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

INDEX NUMBER _____

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: CVX4343 Soil Mechanics**
Academic Year	: 2021/22
Date	: 23rd February 2023
Time	: 0930-1230hrs
Duration	: **3 hours**

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 equation $S = \frac{wG_s}{e}$ represents the phase relationship of an engineering soil. Which of the following statements are true?

   A. G_s is a dimensionless parameter, which is greater than 1 for inorganic soils.

   B. Parameter e always represents values between 0 and 1.

   C. S quantifies the fraction of water present in voids.

   D. Parameter w has an input value between 0 and 1.

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

   e. A and D only

2. Which of the following statements are true?

   A. At Liquid Limit, soil consistency changes from liquid to semi-liquid state.

   B. At Plastic Limit, soil consistency changes from semi-liquid to plastic state.

   C. When standard groove closure occurs at 22 blows, water content of the specimen tested is more than the Liquid Limit.

   D. Plastic Limit of a soil depends on its natural moisture content.

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

   e. A and D only

3. Which of the following statements are true?

   A. The Plasticity Chart is used to classify soils when fine fraction exceeds 5%.

   B. The Plasticity Chart plots the variation of Plastic Limit with Liquid Limit.

   C. The A-line divides clayey soils from silty soils.

   D. Liquid Limit differentiates a `high plastic' clay from a `low plastic' clay.

   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

4. Which of the following statements are true?

   A. A soil that shows a medium-rapid dilatancy reaction has a high clay content.

   B. Plasticity Test measures soil's ability to adsorb water to clay minerals.

   C. A high plastic soil shows a high toughness of the soil thread.

   D. A low plastic soil may show a slow dilatancy reaction.

   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

5. A saturated soil element in a uniform soil stratum is located 5m below ground surface. The water table is at 1m below ground surface. Which of the following statements are true?

   A. The total stress in the soil element is hydrostatic.

   B. The element is subjected to a vertical stress only.

   C. A pore water pressure of 39.2kPa acts on the soil element.

   D. Horizontal and vertical directions are considered as principal stress directions.

   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 sand cone apparatus is filled with dry uniform sand up to 5 litre mark; corresponding mass of sand is determined to be 7.42 kg. The specific gravity of sand is 2.68. The void ratio of the sand in the cone is:

   a. 0.65 b. 0.8 c. 1.23 d. 1.5 e. 1.68

7. For the state of plane stress shown in Fig. A7, the magnitude of the Minor Principal Stress is:

   a. 47.65 kPa b. 49.25 kPa c. 53.8 kPa d. 62.35 kPa e. 77.65 kPa

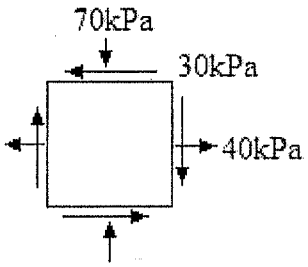


Fig. A7

8. A compressible soil layer, 4.8m 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 $\Delta\sigma'_v = 275\text{kPa}$ is estimated at:

   a. 0.159m b. 0.165m c. 0.173m d. 0.188m e. 0.197m

9. The Standard Proctor Compaction Test specimen has a total volume of 986 cm^3, a total mass of 1940g, at a measured average moisture content of 17.8%. The Specific Gravity G_s is estimated at 2.67. The porosity (%) of the soil specimen is:

   a. 35.2 b. 36.2 c. 37.4 d. 38.1 e. 38.5

10. Which of the following statements are true regarding the Consolidated Drained Triaxial Loading Test performed on a saturated clayey soil?

    A. The test yields shear strength parameters ϕ and c.

    B. The test simulates a situation where the excess pore water pressure is allowed to dissipate.

    C. Zero volume change occurs during the loading stage.

    D. The deviatoric stress is computed based on the proving ring reading.

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

    e. A and D only

11. Which of the following statements are true regarding the Consolidated Undrained Triaxial Loading Test performed on a saturated clayey soil?

    A. The test yields shear strength parameters ϕ' and c'.

    B. During the loading stage excess pore water pressure is allowed to dissipate.

    C. The test yields the Undrained Cohesion, c_u of the soil specimen.

    D. The test needs to be performed on samples with near 100% saturation.

    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

12. Which of the following statements are true regarding the Unconsolidated Undrained Triaxial Loading Test performed on a saturated clayey soil?

    A. The test yields shear strength parameters ϕ' and c'.

    B. During the loading stage excess pore water pressure is allowed to dissipate.

    C. The test yields the Undrained Cohesion, c_u of the soil specimen.

    D. The test needs to be performed on samples with near 100% saturation.

    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

PART B:

1. A combined Sieve-Hydrometer Test performed on a soil specimen is as follows:

Size (mm)	Per cent finer by weight
2	100
0.6	95
0.425	92
0.212	82
0.063	51
0.035	35
0.02	21
0.01	11
0.002	5

The Atterberg Consistency Limits were found to be w_L = 30 and w_P =25.

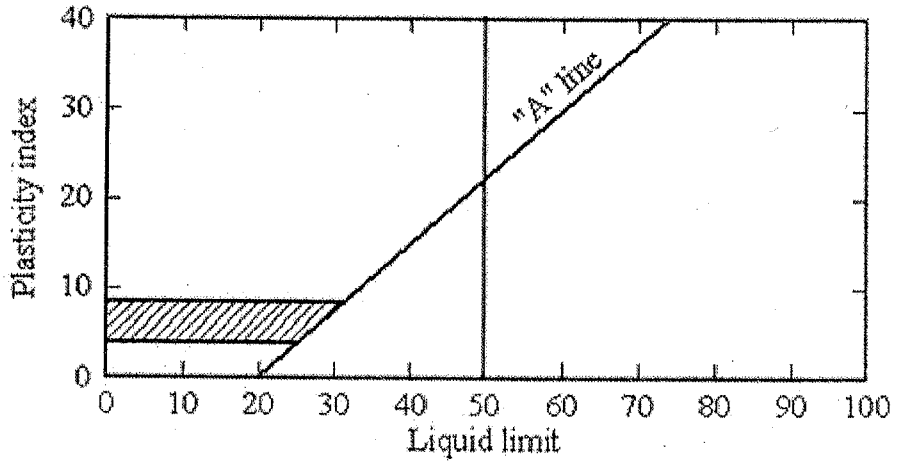
a. State the per cent factions of major soil groups present in the soil specimen. (4 points)

b. Determine the group symbol based on the Unified Soil Classification System (3 points)

c. State its Soil Description. (3 points)

d. Discuss its response to the Dry Strength Test. Give reason(s) for its behaviour. (3 points)

e. Discuss its response to the Dilatancy Test. Give reason(s) for its behaviour. (3 points)



2. Table below shows certain properties of three main clay mineral types.

Type	SSA (m^2/g)	Thickness (μ)	Lateral dimensions (μ)
Kaolinite	15	0.1-1	1-20
Illite	80	0.05-0.5	1-5
Montmorillonite	800	0.01-0.05	1-5

a. Explain why clay particles are platy and elongated and why sands are spherical. (3 points)

b. Explain how you could determine the per cent fraction of clay in a soil specimen. (4 points)

c. Discuss whether the dimensions given in the above table is consistent with the response given in 2(b) above. (3 points)

d. Explain why Montmorillonite shows a high Specific Surface Area compared to the other two clay mineral types. (3 points)

e. List three favourable engineering properties shown by Kaolin soils, in comparison with soils with other clay mineral types. (3 points)

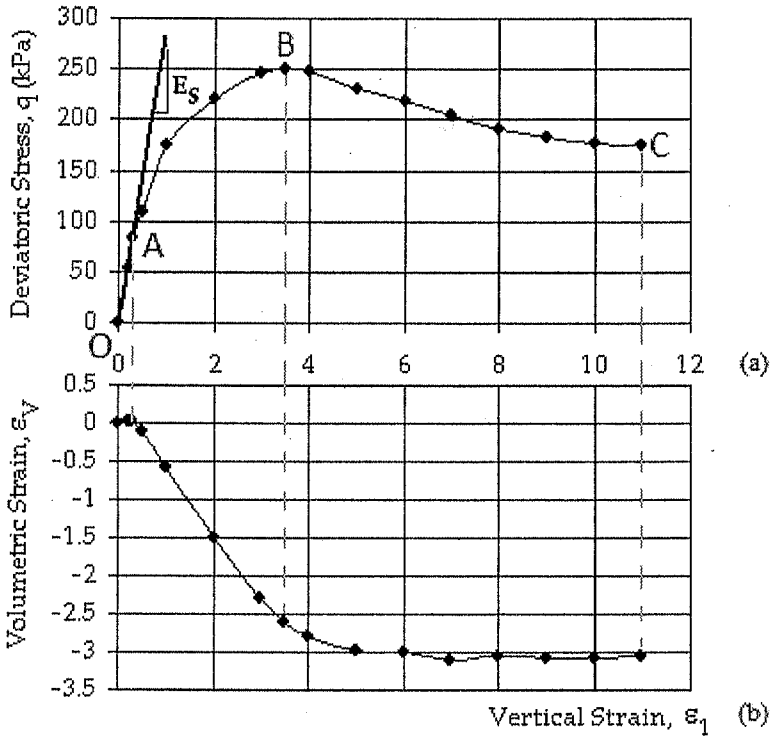
3. Figure below shows the stress-strain and volumetric change behaviour observed in a Consolidated Drained Triaxial Loading Test.

   a. Steel has a Modulus of Elasticity of 200 GPa; Poisson's Ratio of 0.28; Ultimate Strength of 400 MPa and a Yield Strength of 250 MPa. Compare these parameters with the parameters observed for the given soil specimen. (4 points)

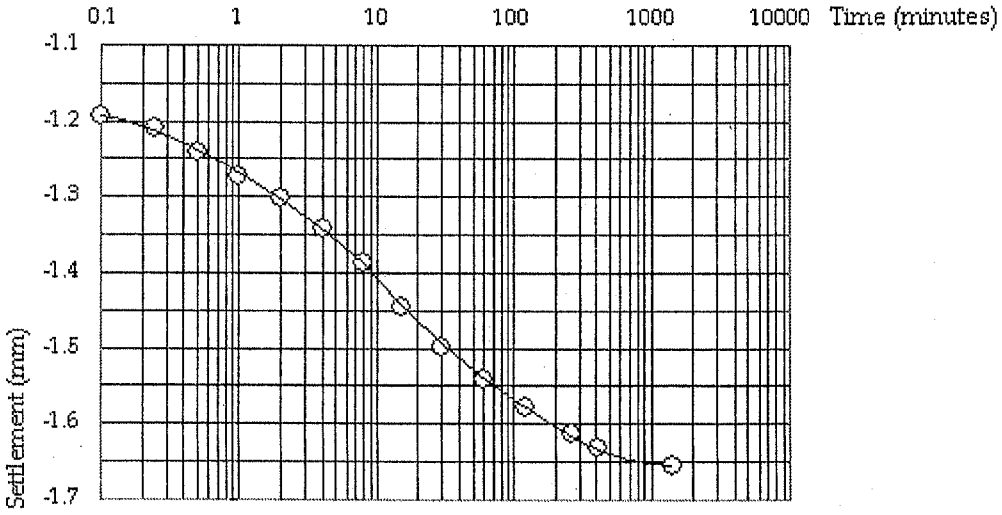
   b. Describe the stress-strain and volumetric change behaviour for the range OA. (4 points)

   c. Describe the stress-strain and volumetric change behaviour for the range AB. (4 points)

   d. Describe the stress-strain and volumetric change behaviour for the range BC. (4 points)



4. Figure below shows the settlement vs. time curve for the stress increment from 39.7 to 78.2kPa.



   a. The specimen has an average diameter of 71.2mm and the lever arm ratio for the device is 1:10. Compute the load in kg for an effective consolidation stress of 39.7kPa. (4 points)

   b. The initial height of the test specimen is 20mm. The total settlement at the end of the test is 4.553mm. The mass of water at the end of the test is 41.248g. Compute the initial void ratio of the specimen. (4 points)

   c. Compute the void ratio corresponding the 24hr. reading (refer above figure). (4 points)

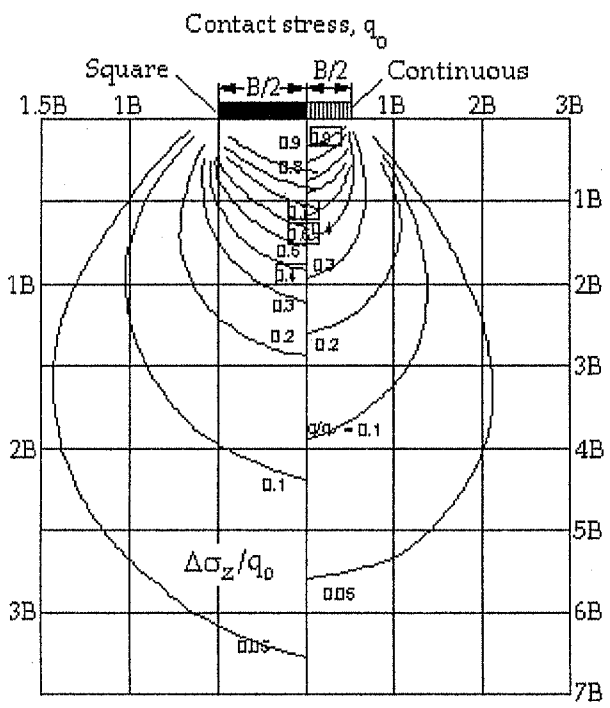
   d. Explain the terms Primary Consolidation and Secondary Compression. Discuss which types of soils demonstrate a high Secondary Compression. (4 points)

5. Fig. 5(a) shows the pressure bulb, which can be used to determine elastic stresses, due to an applied contact stress q_0, beneath a footing, located in a homogeneous and an isotropic elastic half space. Fig. 5(b) shows two footings placed 1m apart, where the shallowest being placed during a recent construction.

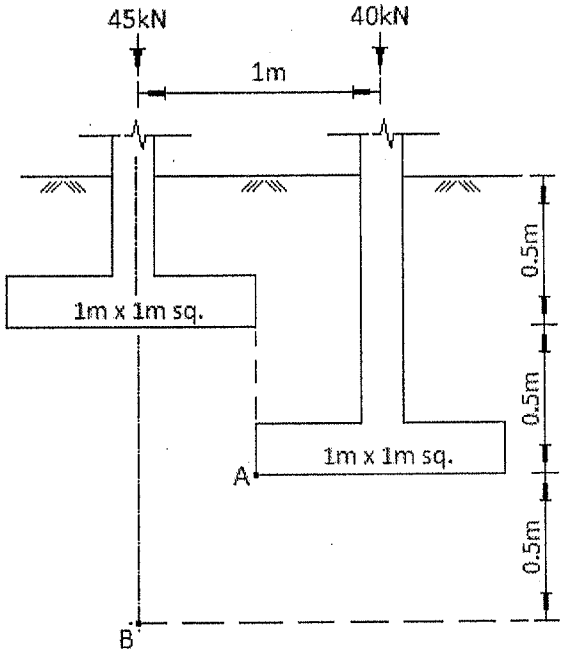
   a. Explain the Principle of Superposition when used to determine the vertical stress at a given point in the ground. (4 points)

   b. Compute the vertical stress at Point A due to the given loads (6 points)

   c. Compute the vertical stress at Point B due to the given loads. (6 points)

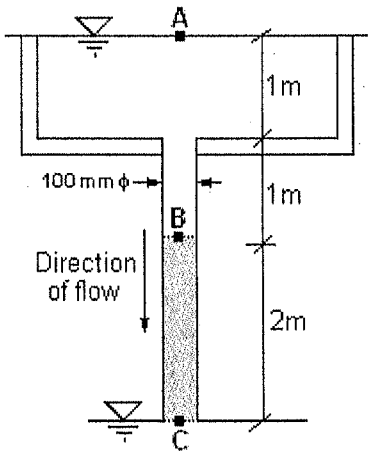


5(a)



5(b)

6. Figure below shows a filtration unit of an industrial rainwater collection system. The system maintains a constant water height of 1m in the upper tank and allows water to flow under gravity to an underground sump. The designer wishes to have a 2m high column of uniformly graded fine sand, in the 100mm internal diameter down pipe (i.e. section BC).



   a. Compute the pressure head, elevation head and total head at points A, B and C, consider the level at Point C as the datum. (3 points)

   b. Discuss, while stating your reasons the possibility of sand boiling, if critical hydraulic gradient condition prevails when the reservoir level is raised. (3 points)

c. Hazen (1930) proposed the empirical relationship $k = CD_{10}^2$ cm/s for granular (i.e., sandy soils). The constant of proportionality C varies between 0.4 – 1.2. Estimate a suitable coefficient of permeability for the fine sand used in this system. Comment on your selection of parameter C. (3 points)

d. Compute the expected flow rate in litres/min. (3 points)

e. During extended use, the sand-filter may get clogged with finer particles, hence may result in a reduced flow rate. Discuss whether this would affect the hydraulic gradient across the sand filter and the Coefficient of Permeability of the sand-filter. (4 points)