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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

23GET102 – BASIC CIVIL AND MECHANICAL ENGINEERING

I YEAR / I SEMESTER

Unit 2 : Building Components

Topic : Sub Structure – Types of Foundation

Sub Structure

- The substructure is the part of the building that is built below the ground level whereas superstructure is the part of the structure that is constructed above the ground level.
- The substructure is the lower part of a building which is constructed below the ground level.
- The function of substructure is the transfer of loads from the superstructure to the underlying soil.
- So, the substructure is in direct contact with supporting soil. Substructure involves footing and plinth of a building.

Sub Structure

Superstructure	Substructure
Part of a building that constructed above ground level	Portion of a building that constructed below ground level
It serves the purpose of building's intended use	It transfers loads received from superstructure to supporting soil
Superstructure elements include walls, columns, beams, doors and windows, etc.	Elements of substructure include foundation and plinth.

Foundation

- Foundation is the lowest portion of a structure which transfers the load into the supporting soil.
- The main purpose of the foundation is to distribute the total weight of the superstructure over a large area of soil.
- Various types of foundations are described below which are used in construction.

Purpose of Foundation

- To distribute the load of the structure on a bigger area so that the intensity of load does not exceed the safe bearing capacity of the underneath soil.
- To distribute the load on underneath soil uniformly and thus to prevent unequal settlement of the foundation.
- To provide a leveled and hard surface for the super-structure to be built over it.
- To increase the stability of the structure against sliding, overturning, or any other forces like wind, rains, etc.
- To prevent lateral movement of the supporting material to ensure the safety of the structure is not at risk.

Types of Foundation

Shallow foundation

- Individual footing or isolated footing
- Combined footing
- Strip foundation
- Raft or mat foundation

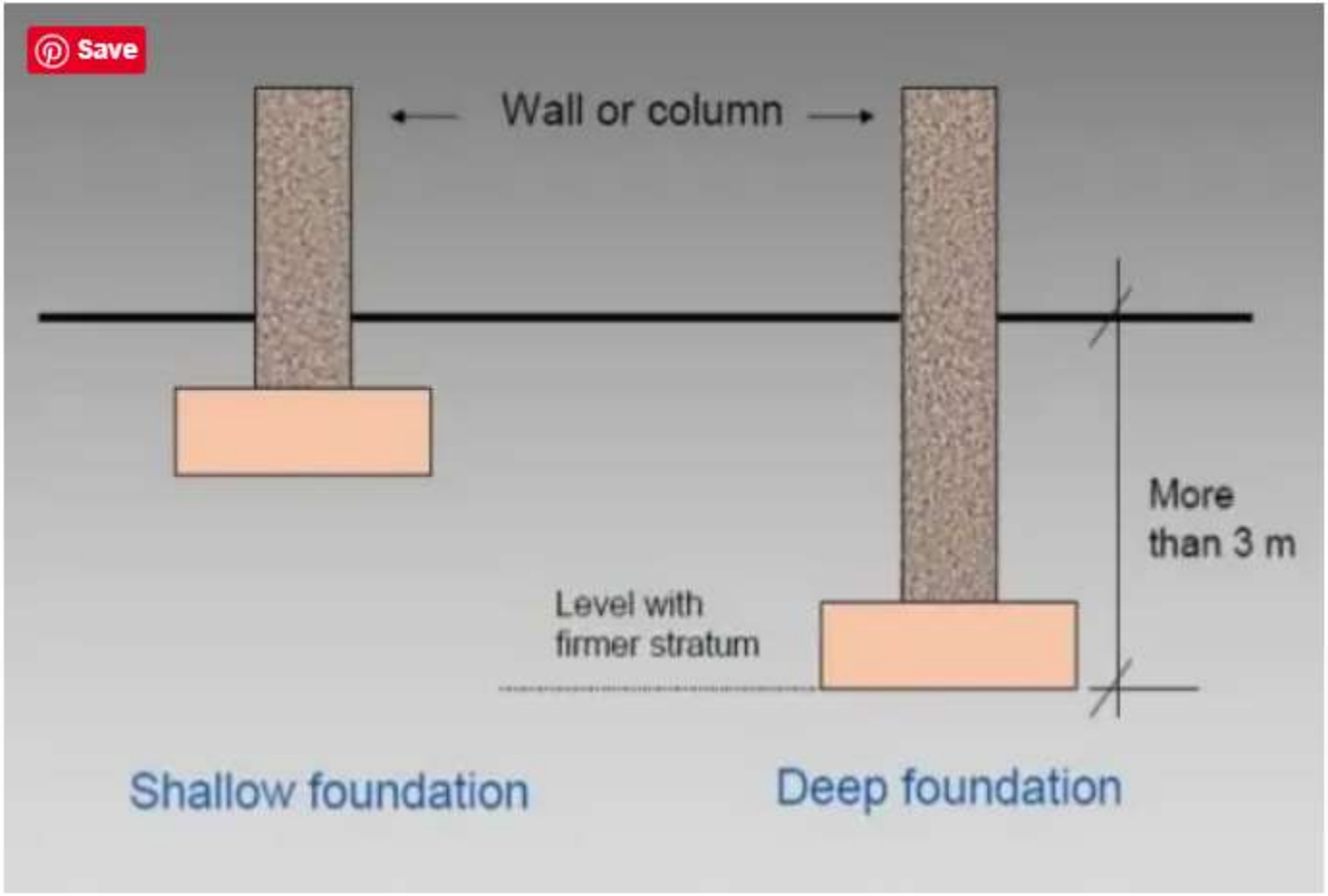
Deep Foundation

- Pile foundation
- Drilled Shafts or caissons

Shallow Foundation

- When the depth of the foundation is equal to or less than its width it is called a shallow foundation.
- In this type of foundation, the foundation part is situated instantly below the lowest part of a structure.
- The total load of the structure is distributed over a horizontal area at shallow depth below the ground level.
- In simple words, if a foundation is constructed at reasonable depth then it is a shallow foundation.

Shallow Foundation



Isolated Footing

- This is the most widely recognized and most straightforward shallow foundation type, as this is the most economical type.
- They are typically utilized for shallow establishments to convey and spread concentrated burdens caused, for instance, by pillars or columns.
- They are generally used for ordinary buildings (Typically up to five stories).
- Individual footing or an isolated footing is the most common type of foundation used for building construction.
- This foundation is constructed for a single column and also called a pad foundation.
- The shape of individual footing is square or rectangle and is used when loads from the structure is carried by the columns.

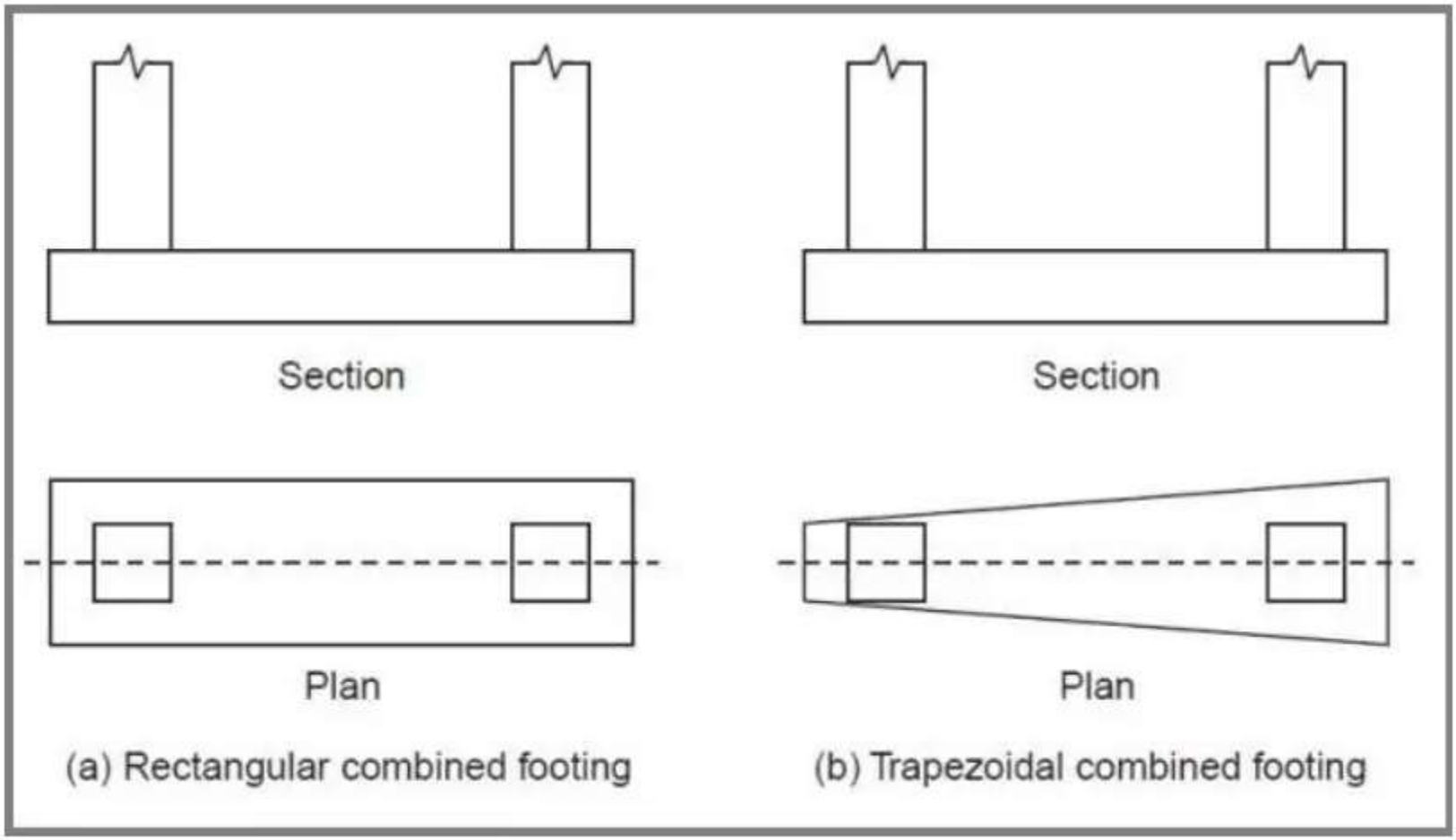
Isolated Footing

- Size is calculated based on the load on the column and the safe bearing capacity of soil.
- Rectangular isolated footing is selected when the foundation experiences moments due to the eccentricity of loads or due to horizontal forces.

Combined Footing

- Combined footing is constructed when two or more columns are close enough and their isolated footings overlap each other.
- It is a combination of isolated footings, but their structural design differs.
- The shape of this footing is a rectangle and is used when loads from the structure is carried by the columns.
- Combined footing consists of a common footing provided to two columns which may be either rectangular or trapezoidal.

Combined Footing



Combined Footing

Spread or Strip Footing

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

Spread or Strip Footing

- **Strip Footing**: This type of footing distributes the weight of a load-bearing wall across the area of the ground. The footing usually has twice the width of the load-bearing wall, sometimes even wider.
- **Strap Footing**: In strap footing, the outer and inner column is connected by a strap beam, which does not transfer any load to the underlying soil.

Spread or Strip Footing

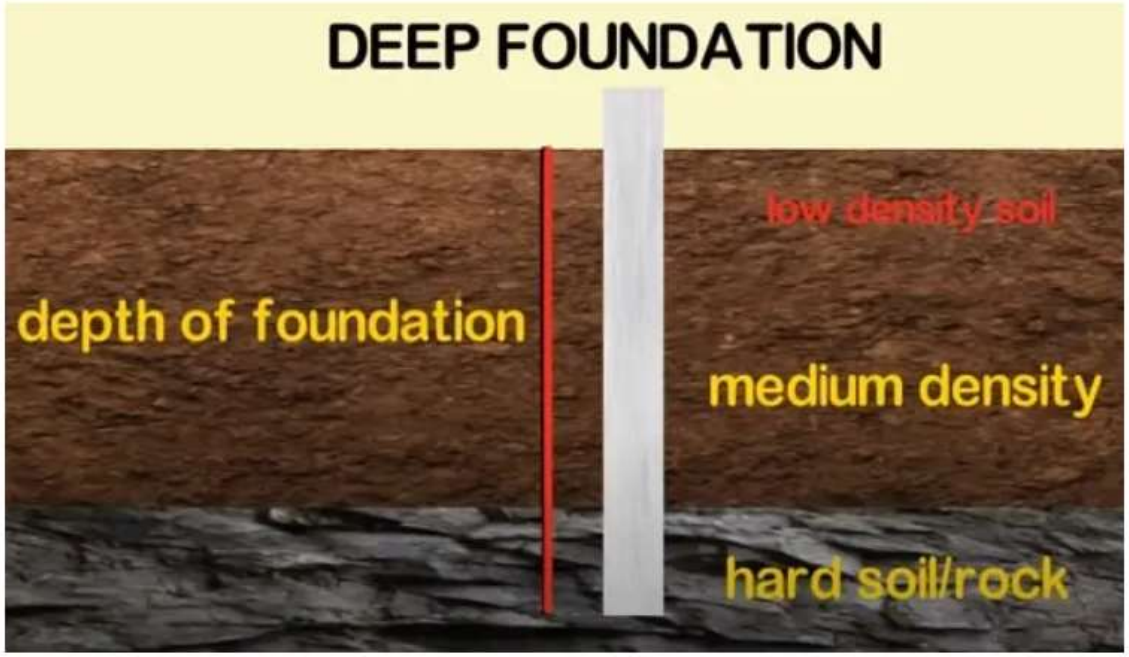
Raft or Mat Footing

- Raft or mat foundations are the types of foundation which are spread across the entire area of the building to support heavy structural loads from columns and walls.
- Raft or Mat foundations are used where other shallow or pile foundations are not suitable. It is also recommended in situations where the bearing capacity of the soil is inadequate, the load of the structure is to be distributed over a large area, or the structure is subjected continuously to shocks or jerks.
- The use of mat foundation is for columns and walls foundations where the loads from the structure on columns and walls are very high.
- This is used to prevent differential settlement of individual footings, thus designed as a single mat (or combined footing) of all the load-bearing elements of the structure.

Raft or Mat Footing

Deep Foundation

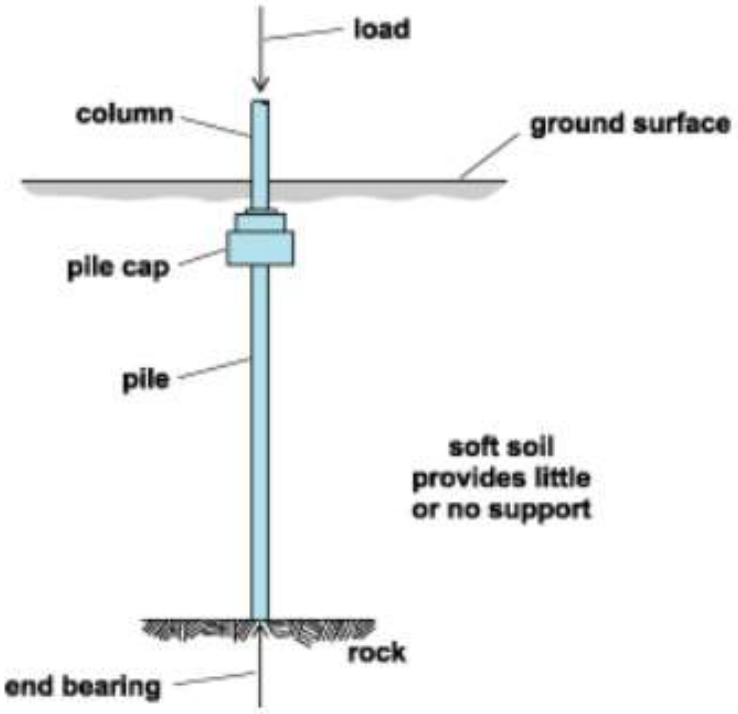
- A deep foundation is a type of foundation in which the foundation is placed at a deeper depth below the ground level. The depth of the foundation is much greater than its width.



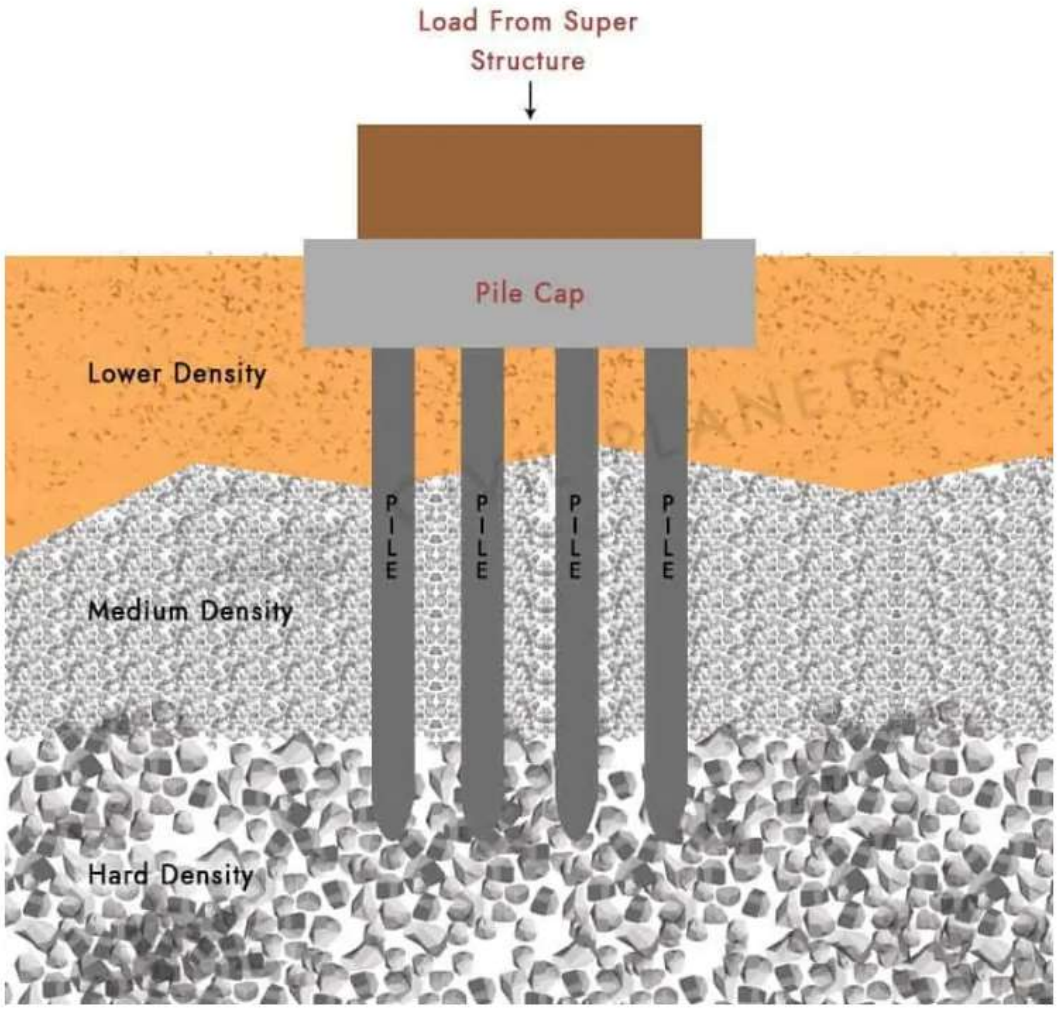
Pile Foundation

- Pile foundation is a type of deep foundation which is used to transfer heavy loads from the structure to a hard rock strata much deep below the ground level.
- Pile foundations are used to transfer heavy loads of structures through columns to hard soil strata which is much below ground level where shallow foundations such as spread footings and mat footings cannot be used.
- This is also used to prevent uplift of the structure due to lateral loads such as earthquakes and wind forces.

Pile Foundation



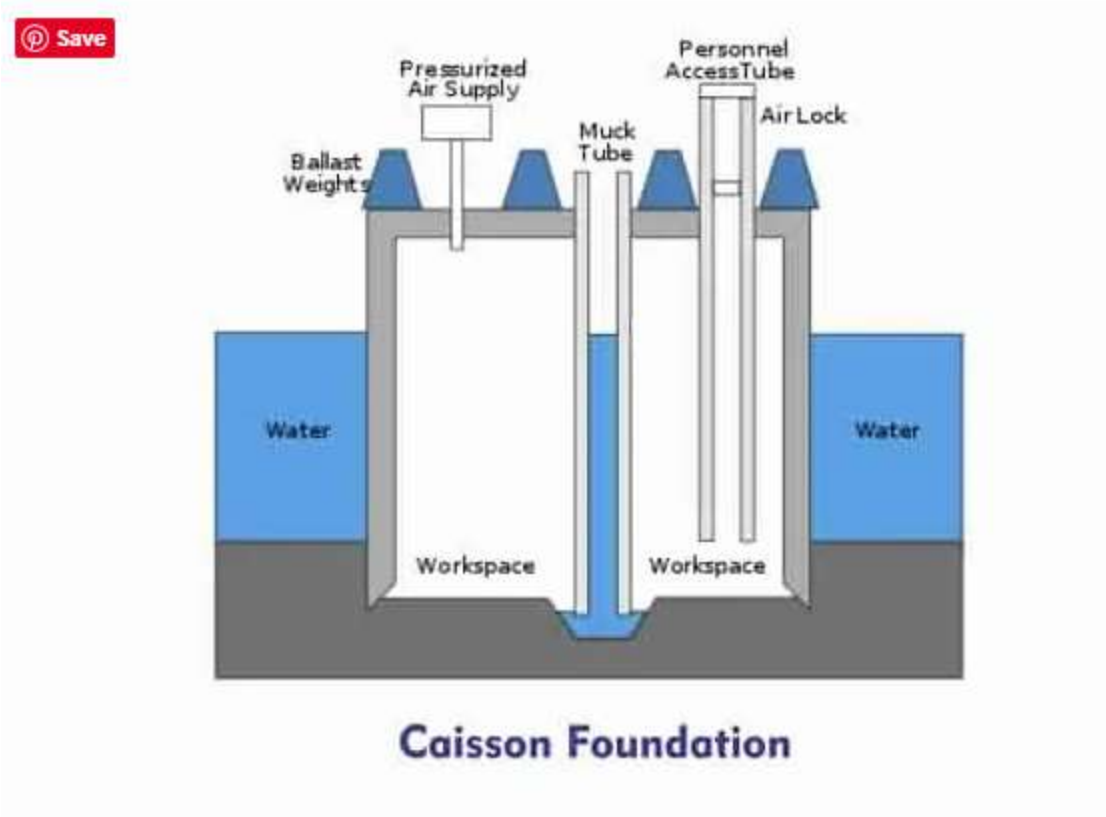
Pile Foundation



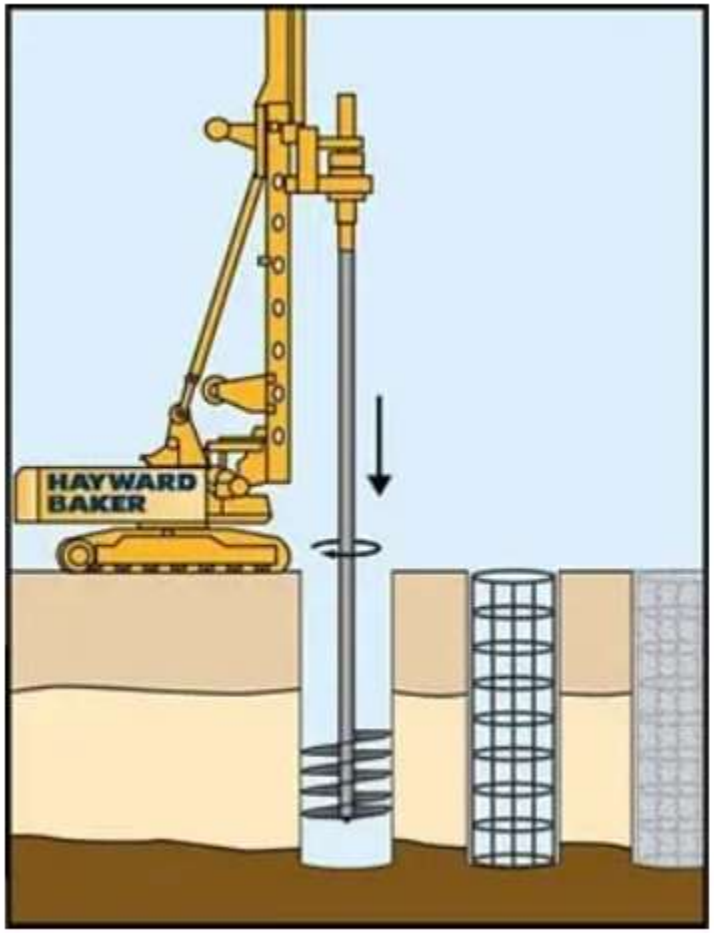
Drilled Shafts or Caisson Foundation

- Drilled shafts, also called as caissons, is a type of deep foundation and has an action similar to pile foundations discussed above, but are high capacity cast-in-situ foundations.
- It resists loads from structure through shaft resistance, toe resistance and/or combination of both of these.
- The construction of drilled shafts or caissons are done using an auger.
- Drilled shafts can transfer column loads larger than pile foundations. It is used where the depth of hard strata below ground level is located within 10m to 100m (25 feet to 300 feet).
- Drilled shafts or caisson foundation is not suitable when deep deposits of soft clays and loose, water-bearing granular soils exist. It is also not suitable for soils where caving formations are difficult to stabilize, soils made up of boulders, artesian aquifer exists.

Drilled Shafts or Caisson Foundation



Drilled Shafts or Caisson Foundation



Bearing Capacity

- The bearing capacity of soil is defined as the capacity of the soil to bear the loads coming from the foundation. The pressure which the soil can easily withstand against load is called allowable bearing pressure.
- When excavating for a foundation, the stress at founding level is relieved by the removal of the weight of soil. The net bearing pressure (qn) is the increase in stress on the soil.

$$qn = q - qo$$

$$qo = g\ D$$

where D is the founding depth and g is the unit weight of the soil removed.

Types of Bearing Capacity

Following are some types of bearing capacity of soil:

1. Ultimate bearing capacity (qu)

The gross pressure at the base of the foundation at which soil fails is called ultimate bearing capacity.

2. Net ultimate bearing capacity (qnu)

By neglecting the overburden pressure from ultimate bearing capacity we will get net ultimate bearing capacity.

$$q_{nu} = q_u - \gamma D_f$$

Where gamma= unit weight of soil, Df = depth of foundation

Types of Bearing Capacity

3. Net safe bearing capacity (qns)

By considering only shear failure, net ultimate bearing capacity is divided by certain factor of safety will give the net safe bearing capacity.

$$qns = qnu/ F$$

Where F = factor of safety = 3 (usual value)

4. Gross safe bearing capacity (qs)

When ultimate bearing capacity is divided by factor of safety it will give gross safe bearing capacity.

$$qs = qu/F$$

Types of Bearing Capacity

5. Net safe settlement pressure (qnp)

The pressure with which the soil can carry without exceeding the allowable settlement is called net safe settlement pressure.

6. Net allowable bearing pressure (qna)

This is the pressure we can used for the design of foundations. This is equal to net safe bearing pressure if qnp > qns. In the reverse case it is equal to net safe settlement pressure.

Requirements of Good Foundation

- ✓ The foundations shall be constructed to sustain the dead and imposed loads and to transmit these to the sub-soil in such a way that pressure on it will not cause settlement which would impair the stability of the building or adjoining structures.
- ✓ Foundation base should be rigid so that differential settlements are minimized, Specially for the case when super-imposed loads are not evenly distributed.
- ✓ Foundations should be taken sufficiently deep to guard the building against damage or distress caused by swelling or shrinkage of the sub-soil.
- ✓ Foundations should be so located that its performed may not be affected due to any unexpected future influence.
- ✓ Foundations should be such that it can easily carry dead load and imposed load of the structure and transfer the loads to the soil.

Requirements of Good Foundation

- ✓ Foundation base should be strong enough to reduce the unequal settlement of soil if imposed load is not distributed equally to the soil.
- ✓ It should have a definite depth so that structure may not be damaged due to expansion or compression of soil volume beneath the foundation.
- ✓ Foundation should be strong and designed with safety factor so that structure may not be damaged due to unexpected effects.

Thank You!!