

Ref. No. : Ex/PG/CIV/PC/T/115B/2025  
M.E. CIVIL ENGINEERING FIRST YEAR FIRST SEMESTER - 2025  
SUBJECT: ADVANCED FOUNDATION DESIGN  
Time: 3 HOURS Full Marks : 100  
Assume reasonable values of data not supplied

**USE ALL RELEVANT IS CODES RELATED TO DESIGN OF FOUNDATIONS**

1. Design a shallow foundation (isolated) for a column load of magnitude 600 kN resting at a depth of 1.5m below existing ground level. Soil stratification at the site is given below.

**Stratum I:** Soft / firm brownish grey silty clay / clayey silt of thickness 3.0m with undrained cohesion  $C_u = 30\text{kPa}$ ,  $\gamma_{\text{sat}} = 18.2\text{kN/m}^3$ ,  $C_c / (1+e_0) = 0.04$ ,  $p_c = 80\text{kN/m}^2$ ,  $C_c / (1+e_0) = 0.14$ .

**Stratum II:** Soft dark grey / grey silty clay / clayey silt with decomposed wood of thickness 15.0m with undrained cohesion  $C_u = 25\text{kPa}$ ,  $\gamma_{\text{sat}} = 16.5\text{kN/m}^3$ ,  $C_c / (1+e_0) = 0.15$ .

**Stratum III:** Stiff bluish grey / mottled brown silty clay / clayey silt with undrained cohesion  $C_u = 75\text{kPa}$ ,  $\gamma_{\text{sat}} = 19\text{kN/m}^3$ ,  $C_c / (1+e_0) = 0.08$  down to 20.0m below ground level.

**Stratum IV:** A deep deposit of sand (below 20.0m to deep depth) of angle of shearing resistance  $35^\circ$  and bulk density  $19.5\text{kN/m}^3$ .

GWT is at the ground level.

- a. Determine the bearing capacity considering layered soil and fix up the size of the foundation.
- b. Determine the settlement of the foundation and apply all corrections to obtain corrected settlement of the foundation.
- c. If the corrected settlement more than the permissible value, modify the design. 25

2. Design a raft foundation of size 15m x 25m carrying superstructure load of 5000 ton. Subsoil stratification at the site is same as that given in Question 1.

a. Determine the proposed depth of foundation considering buoyancy raft if conventional raft is found not suitable.

b. Determine the settlement of foundation and check whether it is within permissible value, if not modify the design. 20

3. A pile group is to be constructed to support design column load (vertical) of 2000kN.

Subsoil at the site consists of top soft clay of thickness 12m (undrained cohesion  $C_u = 20\text{kPa}$ ,  $\alpha = 1.0$ ,  $\phi' = 24^\circ$ ,  $\gamma_{\text{sat}} = 17\text{kN/m}^3$ ,  $C_c / (1+e_0) = 0.15$ ) followed by a layer of medium / stiff clay (undrained cohesion  $C_u = 70\text{kPa}$ ,  $\alpha = 0.64$ ,  $\phi' = 25^\circ$ ,  $\text{OCR} = 4$ ,  $\gamma_{\text{sat}} = 19\text{kN/m}^3$ ,  $C_c / (1+e_0) = 0.07$ ) down to 20.0m below ground level. This is underlain by a deep deposit of sand with angle of shearing resistance  $34^\circ$  and bulk density  $19.5\text{kN/m}^3$ . GWT is at the ground level.

Take length of pile = 22m and cut-off level at 2.0m below the ground level.

Determine the safe vertical capacity of single pile using  $\alpha$  Method with a factor of safety of 2.5. Design the pile group and also determine the settlement of the pile group under superimposed vertical load. 25

4. Determine the bearing capacity of shallow foundation of size 2.0m x 2.0m resting at a depth of 1.0m below ground level in a sandy deposit with  $\phi = 30^\circ$  under one-way eccentric loading with eccentricity,  $e = 0.15\text{m}$ . 10

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5. A well foundation of diameter 8m is required to be provided for supporting a bridge pier at a site with stratification given below :

From River bed to 8.0m : Loose / medium silty sand : Angle of shearing resistance  $32^{\circ}$  and bulk density  $18.5\text{kN/m}^3$ , N value = 20-25 blows/ 30cm

From 8.0m to 20.0m : Medium / dense silty sand : Angle of shearing resistance  $34^{\circ}$  and bulk density  $19.5\text{kN/m}^3$ , N value = 25-35 blows/ 30cm

From 20.0m to 50.0m : Dense / very dense silty sand : Angle of shearing resistance  $36^{\circ}$  and bulk density  $19.5\text{kN/m}^3$ , N value = 45 - 60 blows/ 30cm

Data given : maximum flood discharge = 11000 cumec; width of waterway = 390m;

HFL = 8m above river bed; silt factor = 1.06.

- a. Compute the maximum scour depth and determine the founding level of the well.
- b. Estimate the net allowable bearing capacity of the well
- c. What are the other resisting forces to be considered for stability analysis of the well foundation for a given superimposed vertical and horizontal load?

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5. A concrete block of size 8m x 4m x 2m is to be used as a foundation of a reciprocating machine operating at 500 rpm. The machine is mounted symmetrically with respect to the foundation. The weight of the machine is 10kN. The operation of the machine exerts an unbalanced vertical force of magnitude  $1.8 \sin \omega t$  kN.

The values of the dynamic elastic constants for the design of the foundation may be adopted as below:

Coefficient of elastic uniform compression,  $C_u = 4.5 \times 10^4 \text{ kN/m}^3$  ;  $G = 4.8 \times 10^4 \text{ kN/m}^2$ ;  
bulk density of soil =  $18 \text{ kN/m}^3$ ; bulk density of concrete =  $24 \text{ kN/m}^3$

Determine the natural frequency and amplitude of the block.

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