Bearing Capacity and Settlement of Foundations :-

To perform satisfactory shallow foundations mus have two main characteristics :-

1- The Foundation should be safe against shea Failure in the soil that supports it.
2- The Foundation should not undergo exsessive settlement.

Bearing Capacity Terms,

- over burden pressure :- The vertical pressure at apoint Caused only by the weight geological deposits above it, and not including the effect of Foundation Load.

- Ultimate Bearing Capacity (q_{ult}) :- The average contact pressure between the foundation and the soi which will produce shear failure within the soil

- Allowable Bearing Capacity (q_{all}) :- The maximum allowable net load intensity on the soil allowing for both shear and settlement, and it is simply th ultimate bearing capacity divided by a Factor of Safty

Types of Shear Failure :-

Shear Failure beneath a Foundation occurs when the mass of soil divided into separate blocks or Zones, which moves tangentially with each other

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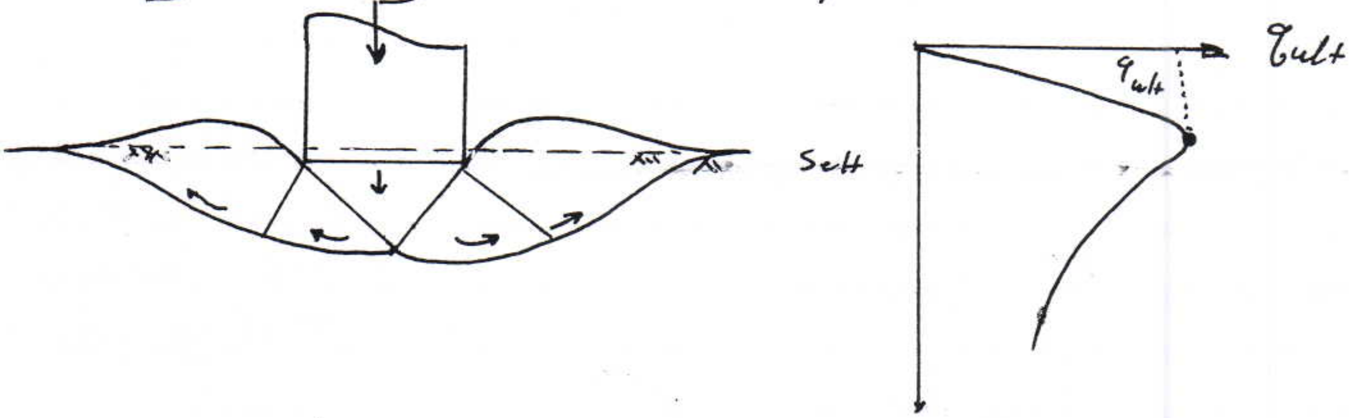
Three principal modes of shear failure may be defined in soil :-

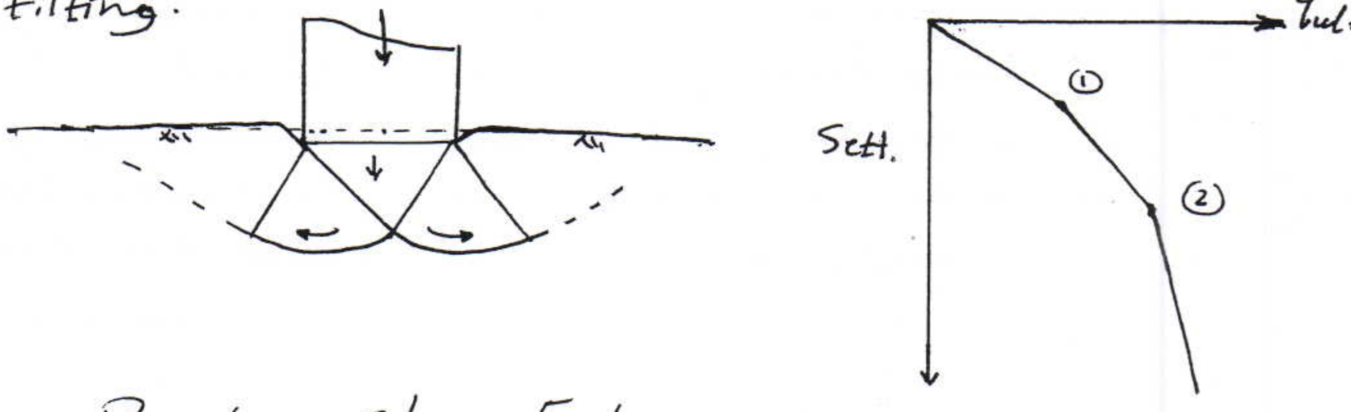
1- General shear failure :-

This is occur when failure surface develops on one or both sides of the footing, extending from the edge of footing on one side to the ground surface on the other. It accompained by sever tilting leading to a final Collaps to one side.



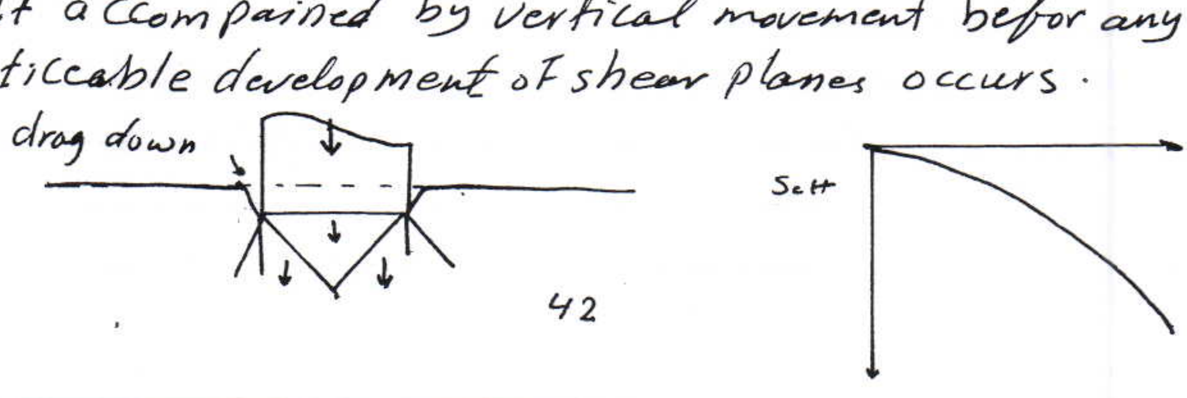
2- Local shear failure :-

In this Case the failure surfaces start at the edge of footing, but end within the soil mass, instead of meeting the surface, it accompained by very little tilting.



3 - Punching Shear Failure: -

It accompained by vertical movement befor any noticeable development of shear planes occurs.



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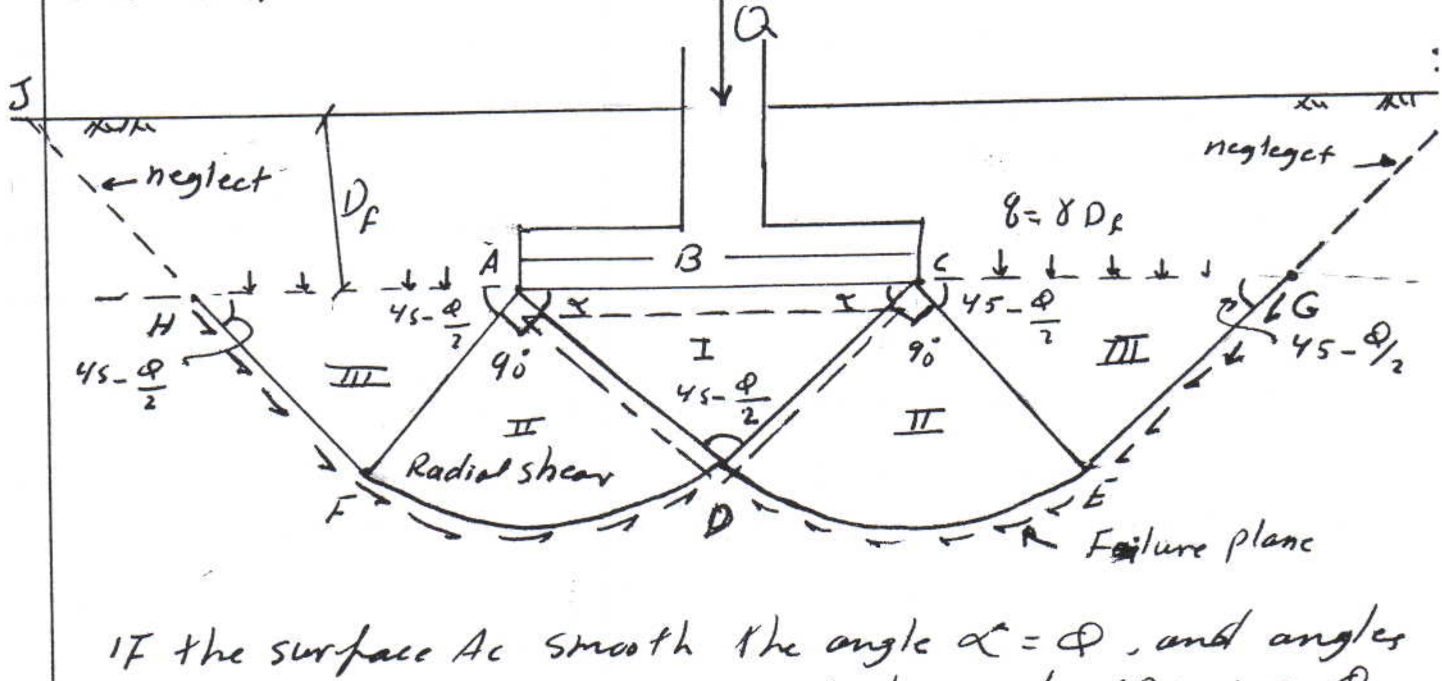
The Failure mode depends mainly on the Compressibility of the Soils. In Frictional soil and cohesive soils of low Compressibility, the general shear Failure will usually occur. In highly Compressible clays or silts, punching shear Failure is most likly, which is also observed in loose Sand, and it occurs as a result of the Compression of an underlying soft layer. In normally Consolidated clays, the drainage Conditions may influnce the mode of Failure.

Determination of The Ultimate Bearing Capacity of Soil:

- Terzaghi's Bearing Capacity Theory :-

He suggested that for a Centinous or Strip Footing the Failure Surface in Soil at ultimate Load may be assumed to be similar to that shown in fig below:-



IF the surface Ac smooth the angle $\alpha = \phi$, and angles FAD, DCE equal 90° each, and the angle $ADC = 45 - \frac{\phi}{2}$

Assumptions:-

1- $D_f \lesssim B$ (shallow Footing)

2- Rough surface of Footing

3- Neglect the shear resistance of soil above horizontal pla

4- Replace the soil above Foundation level with a surcharge $q = \gamma D_f$ placed at Foundation level.

The application of Load Q tends to:

1- Push the wedge (I) into the ground

2- a lateral displacement of Zones II & III, this displacement resisted by shear stresses developed alon the slip plane (DEG) and (DFH), and the weight of soil in the Zones.

From static equilibrium :-

$$q_{ult} = C N_c + q N_q + 0.5 \gamma B N_\gamma \quad \text{(Continuous \& strip Footing)}$$

$$q_{ult} = 1.3 C N_c + q N_q + 0.4 \gamma B N_\gamma \quad \text{(Square Footing)}$$

$$q_{ult} = 1.3 C N_c + q N_q + 0.3 \gamma B N_\gamma \quad \text{(Circular Footing)}$$

$$q_{ult} = (1+0.3\frac{B}{L}) C N_c + q N_q + (1-0.2\frac{B}{L}) 0.5 \gamma B N_\gamma \quad \text{(Rectangular Foo}$$

Where:-

q_{ult} = Ultimate bearing capacity

C = Cohesion of soil beneth Foundation

q = (γD_f) Surcharge of Foundation level.

γ = Unit weight of the soil

B = least width (or diameter) of Footing

N_c, N_q, N_γ = Terzaghi's bearing capacity Factors depend on the values of (Φ) (See table (4-2) Bowles).

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Modified Bearing Capacity Eq. :-

The ultimate bearing capacity eq. By Terzaghi do not address different shape of footing and the shearing resistance along the failure surface in soil located above the bottom of foundation. In addition the load on the foundation may be inclined. In order to take all these into consideration the following form of bearing capacity equation has been suggested by Meyerhof

$$q_{ult} = C N_c S_c d_c i_c + q N_q S_q d_q i_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma$$

where:

S_c, S_q, S_γ = shape factors
d_c, d_q, d_γ = depth factors
i_c, i_q, i_γ = Inclination factors
N_c, N_q, N_γ = Bearing Capacity Factors (table 4-4)

$$N_c = (N_q - 1) \cot \phi$$

$$N_q = e^{\pi \tan \phi} \tan^2 (45 + \phi/2).$$

$$N_\gamma = (N_q - 1) \tan (1.4 \phi).$$

General Bearing Capacity:

Hansen (1970) Proposed general bearing capacity Eq. which includes with addition to shape factors, depth factor and inclination factors ground factors and base factors.

$$q_{ult} = C N_c s_c d_c i_c g_c b_c + q N_q s_q d_q i_q g_q b_q + 0.5 \gamma B N_\gamma s_\gamma d_\gamma i_\gamma g_\gamma b_\gamma .$$

For $\phi = 0$

$$q_{ult} = C_u N_c (1 + s_c' + d_c' - i_c' - b_c' - g_c') + \bar{q}$$

N_q, N_c = Same as Meyerhof.

$N_\gamma = 1.5 (N_q - 1) \tan\phi$

Shape Factors:- (H - for Hansen, V - for Vesic).

$S_{c(H)}' = 0.2 B'/L'$ For $\phi = 0$

$S_{c(H)} = 1 + \frac{N_q}{N_c} \frac{B'}{L'}$, $S_{c(v)} = 1 + \frac{N_q}{N_c} \frac{B}{L}$, $S_c = 1.0$ for Strip

$S_{q(H)} = 1 + \frac{B'}{L'} \sin\phi$, $S_{q(v)} = 1 + \frac{B}{L} \tan\phi$

$S_{\gamma(H)} = 1 - 0.4 \frac{B'}{L'} \geq 0.6$, $S_{\gamma(v)} = 1 - 0.4 \frac{B}{L} \geq 0.6$

Depth Factors:

1- For $D/B \leq 1$ (Shallow Foundations):

$d_c = 1 + 0.4 \frac{D}{B}$

$d_q = 1 + 2 \tan\phi (1 - \sin\phi)^2 \frac{D}{B}$

$d_\gamma = 1$ For all ϕ

$d_c' = 0.4 D/B$. For $\phi = 0$

2. For $D/B > 1$

$d_c = 1 + 0.4 \tan^{-1} (\frac{D_f}{B})$