CONFIDENTIAL

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	SOFT SOIL ENGINEERING
COURSE CODE	:	BFG 40603
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1 (a) Comment a common procedure of vibro compaction and compaction grouting technique with a suitable illustration.

(6 marks)

(b) Discuss in details **TWO (2)** possible soft soil improvement technique of a very thick peat layers.

(6 marks)

(c) An embankment as shown in **Figure Q1(b)** is to be constructed on a normally consolidated soft clay with a thickness of 11 m underlain by an impermeable rock layer. To minimize the service settlement, a surcharge load up to 5 m will be constructed in a month. After that, it will be use to preload the soil for another 6 months. At the end of the preloading period, 2 m of the surcharge will be trimmed out into the designated invert level. Prefabricated vertical drain (PVD) with the dimension of 100 mm and 5 mm was selected to be penetrated into the soft soil layer. The PVD will be arrange in a square pattern and 1 m spacing. The discharge capacity of the drain is 0.00081 m^3/s under 50 kPa normal stress and 0.00014 m^3/s under 150 kPa. Assume there is no smear effect during the installation of PVDs.

(i) Predict the factor of safety against bearing failure at the end of surcharge construction, before it will be loaded for 6 months.

(5 marks)

(ii) By considering PVD design as specified earlier, estimate a degree of consolidation achieved by the end of the 6 months preloading.

(8 marks)

Q2 (a) Comment your understanding on a phenomena of a peat fire issue.

(6 marks)

(b) Normally, settlement issues of a soft soil are influence by a geological factors or human activities. Based on your understanding, discuss on the settlement of a peat soil at Mukim Ayer Hitam, Muar and a coastal alluvium along the shoreline of Batu Pahat, Johor based on these factors.

(8 marks)

(c) As a final year student of Faculty of Civil and Built Environment, you are assigned to conduct a cone penetration test (CPT) at the Research Centre for Soft Soil (RECESS) site. Based on your result, the groundwater table is at 1.5 m below the ground surface. The unit weights of the soil above and below the groundwater table are 18.5 kN/m^3 (imported soil) and 18.5 kN/m^3, respectively. The measured tip resistance at a depth of 6 m is 8 MPa and the sleeve friction is 0.5 MPa.

(i) Classify the type of the soil according to **Figure Q2(b)**.

(4 marks)

(ii) If the soil is a sandy soil, determine the relative density and friction angle. If it is a clayey soil, determine the undrained shear strength and OCR.

(7 marks)

Q3 (a) The excavation in the soft soil will be performed to widen the Muar river. The sheet pile will be used to retain the soil prior commencing the excavation. You are required to recommend and justify, the best triaxial test method for this project in the determination of the excavation stability.

(5 marks)

(b) The soft soil can be classified as normally consolidated clay and overconsolidated clay. Your client requires a report about the value of overconsolidation ratio (OCR) for soft soil. Produce your report to the client in terms of introduction, formation, site investigation, laboratory testing and laboratory interpretation about the overconsolidation ratio of soft soil.

(8 marks)

(c) The undisturbed soil sample with a diameter of 50 mm and 100 mm long. The results of stress and strain curve obtained from the triaxial test is shown in **Figure Q3(c)**. The axial stress was increased from 100 kN/m^2 to 500 kN/m^2 during shearing.

(i) Determine the changes of vertical displacement at the end of the shearing stage.

(2 marks)

(ii) If the radial expansion is 1.5 mm, determine the Poisson's Ratio, ν.

(2 marks)

(iii) From Figure Q3(c), estimate the Young's Modulus (E), E_{50} and E_{ur}. Then determine the shear modulus and bulk modulus of the soil.

(8 marks)

Q4 (a) Discuss the advantages and disadvantages of multi stage embankment construction on soft soil.

(4 marks)

(b) The performance of preloading embankment of soft soil have to monitored in the field using various instrumentation to obtain the degree of consolidation. Discuss the procedure to predict the degree of consolidation of the embankment by using **TWO (2)** selected instrumentation.

(7 marks)

(c) A road 500 m long will be constructed through the soft soil area. The preloading improvement is selected by constructed a 4.0 m height of embankment to reduce the settlements during construction. To increase the embankment stability, the pressure berms are proposed during the period as shown in **Figure Q4 (c)**. Assume the traffic load is 10 kN/m^2.

(i) Comment on the design of the pressure berms in terms of the stability.
(4 marks)

(ii) Proposed the geometry of the pressure berms (height and width), if the minimum factor of safety is unfulfilled. You may use **Figure Q4 (c) (ii)** as your reference.
(6 marks)

(iii) Recommend other methods to fulfill the minimum factor of safety without changing the geometry of the pressure berms.
(4 marks)

– END OF QUESTIONS –

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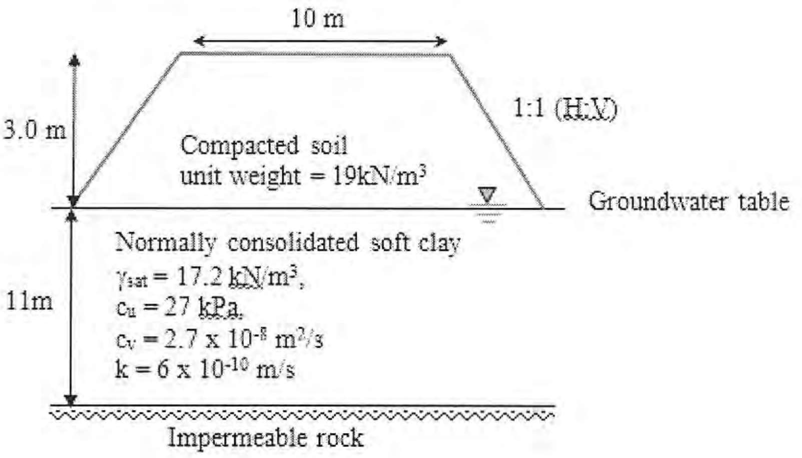
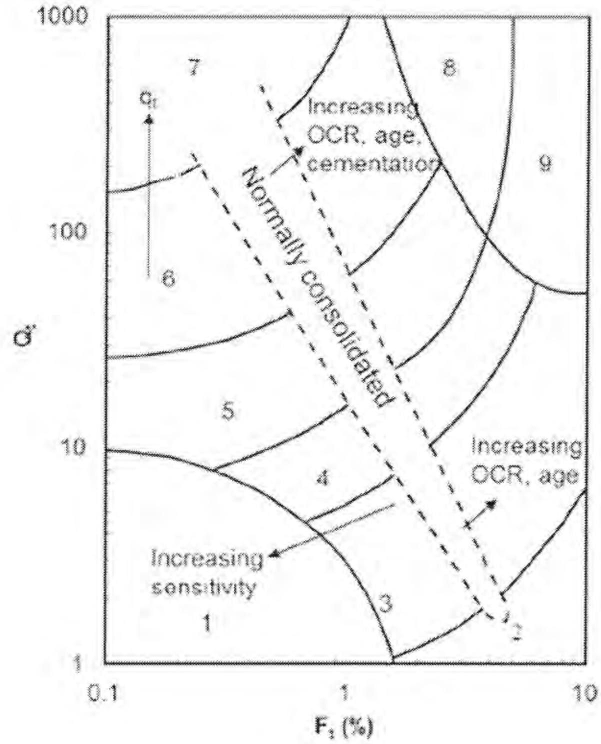


FIGURE Q1(b): Soft soil improved PVD



Zone	Soil behavior type
1	Sensitive, fine grained
2	Organic soil; peat
3	Clay; clay to silty clay
4	Silt mixture; clayey silt to silty clay
5	Sand mixture; silty sand to sandy silt
6	Sand; clean sands to silty sand
7	Gravelly sand to sand
8	Very stiff sand to clayey sand
9	Very stiff fine grained

$$Q_t = \frac{q_t - \sigma_{z_o}}{\sigma'_{z_o}}$$

$$F_t = \left(\frac{f_s}{q_t - \sigma_{z_o}} \right) \times 100\%$$

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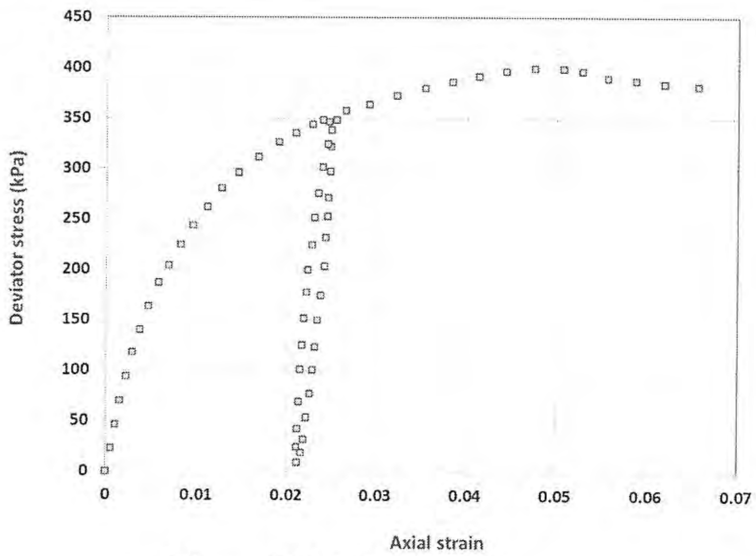

Figure Q3(c): Stress strain curve

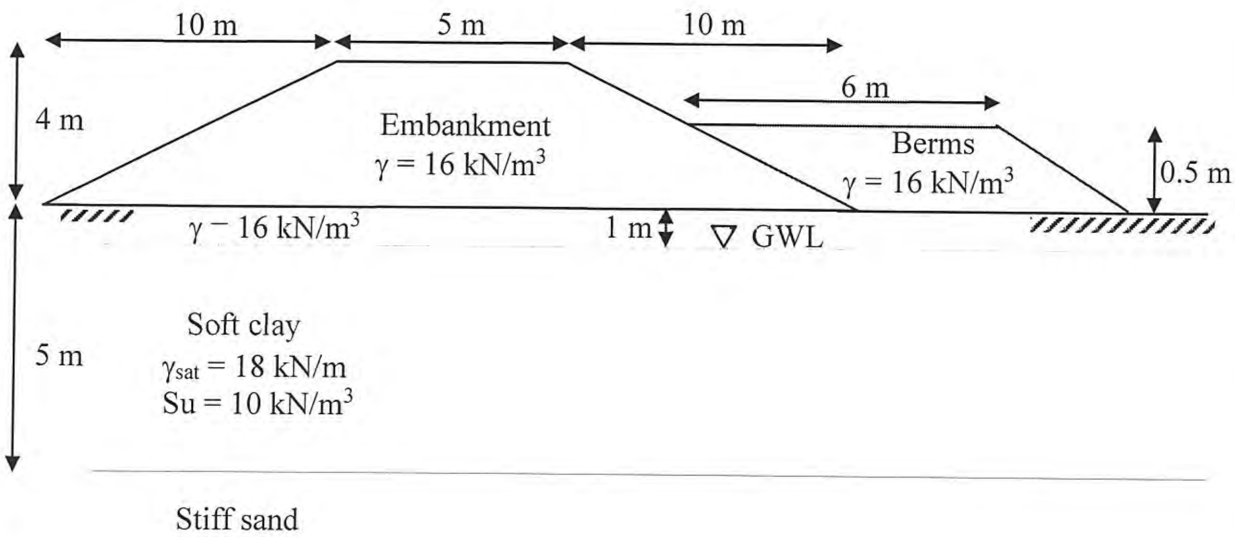

FIGURE Q4(c) : Geometry of embankment on soft soil stabilised with berms

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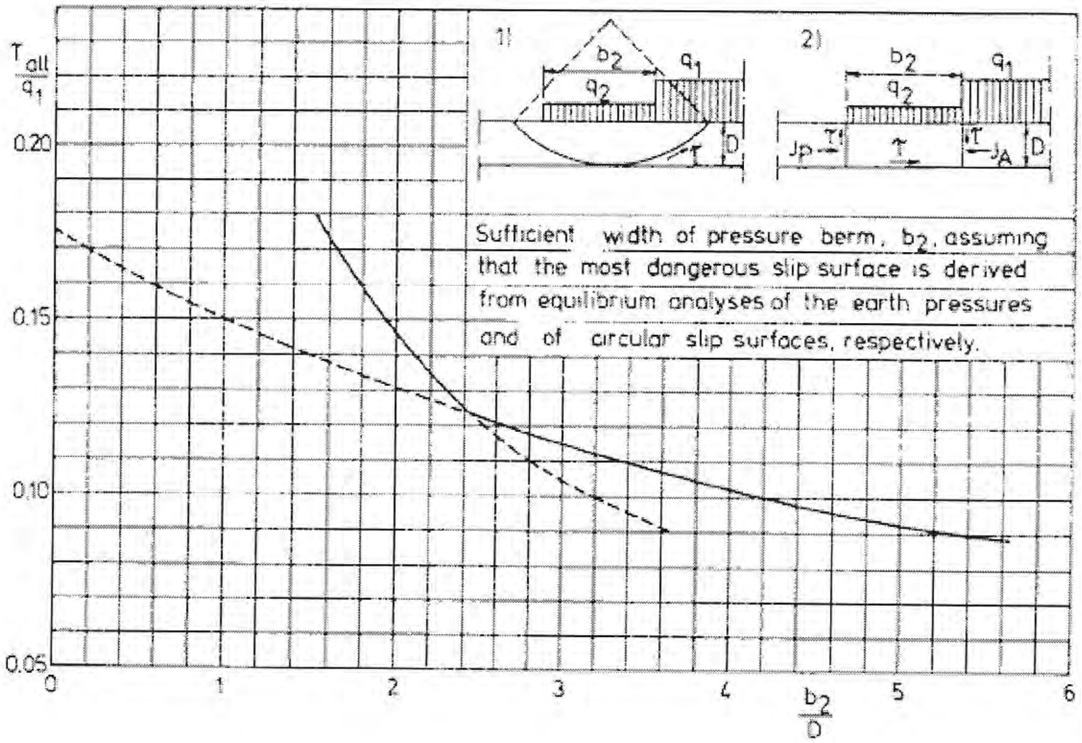

Figure Q4 (c)(ii): Nomogram for estimation of the width of the pressure berms

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The following information may be useful. The symbols have their usual meaning.

Equation for CPT

Relative density of sand (Kulhawy & Mayne, 1990)

$$D_r(\%) = \sqrt{\frac{q_c}{30500 \times OCR^{0.18}}\sqrt{\frac{100}{\sigma'_{z_o}}}}$$

Effective friction angle of sand sand (Kulhawy & Mayne, 1990)

$$\phi' = \tan^{-1}\left[0.1 + 0.38\log\left(\frac{q_c}{\sigma'_{z_o}}\right)\right]$$

The undrained shear strength of clay (Salgado, 2006)

$$c_u = \frac{q_c - \sigma_{z_o}}{11}$$

Preconsolidation pressure of clay (Kulhawy & Mayne, 1990)

$$\sigma_c = 0.33(q_c - \sigma_{z_o})$$

Settlement of shallow foundation (Schmertmann et al., 1978)

$$s_e = C_1C_2C_3p_n\sum\frac{I_\varepsilon}{E_s}\Delta h$$

where C_1 = correction factor for embedment depth foundation, $C_1 = 1 - 0.5(\sigma'_D/P_n)$

C_2 = correction factor for soil creep, $C_2 = 1 + 0.2\log(t/0.1)$, t is time after load is applied

C_3 = correction factor for foundation shape, $C_3 = 1.03 - 0.03(L_f/B_f) \geq 0.73$

$I_{\varepsilon p} = 0.5 + 0.1\sqrt{(P_n/\sigma'_{zp})}$

I_ε = Influence factor at midpoint of each soil sublayer

Δh = thickness of each soil sublayer

E_s = soil elastic modulus at midpoint of each sublayer

Table A: Soil Elastic Modulus Estimated by CPT tip resistance

Soil Type	E_s
Sand (normally consolidated)	$(2-4)\ q_c$
Sand (over consolidated)	$(6-30)\ q_c$
Clayey sand	$(3-6)\ q_c$
Silty sand	$(1-2)\ q_c$
Soft clay	$(3-8)\ q_c$

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The following information may be useful. The symbols have their usual meaning.

Consolidation

$$OCR = \frac{\sigma'_c}{\sigma'_o}$$

$$S_p = H\frac{\Delta e}{1+e_o}$$

$$S_p = \frac{C_c H}{1+e_o}\log\left(\frac{\sigma'_o + \Delta\sigma'}{\sigma'_o}\right)$$

$$S_p = \frac{C_r H}{1+e_o}\log\left(\frac{\sigma'_o + \Delta\sigma'}{\sigma'_o}\right)$$

$$S_p = \frac{C_r H}{1+e_o}\log\left(\frac{\sigma'_c}{\sigma'_o}\right) + \frac{C_c H}{1+e_o}\log\left(\frac{\sigma'_o + \Delta\sigma'}{\sigma'_c}\right)$$

$$T_v = \frac{c_v t}{H_{dr}^2}$$

$$m_v = \frac{a_v}{1+e_{av}} = \frac{(\Delta e/\Delta\sigma')}{1+e_{av}}$$

Embankment

$$h_{berm} = \frac{\left[(h_{emb}\times\gamma_{emb}) + q_{traffic}\right] - \frac{s_u \times 5.52}{FS}}{\gamma_{berms}}$$

PVD design

$$F_s = \frac{N_c c_u}{\Delta\sigma}, \text{where } N_c = 5.14$$

$$T_v = \frac{C_v t}{h_{dr}^2}$$

$$U_v = \sqrt{\frac{4T_v}{\pi}}$$

$$U_{vr} = 1-(1-U_v)(1-U_r)$$

$$U_r = 1 - \frac{(1-U_v)}{(1-U_{vr})}$$

$$d_c = \frac{b+t_g}{2}$$

$d_e = 1.13S$, for square pattern
$d_e = 1.05S$, for triangular pattern

$$N_D = \frac{d_e}{d_c}$$

$$T_r = \frac{C_r t}{d_e^2}$$

$$F_m(N_D) = \ln\frac{N_D}{N_s} + \frac{k_r}{k_s}\ln(N_s) - \frac{3}{4} + \pi z(2h_{dr} - z)\frac{k_r}{Q_c}$$

$$U_r = 1 - \exp\left(\frac{-8T_r}{F_m(N_D)}\right)$$