EWCE: 343
Geotechnical and Foundation Engineering.

Foundation Engineering

What we are going to discussed today?

- Foundation Engineering
- **Definition of Foundation and Aspect of Foundation Engg.**
- Purpose of foundation.
- **Bearing capacity failure**.
- Loads on foundation.
- Types of Foundation
- Factors affecting depth of shallow foundation

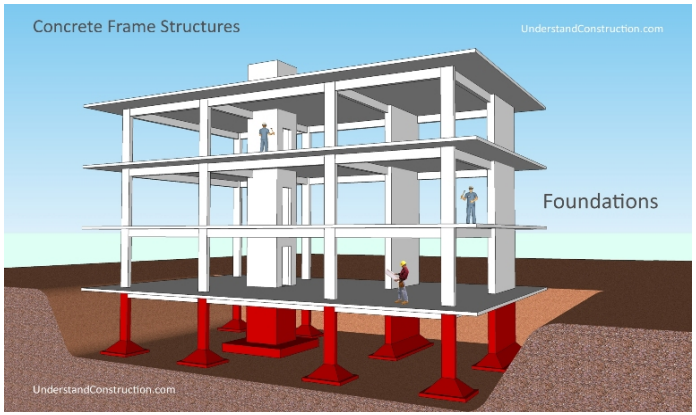
What is Foundation Engineering?

Foundation engineering is a **branch of geotechnical engineering** which applies **soil mechanics**, **structural engineering**, and **project serviceability requirements** for design and construction of foundations for structures.

Definition of Foundation

- **Element of structure** which **connect** **the structure to the ground** and **transfer loads** **from the structure** to the ground **safely and economically**.

- **Structural elements** that **connect buildings**, bridges and other structures **to the ground** are called foundation.





Aspects of Foundation Engineering:

- Deals with the **selection of types** **of foundation** (either shallow or deep)- **most basic aspect**.

- Involves the **development** **of** design parameters (bearing pressure etc)- **important aspect.**

Purpose of Foundations

- **Distribute the load** of the structures to a **large bearing area** of soils.
- **Prevent bearing capacity failure** and **excessive settlement.**
- **Obtain a level of hard strata** or bed for building operations
- **Increase stability** of the structure as a whole.

Bearing Capacity Failure

- Defined as a **foundation failure that occurs when the shear stresses** in the soil **exceed** the **shear strength** of the soil.
- Bearing capacity failures of foundations can be grouped **into three categories**, as general, local and punching shear failures.







General Shear Failure

load (q)

q_{ult}

q_a

Failure surface in soil

settlement

Local Shear Failure

load/Area (q)

Failure surface

settlement

series

Punching Shear Failure

load/Area (q)

Failure surface

settlement

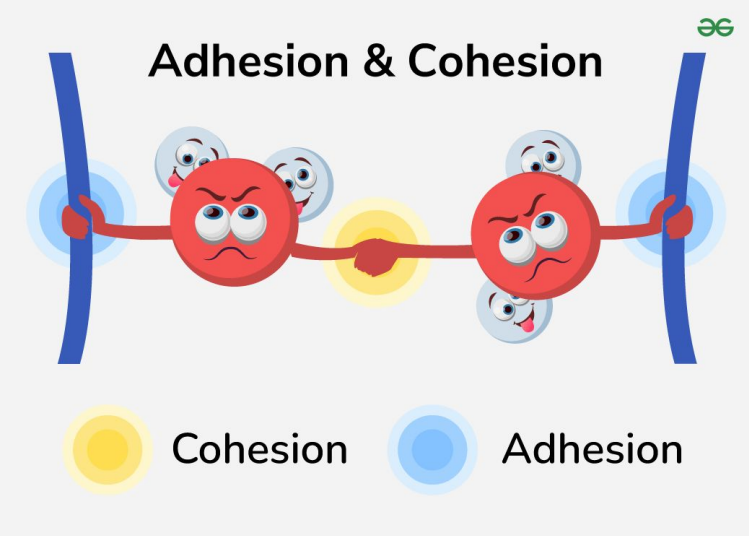
How soils derive the Shear Strength

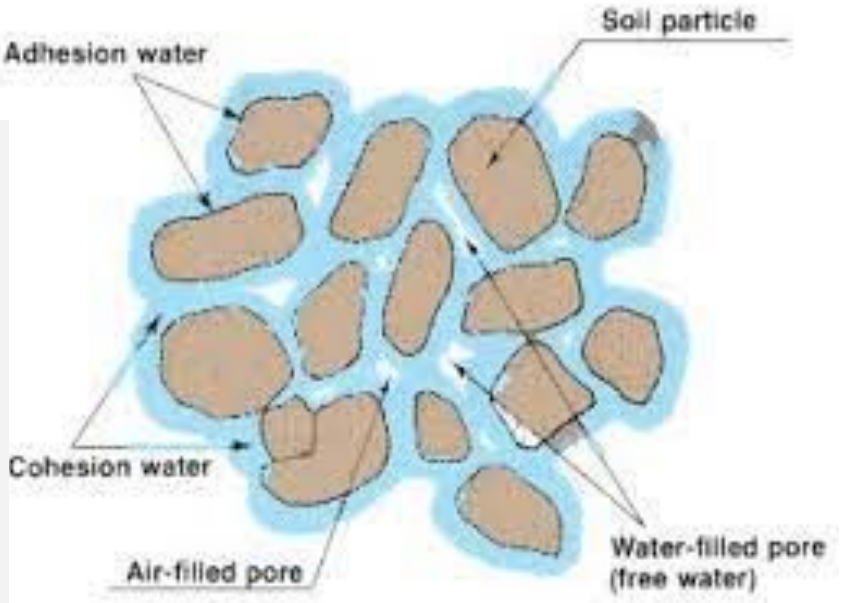
Soil **derives its shearing strength** from the following:

- **Resistance** due to **interlocking of particles**
- **Frictional resistance** between the individual soil grains
- **Adhesion:** Firm attachment to water molecules and sold surface of soils.
- **Cohesion** : Ability of **like particles** within soil to hold onto each other.

$$S = c + \sigma \tan \varphi$$

Value of Q_{ult} divided BxL of the footing (Area) is considered to be the ***ultimate bearing capacity*** (q_{ult}) of the footing.





Loads on Foundation:

Dead Loads: the downwards force on the building coming from the **weight of the building itself**.

Live Loads/Imposed load: the **downwards force on the building** coming from the expected **weight of the occupants** and **their possessions**.

Dynamic Loads: these occur commonly in **bridges and similar infrastructure**, and are the **loads created by traffic**, including braking and accelerating loads.

Wind Loads: A very important design factor, especially for tall buildings, or buildings with large surface area.

Earthquake Loads: In an earthquake, the **ground vigorously shakes** the building both horizontally and vertically

Types of foundations



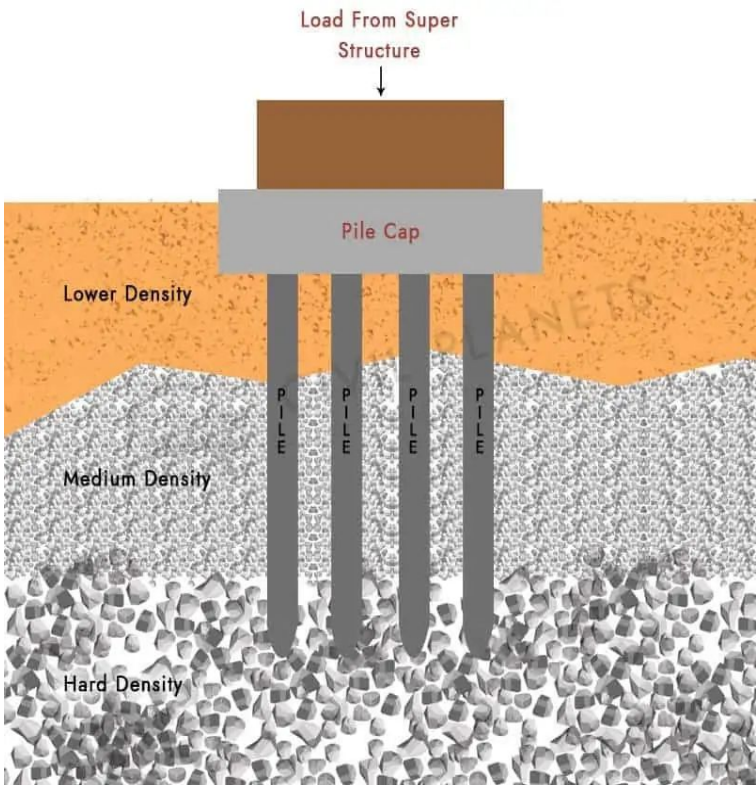
Categories

Shallow Foundations:

Transmit structural loads to near surface soils/rocks.

Deep foundations:

Transmit some or all of the structural loads to a deeper soils/rocks.



Shallow Foundations

- **Transmit** the structural loads to **nearby soils/rocks.**
- **Placed on a firm soil near the ground surface**, generally **1m-3m** from the ground surface.
- **Foundation depth** must meet the **safety requirements** that after the load application, the complete structure **settlement will be within acceptable limits**.
- **Foundation depth** is also **conditioned by local climate and other conditions.**

$\frac{D}{B} \leq 1$

Why we use Shallow Foundation?

- To **distribute** the structural loads **over a large areas at shallow depth**.
- **Favorable** where **D ≤ B**

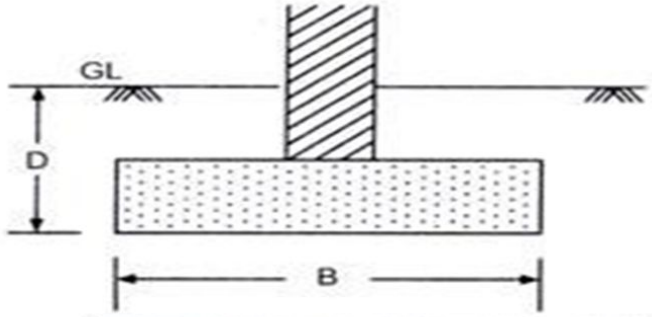


FIG. 11.2 Shallow foundation

Advantages of Shallow Foundations

- Construction **works are simple**
- **Equipment** used are **less costly and simple**
- **Less time** is required
- Causes **less disturbance** of ground, hence good for ecology and environment
- **Less uncertainty** of soil behavior
- Comparatively **less costly**

Disadvantages of Shallow Foundations

- **Chance of scouring** if the structure is near river or sea.
- **Uneconomical** if ground water is high
- **Can not be used** where **bearing capacity** of soils are not adequate

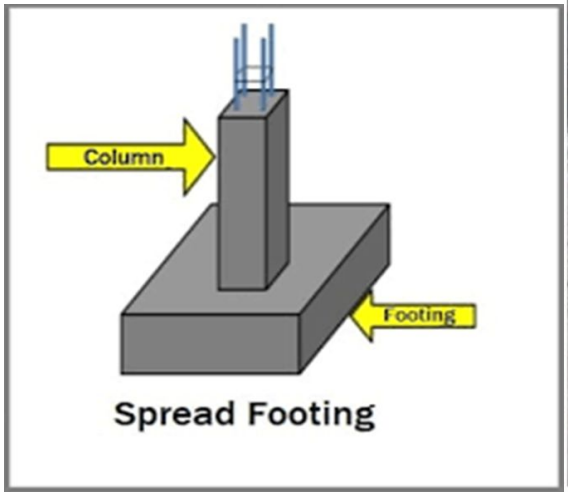
Types of Shallow Foundation

- Spread or isolated footing
- Strip footing\Continuous Footing
- Combined footing
- Raft Footing or Mat Foundation

Spread Footing

- Also called as **isolated footing**, **pad footing** and **individual footing** is **provided to support an individual column.**

- **Spread the super-imposed load of column over a larger area.**

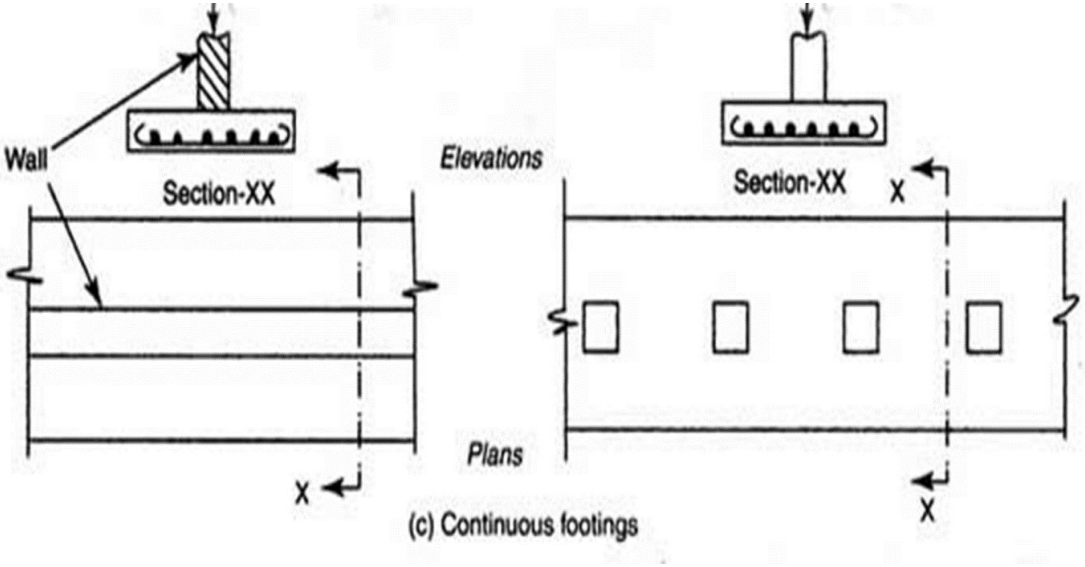




Strip Footing

- Also called **wall footing or continuous footing**.
- Carry **closely spaced columns or a continuous wall** so that the **load intensity is low and uniform on the supporting soil or rock** .
- When it is **more economical to provide a strip footing** than to provide a **number of spread footings** in one line.
- Used for an L/B> 5.
- **Prevent the horizontal distortion** of individual foundations and **strengthen** them.





Combined Footing

•Supports **two columns in a row.**

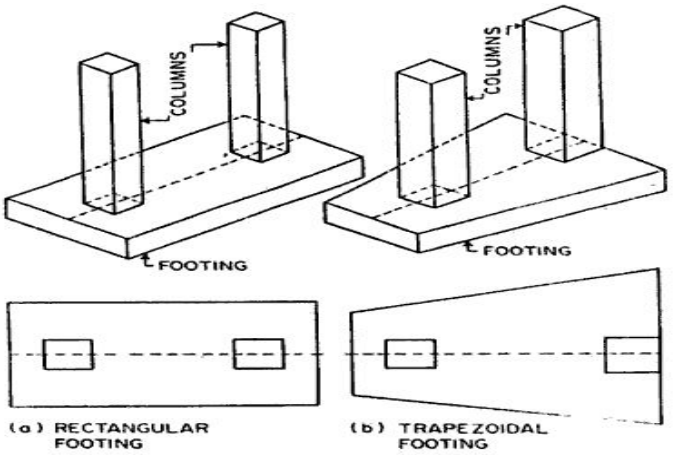
•Can be **rectangular** in shape if both the columns carry equal loads, or can be **trapezoidal** if there are space limitations.

Uses of Combined Footing

- When the **two columns are close together** so that two or more **separate isolated footings would overlap**.
- When the **distance between two columns is small** and **bearing capacity of soil is lower**.
- When the **dimensions of one side of footing are restricted to some lower value**.



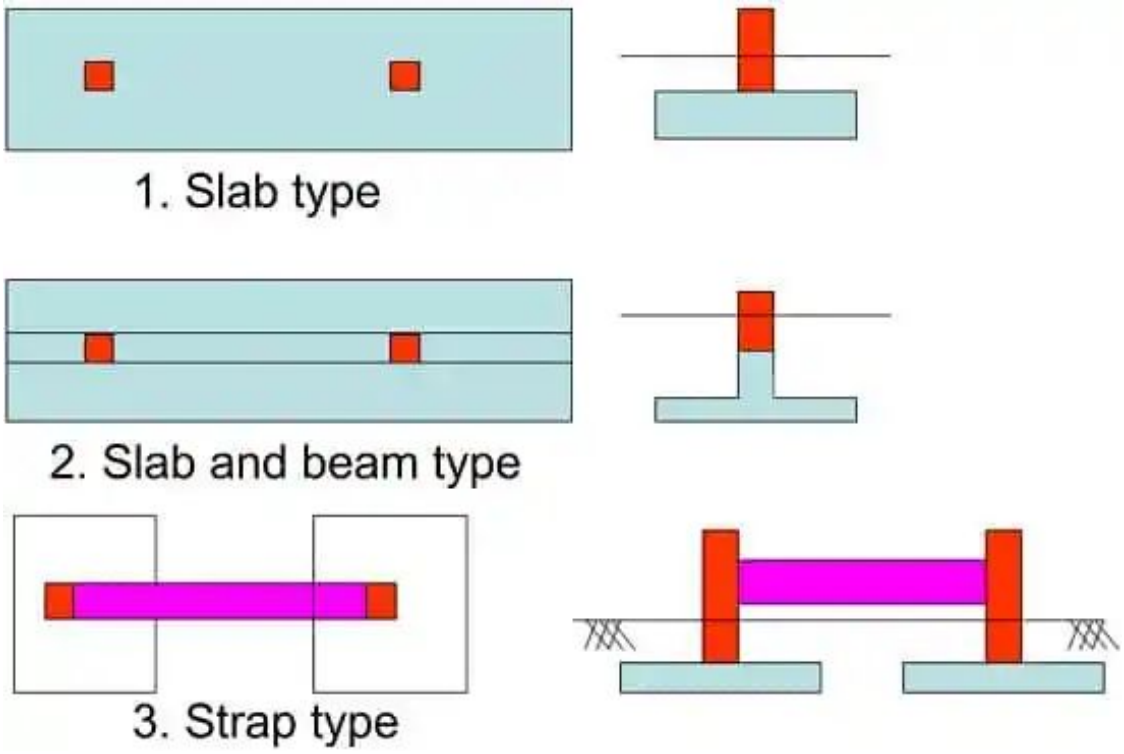




Types - Combined Footing

- **Slab type** - supports two or more column **with bottom slab only**.

- **Slab-beam type** - supports two or more column **with bottom slab and beam**.



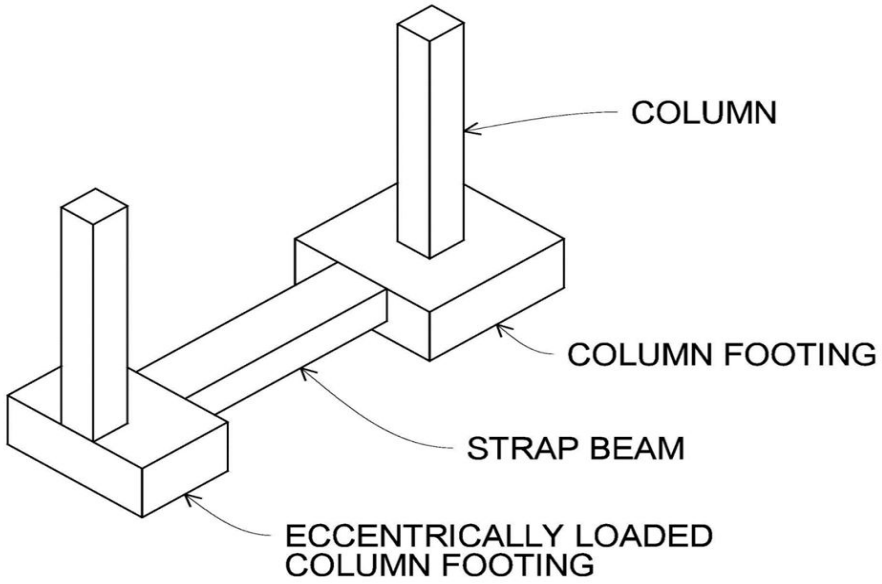




Strap-beam type combined footing:

•Used when **one column is located on a property line**, resulting in is an **eccentric load** on a portion of the footing.

•**Provide a strap beam** in the footing to the adjacent column footing **to restrain the overturning effect.**





Raft Footing or Mat Foundation

•A **thick concrete slab**, **resting on a large area of soil, reinforced** with steel, **supporting columns or walls** and **transfer loads** from the structure to the soil.
•Spread over the entire area of the structure **or even more,** it is supporting.

Generally used to **support structures:**

- Residential or commercial buildings where **soil condition is poor,**
- **Storage tanks**,
- **Silos,**
- Foundations for **heavy industrial equipment** etc.
- When **Basement** is required

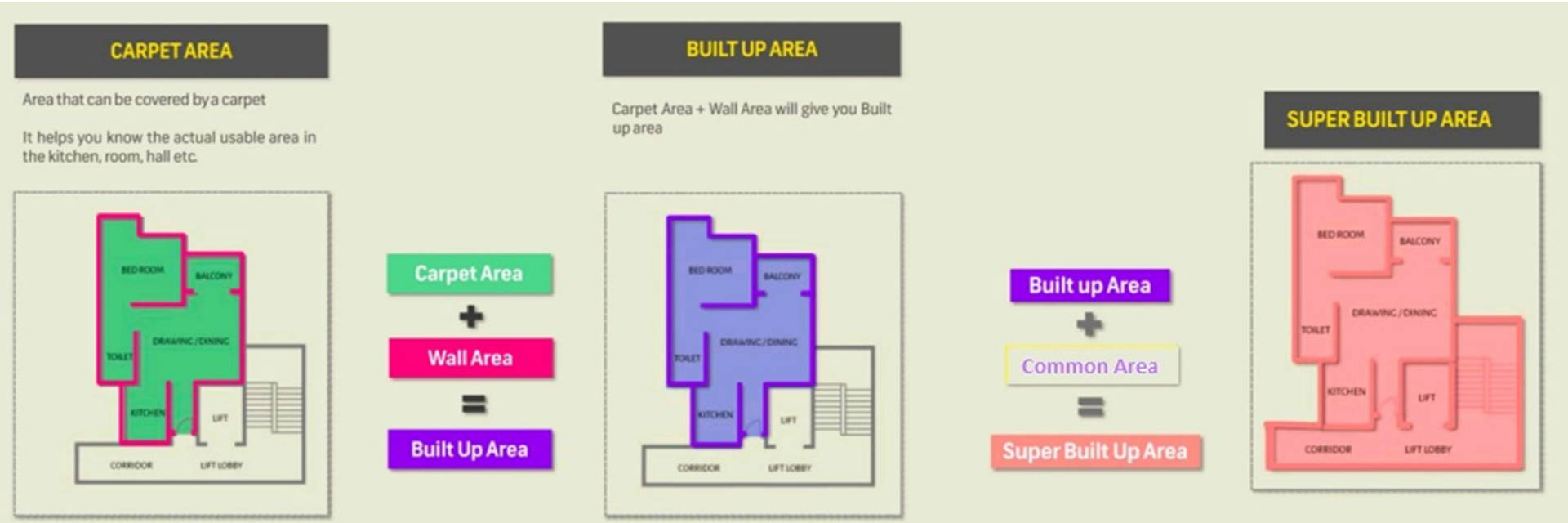


Plinth Area & Carpet Area

Plinth Area:

- Covered total **built-up area at floor level**.
- **Entire area occupied by the building** including internal and external walls.
- Area is generally **10-20% more than carpet area.**

Carpet Area: Covered area of the usable spaces of rooms at any floor.



Difference between Carpet area, builtup area and super area

When to Choose Mat Foundation ?

- **Soil has a low bearing capacity** and stresses on soil needs to be reduced.
- **Load** of the structure **need to be distributed over a large area.**
- Individual or any other foundation area would **approximately cover 50%** of the total ground area beneath the structure.
- **Columns or walls are placed so closely** that the **individual footings would overlap.**
- **Possibility of differential settlement** in case individual footing is used.
- **When soil strata** are **unpredictable** and **contain pockets** of compressible soil.
- **Basement** is to be constructed.
- Any other type of **footing cannot be used** advantageously.

Types of Mat Foundation

Depending on the **condition of soil and the load imposed** on the foundation.

Different types of raft foundations:

- **Flat Plate**
- **Plate thickened under column**
- **Two-way beam and slab raft**.
- **Plate raft with pedestals**
- **Piled raft**
- **Cellular raft foundation**.

Flat plate mat foundation:

- **Simplest** form.
- Used when columns and walls are uniformly **spaced at small intervals** and the subjected **loads are relatively small.**

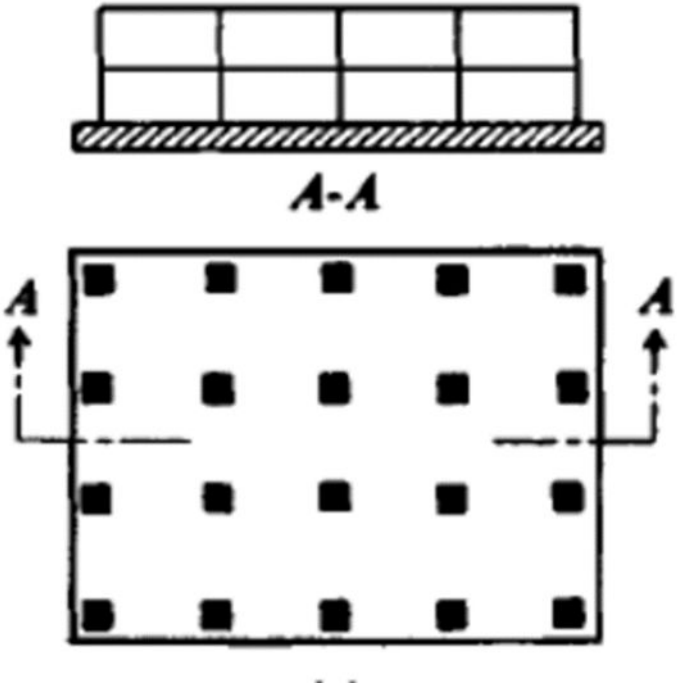
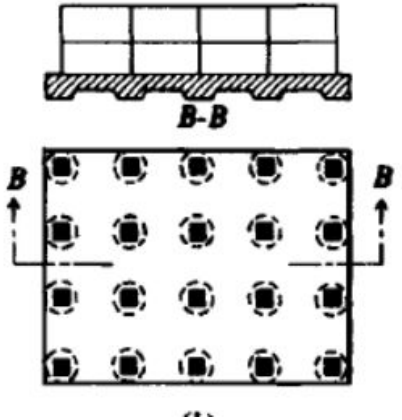


Plate Thickened under Column's Raft

- When the **columns and load bearing walls** are **subjecte** the **slab is thickened under the columns and walls**.



Two-way Beam and Slab raft:

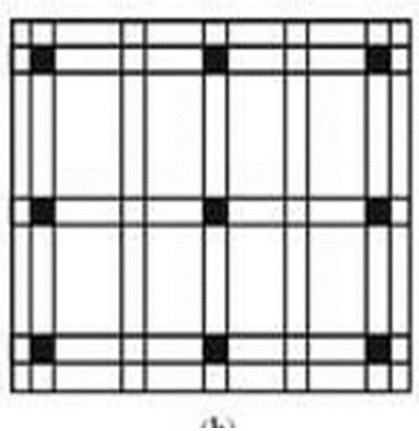
- **Beams are cast monolithically** with the **raft slab**

connecting the columns and walls.

- Suitable when:

  -the **columns are placed at a larger distance** and

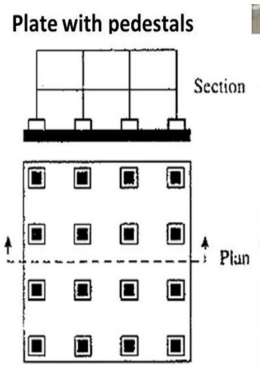
  -the **loads on the columns are variable.**



Plates with Pedestals

- **Pedestals are provided** at the base of the columns.

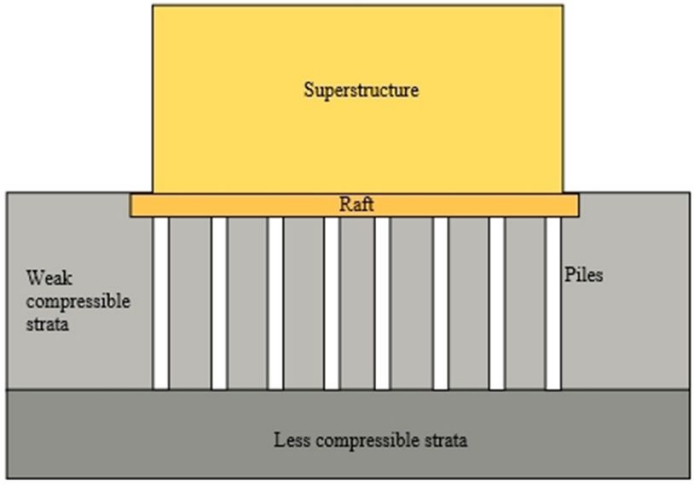
- Purpose of this type of foundation is when the **columns and load bearing walls** are subjected tc **heavier loads**



(d)

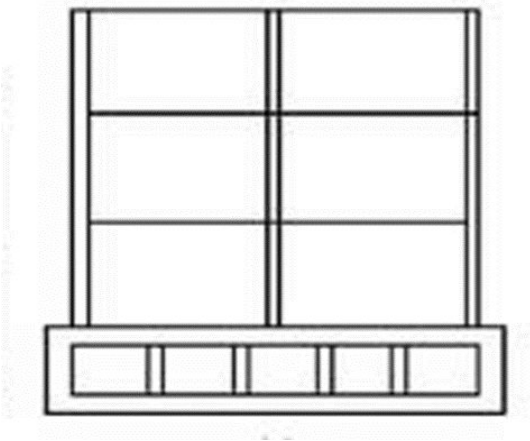


Piled Raft - Foundation



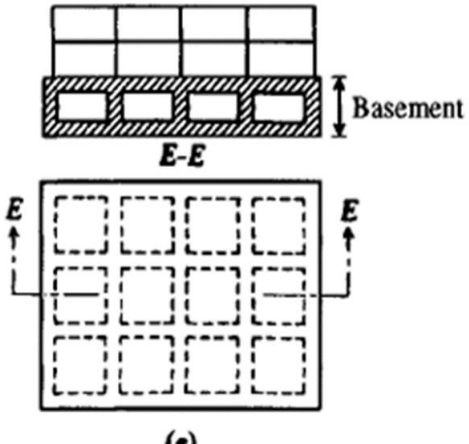
- **Raft foundation** is **supported on piles**.
- Used when the soil at a shallow depth **is highly compressible** and the **water table is high**.
- Piles under raft help in **reducing settlement and provides resistance** against buoyancy.

Cellular Raft Foundation



- In this type of raft, the **foundation walls act as a deep beam**.

- Here **two concrete slabs are placed**, one on top of another and **connected with foundation walls** in both directions and thus **forms a cellular raft.**



- **Very rigid** and is **economical** when the required **slab thickness is very high.**

Factors Affecting the Depth of Shallow Foundation.

1. Thickness of top layer:

- If soils contain a good percentage of vegetable and organic decaying mater, **then foundation to be placed below the thickness of this organic matter**.

2. Ground freezing:

- When, air temperature falls below 0°C for extended periods, soil temperature drops and **pore water turns to ice** which is **called ground freezing**.

- Has significant impacts on foundations built on such soils due to **frost heave**, due to formation of underground ice, **called ice lens**.

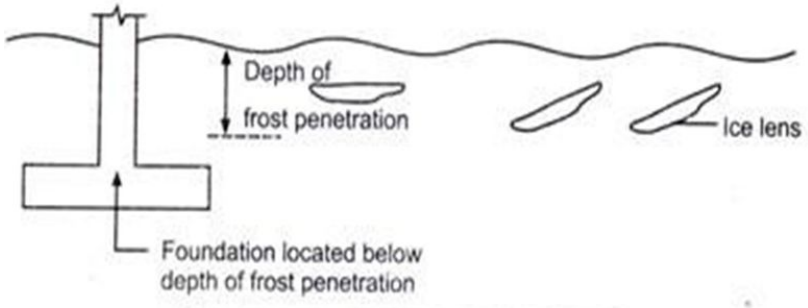


FIG. 11.9 Formation of ice lenses

3. Depth of volume change:

- Some soils undergo **volume changes due to alternate wetting and drying**, like **black cotton soil**.

- In such soil, **foundation should be located below the zone of volume change.**

4. Depth of scour:

- For **structure adjoining rivers or streams**, subjected to scouring action of water**, depth of scour should be kept in mind** for location of foundations.

5. Groundwater Level:

- As far as possible shallow **foundations are placed above groundwater level** in order to **avoid construction difficulties** and to **prevent uplift forces** acting on foundations.

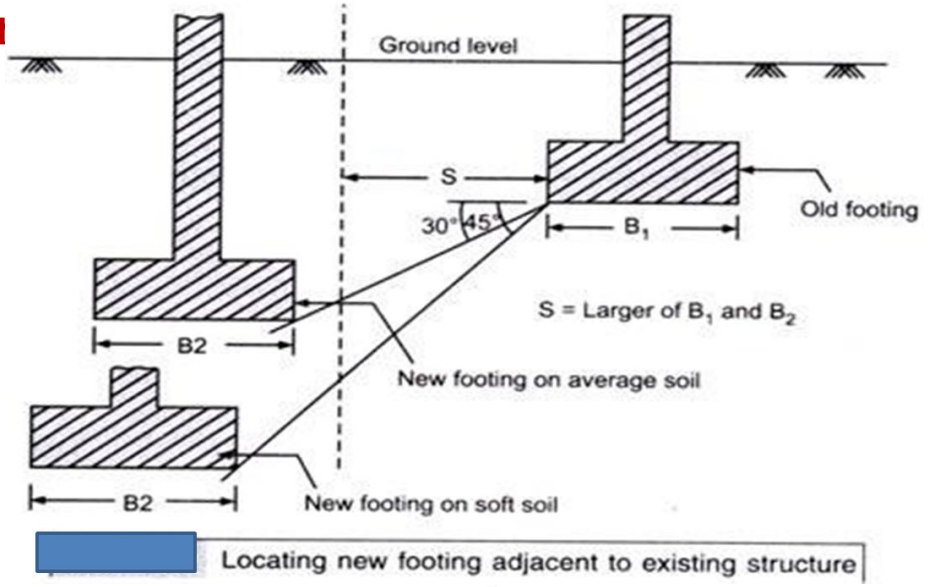
6. Underground utilities and defects:

- **Underground utilities** like water supply lines, sever lines etc. should be kept in mind while deciding the depth of foundation.

- **Underground defects** like cavities, abandoned mines etc. should also be considered while planning location of foundation.

7. Property line and adjoining structu

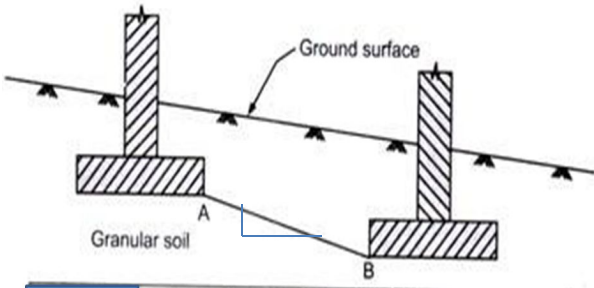
- If a construction is to be made near an adjacent property line, the foundation should be so located that it **should not extend into adjacent property line** to avoid legal disputes.



Locating new footing adjacent to existing structure

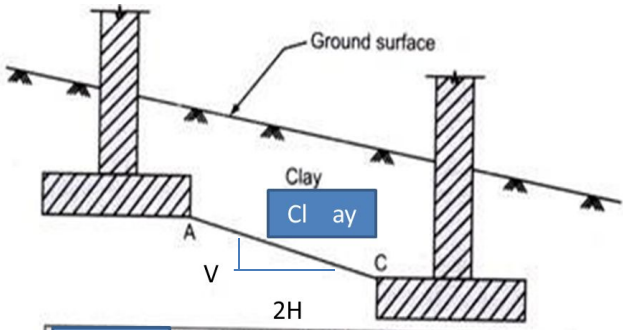
8. Footing at Different Level

- **Granular Soils**: For footing in **granular soil**, a line drawn between the lower adjacent edges of adjacent foundations **should not have a slope steeper than 2 H: 1 V.**



Foundations at different level in granular soils

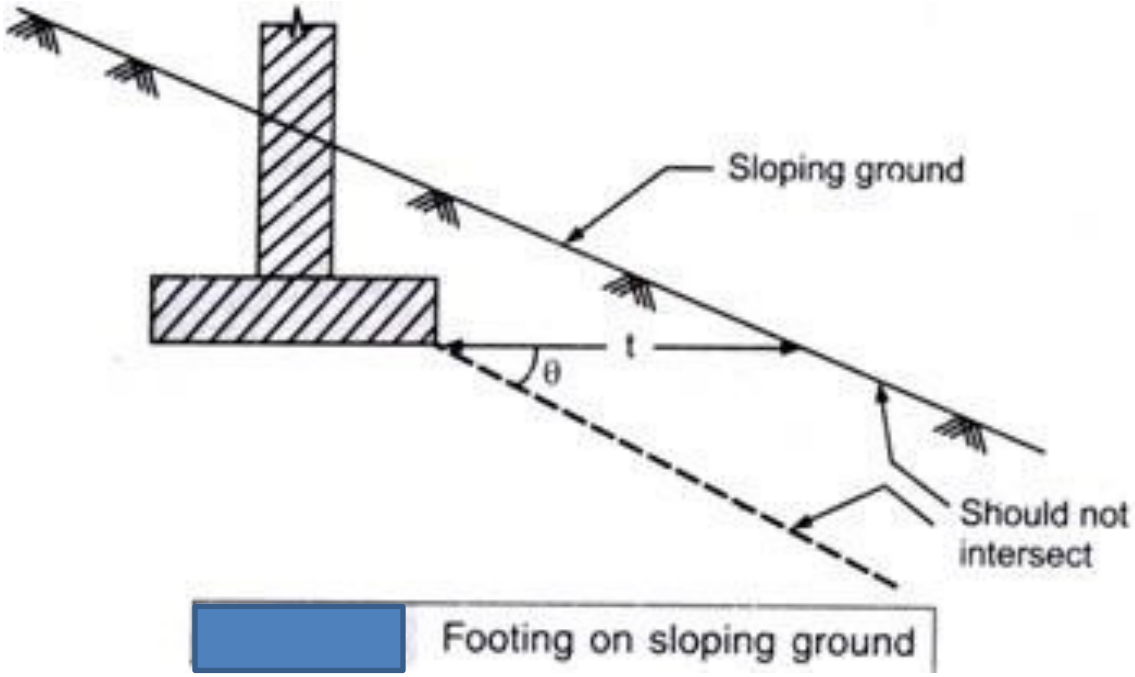
- **Clay Soils**: For footing in **clay soils**, a line drawn between the lower adjacent edge of the upper footing and upper adjacent edge of lower footing **should not have a slope steeper than 2H: 1 V .**



Foundations at different levels in clay soils

9. Sloping Ground:

When foundation is to be located on a sloping ground, the depth of foundation should be such that **a line drawn from the bottom edge of the foundation at angle of 30° and at a horizontal distance of 90 cm should not intersect**.



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