Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	SOFT SOIL ENGINEERING
COURSE CODE	:	BFG 40603
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 (a) Monitoring the behaviour of embankments on soft soil is essential in order to proven sudden failures, to recognise changes in rate of consolidation and to verify design parameters.

(i) List **THREE (3)** basic instrumentation and its suitable location in the field using the aid of diagrams in monitoring the performance of embankments.
(3 marks)

(ii) Discuss the important of these instruments in the real highway project.
(4 marks)

(b) **Figure Q1 (b)** shows the effect of vertical drain installation in soft soil. Discuss in details based on the provided graph along with some justifications.
(4 marks)

(c) An embankment is to be constructed on normally consolidated soft soil as shown in **Figure Q1(c).** The details pertaining to a project is shown in **Table 1**. The selected PVDs have the cross sectional dimensions of 100 mm and 5 mm. The smear zone is assume to be 2 times the equivalent diameter of PVD.

(i) Determine the average consolidation ratio, U_{vr} after 12 months of preloading by considering both the smear effect and well resistance effect.
(10 marks)

(ii) Predict the outcome on consolidation behaviour of embankment when the smear and well resistance effect were ignored.
(4 marks)

Q2 (a) Discuss the advantages and disadvantages of open stand pipe and piezometer instruments in determination of the ground water table in the field.
(5 marks)

(b) The soil test can be performed either in the field or in the laboratory. Discuss the advantages and disadvantages of in situ and laboratory testing.
(8 marks)

(c) A soft clay layer is found to have liquid limit and plastic limits of 110% and 35%, respectively. A series of vane shear tests with a flat vane in a dimension of 60 mm in diameter and 120 mm long are performed at different depths. The measured torques at depths are tabulated in **Table 2**.

(i) Calculate the soil uncorrected and corrected undrained shear strength at each depth.
(6 marks)

(ii) Develop a profile of corrected undrained shear strength versus depth.
(3 marks)

(iii) If the undrained shear strength of the remolded soil at depth of 9 m is 10N.m, predict the soil sensitivity of the soil.

(3 marks)

Q3 (a) A cylindrical sample of soil 50 mm in diameter and 100 mm long is subjected to an axial effective stress of 400 kN/m^2 and radial effective stress of 100 kN/m^2. The axial and radial displacements are 0.5 mm and – 0.04 mm respectively. Assuming the soil is anisotropic and elastic material, determine the following:

(i) The mean stress (p') and deviatoric stress (q)

(3 marks)

(ii) The volumetric strain (ε_v) and shear strain (ε_s)

(3 marks)

(iii) The shear modulus (K') and bulk modulus (G)

(3 marks)

(iv) The Poisson's ratio and Young's modulus (E)

(3 marks)

(b) A 5.5 m deep compacted fill is to be placed over the soil profile shown in **Figure Q3(b)**. A consolidation test on a sample from points A and B produce the results as depicted in **Table 3**. These points represent the entire soft clay stratum of each layer. Estimate the ultimate consolidation settlement due to the weight of this fill.

(13 marks)

Q4 (a) The selection of the foundation is depending on many factors. Describe in detail the procedure in selecting the best foundation in soft soil.

(6 marks)

(b) There are many factors causing the embankment failure of soft soil during construction. In your own words, discuss in detail the factors that contribute to this failure.

(6 marks)

(c) The raft foundation with dimensions of 20 m x 15 m will be constructed over a soft soil deposit. The depth of the foundation (D_f) is 1 m mesured from ground surface as shown in **Figure Q4(c)**. The Groundwater table (GWT) is located 1 m below the ground surface. The total load and live load on the raft foundation is 50 MN.

(i) Predict the factor of safety against bearing capacity failure and evaluate your answer.

(5 marks)

(ii) Estimate the consolidation settlement at the center of the foundation.

(8 marks)

– END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : SOFT SOIL ENGINEERING
PROGRAMME CODE : 4 BFF
COURSE CODE : BFG 40603

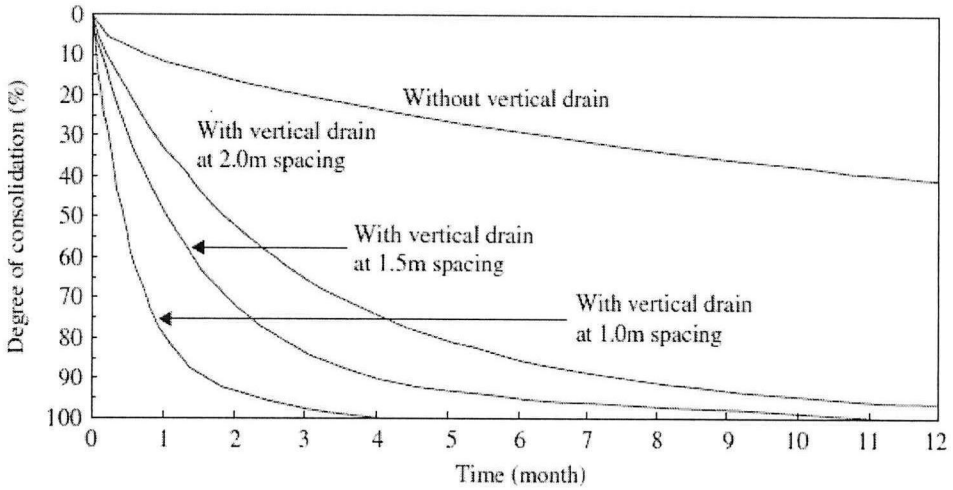

FIGURE Q1(b): Degree of consolidation against time

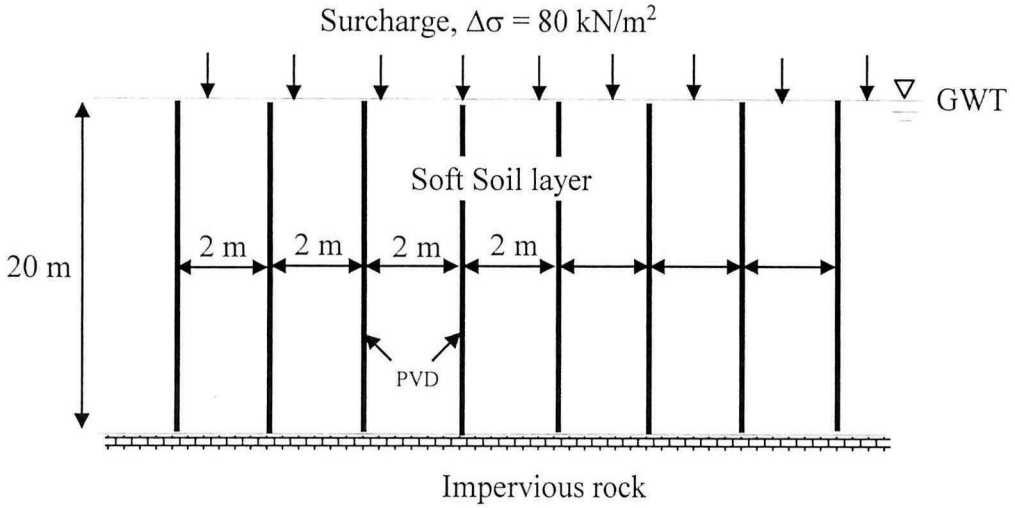

FIGURE Q1(c): Soil profile of soft soil improved PVD

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020 PROGRAMME CODE : 4 BFF
COURSE NAME : SOFT SOIL ENGINEERING COURSE CODE : BFG 40603

TABLE 1: Data for PVD project

Item	*Parameters*	*Value*
Surcharge	$\Delta\sigma$	80 kN/m^2
Soft soil layer	Saturated unit weight, γ_{sat}	17 kN/m^3
	Compression index, C_c	0.7
	Coefficient of vertical consolidation, C_v	0.6 m^2/year
	Coefficient of horizontal consolidation, C_r	1.2 m^2/year
	Initial void ratio, e_o	1.4
	Vertical Permeability in undisturbed zone, k_v	5 x 10^{-9} m^2/s
	Horizontal Permeability in undisturbed zone, k_h	1 x 10^{-8} m^2/s
	Horizontal Permeability in smear zone, k_s	3.3x 10^{-9} m^2/s
PVD properties	Discharge capacity, Q_c	2.5 x 10^{-4} m^3/s

TABLE 2: Vane shear test results

Depth (m)	4	5	6	7	9
Torque (N.m)	8.3	9.4	10.5	12.3	15.2

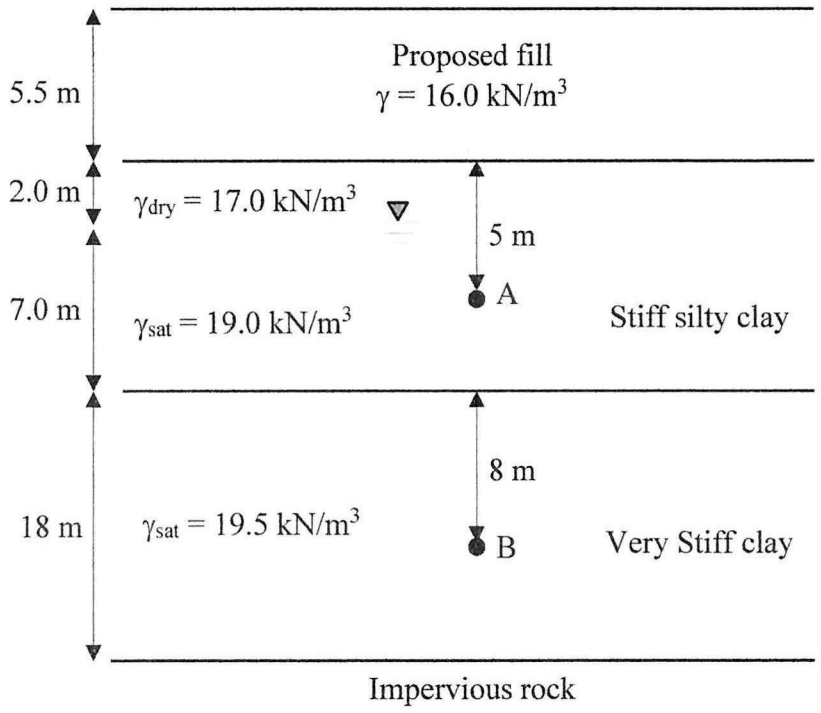

FIGURE Q3(b): Soil profile

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : SOFT SOIL ENGINEERING
PROGRAMME CODE : 4 BFF
COURSE CODE : BFG 40603

TABLE 3: Consolidation test results

Parameters	Point A	Point B
C_c	0.25	0.20
C_r	0.08	0.06
e_o	0.85	0.65
σ'_c	101 kN/m^2	510 kN/m^2

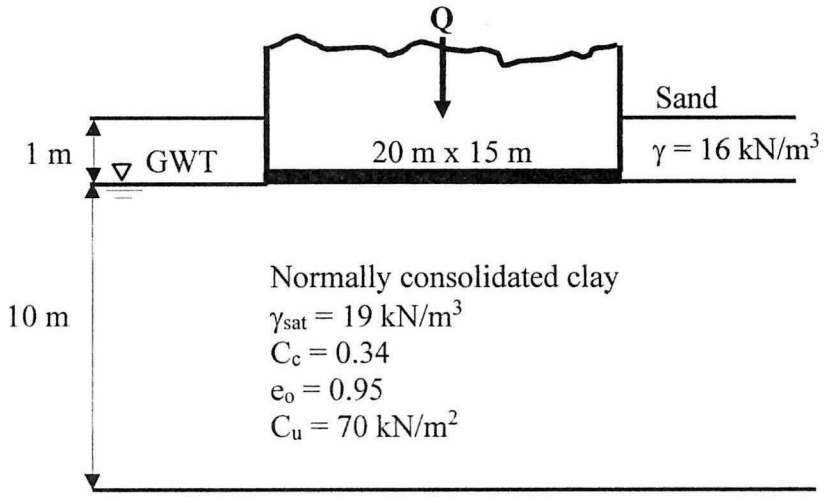

FIGURE Q4(c): Raft foundation in soft soil

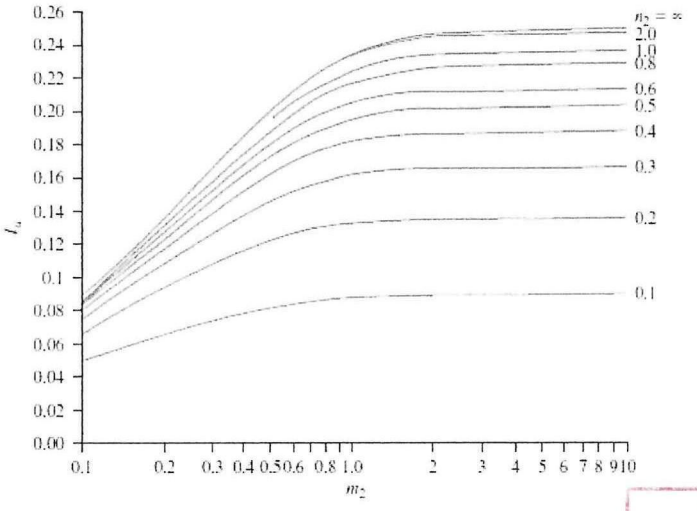

Figure Q4(c)(ii): Griffith's influence factor, I_a

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : SOFT SOIL ENGINEERING
PROGRAMME CODE : 4 BFF
COURSE CODE : BFG 40603

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

Consolidation

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

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

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

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

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

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

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

Vane shear test

$$c_u = \frac{2T_f}{\pi d_v^{\,2}\left(L_v+0.33d_v\right)}$$

$$c_{uc} = \lambda_v c_u$$

$$c_u = \frac{0.3183T_f}{1.354d_v^{\,3}+0.354\left(d_l d_v^{\,2}-d_v d_l^{\,2}\right)+0.2707d_l^{\,3}}$$

$$\lambda_v = 1.18-0.0107PI+0.0000513PI^2 \le 1$$

PVD design

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

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

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

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

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

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

$$d_e = 1.13S, \text{ for square pattern}$$

$$d_e = 1.05S, \text{ for triangular pattern}$$

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

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

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

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

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : SOFT SOIL ENGINEERING
PROGRAMME CODE : 4 BFF
COURSE CODE : BFG 40603

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

Stress strain behaviour

$$q' = \sigma'_1 - \sigma'_3$$

$$p' = \frac{1}{3}(\sigma'_1 - \sigma'_3)$$

$$\varepsilon_s = \frac{2}{3}(\varepsilon_1 - \varepsilon_3)$$

$$\varepsilon_v = \varepsilon_1 + 2\varepsilon_3$$

$$K' = \frac{\delta p'}{\delta \varepsilon_v}$$

$$3G' = \frac{\delta q'}{\delta \varepsilon_s}$$

$$E' = \frac{\delta' \sigma'_1}{\delta \varepsilon_1}$$

$$\upsilon' = -\frac{\delta' \varepsilon_3}{\delta \varepsilon_1}$$

$$\upsilon' = \frac{3K' - 2G}{2G + 6K'}$$

$$G' = \frac{E'}{2(1+\upsilon')}$$

$$K' = \frac{E'}{3(1-2\upsilon')}$$

Foundation design

$$q_u = 5.14 c_u \left(1 + \frac{0.195B}{L}\right)\left(1 + 0.4\frac{D_f}{B}\right)$$

$$FS = \frac{q_u}{q_{all}}$$

$$q_{all} = \frac{Q}{A} - \gamma D_f$$

$$S_c = \frac{C_c H}{1 + e_o} \log\left(\frac{\sigma'_o + \sigma'_{av}}{\sigma'_o}\right)$$

$$\Delta\sigma'_{av} = q_o\left[\frac{H_2 I_{a(H_2)} - H_1 I_{a(H_1)}}{H_2 - H_1}\right]$$

$$m_2 = \frac{B}{H}$$

$$n_2 = \frac{L}{H}$$