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THE HONG KONG POLYTECHNIC UNIVERSITY
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
2014/15 SEMESTER II EXAMINATION

Programme: Higher Diploma in Civil Engineering (31363)

Subject: Soil Mechanics

Subject Code: CSE10256

Session: 2014/15

Date: 28 April 2015

Time: 8:45am - 11:45am

Time Allowed: **Three** Hours

This question paper has **Nine** pages.

Instructions to Candidates:

1. This question paper contains two parts.
2. Part I is **compulsory**. Answer **TWO** out of three questions in Part II.
3. All questions carry equal marks.

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Part I: Compulsory section and answer all questions (Total of 50 marks)

Question 1:

(a) A soil mass of volume 0.025m^3 weighed 55 kg and after being dried it weighed 51 kg. The specific gravity of the solid particles is 2.71. Determine the water content, void ratio, degree of saturation, porosity, and air content of the soil. (5 marks)

(b) An architect proposed a strange building plan as shown in Figure 1(a) for a hotel. The idea is to have private open space within the hotel, which is formed by a cross within the circular building. The surface loading induced by building blocks shown by the hatched-line areas is 100 kPa. These buildings are built on flexible shallow foundations. Find the vertical stress increment at a depth of 10m below point C. (7 marks)

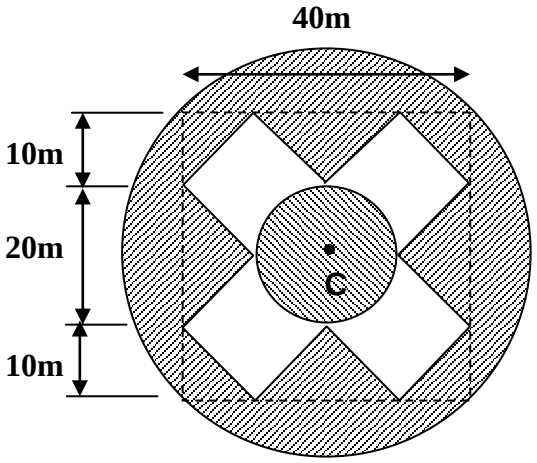

Figure 1(a)

Hints: Use Fadum chart and the following formula for the vertical stress increment at a depth z subject to a surface circular load q of radius R to solve the problem (Figure 1(b))

$$\sigma_z = q\left[1-\left\{\frac{1}{1+(R/z)^2}\right\}^{3/2}\right] = qI_c$$

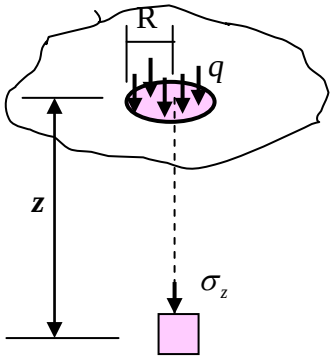

Figure 1(b)

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(c) An 8m thick sand layer overlies a 4m thick clay, with initial water table 2m below the ground. An impermeable layer of rock further locates underneath the clay. The unit weights of the clay, the dry sand and saturated sand are 20 kN/ m^3, 16 kN/ m^3 and 21 kN/ m^3 respectively. Over a short period of time, surface load of 50 kN/ m^2 is applied on the ground surface with a 4m drop in water table. What are the water pressures and effective stresses at 7m and 10 m below the ground immediately and many years after these changes?

(Hints: 8 answers are needed) (8 marks)

(d) Following Question 1(c) above, if the coefficient of volume compressibility of the clay is 0.5 m^2/MN and the coefficient of consolidation is 0.9 m^2/year. It is given that the initial water content of the clay is 0.20 and the specific gravity of the solid particles is 2.70.

(i) Find the long term settlement due to consolidation of the clay layer. (2 marks)

(ii) Find the settlement 5 years after the changes. (3 marks)

Useful results: $T_v \approx (\pi/4)U^2$ for $U < 0.6$

$T_v \approx -0.933 \log_{10}(1-U) - 0.085$ for $U > 0.6$

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Fadum chart for Question 1

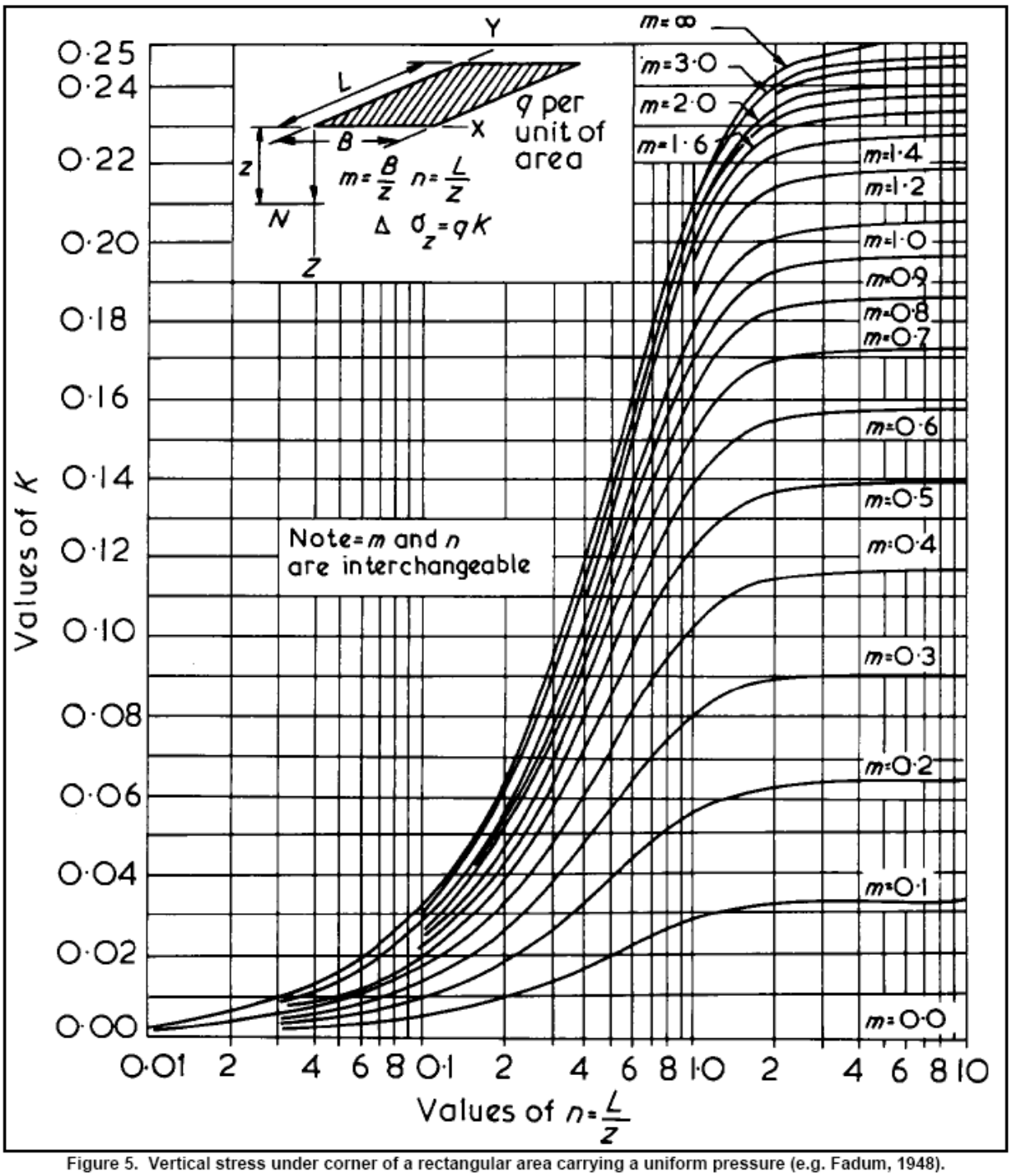

Figure 5. Vertical stress under corner of a rectangular area carrying a uniform pressure (e.g. Fadum, 1948).

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Question 2:

A concrete retaining wall of width *d* is built to retain a 2-layered soil shown in Figure 2 with a surface surcharge of 50 kPa. The soil parameters are given in Figure 2. During raining season, ground water rises to interface between soil 1 and soil 2. Assume that there is no friction between the vertical wall and the soil. The sliding friction angle between the base and the soil is 25°. The unit weight of concrete is 23.5 kN/m^3.

(i) Plot the earth pressure behind the retaining wall at active failure state and also the water pressure.

(10 marks)

(ii) Find the total thrust acting on the wall.

(6 marks)

(iii) Find maximum and minimum base pressures on the wall.

(3 marks)

(iv) Find the factor of safety against sliding.

(3 marks)

(v) Revise the width of the retaining wall such that factor safety against sliding is 1.5.

(3 marks)

Hints: Take moment about A when calculate the eccentricity

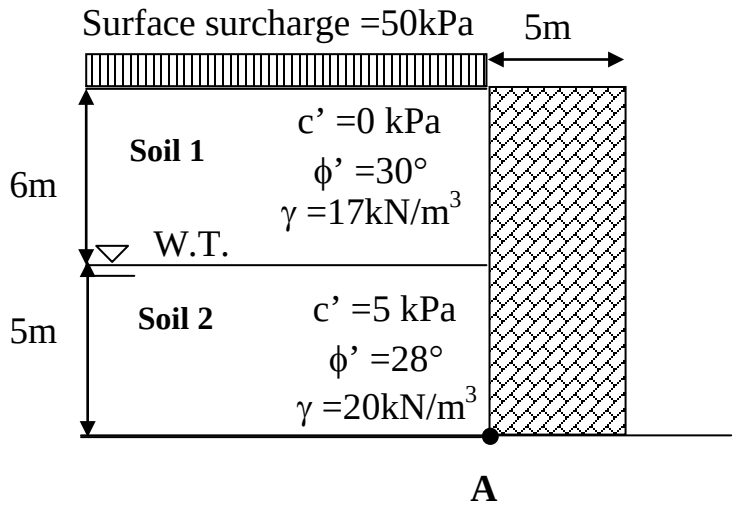

Figure 2

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Part II: Answer any 2 out of 3 questions (each question carries 25 marks)

Question 3:

(a) Derive the following formula starting from the definitions of all the parameters involved (hints: you have to prove any formula that you use them):

$$e = \frac{G_s \rho_w - \rho_{bulk}}{\rho_{bulk} - S_r \rho_w} \quad \text{(3 marks)}$$

$$G_s w = S_r e \quad \text{(2 marks)}$$

where e, G_s, ρ_w, S_r and ρ_{bulk} are the void ratio, specific gravity of solid particles, density of water, degree of saturation, and bulk density of a soil.

(b) Figure 3 gives a concrete dam built on a soil. It is given that saturated unit of soil is 20kN/m^3. The flownet is not drawn to proportion and thus do not measure any length in the following flownet.

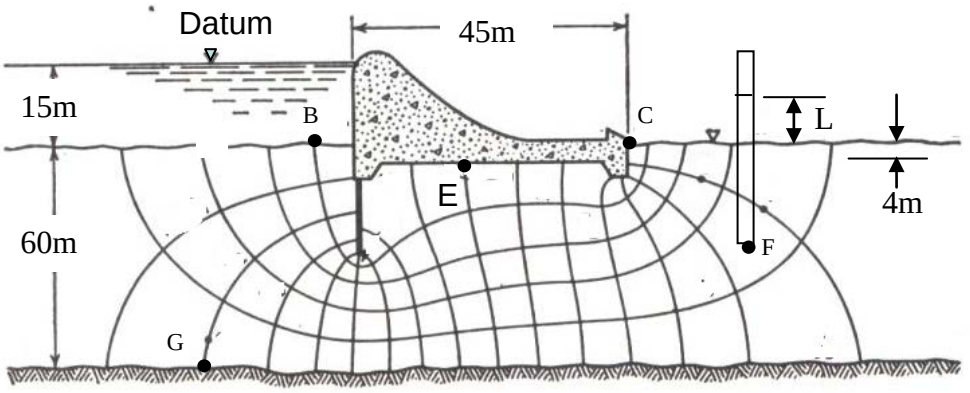

Figure 3

(i) Find the total heads of Points B and C (4 marks)

(ii) Find the pressure head at Point E (4 marks)

(iii) Find the effective stress at Point G (4 marks)

(iv) Find the water level L rising above the ground level on the downstream of the dam (4 marks)

(v) Find the flow rate of the problem if the coefficient of permeability of the soil is 10^{-4}m/s (4 marks)

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Question 4:

(a) A container containing two soils is shown in Figure 4. The coefficients of permeability for Soils 1 and 2 are with $k_1 = 2\times10^{-6}$m/s and $k_2 = 1\times10^{-6}$m/s respectively.

(i) Find the total heads at point A, B, and C (6 marks)

(ii) Find an equivalent formula for the coefficient of permeability for the two layer soil system. (6 marks)

(iii) Estimate the seepage (flow rate in m^3/s) if the cross-section area is 0.2 m^2; (3 marks)

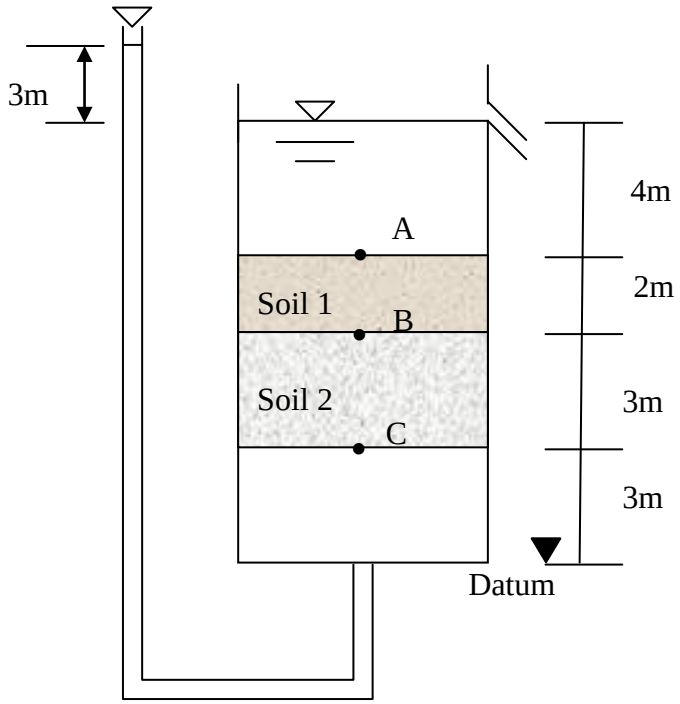

Figure 4

(b) A CD triaxial test was conducted on a marine sand under an all round pressure of 400 kPa. The initial length, area and volume are 100mm, 19.6cm^2, and 196cm^3.

(i) During the consolidation phase, the volume change is 2 ml, find the updated length, area and volume; (3 marks)

(ii) In the compression phase, the axial deformation is 9 mm, volume change is 5 ml, and axial force is 0.8 kN at failure. What is the principal stress difference at failure? (5 marks)

(iii) Find the c' and ϕ' of the soil. (2 marks)

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Question 5:

(a) Give the size ranges for clay, silt, sand and gravel. (2 marks)

(b) What are the methods in determining the liquid limit of a fine grained soil? (2 marks)

(c) If a particle of size 0.02 mm settles in a muddy water column in 5 seconds. Find the time for a particle of size 0.05 mm to settle in the same muddy water column. (Hint: use Stokes's law) (3 marks)

(d) Taylor's root time method is applied to find consolidation parameters of a clay given by the technician in the soil laboratory. The following dial gauge readings with various time are obtained under a vertical stress of 100 kPa. The initial thickness is 19mm and the final thickness is 16.1 mm at 24 hours. The unit weight of the clay is 19 kN/ m^3.

Time (min)	Dial gauge reading (division)
0	0
0.25	430
0.5	485
1	570
2	685
4	842
9	1108
16	1333
25	1453
36	1496

(i) Use the root time method to find the coefficient of consolidation of the clay (in the unit of m^2/year); (6 marks)

(ii) Find the coefficient of volume compressibility (in the unit of m^2/MN); (2 marks)

(iii) Find the coefficient of permeability of the clay (in the unit of m/s). (2 marks)

(e) The most popular methods in finding the coefficient of consolidation is the root time method.

(i) Please derive the ratio of AB:AC in Figure 5(a) for the case of root time method. (4 marks)

(ii) A smart student argued that the AB:AC ratio for Taylor's root time method is small and there can be a large error in graphical construction. Therefore, he proposed to use U = 95% instead. Please calculate the ratio of AB:AC for the revised root time method (Figure 5(b)). (4 marks)

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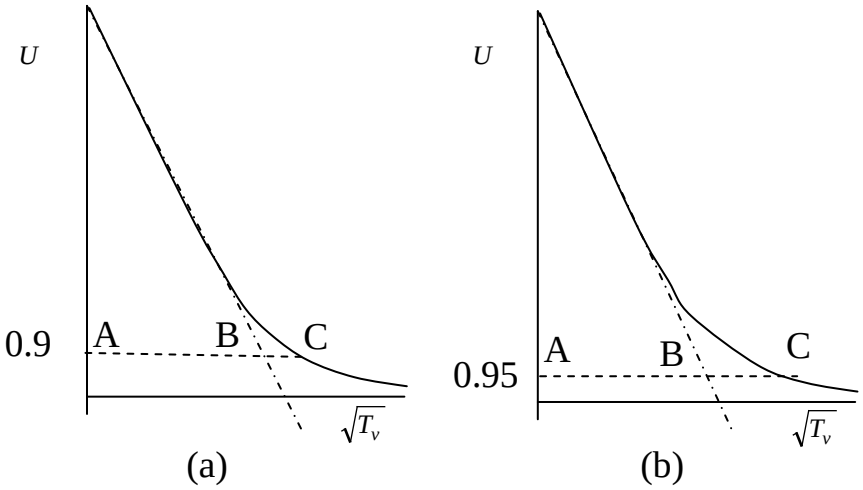

Figure 5

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