation by walls.	Load from roof and walls is transferred by columns or footings.
Walls need foundation throughout their run.	Footings are required on columns only. Walls may be built on beams or floors.
Plan for different floors remain the same.	Plan for different floor may be different.
Thickness of walls should be at least 200 mm.	Only exterior walls are 200 mm thick. Others can be 100 mm thick
Walls should not be dismantled for alternation.	Walls may be dismantled for alteration.
Suited for residential one or two storey building.	Suitable for multi-storey buildings

BRICK MASONRY

- Art of building structures using brick and mortar.

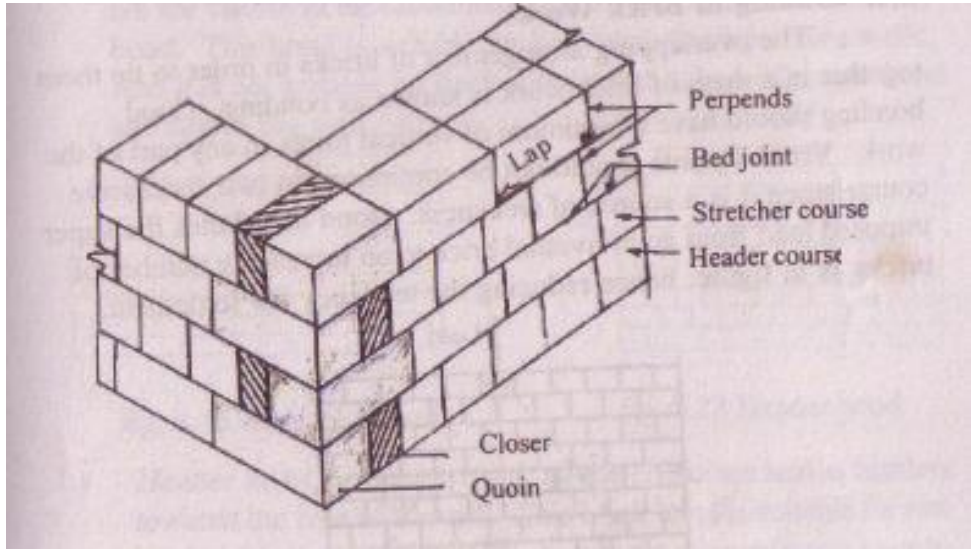
TERMINOLOGY

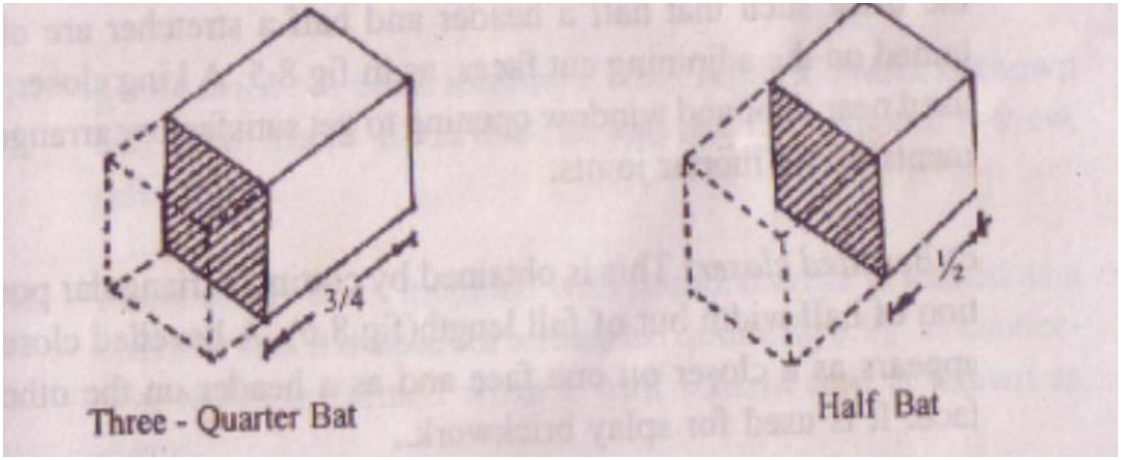
Stretcher

- It is a brick with its longer face (19×9 cm) in the direction of the wall.

Header

- It is a brick with its shorter face (9×9 cm) in the direction of the wall.





Bed

- It is the lower portion of brick when laid flat.

Lap

- It is the horizontal distance between vertical joints in the alternate courses.

Perpends

- It is an imaginary line passing through the vertical joints in the alternate courses.

Quoin brick

- A brick forming a corner in brick work.

Bat

- It is the portion of brick cut across the width.
- Length of brick may be half or three quarter of the original length, accordingly they may be called ½ bat and ¾ bat.

Closer

- It is the portion of brick cut along its length. Various types are

a. Queen closer

- It is a half brick cut longitudinally.

b. King closer

➢It is obtained by cutting a triangular portion of the brick such that half a header and half a stretcher are obtained on the adjoining cut faces.

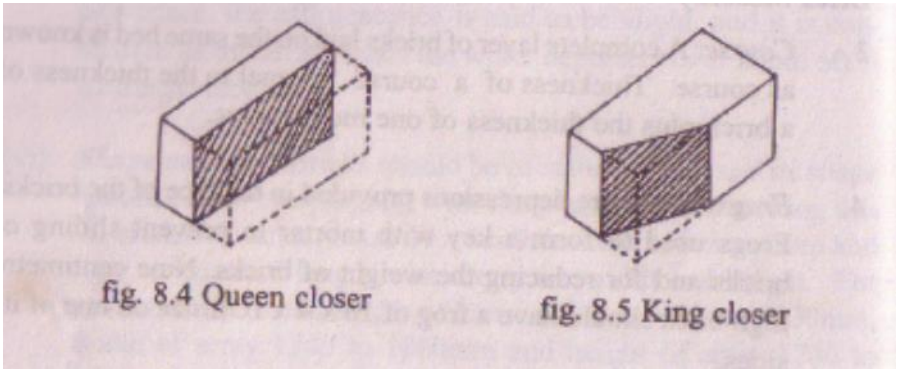
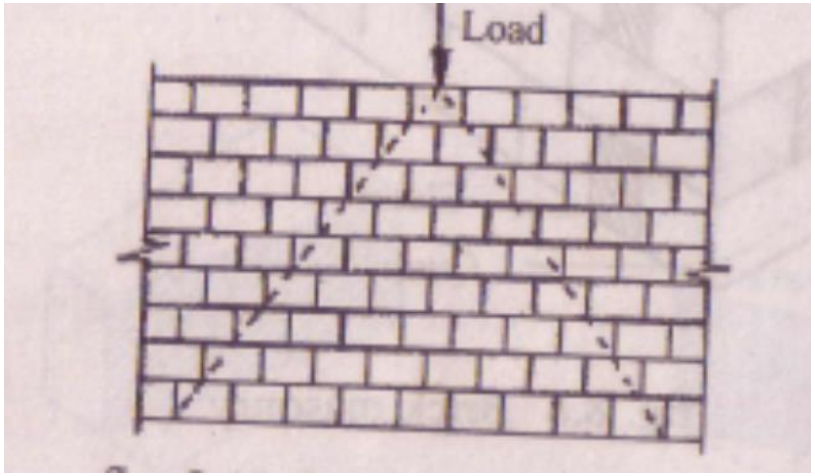


fig. 8.4 Queen closer

fig. 8.5 King closer



BONDS IN BRICK MASONRY

➢The overlapping arrangement of bricks in order to tie them together in a mass of brick work is called bonding. For good bonding

a) Vertical joints should be minimum.

b) Vertical joints are broken so as to ensure distribution of load on lower courses.

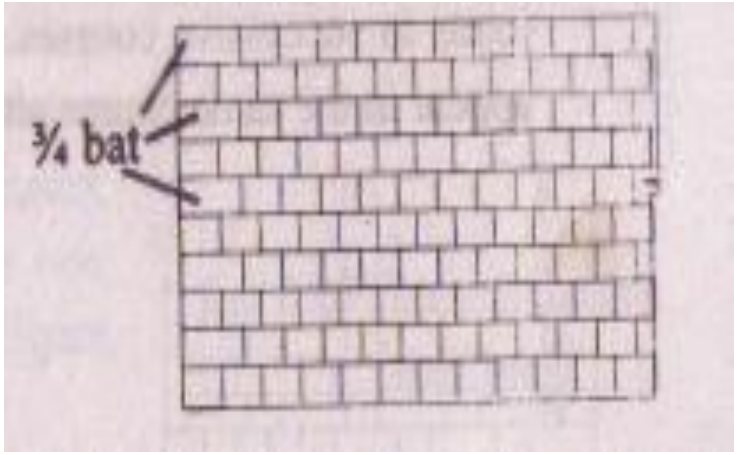
TYPES OF BONDS

1. STRETCHER BOND

- All bricks are arranged in stretcher courses.
- Care should be taken to break vertical joints by using ½ brick bats.
- Used for construction of partition walls that are half brick thick.

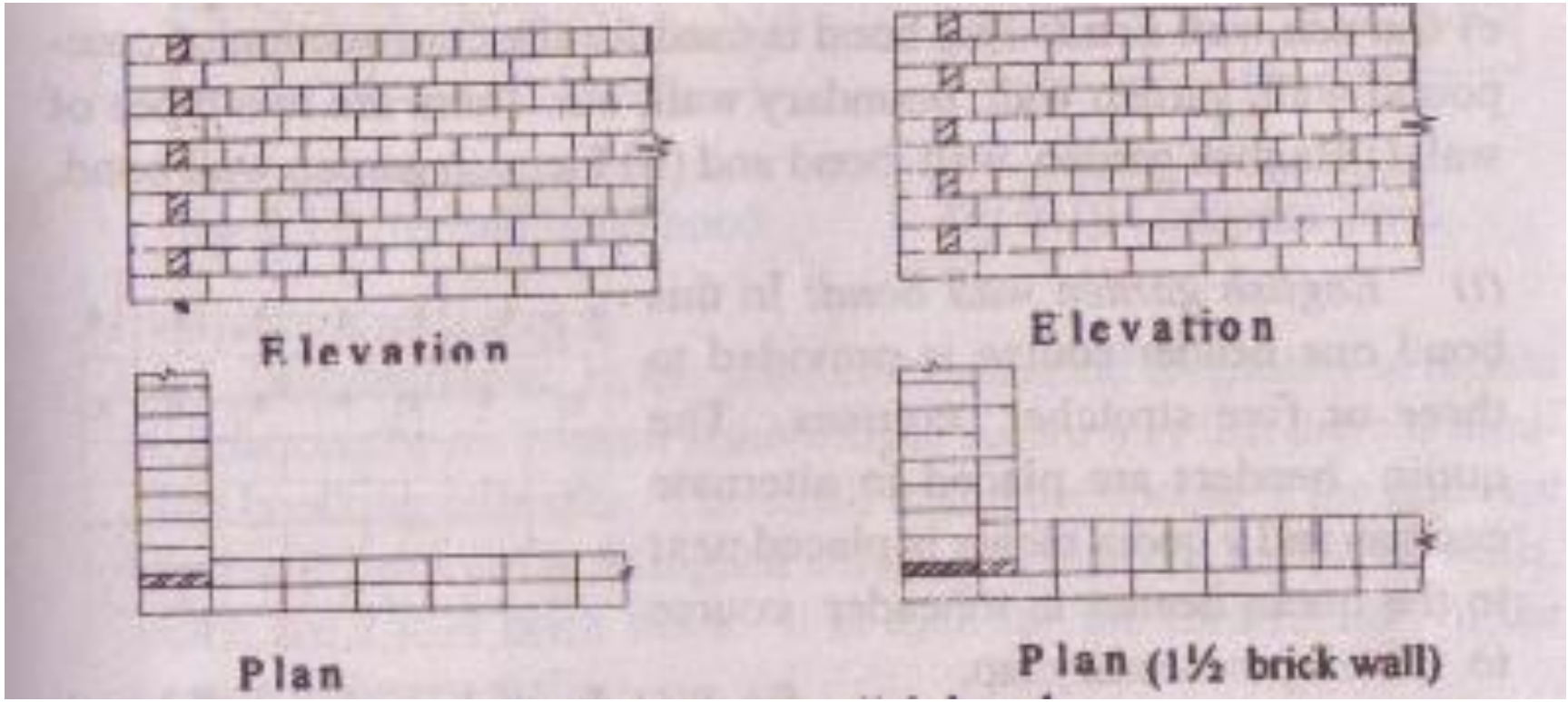
2. HEADER BOND

- All bricks are arranged in header courses.
- Used for construction of walls that are one brick thick.



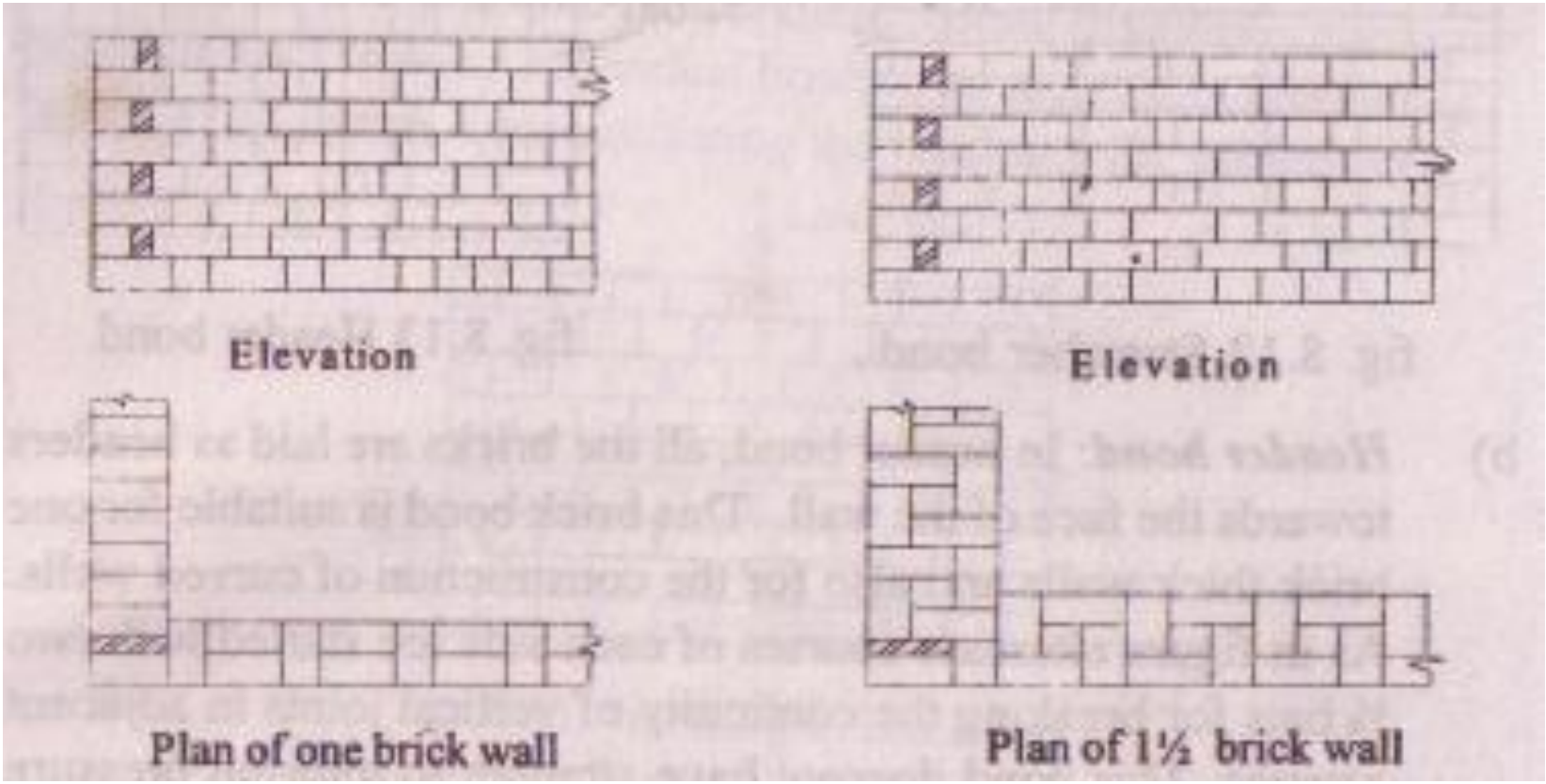
3. ENGLISH BOND

- Bricks are arranged in alternate courses of headers and stretchers.
- Strongest bond that is commonly used for walls of all thickness.
- Queen closer is used at the beginning and end of a wall after the header to break continuity of vertical joints.



4. FLEMISH BOND

- Bricks are arranged alternatively as header and stretcher in one course.
- Header in any course is centrally supported over a stretcher below it.
- Queen closer is used at the beginning and end of a wall after the header to break continuity of vertical joints.



COMPARISON (ENGLISH AND FLEMISH BOND)

1. English bond is found to possess more strength than Flemish bond for walls having thickness greater than 1½ bricks.
2. Flemish bond gives better appearance than English bond, but it is not so strong as English bond.
3. It is possible to use broken bricks in the form of brick bats in case of Flemish bond.
4. Construction of Flemish bond requires skilled labour.

RANDOM RUBBLE MASONRY

- Stones of irregular shapes are used.
- Thickness of mortar joint should be less than 12 mm.
- Face stones are chisel dressed.
- Can be used for residential buildings, compound walls, garages.

i. Coursed random rubble masonry

- Stones are laid to some what level courses.
- In each course, headers of full course height are placed at certain intervals.
- Header has a width not less than its height and project into the wall atleast three times its height.

ii. Uncoursed random rubble masonry

- Built without dressing.
- Stones are of different shape and mason selects the stone at random from heap and place them to form a strong bond.
- Large stones are placed at corners.
- Affords a very high rough appearance.

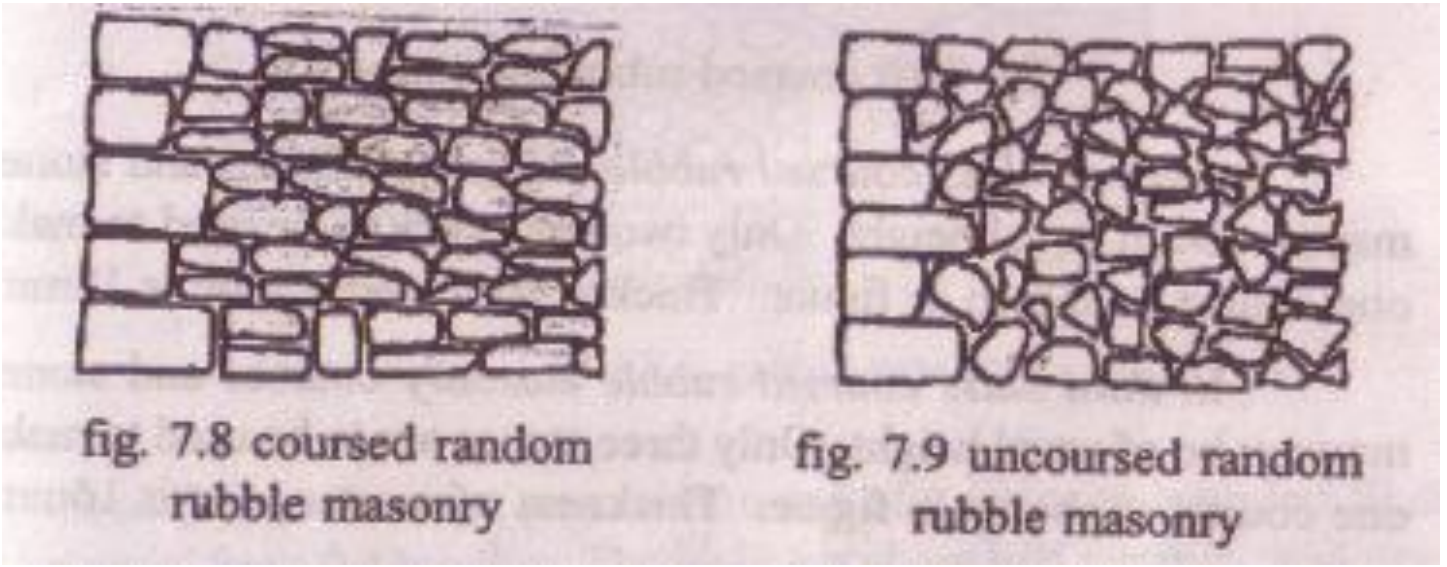


fig. 7.8 coursed random rubble masonry

fig. 7.9 uncoursed random rubble masonry

ROOF

- Top most portion of building that gives protection from rain, snow, wind , direct sun light etc.
- Classified based on the shape as

- Pitched roof or sloping roof- Have sloping top surface and used for heavy rainfall areas.
- Flat roof-used for moderate rainfall areas.
- Curved roof- have their top surface curved in the form of shells and domes.

PITCHED ROOF

- Different slopes can be given to pitched roof depending upon the area covered, availability of material, quantity of light etc.

a. Shed roof or lean to roof

- Simplest type of roof
- Slopes in one direction and used for covering verandah portion, shed or extension.

b. Gable roof

- Slopes in two direction

c. Hip roof

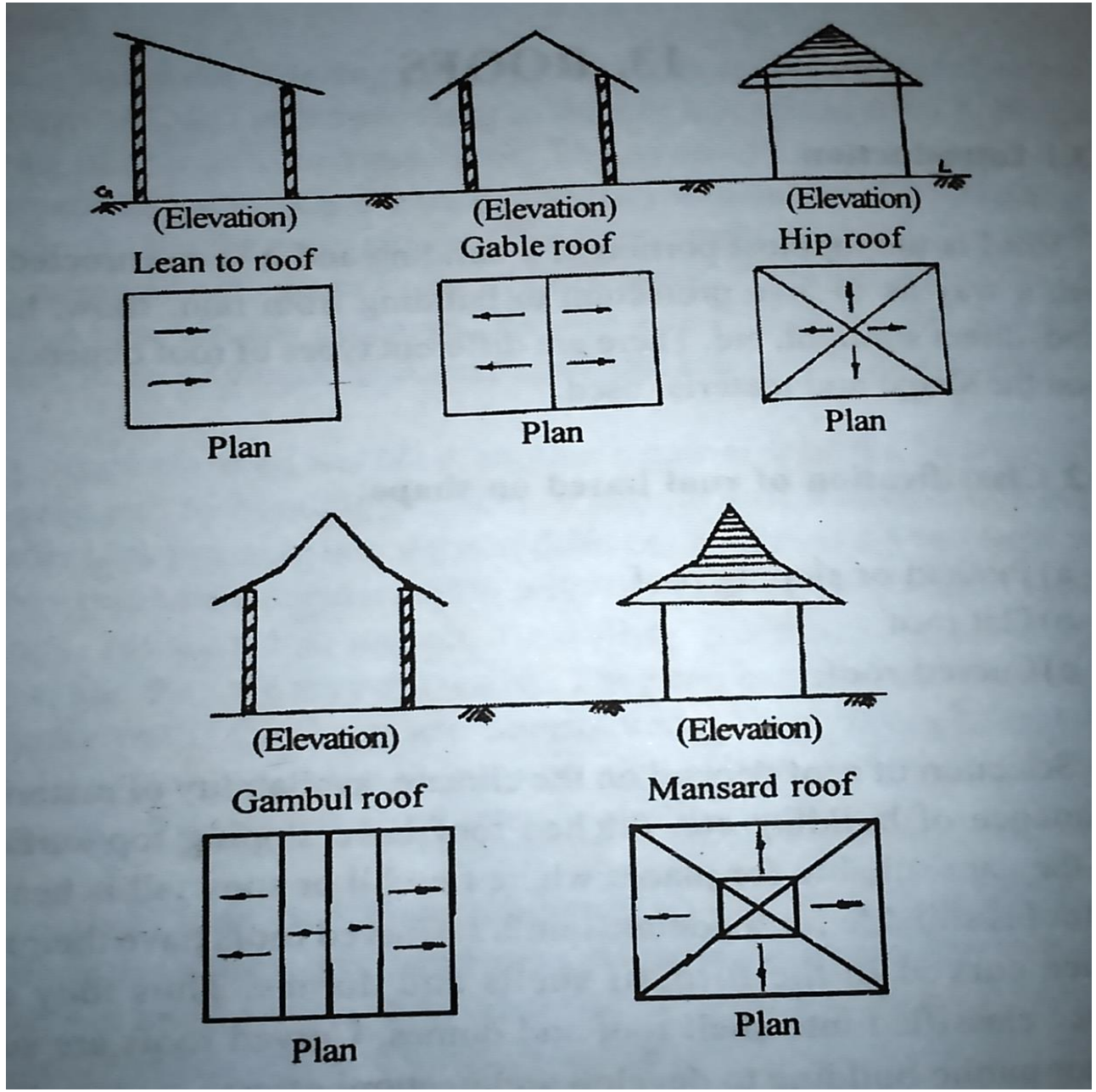
- Slopes in four direction

d. Gambrel roof

- Slopes in two directions but there is a break in slope.

e. Mansard roof

- Slopes in four directions but there is break in slope.


(Elevation)
Lean to roof
Plan
(Elevation)
Gable roof
Plan
(Elevation)
Hip roof
Plan
(Elevation)
Gambul roof
Plan
(Elevation)
Mansard roof
Plan

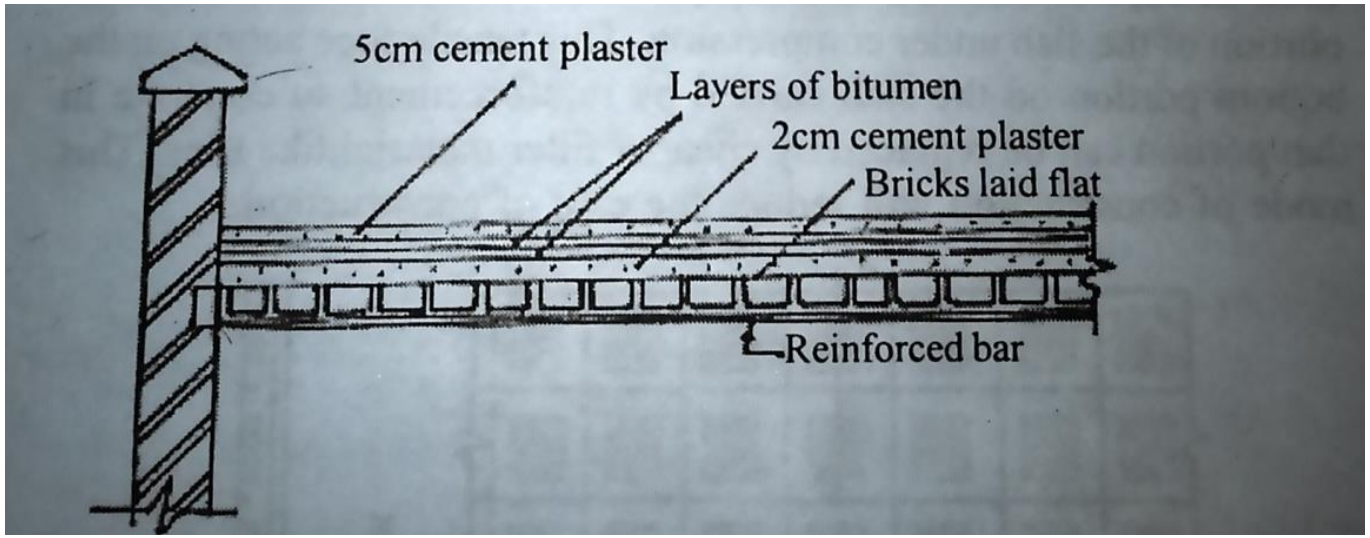
FLAT ROOF

- Provided in areas of less rainfall or snow fall.
- A small slope has to be provided to drain away rain water in case of flat roof.

TYPES OF FLAT ROOF

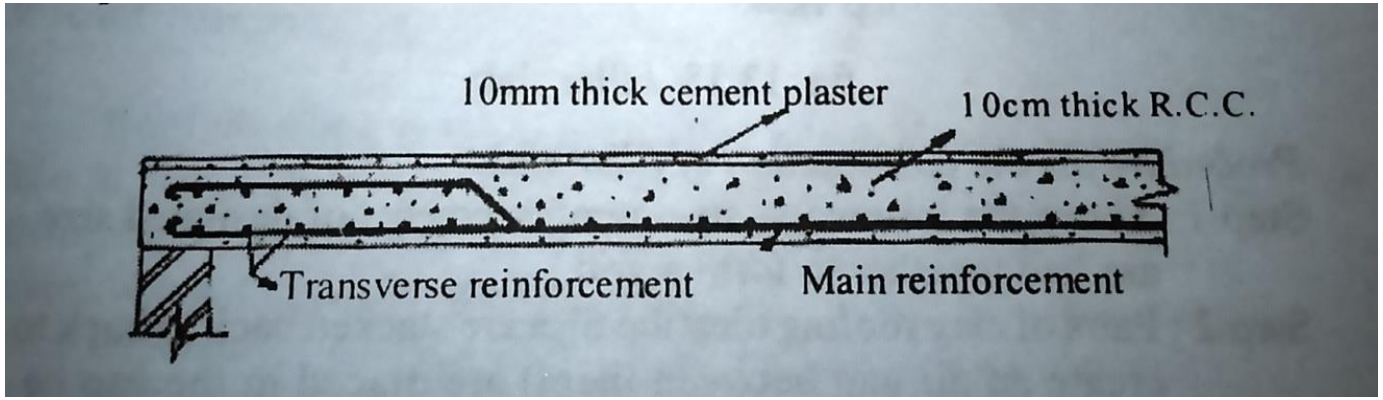
a. Reinforced brick cement roof

- Consists of reinforcement, brick and concrete.
- Bricks are laid horizontally between steel bars and concrete mix is inserted in the joints to fill gap between bricks and for covering reinforcement.
- Top surface is plastered with 2 cm thick cement mortar and over that apply two coats of bitumen for water proofing.
- Over the bitumen apply one more coat of cement paste of thickness 5 cm.
- Provide sufficient slope at the top for drainage of rain water.



b. Reinforced cement concrete roof

- Very common in the construction of modern buildings.
- Made up of concrete and steel.
- Two types of roof slab- One way and two way.
- When length of room to width is greater than 2, one way slab. Main reinforcement runs in shorter direction.
- When length of room to width is less than 2, two way slab. Main reinforcements runs in both directions and at corners mesh reinforcement is provided.
- Thickness of roof slab depends upon type of concrete, span, floor loads etc.



c. Filler Slab

- Concrete slab in which bottom portion is replaced with flat clay tiles or Mangalore pattern tiles.
- In concrete slab, bottom portion is under tension and top portion is under compression.
- Tensile force at the bottom is taken care by reinforcement so concrete in that portion is replaced by tiles.
- Reduces the cost of construction as amount of concrete can be reduced to 50 %.
- Better insulating property.
- Good appearance than RCC slab.

ROOF COVERINGS

- Material that gives protective surface to roofing structure.
- Selection of covering material depends upon type of building, roofing structure provided, climate, cost etc.
- Commonly used material are tiles, A.C. sheet and G.I sheet.

Tiles

- Manufactured from clay
- Impervious, fire resistant, cheap and durable.
- Non conductor of heat and cold so retain temperature inside the room.
- Battens are laid across rafters for fixing of tiles.
- Tiles are kept in position by a sort of interlocking action due to self weight.

Asbestos Cement Sheet (AC Sheets)

- Asbestos is a mixture of cement and asbestos.
- Available in two varieties- with corrugation and with wider channels.
- Thickness is 3 mm to 6 mm and spacing of purlin is 1 m to 1.5 m.

- Galvanised iron screws are used for fixing sheet on purlins.
- Length of AC sheet varies from 1.5 m to 3.05 m
- They are light in weight, have low cost, are tough, durable, water tight, fire resistant and available in bigger sizes.
- Do not require any protective paint and no maintenance cost.
- One of the disadvantage is that it transfers heat and cold easily.

Galvanised Corrugated Iron Roofing

- Corrugated Iron sheet galvanised with zinc to protect it from rusting in wet condition is called galvanised corrugated iron sheet.
- Length of GI sheet varies from 1 m to 3.5 m
- Thickness of sheet is 0.15 to 1.8 mm and spacing of purlin is 2 to 2.5 m.
- GI nails are used for fixing sheets.
- Weight is lighter than AC sheet roof.

S.I No.	A.C. Sheet	G.I Sheet
1.	Manufactured from asbestos fiber and cement.	Galvanising wrought iron plates.
2.	Heavy weight, thickness 3 mm to 6mm.	Light weight, thickness 0.15 mm to 1.8 mm.
3.	Durable, fire resistant and sound proof.	Easily corroded, not able to resist fire and not sound proof.
4.	Not affected by acids and fumes.	Affected by acids and fumes.
5.	Less initial and maintenance cost	High initial and maintenance cost.
6.	Look neater and cleaner	Look dull.

PVC corrugated sheets

- Sheets are made up of Poly Vinyl Chloride plastic.
- Available in different colours in market.
- Light in weight
- Give colourful appearance to building so used in waiting shed, restaurant and porches.

FLOOR

The essential requirements of floor are

- It should have a level surface.
- It should be hard and durable.
- It should have an attractive finish.
- It should be impervious and dampproof.
- It should be easy to clean.
- It should be economical to build.
- Its maintenance cost should not be high.

TYPES OF FLOOR

a. Depending upon the position of floors, it can be classified as-

1. Ground Floor:-Floor constructed just above the ground level

2. Basement Floor :-Floors constructed below the ground level

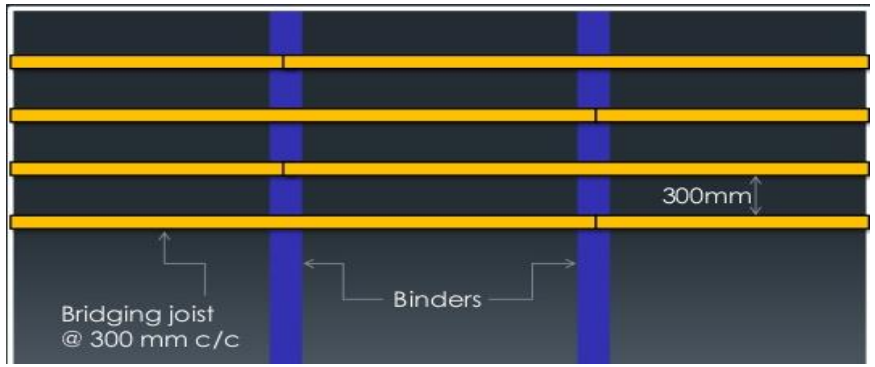
3. Upper Floors:-Floors above ground level.

4. Mezzanine Floors:-An intermediate floor between two floors of any storey.

b. Depending upon the material used.

1. Timber floors

- Commonly used in olden days.
- They are prone to fire and termite attack.
- Single joist timber floors were used for span upto 4 m, where as double joist is used for span of 4.5 to 7 m.

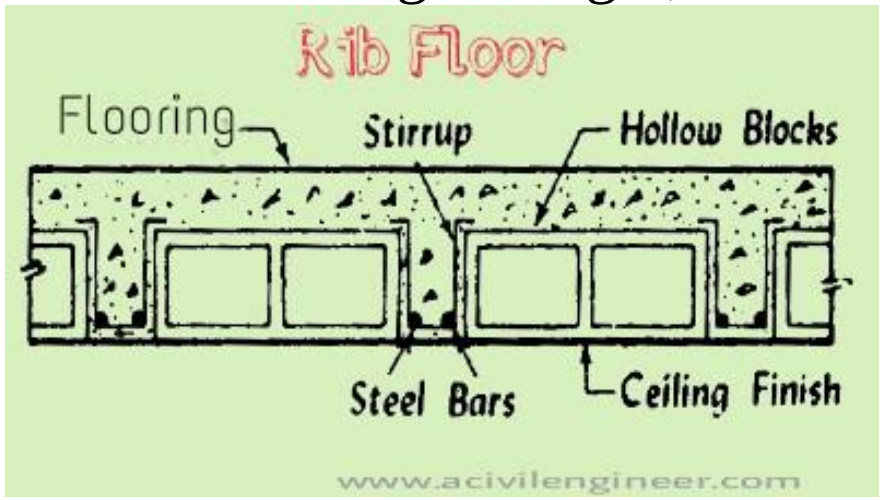


2. RCC floor

- This type of floor are widely used in modern construction world.
- RCC floor can be cast in-situ or precast.
- Materials used to build RCC floor are Concrete and M.S. bar (mild steel bar).
- The advantages of RCC floor are it is economical, durable, easy to construct and fire proof.

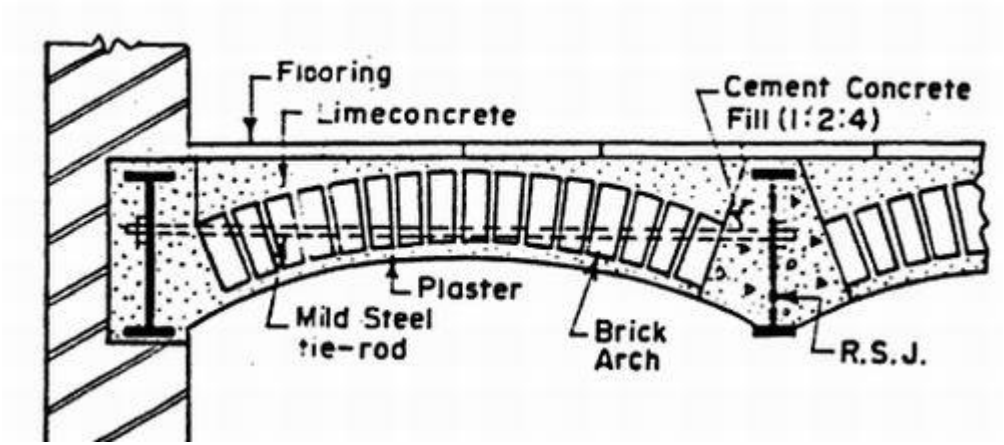
3. Hollow block and rib floor

- This type of floor is made with “rib” and “hollow block”
- Rib is a RCC beam which is placed between the rows of hollow block. Clay hollow block or concrete hollow block are mostly used for this purpose.
- Advantage of this type of floor are light weight, economical, fire-proof and sound proof.



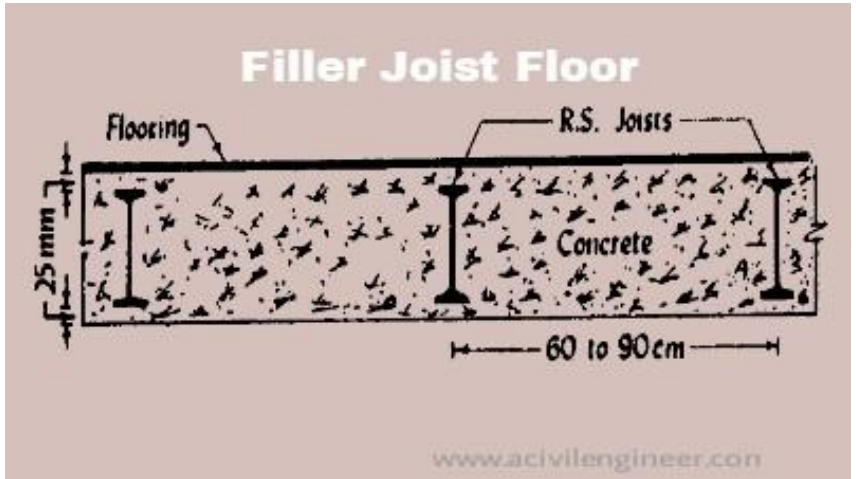
4. Jack Arch floor

- Components in this type of floor are Arch (brick arch or concrete arch), Rolled steel joist, Rolled steel beam, Wall and Tie rod.
- Joists are placed on wall or beam and tied together with the tie rod.
- Then concrete arches or brick arches are constructed and rest on lower flanged of Joists.



5. Filler Joist slab

- Materials or components of this type of floor are Rolled steel joist, Rolled steel beam, Concrete and Wall.
- In this type of floor Joists are surrounded by concrete and place on wall or rolled steel beam.



BUILDING SERVICES

- Everything inside a building which make it safe and comfortable to be in comes under the building services.
- A building must do what it is designed for , rather than just fulfilling the concept of mere shelter i.e environment to live, work and achieve.
- Building services include

a) Energy supply like gas, electricity

b) Escalators and lifts

c) Fire safety, detection and protection.

d) Heating, ventilation and air conditioning (HVAC).

e) Lighting (natural and artificial)

f) Refrigeration

g) water, drainage and plumbing.

MEP

- Mechanical, Electrical and Plumbing refers to these aspects of building design and construction.
- Mechanical services include HVAC – Heating Ventilation and Air conditioning, transportation services like lift, escalator and fire protection.
- Electrical services include power supply and distribution, interior and exterior lighting, Control systems, Security and access systems, detection and alarm system.
- Plumbing services include water supply, sewerage, water management

  waste water management and rainwater management.

HVAC

- It’s a system or combination of system used to provide comfortable temperature in buildings and maintain high level of air quality.
- Function of HVAC is to :
  - Maintain internal air quality
  - Regulate internal temperature
  - Regulate internal humidity
  - To hold air contamination within acceptable limit
- Internal air quality can be maintained by introducing fresh air into the building and taking away stale air.
- Internal temperature can be regulated by heating and cooling systems.
- Humidity can be regulated by ventilation, dehumidification and humidification

CLASSIFICATION

- CENTRAL SYSTEM- entire building will get air conditioning.
- DECENTRALIZED SYSTEM – Equipments are separately provided.

TYPES

- HVAC split system- one system for heating and one for cooling.
- Hybrid split system – hybrid system for heating and cooling.
- Ductless mini split system – multiple inside units located in each room that can be separately controlled for heating and cooling.
- Packaged heating and air system – combination unit for heating and air

PLUMBING

- Plumbing is a system of Pipes, Drains, Fitting, Values and Fixtures installed for distribution of potable water, removal of waste water etc and maintaining the same.
- Mainly consist of supply that brings in water and takes out used water.
- Other areas of plumbing include Potable hot and cold water supply, Drainage and sewage system, External water supply and Sewage treatment plants.

FIRE SAFETY

- Primary goal is to protect building occupants from injury, to prevent loss of life and to prevent property damage.
- According to Indian law, minimal fire safety equipment is mandatory.

NBC NORMS

- FIRE WAY with minimum width, say 5m for the entry of fire engines.
- Alternate fire stairs and lift.
- Use non combustible material for construction.
- Emergency power supply system.
- Sufficient storage of water.
- Landings of fire stair should closed with breakable glass.
- Sufficient space should be kept free at terrace for rescue operations

VERTICAL TRANSPORTATION

- It is an important service to be designed with due care in multistore buildings for circulation of traffic and people both in normal uses and in emergencies.
- Various measures of vertical transport are staircase, ramp, elevator, escalator

ELEVATOR OR LIFTS

- It is designed to transport persons or materials between two or more levels in a vertical direction by means of a platform.
- It is to be used in buildings having more three stories.
- They are either electric traction elevators or hydraulic elevators.
- Electric traction elevators are used exclusively in tall buildings.
- Hydraulic elevators are generally used for low rise buildings which rises upto about six storeys.
- Various types of lifts are passenger lift, hospital lift, goods lift, service lift etc.
- Location of elevator should be such that it can be easily accessed by people.

- Important consideration in the design of lift system are number of floors to be served, floor to floor distance, population of each floor and maximum peak demand.
- Various design parameters are population (Total population and its future projections are required), quantity of service (Handling capacity is the measure of passenger handling capacity), and quality of service (Time interval a passenger has to wait)

ESCALATOR

- Escalators are power driven, inclined and continuous stairway used for raising and lowering passengers.
- These are used to move large number of people from floor to floor of buildings.
- Escalators are installed at commercial centres, shopping malls, airports, railway stations and other public buildings where heavy people movement is expected.
- They are in continuous movement without operators.

- Escalators with electronic sensors are also available which operate automatically only when people approach to use it so as to save energy.
- They are in the form of an inclined bridge spanning between the floors and generally installed as pair. Up going traffic and down moving traffic are carried by this pair of escalators.
- They are generally operated at a speed of 0.5 to 0.75 m/s. Slope of stairs is standardised at 30°.
- For a given speed, the width of steps decides the capacity of the powered stairs. Normally a design capacity of 3200 to 6400 persons per hour in one stretch is adopted depending upon the width of escalator.
- The arrangement of escalators in each storey can be either parallel or criss-cross. Criss cross is more compact and reduces walking distance.

TYPES:

Escalator typical configurations:

PARALLEL

CRISS CROSS LAYOUT

RAMP

- Ramps are sloping surfaces used to provide an easy connection between the floors or access from ground to the floors.
- They are especially useful when large number of people or vehicles have to be moved from floor to floor.
- They are usually provided at places such as garages, railway stations, stadium, town halls etc.
- As per the prevailing building bye laws, ramps are to be provided in all public buildings and residential apartments for the use of physically challenged persons.
- It is also provided in hospitals to facilitate movement of stretchers and wheel chairs from one floor to other floor.

- Ramps are generally given a slope of 15 percent. But a slope of 8 to 10 percent is usually preferred. A level landing of minimum 1.1 m is provided at places where direction of ramp changes or at door steps.
- Minimum width of pedestrian ramp is 1.2 m.

GREEN BUILDINGS

- Green building is a building, which can function using an optimum amount of energy, consume less water, conserve natural resources, generate less waste and create space for healthy and comfortable living.
- Materials used in construction of green building has minimum release of carbon dioxide in production stage of these materials.

OBJECTIVES

- Green Buildings are designed to reduce the overall impact on human health and the natural environment by the following ways:

- Using energy, water and other resources efficiently.

- By reducing waste, pollution, and environmental degradation.

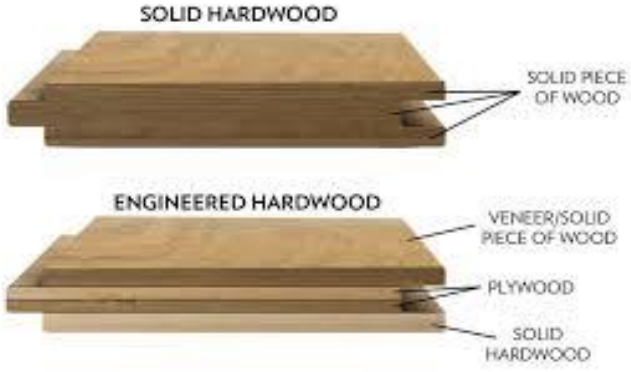
Suzlone one Earth, Pune

Rajiv Gandhi International Airport (RGIA), Hyderabad

GREEN BUILDING MATERIALS

a) Earthern materials are used for construction purpose. Better strength is obtained by reinforcing it with straw or other fibers.

b) Engineered wood – process of conversion of raw timber to wood boards has wastages. Such wastages used to make parts like door, wall etc



c) Structural Insulated Panel : Consist of two sheets of oriented boards with a foam layer between them. They are available in large size. Heavy equipment are necessary for installation.

d) Insulated concrete form : Contains two insulation layers with space in between them. The space contain reinforcement bars. Once the system is placed in site concrete is poured into the space

e) Cordwood - Short and round piece of wood laid one above the another widthwise and bounded with mortar.

f) Timbercrete - formed from wooden waste and concrete. It allows minimum transfer of heat and radiation, use friendly.

g) Ferrock - concrete + recycled materials like steel dust. It is stronger than concrete and carbon neutral.

ENERGY SYSTEMS FOR GREEN BUILDINGS

In modern world 30-40 % of energy is consumed by buildings. It is predicted to increase upto 48% by 2025. Methods to improve energy efficiency are

- Usage of solar energy
- Natural lighting
- High efficiency light fixtures like LED lamps
- Motion detectors for lighting control
- HVAC designed to minimise the amount of airflow necessary for heating and cooling.

WATER MANAGEMENT IN GREEN BUILDINGS

- Optimal use of water in green buildings start from the planning stage itself
- Water efficiency in green buildings means reduce the usage of water and minimise the waste water.
- Water management aspects are

  a) Rainwater harvesting

  b) Plumbing arrangements to use potable water for potable purpose only.

  c) Dual plumbing system.

  d) Toilets with low water consuming flushes.

  e) Water taps with motion sensors.

  f) Water efficient appliances like washing machines and dish washers