CLASS TEST

S.No.: 02DLSK_CE_NOPQ_100926

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SOIL MECHANICS

CIVIL ENGINEERING

Date of Test : 10/09/2026

ANSWER KEY

1.	(a)	7.	(a)	13.	(c)	19.	(d)	25.	(c)
2.	(a)	8.	(c)	14.	(b)	20.	(a)	26.	(c)
3.	(c)	9.	(b)	15.	(d)	21.	(c)	27.	(d)
4.	(a)	10.	(c)	16.	(a)	22.	(d)	28.	(d)
5.	(b)	11.	(c)	17.	(d)	23.	(d)	29.	(d)
6.	(a)	12.	(d)	18.	(c)	24.	(c)	30.	(c)

DETAILED EXPLANATIONS

1. (a)

$$\text{Equation of A line, } I_p = 0.73(w_L - 20)$$
$$\Rightarrow I_p = 0.73(60 - 20)$$
$$\Rightarrow I_p = 29.2\%$$
$$(I_p)_{soil} = w_L - w_p = 60 - 25 = 35\%$$
$$\therefore (I_p)_{soil} > (I_p)_{A\text{ line}} \Rightarrow \text{Clay (C) soil}$$
$$\because w_L = 60\% > 50\% \Rightarrow \text{High compressibility (H)}$$

$\therefore$Soil can be classified as CH.

2. (a)

$$\frac{\Delta H}{H_0} = \frac{\Delta e}{1+e_0}$$
$$\Rightarrow \frac{\Delta H}{6} = \frac{1.70-1.61}{1+1.70}$$
$$\Rightarrow \Delta H = 0.0333 \times 6\text{ m} = 0.2\text{ m}$$
$$\Rightarrow 0.2 = m_v \times 150 \times 6$$
$$\Rightarrow m_v = 2.22 \times 10^{-4}\text{ m}^2/\text{kN}$$

3. (c)

4. (a)

$$\text{Critical hydraulic gradient, } i_c = \frac{G-1}{1+e} = \frac{2.6-1}{1+0.7} = \frac{16}{17}$$

$$\text{Now, Seepage pressure} = \Delta h\gamma_w \times \frac{L}{L}$$
$$= i_c\gamma_w L$$
$$\therefore \text{Seepage force} = i_c\gamma_w L\cdot A = \frac{16}{17}\times 9.81\times 10^3 \times \frac{5}{100}\times\frac{5}{10^4}\text{N}$$
$$= 0.2308\text{ N} \simeq 0.23\text{ N}$$

5. (b)

$$\gamma_d = \frac{G\gamma_w}{1+e} = \frac{G\gamma_w}{1+\frac{wG}{S}}$$
$$\Rightarrow 1.7 = \frac{2.7\times 1}{1+\frac{0.16\times 2.7}{S}}$$
$$\Rightarrow 1+\frac{0.16\times 2.7}{S} = \frac{2.7}{1.7}$$
$$\Rightarrow S = 0.7344$$
$$\text{Now, } S + a_c = 1$$
$$\Rightarrow 0.7344 + a_c = 1$$
$$\Rightarrow a_c = 0.2656 = 26.56\%$$

6. (a)

$$\text{Radius of loaded area} = 1.5 \text{ m}$$
$$q = 90 \text{ kN/m}^2$$
$$z = 1.5 \text{ m}$$
$$\sigma_z = q\left[1 - \frac{1}{\left\{1+\left(\frac{a}{z}\right)^2\right\}^{3/2}}\right]$$
$$= 90\left[1 - \frac{1}{\left\{1+\left(\frac{1.5}{3}\right)^2\right\}^{3/2}}\right] = 25.6 \text{kN/m}^2 \simeq 26 \text{kN/m}^2$$

7. (a)

$$\sigma_n = \gamma z \cos^2 i = 17.8(6)\cos^2 30° = 80.1 \text{ kN/m}^2$$
$$\tau = \gamma z \cos i \sin i = 17.8(6) \cos 30° \sin 30° = 46.25 \text{ kN/m}^2$$

8. (c)

Corrected N, after over burden pressure correction

$$N' = N_o \times \frac{350}{\sigma' + 70} = 38 \times \frac{350}{(20.7 - 9.81) \times 15 + 70} = 38 \times 1.5 = 57$$

Corrected N, after application of water table correction

$$N'' = 15 + \frac{1}{2}(N' - 15) = 15 + \frac{1}{2}(57 - 15) = 36$$

9. (b)

Given: $C = 20 \text{ kN/m}^2, \gamma = 18.5 \text{ kN/m}^3$

$$k_a = \frac{1 - \sin\phi}{1 + \sin\phi} = \frac{1 - \sin 8}{1 + \sin 8} = 0.7557$$

$\therefore$ $$z = \frac{2C}{\gamma\sqrt{k_a}}$$

$\Rightarrow$ $$z = 2.487 \text{ m} \simeq 2.49 \text{ m}$$

10. (c)

11. (c)

$$(\gamma_d)_{\min} = \frac{\text{Weight}}{V_{\max}} = \frac{220}{5 \times 5 \times 5} = 1.76 \text{ g/cc}$$

$$\text{Volume in densest state} = 5 \times 5 \times (5 - 1) = 100 \text{ cc}$$

$$(\gamma_d)_{\max} = \frac{\text{Weight}}{V_{\min}} = \frac{220}{100} = 2.2 \text{ g/cc}$$

$$(\gamma_d)_{\text{natural}} = \frac{\gamma}{1 + w} = \frac{2.05}{1 + 0.10} = 1.86 \text{ g/cc}$$

$\therefore$ Density Index, $$I_D = \frac{\left(\frac{1}{\gamma_d}\right)_{\min} - \frac{1}{\gamma_d}}{\left(\frac{1}{\gamma_d}\right)_{\min} - \left(\frac{1}{\gamma_d}\right)_{\max}} \times 100 = \frac{\frac{1}{1.76} - \frac{1}{1.86}}{\frac{1}{1.76} - \frac{1}{2.2}} \times 100$$

$\Rightarrow$ $$I_D = 26.88\%$$

12. (d)

$$V = V_{solid} + V_w + V_{air}$$

$$\Rightarrow \quad V = \frac{W_{solid}}{G\gamma_w} + \frac{w(W_{solid})}{\gamma_w} + n_a V$$

$$\Rightarrow \quad 500 = \frac{W_{solid}}{2.7 \times 1} + \frac{0.10(W_{solid})}{1} + 0.08(500)$$

$$\Rightarrow \quad W_{solid} = 978 \text{ g}$$

$$\therefore \quad W_w = 0.10 \times 978 = 97.8 \text{ gm}$$

$$\therefore \quad V_w = \frac{W_w}{\rho_w} = 97.8 \text{ cc} = 97.8 \text{ ml}$$

13. (c)

Given:

Sample	V_{soil}	e
A	$1\,m^3$	0.6
B	$1.5\,m^3$	0.9

Before compaction,

$$V_{soil,\,C} = V_{soil,\,A} + V_{soil,\,B} = (1 + 1.5)m^3 = 2.5\ m^3$$

Now, $$V_{solid,\,C} = V_{solid,\,A} + V_{solid,\,B}$$

$$\Rightarrow \quad \left(\frac{V_s}{1+e}\right)_C = \left(\frac{V_s}{1+e}\right)_A + \left(\frac{V_s}{1+e}\right)_B$$

$$\Rightarrow \quad \frac{2.5}{1+e_{c1}} = \frac{1}{1+0.6} + \frac{1.5}{1+0.9}$$

$$\Rightarrow \quad e_{c1} = \frac{2.5}{\left(\frac{1}{1.6} + \frac{1.5}{1.9}\right)} - 1$$

$$\Rightarrow \quad e_{c1} = 0.767$$

After compaction,

$$V_{soil,\,C} = 2\ m^3$$

Now, $$\left(\frac{V_s}{1+e}\right)_C = \left(\frac{V_s}{1+e}\right)_A + \left(\frac{V_s}{1+e}\right)_B$$

$$\Rightarrow \quad \left(\frac{2}{1+e_{c2}}\right) = \frac{1}{1+0.6} + \frac{1.5}{1+0.9}$$

$$\Rightarrow \quad e_{c2} = \frac{2}{\left(\frac{1}{1.6} + \frac{1.5}{1.9}\right)} - 1$$

$$\Rightarrow \quad e_{c2} = 0.414$$

Percentage change in void ratio $= \dfrac{0.767 - 0.414}{0.767} \times 100$

$= 46.023\% \simeq 46\%$

We know, $k \propto \dfrac{e^3}{1+e}$

$\Rightarrow \quad \dfrac{k_1}{k_2} = \dfrac{e_1^3}{1+e_1} \times \dfrac{1+e_2}{e_2^3}$

$\Rightarrow \quad \dfrac{k_1}{k_2} = \dfrac{0.767^3}{1+0.767} \times \dfrac{1+0.414}{0.414^3}$

$\Rightarrow \quad \dfrac{k_1}{k_2} = 5.089$

Percentage change in permeability $= \dfrac{k_1 - k_2}{k_1} \times 100 = \left(1 - \dfrac{k_2}{k_1}\right) \times 100$

$= \left(1 - \dfrac{1}{5.089}\right) \times 100 = 80.3498\% \simeq 80.3\%$

14. (b)

$$k = \frac{2.303aL}{At} \log \frac{h_1}{h_2}$$

$\Rightarrow \quad k = 2.303 \times \dfrac{1.5 \times 30}{\frac{\pi}{4} \times 4^2 \times (1 \times 60)} \log \dfrac{100}{50}$

$\Rightarrow \quad k = 0.04138 \text{ cm/sec}$

Now, $k = 2.303 \dfrac{aL}{At} \log \dfrac{h_1}{h_2}$

$\Rightarrow \quad 0.04138 = 2.303 \times \dfrac{1.5 \times 30}{\frac{\pi}{4} \times 4^2 \times t} \log \dfrac{100}{20}$

$\Rightarrow \quad t = 139.3 \text{ sec}$

$\therefore \quad \Delta t = 79.3 \text{ sec} = 1.322 \text{ min}$

15. (d)

For sample A: $\sigma_3 = 150 \text{ kN/m}^2$ $\quad \sigma_d = 350 \text{ kN/m}^2$

$\sigma_1 = \sigma_3 + \sigma_d = 500 \text{ kN/m}^2$

For sample B: $\sigma_1 = \sigma_3 + \sigma_d = 800 \text{ kN/m}^2$

We know that, $\sigma_1 = \sigma_3 \tan^2\theta_c + 2c\tan\theta_c$

$500 = 150\tan^2\theta_c + 2c\tan\theta_c$ ...(i)

$800 = 300\tan^2\theta_c + 2c\tan\theta_c$ ...(ii)

Solving equations (i) and (ii),

$$\begin{array}{l} 500 = 150\tan^2\theta_c + \cancel{2c\tan\theta_c} \\ \underline{\overset{-}{800} = 300\tan^2\theta_c \overset{-}{+} \cancel{2c\tan\theta_c}} \\ \underline{-300 = -150\tan^2\theta_c} \end{array}$$

$\therefore \quad \theta_c = 54.7356° = 45° + \frac{\phi}{2}$

$\therefore \quad \phi = 19.4712°$

Put in equation (i),

$\therefore \quad c = 70.71$ kPa

Now, $\quad \sigma_n = \frac{\sigma_1 + \sigma_3}{2} + \left(\frac{\sigma_1 - \sigma_3}{2}\right)\cos 2\theta_c$

$\Rightarrow \quad \sigma_n = \frac{500+150}{2} + \left(\frac{500-150}{2}\right)\cos(2 \times 54.7356°) = 266.67$ kPa

$\therefore \quad \tau = c + \sigma_n \tan \phi$

$\Rightarrow \quad \tau = 70.71 + 266.67 \tan(19.4712)$

$\Rightarrow \quad \tau = 164.99$ kPa $\simeq 165$ kPa

16. (a)

Load (kN)	10	20	30	40	50
Settlement (mm)	2	3.5	5.5	7.5	10.5
$q = \frac{Q}{0.4 \times 0.4}$ kN/m^2	62.5	125	187.5	250	312.5

$$\delta_p = \delta_f \left[\frac{B_p(B_f + 0.3)}{B_f(B_p + 0.3)}\right]^2$$

$$\delta_p = 19.5 \times \left[\frac{0.4(3.5+0.3)}{3.5(0.4+0.3)}\right]^2 = 7.51 \text{ mm}$$

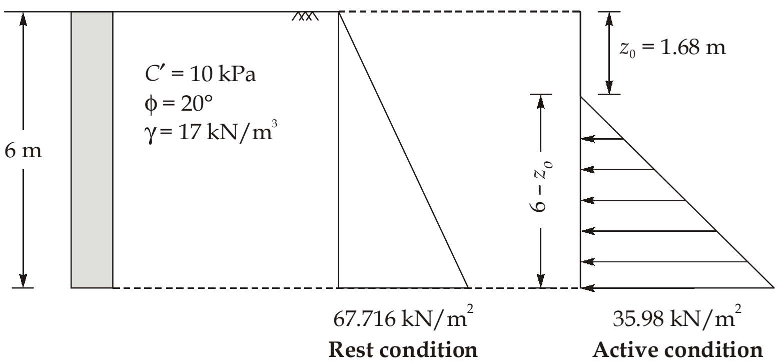
For $\delta_p = 7.51$ mm ; $q_p = 250.208$ kN/m^2

$$q_f = q_p \times \frac{B_f}{B_p} = 250.208 \times \frac{3.5}{0.4} \text{ kN/m}^2$$

$= 2189.32$ kN/m^2

Load on footing $= 2189.32 \times 3.5 \times 3.5 = 26819.17$ kN

17. (d)



When top of wall is not allowed to yield, rest condition develops.

$K_o = 1 - \sin\phi = 1 - \sin 20° = 0.658$

Rest pressure at base $= \gamma z K_o = 17 \times 6 \times 0.658 = 67.116$ kN/m^2

Earth pressure force on wall at rest

$$= \frac{1}{2} \times 67.116 \times 6 = 201.348 \text{ kN/m}$$

When top of wall is allowed to yield, active pressure condition develops.

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 20°}{1+\sin 20°} = 0.49$$

$$z_o = \frac{2c}{\gamma\sqrt{K_a}} = \frac{2\times 10}{17\times\sqrt{0.49}} = 1.68 \text{ m}$$

Active earth pressure on wall $= \frac{1}{2}(\gamma z K_a - 2c\sqrt{K_a})(H - z_o)$

$$= \frac{1}{2}\left[17(6)(0.49) - 2(10)\sqrt{0.49}\right][6-1.68]$$

$$= 77.717 \text{ kN/m}$$

$$\Delta P = 201.348 - 77.717 = 123.631 \text{ kN/m}$$

$$\% \text{ decrement} = \frac{123.631}{201.348}\times 100 = 61.4\%$$

18. (c)

$$\sigma_1 = \sigma_3 \tan^2\theta_c + 2c\tan\theta_c$$

$$\Rightarrow \quad (\sigma_3 + \sigma_d) = \sigma_3 \tan^2\theta_c + 2c\tan\theta_c$$

$$\Rightarrow \quad (600 + 200) = 200\tan^2\theta_c \qquad (c = 0 \text{ for sand})$$

$$\Rightarrow \quad \theta_c = 63.435°$$

$$\because \quad \theta_c = 45° + \frac{\phi}{2}$$

$$\Rightarrow \quad 63.435° = 45° + \frac{\phi}{2}$$

$$\Rightarrow \quad \phi = 36.87°$$

19. (d)

Quick clay has very high sensitivity.

20. (a)

$$\gamma_1 = \frac{G\gamma_w}{1+e}(1+w) = \frac{2.65}{1.85}\times 1.08\times 9.81 = 15.176 \text{ kN/m}^3$$

$$\gamma_2' = \frac{(G-1)\gamma_w}{1+e} = \frac{(2.7-1)\times 9.81}{1.8} = 9.265 \text{ kN/m}^3$$

$$\gamma_3' = \frac{(G-1)\gamma_w}{1+e} = \frac{(2.7-1)\times 9.81}{1.6} = 10.423 \text{ kN/m}^3$$

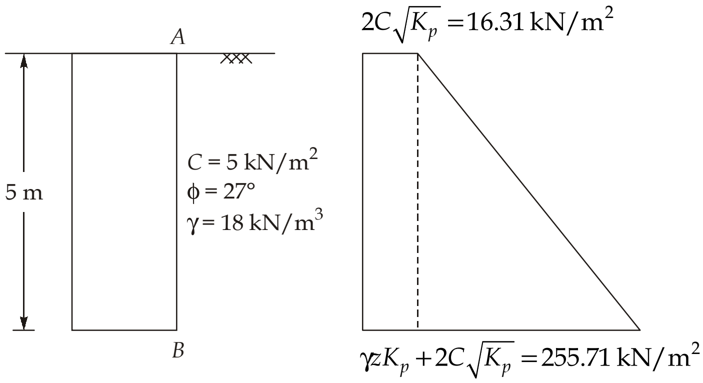
$$K_{a_3} = \frac{1-\sin 20°}{1+\sin 20°} = 0.49$$

$$P_A = K_{a_3}\gamma_1 z_1 + K_{a_3}\gamma_2' z_2 + \gamma_w z_2 + K_{a_3}\gamma_3' z_3 + \gamma_w z_3 - 2c_3\sqrt{K_{a_3}}$$

$$P_A = 0.49(15.176)(2) + 0.49(9.26)(5) + 9.81(5) + 0.49(10.42)(1) + 9.81(1) - 2(12)\sqrt{0.49}$$

$$P_A = 84.725 \text{ kN/m}^2$$

21. (c)



$$K_p = \frac{1+\sin 27°}{1-\sin 27°} = 2.66$$

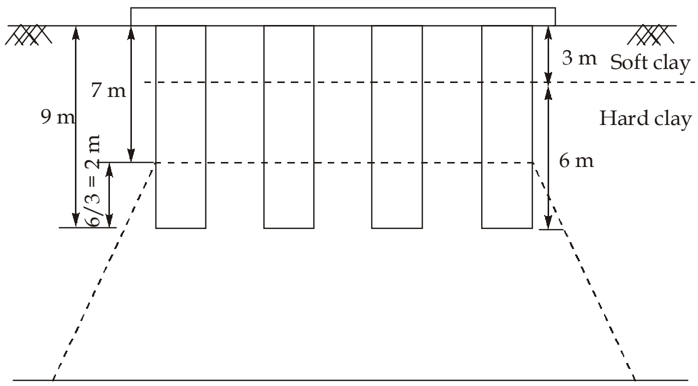
$$(P_p)_A = 2\times 5\times\sqrt{2.66} = 16.31\ \text{kN/m}^2$$

$$(P_p)_B = 2\times 5\sqrt{2.66} + 18(5)(2.66) = 255.71\ \text{kN/m}^2$$

$$\text{Passive pressure on wall} = 16.31(5) + \frac{1}{2}(255.71 - 16.31)(5) = 680.05\ \text{kN/m}$$

22. (d)

Raft should be considered at $\frac{L_2}{3}$ distance from base of pile i.e. $\frac{6}{3} = 2\,\text{m}$ from base of pile i.e., 7 m below ground level.



23. (d)

- Driving of piles causes densification of loose cohesionless soil upto a radial distance of 3.5 times the pile diameter.
- Driving of pile in clay causes remoulding of clay upto a distance of 2 times of pile diameter.
- For same area of pile, point bearing resistance of pile is less for bored pile than for driven pile.

24. (c)

As per Terzaghi's net safe load carrying, capacity of footing,

$$q_{ns} = \frac{1.3\times 5.7C}{FOS}$$

$$q_{\text{safe}} = \frac{1.3\times 5.7\times C}{FOS} + \gamma_{\text{avg.}} D_f R_q^*$$

$$R_q^* = \frac{1}{2}\left[1+\frac{Z_\gamma}{D_f}\right] = \frac{1}{2}\left[1+\frac{0.5}{1.5}\right] = \frac{2}{3}$$

$$\gamma_{avg.} = \frac{20.2\times 0.5 + 21.8\times 1}{1.5} = 21.267 \text{ kN/m}^3$$

$$\therefore \quad q_{safe} = \frac{1.3\times 5.7(48)}{3.5} + \left[21.267(1.5)\left(\frac{2}{3}\right)\right]$$

$$= 122.89 \text{ kN/m}^2$$

$$\therefore \quad Q_{safe} = q_{safe} \times A$$

$$= q_{safe} \times \frac{\pi}{4} \times D^2$$

$$= 122.89 \times \frac{\pi}{4} \times 2.3^2 = 510.58 \text{ kN} \simeq 510 \text{ kN}$$

Alternatively:

$$q_{safe} = \frac{1.3\times 5.7\times C}{FOS} + (\bar{\sigma})_{FL}$$

$$= \frac{1.3\times 5.7\times 48}{3.5} + 20.2\times 0.5 + (21.8 - 9.81)\times 1$$

$$= 123.71 \text{ kN/m}^2$$

$$\therefore \quad Q_{safe} = q_{safe} \times \frac{\pi}{4} \times D^2 = 123.71 \times \frac{\pi}{4} \times 2.3$$

$$= 513.997 \text{ kN}$$

25. (c)

$$S_i = qB\left[\frac{1-\mu^2}{E}\right] I_f$$

$$\Rightarrow \quad S_i = 150\times 1\times\left[\frac{1-0.5^2}{6\times 10^4}\right]\times 1.52 = 2.85 \times 10^{-3} \text{ m}$$

$$\Rightarrow \quad S_i = 2.85 \text{ mm}$$

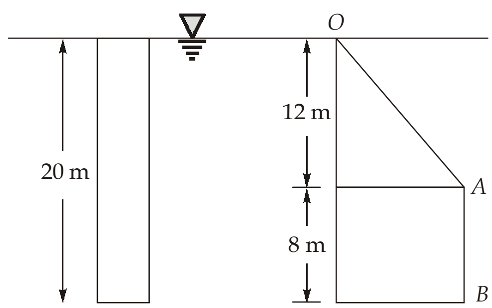
If we use rigidity factor of 0.8, then

$$(S_i)_{\text{rigid footing}} = 0.8 \times 2.85 = 2.28 \text{ mm}$$

26. (c)

As per archling effect in dense sand, effective stress will remain constant after effective length of 20D (le = 20D for dense sand)

$$l_e = 20D = 20 \times 0.6 = 12 \text{ m}$$



$$\sigma'_A = (18 - 9.81) \times 12 = 98.28 \text{ kN/m}^2$$

$$\sigma'_B = 98.28 \text{ kN/m}^2$$

$$Q_u = (\gamma L_{eff} N_q)A_b + (K\sigma'_{avg} \tan \delta)A_s$$

$$\gamma L_{eff} N_q = (18 - 9.81)(12)(88) = 8648.64 \text{ kN/m}^2 < 11000 \text{ kN/m}^2$$

$$(K\sigma'_{avg} \tan \delta)_{AB} = 2 \times \frac{0 + 98.28}{2} \times \tan 28.5 = 53.36 \text{ kN/m}^2 < 100 \text{ kN/m}^2$$

$$(K\sigma'_{avg} \tan \delta)_{BC} = 2 \times \frac{98.28 + 98.28}{2} \times \tan 28.5 = 106.72 \text{ kN/m}^2 > 100 \text{ kN/m}^2$$

$$\therefore \quad (f_s)_{BC} = 100 \text{ kN/m}^2$$

$$\therefore \quad Q_u = 8648.64 \times \frac{\pi}{4} \times 0.6^2 + 53.36(\pi \times 0.6 \times 12) + 100(\pi \times 0.6 \times 8)$$

$$Q_u = 5160.30 \text{ kN}$$

27. **(d)**

Given pile group is square pile group

$$\therefore \quad \text{Width of pile group} = 4S + D$$

$$= 4(1.5) + 0.6 = 6.6 \text{ m}$$

$$\text{Cohesion of clay, } C = \frac{70}{2} = 35 \text{ kPa}$$

Load carrying capacity of pile group,

$$Q_{ug} = 9CA_b + \alpha\bar{C}A_s \qquad \{\alpha = 1 \text{ for pile group}\}$$

$$= 9CB^2 + \alpha\bar{C}(4BL)$$

$$= 9(35)(6.6)^2 + 1(35)(4. \times 6.6 \times 14) = 26657.4 \text{ kN}$$

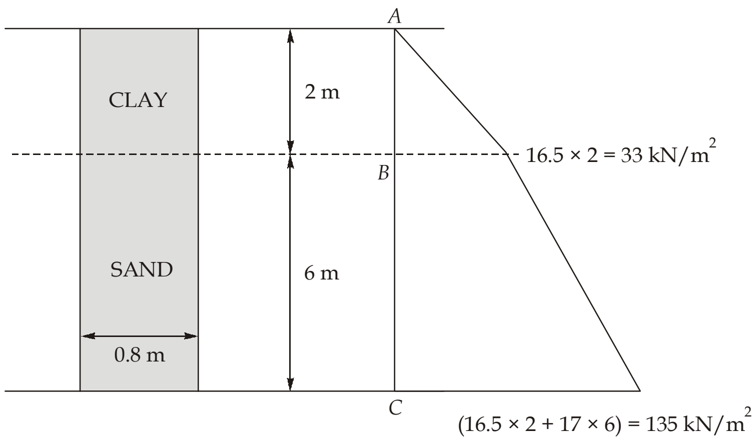
Load carrying capacity of individual pile,

$$Q_{up} = 9CA_b + \alpha\bar{C}A_s$$

$$= \left(9 \times 35 \times \frac{\pi}{4} \times 0.6^2\right) + (0.9 \times 35 \times \pi \times 0.6 \times 14) = 920.33 \text{ kN}$$

$$\text{Efficiency of pile group, } \eta_g = \frac{Q_{ug}}{n \times Q_{up}} \times 100 = \frac{26657.4}{25 \times 920.33} \times 100 = 115.86\%$$

28. **(d)**



End bearing resistance $= \left(\sigma' N_q\right) A_B \qquad \left\{\frac{L}{D} = \frac{8}{0.8} = 10 < 15\right\}$

$$= 135 \times 78 \times \frac{\pi}{4} \times 0.8^2 = 5292.955 \text{ kN}$$

Frictional resistance,

$$(Q_{Sf})_{AB} = \alpha \bar{C} A_s = 0.4(40)(\pi \times 0.8 \times 2) = 80.424 \text{ kN}$$

$$(Q_{Sf})_{BC} = \left(k\sigma'_{avg} \tan\delta\right) A_s$$

$$= 2\left(\frac{33+135}{2}\right) \tan 14° \times (\pi \times 0.8 \times 0.6)$$

$$= 41.89(\pi \times 0.8 \times 6) = 631.642 \text{ kN}$$

$\therefore$ Total ultimate load carrying capacity = 5292.955 + 80.424 + 631.642 = 6005.021 kN $\simeq$ 6005 kN

29. **(d)**

At optimum moisture content the degree of saturation is less than 100%. Thus Statement (I) is incorrect.

30. **(c)**

Tap water contains a considerable amount of air. During permeability test, this air gets struck and remains trapped between sand grains thereby lowering the permeability.

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