Shallow Foundation

A shallow foundation is a foundation type, and foundations are those structures designed to transfer a load of superstructure beneath a layer of soil. The design of the shallow foundation is carried out when the bearing capacity of the top layer of the soil is sufficient enough to transfer the load of the superstructure.

In the case of a shallow foundation, the depth of its foundation is relatively less, and it would be lesser than the width of the foundation. In such cases bearing capacity of soils should be such that it can bear the load of the superstructure and not allow the differential settlement of the foundations. This is a high-scoring concept for the GATE exam. Let's understand more about the bearing capacity of soils.

Bearing Capacity of Soils

The bearing capacity of soil is the load-carrying capacity of the soil. Based on the bearing capacity of the soil type, a foundation is preferred for the design of structures. The bearing capacity of soils can be classified into many types based on considering different parameters.

Ultimate Bearing Capacity or Gross Bearing Capacity (q_u)

It is the least gross pressure that will cause the shear failure of the supporting soil immediately below the footing.

Net Ultimate Bearing Capacity (q_{nu})

The net pressure applied to the footing by external loads will initiate failure in the underlying soil. It is equal to the ultimate bearing capacity minus the stress due to the weight of the footing and any soil or surcharge directly above it. Assuming the density of the footing (concrete) and soil (**γ**) are close enough to be considered equal, then

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

Where D_f is the depth of footing

Safe bearing capacity

It is the bearing capacity after applying the factor of safety (FOS). safe bearing capacity can be classified into two types,

1. Safe net bearing capacity (q_{ns})

The net soil pressure that can be safely applied to the soil considering only shear failure.

It can be expressed as $q_{ns} = q_{nu}/FOS$.

2. Safe gross bearing capacity (q_s)

It is the maximum gross pressure that the soil can carry safely without shear failure.

It can be expressed as $q_s = q_{ns} + \gamma D_f$.

Allowable Bearing Pressure

The maximum soil pressure without any shear or settlement failure that can be allowed for a particular structural member is called allowable bearing pressure.

Method to Determine Bearing Capacity

Determination of the bearing capacity is very important before designing the structure. The bearing capacity of soil can be determined with the help of different methods based on the soil type and foundations.

(i) Rankine's Method (C - Ø soil)

With the help of Rankine's method bearing capacity of the C-Ø soil is determined based on the following equations.

$q_u = \gamma D_f \tan^2\{45° + (\varphi/2)\}$

(ii) Bells Theory (C - Ø)

$q_u = CN_c + \gamma D_f N_q$

where N_c and N_q are bearing capacity factors.

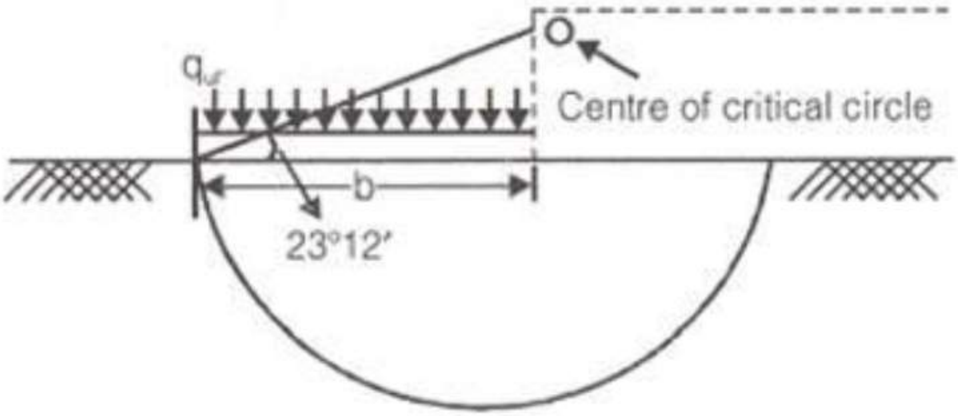
(iii) Fellinious Method (Cohesive soil)

- The failure is assumed to occur by slip, and the consequent heaving of a soil mass is on one side.

$Q_{ult} = [W.I_r + CR]/b.I_0$

$q_u = 5.5\ C$

- Location of Critical circle



Location of critical circle for surface footing in Fellenius' method

(iv) Prandtl Method: (C - Ø)

For strip footing

$q_u = CN_c + \gamma D_f N_q + 0.5\gamma B N_\gamma$

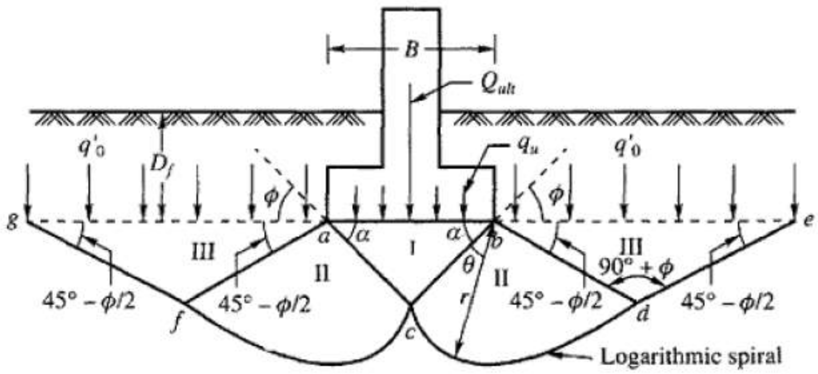
For C-soil

N_c 5.14, $N_q = 1$, $N_\gamma = 0$

(v) Terzaghi Method (C - Ø)

With this method, an analysis of the bearing capacity of C - Ø soil is carried out. This analysis is carried out based on the following assumptions:

1. The soil mass below the footing is considered homogenous and isotropic.
2. The shear strength of the soil is calculated with the help of Coulumb's criteria of failure.



For strip footing

$q_u = CN_c + \gamma D_f N_q + 0.5\gamma BN_\gamma$

For square footing

$q_u = 1.3CN_c + \gamma D_f N_q + 0.4\gamma BN_\gamma$

For rectangular footing

$q_u = \{1 + 0.3(B/L)\}CN_c + \gamma D_f N_q + 0.5\{1 - 0.2(B/L)\}\gamma BN_\gamma$

For circular footing

$q_u = 1.3CN_c + \gamma D_f N_q + 0.3\gamma BN_\gamma$

where,

- D = Dia of circular footing
- CN_c → Contribution due to the soil's constant component of shear strength.
- $\gamma D_f N_q$ → Contribution due to surcharge above the footing
- $0.5\gamma BN_\gamma$ → Contribution due to bearing capacity due to self-weight of soil.

Bearing capacity factors

$N_q = N_\varphi \theta^{\pi \tan\varphi}$

where,

- N_φ= influence factor
- $N_\varphi = \tan^2\{45° + (\varphi/2)\}$
- $N_\gamma = 1.8 \tan \varphi(N_q - 1)$
- $N_C = \cot \varphi(N_q - 1)$

For C-soil

$N_C = 5.7$, $N_q = 1$, $N_\gamma = 0$

(vi) Skemptons Method (c-soil)

This method gives the net ultimate value of bearing capacity.

Applicable for purely cohesive soils only.

$q_{nu} = CN_c$

For strip footing.

N_c = 5 to 7.5

For circular and square footing.

N_c = 6 to 9

Values of N_C

$(D_f/B) = 0 \Rightarrow$ i.e. footing at the surface.
Then N_C = 5 For strip footing.
N_C = 6.0 For square and circular footing.
where D_f = Depth of foundation.

- If $0 \leq (D_f/B) \leq 2.5$
  $N_c = 5[1 + 0.2(D_f/B)]$ For strip footing
  $N_c = 6[1 + 0.2(D_f/B)]$ For square and circular footing.
  B = D in the case of circular footing.
  $N_c = 5[1 + 0.2(B/L)][1 + 0.2(D_f/B)]$ For rectangular footing
- If $(D_f/B) \leq 2.5 \Rightarrow N_C = 7.5$
  For strip footing
  N_C = 9.0 for circular, square and rectangular footing.

(vii) Meyorhoff's Method → (C - Ø soil)

$q_u = CN_cs_cd_ci_c + \gamma D_fN_qs_qd_qi_q + 0.5\gamma BN_\gamma s_\gamma d_\gamma i_\gamma$

(viii) IS code

$q_{nu} = CN_cs_cd_ci_c + \gamma D_f(N_q - 1)s_qd_qi_q + 0.5\gamma BN_\gamma s_\gamma d_\gamma i_\gamma$

Type of Shallow Foundation

Shallow foundations are the foundation used to transfer a load of the superstructure to the subsequent layer of the soil. A shallow foundation is provided when the top layer of the soil has the sufficient bearing capacity to transfer the load. The types of shallow foundations depend on various parameters including their shape and size.

Shallow foundations can be classified into the following types:

- Isolated footing
- Wall footing
- Strap footing
- Mat footing
- Combined footing

Comparison of Shallow Foundation and Deep Foundation

Shallow foundation and deep foundation both are types of foundation. These foundation types are classified based on the depth of the foundation. If the depth of the foundation is lesser than the width of the foundation then it is called a shallow foundation and if the depth of the foundation is greater than the width of the foundation then it is called a deep foundation.

A deep foundation is provided at great depth when the above layer of soil does not have the sufficient bearing capacity to transfer the load. While shallow foundations are provided at a shorter depth of foundation and in some cases, they can also be placed at the ground level.