THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING

INDEX NUMBER 00088

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: **CVX4530, CEX4230 Soil Mechanics and Introduction to Rock Mechanics**
Academic Year	: 2019/20
Date	: 7th October 2020
Time	: 0930-1230hrs

General Instructions

1. This is a Closed Book Test.
2. Read all instructions carefully before answering the questions.
3. This question paper consists of Part A and Part B in **Eight (8)** pages.
4. Answer all questions in Part A. All questions carry equal marks. Attach this page, with your answers to Part A, to your answer script. You are advised to spend approximately One (1) hour on Part A (3x12 = 36 points).
5. Answer four questions in Part B. All questions carry equal marks. You are advised to spend approximately 28 minutes per question (16x4 = 64 points).

PART A:

Circle the correct response.

Question 1	a	b	c	d	e
Question 2	a	b	c	d	e
Question 3	a	b	c	d	e
Question 4	a	b	c	d	e
Question 5	a	b	c	d	e
Question 6	a	b	c	d	e
Question 7	a	b	c	d	e
Question 8	a	b	c	d	e
Question 9	a	b	c	d	e
Question 10	a	b	c	d	e
Question 11	a	b	c	d	e
Question 12	a	b	c	d	e

PART A:

1. The sand cone apparatus is filled with dry uniform sand up to 5 litre mark; corresponding mass of sand is determined to be 7.72 kg. The specific gravity of sand is 2.65. The porosity of the sand in the cone is:

   a. 0.42 b. 0.55 c. 0.62 d. 0.68 e. 0.72

2. Which of the following statements are true?

   A. The hydrometer reading indicates the mass of solid particles in suspension.

   B. A dispersing agent is expected to neutralize the attraction between fine grained particles.

   C. Parameter H_R determines the average terminal velocity at a given time, t.

   D. The test assumes that particles are spherical and of the same specific gravity.

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

   e. A, B, C and D

3. Which of the following statements are true?

   A. Silt shows a very low dry strength, rapid dilatancy reaction, and a low toughness of soil thread.

   B. High plasticity clay shows a very high dry strength and a low toughness of soil thread.

   C. A silty clay shows a medium dry strength, rapid dilatancy reaction, and a low plasticity.

   D. A clayey silt shows a low dry strength, slow dilatancy reaction and a low plasticity.

   a. A and B only b. B and C only c. C and D only d. A and D only

   e. A and C only

4. A soil has 15% of soil fraction passing 0.063mm sieve size. The soil type could be:

   a. SW b. SW-SM c. SM d. SW-GM e. GW-SM

5. Which of the following statements are true, regarding classification of engineering soils?

   A. Liquid Limit differentiates organic clays from inorganic clays.

   B. Liquid and plastic limit tests are determined when GP soils are classified.

   C. Silty sands have its fine fraction between 12 – 50%.

   D. A-line differentiates clays from silts.

   a. A and B only b. B and C only c. C and D only d. A and C only

   e. A and D only

6. Which of the following statements are true?

   A. A clay soil with a flocculated structure settles less than a clay with a dispersed structure.

   B. High plasticity clay soils form a flocculated clay structure.

   C. Clay soils with a dispersed clay structure has a low specific surface area.

   D. Montmorillonite clays form a dispersed structure.

   a. A and B only b. B and C only c. C and D only d. A and D only

   e. A and C only

7. A 1.75m wide strip footing is subjected to an allowable contact pressure of 100kPa. The stress acting at a depth of 3.5m, along the centreline of the footing (refer Fig. A7) is:

   a. 8.0 b. 9.5 c. 12.5 d. 14.1 e. 15.3

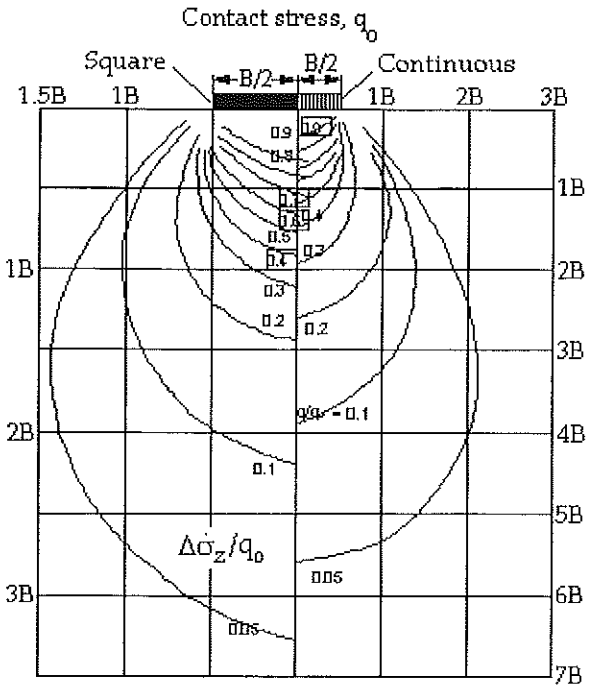

Fig. A7

8. For the state of plane stress shown in Fig. A8, the angle between the horizontal plane and the minor principal stress plane is:

   a. 12.1 b. 14.3 c. 16.4 d. 17.8 e. 20.0

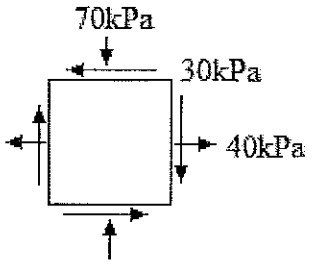

Fig. A8

9. A sandy soil is subjected to a consolidated drained triaxial loading test, at a constant cell pressure of 150kPa. The deviatoric stress at failure is found to be 340kPa. The friction angle ϕ' is equal to:

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

10. A compressible soil layer, 4.5m thick has the following properties: $\sigma'_{vo} = 75\text{kPa}$; $e_o = 2.8$; $C_c = 0.7$; $C_r = 0.15$; $\sigma'_p = 210\text{kPa}$. The total settlement of the layer for a stress increment $\Delta\sigma'_v = 200\text{kPa}$ is:

    a. 0.156m b. 0.161m c. 0.176 d. 0.183 e. 0.195m

11. A soil with two states of compaction A and B has porosities of 0.35 and 0.4, respectively. The coefficient of permeability of state A is 0.025 cm/s. The respective value for B is:

    a. 0.025 b. 0.031 c. 0.037 d. 0.047 e. 0.055

12. Which of the following assumptions are made when developing Terzarghi's One Dimensional Consolidation Theory for a clay soil formation?

    A. Soil is isotropic and completely saturated.

    B. Drainage occurs at the top and bottom of the soil layer.

    C. Solid soil grains and water are incompressible.

    D. Soil compression and water flow occurs in the same direction.

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

    e. A, B, C and D

PART B:

1. During a Consolidated Drained triaxial loading test performed on a fully saturated clayey soil, the following measurements were made.

   Average diameter of the specimen = 52.5 mm

   Average height of the specimen = 110.0 mm

   Total weight = 479.52 g

   a. Assuming that the Specific Gravity of solids is 2.72, compute the following:

      i. Water Content (%) (3 points)

      ii. Porosity (%) (3 points)

      iii. Dry unit weight (kN/m^3) (3 points)

      iv. Saturated unit weight (kN/m^3) (1 points)

   A cell pressure of 100kPa was applied to the specimen while allowing it to undergo consolidation. The following were observed:

   Change in the displacement dial, ΔH = 2.52 mm

   Change in volume, ΔV = 2.53 cm^3

   b. If the specimen has maintained its cylindrical shape at the end of the said consolidation stage, compute the following:

      i. Porosity (%) (3 points)

      ii. Water content (%) (3 points)

2. Fig. B2 shows a schematic diagram of a Falling-head permeameter. Two porous stones are placed on either side of the soil specimen to facilitate drainage. Level E is the datum level. The time interval for the water level to drop from Level A to Level B is recorded.

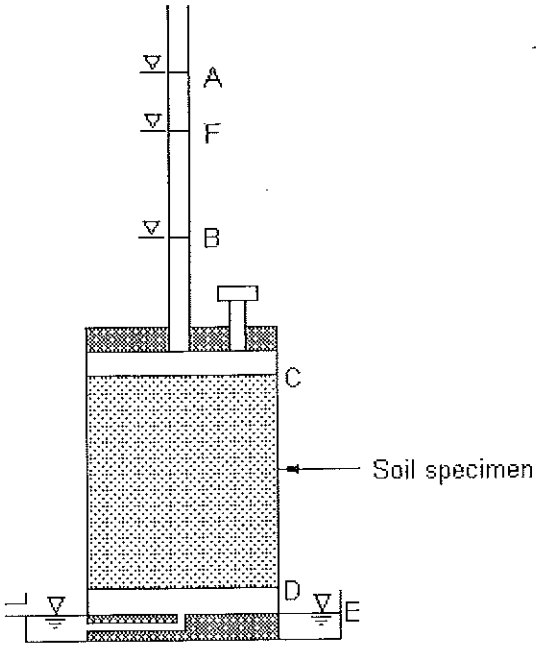

Fig. B2

   a. Sketch Fig. B2 on your answer script. Indicate the total head at points C and D when the water level is at A, as a height measured from datum E. (3 points)

   b. Indicate the total head at points C and D when the water level is at B, as a height measured from datum E. (2 points)

   c. Suppose that the total head measured from the datum to water level at point F is h, and it drops by an amount dh over a time period dt,

      i. Use Darcy's Law to express the average velocity of flow, using the given parameters. (3 points)

      ii. Use the Equation of Continuity to express the flow rate through the soil specimen. (3 points)

iii. Derive an expression for the Coefficient of Permeability, k, for water level drop from A to B. (3 points)

d. Explain why a constant average velocity is not maintained during the experiment. (2 points)

3. Fig. B3 shows a uniform compacted fill placed over a large area of land underlain by a compressible clay soil.

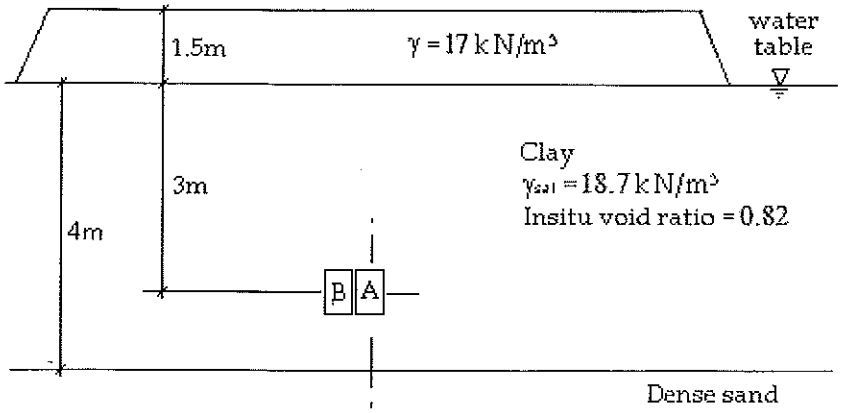

Fig. B3

a. Compute the vertical effective overburden stress of soil element A, before placing the compacted fill. (2 points)

b. Compute the vertical stress increment experienced by soil element A. (2 points)

c. Sketch the rectangular soil element A. At end of primary consolidation, if K_o = 0.5, compute and show the stress values acting on the vertical and horizontal planes of element. (4 points)

d. Explain why you would consider the above stresses to be principal stresses. (2 points)

e. Discuss why the compression of elements A and B is considered to occur in the vertical direction only. (3 points)

f. Discuss why the dissipation of excess pore water pressure is considered to occur in the vertical direction only. (3 points)

4. Fig. B4 shows the stress-strain behaviour of a saturated dense sand as obtained during a Consolidation Drained Triaxial Loading test.

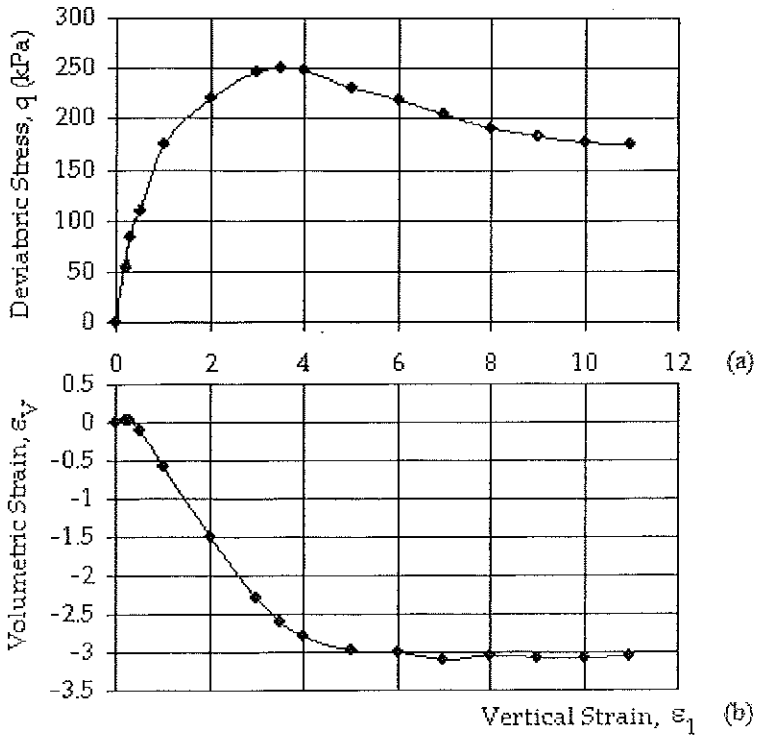

Fig. B4

a. Compare the variation of deviatoric Stress and the vertical strain, i.e. Fig. B4(a), with the observed stress-strain behaviour of steel obtained from a Tensometer Test. Candidates may identify similarities and the differences. (5 points)

b. Discuss how we could compute the Young's modulus for this soil (3 points)

c. Fig. B4(b) shows the variation of the total specimen volume with increasing vertical strain. The negative y-axis shows that the specimen volume increases compared to its initial volume.

i. Describe how the volume changes during the test. (2 points)

ii. Explain why it increases beyond its original volume. (2 points)

d. Compare the shear strength parameters, i.e. angle of internal friction and cohesion, obtained from the CD triaxial test with the respective parameters obtained from the Unconfined Compression (UC) Test and the Consolidated Undrained (CU) triaxial test. (4 points)

5.

a. State Terzaghi's Bearing Capacity equation for a strip footing; define its terms. (4 points)

b. Discuss design and construction benefits of placing a shallow footing at a depth, *d*, from the ground level than placing it at the ground level. (3 points)

c. A footing 1.2m square is placed on a sandy soil 1m below ground level. The properties of the soil are as follows: $\gamma_{bulk} = 16.5\ kN/m^3$, $\gamma_{sat} = 19.6\ kN/m^3$, $\phi' = 30°$ and c = 0 kPa. The water table is 3m below the ground surface. Determine the allowable bearing capacity based on ultimate strength assuming a factor of safety of 2.5. Terzaghi's equation is: $q_u = 1.3cN_c + \bar{q}(N_q - 1) + 0.4\gamma BN_\gamma + q$. (6 points)

d. Explain how Fig. B5d is used when designing a shallow footing. (3 points)

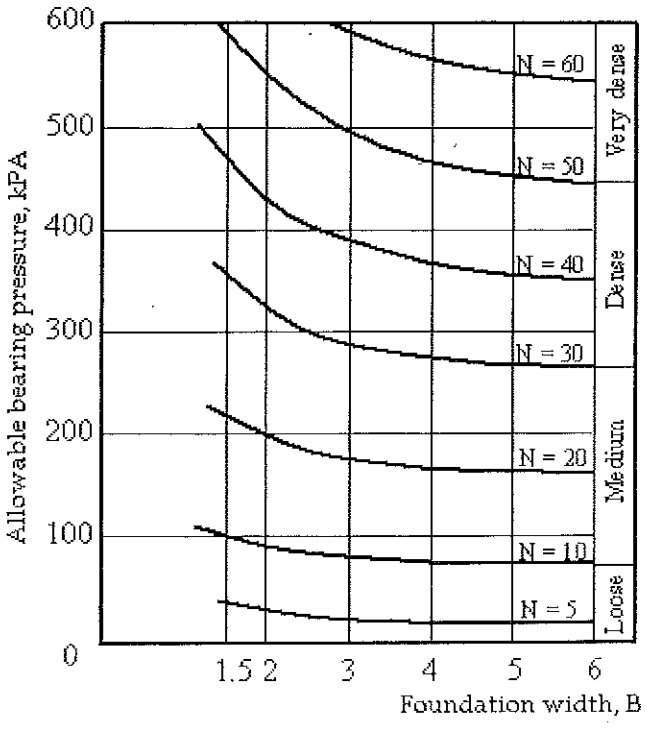

Fig. B5d

6.

a. Discuss the use of the Standard Penetration Test when designing a shallow foundation system. (4 points)

b. Explain the Active Rankine State of plastic equilibrium. (4 points)

c. Fig. B6c shows a soil element of a dry slope that may slide along a plane parallel to the ground surface. Derive expressions for the shear stress, τ and the shear strength τ_{max} based on the given quantities. Express the factor of safety. (4 points)

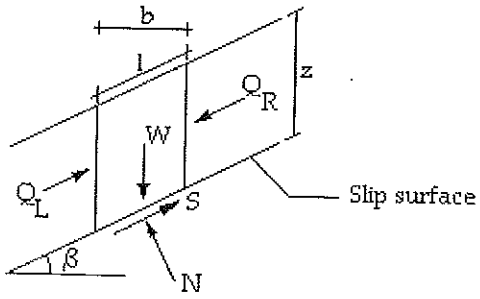

Fig.B6c

d. Fig. B6d represents these configurations of bearing pressure exerted on the base of a gravity retaining wall. Discuss how each distribution is caused. (4 points)

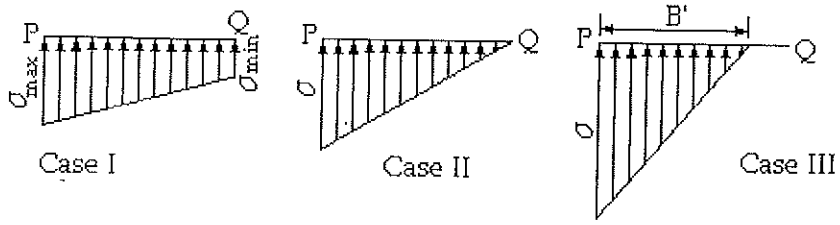

Fig. B6d