

# MODULE 3

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## Building construction

Foundations

Bearing capacity of soil

Functions of foundations

Types - shallow and deep

**Roofs** - Functions, types, roofing materials (brief discussion only)

**Floors** – functions, types; flooring materials (brief discussion only)

# FOUNDATION

- ❖ Structural component in direct contact with soil
- ❖ Transmits load from super structure to ground

## *Functions*

- ✓ Spreads load from super structure on to a large area
- ✓ Decreases differential settlement by evenly distributing the load
- ✓ Stability against scouring and undermining by flood
- ✓ Safety against sliding
- ✓ Provides a level surface for construction of super structure

# BEARING CAPACITY OF SOIL

**Bearing capacity of soil-** *Ability of soil to support the super imposed load without excessive settlement or failure*

☐ **Ultimate Bearing Capacity-** *gross pressure at which soil fails*

☐ **Safe Bearing Capacity** – *maximum pressure which soil can carry without the risk of shear failure*

Safe Bearing Capacity= Ultimate Bearing Capacity/ factor of safety

fos- 2 to 3

☐ **Allowable Bearing Capacity-** *maximum allowable load intensity that can be applied to soil*

Type of soil	Safe Bearing Capacity in kN/sq.m
Soft rock	450
Gravel	250 to 450
Sand	150 to 250
clay	100 to 150

# TYPES OF FOUNDATION

Two categories:

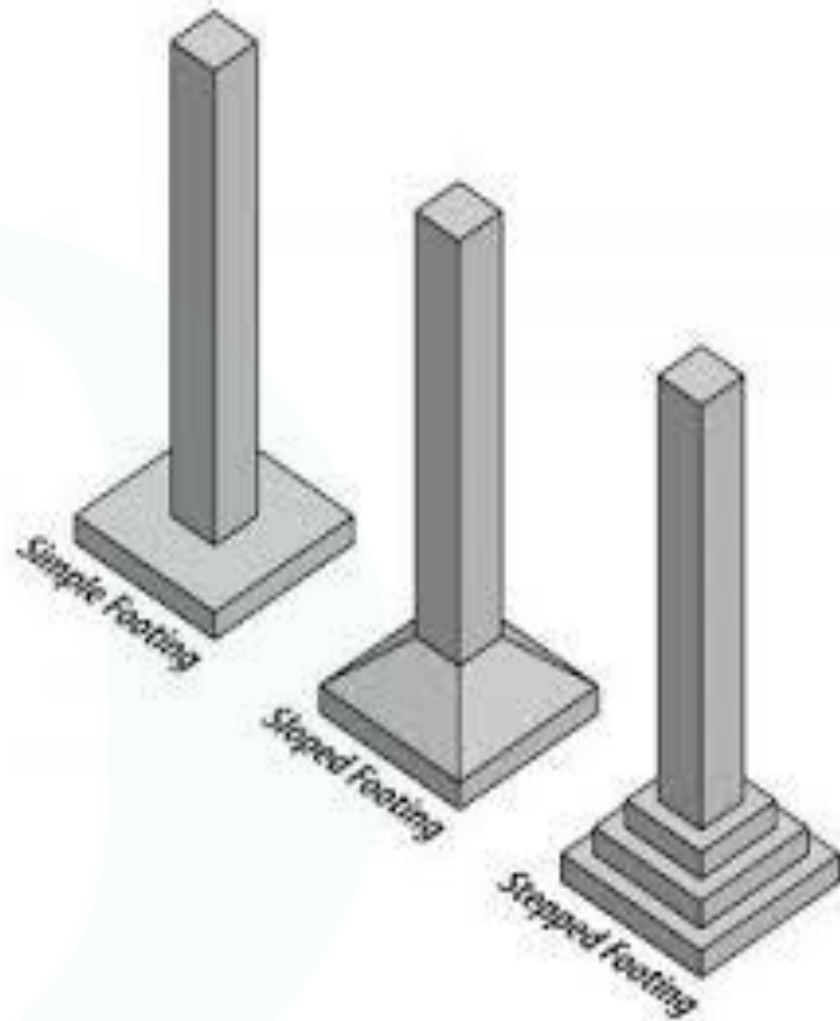
- Shallow (open foundation)- depth  $\leq$  width of foundation
- Deep – depth  $>$  width of foundation

# 1. Shallow foundation

- ❖ Also known as Footing- constructed in masonry or concrete under the base of column or wall
- ❖ Various types :
  - @ Isolated or column footing
  - @ Wall or strip footing
  - @ Combined footing
  - @ Continuous footing
  - @ Cantilever footing
  - @ Inverted arch footing
  - @ Grillage foundation
  - @ Raft or mat foundation

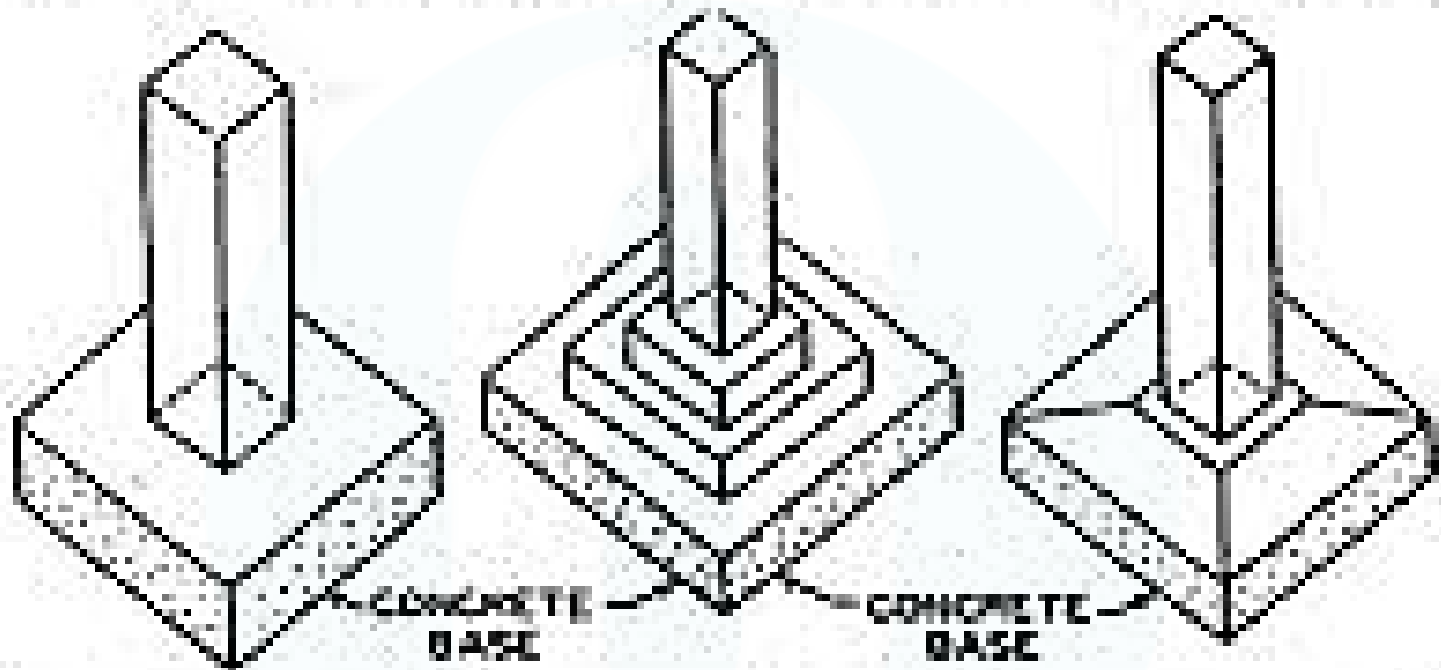
## *Isolated footing*

- Load on column is less-  
isolated footing under column
- For medium and heavy loads-  
sloped or stepped footing
- Constructed in stone, brick ,  
concrete or a combination of  
these

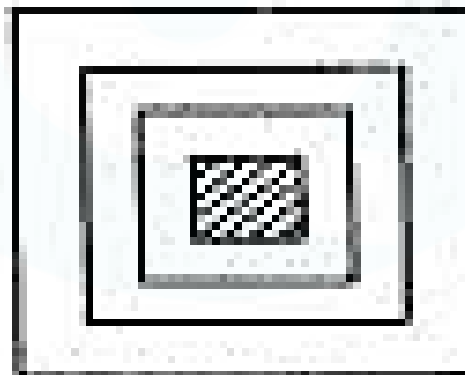




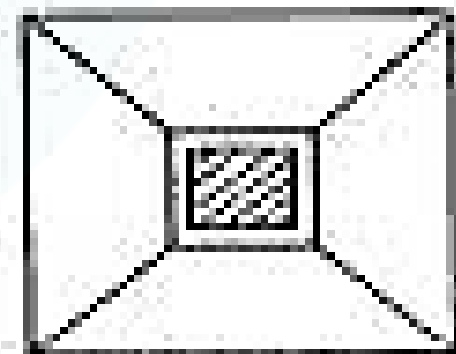
# COLUMN FOOTING OR ISOLATED FOOTING



(a) SINGLE  
FOOTING



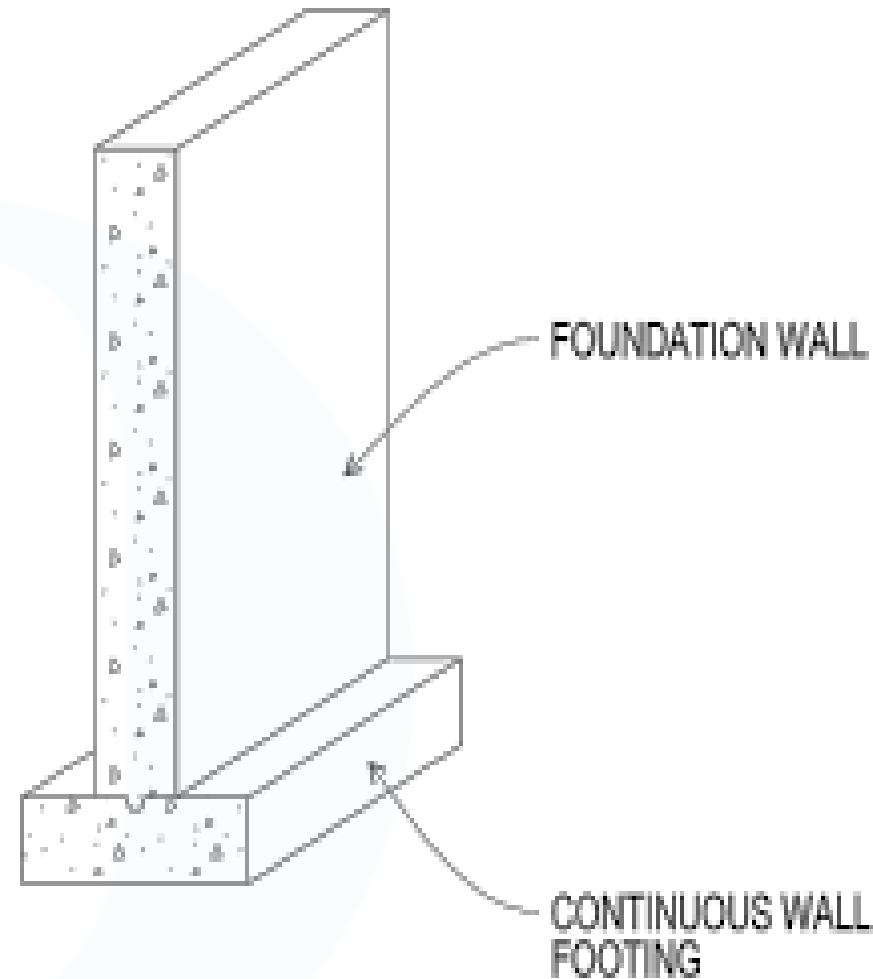
(b) STEPPED  
FOOTING



(c) SLOPED  
FOOTING

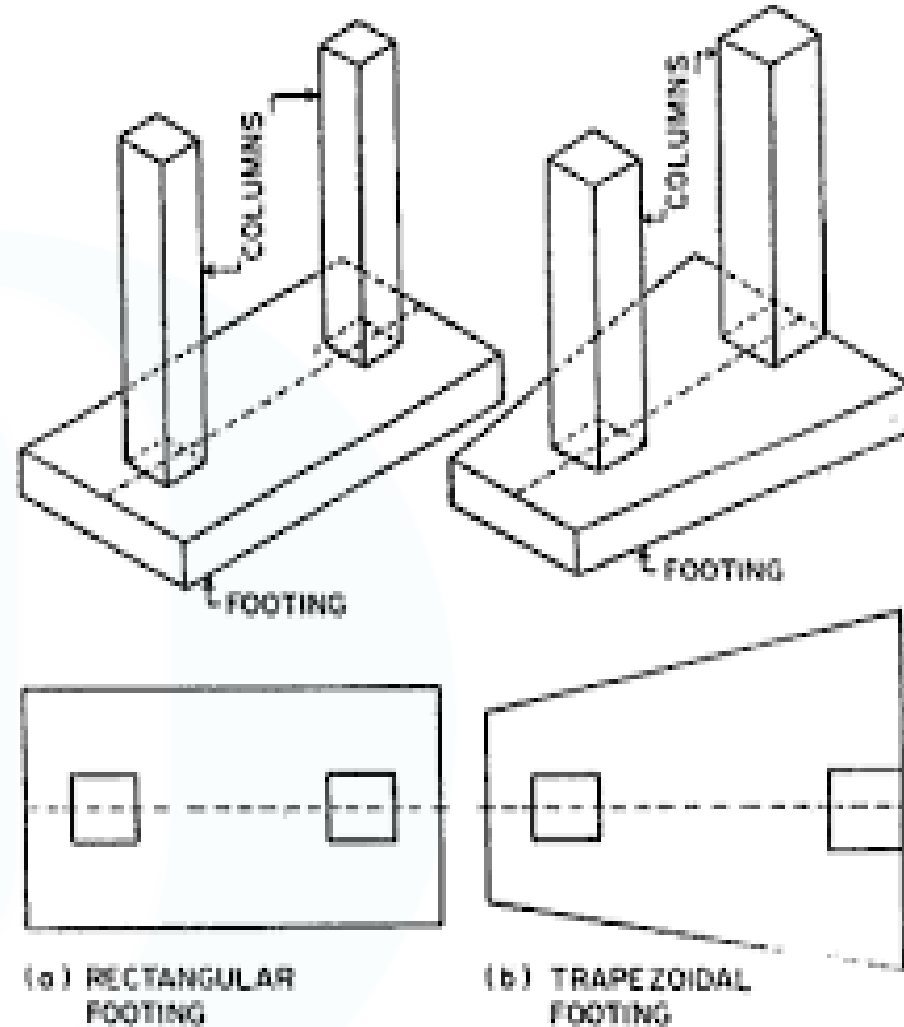
## *Wall or strip footing*

- Provided through out the structure
- Used for load bearing walls
- Can be simple or stepped



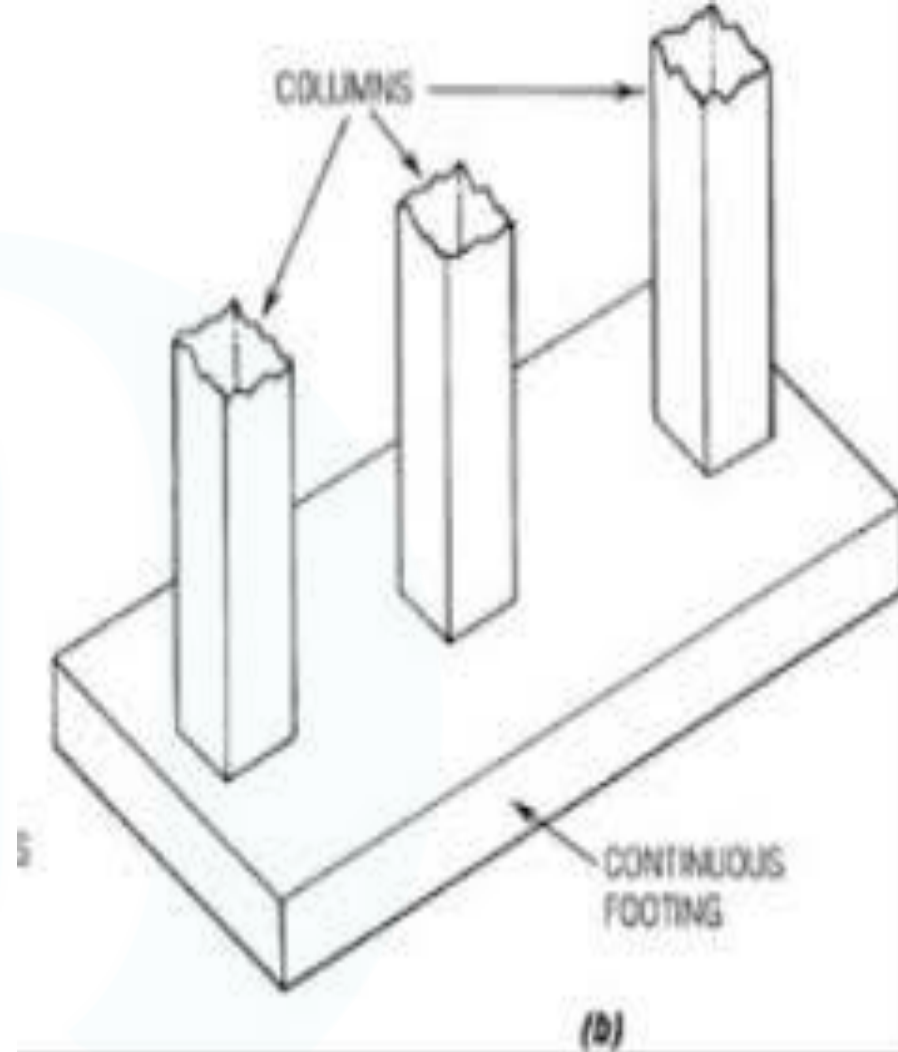
## Combined footing

- When a footing for two or more columns
- Rectangular or trapezoidal in shape
- Centroid of footing area coincides with center of gravity of load on footing
- Adopted when:
  1. Two footings overlap
  2. Bearing capacity of soil is low – requiring more area for individual footing
  3. When footings are constructed near boundaries



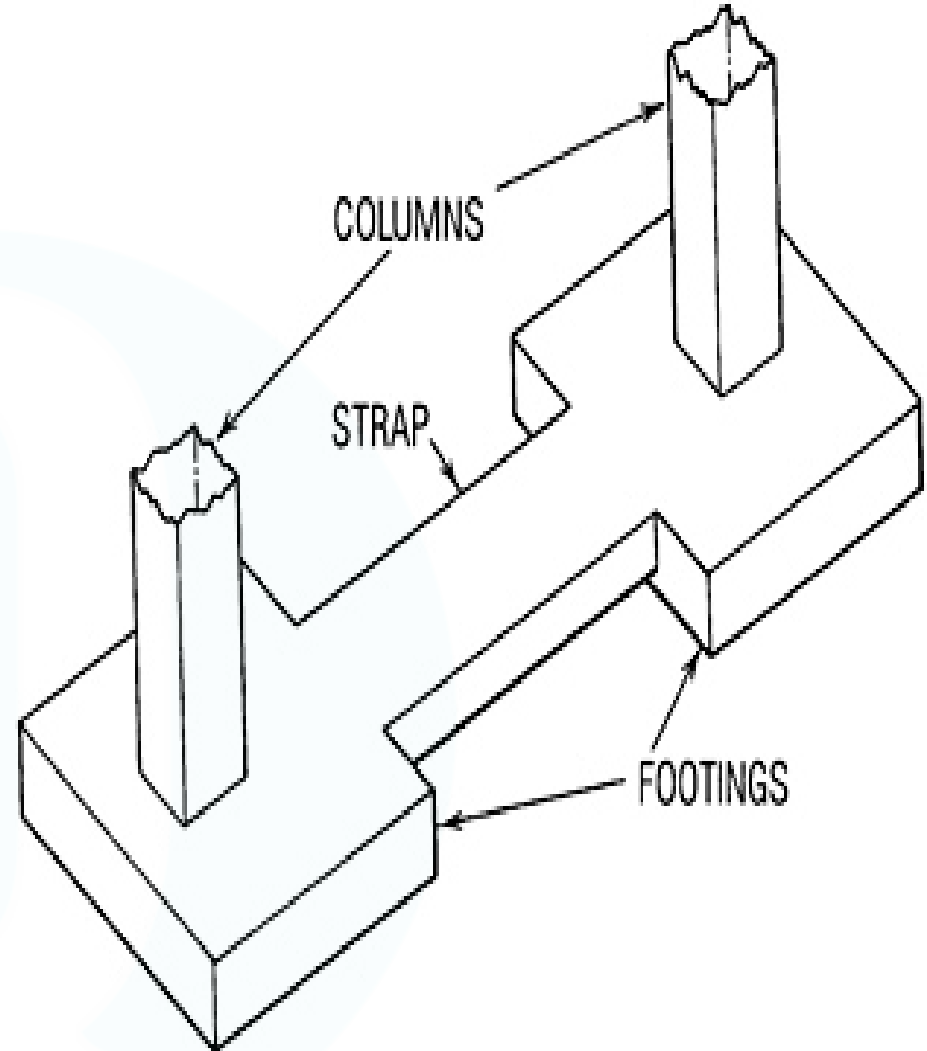
## *Continuous footing*

- A single RCC slab acts as a foundation
- Used when two or more columns in one row and footings may overlap



## ***Cantilever footing***

- Used when a footing cannot be placed directly beneath column due to limitations of land, adjacent building etc.
- Columns are connected by a strap or cantilever beam
- RCC beam acts as ***Strap***
- Used when two columns are near but combined footing is uneconomical



## *Inverted arch footing*

- Inverted arches between two walls at the base
- Suitable for soil with low B C and footing with very low depth
- Load transmitted through arch-distributed over a large area
- Suitable for bridges, culverts, dams, reservoir etc.

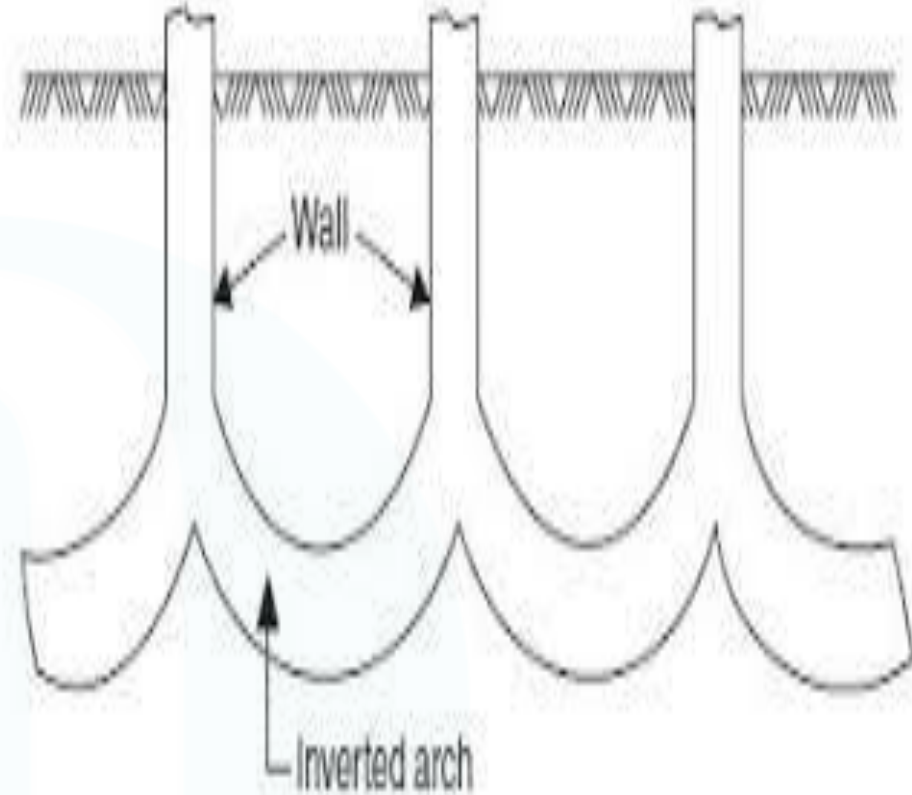
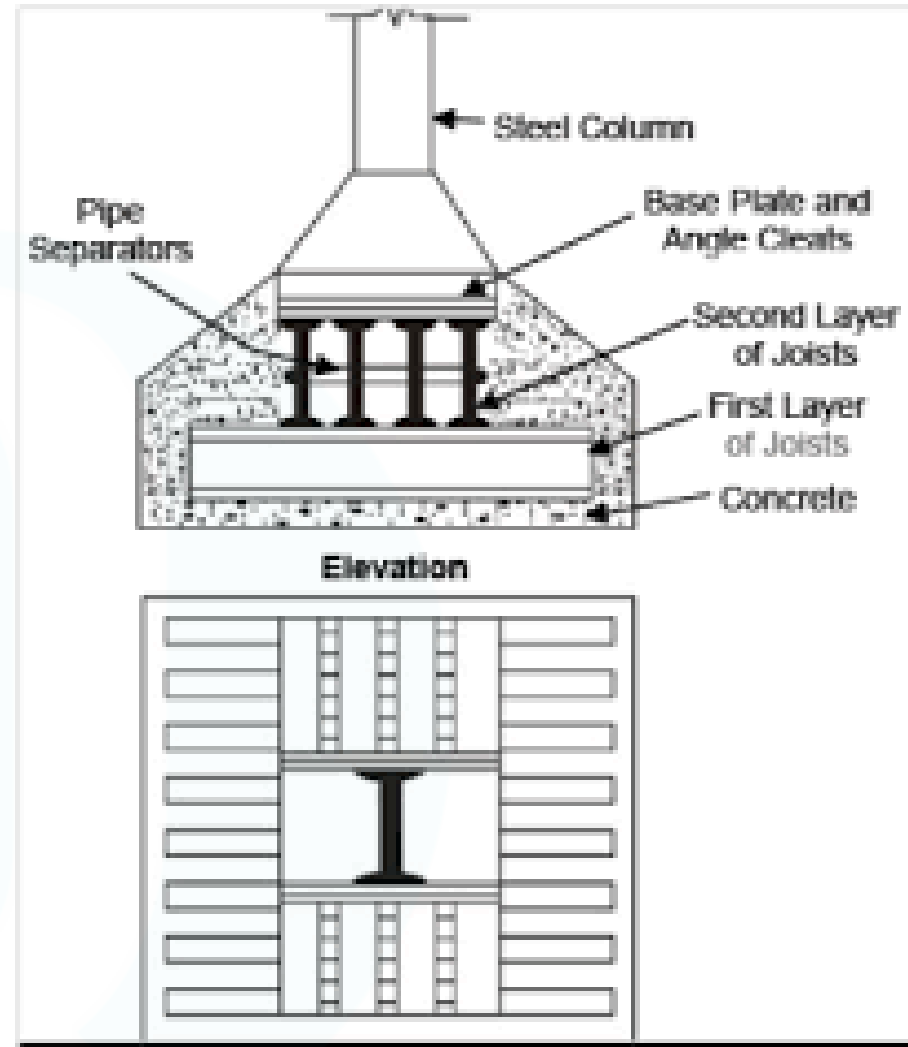


Fig. 7.8. Inverted arch footing

## Grillage foundation

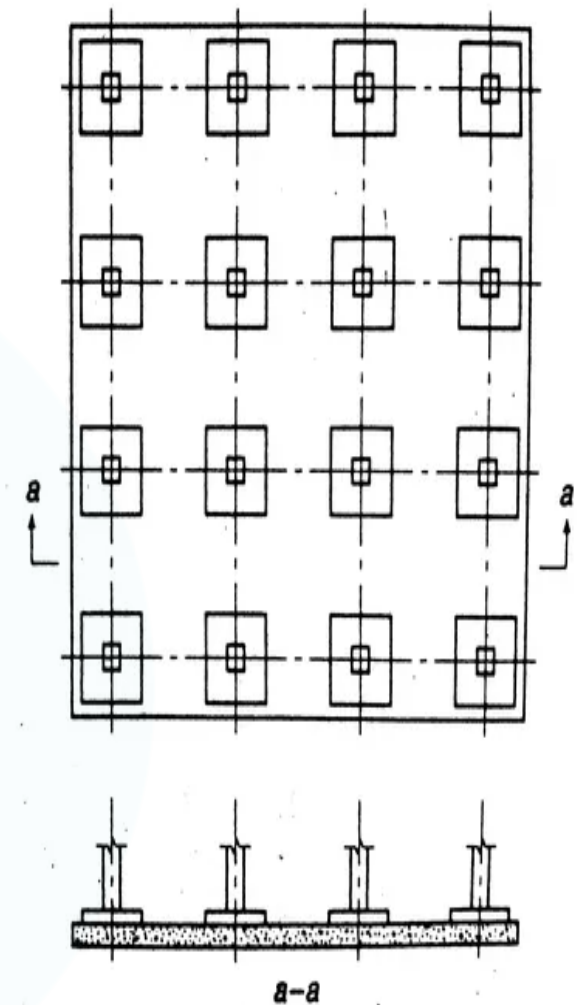
- Used to:
  - ❖ Transfer heavy loads from steel columns to soil with low BC
  - ❖ Depth of footing limited to 1m to 1.5m
- Constructed using I sections
- Single tier or double tier
- In double tier- lower tier perpendicular to upper tier
- A base plate on upper tier on which column rest
- All members are embedded in concrete
- Useful for factories, auditoriums etc.



Mat foundation.

## ***Raft or Mat foundation***

- Also called flat foundation
- Concrete slab covering entire area
- Supports all walls and columns
- Slab thickness depends on loads





## 2. Deep foundation

- Foundations having depth much greater than width
- Various types :
  - Piles
  - Piers
  - Well foundation

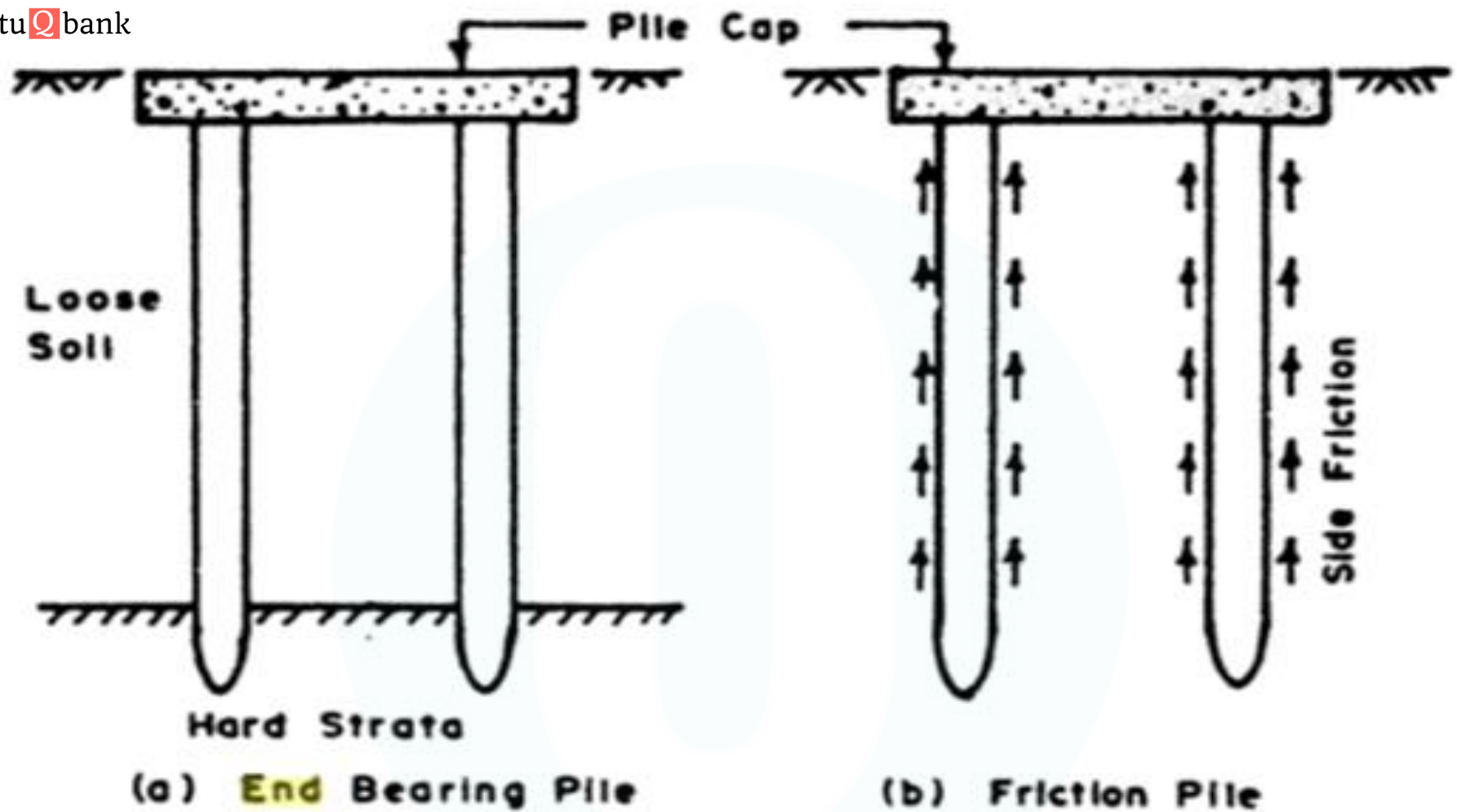
## Pile foundation

- Slender structural member
- Made up of steel, concrete, timber or composite materials
- Used when:
  - Loose foundation soil but hard strata at depth of 10-15m
  - Heavy loads to be transferred
  - Position of water table likely to fluctuate
  - Raft or grillage is uneconomical
  - Scouring action likely to takes place near river or sea
  - Top layer of soil being expansive

# Types of Pile Foundations

## ***Based on Method of load transfer***

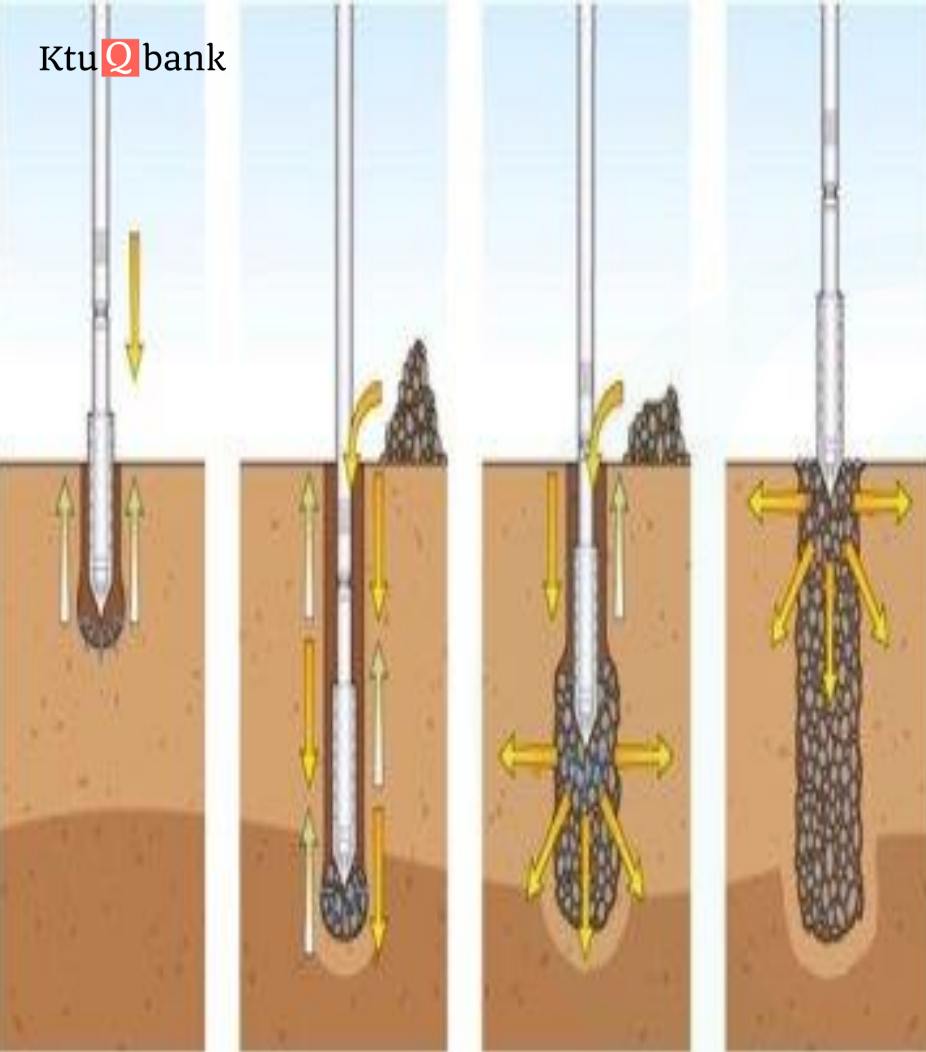
- ✓ End bearing piles
  - Rest on hard strata under surface soil
  - Used when hard strata available at 10-15m
- ✓ Friction Piles
  - Used to transfer loads to a depth by skin friction along the surface area of the piles



## *Based on function or action*

- ✓ **Compaction Piles**
  - Used to compact granular soils in order to increase the bearing capacity
  - Do not carry any load themselves
  - Example: sand pile
- ✓ **Tension or uplift piles**
  - Used to anchor structures subjected to uplift due to hydrostatic pressure or overturning moment due to horizontal forces
- ✓ **Anchor piles**
  - Used to provide anchorage against horizontal pull

- ✓ Fender piles
  - Used to protect waterfront structures against impact from ships or other floating objects
- ✓ Sheet piles
  - Used to retain earth or to reduce seepage flow of water in hydraulic structures
  - They are made up of steel or timber



Compaction pile



Sheet pile



## Fender piles



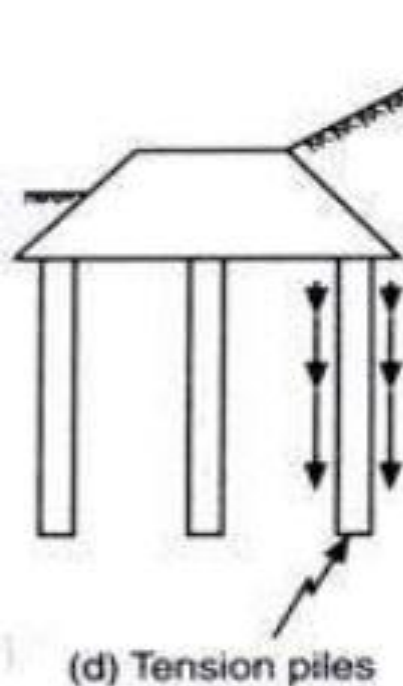
Soft

Rock

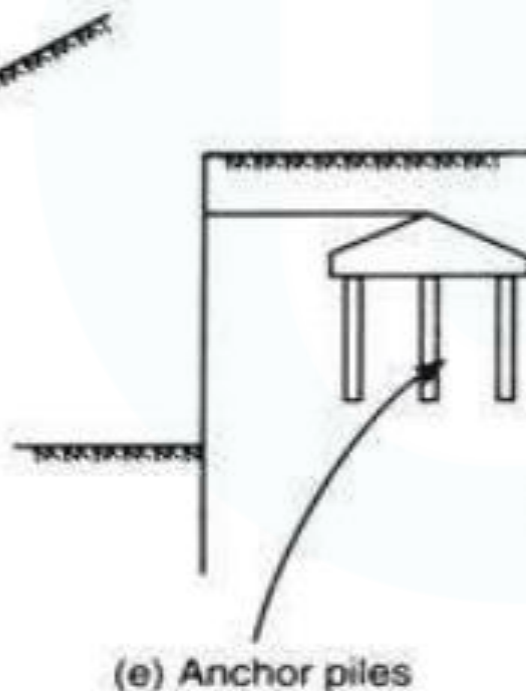
(a) end bearing pile

(b) Friction pile

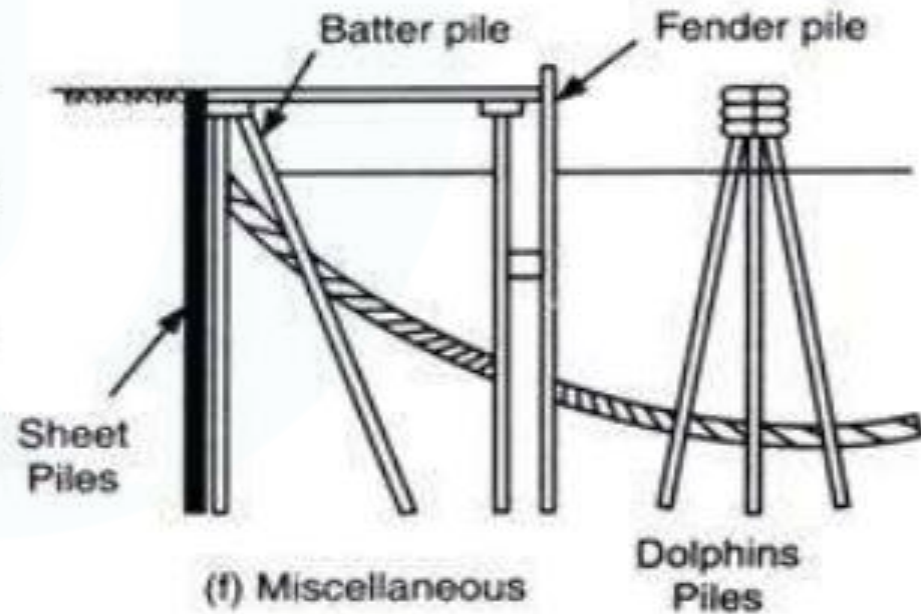
(c) Compression pile



(d) Tension piles



(e) Anchor piles



(f) Miscellaneous

**FIG. 11.15** Classification based on function

## ***Based on material***

### ✓ Timber piles

- Perform well both in fully dry condition and in submerged condition
- Trunks of trees are used as piles with an iron shoe at the bottom and steel plate at top

### ✓ Steel piles

- Rolled steel H-sections, thick pipes and steel sheets
- Steel piles can resist lateral forces, impact etc.
- Durability is also considerably high
- Used in marine structures

- ✓ Concrete piles
  - These may be precast or cast in situ
  - Made of Reinforced Cement concrete.
- ✓ Composite piles
  - Made of either concrete and timber or concrete and steel
  - Used when part of the pile is submerged under water

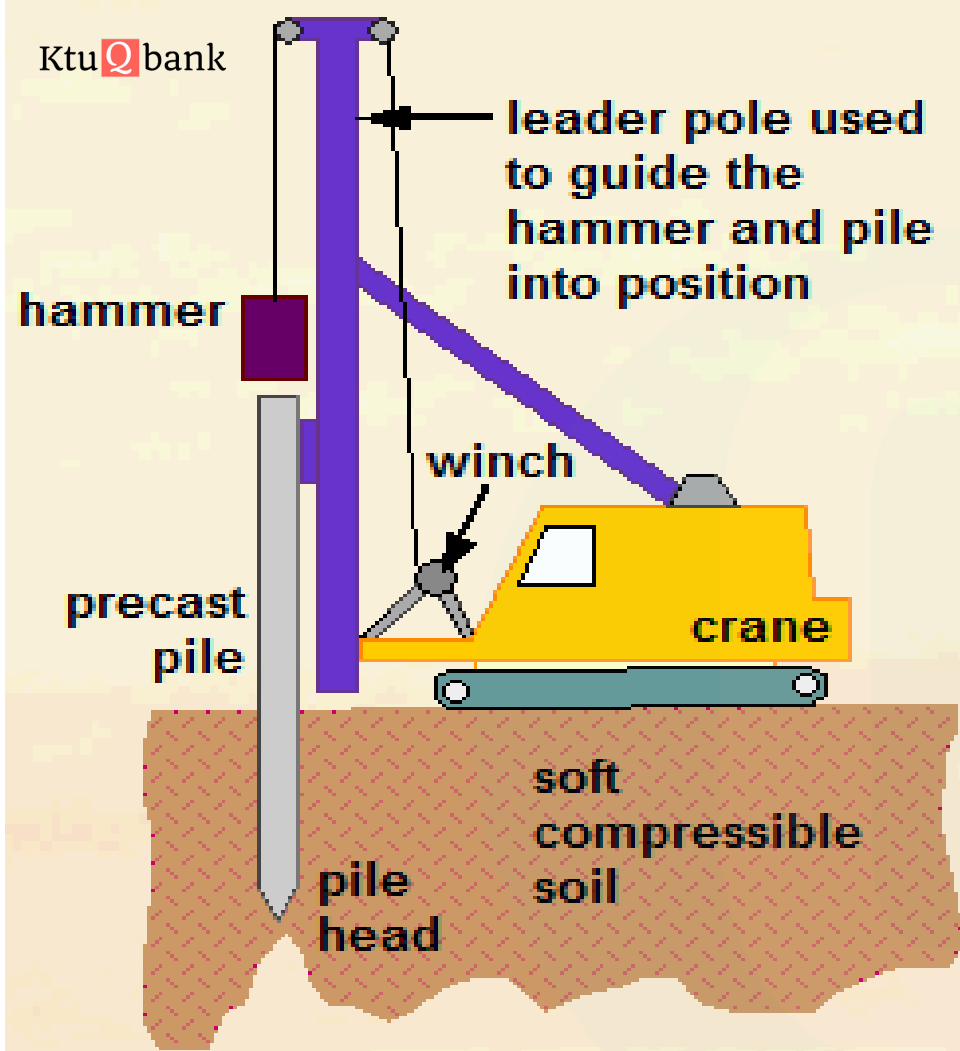
## ***Based on installation***

- ✓ Driven pile/precast pile
  - Cast and cured in a yard, transported to the site and are driven into the ground
  - While driving - cast iron or mild steel shoes -at the lower end
  - Reinforcement is provided in all pre-cast piles
- ✓ Cast in situ piles
  - A hole is made by excavating soil or by driving a casing
  - The hole is filled up with cement concrete
  - Piles are essentially provided with the reinforcement
  - The casing may be withdrawn after the hole is made (uncased) or it may be left in its position(cased)



## Cast in situ pile



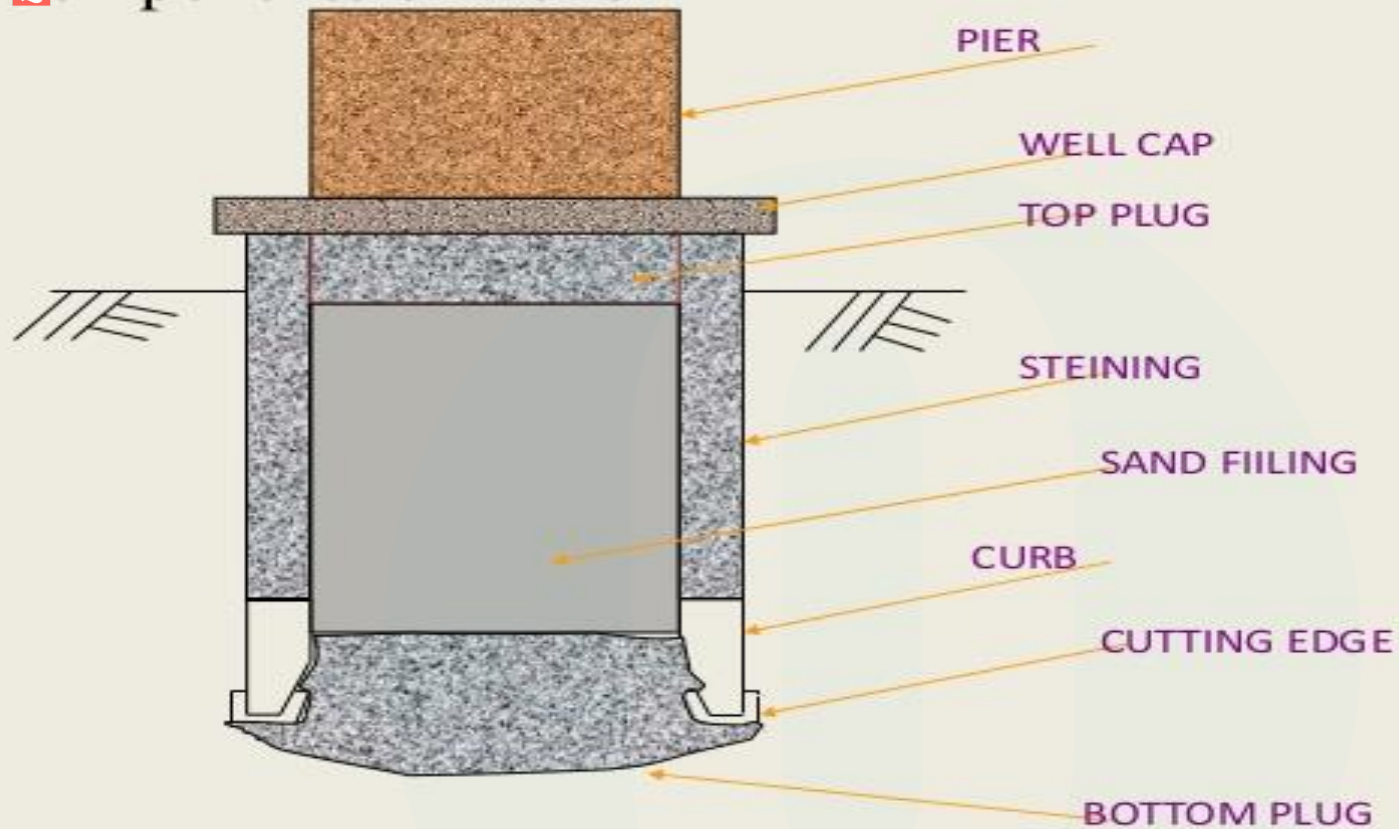


## Pre cast piles

## Well foundations

- ❖ Also known as open caissons
- ❖ Used for the foundation of bridges and other important structures
- ❖ Solid and massive foundation for heavy loads
- ❖ Top and bottom of the well foundation/caisson is open during construction
- ❖ They may be of any shape in plan as circular, rectangular etc.

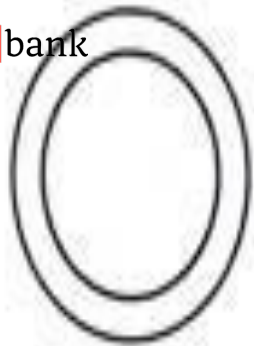
# Components of wells



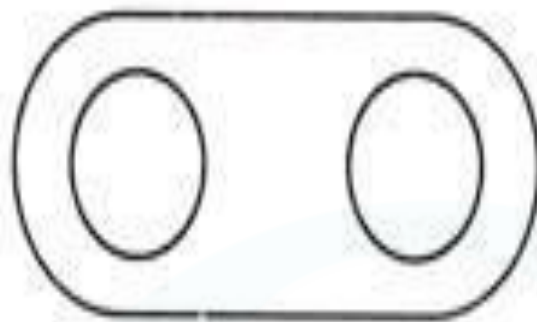
## WELL FOUNDATION

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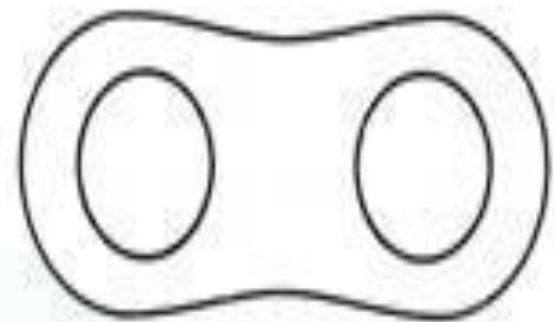




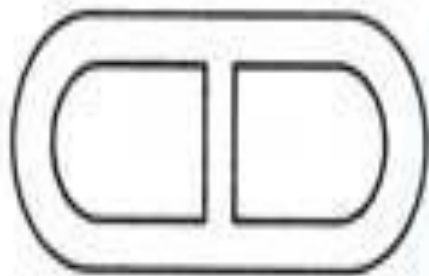
Single circular



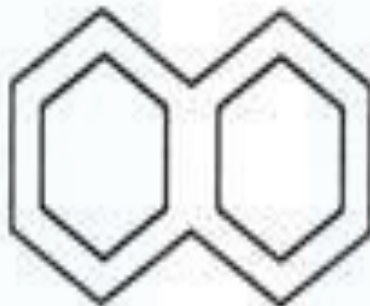
Twin circular



Dumb well



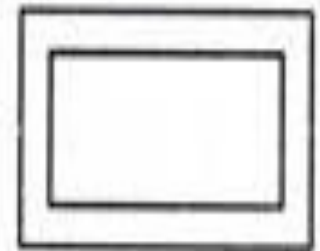
Double D



Twin hexagonal



Twin octagonal



Rectangular

**FIG. 11.30** Different shapes of wells

# ROOFS

- Uppermost part of the building provided as a structural covering
- To protect the building 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*

- ☐ It should protect the building from weathering agencies like sun, rain, wind etc.
- ☐ It should be durable
- ☐ Roof should be waterproof with good drainage arrangements
- ☐ It should be fire resistant
- ☐ Should have adequate strength and stability
- ☐ It should have thermal and sound insulation properties

## *Types of Roofs*

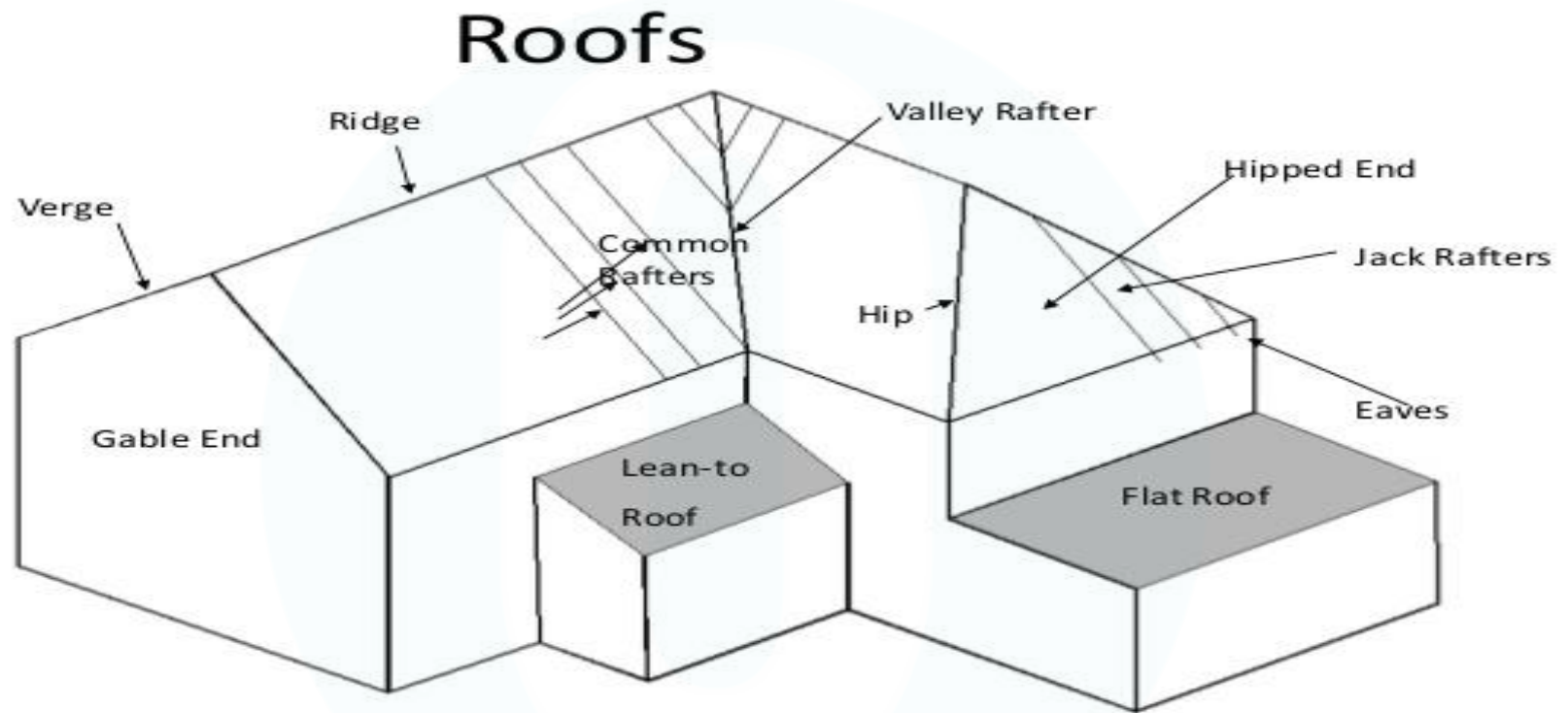
- ➡ Pitched or sloping roofs
- ➡ Flat roofs
- ➡ Curved roofs

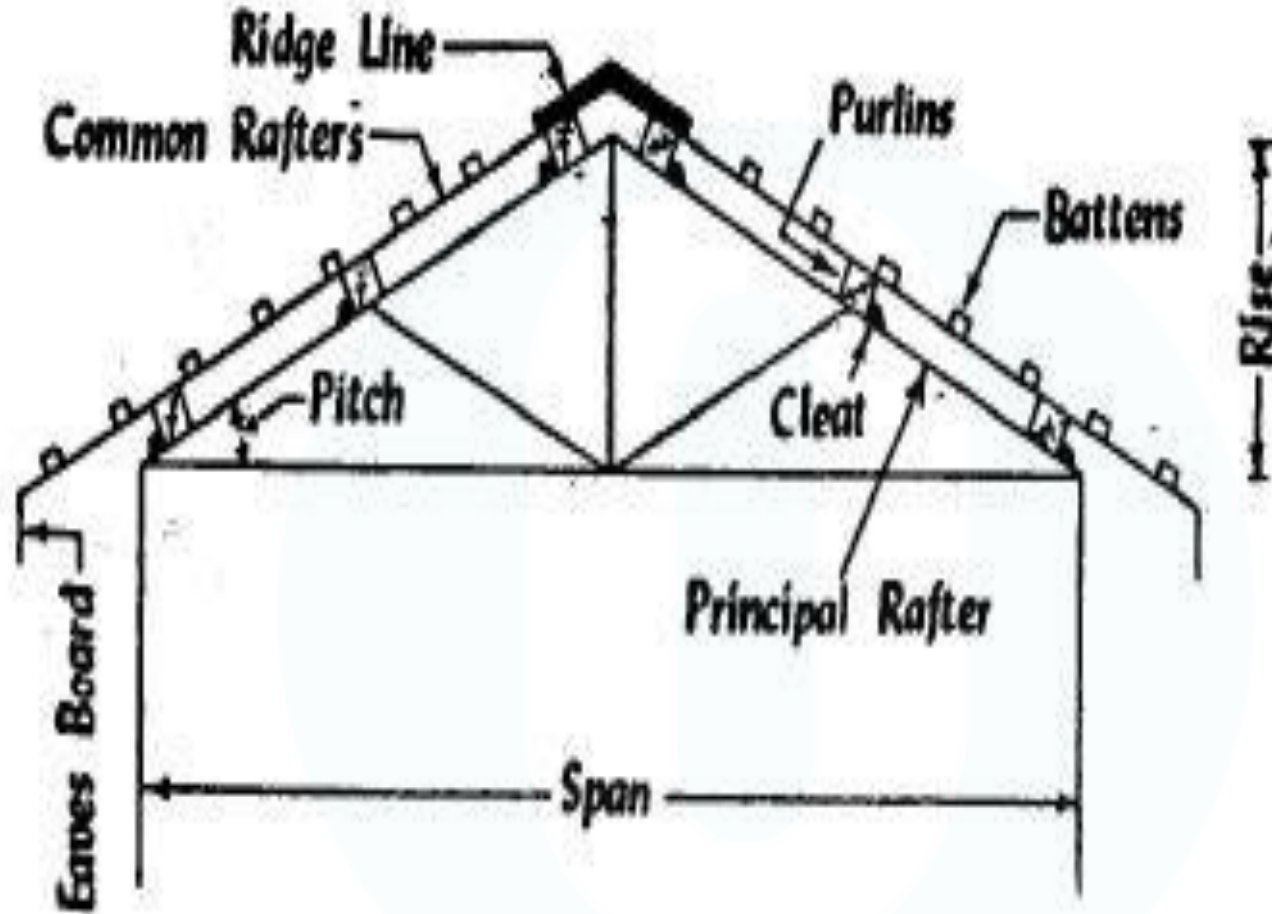
## *Pitched Roof*

-  Sloped roofs
-  The slope is given towards different sides
-  Since the top surface is sloped, the drainage is excellent in these roofs



# Parts of a Pitched Roof





**Span:** It is the clear distance between the supports of roof

**Rise:** It is the vertical distance between the top of the ridge and wall plate

**Pitch:** It is the slope of the roof. It is obtained as the ratio of *rise to span*

**Ridge:** It is the apex line of the sloping roof

**Eaves:** The lower edge of the inclined roof surface is called eaves

**Hip:** It is the ridge formed by joining of two sloping surfaces, external angle is greater than 180

**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



**Principal rafter:** This is the inclined member running from the ridge to the eaves.

**Purlins:** These are horizontal wooden or steel members, used to support roofing material of a roof. Purlins are supported on trusses or walls.

**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.

**Battens:** These are thin strips of wood, called scantlings, which are nailed to the rafters for lying roof materials above.

**Cleats.** These are short sections of wood or steel, which are fixed on the principal rafters of trusses to support the purlins.

## *Flat roof*

- Suitable for places where rainfall is moderate, where there is no snowfall
- Two types:
  - *One way slab*-reinforcement is provided in shorter span direction only
  - *Two way slab* - reinforcement is provided in both spans



## *Curved roof*

- The top surface curved
- Examples are shells and domes

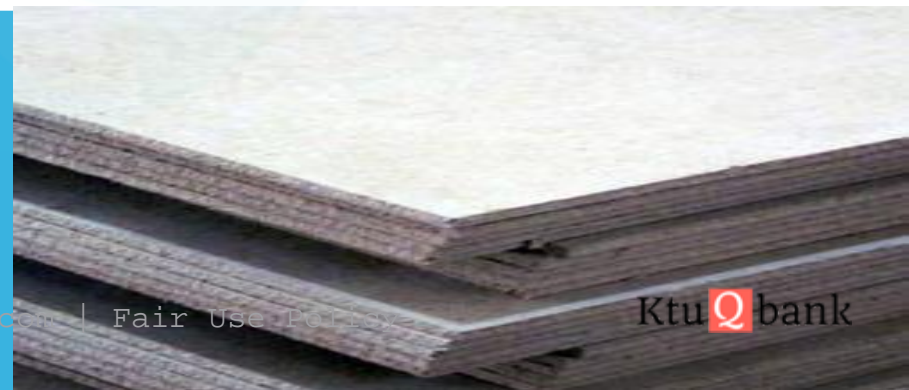
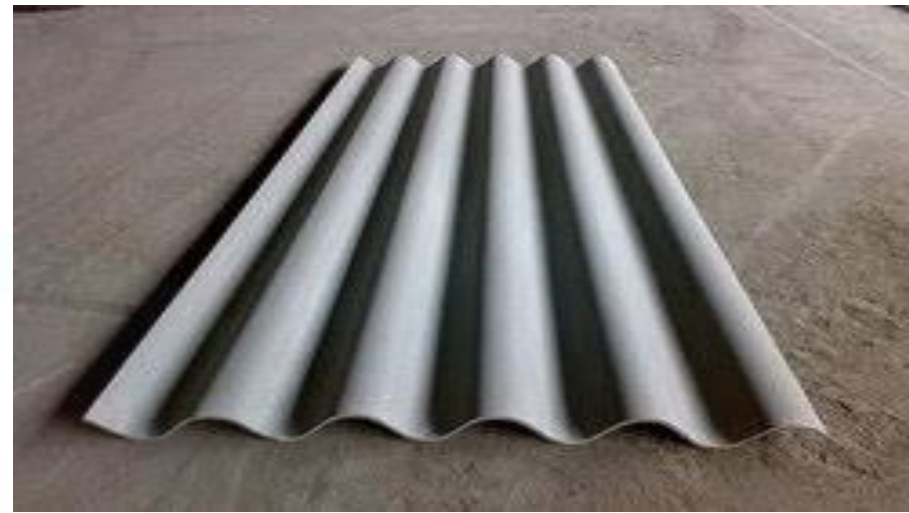


## Roof Coverings

- ❖ Provided over the formwork of roof structure to act as a barrier for rain, sun, wind or other atmospheric agencies
- ❖ Various materials are:
  - ✓ Asbestos cement sheet (A.C sheet)
  - ✓ Galvanized iron corrugated sheets(GI sheets)
  - ✓ Aluminium sheets
  - ✓ FRP sheets(fibre glass sheets)
  - ✓ Powder coated sheets
  - ✓ Roof tiles

## ● AC sheets

- ❖ Cement is mixed with 15% of asbestos fibre to make AC sheets
- ❖ Usually fixed with their smoother side upwards
- ❖ Both wooden and steel purlins can be used to fix AC sheets
- ❖ They are cheap, light in weight and durable
- ❖ Water tight, fire resisting and termite resistant
- ❖ These are available in larger size. This makes laying fast
- ❖ AC sheets do not require any protective paints etc.
- ❖ Less maintenance
- ❖ Corrugated, semi corrugated and plane sheets







## Galvanized Iron sheets

- Extensively used as roof covering material in factories, workshops, sheds etc.
- They are light in weight, fire proof and durable
- They are galvanized with zinc to protect them from rusting action of water and wet weather
- They may be corrugated or bend. Corrugations helps in drainage



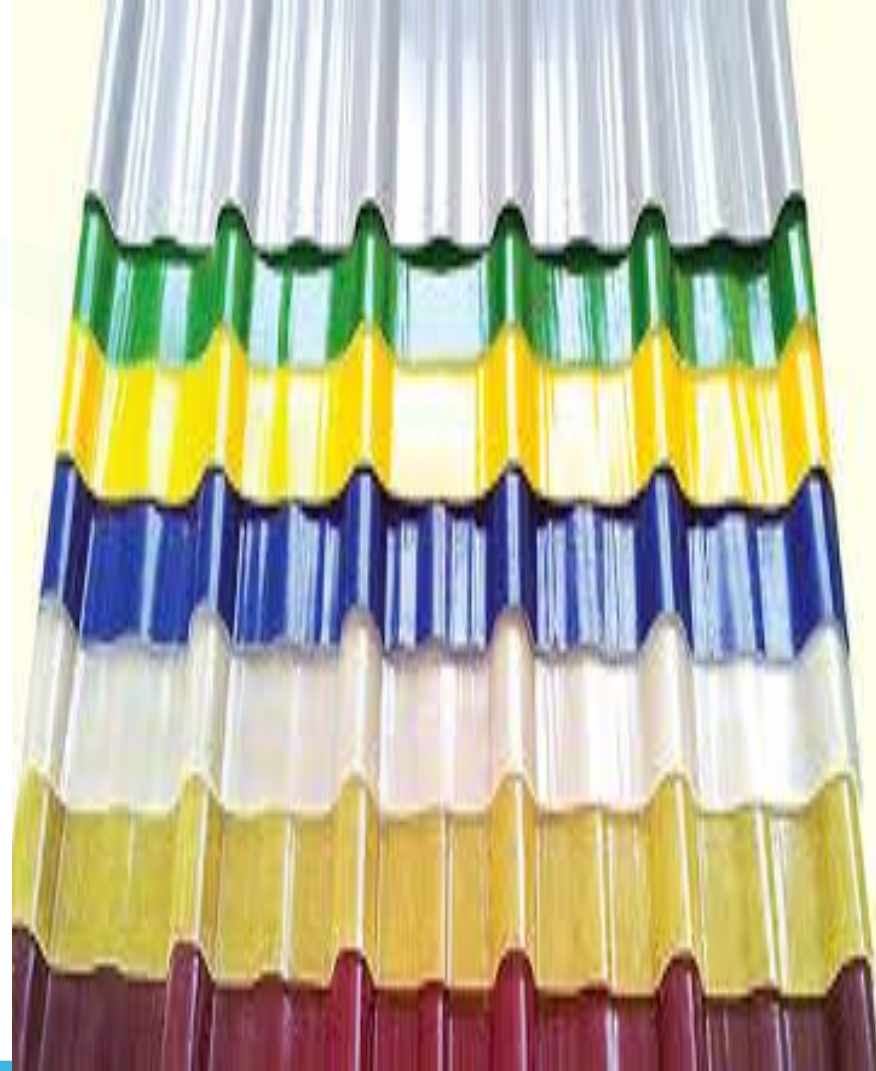
## Aluminium sheets

- Long lasting and economical than steel and cement sheets
- Corrosion free
- This has zero maintenance It has very good scrap value
- Light in weight and better appearance
- Used for sheds, industrial building etc.



## ● Fiber reinforced Polymer sheets(FRP sheets)

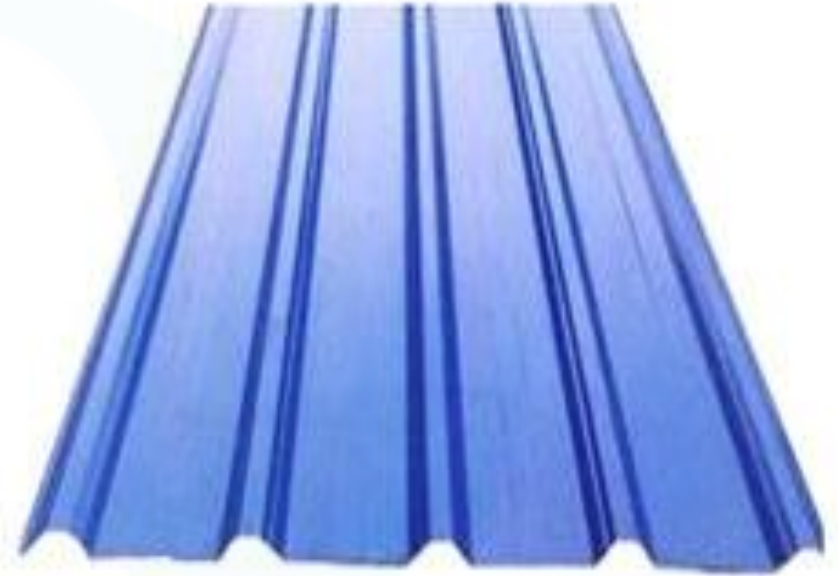
- Made with glass or any suitable fiber with a suitable resin.
- It is popularly known as fiber glass sheets
- It is available in different colors and shapes
- UV protected
- Does not warp or wilt
- Resist the corrosive action of chemicals and acidic vapours





## ● Powder coated sheets

- Aluminium and GI sheets are enhanced by applying powder coating on the surface
- It minimizes the rusting of GI sheets
- It improves the appearance and life



## Plain tiles

- Rectangular in shape and with a thickness of 10 to 17 mm
- Size of tile 25x15 cm to 28x18 cm



## ● Pan tiles

- These are of curved shape (S-shape)
- 33cm to 38 cm in length
- 23 cm in width



## ● Pot tiles

- Semi circular tiles
- Tapering along the length
- The diameter at larger end is 23 cm and smaller end is about 20 cm
- These are also called *half round tiles*





## ● Mangalore tiles

- These are machine moulded
- Burnt in kilns
- The sides of this tiles have grooves to lock with the adjacent tile
- The standard size is 12.5 inches, 13.5 inches and 13.75 inches.



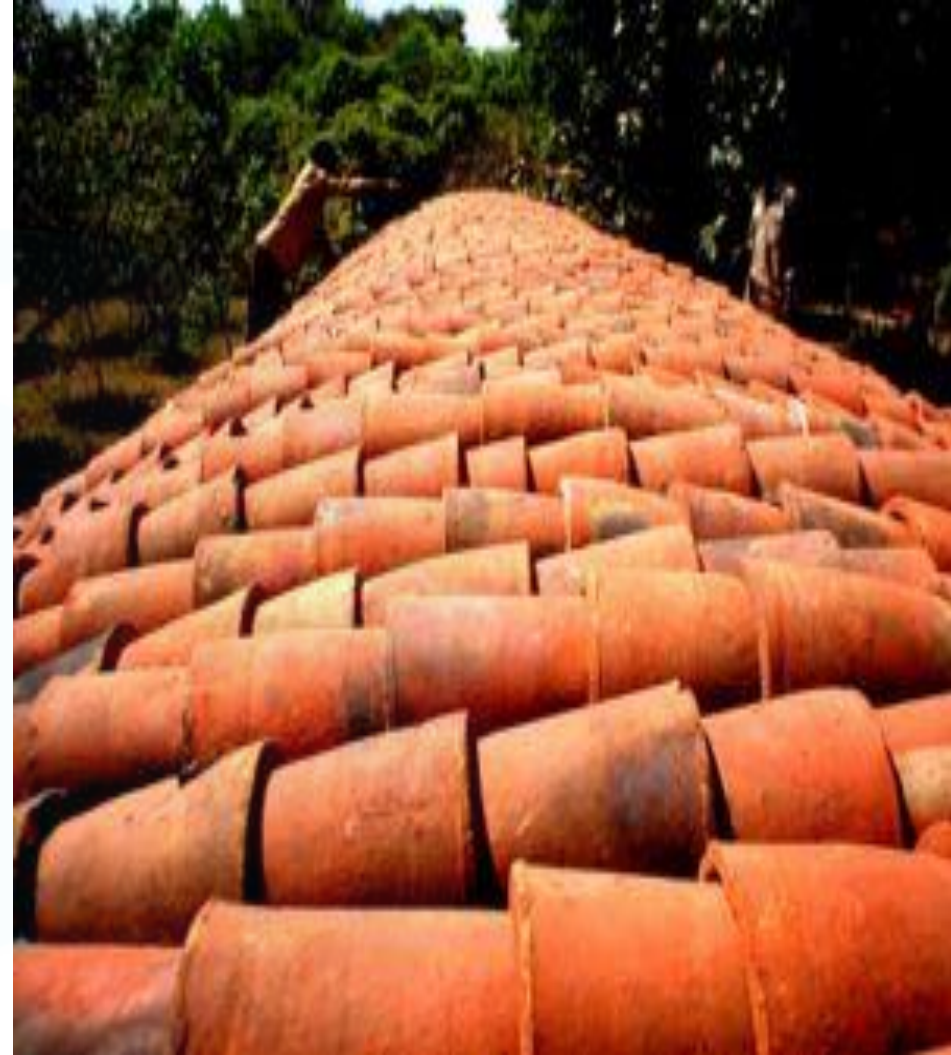
## ● Allahabad tile

- Two sets of tile under tile and over tile constitute Allahabad tile
- The under tile is ***rectangular trough shaped*** and over tile is ***semi-circular shape***



## Guna tile

- These are conical shaped tiles with burnt clay
- These can be inserted one into another to form a ring of tiles



# FLOORS

- Horizontal elements
- Divide building into different levels
  - Ground floor- Floor just above the ground level
  - Upper floor- floors above
  - Basement floor- Floors below natural ground
- Two components-
  - Sub floor- provides proper support to the floor covering and all loads carried on it
  - Floor covering- covering over sub floor which provides a smooth, clean, impervious and durable surface



## *Types of floors*

### ❖ *Ground floor*

- ❖ Filling up the basement with some inert material about 30 to 45 cm from ground level
- ❖ Uniform wearing coat or floor covering is provided

- ❖ Timber floors- made of timber beams and wooden planks
- ❖ Filler joist floor- Rolled steel joists encased in concrete are used in this type of floor
- ❖ RCC Floor- most common type
- ❖ Flat slab floors- beams are avoided and slab directly rests on columns
- ❖ Hollow brick ribbed floor- Hollow bricks or tiles with clay or cement are replaced in the gap of steel reinforcement-empty spaces are filled with concrete
- ❖ Precast concrete floors- Precast concrete floor units are jointed and grouted with cement mortar at site



Timber floor



Filler joist floor



RCC floor





Hollow brick ribbed





## *Floor coverings*

### Mud flooring

-  Cheap and easy to construct and maintain
-  Mud floor is hard impervious and has good thermal insulation capacity





## Stone floor covering

-  Use of square or rectangular slabs of stones like granite, sand stone or marble
-  Stone should be hard durable tough and of good quality






## Brick floor covering

-  Used for cheap constructions like go-downs, barracks, stores etc.
-  The floor is non slippery, hard and durable



## Concrete floor covering

-  Two parts- base course and wearing course
-  Non absorbent, highly durable, smooth surface and fire resistant
-  Poor insulation for sound and heat





## # Mosaic floor covering

- # Concrete base is constructed
- # Over this lime or cement mortar is placed
- # A layer of cementing material 3 mm thick is spread
- # After 4 to 5 hours mixture of colored cement and pieces of broken glazed tiles are laid
- # This is compacted with a light roller
- # The surface is left for 24 hours and is rubbed with pumice stone to get a smooth and polished surface



## + Terrazzo flooring

- + Consist of marble chips as aggregate
- + The flooring laid with this concrete is polished with *carborundum* stone to obtain a smooth finish
- + Marble chips 3-6mm are mixed with white or colored cement in 1:2 or 1:3 to get terrazzo mixture





## ✚ Marble flooring

- ✚ Marble slabs are directly laid over sub grade set in mortar
- ✚ Polished with carborandum stones
- ✚ Hard ,durable and good appearance
- ✚ Adopted in superior type of constructions like hospitals ,theatres, places of worship etc.



## + Granite floor covering

- + Available in different colors and textures
- + Laid in similar way of marble



## + Tiled flooring

- + Used in public, semi public ,residential commercial and industrial buildings
- + Short time of installation, pleasing appearance and durability



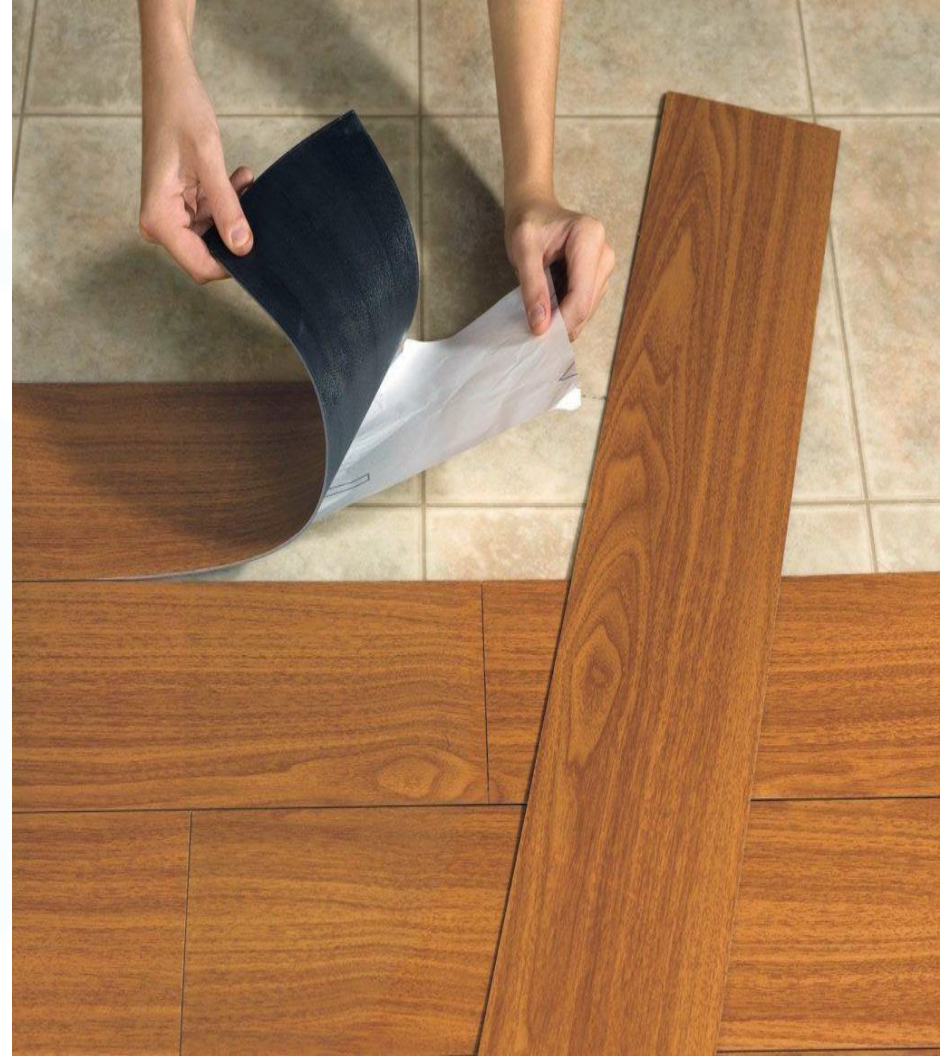
## + Glass flooring

- + Used when desired to allow light to floor below
- + Glasses of thickness 10 to 30 mm are fitted within frames



## + Plastic floor covering

- + Used in all types of buildings
- + Economically used as floor covering on concrete





## + Linoleum floor covering

- + Fabricated form of mixture of resins, linseed oil, gums, pigments, wood flour, cork dust and filler material
- + Available in rolls of 2-4 m width, 2-6mm thick
- + Laid over floors or pasted with adhesives
- + Surface can be easily washed and cleaned

