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

INDEX NUMBER _____

112

Study Programme	: Bachelor of Technology Honours in Engineering : Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: CVX4343 Soil Mechanics**
Academic Year	: 2022/23
Date	: 22nd February 2024
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 and Question B4, 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

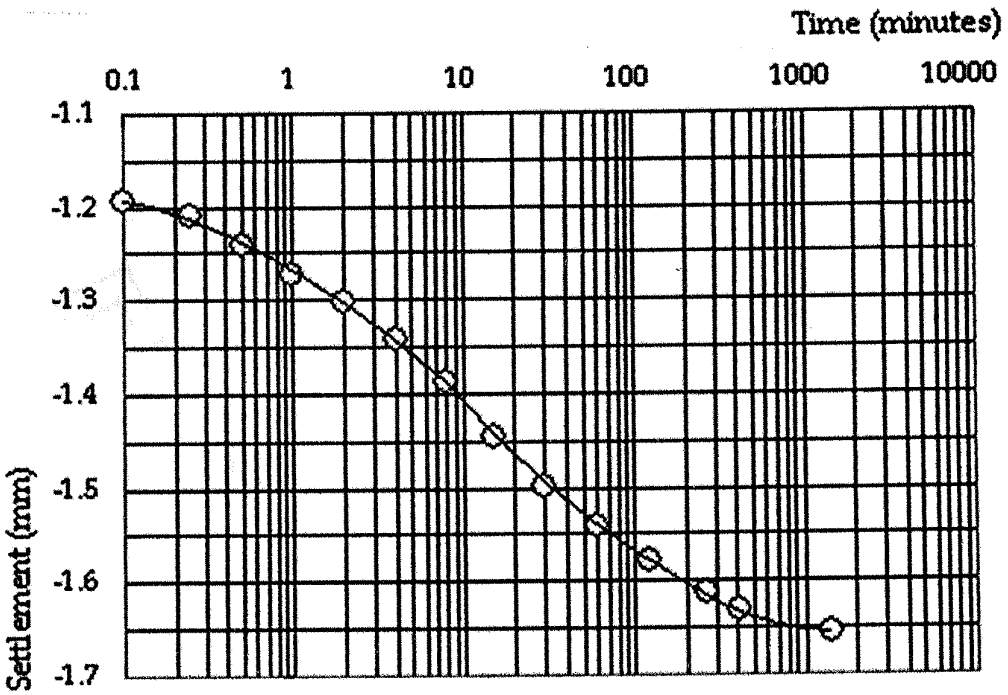

Time (minutes)
0.1
1
10
100
1000
10000
-1.1
-1.2
-1.3
-1.4
-1.5
-1.6
-1.7
Settlement (mm)

Figure B4

PART A:

1. The equation $\rho_{bulk} = [(1-n)G_s + Sn]\rho_w$ represents a phase relationship of an engineering soil. Which of the following statements are true?

   A. During saturation parameter n increases.

   B. Parameter S takes values 0 and 1, and any other in-between value.

   C. The Dry Density can be obtained by substituting n = 0.

   D. The water content is proportional to parameter S.

   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 regarding a fine-grained soil?

   A. Visual classification tests on fine-grained soils are performed on the fraction passing 0.063mm sieve size.

   B. Soils that show a high Dilatancy reaction also show a high Dry Strength.

   C. The Plasticity of the soil is determined based on the number of rolling and re-rolling required to reach the Plastic Limit.

   D. High plasticity soils always show a high toughness.

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

   e. C and D only

3. Which of the following statements are true regarding the Hydrometer Test?

   A. The hydrometer reading represents the mass of soil particles in suspension at a given time.

   B. With time, the buoyancy force acting on the Hydrometer increases.

   C. The presence of the dispersing agent does not affect the particle settling velocity.

   D. The soil particles accelerate through the medium to reach the bottom of the jar.

   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

4. 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 17.2%. The Specific Gravity G_s is estimated at 2.65. The degree of saturation (%) of the soil specimen is:

   a. 78.8 b. 80.2 c. 82.5 d. 83.8 e. 85.1

5. For the state of plane stress shown in Fig. A5, the magnitude of the shear stress acting along the stress direction that makes an angle of $+45^0$ from the x – direction is:

   a. 43 kPa b. 45 kPa c. 51 kPa d. 55 kPa e. 58 kPa

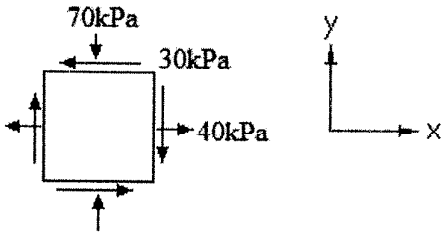


Fig. A5

6. Which of the following statements are true regarding the Unconfined Compression (UC) Test performed on a saturated clayey soil?

   A. The shear strength parameters c_u and c for a similar soil formation is identical.

   B. The shear strength parameter $\phi_u > 0$ when the soil is partially saturated.

   C. UC Test gives accurate shear strength parameter values for low plasticity silts.

   D. During the UC Test, the volumetric strain is not expected to change.

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

7. Which of the following statements are true regarding the 1-dimensional Consolidation Test?

A. For a Normally Consolidated (NC) Clay, the ratio $\Delta e/\Delta\sigma'_v$ increases with increasing effective vertical consolidation stress.

B. For a NC Clay, C_r is not defined.

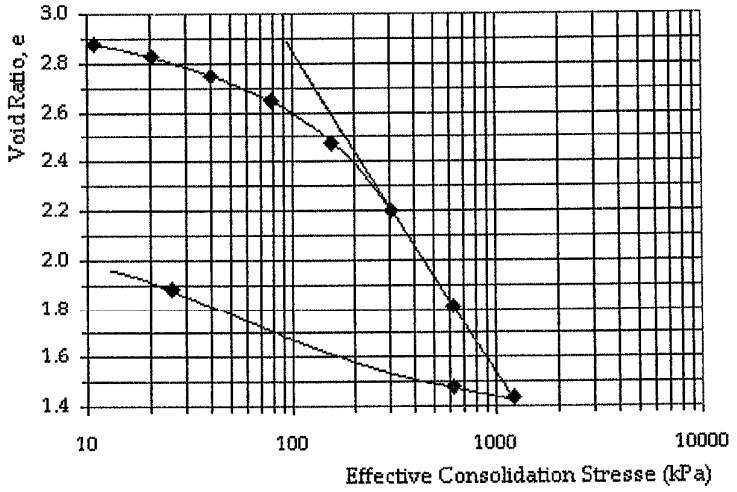
C. The Degree of Consolidation determines whether the soil is Normally Consolidated or Over-Consolidated.

D. In-situ Pre-consolidation Pressure can be determined from this test.

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

e. A, B, C and D

Questions 8 – 9: Figure below shows a plot of e vs. $\log_{10}(p')$ obtained during a One-dimensional Consolidation Test. The sample had an initial height, H_0 = 20mm; e_0 = 2.97.



8. The settlement in mm corresponding to p′ = 300 kPa is:

a. 3.78 b. 4.03 c. 4.12 d. 4.17 e. 4.22

9. The Recompression Index is:

a. 0.08 b. 0.13 c. 0.28 d. 0.34 e. 1.32

10. Which of the following statements are true regarding fluid flow through a porous medium?

A. The hydraulic gradient is a measure of energy loss per unit length of travel.

B. During laminar flow, average flow velocity decreases with the length of travel.

C. Darcy's Law is applicable only to a real fluid.

D. The measured Coefficient of Permeability depends on the fluid viscosity.

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

e. A, B, C and D.

11. Which of the following statements are true regarding the Mohr-Coulomb failure criterion?

A. The said criterion defines the maximum shear stress acting in the element considered.

B. For a soil, the shear stress at failure depends on the Angle of Internal Friction and the Cohesion.

C. When testing a saturated soil specimen under undrained conditions, the test yields only a cohesion intercept.

D. A medium dense sand has an angle of internal friction value between 32^0 to 36^0.

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

e. A, B, C and D.

12. The saturated unit weight of a sandy soil estimated to be 20.2kN/m3. The theoretical value of its Critical Hydraulic Gradient is:

a. 0.93 b. 0.97 c. 1.0 d. 1.03 e. 1.06

PART B

Answer four questions. All questions carry equal marks.

1. The bulk density ρ_{bulk} is expressed as $\rho_{bulk} = [(1-n)G_s + Sn]\rho_w$.

A. Define all five (5) terms used in this equation, in terms of volume and mass parameters representing the 3-phase soil model. (5 points)

B. If you are given a uniform and undisturbed cylindrical silty clay soil specimen obtained from a borehole, explain how you would compute the following parameters:

i. The average water content of the specimen. (2 points)

ii. The specific gravity of the silty clay soil. (3 points)

iii. The degree of saturation of the undisturbed specimen. (3 points

C. A clayey soil specimen has the following parameters w = 18% and G_s = 2.7. Compute its saturated density in kg/m^3. (3 points)

2. Figure B2 shows stress-strain and volume change behaviour of a saturated dense sandy soil observed during a conventional triaxial loading test.

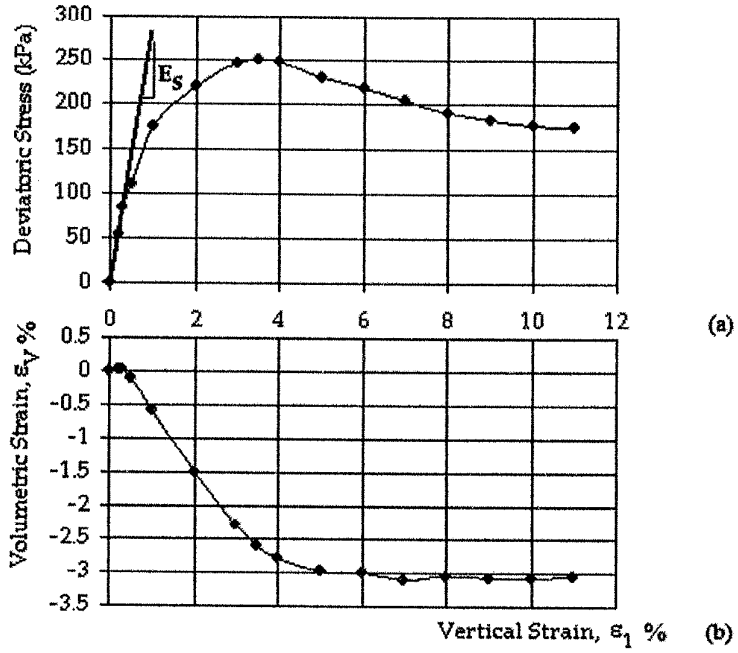


Figure B2

A. State whether the said test is performed under drained or undrained conditions. State your reasons. (2 points)

B. Describe the observed volume change behaviour while stating the reasons for the observed behaviour. (4 points)

C. Explain why there is a difference between the Peak Strength and the Residual strength. (4 points)

D. The said test is performed on a cylindrical saturated test specimen. It had an average initial height of 105.2mm and an average diameter of 38.32mm. At the end of the consolidation stage, ΔH = 1.35mm and a ΔV = 1.83cm^3 were observed.

i. Compute the average height and the average diameter of test specimen at the end of the consolidation stage. (4 points)

ii. Compute the volume change during the second stage of the test corresponding to a vertical strain of 6%. (2 points)

3. Figure B3 shows the variation of total volume of a soil pat with water content.

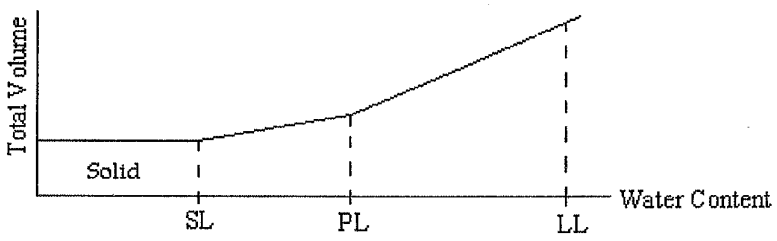


Figure B3

A. Explain how you would determine the Liquid Limit of a clayey soil. (3 points)

B. During the experiment discussed in Q3A, explain why the total volume is reduced when reaching the Liquid Limit. (3 points)

C. Define Specific Surface Area (SSA). Discuss the relationship between the SSA and the Plasticity Index. (3 points)

D. During the Visual Soil Classification of Fine-grained soils, it was found that certain soils show a high Dry Strength. Explain what causes such soils to show a high Dry Strength (4 points)

E. During the Dilatancy Test, when a silt pat is squeezed between your thumb and the index finger, water on the surface disappears into the soil. Explain why it happens so. (3 points)

4. Figure B4 shows the variation of δ vs. log(t) observed for a stress-increment, from 40kPa to 80kPa. δ corresponding to an Effective Consolidation Stress of 40kPa is -1.106mm.

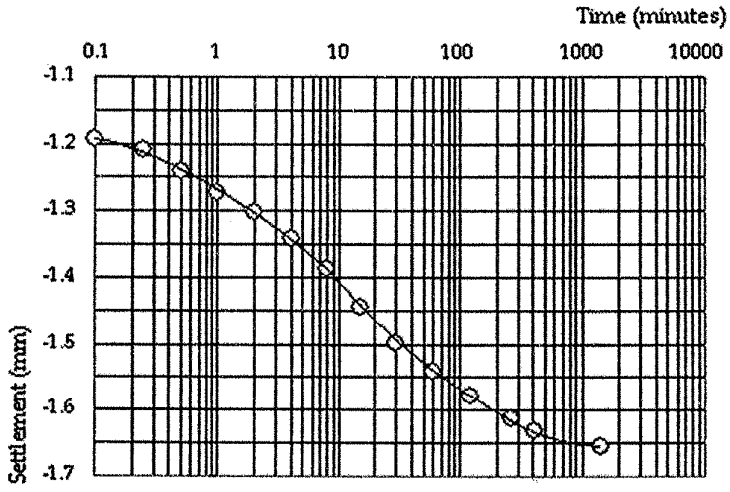


Figure B4

A. Compute the settlement values corresponding to the three distinct regions identifiable in Figure B4. Attach Figure B4 given in Page 2. (6 points)

B. Name the three distinct regions described in B4 above. Describe their significance and how they differ from each other. (4 points)

C. Explain how you could determine the Coefficient of Consolidation for the given stress range. (3 points)

D. When computing parameter c_v the concept of drainage path is used. Explain how you could compute the drainage path, and its effect on parameter c_v. (3 points)

5. Fig. B5 shows a Constant Head Permeability Test apparatus.

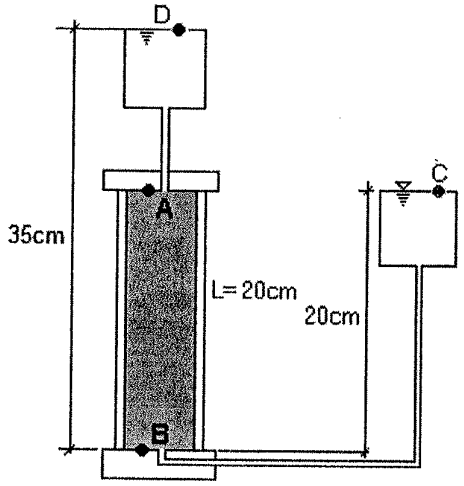


Fig. B1

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

Point	Elevation Head	Pressure Head	Total Head
A			
B			
C			
D			

B. Explain the concept that governs flow from points D to A. (2 points)

C. Determine the Pressure Head at mid-point of specimen length AB. (2 points)

D. Determine k_{20} for a measured flow rate of 0.072 litres per minute. The average diameter of the soil sample is 50mm. The flow rate is measured at 30°C. η_{20} = 1.002 mPa.s; η_{30} = 0.798 mPa.s; $\rho_{30}/\rho_{20} \approx 1.0$. (4 points)

E. The Intrinsic Permeability $\overline{K}$ of a soil is expressed in the equation $k = \frac{\overline{K}\rho g}{\eta}$, where ρ, η are the density and viscosity of the fluid; k is its Coefficient of Permeability.

i. Determine the SI units of $\overline{K}$. (2 points)

ii. Explain the importance of $\overline{K}$ as a parameter. (2 points)

6.

A. During an Unconfined Compression Test (UC) performed on a saturated clay soil specimen, the failure plane makes an angle θ of 45°, measured from the horizontal plane. If the same test is performed on a specimen which is 80% saturated, would the angle θ<45° or θ>45°? Explain the basis for your conclusion. (4 points)

B. During a 1-dimensional consolidation test a 20mm high cylindrical clay soil specimen is loaded. State the smallest amount of settlement you could estimate using the standard dial gauge that is used to measure settlement. If you are requested to estimate the settlement of a 20m deep clay stratum, state the minimum settlement that you could estimate based on the said test. Explain the basis for your response. (4 points)

C. 3-dimensional strains acting on a material element, in terms of stresses σ_{xx}, σ_{yy} and σ_{zz} are expressed as:

$$\varepsilon_{xx} = \frac{1}{E}\left[\sigma_{xx} - \nu(\sigma_{yy} + \sigma_{zz})\right]; \quad \varepsilon_{yy} = \frac{1}{E}\left[\sigma_{yy} - \nu(\sigma_{xx} + \sigma_{zz})\right]; \quad \varepsilon_{zz} = \frac{1}{E}\left[\sigma_{zz} - \nu(\sigma_{xx} + \sigma_{yy})\right]$$

Explain the basis for this formulation. Suppose that the normal stresses are acting on the x – y plane only, derive expressions for the three strains in terms of σ_{xx} and σ_{yy}. Suppose that the normal strains are occurring in the x – y plane only, derive expressions for the three strains in terms of σ_{xx} and σ_{yy}. (4 points)

D. During the Standard Proctor Compaction Test, it is observed that the Dry Density increases for moisture contents dry of optimum; then it decreases for moisture contents wet of optimum. Explain why the observed phenomena occur. (4 points)