BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI

First Semester 2023-24
CE F313 (Foundation Engineering) Comprehensive Examination (Open Book)
Date: December 6, 2023

Duration: 180 mins (9:00 AM to 12:00 Noon) **Max. Marks: 90**

1) At a site, 20 m thick saturated clay layer was found overlying a rock layer. A 5 m thick sand fill was placed on top of the clay layer. Determine the magnitude of negative skin friction exerted on a 15 m long pile of diameter 0.7 m, having 10 m of the pile embedded in the clay layer. Assume water table to coincide with the surface of the sand fill. Laboratory tests were conducted on representative specimens collected from the clay layer and fill material and the salient test details are: **[15]**

NC Clay:
$k_x = k_y = 7 \times 10^{-9}$ m/s
Average deviatoric stress at failure during a UU test = 300 kPa
Effective confining pressure at the end of consolidation stage of CD test = 100 kPa and the effective major principal stress at failure = 246.38 kPa.
$\gamma_{sat} = 20$ kN/m^3

Sand fill:
$k_x = k_y = 1 \times 10^{-4}$ m/s
$c' = 0$ kPa; $\phi' = 32^o$
$\gamma_{sat} = 17$ kN/m^3

Assume $\delta' = 0.6$ x effective friction angle. The negative skin friction should be estimated without using the ready-to-use equation available for estimating Q_n.

2) A 4x3 group pile having pile diameter of 400 mm and center-to-center distance of 1.2 m passes through a 5 m thick clay layer overlying another 30 m thick clay layer. The length of the pile is 15 m. Determine the group efficiency if the representative undrained cohesion of the 5 m thick clay layer is 300 kPa and that of the underlying clay layer is 250 kPa. Use α-method as per Terzaghi for estimating pile skin friction and Meyerhof's method for estimating the pile tip resistance. **[10]**

3) Assuming shear failure of the soil to be the governing factor, determine the ultimate lateral resistance of a 5 m long pile, having 0.5 m diameter, which passes through a sand layer having effective friction angle of 35 deg. Assume unit weight of soil $\gamma = 18$ kN/m^3. Also assume that the pile will be having a pile cap. Use the method of Broms for estimating ultimate lateral resistance. **[5]**

4) A 6 m high gravity retaining wall, having cross section shaped like a trapezium with top width of 0.5 m and bottom width of 3 m, will be constructed. The surface of the wall, which will be

in contact with the retained soil, will be vertical. The backfill surface will be horizontal, and it is expected to carry a uniformly distributed vertical surcharge stress of 100 kPa. Assuming that the backfill and foundation soils will be dry, perform a stability check for overturning and sliding. The unit weight, effective cohesion, and effective friction angle of the backfill soil and foundation soil are 19 kN/m^3, 50 kPa, and 25^o and 18 kN/m^3, 0 kPa and 35^o, respectively. Unit weight of concrete is 24 kN/m^3. Ignore the contribution of passive force that might be mobilized due to the 1 m soil layer that will be in contact with the front face of the wall. **[15]**

5) The load carrying capacity of a prestressed concrete pile 15 m long driven into clay is 1500 kN and the working load is same as the allowable load with FOS considered = 3. The pile is 300 mm x 300 mm square in cross section and the pile tip carries 150 kN of the working load. Use $E_p = 20 \times 10^6$ kN/m^2, $E_s = 25 \times 10^3$ kN/m^2, $\mu_s = 0.30$, and assume distribution of unit skin friction to be parabolic. Determine the elastic settlement of the pile using Vesic's method. **[10]**

6) A trapezoidal combined footing has to carry 800 kN and 400 kN forces coming from two columns that are 3 m apart. If the distance from the parallel edges of the footing to the nearest columns' face is 1 m each and the $q_{all(net)} = 120$ kPa, determine the dimension of the footing. **[10]**

7) A 4 m x 3 m rectangular footing has to carry net stress of 200 kPa. If the depth of foundation is 1 m and unit weight the soil is 18 kN/m^3, determine the immediate settlement of the soil if the underlying sandy soil has the following E_s values:

Depth below base of footing (m)	E_s (kPa)
0-2	3000
2-5	3500
5-9	4500
9-15	5000
15-20	7800

The water table was not encountered till depth of 20 m below base of footing. Consider the effect of creep for 25 years. **[15]**

8) Determine the height of a slope (1 vertical to 1 horizontal) in saturated clay having an undrained shear strength of 25 kN/m^2. The desired factor of safety against sliding is 2.5 Given: $\gamma = 18$ kN/m^3 and ratio of vertical distance from top of slope to firm base to height of the slope is 1.20. **[5]**

9) State the major differences between ordinary method of slices and Bishop's simplified method of slices of slope stability analysis. **[2]**

10) For the stability analysis of infinite slope with seepage, derive the expression for pore water pressure at a point 'h' measured vertically below the slope surface. Assume that the surface of seeping water and the slope surface are coinciding. **[3]**