MACHAKOS UNIVERSITY

University Examinations for 2022/2023

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING AND CIVIL ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECV 301 SOIL MECHANICS I

DATE: **TIME:**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

Necessary tables and charts are provided in the appendix at the end of the questions

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Discuss the role of the following persons in the history and development of soil mechanics (6 marks)

   a. Arthur Casagrande
   b. Henry Darcy
   c. Karl Terzaghi

b) Briefly discuss any three main properties of clay minerals in engineering context (6 marks)

c) State any three simple tests of soils in the field and the respective descriptive terms (3 marks)

d) With a well labelled sketch of a unit solid volume model, show that:

   i) $A_v = \frac{e - wG_s}{1+e}$

   ii) $\rho_d = \frac{\rho_w G_s}{1+wG_s}(1 - A_v)$

   In which:
   A_v is air-voids content of the soil
   e is void ratio of the soil
   w is water content of the soil
   G_s is specific gravity of the grains of the soil
   ρ_d is dry density of the soil
   ρ_w is the density of water

   (7 marks)

e) In a falling head permeameter test, the hydraulic head at t = 0 is 40 cm and drops 1 cm in 3.5 minutes. It is desired to run the test until this head is 20 cm. How much longer must the test continue? (3 marks)

f) In a site reclamation project, 2.5 m of graded fill (γ = 22 kN/m^3) were laid in compacted layers over an existing layer of silty clay (γ = 18 kN/m^3) which was 3 m thick. This was

underlain by a 2 m thick layer of gravel (γ = 20 kN/m^3). Assuming that the water table remains at the surface of the silty clay, draw up the total stress/effective stress profiles for:

i) Before the fill is placed

ii) Immediately the fill has been placed (5 marks)

QUESTION TWO (20 MARKS)

The data in Tables Q2.1, Q2.2 and Q2.3 were recorded during particle size analysis test in the laboratory on a 575 g sample of soil.

Table Q2.1 Stage 1: Wet and dry sieving

Sieve size (mm)	14	10	6.3
Mass retained (g)	0	4.6	14.9

Table Q2.2 Stage 2: Wet and dry sieving on sub-sample of 168.2 g

Sieve size (mm or μm)	5.00	3.35	2.00	1.18	600	425	300	212	150	63	Pan
Mass retained (g)	4.5	14.5	24.0	27.2	14.1	4.0	3.3	3.1	2.1	7.6	63.7

Table Q2.3 Stage 3: Sedimentation analysis on the soil passing 63 μm in Stage 2

Size (μm)	40	20	10	6	2
% coarser than	13.1	16.9	25.4	12.0	20.8

i) Plot the grading curve for the soil (12 marks)

ii) Determine the grading characteristics (6 marks)

iii) Classify the soil according to the BS Classification System (2 marks)

QUESTION THREE (20 MARKS)

Table Q1

Bulk density (Mg/m^3)	1.895	2.050	2.157	2.169	2.140	2.101
Water content (%)	8.4	10.6	12.9	14.4	16.6	18.6

a) Plot the curve of dry density against water content (8 Marks)

b) Determine the maximum dry density (MDD) and optimum water content (OWC) for the compacted soil (1 mark)

c) On the same axis in (i) above, plot the dry density/water content curves for zero and five percent voids and obtain the air-voids content of the soil at the optimum water content (6 marks)

d) Under field conditions variations in the applied compactive effort may cause the air-voids content to vary by ± 2 percent. Also, the field water content may vary above and below the optimum value by 2 per cent. Calculate and indicate, on the axis in (i) above, the range of dry densities that may be found after compaction in the field. (5 marks)

QUESTION FOUR (20 MARKS)

An earth dam made of a homogeneous material has the following data:

Coefficient of permeability of dam material	= 5 x 10-4 cm/sec
Level of top of dam	= 200.0 m
Level of deepest river bed	= 178.0 m
Highest flood level of reservoir	= 197.5 m
Width of top of dam	= 4.5 m
Upstream slope	= 3H: 1V
Downstream slope	= 2H: 1V

Determine the phreatic line for the dam section and the discharge passing through the dam.

QUESTION FIVE (20 MARKS)

An impervious paved area is to be constructed on a base of clayey silt during the wet season. Observations indicate that the water table will stabilize at 1.7 m below formation level. Using the data given in Table Q5, prepare an equilibrium water content profile and compare it with in situ water contents.

Data:

WL = 66%, Wp = 35%, average unit weight = 18.7 kN/m3.
Contact pressure at formation level = 7.5 kPa
Wetting curve (pF = 1.0 to 4.0): Equilibrium water content = 48 – 9.0 pF

Table Q5

Depth below formation (m)	0.1	0.5	1.5	2.5	4.0	5.0	6.0
In-situ water content before construction (%)	24.7	25.3	25.8	25.0	24.5	24.0	23.8