THE OPEN UNIVERSITY OF SRI LANKA
Department Of Civil Engineering
Bachelor of Technology (Civil) – Level 4

CEX4230 – Soil mechanics and Introduction to rock mechanics

FINAL EXAMINATION – 2010/2011

Time Allowed: Three Hours

Date: 2011 - 03 – 25 (Friday) Time: 14.00 – 17.00 hrs

The Paper consists of 8 questions, Answer 5 questions only

Q1

The oldest and the simplest type of shear test that is performed in a laboratory to determine shear parameters of soil is the direct shear box test.

a) Plot the shear stress vs. shear displacement for loose soil and dense soil [3 marks]

b) Plot the change in height of specimen vs. shear displacement [3 marks]

c) The following results (Table Q1) were obtained from shear box test on a specimen of sandy clay of cross section 6 cm x 6 cm

Table Q1

Test	Normal load (kg)	Shear force (kg)
1	28	24
2	56	32
3	108	46

i) Find the shear strength parameters [8 marks]

ii) If the triaxial test is carried out in a specimen of the same soil with the cell pressure of 1.2 kg/cm², Find the total axial stress at which the failure would be expected. [6 marks]

Q2

The ultimate bearing capacity of a strip foundation with width B can be expressed as,

$$q_{ult} = CN_c + qN_q + 0.5\gamma BN_\gamma$$

Determine the ultimate and net bearing capacity for the following three cases using the symbols given in figures

a) Water table is at a depth of h_1 (Figure Q2(a)) [4 marks]

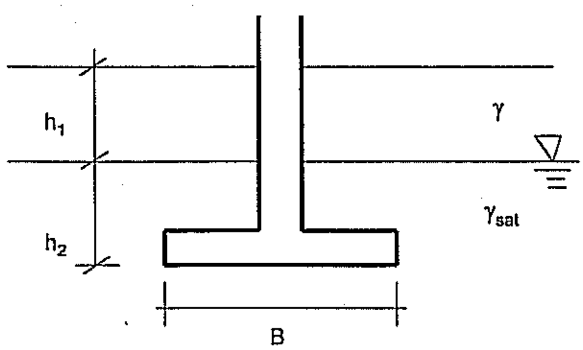

Figure Q2(a)

b) Water table is at a depth of 0.25B away from foundation footing (Figure Q2(b)
[4 marks]

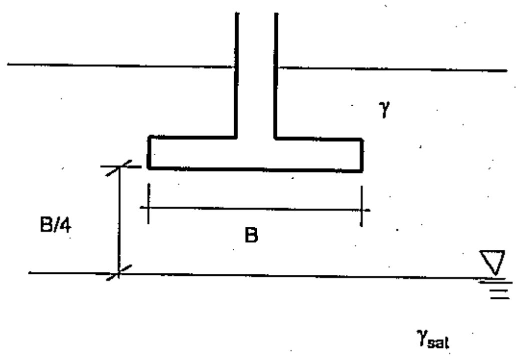

Figure Q2(b)

c) Water table is at a depth of B away from foundation footing (Figure Q2(c))
[2 marks]

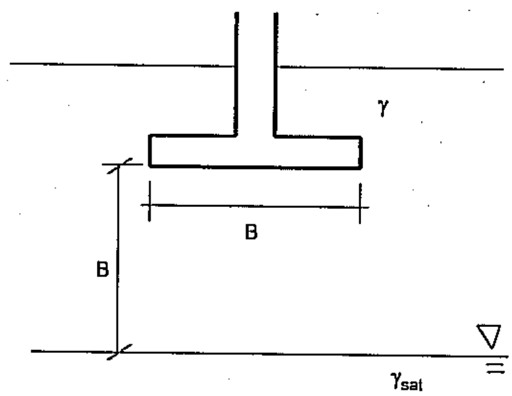

Figure Q2(c)

d) Skempton's solution for saturated clay subjected to undrained condition (ϕ_u=0) is given as follows $q_{ult} = CN_c + q$ all the terms have their normal meaning.
The square foundation shown in Figure Q2(d) is constructed in a saturated clay

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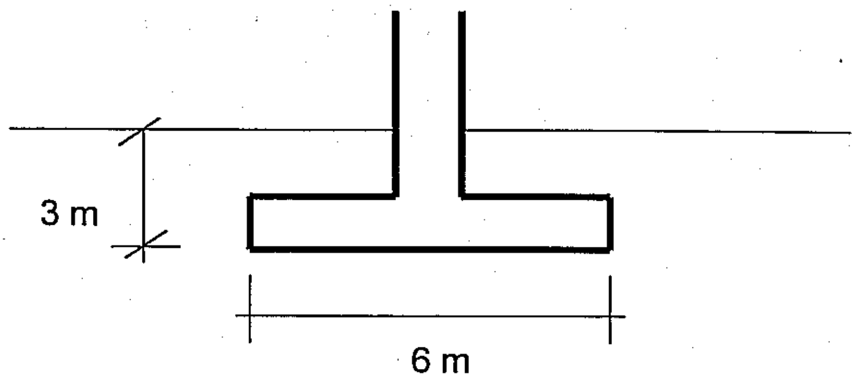

Figure Q2(d)

The soil properties were obtained from laboratory experiments; $\phi u=0$, $C_u = 90\ kN/m^2$. Determine the net ultimate bearing capacity. The saturated unit weight of the clay is $20\ kN/m^3$ (Figure 1 shows the Skempton's values). [10 marks]

Q3

Explain the following in brief. You are encouraged to use diagrams when necessary

a. Area correction used in the uniaxial compression test is $A=Ao/(1-\varepsilon)$. Explain the importance of this correction when the sample is stressed in unidirectional under undrained condition. [3 marks]

b. Using a sketch of particle size distribution curve explain how you determine D_{10}, D_{60} and C_u [3 marks]

c. Why is it important to use a dispersing agent such as Na-hexa-meta-phoshate in hydrometer test. [2 marks]

d. Sketch a square, a strip and a raft footing [3 marks]

e. Explain why tension cracks develop in an unsupported cohesive soil [2 marks]

f. Explain briefly how you determine the liquid limit of a given clay sample in a laboratory [3 marks]

g. Explain the reasons for the variation of dry density with moisture content observed during the compaction test. [4 marks]

Q4

It is often necessary to obtain the ground stresses in geotechnical and mining engineering. The accuracy of the numerical models of geothermal wells and ground subsidence due to oil or metal extraction depends on the accuracy of ground stresses. The following stress state gives the stress at a certain location in the ground. You are asked to carry out the following tasks

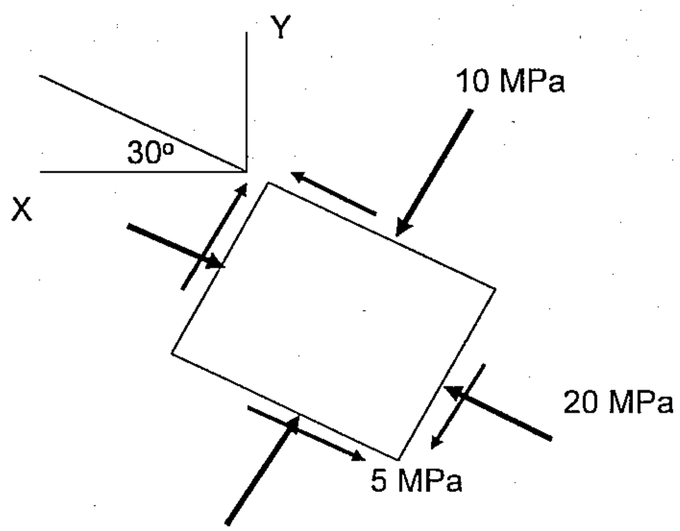

Figure Q(4)

a) Draw the Mohr circle for the stress state [4 marks]
b) Determine the stress in X Y plane after rotating the original stress by 30°
(Hint: You can use either 2θ or pole method) [3 marks]
c) Determine the maximum shear stress [3 marks]
d) The normal stress when the shear stress becomes maximum [5 marks]
e) The principle stresses and their directions. [5 marks]

Q5

Hydraulic conductivity of the soil sample is to be estimated. Two methods are used to determine the hydraulic conductivity of the soil in your laboratory. Constant head method will be used as described in following section to obtain the hydraulic conductivity of soil discussed below.

The packed soil columns were saturated with water and connected to a water reservoir as in Figure Q5(a). The water level of the reservoir was kept constant and the outlet tube was water filled throughout the experiment. The flow rate through the sample was monitored using a fraction collector, whereby the volume of water flowing through the sample during a specific time was measured. The elevations of the water level of the reservoir, the outlet tube, the bottom and the top of the soil sample are shown in Figure Q5(a). The inner diameter of the soil column was *3 cm* and the steady-state water flow was *0.11 ml* s^{-1}. The friction losses in the tubs are negligible.

a) Considering the datum as given in the Figure Q5(a) complete the following chart. [4 marks]

Point	Elevation head	Pressure head	Total head
Inlet			
Outlet			

b) Determine the hydraulic conductivity (*K*) of the soil sample assuming that Darcy's law can be applied for the system (answer in *m* s^{-1}) [6 marks]

c) The experimental equipment is modified such that the inlet tube is connected to the bottom of the soil sample and the outlet tube is connected to the top of the soil sample, according to Figure Q5(b). **Except for this change, the experimental set-up is identical with the set-up of Figure Q5(a).** What will be the follow rate in Figure Q5(b). Show your calculation clearly together with your assumptions

[4 marks]

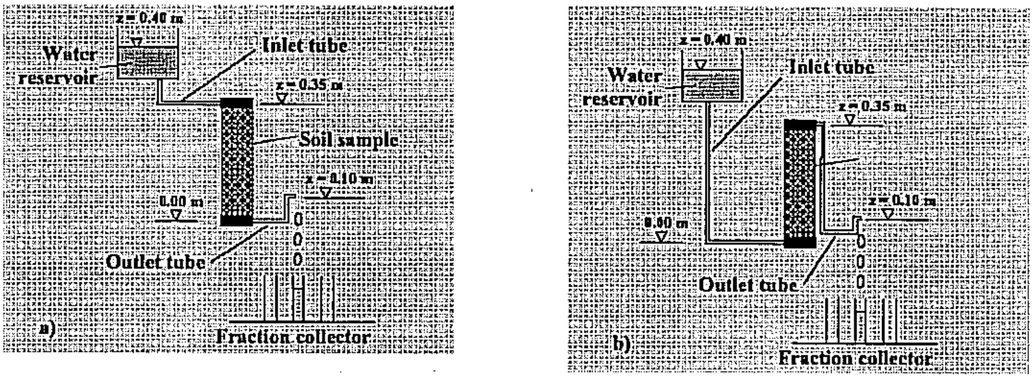

Figure Q5(a) and Q5(b)

d) In your laboratory experiments it was assumed that the hydraulic conductivity is proportional to e^3. However, Samarainghe, Huang and Denerich, 1982 suggested a better relationship between hydraulic conductivity and porosity as follows $K = C\left(\frac{e^n}{1+e}\right)$

where K- hydraulic conductivity, e porosity and C and n are constants

Following results were obtained for normally consolidated clay

i. State three factors that govern the hydraulic conductivity of soil ?

[3 marks}

ii. Following results were obtained from a certain lab experiment.

	Void ratio (e)	K (m"/sec)
1)	1.1	0.302×10^{-7}
2)	0.9	0.12×10^{-7}

Find n and C

[3 marks]

Q6

a) A soil mass consists of solid soil particles containing voids spaces between them. These voids may be filled either with air or water or both. Using the first principals, derive the following relationships

i) $\gamma = \dfrac{S_s \gamma_w (1+\omega)}{(1+e)}$ where all the terms have their normal meaning

together with $S_s = \dfrac{\omega_s}{V_s}, \omega = \dfrac{\omega_w}{\omega_s}$

[6 marks]

ii) For dry soil show that

$$\gamma_d = \frac{\gamma_w S_s}{(1+e)}$$ [4 marks]

b) While carrying out soil investigation in a oil spill site, it was found that the soil is saturated with the oil. The saturated density of the soil found to be 24 kN/m³. <u>Determine</u> the void ratio and dry density of soild if the specific gravity of soil grains and the oil be 2.65 and 0.89 respectively. [10 marks]

Q7

a) Using first principles show that $\Delta H/H = \Delta e/(1+e)$ all the terms have their normal meaning [4 marks]

b) Due to the disturbances in sampling the slope of the virgin consolidation curve is slightly greater that the slope of the consolidation curve obtained from a laboratory test. <u>Draw</u> the behavior of laboratory consolidation curve and the virgin consolidation curve in a plot and indicate their intersection together with significant values. [6 marks]

c) The settlement (S) of soil can be approximately calculated using the following relationship depending on the stress history.

If $\sigma_0 + \Delta\sigma \le \sigma_c$ then where σ_c is the pre-consolidation pressure and σ_0 is the stress before application of the load

$$S = \frac{C_s H}{1+e_0}\log\frac{\sigma_c'}{\sigma_0}$$

If $\sigma_0 + \Delta\sigma \ge \sigma_c$ then

$$S = \frac{C_s H}{1+e_0}\log\frac{\sigma_c'}{\sigma_0} + \frac{C_c H}{1+e_0}\log\frac{\sigma_o' + \Delta\sigma'}{\sigma_c}$$ All the terms have their normal meanings

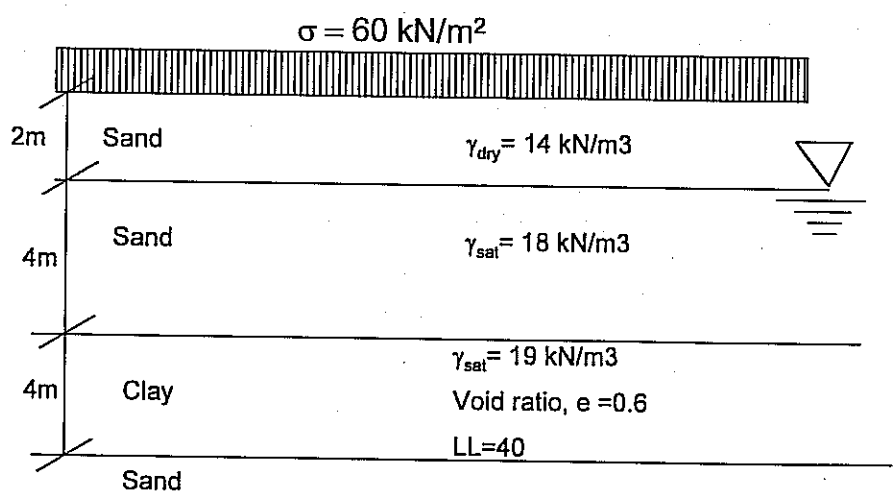

Figure Q(7)

The road section is to be constructed in a area where different soil types are expected as shown in Figure. The additional load due to road construction can be approximately assumed as 60 kN/m². You are given σ_c' for the sub base clay is 125 kN/m². (**Hint.** $C_s=(1/6)C_c$ and $C_c=0.009(LL-10)$)

i) Determine the stress at the center point of the clay layer [4 marks]
ii) Hence drive the settlement of the clay layer caused by primary consolidation. [6 marks]

Q8

a) Draw the variation of lateral earth pressure with wall tilt. (Mark clearly active and passive pressure value at limit equilibrium stage) [3 marks]

b) The wall given below is at rest and all the terms have their normal meaning.

i. Determine the vertical and horizontal stresses acting at element A (You may use standard notation for the derivation of horizontal stress [2 Marks]

ii. If they represent principle stresses state draw the Mohr circle for the above stress state. Draw the failure envelop in the same plot. [4 marks]

iii. Due to additional load q /m² on the surface level of ground, the wall starts moving away from the soil making the limit equilibrium state. Assuming that coefficient of Rankine's active earth pressure K_a write the stress state at A and plot the mohr circle in the same plot. [6 marks]

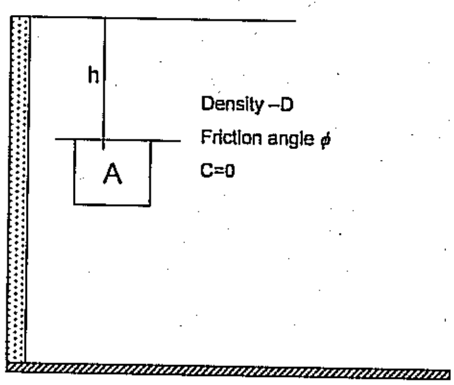

Figure Q8(a)

iv. Determine the Rankine's active force per unit length at the base of the wall. The water table is located a depth 1.5 m below the ground surface [5 marks]

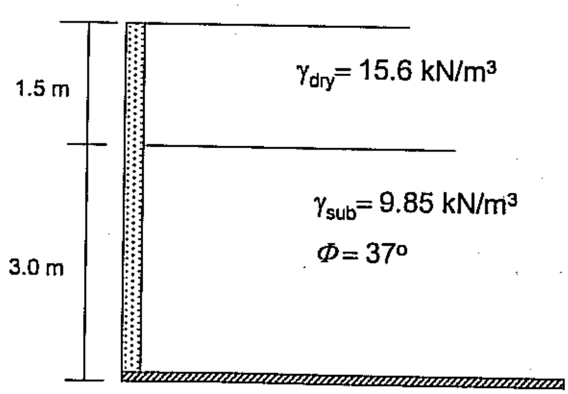

Figure Q8(b)

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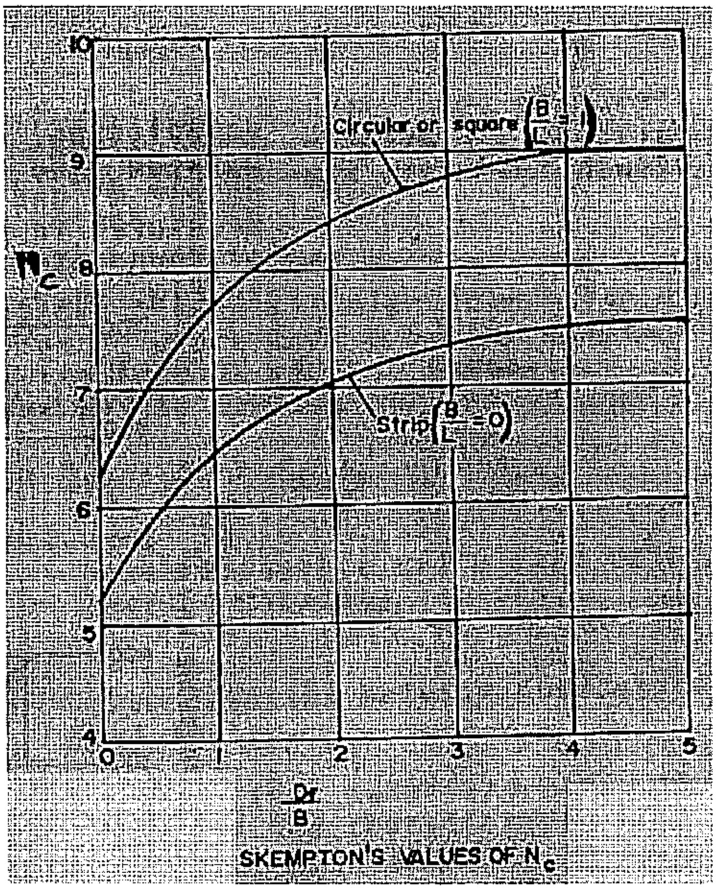

Figure 1- Skempton's values