B.Sc. Engg. (CEE)/8th Sem. 20th May 2024 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Semester Final Examination — Summer Semester: 2022 - 2023
Course No. : CEE 4847 — Full Marks: 150
Course Title : Sub-surface Soil Investigation and In-Situ Testing — Time: 3.0 Hours

Answer all the questions. Programmable calculators are not allowed. The symbols have their usual meanings. Marks of each question and the corresponding CO and PO are written in brackets. Assume reasonable values for any data not given.

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1 (a) What are the methods of subsurface soil investigation? Discuss the necessity of investigation to find the causes of defects or failure of existing structures. (3+5) (CO1, PO1)

(b) Compare between the following pair of terms: (4+4) (CO1, PO1)
(i) Representative and non-representative samples.
(ii) Disturbed and undisturbed samples

(c) A static cone penetration test (CPT) has been conducted at a site and recorded data at various depths. Determine the soil types using CPT data for all levels. Use Robertson and Wride (1997) chart for this purpose. Consider the groundwater table at the ground surface and the saturated unit weight of soil throughout the depth as 19 kN/m^3. (9) (CO2, PO2)

Depth (m)	Tip resistance (MPa)	Sleeve friction (kPa)
1.5	0.085	1.7
3	0.280	11.1

Depth (m)	Tip resistance (MPa)	Sleeve friction (kPa)
4.5	0.92	2.6
6	33.20	100.0

2 (a) What are the key contents of a bore log? Discuss briefly. (07) (CO1, PO1)

(b) Discuss the step-by-step procedure of the cone penetration test. Write the advantages and limitations of this test. (5+5) (CO1, PO1)

(c) What are the reasons for geotechnical instrumentation in the field? Discuss them briefly. (08) (CO1, PO1)

3 (a) Prove that the permeability of soil can be determined using the following equation: (4+3) (CO1, PO1)

$$k = \frac{2.3q}{\pi D_0(2H - D_0)}\log_{10}\frac{R_i}{r_0}$$

Also, write the notations of the symbols.

(b) How many types of pressuremeter probes are used in PMT? Compare all the types of pressuremeter probes in a tabular form. (4+4) (CO1, PO1)

3 (c) A pressuremeter test was conducted at a site. Following are the test records at a depth of 8m based on the BX probe having the volume of the uninflated probe of 535 cm^3. Determine the pressuremeter modulus and limiting pressure at the depth of investigation. Assume $\gamma = 0.33$. (10) (CO2, PO2)

Pressure (kPa)	Volume Change (cm^3)
50	105
100	172
150	212
200	242

Pressure (kPa)	Volume Change (cm^3)
250	262
350	280
450	296
550	315

Pressure (kPa)	Volume Change (cm^3)
650	453
750	770
800	1030

4 (a) What are the main contents of engineering geological maps? Discuss them briefly. (10) (CO1, PO1)

(b) Consider that you have recorded the following data from a dilatometer test: (15) (CO2, PO2)

- Lift-off pressure without soil = 0.18 kg/cm^2,
- Pressure at 1.1mm membrane expansion without soil = 0.30 kg/cm^2,
- Pressure reading when vented to atmosphere = 1.0 kg/cm^2,
- The ground water table is at the ground surface and the saturated unit weight of soil is 1.95 gm/cm^3. Assume Poison's ratio = 0.3.

At 1.5m depth:

- Lift-off pressure = 4.8 kg/cm^2,
- Pressure at 1.1mm membrane expansion = 33.0 kg/cm^2.

At 3m depth:

- Lift-off pressure = 1.93 kg/cm^2,
- Pressure at 1.1mm membrane expansion = 3.0 kg/cm^2, and
- Hydrostatic pressure = 0.83 kg/cm^2.

Determine-

(i) The initial and limit pressure at 1.5m and 3m depth,
(ii) The dilatometer modulus at 1.5m and 3m depth, and
(iii) The Young's modulus (at 3 m)

5 (a) (i) Explain the guidelines for the interpretation of topographic maps. (08) (CO1, PO1)

Or

(ii) List the components of a CPT probe and illustrate them with clear drawings. Explain the functions of these components. (4+4) (CO1, PO1)

(b) (i) Prepare a list of step-by-step tasks for systematic planning and monitoring programs using geotechnical instrumentation. (9) (CO1, PO1)

Or

(ii) Consider that you have to determine the undrained shear strength of a saturated cohesive soil at shallow depth. What type of test do you think is better to conduct in the field for this purpose? Explain the reasons in favor of your answer. Also, write the limitations of this test. (5+4) (CO1, PO1)

5 (c) (i) A borehole permeability test has been conducted at a site. The permeability of the soil was obtained as 2.3 mm/minute from the falling water level method. If the piezometric head at 20 minutes is 5m, determine the piezometric heads at 1 hour and 10 hours. The diameter of the test well is 20 cm. (08) (CO2, PO2)

Or

(ii) A well is driven into a confined aquifer. The following data are available: (08) (CO2, PO2)

- The original piezometric level from the bed of the aquifer = 20 m,
- The depth of water in the well at a steady state is 8 m.
- Hydraulic conductivity of soil = 1.5 m/hour.
- Diameter of the well = 20 cm, the diameter of influence = 500 m.

Calculate the yield per hour if -

- The aquifer thickness is equal to 10 m
- The aquifer thickness is equal to 5 m

6 (a) (i) What is a snaked casing? How can it be solved? Discuss briefly. (3+4) (CO1, PO1)

Or

(ii) Why is it essential to make different modifications to the SPT value obtained in the field? Give a brief explanation. (07) (CO1, PO1)

(b) (i) Given the following SPT data. Determine the size of square footing at a depth of 3m below the EGL for a settlement of 25 mm if the net applied load on the footing is 600 kN. Consider that the ground water table is at great depth. Use the Bowles (1977) correlations (modified after Meyerhof (1956)). The unit weight of soil throughout the depth as 18.5 kN/m^3. (18) (CO2, PO2)

Depth (m)	SPT (N_{55})	Soil Type
1.5	5	Sand
3.0	7	Sand
4.5	9	Sand
6.0	8	Sand

Depth (m)	SPT (N_{55})	Soil Type
7.5	12	Sand
9.0	20	Sand
10.5	22	Sand
12.0	27	Sand

Or

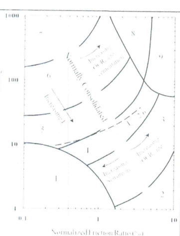
(ii) Given the following SPT data. Determine the diameter of a bored pile for a factor of safety of 3.50 if the net applied load on the pile is 750 kN. Consider the length of the pile equal 24m. Follow the BNBC (2020) recommended method. Ignore the self-weight of the pile. The saturated unit weight of soil throughout the depth is 19.5 kN/m^3. (18) (CO2, PO2)

Depth (m)	SPT (N_{60})	Soil Type
1.5	3	Soft Clay
3.0	4	Soft Clay
4.5	3	Soft Clay
6.0	3	Soft Clay
7.5	7	Loose Fine Sand
9.0	8	Loose Fine Sand
10.5	10	Loose Fine Sand
12.0	15	Medium dense Sand
13.5	20	Medium dense Sand

Depth (m)	SPT (N_{60})	Soil Type
15.0	30	Dense Sand
16.5	35	Dense Sand
18.0	41	Dense Sand
19.5	37	Dense Sand
21.0	42	Dense Sand
22.5	39	Dense Sand
24.0	43	Dense Sand
25.5	46	Dense Sand
27.0	49	Dense Sand

- Robertson and Wride (1997)

1 Sensitive, fine grained
2 Organic soils – peats
3 Clays – silty clay to clay
4 Silt mixtures – clayey silt to silty clay
5 Sand mixtures – silty sand to sandy silt
6 Sands – clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand*
9 Very stiff fine grained*
* Heavily overconsolidated cemented



- $p_0 = 1.05(A - Z_m + \Delta A) - 0.05(B - Z_m - \Delta B)$
- $p_l = B - Z_m - \Delta B$
- $I_D = (p_l - p_0)/(p_0 - u_0)$
- $K_D = (p_0 - u_0)/\sigma'_{v0}$
- $E_D = 34.7(p_l - p_0)$
- $K_0 = (\frac{K_D}{1.5})^{0.47} - 0.6$ for $I_D < 1.2$
- $E = \frac{(1+v)(1-2v)}{1-v} M$
- $M = R_m E_D$
- $R_m = 0.14 + 2.36 log K_D$ for $I_D \leq 0.6$
- $R_m = R_{m,0} + (0.25 - R_{m,0}) log K_D$ for $0.6 < I_D \leq 3$ with $R_{m,0} = 0.14 + 0.15(I_D - 0.6)$
- $R_m = 0.5 + 2 log K_D$ for $I_D \geq 3$
- $R_m = 0.32 + 2.1 log K_D$ for $K_D > 10$
- $R_m < 0.85, R_m = 0.85$
- v = 0.25-0.30

Bearing capacity of driven pile:

For cohesive soil:

$f_s = 1.8\bar{N}_{60}$ (in kPa) ≤ 70 kPa

$f_b = 45N_{60}$ (in kPa) ≤ 4000 kPa

For sand:

$f_s = 2\bar{N}_{60}$ (in kPa) ≤ 60 kPa

$f_b = 40N_{60}\left(\frac{L}{D}\right)$ (in kPa) $\leq 400N_{60}$ and ≤ 11000 kPa

For non-plastic silt:

$f_s = 1.7\bar{N}_{60}$ (in kPa) ≤ 60 kPa

$f_b = 30N_{60}\left(\frac{L}{D}\right)$ (in kPa) $< 300N_{60}$ and < 11000 kPa

Bearing capacity of bored pile:

For cohesive soil:

$f_s = 1.2\bar{N}_{60}$ (in kPa) ≤ 70 kPa

$f_b = 25N_{60}$ (in kPa) ≤ 4000 kPa

For sand:

$f_s = 1.0\bar{N}_{60}$ (in kPa) ≤ 60 kPa

$f_b = 15N_{60}\left(\frac{L}{D}\right)$ (in kPa) $\leq 150N_{60}$ and ≤ 4000 kPa

For non-plastic silt:

$f_s = 0.9\bar{N}_{60}$ (in kPa) < 60 kPa

$f_b = 10N_{60}\left(\frac{L}{D}\right)$ (in kPa) $\leq 100N_{60}$ and ≤ 4000 kPa

$$q_a = \frac{N}{F_1}K_d \qquad B \leq F_4$$

$$q_a = \frac{N}{F_2}\left(\frac{B + F_3}{B}\right)^2 K_d \qquad B > F_4$$

$$K_d = 1 + 0.33\frac{D}{B} \leq 1.33$$

	N_{55}		N_{70}	
	SI	**Fps**	**SI**	**Fps**
F_1	0.05	2.5	0.04	2.0
F_2	0.08	4	0.06	3.2
F_3	0.3	1		
F_4	1.2	4	Same	Same