RPSC AEn-2024 Main Test Series | CIVIL ENGINEERING | Test 6

Test Mode : • Offline • Online

Subjects : Soil Mechanics & Foundation Engineering

DETAILED EXPLANATIONS

1. Solution:

Given: $w = 0.32, G = 2.67, S = 1$

$$e = wG = 0.32 \times 2.67 = 0.8544$$

$$\therefore \quad \frac{V_v}{V} = n = \frac{e}{1+e} = 0.461$$

2. Solution:

A clay is said to be normally consolidated when the present effective stress equals the maximum effective stress experienced in its stress history.

3. Solution:

Quicksand condition occurs when upward seepage pressure balances the submerged weight of soil particles, causing loss of effective stress.

4. Solution:

Coefficient of permeability, $k = 2.303 \frac{aL}{At} \log\left(\frac{h_1}{h_2}\right)$

$$\Rightarrow \quad k = \frac{2.303 \times 0.9 \times 8}{60 \times 210} \log_{10}\left(\frac{70}{25}\right)$$

$(t = 3 \text{ min. } 30 \text{ sec} = (3 \times 60) + 30 = 210 \text{ sec}$

$$\Rightarrow \quad k = 5.88 \times 10^{-4} \text{ cm/s}$$

5. Solution:

Compaction piles are piles driven into loose granular soils to densify the soil mass and increase its bearing capacity.

6. Solution:

For maximum depth of stable excavation, $FOS = 1$.

Maximum depth, $$H = \frac{c_u}{S_n \gamma (FOS)} = \frac{50}{(0.261)(18)(1)} = 10.6 \text{ m}$$

7. Solution:

Sensitivity of clay is the ratio of unconfined compressive strength of undisturbed soil to remoulded soil at same water content.

8. Solution:

For overconsolidated soils, $K_0 = K_{0(NC)} \sqrt{OCR}$

$\Rightarrow$ $K_0 = 0.55 \times \sqrt{4} = 1.1$

9. Solution:

Recovery ratio is the ratio of recovered sample length to sampler penetration length. It indicates sample disturbance during sampling.

10. Solution:

Soil above the water table remains partially saturated due to capillary action, which holds water in soil pores against gravity.

11. Solution:

For a given compactive effort, permeability decreases sharply with increase in water content on the dry side of optimum due to reduction in void size and improved particle orientation. Minimum permeability occurs at or near *OMC*. Beyond *OMC*, permeability shows a slight increase on the wet side due to the effect of a decrease in the dry unit weight, though it remains lower than on the dry side.

12. Solution:

Initial area of specimen, $A_o = \frac{\pi}{4} \times 34^2 = 907.92 \text{ mm}^2$

Axial strain, $\varepsilon = \frac{15}{60} = 0.25$

Corrected area of specimen at failure, $A_f = \frac{A_o}{1-\varepsilon} = \frac{907.92}{1-0.25}$

$$\Rightarrow \quad A_f = 1210.56 \text{ mm}^2$$

Unconfined compressive strength, $q_u = \frac{30\times10^3}{1210.56}$ kN/m² = 24.78 kN/m²

Undrained shear strength of clay, $c_u = \frac{q_u}{2} = \frac{24.78}{2}$ = 12.39 kN/m²

13. Solution:

Negative skin friction develops when a pile is installed in soft or compressible soil, or in recently placed fill, which settles after the pile has been driven. As the soil moves downward relative to the pile, it drags the pile along its surface, producing a downward shear force called negative skin friction. This drag force adds to the load acting on the pile instead of resisting it. As a result, the effective load-carrying capacity of the pile is reduced.

14. Solution:

Correction for over burden,

$$N_C = N\frac{35}{\bar{\sigma}+7}$$

where $\bar{\sigma}$ = Effective overburden pressure in t/m² (not to exceed 28 t/m²)

$$\therefore \quad N_C = 18\times\frac{35}{12+7} = 33.158$$

Correction for submergence,

$$N_C' = 15+\frac{1}{2}(N_C-15) = 15+\frac{1}{2}(33.158-15)$$

$$\Rightarrow \quad N_C' = 24.08 \simeq 24 \text{ (say)}$$

15. Solution:

$k_1 = k_3 = 2.2 \times 10^{-4}$ cm/s, $k_2 = 3 \times 10^{-2}$ cm/s, $z_1 = z_2 = z_3 = z$

$$k_H = k_x = \frac{k_1z_1+k_2z_2+k_3z_3}{z_1+z_2+z_3} = \frac{k_1z+k_2z+k_3z}{z+z+z}$$

$$\Rightarrow \quad k_x = \frac{1}{3}(k_1+k_2+k_3) = \frac{1}{3}\left(2.2\times10^{-4}+3\times10^{-2}+2.2\times10^{-4}\right)$$

$$\Rightarrow \quad k_x = 0.03044 \text{ cm/s}$$

$$\Rightarrow \qquad k_v = k_y = \frac{z_1 + z_2 + z_3}{\frac{z_1}{k_1} + \frac{z_2}{k_2} + \frac{z_3}{k_3}} = \frac{3}{\frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3}}$$

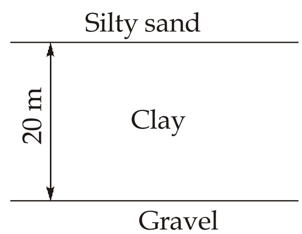
$$k_y = \frac{3}{\frac{1}{2.2\times10^{-4}} + \frac{1}{3\times10^{-2}} + \frac{1}{2.2\times10^{-4}}} = 3.288 \times 10^{-4} \text{ cm/s}$$

$$\therefore \qquad \frac{k_H}{k_v} = \frac{k_x}{k_y} = 92.58$$

16. Solution:

Liquefaction is the sudden loss of shear strength of loose, saturated sand when subjected to rapid loading under undrained conditions. The applied stress causes a sharp rise in pore water pressure, reducing effective stress nearly to zero. As a result, the soil behaves like a fluid. Liquefaction commonly occurs during earthquakes, vibrations, blasting, or pile driving.

17. Solution:



$$T_v = \frac{C_v t}{d^2}$$

$$\Rightarrow \qquad T_v = \frac{0.003\times2\times86400\times365}{\left(\frac{20}{2}\times100\right)^2}$$

$$T_v = 0.1892 < 0.2827 \left(= \frac{\pi}{4}\times0.6^2\right)$$

$$\therefore \qquad T_v = \frac{\pi}{4}U^2 = 0.1892 \qquad (\because U < 60\%)$$

$$\Rightarrow \qquad U = 0.4908$$

$$\therefore \quad \text{Total consolidation} = \frac{30}{0.4908} = 61.12 \text{ mm}$$

Degree of consolidation for 50 mm settlement,

$$U = \frac{50}{61.12} = 0.818 = 81.8\%$$

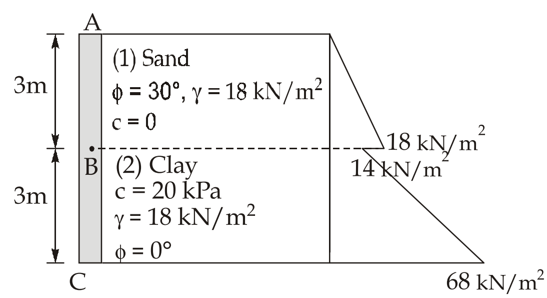
$$\therefore \quad T_v = 1.781 - 0.933 \log(100 - 81.8) = 0.60535$$

$$\therefore \quad T_v = 0.60535 = \frac{C_v t}{H^2}$$

$$\Rightarrow \quad t = \frac{0.60535 \times (10)^2}{0.003 \times 10^{-4}} \text{s} = 6.398 \text{ years}$$

$\therefore$ Additional number of years = 6.398 – 2 = 4.398 years

18. Solution:



$$\phi_{clay} = 0$$

$$K_{a_1} = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1}{3}$$

$$K_{a_2} = 1$$

$$p_B = K_{a_1}\gamma z = \frac{1}{3} \times 18 \times 3 = 18 \text{ kN/m}^2$$

$$p_{B'} = K_{a_2}\gamma z - 2c\sqrt{K_{a_2}}$$

$$= 1 \times 18 \times 3 - 2 \times 20\sqrt{1} = 14 \text{ kN/m}^2$$

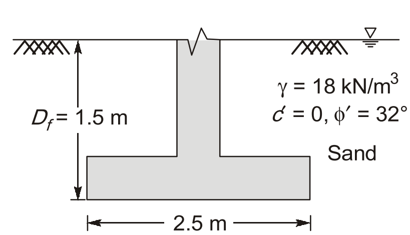
$$p_C = K_{a_2}\gamma z - 2c\sqrt{K_{a_2}}$$

$$= 18 \times 6 - 2 \times 20\sqrt{1} = 68 \text{ kN/m}^2$$

$\therefore$ Total active earth pressure per unit length of wall,

$$P_a = \frac{1}{2} \times 18 \times 3 + \frac{1}{2}(68 + 14) \times 3 = 150 \text{ kN/m}$$

19. Solution:



For square footing in a cohesionless soil

$$q_{ult} = \gamma D_f N_q R_{w1} + 0.4 B \gamma N_\gamma \cdot R_{w2}$$

For water table at ground surface,

$$R_{w1} = R_{w2} = 0.5$$

$$\therefore \quad q_{ult} = (18 \times 1.5 \times 20.3 \times 0.5) + (0.4 \times 2.5 \times 18 \times 19.7 \times 0.5)$$

$$= 451.35 \text{ kN/m}^2$$

$$q_{netult} = q_{ult} - \gamma d_f$$

$$= 451.35 - (18 - 10) \times 1.5 = 439.35 \text{ kN/m}^2$$

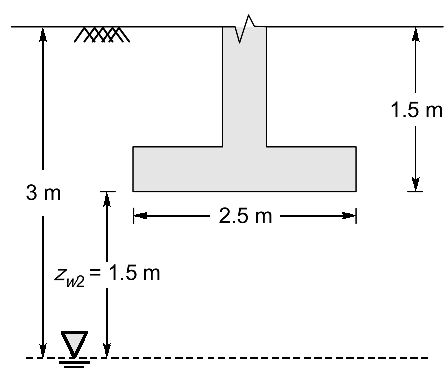
Considering factor of safety $= \text{FOS} = 3$

$$\therefore \quad q_{netsafe} = \frac{q_{netult}}{\text{FOS}} = \frac{439.35}{3} = 146.45 \text{ kN/m}^2$$

$$\therefore \quad q_{safe} = q_{netsafe} + \gamma' . D_f = 146.45 + (18 - 10) \times 1.5 = 158.45 \text{ kN/m}^2$$

Safe bearing capacity when water table goes down to 3 m below the ground surface

$$q_u = \gamma D_f N_q \cdot R_{w1} + 0.4 B \gamma \cdot N_\gamma R_{w2}$$



$$R_{w1} = 1$$

$$R_{w2} = \frac{1}{2}\left(1 + \frac{z_{w2}}{B}\right) = \frac{1}{2}\left(1 + \frac{1.5}{2.5}\right) = 0.8$$

$$\therefore \quad q_u = (18 \times 1.5 \times 20.3 \times 1) + (0.4 \times 2.5 \times 18 \times 19.7 \times 0.8)$$

$$= 831.78 \text{ kN/m}^2$$

$$\therefore \quad q_{netult} = 831.78 - (18) \times 1.5 = 804.78 \text{ kN/m}^2$$

$$\therefore \qquad q_{\text{netsafe}} = \frac{804.78}{3} = 268.26 \text{ kN/m}^2$$

$$\therefore \qquad q_{\text{safe}} = 268.26 + (18) \times 1.5 = 295.26 \text{ kN/m}^2$$

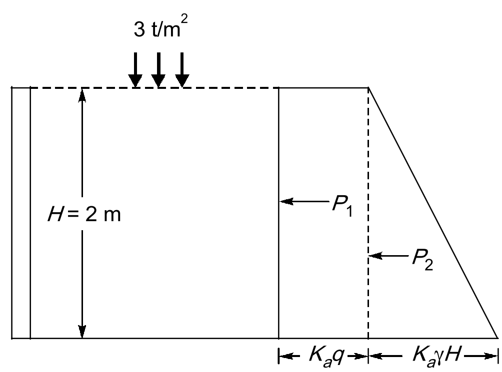
20. Solution:

Given data: $H = 2$ m; $\gamma = 1.8$ t/m^3; $\phi = 30°$; $c = 0$

Surcharge, $q = 3$ t/m^2

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 30°}{1+\sin 30°} \quad \frac{0.5}{1.5} = \frac{1}{3}$$

(i)



Active thrust: $P_1 = K_a q H = \frac{1}{3} \times 3 \times 2 = 2$ t/m at $\frac{H}{2}$ from base i.e. 1 m from base.

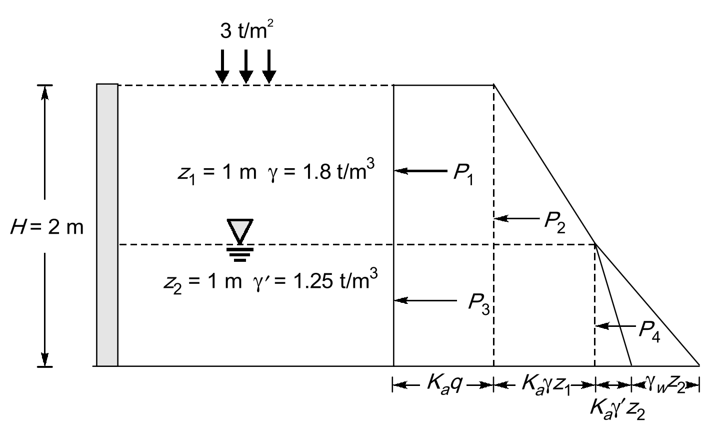
$$P_2 = \frac{1}{2} \times K_a \gamma H \times H = \frac{1}{2} \times \frac{1}{3} \times 1.8 \times 2^2$$

$$= 1.2 \text{ t/m at } \frac{H}{3} \text{ from base i.e. } \frac{2}{3} \text{ m from base.}$$

$$\therefore \text{ Location of resultant thrust from base} = \frac{2 \times \frac{2}{2} + 1.2 \times \frac{2}{3}}{2 + 1.2} = 0.875 \text{ m}$$

Total active earth pressure per unit length of wall = 2 + 1.2 = 3.2 t/m

(ii)



Active Pressure, $P_1 = K_a q z_1 = \frac{1}{3} \times 3 \times 1 = 1$ t/m at $\left(1 + \frac{1}{2}\right) m$ from base

$$P_2 = \frac{1}{2} K_a \gamma z_1^2 = \frac{1}{2} \times \frac{1}{3} \times 1.8 \times 1^2 = 0.3 \text{ t/m at } \left(1 + \frac{1}{3}\right) m \text{ from base}$$

$$P_3 = (K_a q + K_a \gamma z_1) z_2 = \left(\frac{1}{3} \times 3 + \frac{1}{3} \times 1.8 \times 1\right) \times 1$$

$$= 1.6 \text{ t/m at } \frac{1}{2} \text{ m from base}$$

$$P_4 = \frac{1}{2} K_a \gamma' z_2^2 + \frac{1}{2} \times \gamma_w z_2^2$$

$$= \frac{1}{2} \times \frac{1}{3} \times 1.25 \times 1^2 + \frac{1}{2} \times 1 \times 1^2 = 0.71 \text{ t/m at } \frac{1}{3} \text{ m from base}$$

Total active earth pressure per unit length of wall

$$P = P_1 + P_2 + P_3 + P_4 = 1 + 0.3 + 1.6 + 0.71 = 3.61 \text{ t/m}$$

Location of resulant thrust from base

$$= \frac{(1 \times 1.5) + \left(0.3 \times \frac{4}{3}\right) + (1.6 \times 0.5) + \left(0.71 \times \frac{1}{3}\right)}{3.61} = 0.813 \text{ m}$$

∴ Change in total active thrust due to rise in water table = 3.61 – 3.2 = 0.41 t/m

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