258

INDEX NUMBER ________

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

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: CVX4343 Soil Mechanics**
Academic Year	: 2020/21
Date	: 29th January 2022
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 sand cone apparatus is filled with dry uniform sand up to 5 litre mark; corresponding mass of sand is determined to be 7.4 kg. The specific gravity of sand is 2.68. The void ratio of the sand in the cone is:

   a. 0.45
   b. 0.53
   c. 0.67
   d. 0.81
   e. 0.85

2. Fig. A2 shows a sketch of a hydrometer stem, when the hydrometer is laid on the table. When reading the hydrometer, the bottom reading is recorded as h'_R

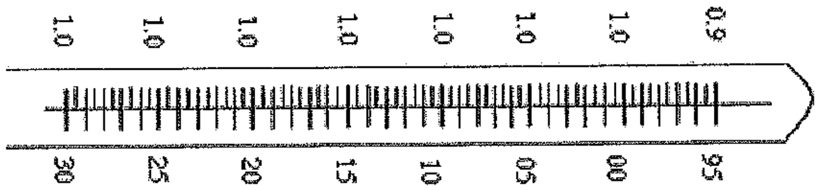


Fig. A2

   A. When the hydrometer is dipped in the dispersion agent solution, at the standard temperature, h'_R would be between 95 and 00.

   B. Hydrometer can be used to measure the mass of solids in suspension.

   C. Hydrometer gives the size distribution of particle sizes smaller than 0.002mm only.

   D. This hydrometer can be used to determine the density of milk, which is ~ 1025 kg/m^3.

   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. Atterberg limit tests are performed on the fraction passing 0.063mm sieve.

   B. Atterberg limit tests are performed on soils with fine sand, silt and clay sizes.

   C. Soils with per cent fines between 5 – 12% require performing Liquid and Plastic Limit tests.

   D. The fine fraction is determined based on 0.425mm sieve.

   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. Which of the following statements are true regarding the Visual Soil Classification tests performed to identify soils for engineering purposes?

   A. The said tests can be performed on site using disturbed borehole soil specimens.

   B. The moisture content in the soil specimens may affect the classification.

   C. The Dilatancy Test is used to differentiate between fine-sand and coarse-sand.

   D. The Toughness of the soil thread is determined based on finger pressure applied when making the thread diameter to 3mm.

   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

5. For the state of plane stress shown in Fig. A5, the angle between the horizontal plane and the maximum shear stress plane, in degrees is:

   a. 25.7   b. 33.4   c. 56.4   d. 93.7   e. 183.4

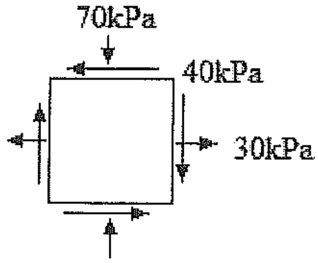


Fig. A5

Questions 6 and 7: The following data were collected during a One-dimensional Consolidation Test:

Initial dimensions of specimen	
Average height of ring (mm)	20.0
Average diameter of ring (mm)	75.0
Mass of consolidation ring (g)	116.692
Mass of container (g)	9.683
Mass of ring + specimen without filter paper + container (g)	277.643
Measurements taken at the end of test	
Mass of container (g)	9.479
Mass of ring + specimen without paper + container (g)	274.974
Measurements after Oven Drying	
Mass of container (g)	9.481
Oven dried specimen without filter paper + container (g)	110.085
Total change in dial reading dH (mm)	1.548

6. The initial degree of saturation (%) of the soil specimen is:

   a. 91.8 b. 92.1 c. 92.8 d. 93.4 e. 94.3

7. The initial porosity (%) of the soil specimen is:

   a. 62.3 b. 75.2 c. 100.2 d. 126.1 e. 155.0

8. The Unconfined Compression Test is performed on a soil specimen of average height 100mm and average diameter 37.5mm. What would be the percentage change in the average area of the specimen corresponding to 700 division of the displacement dial gauge?

   a. 6.3 b. 7.1 c. 7.5 d. 8.7 e. 10.1

9. The Standard Proctor Compaction Test specimen has a total volume of 986 cm^3 and a total mass of 1943g. The measured average moisture content is 18.4%. The Specific Gravity G_s is estimated at 2.68. The degree of saturation (%) of the soil specimen is:

   a. 55.3 b. 62.3 c. 68.9 d. 75.2 e. 80.8

10. Which of the following statements are true regarding the water flow between two points in a granular medium?

    A. The energy loss between the two points causes an increase in the flow rate.

    B. When both points are at the same elevation, the pressure head difference causes flow.

    C. The Critical Hydraulic Gradient determines soil instability during downward flow.

    D. An increase in fluid temperature increases the flow rate.

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

11. Which one of the following statements is <u>not true</u> regarding the shear strength of a soil?

    a. A well graded sand has a greater shear strength than a poorly graded sand.

    b. The shear strength of a soil depends on the surface roughness of particles.

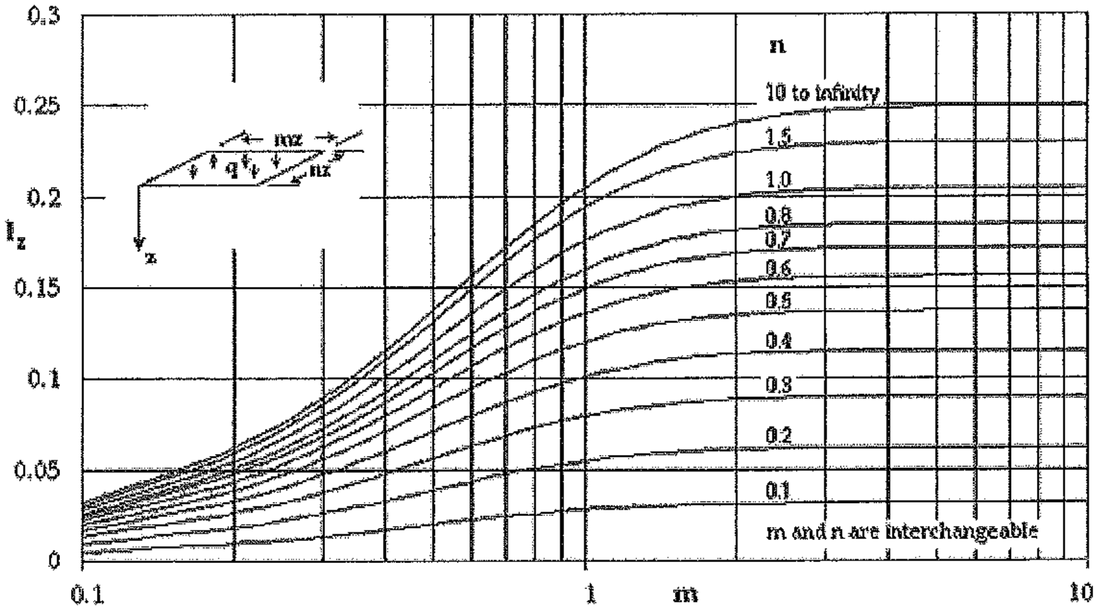
    c. The shear strength of a saturated soil depends on its water content.

    d. The shear strength of a saturated soil increases with the dissipation of excess pore water pressures.

    e. The Unconfined Compression Test yields drained shear strength parameters.

12. Figure below shows Influence factor, I_z below a corner of a rectangular area. A 2m×4m footing bears 50kPa. The bearing stress along the centreline of the footing, at 2m depth is:

a. 6 kPa b. 12 kPa c. 18 kPa d. 24 kPa e. 30 kPa   a b c d e



PART B:

1. Fig. B1 shows an element of clay located at a depth 8m from the surface.
   a. Explain the use of the Principle of Effective Stress when determining the stresses (3 points)
   b. Compute σ_{yy}, σ'_{yy} and u at depths 0m, -1m, -4m and -8m. (3 points)
   c. Assuming that $\sigma'_{xx} = 0.5\sigma'_{yy}$, compute the total horizontal stress and effective horizontal stress at depth -8m. (2 points)
   d. For the soil element described in 1(c) above:
      i. Sketch the Mohr's circle of effective stress. Name the axes and show principal values. You may consider that shear stress τ_{xy} is negligible. (3 points)
      ii. Sketch the Mohr-Coulomb failure envelope for ϕ' = 30° and c' = 0 kPa. (2 point)
      iii. Prove that the average shear stress at any point on the said soil element does not exceed the shear strength of the soil. (3 points)

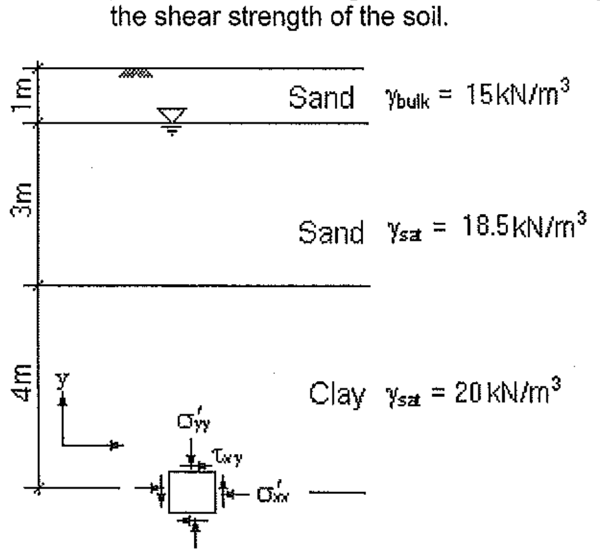


Fig. B1

2. Fig. B2 shows a typical e-log(p) curve obtained during the 1-D Consolidation Test. The laboratory curve is used to construct the 'ideal' e-log(p) curve (OABC) that represents in-situ consolidation settlements.

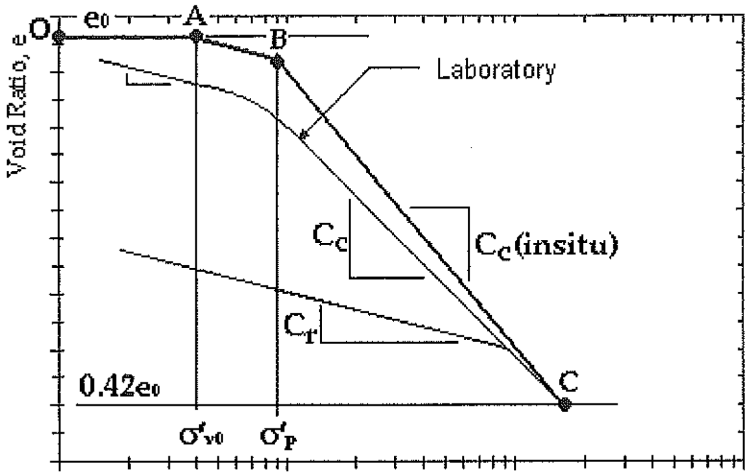


Fig. B2

a. Explain how you would determine the parameter e_0. (3 points)

b. Explain how you would determine the parameter σ'_{v0}. (3 points)

c. Explain how you would determine the slope of the line segment AB. (3 points)

d. Discuss what the parameter σ'_p signify and its importance when determining the settlement. (4 points)

e. Explain why the laboratory compression curve differs from the in-situ curve. (3 points)

3. The shear strength of a soil is expressed in terms of the Mohr-Coulomb failure criterion. When a saturated soil element is subjected to a deviatoric stress, its stress-strain behaviour occurs under drained or undrained condition. During a drained test the excess pore water pressure is allowed to dissipate while in an undrained test such dissipation is prevented.

   a. State the equation that expresses the Mohr-Coulomb failure criterion during an undrained test. Define its terms. (2 points)

   b. Compare the volume change behaviour observed during a 1-dimensional Consolidation Test with the volume change behaviour during an Unconfined Compression Test (are they the same or are they different? State your reasons.) (3 points)

   c. Sketch the Mohr's Circle of Stress at failure for the Unconfined Compression Test. Define the axes. Sketch the Mohr-Coulomb failure envelope and define its parameters. (4 points)

   d. Explain how you would identify the point corresponding to shear failure, on the Mohr's circle of stress. State your reasons. (3 points)

   e. Sketch the stress-strain behaviour of an in-situ saturated clay soil element when subjected to a deviatoric stress when sufficient time is given to dissipate its excess pore water pressures. Name the axes. (4 points)

4. Fig. B4 shows a steady state pumping test where water is extracted from a confined aquifer.

   a. Discuss how a confined aquifer is formed beneath the ground. (3 points)

   b. Compare the aquifer conditions of the pumping well shown in Fig. B4 with the aquifer conditions of open dug wells commonly used in urban and peri-urban households. (3 points)

   c. Explain the condition "steady state pumping". (2 points)

   d. Explain the term "piezometric surface" and the relevance of the two piezometric surfaces shown in Fig. B4. (4 points)

   e. The equation $k = \frac{Q_0}{2\pi L(h_2 - h_1)} \ln \frac{r_2}{r_1}$ models the situation shown in Fig. B4. Define the terms given in this equation. Explain how they are determined during the test. (4 points)

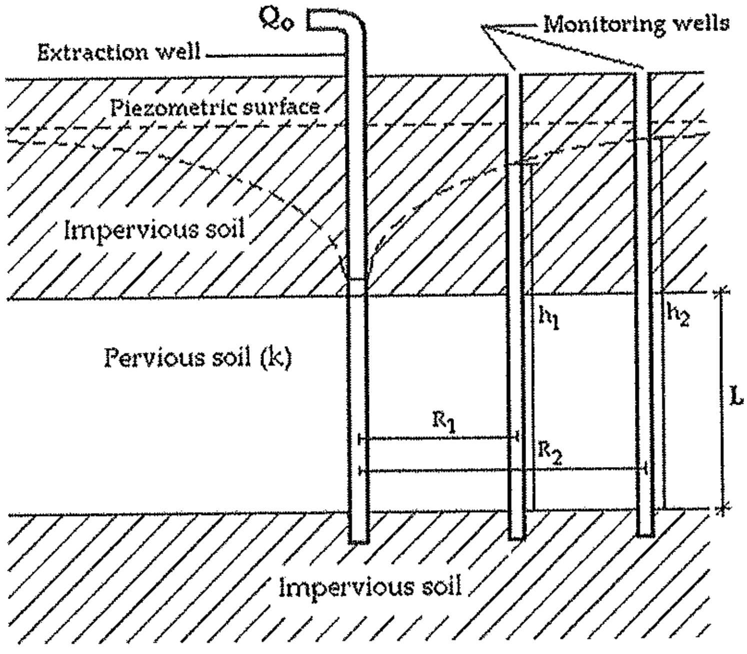


Fig. B4

5. When answering the sub-questions, you are expected to provide logical and sound reasons in support of your responses.

   a. Terzarghi's 1-dimensional Consolidation Theory assumes that the compression and flow occur in the same direction. Discuss the validity of this assumption when applying the said theory to a field pre-loading situation. (4 points)

   b. The relationship $T = \frac{\pi}{4} U^2$ for $U < 60\%$; $T = 1.781 - 0.933 \log_{10}(100 - U\%)$ for $U > 60\%$ defines the outcome of the 1-dimensional consolidation theory. Discuss how you would relate this variation of T versus U to the observed primary consolidation settlement with time. (4 points)

   c. When determining the end of primary consolidation, we consider that the settlement δ_{100} has occurred before the 24-hour loading period. Explain how you would determine δ_{100} during the 1-dimensional consolidation test. Discuss how you would confirm that δ_{100} has occurred within the 24hr period. (4 points)

   d. Fig. B5d shows the variation of Void Ratio versus Effective Consolidation Stress. Based on the given information compute the Coefficient of Volume Compressibility and the Compression Index for said soil specimen. (4 points)

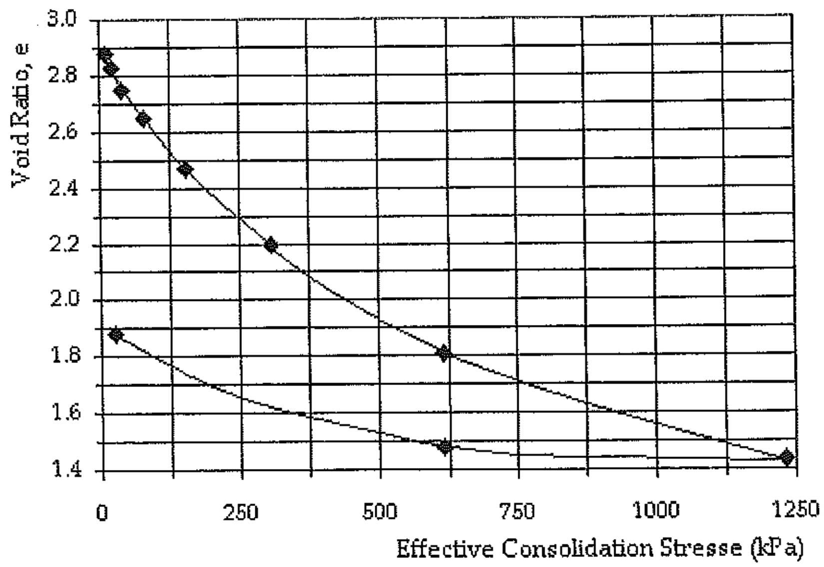


Fig. B5d

6. Water in a soil formation is present as bound water and free water. Table B6 (Hansbo, 1975) lists the heights of capillary rise in different soils.

Table B6

Soil type	Loose	Dense
Coarse sand	0.03 – 0.12m	0.04 – 0.15m
Medium sand	0.12 – 0.50m	0.35 – 1.10m
Fine sand	0.30 – 2.0m	0.40 – 3.5m
Silt	1.5 – 10m	2.5 – 12m
Clay	≥ 10m	

a. Discuss the reason for clay soils to display a very high capillary rise compared to other soil types. (4 points)

b. Sketch the variation in pore water pressure present in the regions of bound water and free water. Identify the regions of positive and negative pore water pressures. (3 points)

c. Explain why loose formations show a lesser capillary rise compared to dense formations of sand types and silts. (3 points)

d. Explain why coarse sand formations show a lesser capillary rise compared to fine sand formations. (3 points)

e. Discuss water extractability from the capillary zone of the soil formation. (3 points)