THE OPEN UNIVERSITY OF SRI LANKA
DIPLOMA IN TECHNOLOGY (CIVIL) – LEVEL 04
Final Examination 2011/2012

00111

CEX4230 – SOIL MECHANICS AND INTRODUCTION TO ROCK MECHANICS

Time allowed: Three Hours. Index No. _____

Date: Friday, 16th March, 2012 Time: 1400-1700

PART A:
Answer all questions. All questions carry equal marks. Attach Part A of this paper to your answer script. You are advised to spend approximately One (1) hour for Part A. State your response within the space provided. (3x12 = 36 points)

1. Which of the following statements are true?

   A. 100g of mineral Kaolinite adsorbs less water than 100g of mineral Montmorrilonite.
   B. Plastic limit is the consistency limit between semi-liquid and semi-solid states.
   C. A 'ML' soil is a silty soil.
   D. A 'CH' soil should have Plasticity Index greater than 20.

   a) A, B and C only b) A, B and D only c) B, C and D only d) A, C and D only
   e) A, B, C and D.

2. A saturated clay soil specimen has the following properties:

Natural water content	= 60%
Void Ratio	= 0.67
Liquid Limit	= 82
Plastic Limit	= 35

   Its Liquidity Index is:

   a) 0.47 b) 0.53 c) 0.68 d) 0.73 e) 0.77

3. Bulk Density of a soil is expressed as $\rho = \frac{G_s + Se}{X} \cdot \rho_w$. The denominator, X is equal to:

   a) 1 + w b) 1 + n c) 1 + S d) 1 + e e) n

4. A sandy soil is subjected to a consolidated drained triaxial loading test, at a constant cell pressure of 100kPa. The deviatoric stress at failure is found to be 225kPa. The friction angle ϕ' is equal to:

   a) 32 b) 33 c) 34 d) 35 e) 36

5. Which of the following statements are true regarding Terzaghi's 1-dimentional consolidation theory?

   A. During initial compression it is considered that excess pore water pressure dissipation takes place.
   B. Time taken for primary consolidation to occur depends on the permeability of the soil.
   C. Degree of consolidation measures primary consolidation settlement at a given time after placing the load.
   D. A plot of settlement versus logarithmic time is used to estimate settlement at zero excess pore water pressure.

   a) A, B and C only b) A, B and D only c) B, C and D only d) A, C and D only
   e) A, B, C and D.

6. The results obtained during a Standard Proctor Compaction test specimen are given below:

Weight of soil + mould (g)	= 3921.4
Weight of mould (g)	= 1933.0
Average water content (%)	= 10.1
Volume of mould (c.c.)	= 1000
G_s	= 2.65

   The dry density in kN/m^3 is equal to:

a) 17.7 b) 18.1 c) 18.7 d) 19.2 e) 19.6

7. Which of the following statements are true?

   A. Coefficient of permeability is measured in cm^2/sec.
   B. Coefficient of permeability increases with fluid viscosity.
   C. `Sand boiling' occurs at a hydraulic gradient of around 1.0.
   D. Darcy's law is applicable only for laminar flow situations.

   a) A and B only b) A and C only c) A and D only d) B and C only
   e) C and D only

8. Angle of repose of a cohesionless granular soil does not depend on:

   a) Surface roughness of soil grains.
   b) Size distribution of particles in the soil heap.
   c) Shape of soil grains.
   d) Moisture content.
   e) Complete submergence of soil heap.

9. A material with $\gamma' = 12\ kN/m^3$, $\phi' = 0$ and $c' = 0$ is retained by a vertical wall of 5m height. The force exerted per 1m of wall length is:

   a) 50kN b) 100kN c) 150kN d) 200kN e) 450kN

10. Which of the following statements concern the Unconfined Compression Test?

    A. The test yields the shear strength parameter c'.
    B. The test is performed on cohesive soils only.
    C. The test gives a zero friction angle.
    D. The test is performed on fully saturated specimens only.

    a) A, B and C only b) A, B and D only c) B, C and D only d) A, C and D only
    e) A, B, C and D.

11. A well graded sandy soil specimen has 10% fines. Which of the following statements are true?

    A. Unified Soil Classification System (USCS) classifies the soil as SW.
    B. USCS requires us to determine the type of fines.
    C. USCS recommends Liquid and Plastic Limit tests to determine the type of fines.
    D. The soil may be classified as SC.

    a) A and B only b) A and C only c) A and D only d) B and C only
    e) B and D only

12. Which of the following statements are true?

    A. Auger boring with periodic withdrawal of material is suitable for soft clays.
    B. Rotary drilling removes cutting using circulating drilling fluid.
    C. Standard Penetration Test uses a split barrel sampler.
    D. Undisturbed samples are obtained by driving a tube sampler.

    a) A, B and C only b) A, B and D only c) B, C and D only d) A, C and D only
    e) A, B, C and D.

PART B:

Answer four questions. All questions carry equal marks. You are advised to spend approximately 28 minutes per question. (16x4 = 64 points)

1. Figure B1 shows compaction curves observed for various soil types.

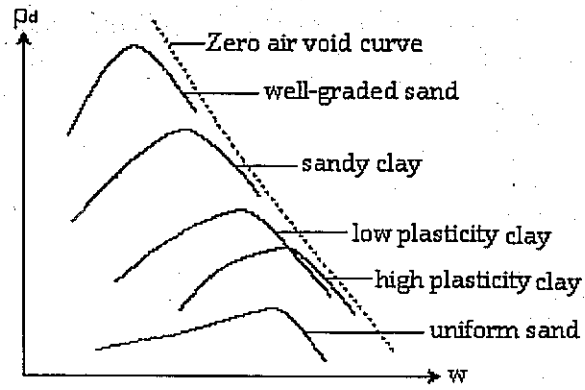


Figure B1

a) Derive the relationship for dry density, ρ_d in terms of degree of saturation, S, specific gravity, G_s and water content, w. (4 points)

b) Sketch to the same approximate scale, the 3-phase diagrams for:

i) A soil element, which is wet of optimum moisture content. (2 points)

ii) A soil element, which is completely saturated. (2 points)

c) Discuss the relative changes in each phase for the two cases discussed in question 1(b) above. (2 points)

d) Explain why dry density decreases with moisture content, at wet of optimum water content. (2 points)

e) Explain why well-graded sands have higher dry densities than uniformly graded sands. (2 points)

f) Explain why clays with low and high plasticity have their respective compaction curves closer to the zero air void curve. (2 points)

2. Figure B2 shows a retaining wall of a waterfront structure.

a) Draw the variation of i) total vertical stress ii) hydro-static stress and iii) vertical effective stress, with depth. State principal values. (4 points)

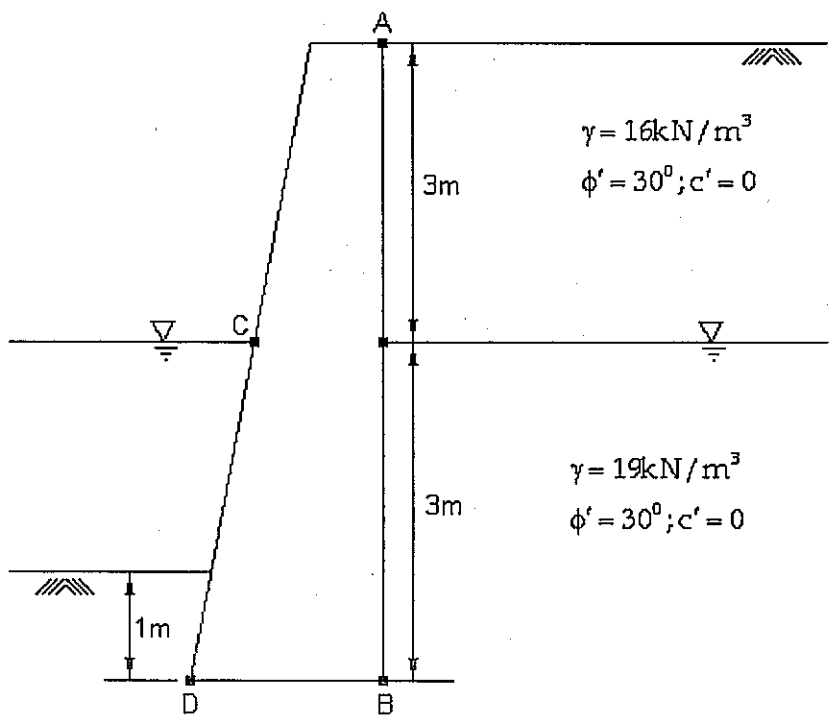


Figure B2

b) Draw the effective horizontal stress distribution acting on smooth wall, along a meter length of AB, if 'at-rest' condition (i.e. K_0 condition) exists. State principal values. Hence compute the total force per meter length of wall, exerted by the retained soil. (6 points)

c) State the forces that prevent sliding along base DB. (3 points)

d) State the forces that prevent overturning about point D. (3 points)

3. Figure B3 shows a sloping ground AB, retaining a soil height of 3m. AC represents a trial failure plane along which soil wedge ABC may slide. Soil properties are $\gamma = 16kN/m^2$, $\phi' = 28^0$, and $c' = 20kN/m^2$.

The respective factors of safety are expressed as: $F_{\phi'} = \frac{\tan\phi'}{\tan\phi'_d}; F_{c'} = \frac{c'}{c'_d}$.

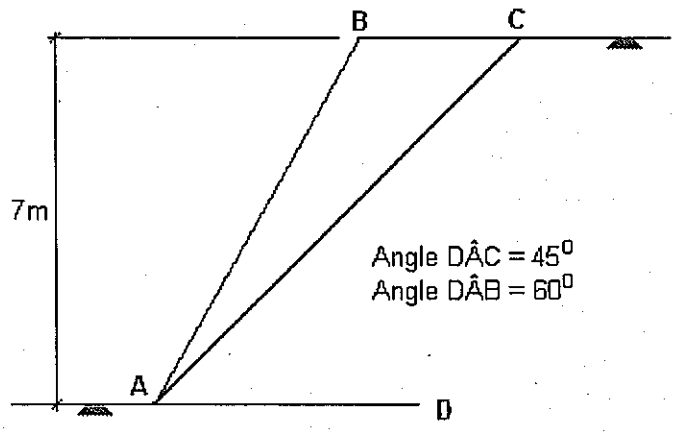


Figure B3

a) Define the terms stated in the two equations representing factors of safety. (4 points)

b) Compute the normal stress, σ_n acting on plane AC. (4 points)

c) Compute the shear stress, τ acting on plane AC (4 points)

d) Hence compute the factor of safety against shear failure. (4 points)

4. Figure B4(a) shows a plot of $e - \log\sigma'_v$ obtained during an Oedometer test. The sample had an initial height, $H_0 = 20mm$; average diameter = 50mm; $e_0 = 2.93$; total settlement, $\Delta H = 2.705mm$.

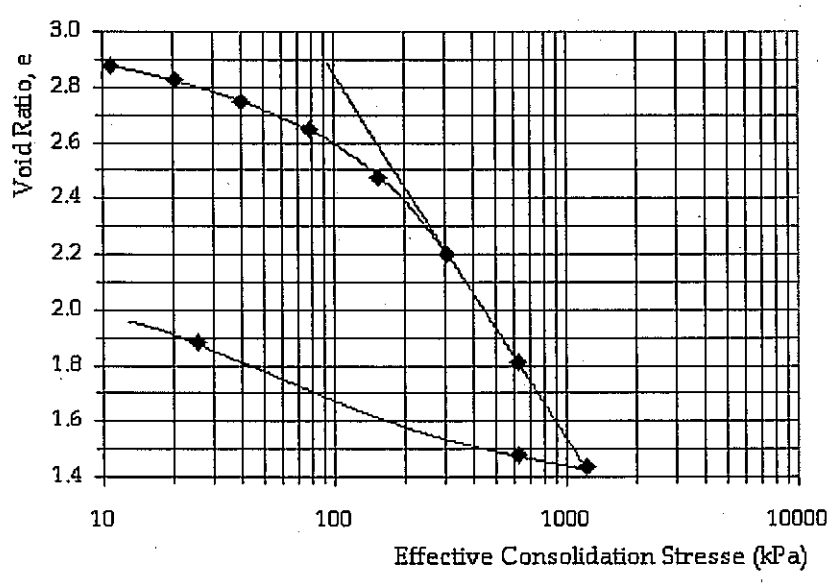


Figure B4(a)

a) Determine the Compression Index and Recompression Index. (5 marks)

b) Determine the Pre-consolidation pressure. (3 marks)

c) Figure B4(b) shows the 16m thick clay layer subject to a 1.5m surcharge fill. The above mentioned specimen is obtained from a 8m depth below ground level.

i) Compute the effective vertical overburden stress. (3 marks)

ii) State whether the soil is Normally Consolidated or Over Consolidated. (2 marks)

d) Estimate the expected total settlement of the clay layer. (3 marks)

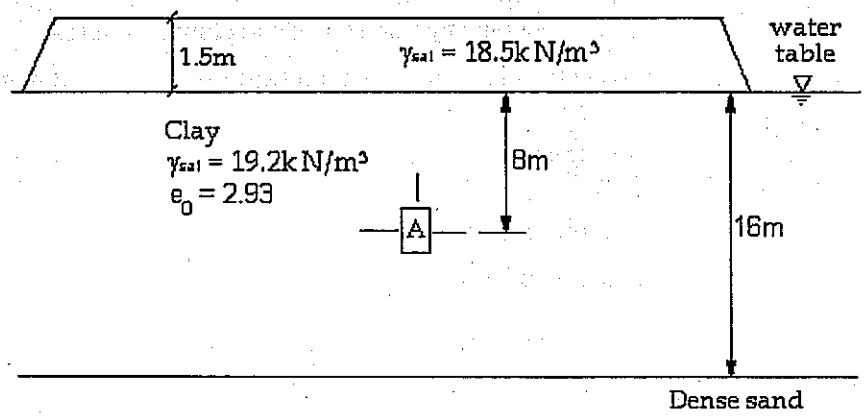


Figure B4(b)

5.

a) Suppose that you are given a tube sample containing a fine-grained soil; list the standard tests you would perform in order to classify the soil based on Unified Soil Classification System (USCS). (3 points)

b) Explain how you would determine its plasticity characteristics based on USCS. (3 points)

c) Table below lists results of a laboratory test specimen:

Particle size (mm)	% passing
4.75	100
0.15	89
0.425	63
0.063	57
0.04	41
0.02	35
0.01	20
0.001	6

Natural moisture content = 8%

Liquid Limit = 10; Plastic Limit = 7

i) Determine Gravel, Sand, Silt and Clay fractions. (6 points)

ii) Classify the soil based on USCS. (4 points)

6. Figure B6 shows a pad foundation transmitting its column load to ground.

a) Sketch the pressure bulb that demarcates the zone of influence corresponding to 10% of footing pressure. State important dimensions. (6 points)

b) Hence estimate the depth of investigation to ensure that the footing may not undergo excessive settlement. (2 points)

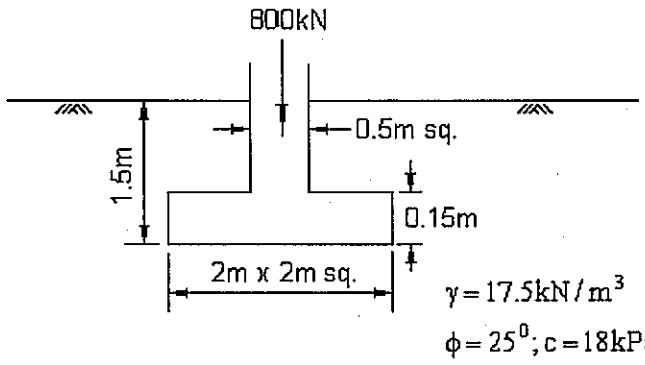


Figure B6

c) Compute the Ultimate Bearing Capacity for the given footing if the super-structure load is 800kN. A suitable unit weight for concrete can be assumed. The Ultimate Bearing Capacity of a square footing is expressed as $q_u = 1.3cN_c + qN_q + 0.4\gamma BN_\gamma$. (6 points)

d) Compute the Factor of Safety against ultimate failure. (2 points)

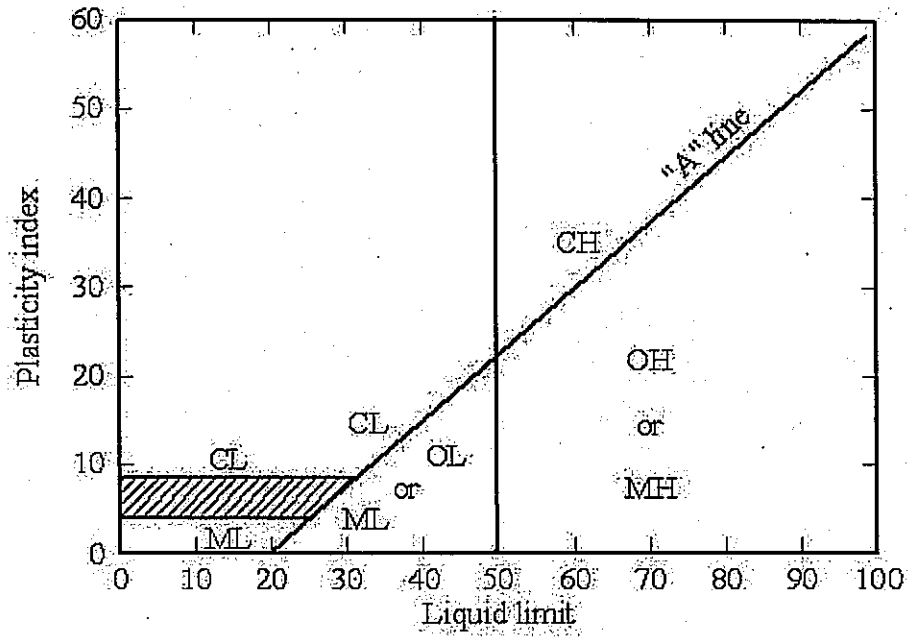
7. Explain the following mechanisms by providing a sketch with explanatory notes.

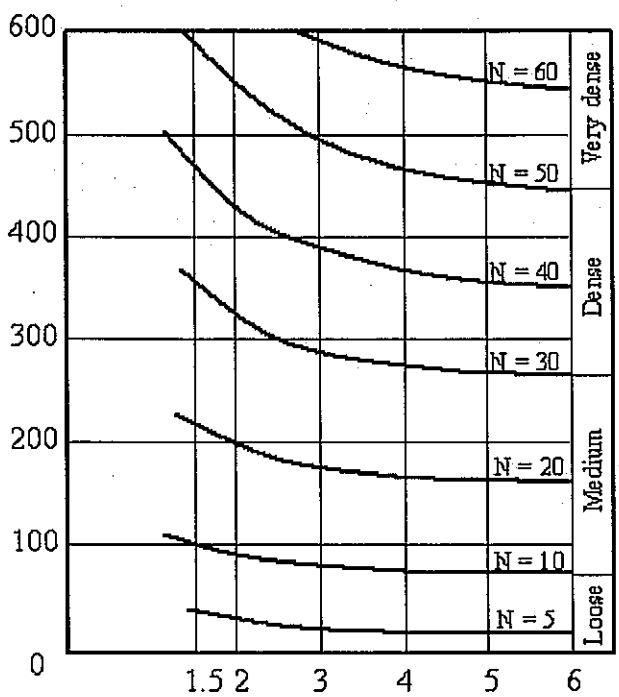
a) The state of a sandy soil surrounding a split barrel sampler when it is driven in, during the Standard Penetration Test. (4 points)

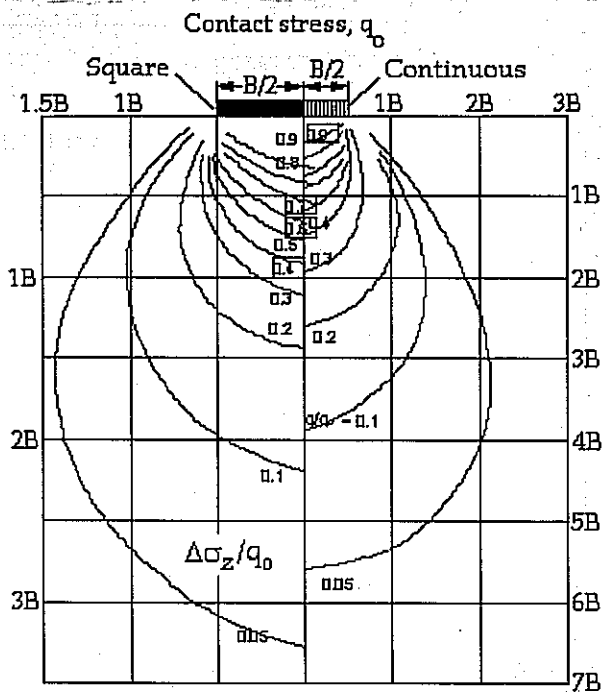
b) The state of a sandy soil specimen in a constant head permeameter, when it reaches its critical hydraulic gradient. (4 points)

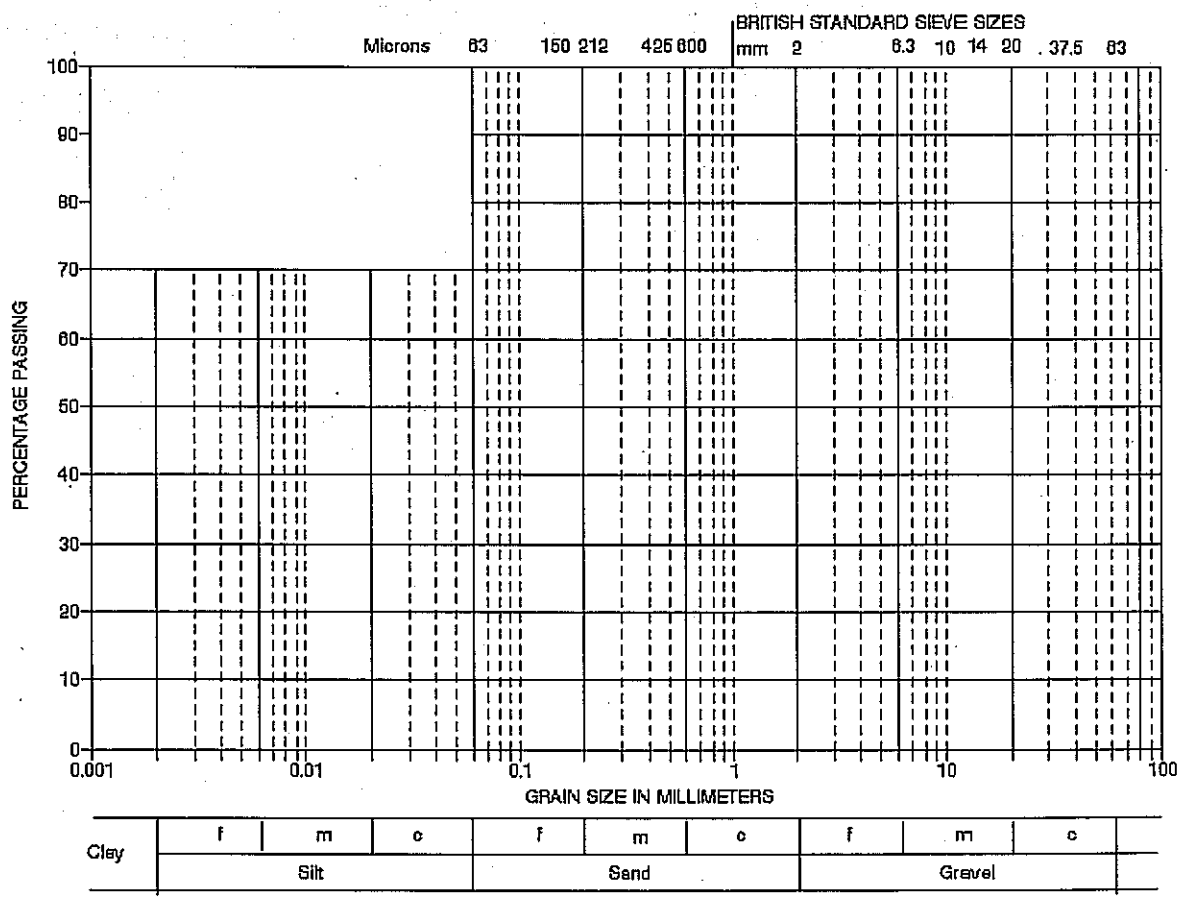
c) State of a soil element at an active state of plastic equilibrium. (4 points)

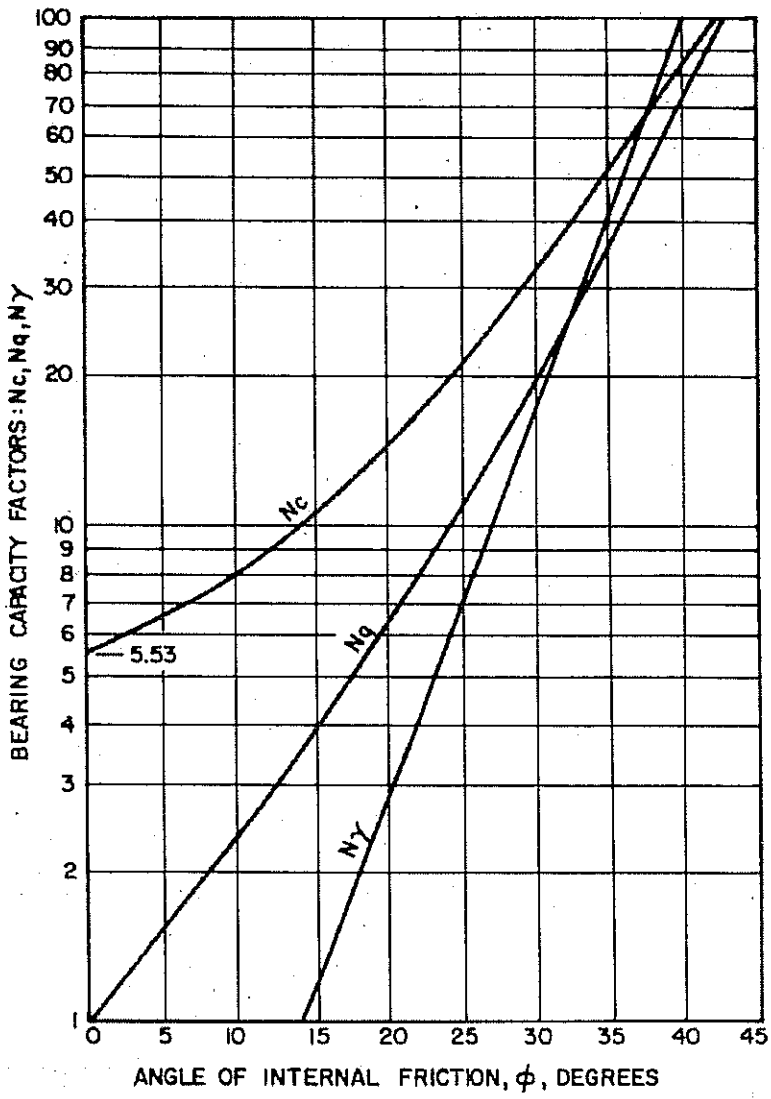
d) A fine grained soil that shows a high dilatancy reaction. (4 points)






Contact stress, q_o
Square
B/2
B/2
Continuous
1.5B
1B
1B
2B
3B
1B
2B
3B
4B
5B
6B
7B
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.2
0.1
0.1
0.05
0.05
$\Delta\sigma_z/q_o$


BRITISH STANDARD SIEVE SIZES
Microns 63 150 212 425 600
mm 2 6.3 10 14 20 37.5 63
PERCENTAGE PASSING
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
10
100
GRAIN SIZE IN MILLIMETERS
Clay
f m c
Silt
f m c
Sand
f m c
Gravel



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

$q' = cN_c + \gamma DN_q$

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

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

SQUARE OR RECTANGULAR FOOTING

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

CIRCULAR FOOTING: R = B/2

$q_{ult} = 1.3\,cN_c + \gamma DN_q + 0.6\gamma RN_\gamma$

FOR COHESIONLESS FOUNDATION SOILS (c = 0)

CONTINUOUS FOOTING:

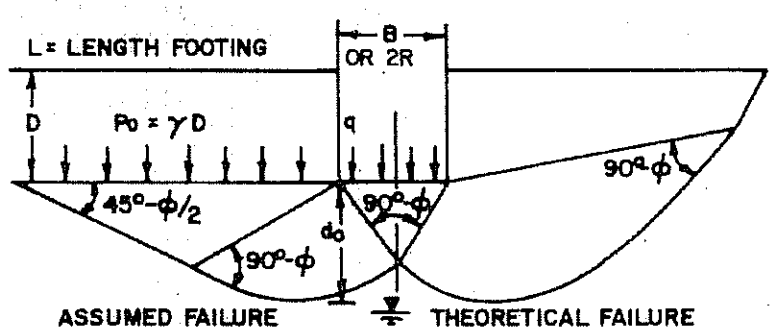
$q_{ult} = \gamma DN_q + \frac{\gamma B}{2} N_\gamma$

SQUARE OR RECTANGULAR FOOTING:

$q_{ult} = \gamma DN_q + 0.4\gamma BN_\gamma$

CIRCULAR FOOTING:

$q_{ult} = \gamma DN_q + 0.6\gamma RN_\gamma$



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. $D \leq B$
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