

**UNIVERSITY OF GREATER MANCHESTER**

**SCHOOL OF ENGINEERING AND BUILT  
ENVIRONMENT**

**BEng (HONS) CIVIL ENGINEERING**

**SEMESTER ONE EXAMINATION 2025/2026**

**GEOTECHNICAL ENGINEERING**

**MODULE NO: CIE6020**

Date: Monday 12<sup>th</sup> January 2026

Time: 2pm – 5pm

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**INSTRUCTIONS TO CANDIDATES:**

There are **FOUR** questions.

Answer **ALL FOUR** questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

The examination paper carries a total of 100 marks.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

Supplementary Geotechnical Information is provided on pages 9-11.

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**Question 1**

- a) Define the terms "Active Earth Pressure" and "Passive Earth Pressure". Sketch a retaining wall and clearly indicate the soil wedges and pressure distributions associated with each state.

**(5 marks)**

- b) A 9.0m retaining wall retains a layered geological sequence (**Q1 - Figure 1**) on page 3. With depth the sequence includes: 1.0m of sandy topsoil, 4.0m of stiff clay and 4.0m of firm clay. The surcharge,  $q = 30 \text{ kN/m}^2$ . The properties of the materials are summarised in the table (**Q1 – Table 1**) below:

Material	Unit weight ( $\text{kN/m}^3$ )	Angle of friction ( $^\circ$ )	Cohesion ( $\text{kN/m}^2$ )
Sandy Topsoil	19.8	27	0
Stiff Clay	20.5	20	20
Firm Clay	22	14	21

**Q1 – Table 1**

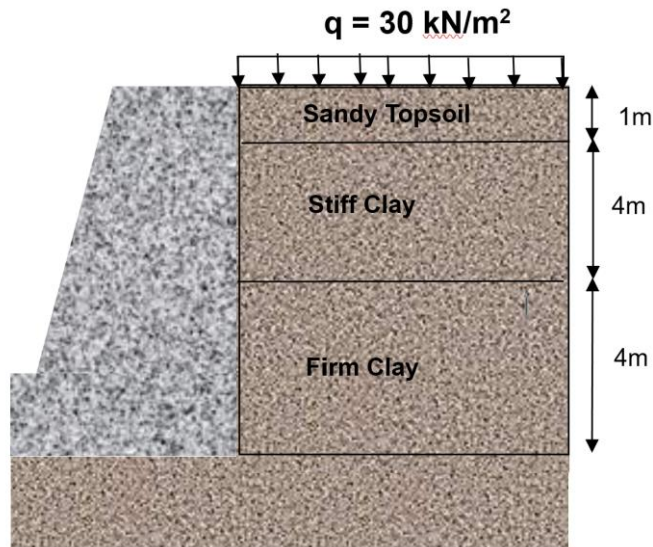
- (i) Calculate and draw the distribution of the active pressure applied to the wall (**Q1 - Figure 1**) on page 3.

**(10 marks)**

- (ii) Calculate the magnitudes and line of action of the thrusts produced by active pressures above the base of the wall.

**(10 marks)****Question 1 continued over page 3****PLEASE TURN THE PAGE**

Question 1 continued



Q1 - Figure 1

**NOTE:** Use the Supplementary Geotechnical Data sheets provided.

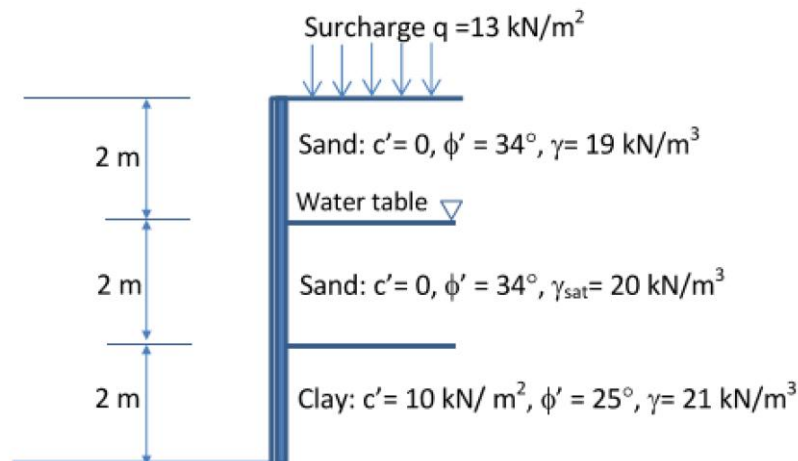
(Total 25 marks)

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### Question 2

A retaining wall is to retain 6.0m of soil. From the top of the wall downwards the soil is composed of 4.0m of sand overlying 2.0m of clay. The water table is at depth of 2.0m from the top. The properties of sand and clay is given in (Q2 – Figure 1) on page 4.

- Calculate the lateral earth pressure on the retaining wall. **(8 marks)**
- Given the values that you calculated in part a) draw the pressure distribution on the back of the wall (i.e. how the pressure changes with depth). **(5 marks)**
- Based on the drawing in part b), calculate the total force applied to the wall. **(6 marks)**
- Determine the position of the line of action (above the base of the wall). **(6 marks)**



Q2 – Figure 1

**NOTE:** Use the Supplementary Geotechnical Data sheets provided.

**(Total 25 marks)**

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## Question 3b continued

Slice	Height (m)	$\alpha$ (°)	u (kN/m <sup>2</sup> )
1	1.10	-8.0	6.2
2	1.70	7.2	13.0
3	2.90	20.5	18.0
4	3.50	42.5	17.5
5	1.35	60.2	0

Q3 - Table 1

Copy this table to your answer booklet to help you determine the factor of safety

Slice	Height h (m)	$\alpha$ (°)	u (kN/m <sup>2</sup> )	Breadth b	Area of each slice A (bxh)	Weight of each slice W ( $\gamma \times A$ )	Cos $\alpha$	Sec $\alpha$	$r_u = (u/\gamma h)$	$(W \times \cos \alpha - r_u \times \sec \alpha) \tan \phi'$	$W \sin \alpha$
1	1.10	-8.0	6.2								
2	1.70	7.2	13.0								
3	2.90	20.5	18.0								
4	3.50	42.5	17.5								
5	1.35	60.2	0								
$\Sigma =$											

Q3 - Table 2

**NOTE:** Use the Supplementary Geotechnical Data sheets provided.

(Total 25 marks)

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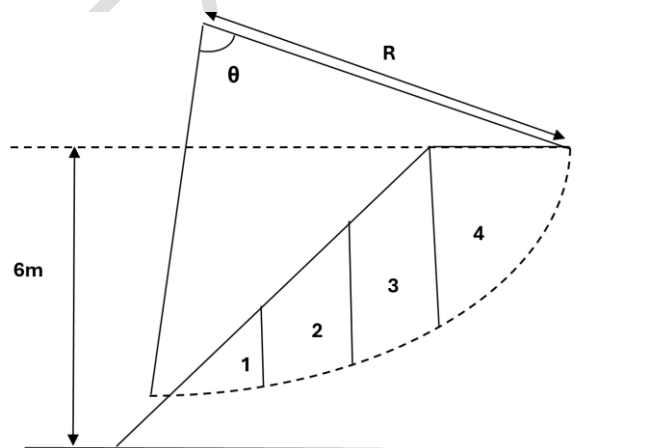
#### Question 4

- a) You are the Site Engineer for a new road cut into a hillside. During a period of heavy rain, you notice new tension cracks at the top of the slope and signs of swelling at the toe.
- Identify the type of mass movement that is likely occurring.
  - Explain the role the heavy rain is playing in reducing the slope's stability.
  - Propose two possible stabilization methods you could recommend.

(7 marks)

- b) An embankment made from silt is to be constructed upon the ground surface (See Q4 - Figure 1 on page 7). The completed embankment can be assumed to be homogenous and thus will possess constant density and constant shear strength throughout its mass. The undrained cohesion ( $c_u$ ) of the silt is  $24 \text{ kN/m}^2$  and the unit weight ( $\gamma$ ) is  $20 \text{ kN/m}^3$ .  $R=12\text{m}$  and  $\theta=70^\circ$ . Determine the factor of safety in the short term (undrained state). Area and angle of base for each slice is calculated in (Q4 - Table 1) on page 8.

(9 marks)



Q4 – Figure 1

Question 4b continued over page 8

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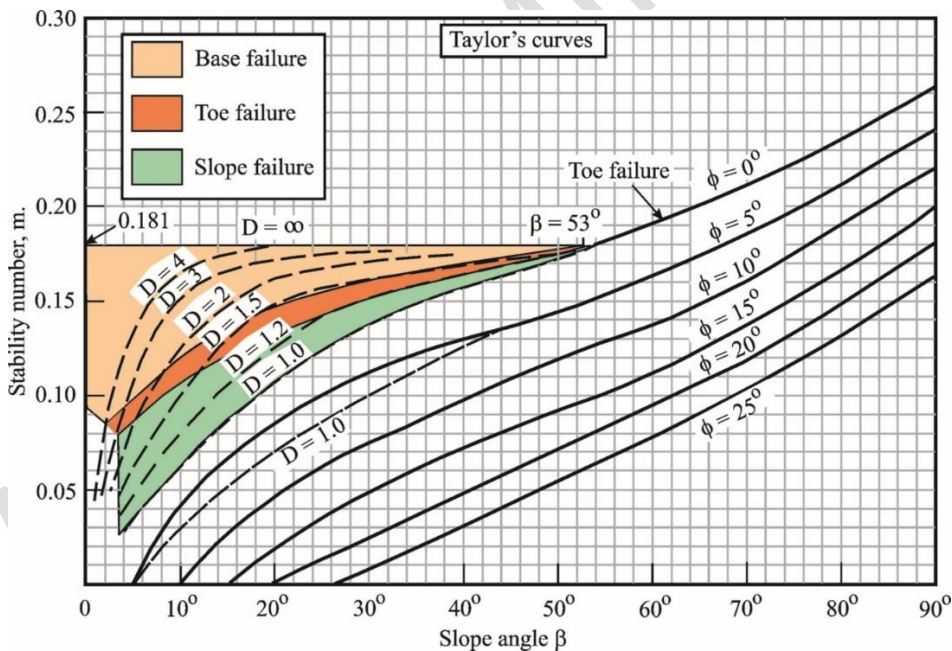
Question 4b continued

Slice	Area (m <sup>2</sup> )	Angle of base (°)
1	5.6	-10.5
2	10.5	17.4
3	13.2	29.8
4	10.6	57.0

Q4 – Table 1

- c) A 7m excavation is required in a mudrock where a hard limestone is known to be 8.4m below ground level. The mudrock has a cohesion of 9kN/m<sup>2</sup> and a unit weight of 19kN/m<sup>3</sup>. Using Taylor’s curves in Q4 – Figure 2 (page 8), what is the angle of the critical slope.

(9 marks)



Q4 - Figure 2

(Total 25 marks)

END OF QUESTIONS

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 SUPPLEMENTARY GEOTECHNICAL INFOMRATION

**Supplementary Geotechnical Information**

**Retaining Walls (Q1 and Q2)**

$$K_a = \frac{1 - \sin \phi}{1 + \sin \phi} \quad ; \quad K_p = \frac{1 + \sin \phi}{1 - \sin \phi}$$

$$\sigma_{ha} = K_a \sigma_v - 2c\sqrt{K_a} \quad ; \quad \sigma_{hp} = K_p \sigma_v + 2c\sqrt{K_p}$$

$$\sigma'_v = \sigma_v - u$$

$$u = \gamma_w z$$

$$\sigma_v = \gamma z + q$$

$$\sigma_h = \sigma'_h + u$$

$$\sigma'_h = K_a(\sigma'_v) - 2c\sqrt{K_a}$$

$$p_A = K_A(\gamma z + q) - 2c'\sqrt{K_A} \quad K_A = \frac{1 - \sin \phi'}{1 + \sin \phi'} = \tan^2 \left( 45 - \frac{\phi'}{2} \right)$$

$$p_P = K_P(\gamma z + q) + 2c'\sqrt{K_P} \quad K_P = \frac{1 + \sin \phi'}{1 - \sin \phi'} = \tan^2 \left( 45 + \frac{\phi'}{2} \right)$$

*( $p_A, p_P, K_A$  and  $K_P$  are the active and passive pressures and coefficients respectively,  $z$  is the depth,  $\gamma$  is the unit weight and  $q$  is the surcharge )*

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**Slope Stability (Q3 and Q4)**

$$m = \frac{c'}{FH\gamma}$$

*(m is the stability number, F is the factor of safety and H is the height of the slope)*

$$M=D.H$$

*(M can be expressed in terms of the height of the slope via D which is known as the Depth factor)*

$$L=d.H$$

*(L is the horizontal distance of the slip circle from the toe of the slope, it can be expressed in terms of H via d which is known as the distance factor)*

**Swedish Method:**

$$F = \frac{\Sigma(c' \times R \times \theta_{rad}) + \Sigma(W \times \cos\alpha - r_u \times \sec\alpha) \tan\phi'}{\Sigma(W \times \sin\alpha)}$$

**Bishop's Method:**

$$F = \frac{1}{\Sigma(W \times \sin\alpha)} [\Sigma(c'l + W(\cos\alpha - r_u \times \sec\alpha) \tan\phi')]$$

$$r_u = \frac{\text{pore water pressure}}{\text{total stress}} = \frac{u}{\gamma z}$$

$$u = r_u \times \gamma \times z = r_u \times \frac{W}{b}$$

$$l = \frac{b}{\cos\alpha} \quad \text{or} \quad b = l \times \cos\alpha \quad \text{and} \quad \sec\alpha = \frac{1}{\cos\alpha}$$

$$u = \frac{r_u \times W}{l} \times \sec\alpha$$

*(W is the weight,  $\alpha$  is the angle of the base of a slice and l is the length of the base of a slice)*

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Weight of each slice  $W = (\gamma \times A)$

$$F = \frac{c_u R \theta}{\sum W \sin \alpha}$$

$$F = \frac{c' R^2 \theta}{W.d}$$

*(R is the radius of the slip circle,  $\theta$  is the included angle  
and d is the eccentricity of the centre of mass)*

**END OF PAPER**

PAST EXAMINATION