THE OPENUNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY (CIVIL) – LEVEL 06
Final Examination 2015/2016

CEX6230 – GEOTECHNICS

Time allowed: Three Hours

Date: Monday, 21st November, 2016 | Time: 0930-1230

Answer five questions. All questions carry equal marks.

1. Fig. 1 shows how various clay mineral types plot on the Plasticity Chart.

   A Define Liquid Limit; state how Liquid Limit is interpreted during the test. (4 points)

   B Compare engineering properties of a high plasticity soil and a low plasticity soil. (4 points)

   C Discuss what lines A and B (refer Fig. 1) represent. (4 points)

   D For a given mineral type, Fig. 1 shows that the Plasticity Index tends to vary linearly with Liquid Limit. Explain why this is so. (4 points)

   E List the engineering properties that correlate with the Plasticity Index. (4 points)

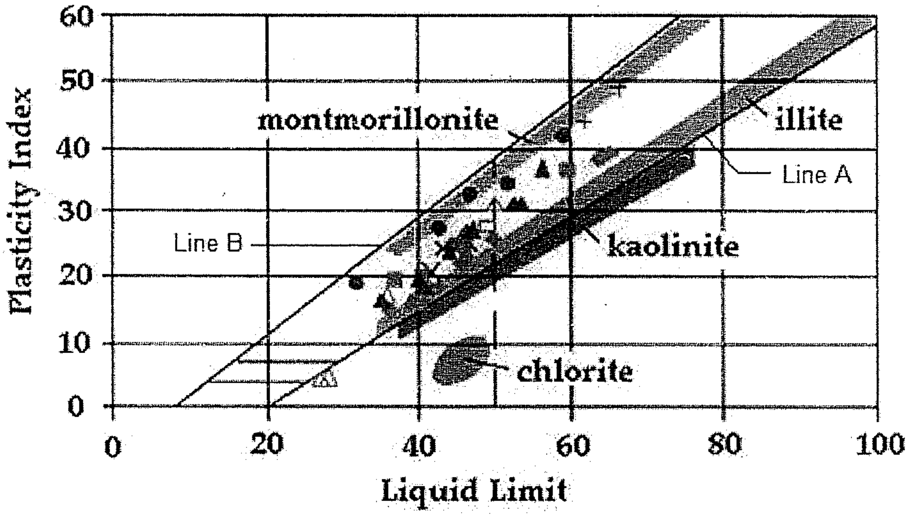

Fig. 1

2. Fig. 2 shows a soil profile of a land, where a compacted surcharge-fill of 1m is applied (surcharge-fill not shown in figure). An undisturbed specimen A is obtained from a depth of 7.5m from ground level, to perform an Unconsolidated Undrained Tri-axial Loading Test.

   A Compute in-situ stresses σ_v, σ'_v, σ_h, and σ'_h of soil element A, assuming that the soil is normally consolidated. State any assumptions you have made. (4 points)

   B Compute stress-path parameters corresponding to the situation described in 2A above. State the assumptions you've made. (3 points)

   C Plot the stress-path co-ordinates corresponding to the situation described in 2B above on a regular graph sheet. Name the axes. (2 points)

   D State the cell pressure and back pressure you wish to maintain in the laboratory test specimen, if you intend to test the specimen at average in-situ conditions. State your reasons for selection of these values. (4 points)

   E If the laboratory test specimen fails at a deviatoric stress of 60kPa, and the measured pore water pressure at failure is 85kPa, plot the failure envelope and the total stress path on the same graph sheet. Show principal values. Sketch the effective stress path on the same graph sheet. (3 points)

   F Assuming that the surcharge fill has a unit weight of 17kN/m^3, plot the total stress path for soil element A, on the same graph sheet. Sketch the corresponding effective stress path for soil element A, on the same graph sheet. (3 points)

   G Comment on the short-term stability of the structure. (1 point)

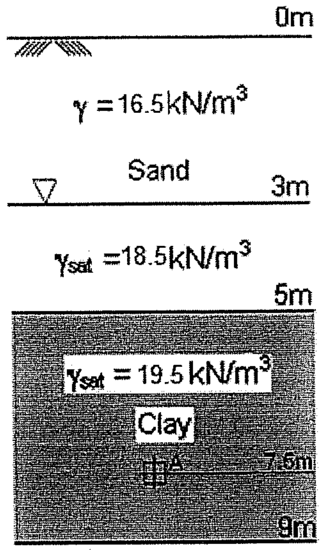

Fig. 2

3. Fig. 3 shows the details of a cantilever retaining wall. The shear strength parameters for the soil are $c' = 0$ and $\phi' = 32^0$. The saturated unit weight of soil is $19 kN/m^3$. The unit weight above the water table is $17 kN/m^3$. The unit weight of concrete is taken to be $23.6 kN/m^3$. If $\delta = 23^0$ on the base of the wall.

   A Draw a free-body diagram that indicates all forces and reactions you would consider in your analysis. (4 points)

   B Determine the factor of safety against sliding. (4 points)

   C Determine the factor of safety against overturning. (4 points)

   D Determine whether the net force on the footing falls within its middle third. (4 points)

   E If you assume that 75% of the available frictional resistance of the soil is mobilised, discuss its influence on earth pressure. (4 points)

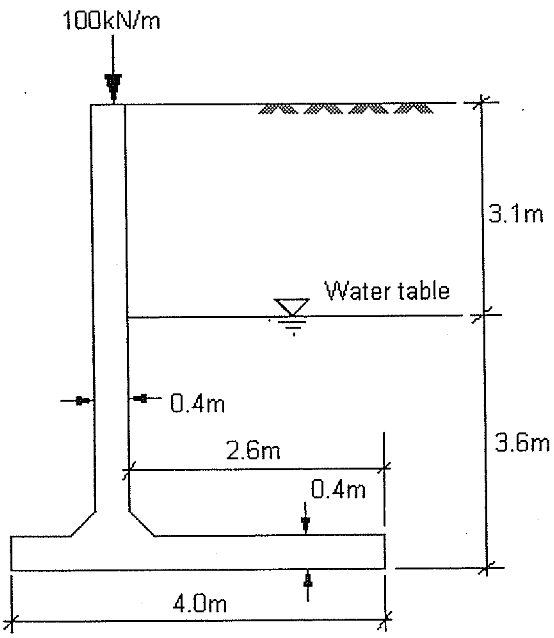

Fig. 3

4. A circular oil tank 10m in diameter exerts a uniform pressure of 120kPa on a sandy soil formation.

   A <u>Compute</u> the stress distribution of soil at ground level, from the centre to the edge of tank. <u>Plot</u> the observed variation on a graph sheet. (4 points)

   B <u>Compute</u> the stress distribution of soil at 5m below ground level, from the centre to the edge of tank. <u>Plot</u> the observed variation on the same graph sheet. (3 points)

   C <u>Discuss</u> whether the stress variations plotted in 4A and 4B above, indicate that the foundation of the the tank is considered to be rigid. <u>State</u> your reasons. (3 points)

   D Plot the variation of vertical stress increment, with depth, along the central axis of tank. (4 points)

   E Hence, find the depth corresponding to a vertical stress increment of 6kPa. (2 points)

   F List all parameters required to estimate the settlement of the tank. (4 points)

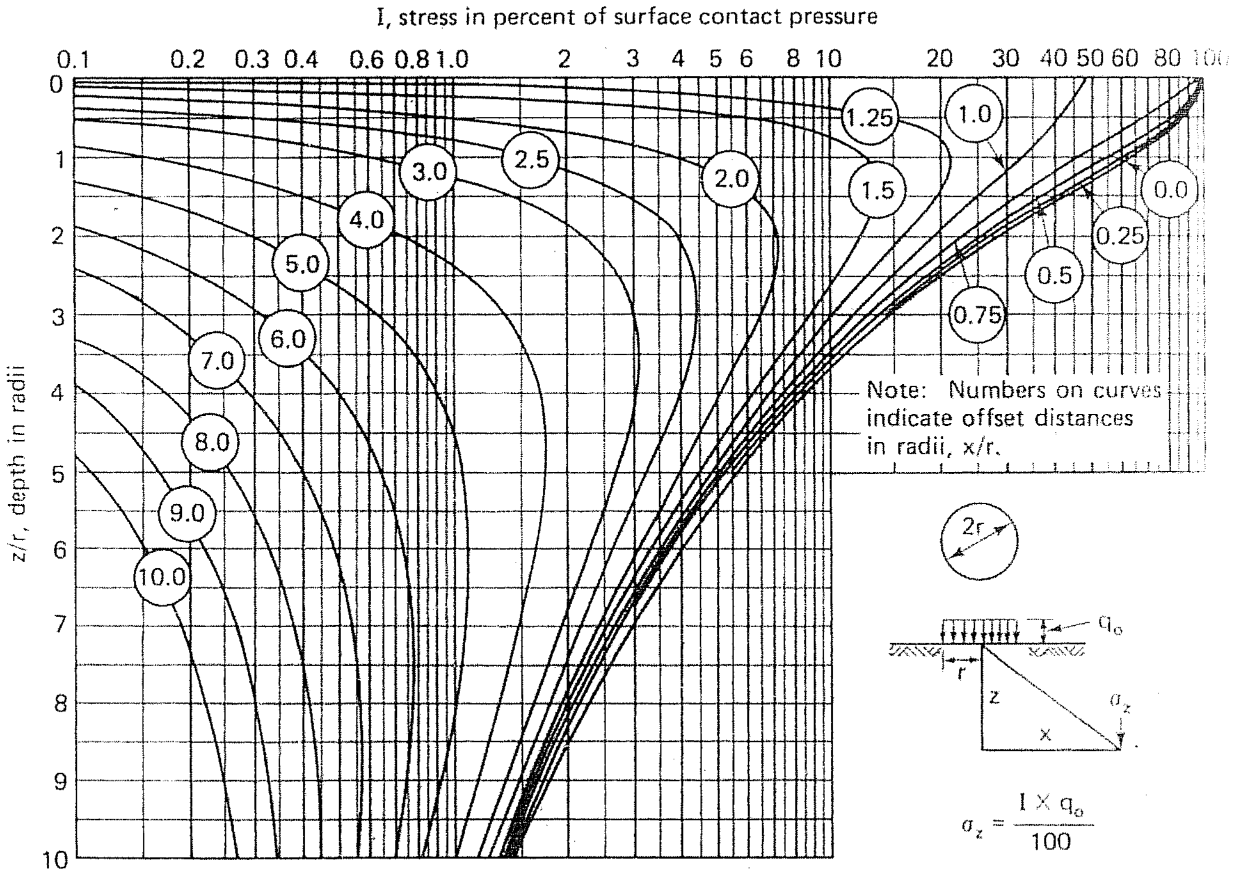

Fig. 4: Influence values, expressed in percentage of surface contact pressure, q_o, for vertical stress under uniformly loaded circular area (after Foster and Ahlvin, 1954, as cited by U.S. Navy, 1971)

5. A 10mx10m square raft foundation is to carry a 10,000kN uniformly distributed load (refer Fig. 5a). The clay layer has the following properties: $e_0 = 0.8; c_v = 2 \times 10^{-3} m^2/day; G_s = 2.7; C_c = 0.8; C_r = 0.2$. The Pre-consolidation Pressure is found to be 80kPa.

   A <u>Discuss</u> the validity of Terzarghi's assumptions in estimating total settlement of the clay layer. (3 points)

   B <u>Compute</u> the saturated unit weight of clay soil. (3 points)

   C <u>Estimate</u> the total settlement of the clay layer. (4 points)

   D <u>State</u> the assumptions you would use when computing the time for a certain settlement to occur. (3 points)

   E <u>Explain</u> which initial excess pore water pressure distribution you would use when computing the time taken for 80% of total settlement to occur. <u>State</u> your reasons for the selection. (3 points)

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F Compute the time for 80% of total settlement. (4 points)

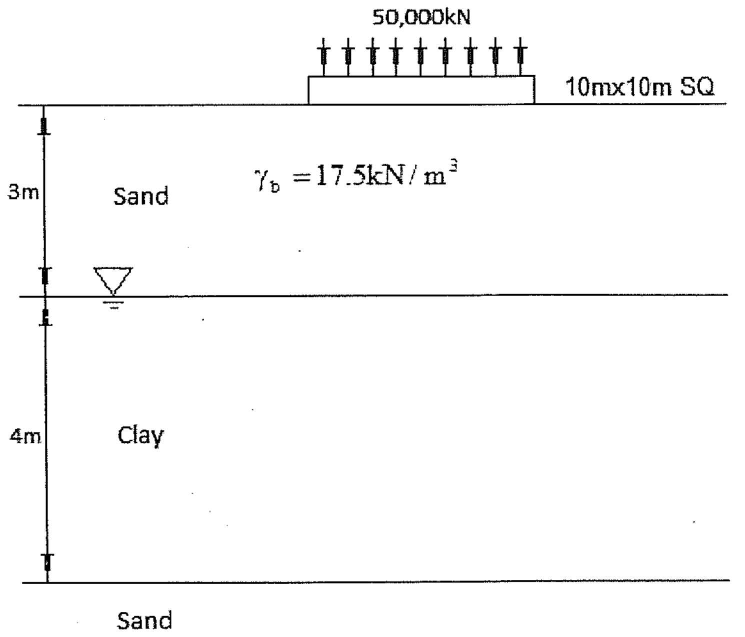
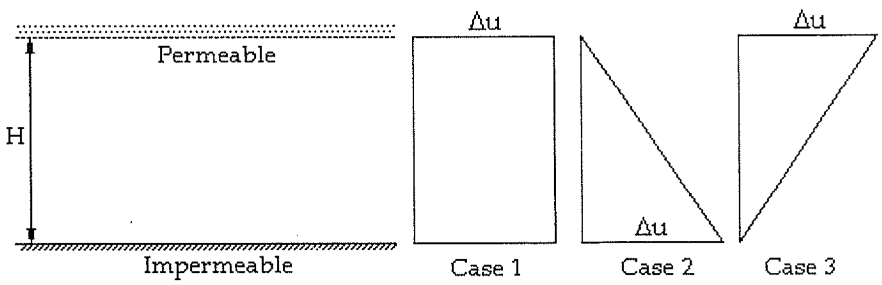


Fig. 5a



Variation of U versus T_v

U	Time Factor, T_v		
	Case 1	Case 2	Case 3
0.000	0.000	0.000	0.000
0.100	0.008	0.047	0.003
0.200	0.031	0.100	0.009
0.300	0.071	0.158	0.024
0.400	0.126	0.221	0.048
0.500	0.197	0.294	0.092
0.600	0.287	0.383	0.160
0.700	0.403	0.500	0.271
0.800	0.567	0.665	0.440
0.900	0.818	0.940	0.720

Fig. 5b

6. The gravity dam shown in Fig. 6 has a 5m cut-off wall at point A. It has an upstream water depth of 20m and a tail-water depth of 5m. The Coefficient of Permeability of the soil is 0.003 cm/s.

A Sketch the flow net. (5 points)

B Compute seepage flow. (5 points)

C Compute the pore pressure at point B. (5 points)

D Sketch the pore pressure distribution you would expect across the bottom surface of the dam. (5 points)

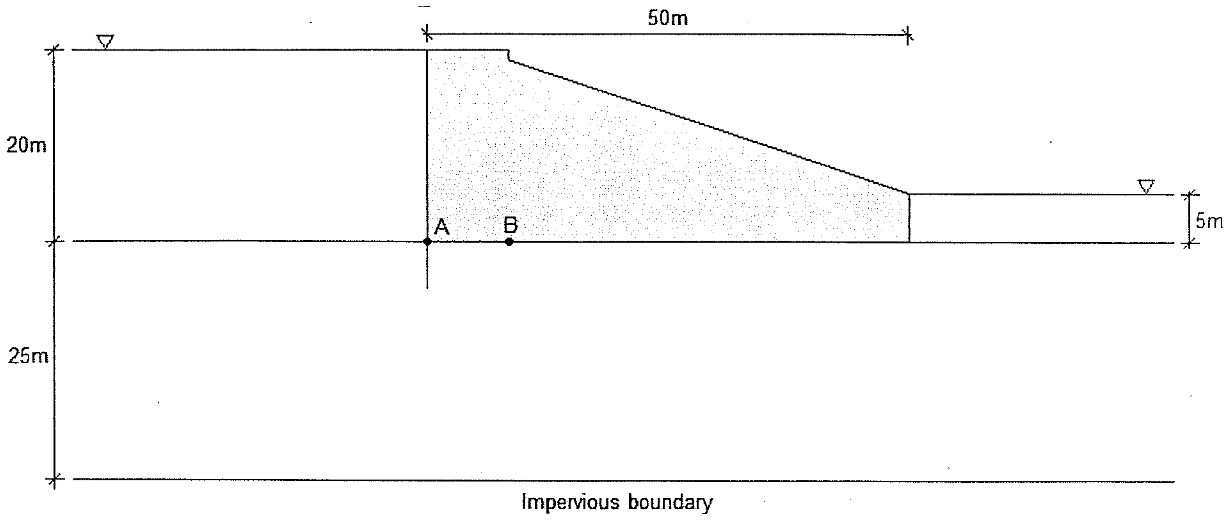


Fig. 6

7.

A Discuss water infiltration through a partially saturated soil, during a rainy spell, occurred after an extended dry weather period. (5 points)

B Explain the use of equations $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$ and $\phi=-k\left[\frac{p}{\rho g}+z\right]+c$ in defining flow through a porous medium. (5 points)

C Discuss the concept explained in Fig. 7C below. (5 points)

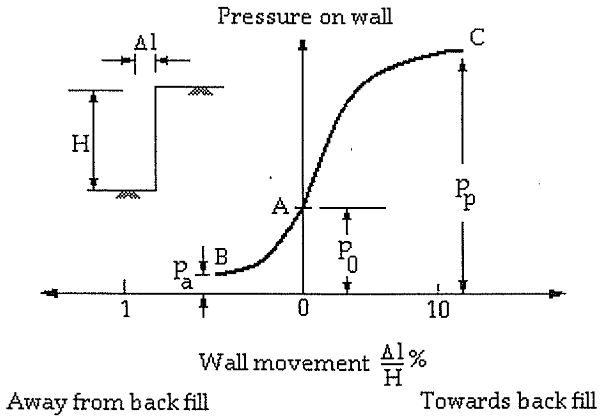


Fig. 7C

D Explain why the Residual Strength of a soil is used when assessing the stability of a slope, rather than using its Peak Strength. (5 points)

8. Fig. 8 shows a two rectangular footings, A and B, which is required to be connected with a strap, located at the same level. Both footings are located at 1m depth. Table 8 lists the required details.

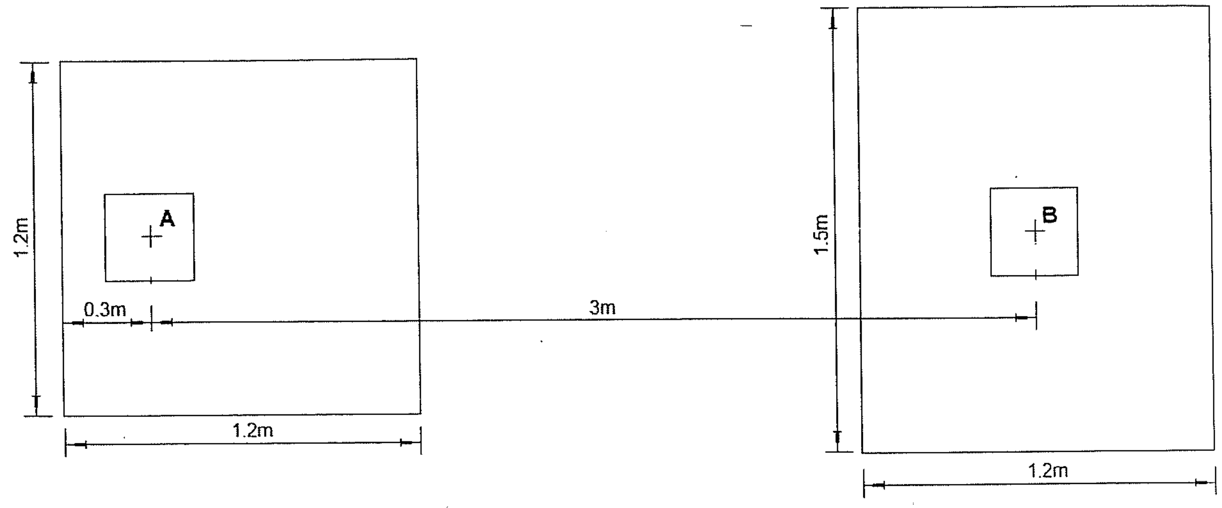


Fig. 8

Table 8

Description	Footing A	Footing B
Dead Load (kN)	125	100
Live Load (kN)	75	125
Footing thickness (mm)	200	300

A <u>Compute</u> the moment that is required to be transmitted via the strap in order to maintain a uniform bearing stress on both footings, when carrying service loads. (4 points)

B <u>Compute</u> the resulting bearing stresses in each footing, when carrying service loads. (4 points)

C <u>Compute</u> the Net-ultimate Bearing Capacity for each footing. (6 points)

D <u>Compute</u> the factors of safety for each footing, based on the results obtained above. (2 points)

E <u>Discuss</u> how you would design the strap to determine its dimensions and reinforcement requirements. (4 points)

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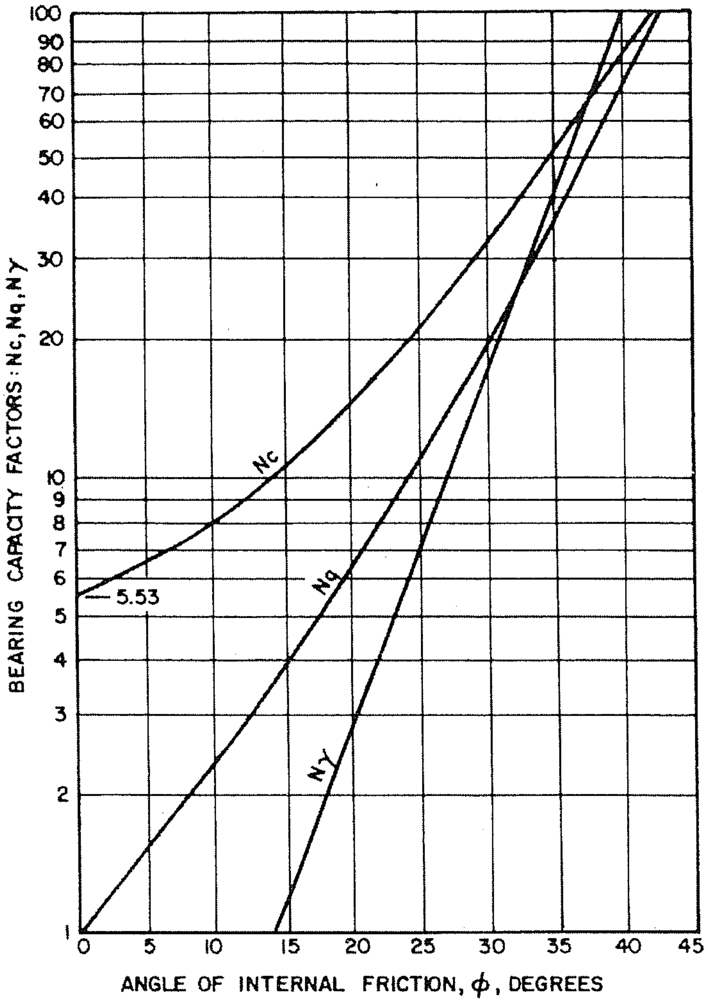

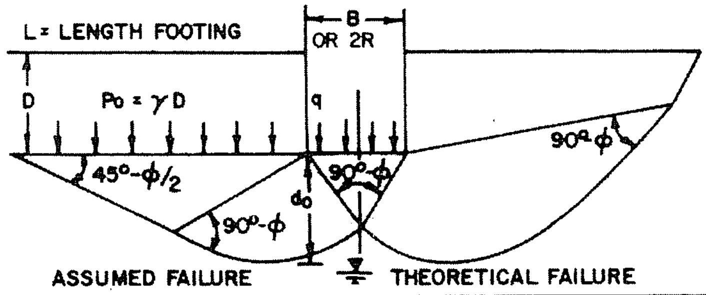

ASSUMED CONDITIONS:

1. $D \leq B$
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

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 ($\phi = 0$)

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:

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

FIGURE 1
Ultimate Bearing Capacity of Shallow Footings With Concentric Loads