[ENG23]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG (HONS) CIVIL ENGINEERING

SEMESTER TWO EXAMINATION 2022/2023

SOIL MECHANICS AND HYDRAULICS

MODULE NO: CIE4020

Date: Wednesday 10th May 2023 **Time: 14:00 – 16:00**

INSTRUCTIONS TO CANDIDATES:

This is an Open- Book Exam.

This exam paper contains two sections: section ‘A’ and section ‘B’

Section A contains TWO questions: you should answer both questions. Each of these questions is worth 25 marks.

Section B contains TWO questions: you should answer both questions. Each of these questions is worth 25 marks.

Marks for parts of questions are shown in brackets.

This assessment carries 100 marks.

All working must be shown.

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Soil Mechanics & Hydraulics
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Section A – Soil Mechanics (Answer Both Questions in this Section)

Question 1

(a) An undisturbed sample of clayey soil is found to have a wet weight of 285 N, a dry weight of 250 N, and a total volume of 14x10^3 cm^3, if the specific gravity of soil solids is 2.70. Determine:

(i) The water content **(3 marks)**

(ii) Void ratio **(3 marks)**

(iii) Porosity **(3 marks)**

(iv) Degree of saturation **(3 marks)**

(v) The air content **(3 marks)**

(15 marks)

(b) Use the percentages of minerals given in the table below to determine the missing values and the name of the soil texture using the soil texture triangle shown in **Figure Q1** (shown on page 6).

No	Percentage (%)			
	Gravel	**Sand**	**Silt**	**Clay**
1	0	55		15
2	15	25	30	
3	0		45	20
4	10	50	10	
5	0		75	10

(**10 marks**)

Total 25 marks

Question 2

(a) Define the term soil compaction and explain three of its applications in civil engineering.

(**4 marks**)

(b) The results of a standard compaction test for a soil having a value of ($G_s = 2.5$) are shown in the table below.

Water Content (%)	6.2	8.1	9.81	11.5	12.3	13.2
Bulk Unit Weight (kN/m^3)	16.9	18.7	19.5	20.5	20.4	20.1

(i) Plot the compaction curve and obtain the maximum dry unit weight (γ_d in kN/m^3) and the optimum water content.

(**7 marks**)

(ii) On the same axes, draw the γ_d vs w curves for 0%, 5% and 10% air content and determine the air content for the maximum dry unit weight.

(**7 marks**)

(iii) Determine the corresponding void ratio and degree of saturation reached for the maximum dry unit weight.

(**7 marks**)

Total 25 marks

END OF SECTION A

Please turn the page…

Section B – Hydraulics (Answer Both Questions in this Section)

Question 3

(a) A rectangular channel is 4 m wide; slope of the channel is 1 in 1500, roughness coefficient (n) is 0.025 and discharge equals 6.0 m^3 /s. Use Manning's equation to determine the depth of flow.
Note: Use the trial-and-error method

(12.5 marks)

(b) A trapezoidal channel with a bed width of 3.8 m and a side slope of 1 vertical to 1.5 horizontal. Assume the C in Chezy's equation is 50 (SI units). Compute the discharge (Q) and the velocity of flow (V) if the depth of water is 1.4 m and the slope of the channel is 1 in 1800.

(12.5 marks)

[Total 25 marks]

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Question 4

(c) Briefly explain the terms involve in Bernoulli's equation. Describe what is meant by 'head losses' in pipelines and give two typical examples.

(7 marks)

(d) Two tanks in a water treatment plant are connected by a pipeline which is 100mm in diameter for 11m and then changes abruptly to 225mm in diameter for the remaining 17m of its length. There are two 45° bends (each of K_L = 0.5) on the 100 mm diameter pipeline and a three-quarter closed gate valve (K_L = 24) on the 225mm diameter pipeline. The flowrate between the tanks is 15 l/sec. The friction factor *f i*s 0.022 for the 225mm pipeline and 0.025 for the 100mm pipeline. Taking account of all energy losses, determine the difference between the water levels in the tanks.

(18 marks)

[Total 25 marks]

END OF SECTION B

END OF QUESTIONS

Formula sheets follow over the page

For use with question 1b on page 2

USDA Soil Triangle

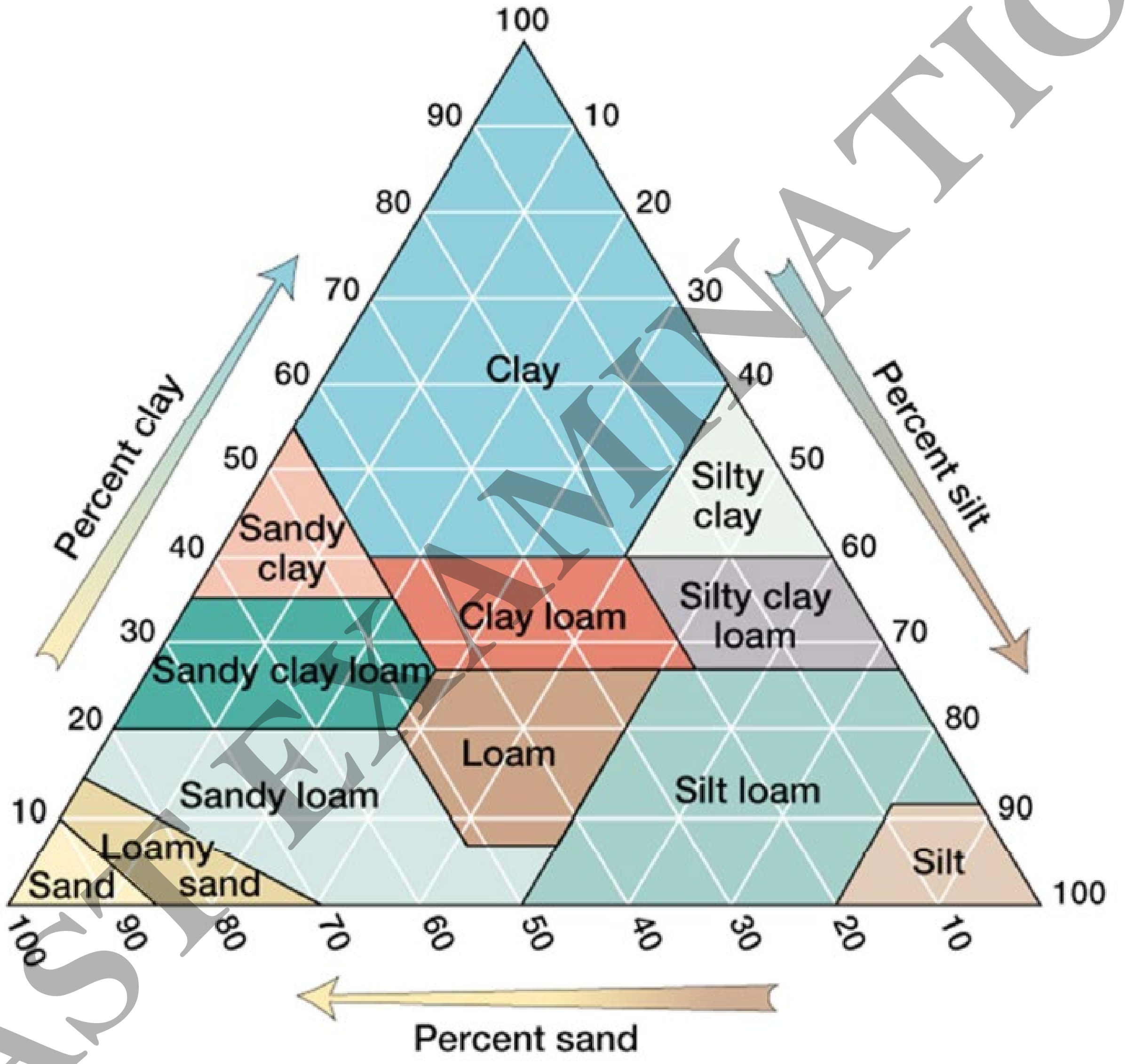

Figure Q1: **Soil Texture Triangle**

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Useful Formulae Handout

TERMINOLOGY, SYMBOLS AND UNITS

Term	Symbol	Units
Volume		m^3
Mass		kg
Gravity	g	9.81 m/sec^2
Weight		kN = (kg x 9.81)/1000
Total volume	V	m^3
Volume of air	V_A	m^3
Volume of water	V_W	m^3
Volume of voids	V_V	m^3
Volume of Solids	V_S	m^3
Mass of water	M_W	kg
Mass of solids	M_S	kg
Total mass	M	kN
Specific gravity	G_s	None
Density of water	ρ_w	1000kg/m^3
Unit weight of water	γ_w	9.81 kN/m^3
Void ratio	e	None
Degree of saturation	S_r	None
Moisture content	w	None
Porosity	n	None
Soil Bulk density	ρ_b	kg/m^3
Dry density	ρ_d	kg/m^3
Saturated density	ρ_{sat}	kg/m^3
Soil Bulk unit weight	γ_b	kN/m^3
Dry unit weight	γ_d	kN/m^3
Saturated unit weight	γ_{sat}	kN/m^3
Coefficient of Permeability	k	m/s
Soil Layer Thickness	H	m

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DEFINITIONS

Term	Expression	
Density of water, ρ_w		
Unit weight of water, γ_w		
Specific gravity, G_s	density of solids / density of water	$\frac{\rho_s}{\rho_w}$
Water content, w	mass of water / mass of solids	$\frac{M_w}{M_s}$
Void ratio, e	volume of voids / volume of solids	$\frac{V_v}{V_s}$
Degree of saturation, S_r	volume of water / volume of voids	$\frac{V_w}{V_v}$
Porosity, n	volume of voids / total volume	$\frac{V_v}{V}$
Bulk density, ρ_b	total mass / total volume	$\frac{M}{V}$
Dry density, ρ_d	mass of solids / total volume	$\frac{M_s}{V}$
Saturated density, ρ_{sat}	total saturated mass / total volume	$\frac{M}{V}$
Bulk unit weight, γ_b	total weight / total volume	$\frac{W}{V}$
Dry unit weight, γ_d	weight of solids / total volume	$\frac{W_s}{V}$
Saturated unit weight, γ_{sat}	total saturated weight / total volume	$\frac{W}{V}$
Air voids, A_v	volume of air / total volume	$\frac{V_a}{V}$

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BASIC PROPERTIES Formulae:

Void space relationship from soil model $w\,G_s = S_r\,e$

Bulk Density

$$\rho_b = \frac{\rho_W\ G_s(1 + w)}{1 + e}$$

$$\rho_b = \frac{(G_s + S_r e)\rho_W}{1 + e}$$

Dry Density

$$\rho_d = \frac{\rho_W\ G_s}{1 + e}$$

$$\rho_d = \frac{\rho_b}{1 + w}$$

$$\rho_d = \frac{\rho_{sat}}{1 + w_{sat}}$$

Theoretical Dry Density

$$\rho_d = \frac{\rho_W\ G_s\ (1 - A_v)}{1 + w\ G_s}$$

Porosity

$$n = \frac{e}{1 + e}$$

Air voids $A_v = n\ (1 - S_r)$

Soil Coefficient of Uniformity

$$C_u = \frac{D_{60}}{D_{10}}$$

Soil Coefficient of Curvature

$$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

$$Constant\ head\ permeability, k = \frac{V_w L}{Aht}$$

$$Falling\ head\ permeabilit, k = \frac{2.303\ a\ L}{At} \log \frac{h_1}{h_2}$$

$$Stratified\ Soil\ Layers, \quad k_H = \frac{1}{H}(k_{H1} x H_1 + k_{H2} x H_2 + \ \dots\dots\dots\dots + k_{Hn} x H_n)$$

$$Stratified\ Soil\ Layers, \quad k_v = \frac{H}{\left(\frac{H_1}{k_1} + \frac{H_2}{k_2} + \frac{H_3}{k_3} + \ \dots\dots\ + \frac{H_n}{k_n}\right)}$$

END OF PAPER