CONFIDENTIAL

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESSION 2021/2022

| | | |
|---|---|---|
| COURSE NAME | : | GEOTECHNIC II |
| COURSE CODE | : | BFC 35403 / BFC 34402 |
| PROGRAMME | : | BFF |
| EXAMINATION DATE | : | JULY 2022 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | 1. | ANSWER ALL QUESTIONS |
| | 2. | THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **CLOSED BOOK.** |
| | 3. | STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK |

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES



CONFIDENTIAL

**Q1** (a) Many failure mechanisms of geotechnical or foundation engineering occurred due to instability in the soil mass. One of the methods to solve the problem is the construction designing of a flow net system that is used for solving groundwater flow problems. **Table Q1(a)** shows the basic symbol used in the equation to calculate flow net. Discuss **FIVE (5)** characteristics for constructing a flow net in the graphical seepage.

(10 marks)

(b) A single row of sheet piles in a permeable soil layer is shown in **Figure Q1(b)**. The soil is homogeneous and isotropic with $k = 4 \times 10^{-4}$ cm/sec and $\gamma_{sat} = 19$ kN/m$^3$. Based on **Figure Q1 (b)**, determine the seepage flow, the total head at points *a* and *b*, and *FS* against boiling. Support your answer with a relevant scale.

(15 marks)

**Q2** (a) Describe the differences between 'active Rankine state' and 'passive Rankine state'.

(4 marks)

(b) The 7m high retaining wall is shown in **Figure Q2 (b)**. Determine;

(i) Rankine active and passive force per unit length of the wall together with the location of the resultant force.

(8 marks)

(ii) Rankine active force per unit length of the wall and the location of the resultant force if the groundwater level was found at 2 m from the ground surface. Given saturated unit weight is 19 kN/m$^3$ with a friction angle of 35°.

(13 marks)

**Q3** **Figure Q3** shows the layer of sand and clay soil. It was observed that the unit weight of the sand and clay layer is 17.5 kN/m$^3$ and 18.5 kN/m$^3$ respectively. The in situ void ratio for the clay layer is 0.7. Given the load due to structure is 115 kPa. The collected data from the laboratory consolidation test is as shown in **Table Q3**.

(a) Make necessary calculations and draw an $e$ versus $\log \sigma'$ curve based on given data in **Table Q3**. Given the dry mass of specimen = 110 g, the height of specimen at the beginning of the test = 25 mm, specific gravity = 2.7 and specimen surface area = 32 $cm^2$.

(10 marks)

(b) Determine pre-consolidation pressure, compression index and swell index by referring to the curve obtained from **Q1 (a)**.

(6 marks)

(c) Determine the settlement of the clay layer caused by primary consolidation if the clay is over consolidated. Use $C_c$ and $C_s$ that obtained from **Q1 (b)**.

(4 marks)

(d) Determine the settlement of the clay layer caused by primary consolidation if the clay is normally consolidated and the groundwater level is located at the middle of sand layer. Given the saturated unit weight of the sand layer is 19 $kN/m^3$ while the clay layer is 20 $kN/m^3$. Use $C_c$ and $C_s$ that obtained from **Q1 (b)**.

(5 marks)

**Q4** (a) One of the assumptions made in the ordinary slice method is that the interslice forces are neglected. Classify whether this assumption is realistic or not.

(5 marks)

(b) **Figure Q4 (b)** shows the construction of a newly developed housing project at a hillside that was badly affected by a recent landslide. Hypothesize **FOUR (4)** possible causes which triggered this geotechnical problem with suitable illustration.

(8 marks)

(c) As a consultant engineer, you are given a slope design task. A cut slope was excavated in a saturated clay with a slope angle, $\beta = 35°$, with the horizontal. Previous soil explorations showed that a rock layer was located at a depth of 15 m below the ground surface. Assuming an undrained condition and $\gamma = 18.7$ $kN/m^3$ and the undrained cohesive value, $c_u = 75$ $kN/m^2$ : Assume D = 1.5. The task is given as follow;

(i) Analyze the maximum height of the slope can be cut.

(3 marks)

(ii) Identify the nature of the critical circle failure.

(3 marks)

(iii) With reference to the top of the slope, plan your working area of the slope analysis by using slope software.

(6 marks)

**- END OF QUESTIONS -**

FINAL EXAMINATION

| | | | | | |
|---|---|---|---|---|---|
| SEMESTER/SESSION | : | SEMESTER II / 2021/2022 | PROGRAMME CODE | : | BFF |
| COURSE NAME | : | GEOTECHNIC II | COURSE CODE | : | BFC 35403 /BFC34402 |

**Table Q1(a)**: Basic symbol flow net equations

| Symbol | Description |
|---|---|
| v | Discharge velocity of water flow through porous media (m/s) |
| k | Coefficient of permeability (m/s) |
| i | Hydraulic gradient |
| A | Cross-sectional area of specimen perpendicular to flow direction ($m^2$) |
| q | Flow rate water ($m^3/s$) |
| Q | Total amount of flow ($m^3$) for a period *t* (second) |

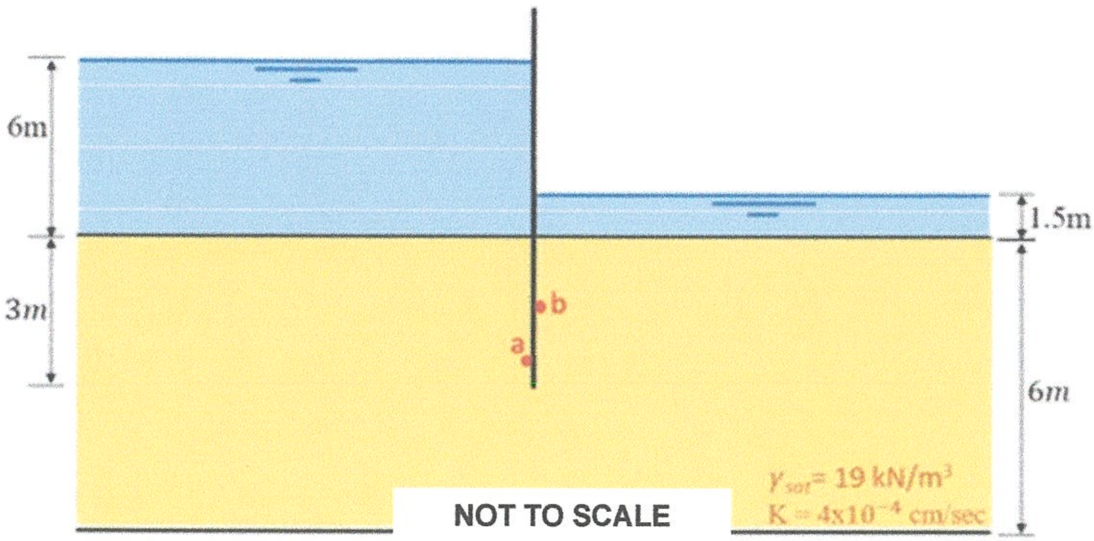



**Figure Q1(b)**: Sheet pile in a permeable soil layer

**FINAL EXAMINATION**

| | | | | | |
|---|---|---|---|---|---|
| SEMESTER/SESSION | : | SEMESTER II / 2021/2022 | PROGRAMME CODE | : | BFF |
| COURSE NAME | : | GEOTECHNIC II | COURSE CODE | : | BFC 35403 /BFC34402 |

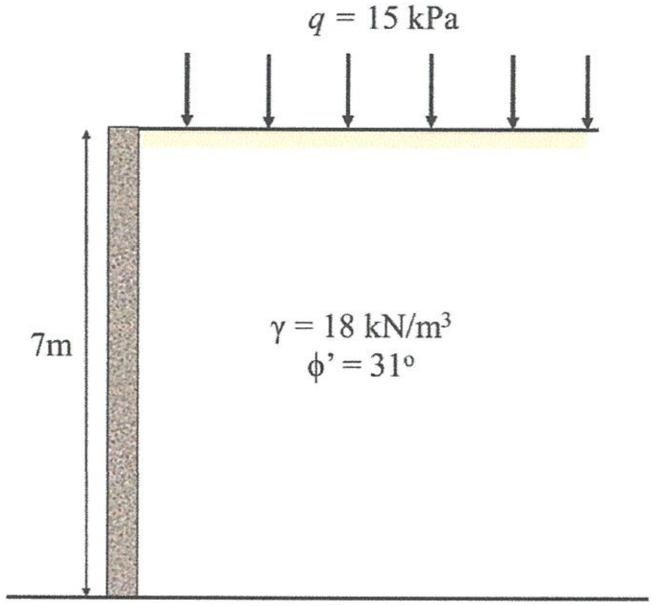



**Figure Q2(b)**: Retaining wall

**Table Q3:** Laboratory consolidation test data

| Remarks | Pressure, σ' (kN/m$^2$) | Height, H (mm) |
|---|---|---|
| Loading | 0 | 25.00 |
| | 25 | 24.92 |
| | 50 | 24.79 |
| | 100 | 24.50 |
| | 200 | 23.80 |
| | 400 | 23.00 |
| | 800 | 22.20 |
| | 1600 | 21.35 |
| Unloading | 800 | 21.55 |
| | 400 | 21.90 |
| | 200 | 22.20 |

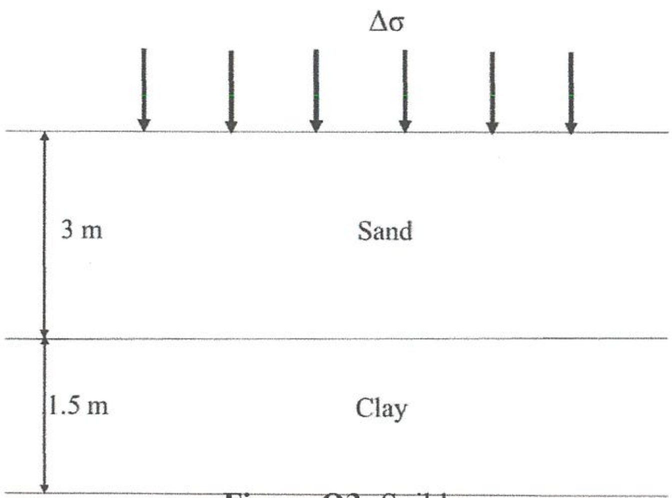



**Figure Q3:** Soil layer

**FINAL EXAMINATION**

| | | | | | |
|---|---|---|---|---|---|
| SEMESTER/SESSION | : | SEMESTER II / 2021/2022 | PROGRAMME CODE | : | BFF |
| COURSE NAME | : | GEOTECHNIC II | COURSE CODE | : | BFC 35403 /BFC34402 |

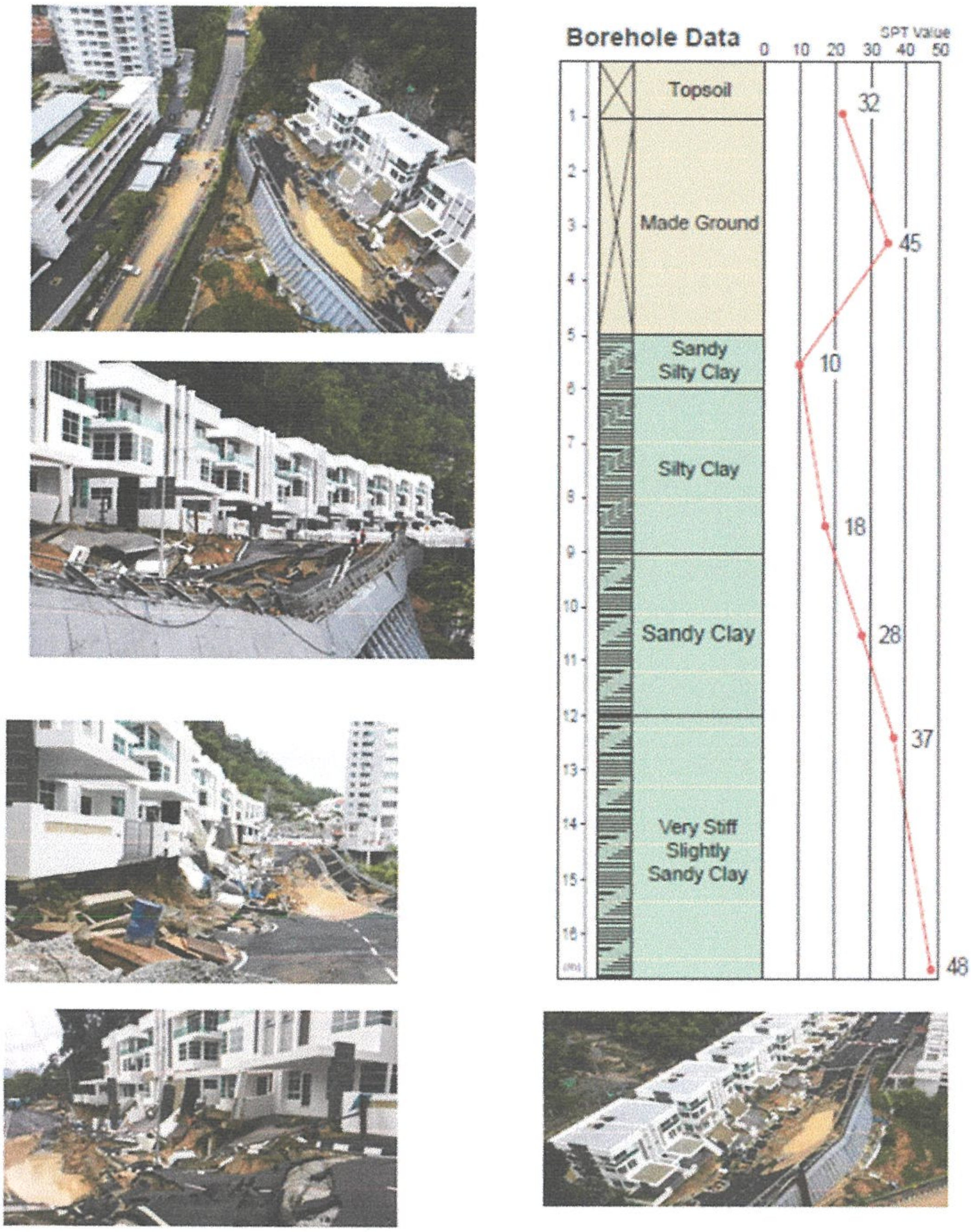
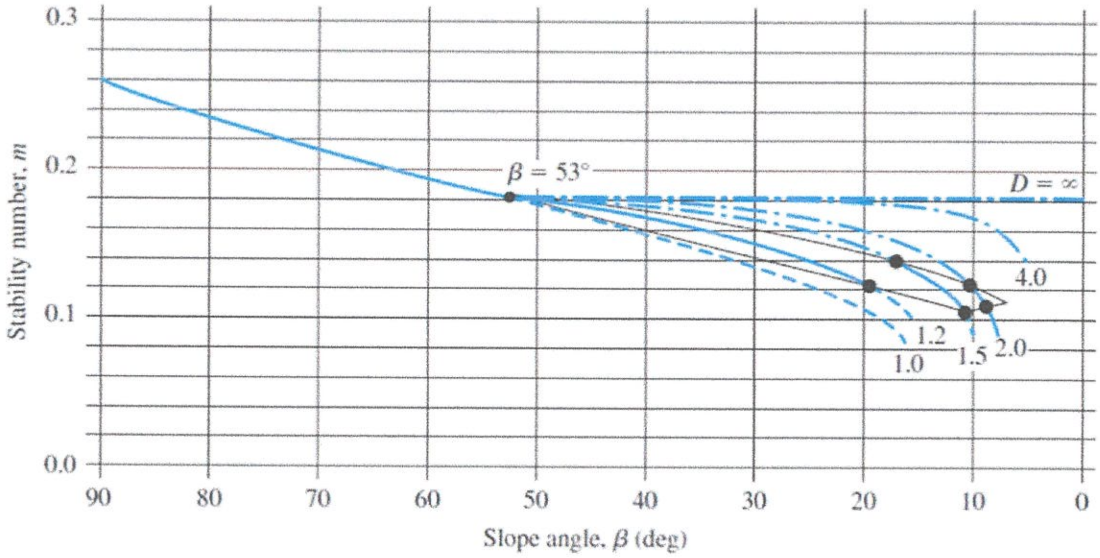


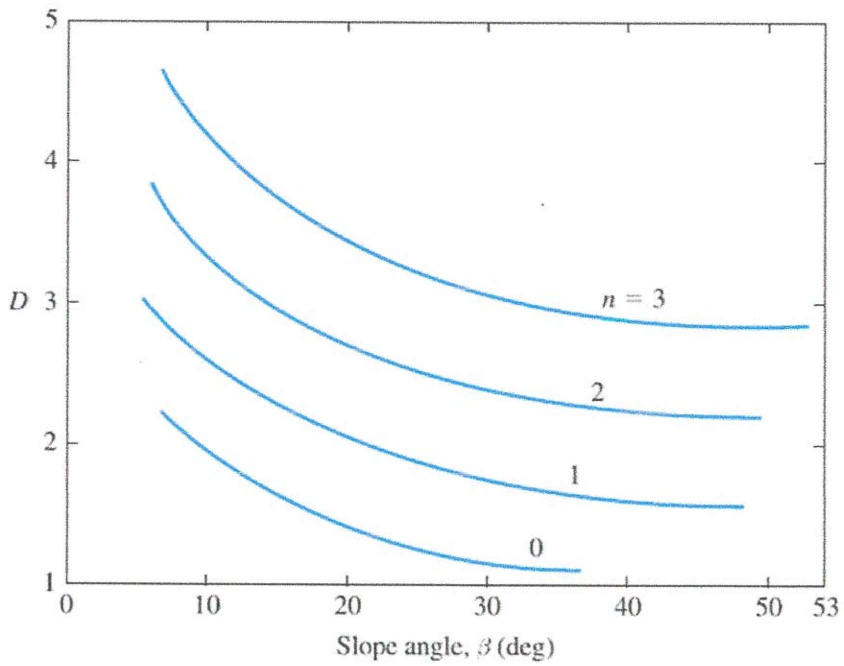

**Figure Q2(b)**: Retaining wall

**FINAL EXAMINATION**

| | | | | | |
|---|---|---|---|---|---|
| SEMESTER/SESSION | : | SEMESTER II / 2021/2022 | PROGRAMME CODE | : | BFF |
| COURSE NAME | : | GEOTECHNIC II | COURSE CODE | : | BFC 35403 /BFC34402 |

## Appendix A: Design Tables and Charts



**FINAL EXAMINATION**

| | | | | | |
|---|---|---|---|---|---|
| SEMESTER/SESSION | : | SEMESTER II / 2021/2022 | PROGRAMME CODE | : | BFF |
| COURSE NAME | : | GEOTECHNIC II | COURSE CODE | : | BFC 35403 /BFC34402 |

## Appendix B: Formulas

*These formulas may be useful to you. The symbols have their usual meaning.*

### Flow in Soil

$$q = k\,\frac{H N_f}{N_d}\ \textit{isotropic soil}$$

$$q = \sqrt{k_x k_z}\,\frac{H\,N_f}{N_d}\ \textit{Anisotropic soil}$$

$$i_{max} = \frac{\Delta h}{L}$$

Head loss of each potential drop, $\Delta \mathrm{h} = \frac{\Delta \mathrm{H}}{\mathrm{N_d}}$

$$p_w = \frac{\square x}{3}\left[u_1 + u_n + 2u_{i(odd)} + 4u_{i(even)}\right]$$

### Stress in Soil

*Conventional retaining walls*

*Rankine active and passive pressure*

$$P_a = \tfrac{1}{2}K_a\gamma_1 H^2 \qquad P_a = \tfrac{1}{2}K_a\gamma_1 H^2 + qK_a H$$

$$P_v = P_a \sin\alpha° \qquad P_h = P_a \cos\alpha°$$

$$P_p = \tfrac{1}{2}K_p\gamma_2 D^2 + 2c'_2\sqrt{K_p}D$$

$$K_a = \tan^2\left(45° - \tfrac{1}{2}\phi'_1\right) \qquad K_p = \tan^2\left(45° + \tfrac{1}{2}\phi'_2\right)$$

*Factor of safety against overturning*

$$FS = \frac{\Sigma W_i X_i}{\Sigma P_{a_i} z_{a_i}} = \frac{\Sigma(A_i \times \gamma_i)X_i}{\Sigma P_{a_i} z_{a_i}}$$

$$FS = \frac{\gamma_{n+i}A_{n+i}x_{n+i} + \mathrm{K} + \gamma_n A_n x_n}{P_a \cos\alpha(H'/3)}$$

*Factor of safety against sliding*

$$FS = \frac{\Sigma V \tan\left(\tfrac{2}{3}\phi'_2\right) + \tfrac{2}{3}Bc'_2 + P_p}{P_a \cos\alpha} \qquad z_o = \frac{2c_u}{\gamma}$$

FINAL EXAMINATION

| | | | | | |
|---|---|---|---|---|---|
| SEMESTER/SESSION | : | SEMESTER II / 2021/2022 | PROGRAMME CODE | : | BFF |
| COURSE NAME | : | GEOTECHNIC II | COURSE CODE | : | BFC 35403 /BFC34402 |

**Slope Stability**

$$FS = \frac{c_n l_n + \sum_{n=1}^{n=p}(W_n cos\alpha_n - r_u sec\alpha_n)tan\phi_n'}{\sum_{n=1}^{n=p} W_n sin\alpha_n}$$

$$FS = \frac{\sum_{n=1}^{n=p}(c'R\theta + W_n cos\alpha_n tan\phi')}{\sum_{n=1}^{n=p} W_n sin\alpha_n}$$

$$FS = \frac{\sum C_u R^2 \theta}{\sum M_d}, \theta \text{ in radian}$$

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

$$S_n = \frac{c_u}{F_c \gamma' H}$$

$$\gamma_{sat} = \frac{(Gs+e)\gamma_w}{1+e}$$

$$S_n = \frac{c'}{F_c \gamma_{sat} H}$$

$$\frac{\phi'}{\phi_u} = \frac{\gamma'}{\gamma_{sat}}$$

TERBUKA