00140

THE OPEN UNIVERSITY OF SRI LANKA
DIPLOMA IN TECHNOLOGY (CIVIL) – LEVEL 04
Final Examination 2008/2009

CEX4230 – SOIL MECHANICS AND INTRODUCTION TO ROCK MECHANICS

Time allowed: Three Hours. Index No. _____

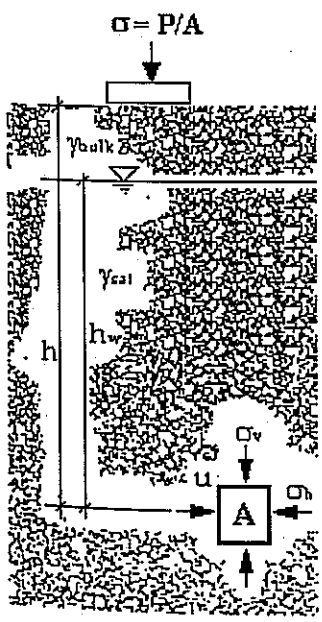
Date: Friday,26th March, 2010 Time: 1400-1700

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. The Unified Soil Classification System (USCS) identifies silt as a fine grained soil.
   a) State the symbol that identifies silt. ____
   b) State the size range for silt in millimeters. _____
   c) A fine grained soil has more than 50% passing 0.425mm sieve. State whether this statement is true or false. _____

2. The USCS uses Effective Size, D_{10} in classifying soils.
   a) D_{10} is used to classify both fine-grained and coarse-grained soils. State whether this statement is true or false. _____
   b) Using a sketch, show how D_{10} is obtained for a given soil. Name the axes.

3. Figure SQ3 shows a soil element located at depth h.



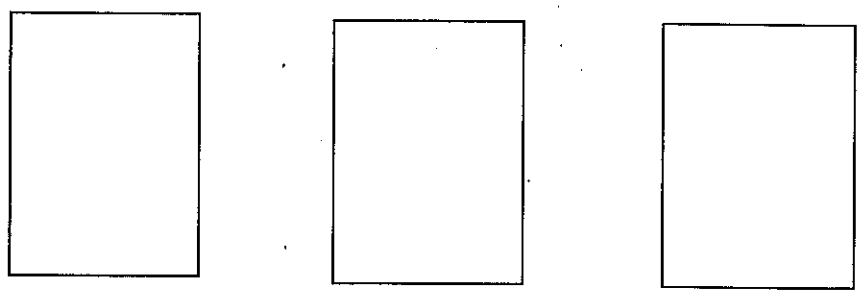
   a) For soil element A (refer Figure SQ3), state the equations that represent effective stresses in horizontal and vertical directions.

   b) The Principle of Effective Stress considers that soil is anisotropic and water is isotropic. Discuss whether this statement is true or false.

Figure SQ3

4. If a set of values {2.65, 0.7, 1.05, 20} are given to you.
   a) State the value that represents the specific gravity of a sandy soil. _____
   b) State the value that represents the porosity of a soil. _____
   c) State the value that represents the saturated density measured in kN/m^3 _____

5. The three-phase diagram is used to show relative amounts of solid, water and air present in a soil mass. Show (refer Figure SQ5) the relative amounts of the three phases present in a completely dry soil, partially saturated soil and a fully saturated soil.

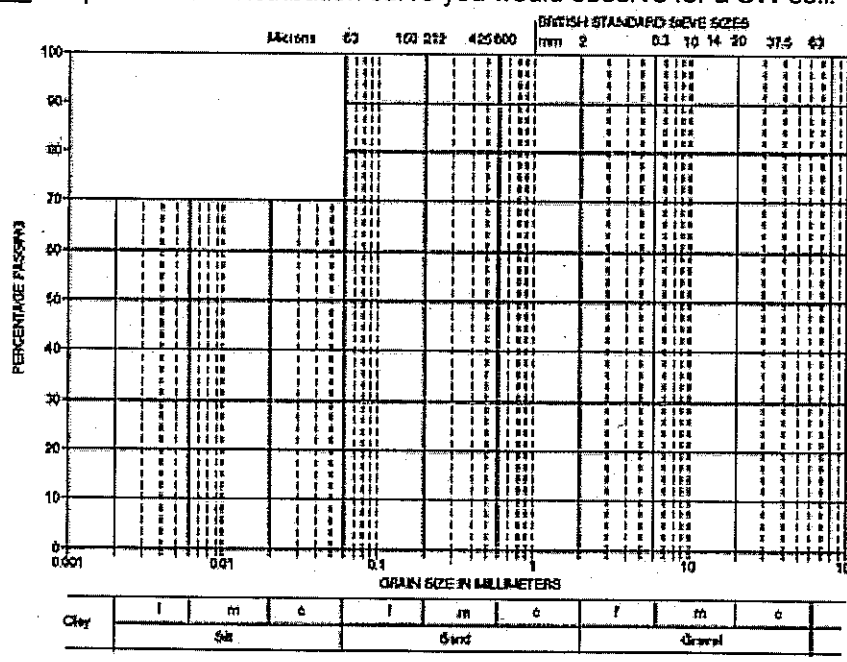


Dry of optimum MC | At optimum MC | Wet of optimum MC

Figure SQ5

6. A retaining wall is designed to resist active pressures caused by supporting soil. Explain the reasons that cause a soil mass to reach an active state of plastic equilibrium.

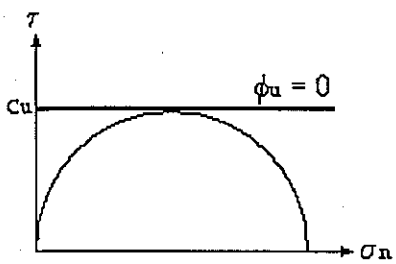
7. Sketch the particle size distribution curve you would observe for a SW soil.



8. The factor of safety for a slope is represented by $F_s = \dfrac{c + \sigma_n' \tan\phi}{c_d + \sigma_n' \tan\phi_d}$ Define its parameters.

9. Terzarghi's Bearing Capacity Equation is expressed as: $q_f = cN_c + qN_q + \frac{\gamma B}{2}N_\gamma$ Explain how you would compute the term q.

10. Figure below shows a Mohr's circle of stress obtained during a UC test.
    a) State the equation of the failure plane. _____
    b) Mark the vertical and horizontal stress values on figure.
    c) State whether these stresses are total stresses or effective stresses. _____



11. Undisturbed samples can be obtained wash boring method. Discuss correctness of this statement.

12.

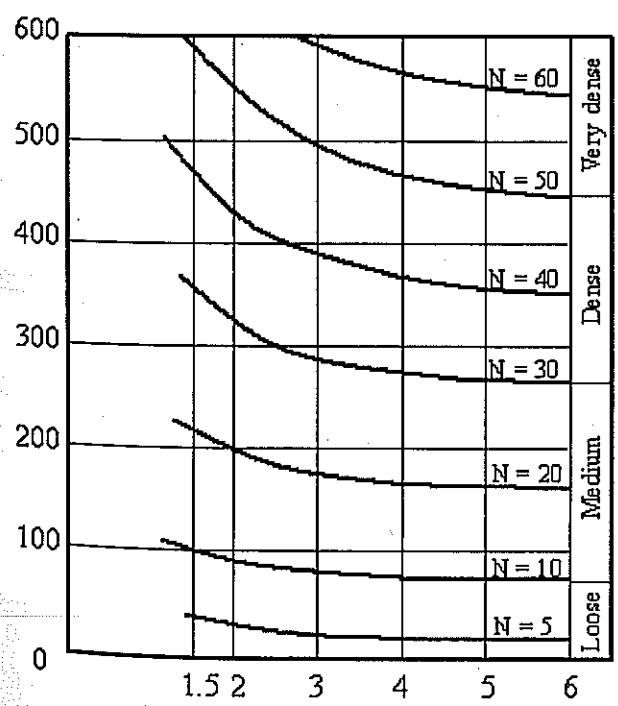
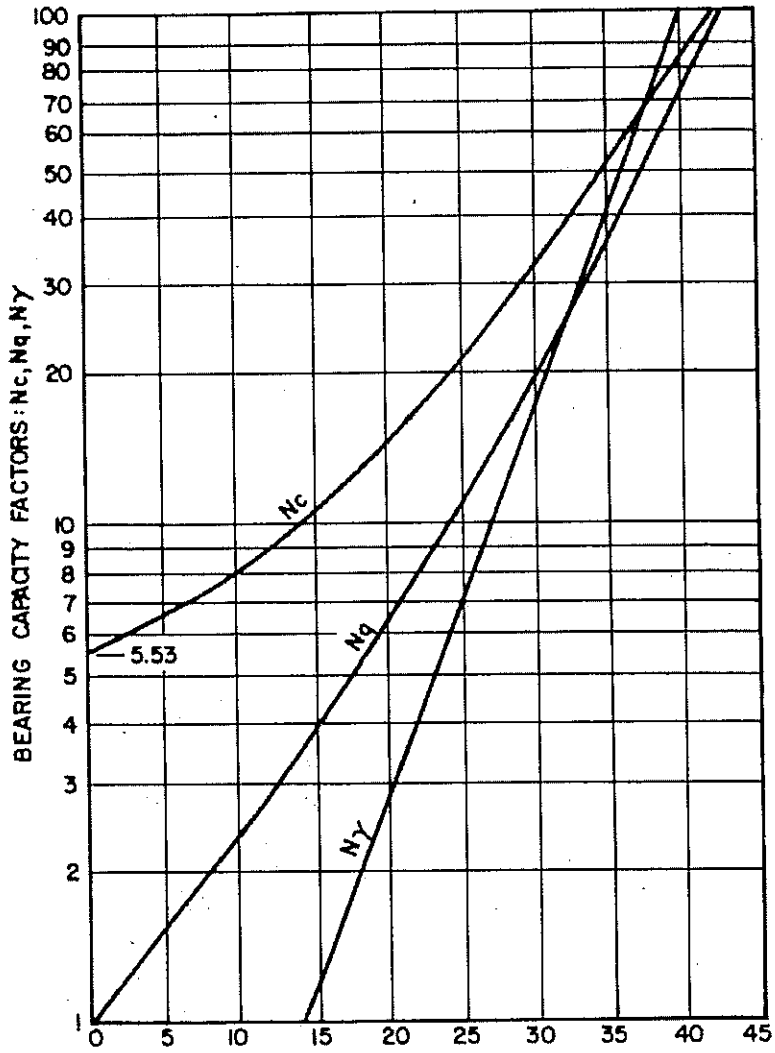
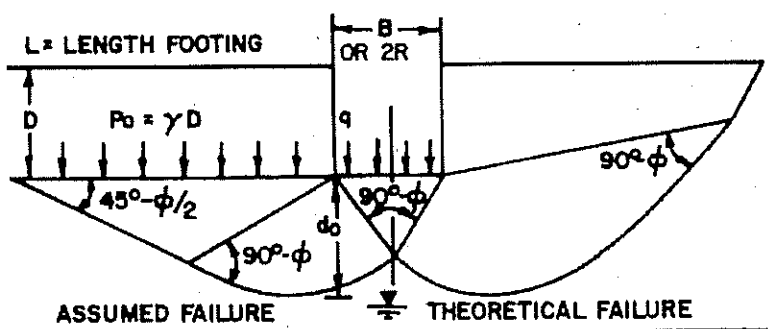


Figure on the left hand side is used when designing a shallow footing founded on a sandy soil.
a) Name the x and y axes.
b) State the units of measurement.
c) Explain the term N.





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

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

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:

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

CIRCULAR FOOTING:

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

PART B:

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

1. The following readings were obtained during a 1-D Consolidation test:

Before loading

Mass of wet soil [g]	= 95.132
Average diameter of ring [cm]	= 49.7
Average height of ring [mm]	= 20.25

End of test

Mass of wet soil [g]	= 91.83
Mass of dry soil [g]	= 74.58
Total change in dial reading [mm]	= 2.243

a) Compute height of solids (in mm). (3 points)
b) Compute initial void ratio, e_0. (2 points)
c) Compute final void ratio, e_f. (2 points)
d) Compute the initial degree of saturation assuming that the specimen is completely saturated at end of test. (3 points)
e) Explain how you would compute in-situ effective overburden stress, σ'_{vo}. for the given specimen. (3 points)
f) Using a sketch show how you would compute the re-compression index. (3 points)

2. When the water content of a saturated clay specimen is reduced, it undergoes a volume change. Figure Q2 shows how total volume changes with soil consistency.

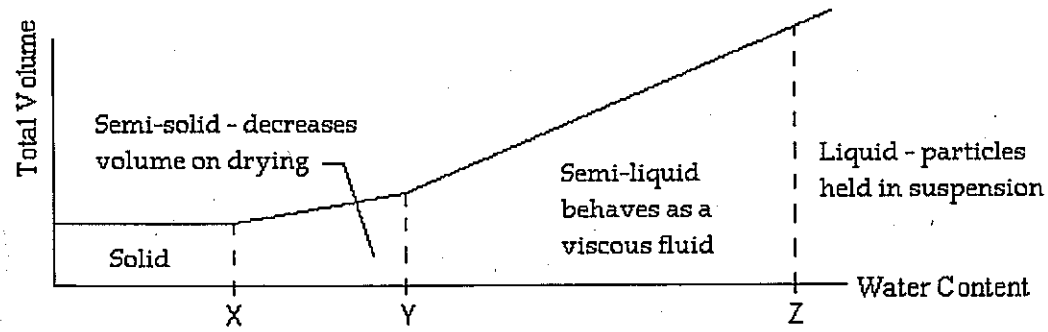


Figure Q2

a) List the consistency indices identified by X, Y and Z, respectively. (3 points)
b) Briefly describe the method used to identify point Z (3 points)
c) Discuss how you would determine whether the soil has reached the consistency at Y. (2 points)
d) If the natural water content of the soil specimen plots at mid-point between Y and Z, Compute its liquidity index. (2 points)
e) If you assume that the above figure represents a clay with low plasticity, show on the same figure, X, Y and Z values corresponding to a clay with high plasticity. (3 points)
f) The Unified Soil Classification System requires you to perform Liquid Limit and Plastic Limit tests if per cent fines exceed 5%. Discuss the correctness of this statement. (3 points)

3. Figure Q3(a) shows a Constant Head Permeability Test apparatus.

a) Considering that the datum passes through point B, determine the Elevation Head, Pressure Head and Total Head at points A and B. (4 points)

Point	Elevation Head	Pressure Head	Total Head
A			
B			

b) Determine the Hydraulic Gradient across the soil sample. (2 points)
c) Using your responses for 3(a) and 3(b) above, determine the Pressure Head at point C, which is located at sample mid-point. (2 points)

d) Determine k_{20} for a measured flow rate of 6 ml per minute. The average diameter of the soil sample is 50mm. The flow rate is measured at 30^0C. η_{20} = 1.002 mPa.s; η_{30} = 0.798 mPa.s; $\rho_{30}/\rho_{20} \approx 1.0$. (4 points)

e) Figure Q3(b) shows an enlarged view of soil element C. List four factors that influence the measured coefficient of permeability of the soil. (4 points)

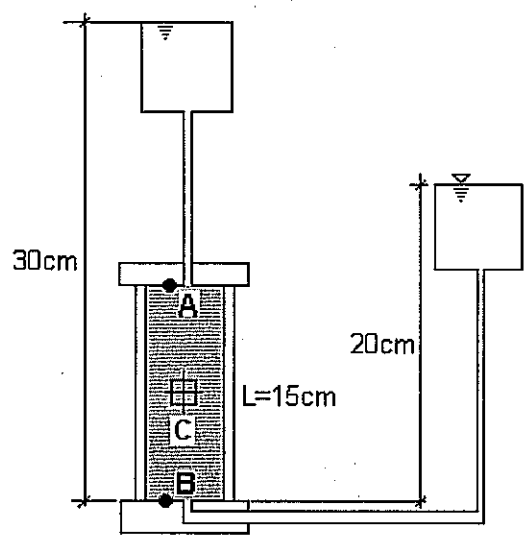


Figure Q3(a)

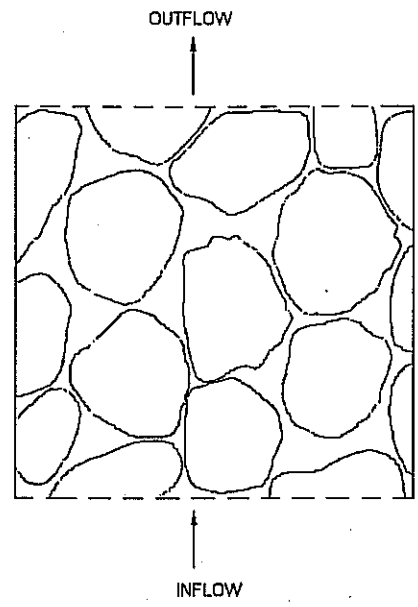


Figure Q3(b)

4. Figure Q4 shows a sand element located at a depth of 5m from the soil surface.

a) If this soil element is at 'at rest' state, determine its principal stresses. (2 points)

b) Sketch the Mohr's circle of stress on a τ vs. σ_n plot. (2 points)

c) Sketch the line representing Mohr-Coulomb failure criterion on the same figure. (1 point)

d) Compute the normal and shear stresses acting on a plane that has an inclination of 45^0 with the horizontal plane. (3 points)

e) Explain whether shear stress acting on any such plane of the soil element is considered 'safe'. (2 points)

f) Suppose that the wall moves to the left causing the soil mass to attain an active Rankin state of plastic equilibrium. Sketch the Mohr's circle of stress corresponding to this state on the same figure. (2 points)

g) Determine the active earth pressure acting on the soil element. (2 points)

h) Determine the angle, which the failure plane makes with the horizontal plane. (2 points)

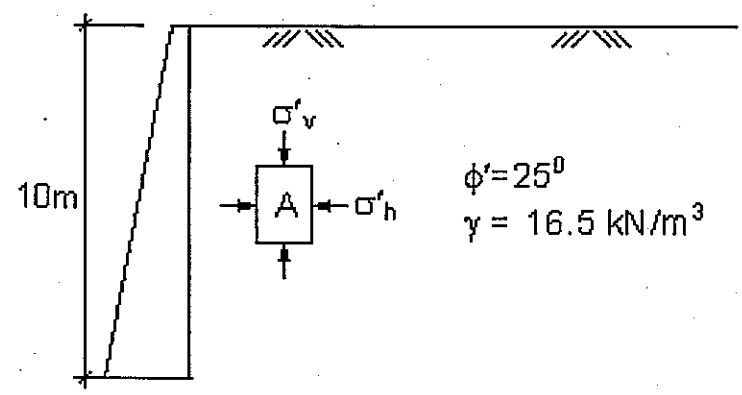


Figure Q4

5.

a) Sketch a square footing, a strip footing and a raft footing. (3 points)

b) Explain the situations where the above three types of footings are used. (3 points)

c) Sketch the variation of settlement vs. Bearing Pressure, as observed for a shallow footing subjected to general shear failure. Show the ultimate bearing capacity, q_f and the maximum safe bearing capacity, q_s, on the same sketch. Name the axes; state all units. (3 points)

d) Terzaghi's bearing capacity equation for a rigid strip footing is given as $q_f = cN_c + qN_q + 0.5\gamma BN_\gamma$. A strip footing is 1.2m wide; depth to founding level is 1.0m, γ = 17 kN/m^3, $\phi = 25^0$, c = 30kPa.

Using Terzaghi's equation, compute the allowable super-structure load for a Factor of Safety of 4. (7 points)

6. Figure Q6 shows a 45^0 slope excavated to a depth of 8m in a deep layer of saturated clay. Its unit weight is found to be $20kN/m^3$. The relevant shear strength parameters are $c_u = 65kN/m^2$ and $\phi_u = 0$.
   a) Explain how you would obtain a soil specimen to determine the above shear strength parameters. (2 points)
   b) List a laboratory test that gives the above shear strength parameters. (2 points)
   c) State the method of analysis you wish to perform to determine the stability of the slope. List the assumptions used in this analysis. (4 points)
   d) State whether you would perform an effective stress analysis or a total stress analysis. (1 point)
   e) Compute the overturning moment for the trial slip circle shown in Figure Q6 (3 points)
   f) Compute the restoring moment for the trial slip circle shown in Figure Q6 (3 points)
   g) Compute the Factor of Safety. (1 point)

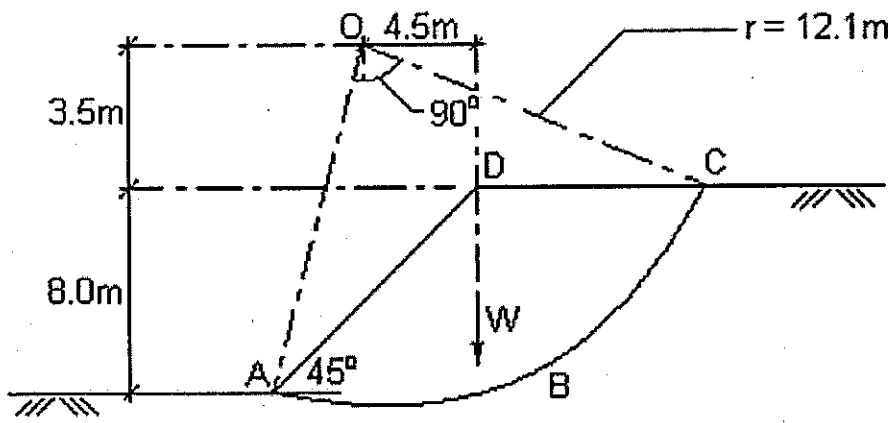


Figure Q6

7. Explain the following: (You are encouraged to use sketches when necessary. Limit your description to a maximum of five sentences.)
   a) Explain why tension cracks develop in an unsupported cohesive soil mass. (4 points)
   b) Differential settlement in shallow footings is a critical issue hence their angular distortions are limited. Explain how you would compute angular distortion. (4 points)
   c) Standard Penetration Test (SPT) is performed during sub-surface explorations. SPT-N values are shown in borehole logs as number of blows per 30cms. Discuss how SPT-N relates to strength and settlement characteristics of a sandy soil. (4 points)
   d) A soil contains all soil groups and therefore it is required to establish the particle size distribution for the whole range of particle sizes. Explain how you would use the sieve analysis test and the hydrometer test to obtain the size distribution curve. (4 points)