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THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY (CIVIL) – LEVEL 06
Final Examination 2011/2012

CEX6230 – GEOTECHNICS

Time allowed: Three Hours

Date: Sunday, 19th March, 2012 | Time: 1400-1700

Answer five questions. All questions carry equal marks.

1. A Direct Shear Test is performed on a normally consolidated saturated clay specimen, at a constant normal stress of 70kPa.

   a) Assuming $K_0 = 0.5$, compute the principal stresses acting on the specimen prior to shearing. Plot these values to scale on a Mohr's circle plot. Name the two axes. (4 points)

   b) The shear stress is increased at a lower strain rate. The shear stress reached an ultimate value of 42kPa. Plot the shear strength envelope on the same graph (2 points)

   c) Compute the angle of internal friction, ϕ'. (2 points)

   d) Compute the principal stresses at failure. (4 points)

   e) Sketch the variation of observed Shear Force versus Shear Displacement and Vertical Displacement versus Shear Displacement. Name the axes. (4 points)

   f) Discuss the outcome of this test, if you had applied a significantly high shear strain rate. (4 points)

2. Figure 2 shows a soil element located in a normally consolidated clay stratum.

   a) Compute the principal stresses acting on Element A in terms of total and effective stresses. (2 points)

   b) Plot to scale the stresses computed in 2(a) above, on p, p' - q space. (2 points)

   c) Plot Mohr-Coulomb failure envelope representing the clay soil stratum, on p' - q space. (4 points)

   d) Suppose that a uniform surcharge load is applied during a short period of time, and the resulting in $\Delta\sigma_3 \approx 0$, $\Delta u_f = 65$kPa, and $(\Delta\sigma_1 - \Delta\sigma_2)_f = 50$kPa. Sketch the Effective Stress Path (ESP) and the Total Stress Path (TSP) on the same plot. Show principal values. Name ESP and TSP. (8 points)

   e) Discuss whether short-term stability is more critical than long-term stability. (4 points)

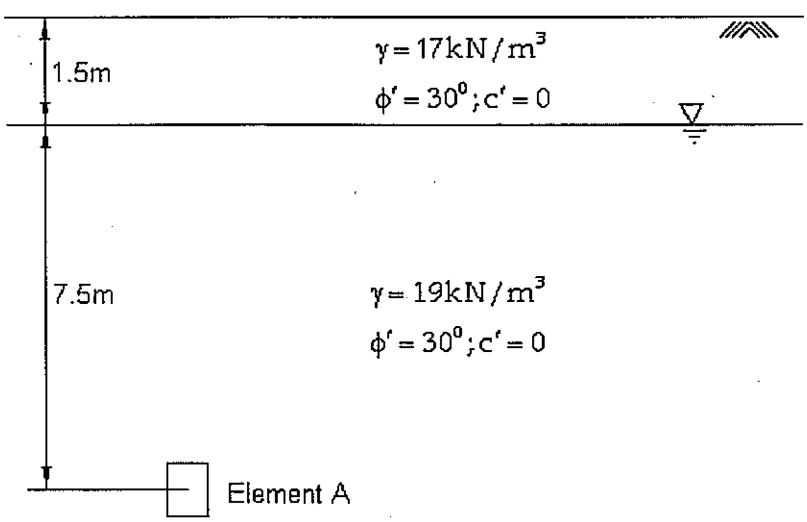


Figure 2

3. A row of anchored steel sheet piles were driven into a medium-dense sand stratum. The stratum has an average unit weight of 17.5 kN/m^3 and $\phi' = 32^0$. The groundwater table is located 4m below the ground level. The saturated unit weight below groundwater level is 21 kN/m^3. The excavated depth is 3.5m. Steel rod anchors are to be placed at 0.5m depth from the ground level.

a) Considering a factor of safety of 2 on available passive earth resistance, sketch the net horizontal pressure distribution with depth. Show principal values. (8 points)

b) Assuming free earth support condition at the bottom of sheet pile wall, compute the required depth of embedment. (6 points)

c) Assuming that the yield strength of steel is 350MPa, compute the anchor spacing required for a factor of safety of 2.0. (6 points)

4.

a) Discuss how you would compute the allowable bearing capacity of a pad footing founded on a sandy soil, based on i) ultimate bearing capacity and ii) allowable limiting settlement of 25mm. (4 points)

b) Figure 4 shows an eccentrically loaded pad footing. Compute the allowable structural load it could carry, for a Factor of Safety of 3.5. (12 points)

c) Sketch the zone of influence for 5% of contact stress. Show important dimensions. (4 points)

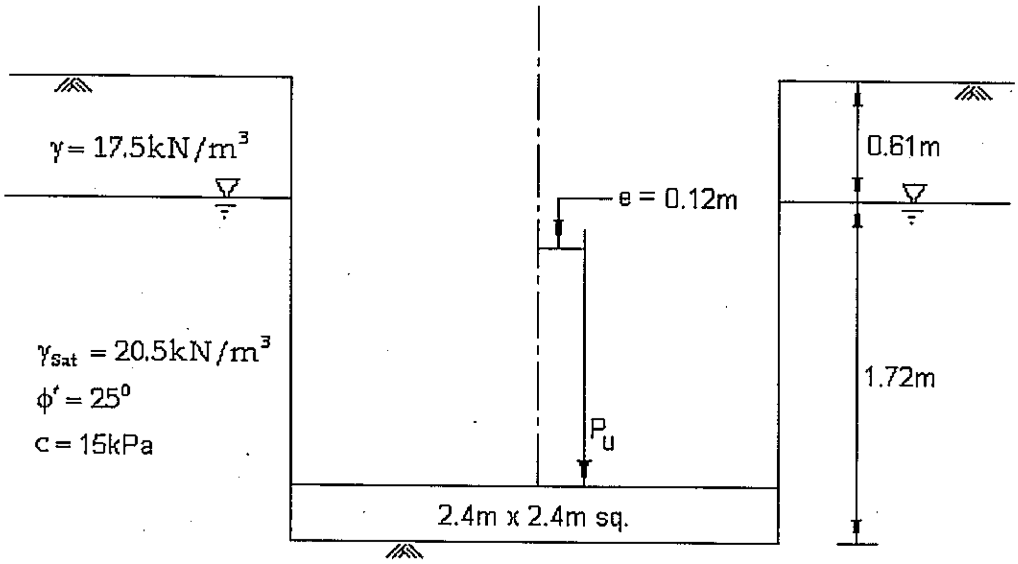


Figure 4

5. Candidates are encouraged to use sketches. Limit written comments to a maximum of five sentences.

a) Figure 5a shows a soil backfill retained. Surface AB is a rough surface. Surfaces AB and BC has reached their limiting equilibrium states that causes an active force on the retaining structure. Draw all forces and reactions that keep the soil wedge ABC in equilibrium. (5 points)

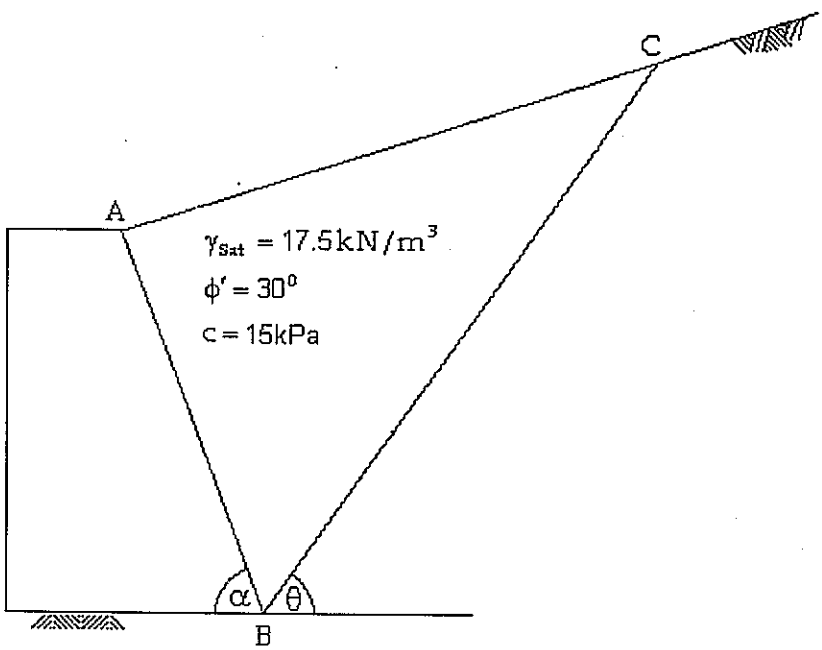


Figure 5a

b) Define the terms used in the relationship $k = c_v m_v \gamma_w$. State their respective units of measurement. Explain the procedure used to determine parameter m_v. (5 points)

c) Figure 5c shows a soil element (i.e. element A) beneath an excavated trench. Suppose that the soil element is saturated and normally consolidated, sketch the total stress path and the effective stress path on the same p, p' - q plot. State any assumptions you have made. (5 points)

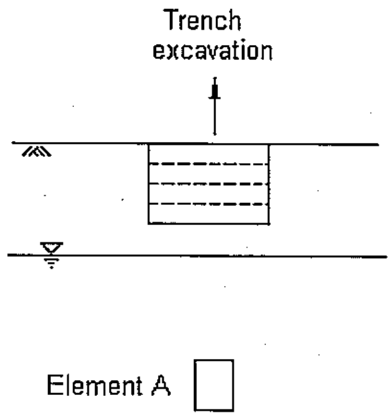


Figure 5c

d) Sketch the variation between SPT N and ϕ', for a cohesionless soil. Name the axis. Discuss the trend you would expect for a cohesive soil. (5 points)

6. Figure 6a shows a Mohr's circle plot obtained during an Unconsolidated Undrained triaxial loading test.

a) Explain why UU test is identified as an 'unconsolidated' test (3 points)

b) Explain why UU test is identified as an 'undrained' test (3 points)

c) Figure 6b shows soil element A, for which the above test is performed.

i) Compute parameters σ_2 and σ_2' as shown in Figure 6b. (6 points)

ii) If the specimen underwent shear failure at a deviatoric stress of 25kPa, determine σ_{1f} and σ_{1f}' (2 points)

iii) Explain why $\phi_u = 0$. (3 points)

d) Suppose that the soil specimen is normally consolidated, estimate it's ϕ'. (3 points)

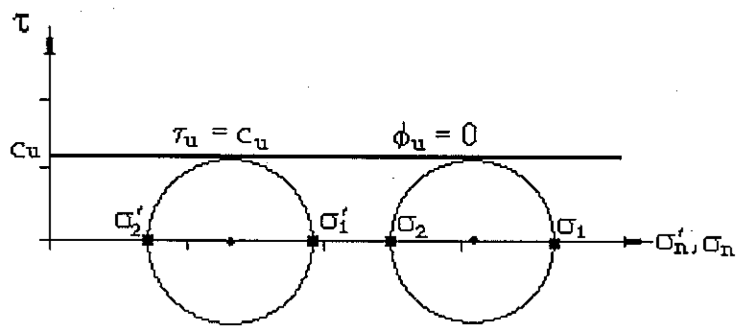


Figure 6a

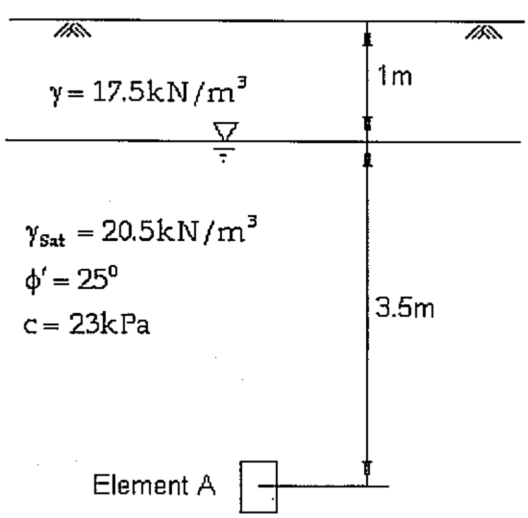


Figure 6b

7.

a) <u>Discuss</u> criteria that explain the spacing of piles in a pile group. (4 points)

b) <u>Explain</u> the methods used to determine the settlement of a pile group. (4 points)

c) Figure 7 shows a driven reinforced concrete pile in sand. <u>Determine</u> the Ultimate end resistance of the pile. <u>Determine</u> the available skin resistance of the pile. <u>Compute</u> the pile capacity available to carry the super-structure assuming a Factor of Safety of 1.5. (12 points)

End resistance: $q_f = \sigma'_0 N_q$

Skin Friction: $f_s = K_s \bar{\sigma}'_0 \tan\delta$ $\quad \bar{\sigma}'_0$ – average effective overburden stress

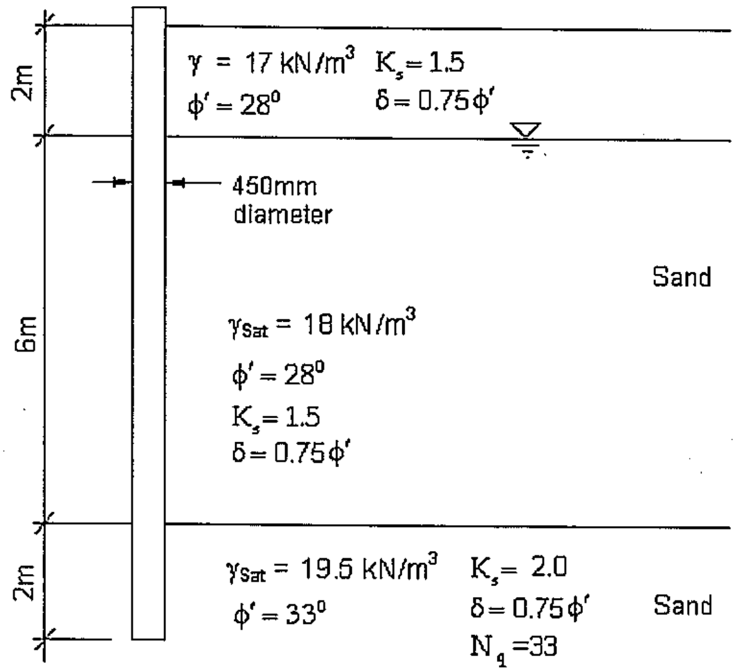


Figure 7

8. Candidates are encouraged to use sketches.

a) Figure 8a analyses a typical soil element of a circular slip surface of infinite length. <u>Derive</u> expressions for the overturning moment about O; the maximum available restoring moment about O and then express Factor of Safety in-terms of shear strength parameters (5 points)

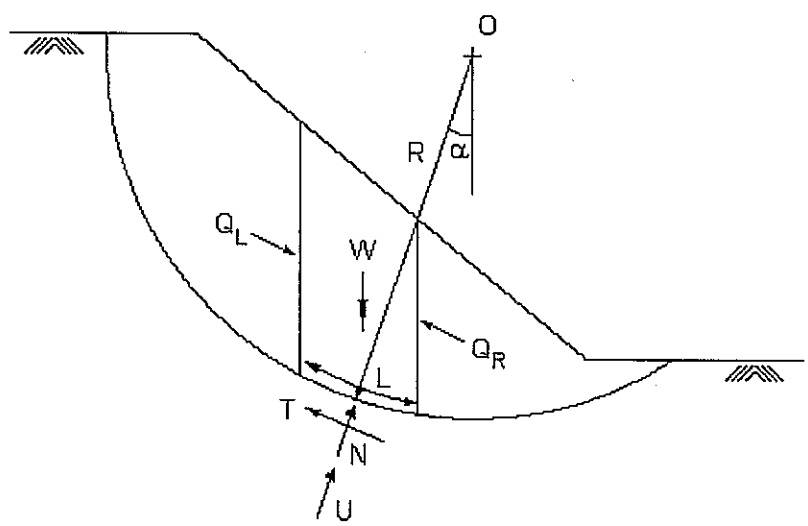


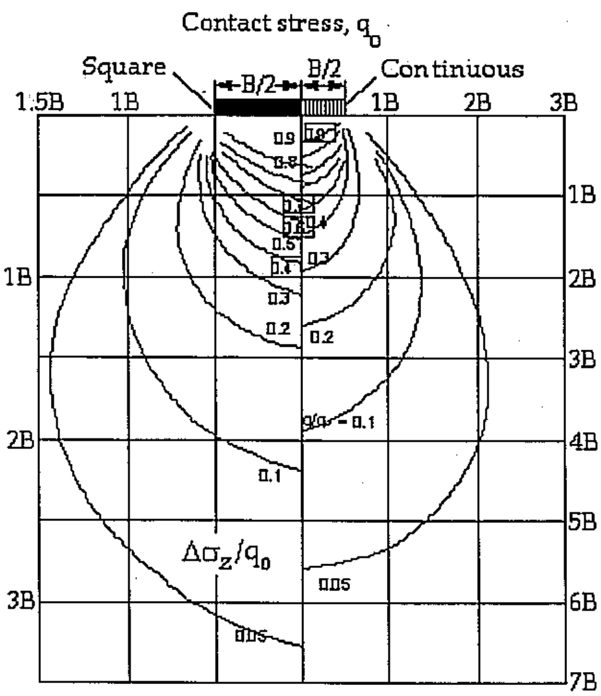
Figure 8a

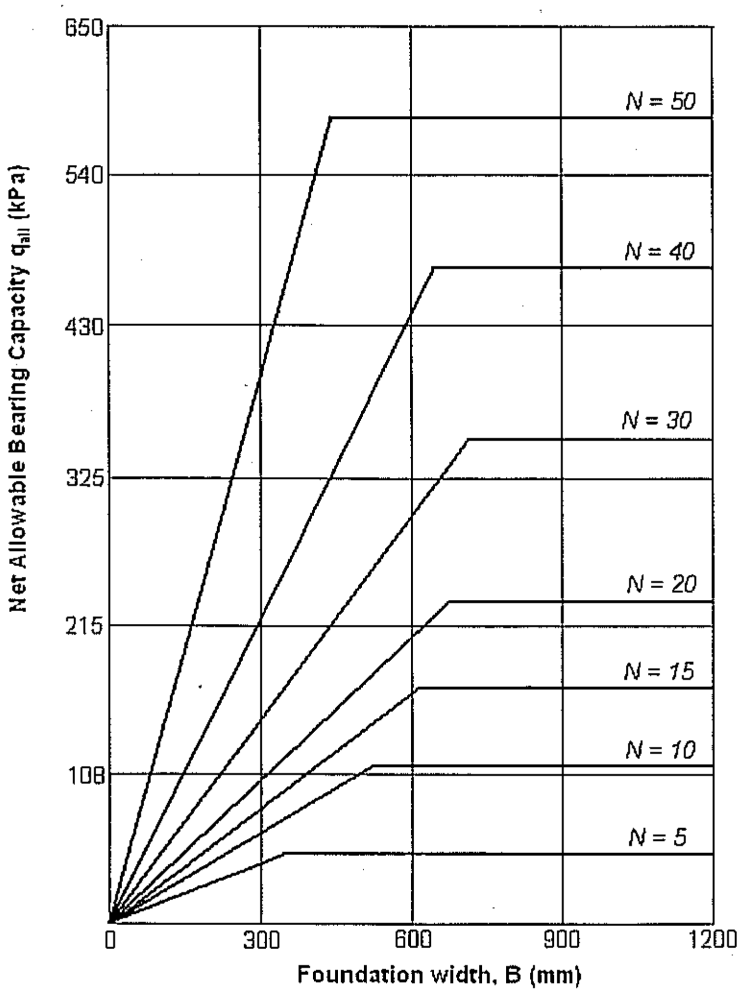
b) The Stability Number is defined as $N = \frac{c_d}{\gamma H}$. <u>Explain</u> how you would determine all parameters of this equation. (5 points)

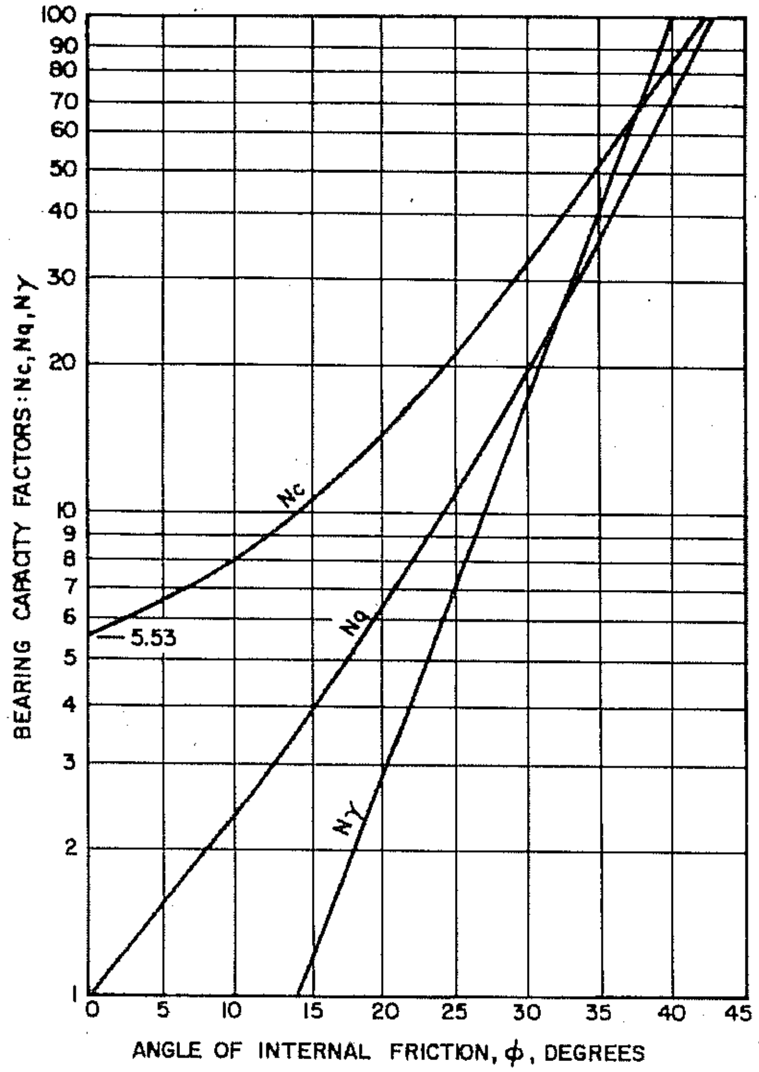
c) <u>Explain</u> Peak Strength and Residual Strength. (5 points)

d) Explain parameters $u, c_h, c_v, z,$ and r as used in the equation $\frac{\partial u}{\partial t} = c_h\left(\frac{\partial^2 u}{\partial r^2} + \frac{1}{r}\frac{\partial u}{\partial r}\right) + c_v \frac{\partial^2 u}{\partial z^2}$.

State their respective SI units of measurement. (5 points)







ULTIMATE BEARING CAPACITY = q_{ult}

CONTINUOUS FOOTING; GENERAL CASE

$q_{ult} = q' + q''$

q' = PORTION OF BEARING CAPACITY ASSUMING WEIGHTLESS FOUNDATION SOIL

q'' = PORTION OF BEARING CAPACITY FROM WEIGHT OF FOUNDATION SOILS

$q' = cN_c + \gamma D N_q$

$q'' = \gamma \frac{B}{2} N_\gamma$

$q_{ult} = cN_c + \gamma D N_q + \frac{\gamma B}{2} N_\gamma$

SQUARE OR RECTANGULAR FOOTING

$q_{ult} = cN_c\,(1 + .3\frac{B}{L}) + \gamma D N_q + 0.4\gamma B N_\gamma$

CIRCULAR FOOTING: R = B/2

$q_{ult} = 1.3\,cN_c + \gamma D N_q + 0.6\gamma R N_\gamma$

FOR COHESIONLESS FOUNDATION SOILS (c = 0)

CONTINUOUS FOOTING:

$q_{ult} = \gamma D N_q + \frac{\gamma B}{2} N_\gamma$

SQUARE OR RECTANGULAR FOOTING:

$q_{ult} = \gamma D N_q + 0.4\gamma B N_\gamma$

CIRCULAR FOOTING:

$q_{ult} = \gamma D N_q + 0.6\gamma R N_\gamma$

FOR COHESIVE FOUNDATION SOILS (ϕ = 0)

CONTINUOUS FOOTING:

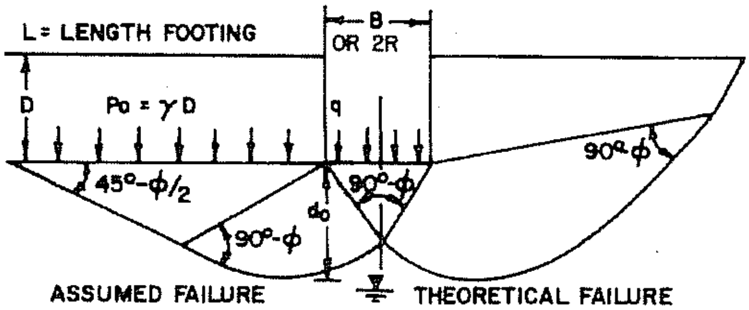
$q_{ult} = cN_c + \gamma D$

SQUARE OR RECTANGULAR FOOTING:

$q_{ult} = cN_c(1 + .3\frac{B}{L}) + \gamma D$

CIRCULAR FOOTING:

$q_{ult} = 1.3\,cN_c + \gamma D$



ASSUMED CONDITIONS:

1. D ≤ B
2. SOIL IS UNIFORM TO DEPTH d_o > B.
3. WATER LEVEL LOWER THAN d_o BELOW BASE OF FOOTING.
4. VERTICAL LOAD CONCENTRIC.
5. FRACTION AND ADHESION ON VERTICAL SIDES OF FOOTING ARE NEGLECTED.
6. FOUNDATION SOIL WITH PROPERTIES c, ϕ, γ

FIGURE 1

Ultimate Bearing Capacity of Shallow Footings With Concentric Loads