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THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY (CIVIL) – LEVEL 06
Final Examination 2008/2009

CEX6230 – GEOTECHNICS

Time allowed: Three Hours

Date: Sunday, 04th April, 2010 — Time: 1400-1700

Answer five questions. All questions carry equal marks.

1. Table Q1 lists test data for a Consolidated Undrained Triaxial (CU) Test, performed on a clay soil specimen. The test was performed at a cell pressure, σ_3 of 150kPa.

   a) Compute p, p′ and q for the given range of strain values (4 points)
   b) Plot q vs. p and q vs. p′ on the same graph sheet. (4 points)
   c) State whether the soil is normally-consolidated or over-consolidated. (1 points)
   d) Determine the shear strength parameters with respect to total stress. (2 point)
   e) Determine the shear strength parameters with respect to effective stress. (2 point)

   Figure Q1 shows the principal stresses of a soil element subjected to a vertical stress increase. u_0 is the static pore water pressure while Δu is the excess pore water pressure due to deviatoric loading.

   f) Plot on the same graph sheet, points (p,q) and (p′,q) for `before loading'. Plot the total stress path (3 points)
   g) Plot on the same graph sheet, points (p,q) and (p′,q) for `end of loading'. Plot the effective stress path. You may assume that expected undrained behaviour is similar to what you've observed in the CU loading test. (3 points)
   h) State whether the soil element is `safe' during short term and during long term. (1 point)

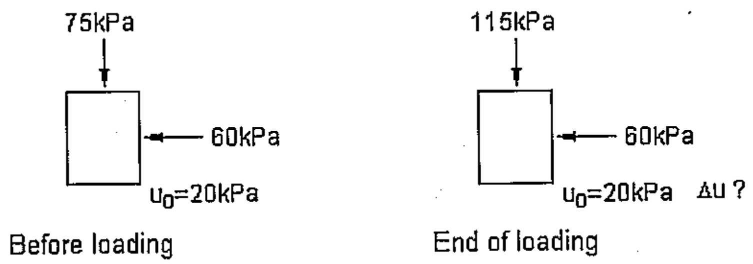


Figure Q1

Table Q1

ε_1	$\sigma_1 - \sigma_3$ kPa	u kPa	p kPa	p′ kPa	q kPa
0.0	0	0			
0.5	24	20			
1.0	49	35			
1.5	64	47			
2.0	74	57			
2.5	81	65			
3.0	87	72			
3.5	92	77			
4.0	96	82			
4.5	99	85			
5.0	100	88			
5.5	98	91			
6.0	97	93			
6.5	96	95			
7.0	95	97			
7.5	95	98			
8.0	95	99			

2. Figure Q2 shows a plot of void ratio versus effective consolidation stress, for a soil specimen representative of a compressible soil stratum. The in-situ (field) compression curve is OABC.

   a) State the in-situ effective overburden stress. (2 points)
   b) Explain how you would determine e_0. (3 points)
   c) Explain how you would establish point B on the in-situ compression curve. (3 points)
   d) Compute in-situ Compression Index and Recompression Index. (3 points)
   e) During construction, the 9m thick clay stratum described above is subjected to a vertical stress increment of 75kPa. Compute the consolidation settlement. (3 points)
   f) The geotechnical engineer recommends pre-loading to reduce later settlements and that the fill should be placed in 15kPa increments. She recommends that 90% of primary consolidation needs to be completed prior to placing the next layer of fill. Compute the time taken (in years) for 90% of settlement, for each layer to occur. The average c_v for the load range considered is 2.8×10^{-3} cm^2/s. $T_{90} = 0.848$. You may assume double drainage. (3 points)
   g) The geotechnical engineer also recommends that pore-pressure monitoring wells to be placed at suitable locations. This is to verify whether observations support the theoretical analysis. Explain how you would make this comparison. (3 points)

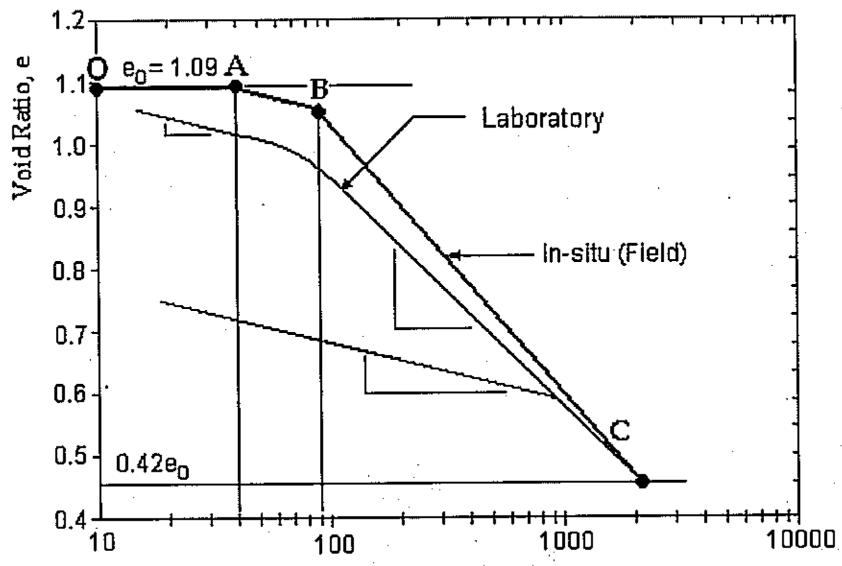


Figure Q2

3. Explain/discuss the following: (You are encouraged to use sketches when necessary. Limit your description to a maximum of five sentences.)

   a) Figure Q3(a) shows laboratory compaction curves obtained for various soil types. Discuss your observations. (5 points)

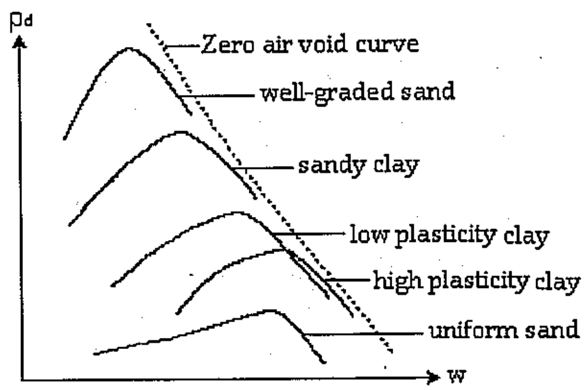


Figure Q3(a)

   b) Sketch the phreatic surface for the earth dam with base permeable at downstream end. (5 points)

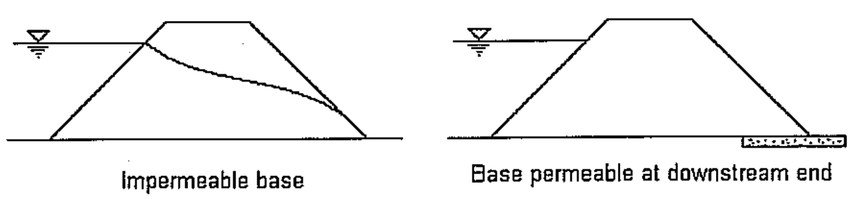


Figure Q3(b)

c) Relative Density, Shear Strength and Angle of Internal Friction are related words. Explain how these parameters are related to each other. (5 points)

d) Figure Q3(d) shows the state of stress in a two-dimensional soil element. Discuss the influence of pore water on normal and shear stresses. (5 points)

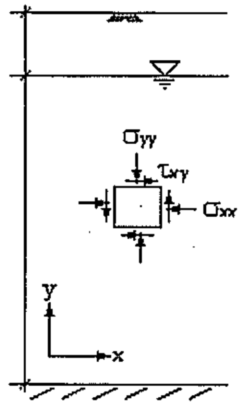


Figure Q3(d)

4.

a) Figure Q4(a) shows variations in wall pressure with wall movement. State the expressions for pressures p_0, p_a and p_p for a cohesionless backfill. (3 points)

b) Compute the respective coefficients of lateral earth pressures for a sandy soil with $\phi = 30^0$. (3 points)

c) Explain how wall pressures change based on $\Delta l/H$. (4 points)

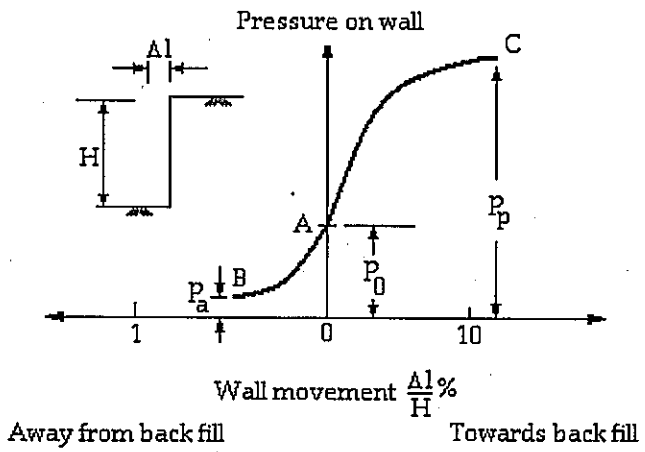


Figure Q4(a)

d) A 5m high retaining wall holds a mass of dry cohesionless soil with its horizontal surface level with the top of the wall. The retaining wall has a smooth vertical back. The soil carries a uniformly distributed surcharge load of $10kN/m^2$. It weighs $20kN/m^3$ and has a $\phi = 35^0$. Determine the active thrust (i.e. force) on the back of the wall, per meter length of wall. (10 points)

5. Figure Q4 shows a rectangular foundation supporting two columns A and B, with centrelines separated by a distance of 2m. The dead and live loads acting on the two columns are as follows:

Column	Dead load (kN)	Live load (kN)
A	200	170
B	500	375

a) Compute the distance of the resultant load from Column A. (4 points)

b) Using the result obtained in 5(a), determine the required footing length L and the locations of columns to ensure that the resultant force falls within the middle third of the footing. It is recommended that the footing should extend 0.6m beyond the centreline of each column. (4 points)

c) Compute the minimum footing width B required to maintain a safety factor of 2.5 against possible bearing capacity failure. (6 points)

d) State whether the selected footing dimensions satisfy design requirements. Use SPT-N = 25 (6 points)

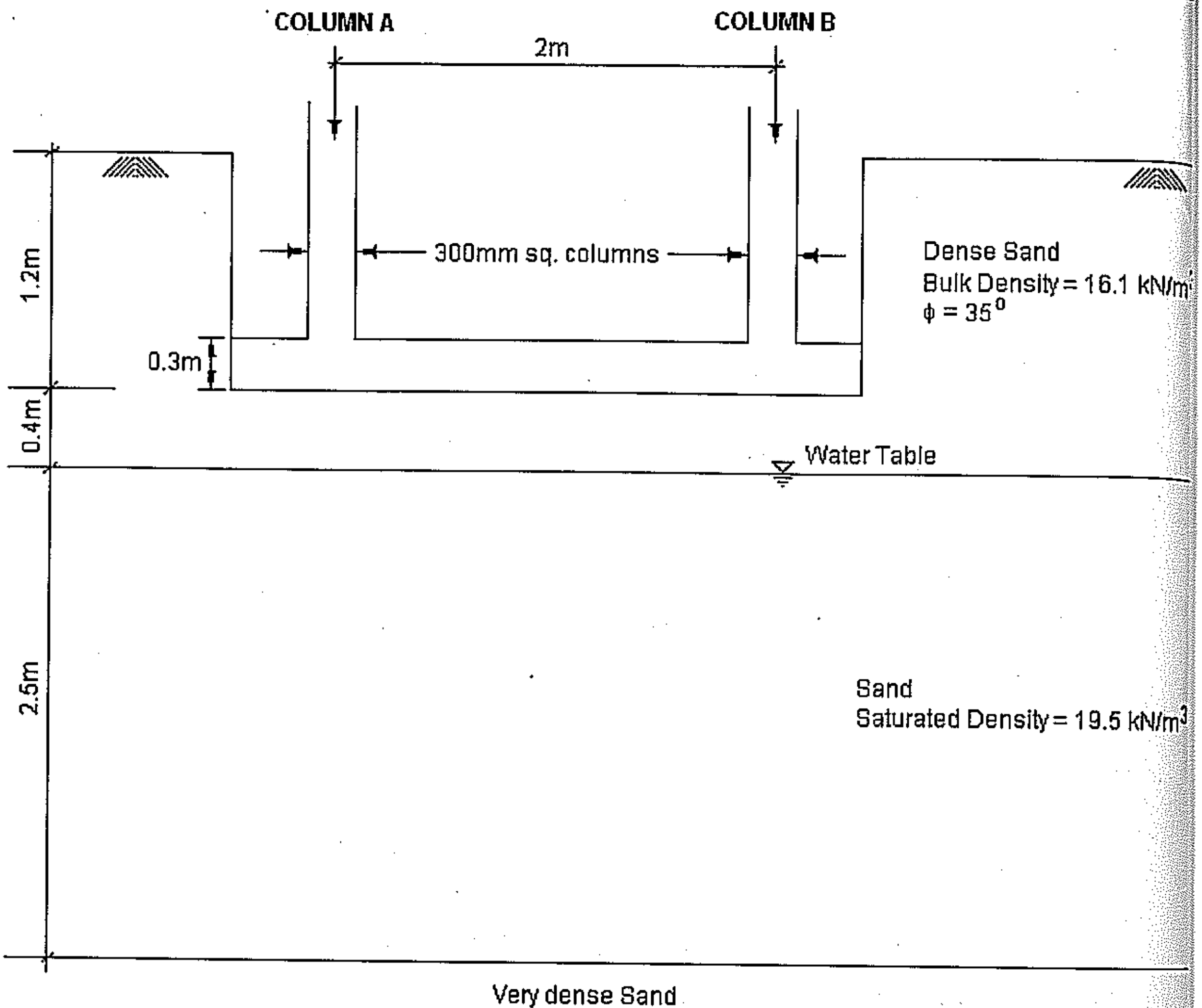


Figure Q5

6. Explain/discuss the following: (You are encouraged to use sketches when necessary. Limit your description to a maximum of five sentences.)

a) Figure Q6(a) shows a strip footing founded on a sandy soil. Discuss the effect of water table i) on Ultimate Bearing Capacity of the soil and ii) on allowable bearing capacity of the soil to satisfy settlement requirements. (5 points)

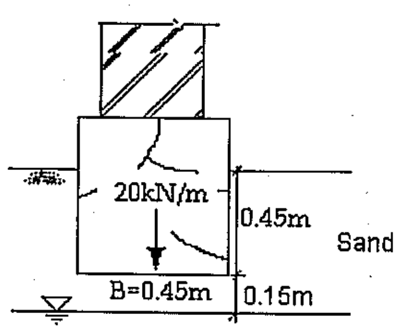


Figure Q6(a)

b) The stress-strain behaviour of a stiff clay or a sand yields a peak strength and a residual strength, which gives us ϕ_{peak} and $\phi_{residual}$ values. Discuss how you would use these values when analysing a slope for stability. (5 points)

c) Discuss the use of Standard Penetration Test N in designing a shallow foundation. (5 points)

d) Figure Q6(d) shows an anchored sheet pile wall with free earth support sytem. Show the forces and reactions contributing to equilibrium of the wall. Sketch the deflected shape. (5 points)

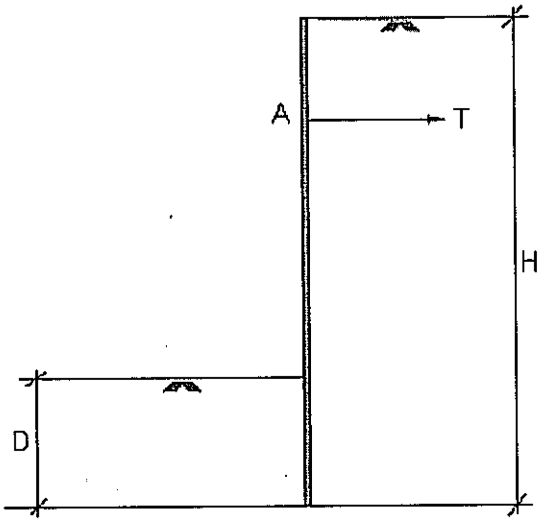


Figure Q6(d)

7. Figure Q7 shows two sheet-pile walls to be driven in a homogeneous river bed. The trench level is located 2.2m below the river bed. It is found that water in the trench needs to be pumped out at a rate of 5 litres per minute per meter length of trench.

a) Compute the total head difference that contributes to seepage. (2 points)
b) Sketch the flow net in accordance with stipulated rules. Use the sheet provided. (8 points)
c) Show potential values corresponding to equipotential lines. (2 points)
d) Show no-flow boundaries. (1 points)
e) Determine the point at which maximum hydraulic gradient occurs. You may indicate this point on a sketch. (2 points)
f) Estimate the maximum hydraulic gradient. Compute the factor of safety against piping. (3 points)
g) Estimate the Coefficient of Permeability of river sand. (2 points)

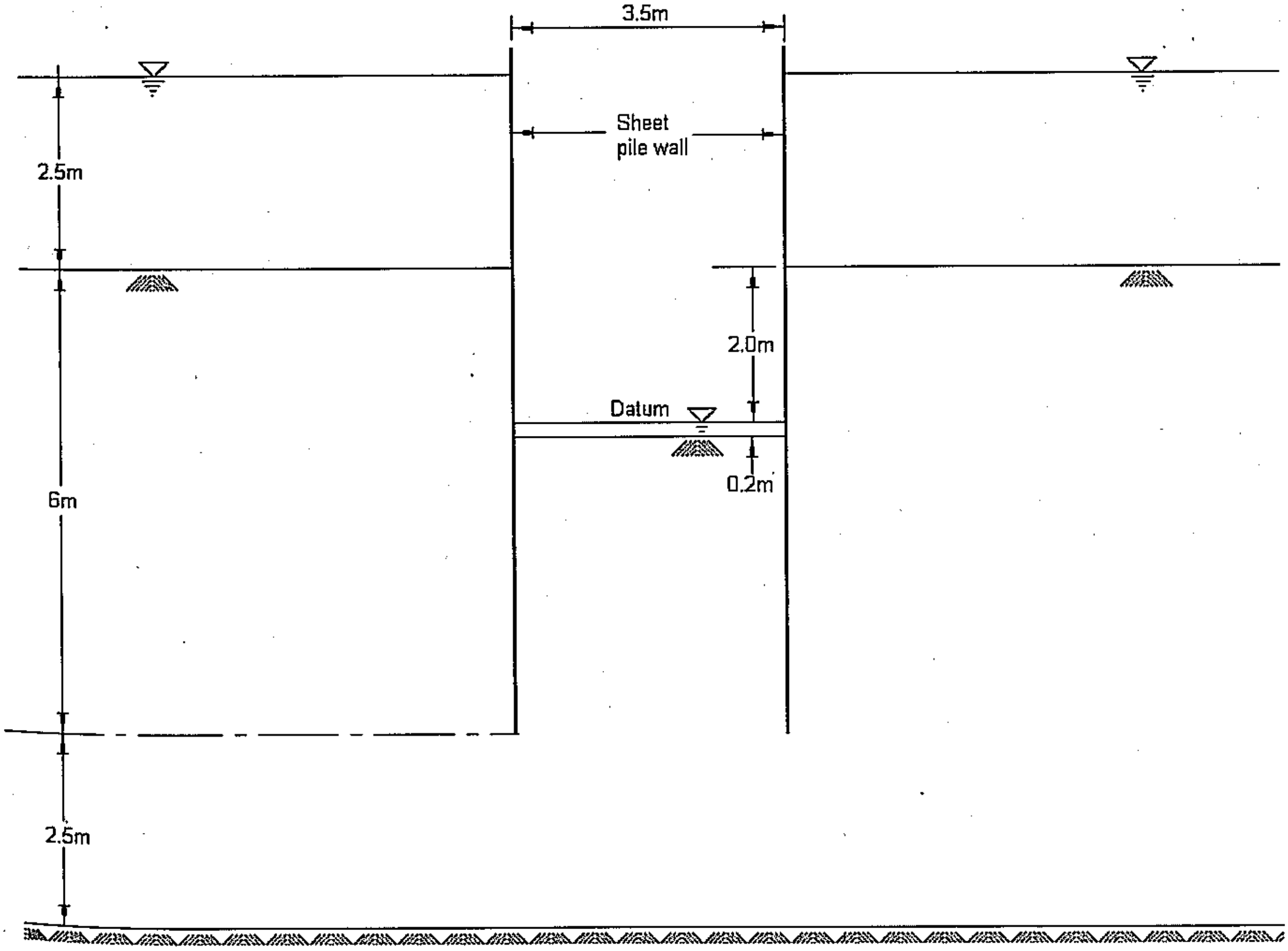


Figure Q7

8. A ready-made garment warehouse store of size 10m x 10m is to be constructed on a reclaimed land (Ref Figure Q8). The structural engineer has sought your opinion on the foundation type to be used. A strip footing of 1m width is required to carry a super-structure stress of 60kPa, while a raft foundation is required to carry a pressure to 25kPa. Both footing types are to be located at a depth of 0.5m from ground surface.

   a) For the strip footing sketch the pressure bulb corresponding to $0.1\Delta\sigma_v$, where $\Delta\sigma_v$ is the applied stress at founding level. (5 point

   b) For the raft footing sketch the pressure bulb corresponding to $0.05\Delta\sigma_v$, where $\Delta\sigma_v$ is the applied stress at founding level. (5 point

   c) <u>Compute</u> the consolidation settlement for both foundation types. You may assume that $C_c/(1+e_0)$ is equal to 0.1.

   d) <u>Discuss</u> your conclusions. (5 point

   e) <u>Discuss</u> the influence of water table on allowable bearing capacity of both footing types. (5 point

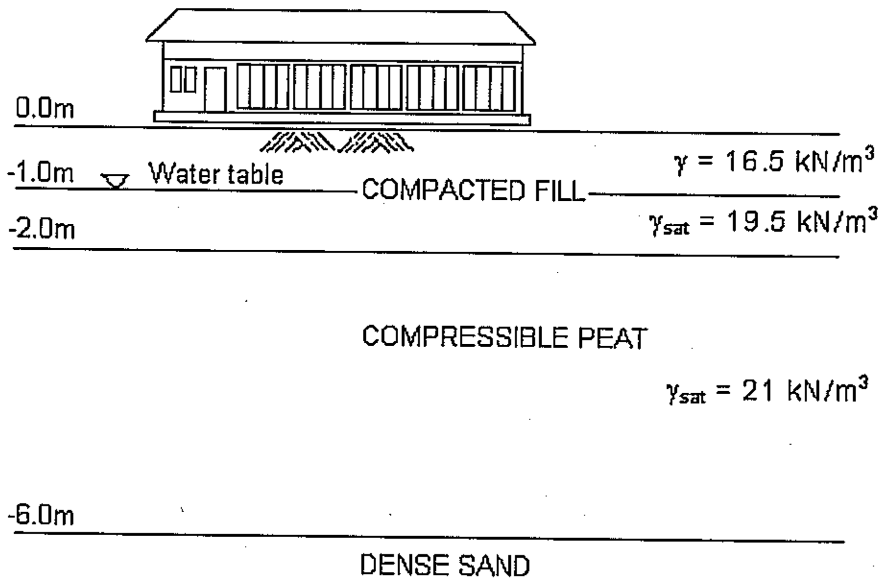
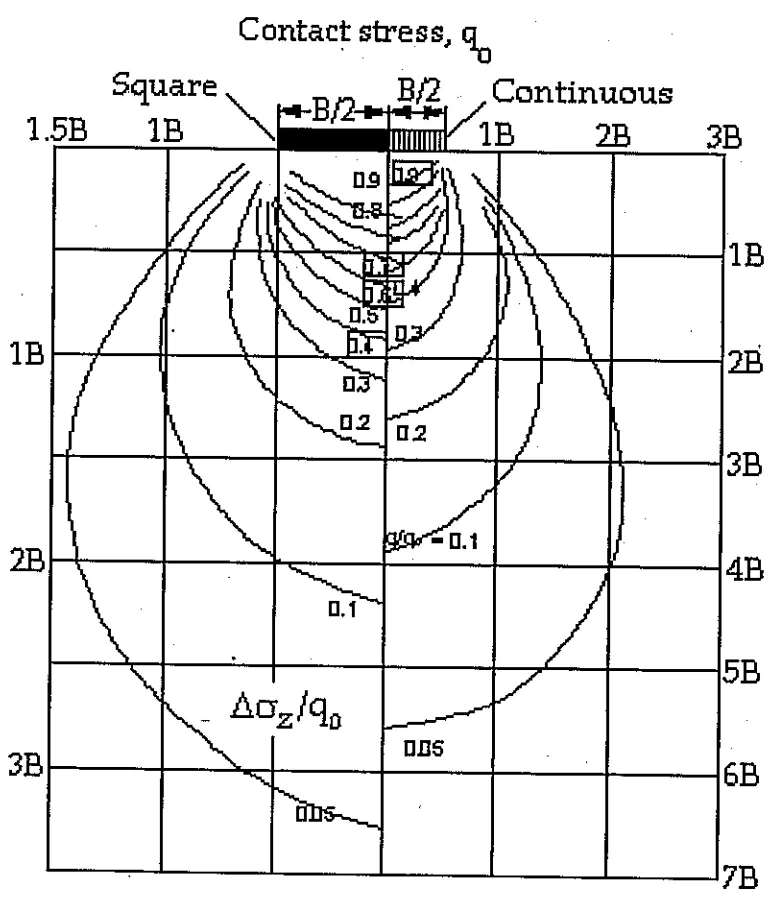
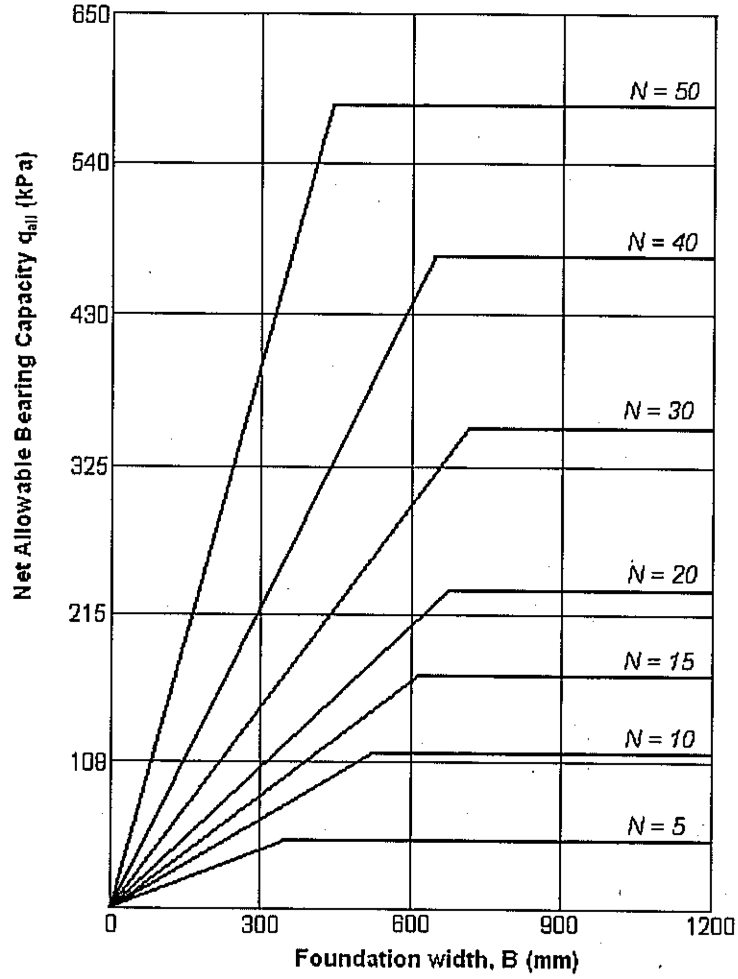
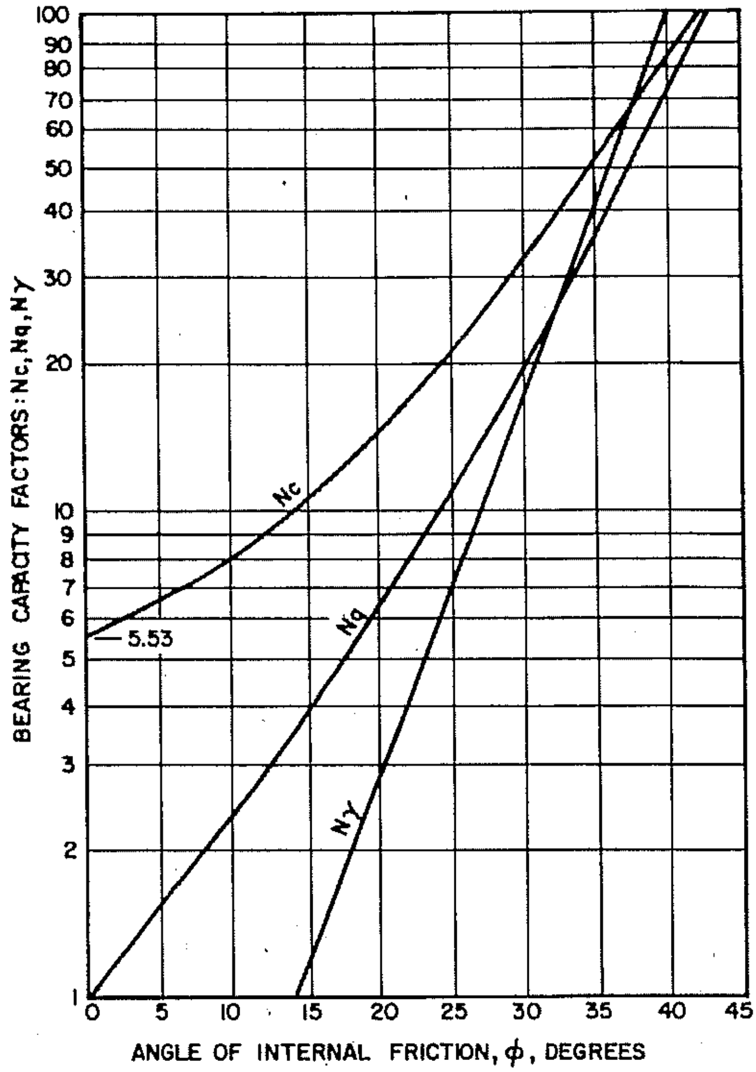


Figure Q8




Net Allowable Bearing Capacity q_{all} (kPa)
650
540
430
325
215
108
0
300
600
900
1200
Foundation width, B (mm)
N = 50
N = 40
N = 30
N = 20
N = 15
N = 10
N = 5



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:

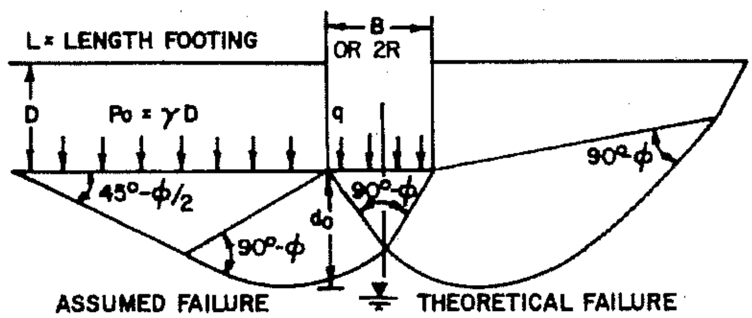
$q_{ult} = \gamma D N_q + \frac{\gamma B}{2} N_\gamma$

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:

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

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

FIGURE 1
Ultimate Bearing Capacity of Shallow Footings With Concentric Loads

Q7 Please attach this sheet to your answer script