**B. Sc. Engg. (CEE)/ 5th Sem.** **09 Dec, 2023 (Group-B)**

# ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING**

**Semester Final Examination** — **Winter Semester: 2022-2023**
**Course No.: CEE 4543** — **Full Marks: 150**
**Course Title: Foundation Engineering** — **Time: 3 Hours**

**There are 7 (Seven) questions. Answer 6 (Six) questions, Questions 1 and 7 are compulsory. Answer 4 questions from question 2, 3, 4, 5, and 6. Programmable calculators are not allowed. Do not write on this question paper. The figures in the right margin indicate full marks. The Symbols have their usual meaning.**

1(a). Briefly discuss the followings: (16) (CO1) (PO1)

- (i) Limitations of Upper Bound and Lower Bound theories in computing bearing capacity of foundation
- (ii) Cone Penetration Test (CPT)
- (iii) Pile Load Test
- (iv) Under Water Concrete

1(b). Briefly describe five modes of slope failures with net sketch (9) (CO1) (PO1)

2. The plan for a mat foundation with column loads is shown in Fig.1, the drawing is not in scale. Calculate the soil pressures at points A, B, C, D, E, and F, where A, C, D and F are corners points. All column dimensions are 40cm X 40cm in section. Net allowable bearing capacity is 50.0 kPa. Check the design of the mat foundation comparing the soil pressures obtained at points A to F with the net allowable bearing capacity. (25) (CO2) (PO3)

$$q = \frac{Q}{A} \pm \frac{M_y x}{I_y} \pm \frac{M_x y}{I_x}$$

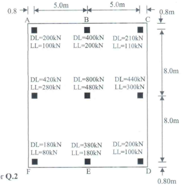



Fig.1 for **Q.2**

3. A footing, 2.0m X 3.0m, carries a load of 200 kPa, and is located at a depth of 2.0m in a cohesionless soil as shown in Fig.2. The water table is located at the surface of the ground. The distributions of SPT N value and unit weight of soils are also shown in the figure. (25) (CO2) (PO3)

Determine the settlement at the center of the foundation taking the effect of the load up to 3.0B below the foundation. Use, De Beer and Martens's method. Use, Griffith influence factor $I_a$ in calculating stress increment. Here, $\gamma_w$ =9.8kN/m$^3$.

$$\rho_t = \frac{H}{C_s} \ln \frac{p_{02} + \Delta\sigma_z}{p_{02}}, \quad C_s = 1.5 \frac{q_c}{p_{o1}}, \quad \Delta\sigma_z = 4qI_a$$

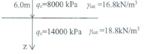



Fig.2 for **Q.3**

4(a). Compute the foundation depth for a fully compensated mat foundation (25m X 30m) in saturated clay ground having $\gamma_{sat}$ =19.8kN/m$^3$ to carry dead load of 20.0MN, and live load of 10.0MN. Use, $\gamma_w$ =9.8kN/m$^3$. (5) (CO2) (PO3)

4(b). Calculate lateral load capacity of a pile considering both Elastic solution and Broom's method of 17.0 m length which is fully embedment in granular soil. The diameter of the circular pile is 0.60 m. The yield stress of the pile material $F_y$= 30 MPa, $n_h$= 12,000 kN/m$^3$, the unit weigh of soil $\gamma$ = 16 kN/m$^3$, and the soil friction angle is 30$^0$. Allowable lateral displacement at the pile head is 12.0 mm. Use, $E_p$= 30 GPa. Consider free head-pile ($M_g$ =0 at the pile head). The water table is far below the pile tip. (20) (CO2) (PO3)

$$T = \sqrt[5]{\frac{E_p I_p}{n_h}}, \quad x_z(z) = A_x \frac{Q_g T^3}{E_p I_p} + B_x \frac{M_g T^2}{E_p I_p}, \quad M_z(z) = A_m Q_g T + B_m M_g, \quad Z = z/T, \quad \eta = \sqrt[5]{\frac{n_h}{E_p I_p}}$$

5(a). The allowable working load on a prestressed concrete pile 25-m long that has been driven into sand is 900 kN. The pile is circular in shape with a diameter of 0.60 m. Skin resistance carries 600 kN of the load, and point bearing carries the rest. Use, $E_p$= 30 GPa, $E_s$= 25 MPa, Poisson's ratio of soil 0.30, $\xi$ = 0.65, $I_{wp}$=0.85, $I_{ws} = 2 + 0.35\sqrt{\frac{L}{D}}$. Determine the settlement of the pile. (10) (CO2) (PO3)

$$s_{e(1)} = \frac{(Q_{wp} + \xi Q_{ws})L}{A_p E_p}, \quad s_{e(2)} = \frac{Q_{wp} D}{A_p E_s}(1-\nu^2) I_{wp}, \quad s_{e(3)} = \frac{Q_{ws} D}{A_s E_s}(1-\nu^2) I_{ws}$$

5(b). Determine the consolidation settlement of a pile group where the total working load is 3000 kN. Pile group information – pile length is 24 m, pile diameter is 500 mm, and spacing of the piles is 1.5 m, number of piles is 9 (3 rows of piles with 3 piles in each row), the top of the piles is at the ground surface. The soil profiles are shown in Fig.3. All clays are normally consolidated. Use, $\gamma_w$ =9.8 kN/m$^3$. (15) (CO2) (PO3)

$$S_{c(i)} = H_{(i)} \cdot \left[ \frac{C_{c(i)}}{1 + e_{0(i)}} \log \frac{\sigma'_{0(i)} + \Delta\sigma_{(i)}}{\sigma'_{0(i)}} \right], \quad \Delta\sigma'_i = \frac{Q_g}{(B_g + z_i)(L_g + z_i)}$$

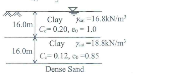



Fig.3 for **Q.5**

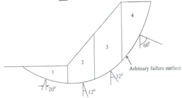
6(a). Compute foundation depth for a partially compensated mat foundation (30m X 38m) in fully in soils ($\phi = 20$, $c = 20.0$ kN/m$^2$, $\gamma_{sat} = 18.8$ kN/m$^3$). Consider factor of safety, FS=2.0; dead load, DL=400 MN; live load, LL=200 MN. Use, $\gamma_w = 9.8$ kN/m$^3$. The water table is at the ground surface. Use, Meyerhof equations for bearing capacity factors, shape factors and depth factors. (12) (CO2) (PO3)

6(b). Calculate the ultimate axial capacity of the pile, both end bearing and skin friction when water table is at 10 m below the ground level for the following conditions. (13) (CO2) (PO3)

Size of the pile = 350 mm × 350 mm
Length of the pile = 18 m
Top of the pile at ground level
**Soil Layers:**
0 – 6 m Sand, unit weight 17 kN/m$^3$, Soil friction angle 30 degree, $\delta = 20$ degree, K= 1.0
0 – 30 m Sand, unit weight 20 kN/m$^3$, Soil friction angle 35 degree, $\delta = 25$ degree, K= 1.5, $N_q$=140
Critical Depth $(L/D)_{cr} = 15D$, unit weight of water is 9.80 kN/m$^3$.

7. As an engineer, you are assigned to check the stability of an embankment, as shown in Fig.4. Soil parameters are cohesion = 0 kPa, angle of internal friction = 35°, and pore pressure ratio =0.50. For the arbitrary failure surface shown in the figure, determine the factor of safety using the Bishop Method. Also, write down your assessment of the stability of the embankment. (25) (CO3) (PO2)

$$F_s = \frac{\sum\left[\{c_i' b_i + W_i(1-r_u)\tan\phi_i'\}/m_a\right]}{\sum W_i \sin\alpha_i}\ ;\ m_a = \left(1+\frac{\tan\alpha_i \tan\phi_i'}{F_s}\right)\cos\alpha_i$$




| Slice no | Breadth b (m) | Weight W (kN) | α (degree) |
|---|---|---|---|
| 1 | 3.50 | 55 | -20 |
| 2 | 3.00 | 105 | 12 |
| 3 | 3.00 | 135 | 32 |
| 4 | 2.75 | 98 | 60 |

Fig.4 for **Q.7**

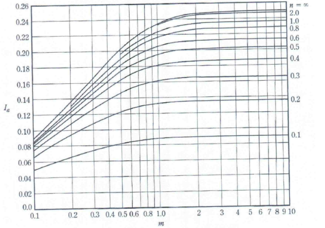



Figure for **Q.3**: Griffith influence factor $I_a$

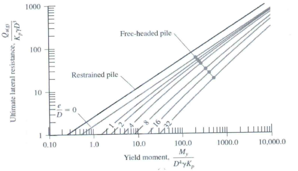



Figure for **Q.4(b)**: Broms's solution for ultimate lateral resistance of long piles in sand

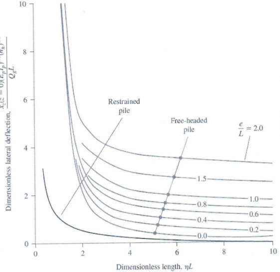



Figure for **Q.4(b)**: Broms's solution for estimating deflection of pile head in sand

**Table for Q.4(b)**: Coefficients for long piles

| $Z$ | $A_x$ | $A_\theta$ | $A_m$ | $A_v$ | $A'_p$ | $B_x$ | $B_\theta$ | $B_m$ | $B_v$ | $B'_p$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 2.435 | −1.623 | 0.000 | 1.000 | 0.000 | 1.623 | −1.750 | 1.000 | 0.000 | 0.000 |
| 0.1 | 2.273 | −1.618 | 0.100 | 0.989 | −0.227 | 1.453 | −1.650 | 1.000 | −0.007 | −0.145 |
| 0.2 | 2.112 | −1.603 | 0.198 | 0.956 | −0.422 | 1.293 | −1.550 | 0.999 | −0.028 | −0.259 |
| 0.3 | 1.952 | −1.578 | 0.291 | 0.906 | −0.586 | 1.143 | −1.450 | 0.994 | −0.058 | −0.343 |
| 0.4 | 1.796 | −1.545 | 0.379 | 0.840 | −0.718 | 1.003 | −1.351 | 0.987 | −0.095 | −0.401 |
| 0.5 | 1.644 | −1.503 | 0.459 | 0.764 | −0.822 | 0.873 | −1.253 | 0.976 | −0.137 | −0.436 |
| 0.6 | 1.496 | −1.454 | 0.532 | 0.677 | −0.897 | 0.752 | −1.156 | 0.960 | −0.181 | −0.451 |
| 0.7 | 1.353 | −1.397 | 0.595 | 0.585 | −0.947 | 0.642 | −1.061 | 0.939 | −0.226 | −0.449 |
| 0.8 | 1.216 | −1.335 | 0.649 | 0.489 | −0.973 | 0.540 | −0.968 | 0.914 | −0.270 | −0.432 |
| 0.9 | 1.086 | −1.268 | 0.693 | 0.392 | −0.977 | 0.448 | −0.878 | 0.885 | −0.312 | −0.403 |
| 1.0 | 0.962 | −1.197 | 0.727 | 0.295 | −0.962 | 0.364 | −0.792 | 0.852 | −0.350 | −0.364 |
| 1.2 | 0.738 | −1.047 | 0.767 | 0.109 | −0.885 | 0.223 | −0.629 | 0.775 | −0.414 | −0.268 |
| 1.4 | 0.544 | −0.893 | 0.772 | −0.056 | −0.761 | 0.112 | −0.482 | 0.688 | −0.456 | −0.157 |
| 1.6 | 0.381 | −0.741 | 0.746 | −0.193 | −0.609 | 0.029 | −0.354 | 0.594 | −0.477 | −0.047 |
| 1.8 | 0.247 | −0.596 | 0.696 | −0.298 | −0.445 | −0.030 | −0.245 | 0.498 | −0.476 | 0.054 |
| 2.0 | 0.142 | −0.464 | 0.628 | −0.371 | −0.283 | −0.070 | −0.155 | 0.404 | −0.456 | 0.140 |
| 3.0 | −0.075 | −0.040 | 0.225 | −0.349 | 0.226 | −0.089 | 0.057 | 0.059 | −0.213 | 0.268 |
| 4.0 | −0.050 | 0.052 | 0.000 | −0.106 | 0.201 | −0.028 | 0.049 | −0.042 | 0.017 | 0.112 |
| 5.0 | −0.009 | 0.025 | −0.033 | 0.015 | 0.046 | 0.000 | −0.011 | −0.026 | 0.029 | −0.002 |