CLASS TEST

Sl. : 01IGCE_ABC_18032024

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SOIL MECHANICS

CIVIL ENGINEERING

Date of Test : 18/03/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)

$$G_{sat} = 1.90$$

We know
$$G_{sat} = \frac{\gamma_{sat}}{\gamma_w} = \frac{G+e}{1+e}$$

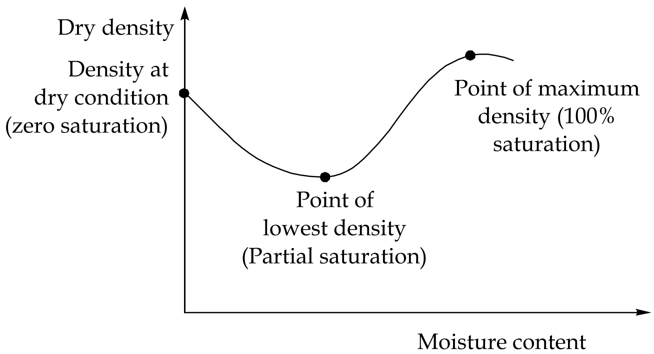
$$\Rightarrow \quad 1.90 = \frac{G+0.4G}{1+0.4G} \qquad \begin{Bmatrix} Se = wG \\ (1)e = 0.4G \end{Bmatrix}$$

$$\Rightarrow \quad 1.90 + 1.90(0.4G) = 1.4G$$

$$\Rightarrow \quad 1.90 = 0.64G$$

$$\therefore \quad G = 2.97$$

2. (c)



3. (d)

$$\Delta\sigma_3 = 300 - 200 = 100 \text{ kN/m}^2$$

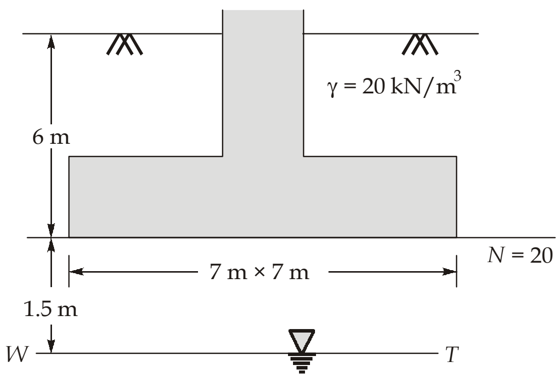
$$B = \frac{\Delta u}{\Delta\sigma_3} \qquad (\because \text{Soil is saturated; } \therefore B = 1)$$

$$\Rightarrow \quad \Delta u = \Delta\sigma_3 = 100 \text{ kN/m}^2$$

$\therefore$ Pore water pressure after increase of cell pressure

$$= 50 + 100 = 150 \text{ kN/m}^2$$

4. (b)



After overburden correction, corrected SPT value

$$N_1 = \frac{350}{(\sigma' + 70)} \times N$$

$$= \frac{350}{(20 \times 6) + 70} \times 20 = 36.84 \simeq 36$$

5. (d)

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

$$= 150 \times 2\left[\frac{1-0.5^2}{6 \times 10^4}\right] \times 1.53 \times 1000$$

$$= 5.74 \text{ mm}$$

6. (a)

$$k_{eq} = \sqrt{k_x \times k_z} = \sqrt{32 \times 8} = 16 \text{ units}$$

7. (c)

$$D_{60} = 0.45 \text{ mm}$$

$$D_{30} = 0.2 \text{ mm}$$

$$D_{10} = 0.04 \text{ mm}$$

$$\therefore \text{Uniformity coefficient, } C_u = \frac{D_{60}}{D_{10}} = \frac{0.45}{0.04} = 11.25$$

$$\text{Coefficient of curvature, } C_c = \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{0.2^2}{0.45 \times 0.04} = 2.22$$

8. (c)

9. (a)

10. (d)

$$\frac{\Delta H}{H} = \frac{\Delta e}{1 + e_o}$$

$$\frac{26 - 24}{26} = \frac{\Delta e}{1 + 1.22}$$

$$\Delta e = 0.171$$

$$e_i - e_f = \Delta e$$

$$e_f = 1.22 - 0.171 = 1.05$$

11. (a)

$$(V_w)_{\text{displaced}} = V_{\text{soil}} + V_{\text{wax}}$$

$$\Rightarrow \quad (V_w)_{\text{displaced}} = V_{soil} + \frac{W_{wax}}{G_{wax}\gamma_w}$$

$$\Rightarrow \quad 345 = V_{soil} + \frac{7}{0.9 \times 1}$$

$$\Rightarrow \quad V_{soil} = 337.2 \text{ cc}$$

Now, $$\gamma_d = \frac{W_{solid}}{V_{soil}}$$

$$\Rightarrow \quad \gamma_d = \frac{550}{337.2} = 1.63 \text{ g/cc}$$

12. (b)

$p = 32\%;\ W_L = 47\%;\ W_p = 35\%$

$$a = p - 35 = 32 - 35 = -3 = 0$$
$$b = p - 15 = 32 - 15 = 17$$
$$c = W_L - 40 = 47 - 40 = 7$$
$$d = I_P - 10 = (W_L - W_p) - 10 = (47 - 35) - 10 = 2$$

Group index, $$GI = 0.2a + 0.005ac + 0.01\ bd$$
$$= 0.2(0) + 0.005(0 \times 7) + 0.01\ (17 \times 2)$$
$$= 0.34$$

13. (b)

As per Darcy's law

$$Q = AK\frac{\Delta h}{L}$$

Given; $Q = 200$ cc in 100 sec; $A = 30\text{ cm}^2$; $\Delta h = 20$ cm; $L = 35$ cm

$$\therefore \quad \frac{200}{100} = 30 \times K \times \frac{20}{35}$$

$$\Rightarrow \quad k = 0.1167 \text{ cm/sec}$$
$$= 1.17 \text{ mm/sec}$$

14. (c)

$$C_v = \frac{K}{m_v \gamma_w}$$

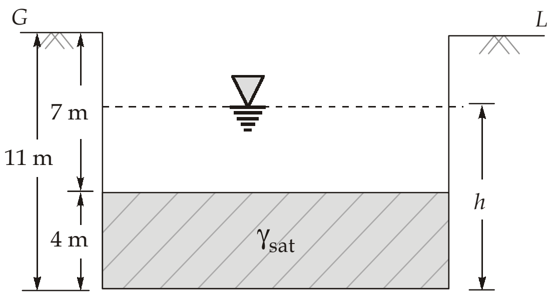
where, $$m_v = \frac{a_v}{1+e_0} = \frac{\Delta e}{(\Delta\sigma)(1+e_0)}$$

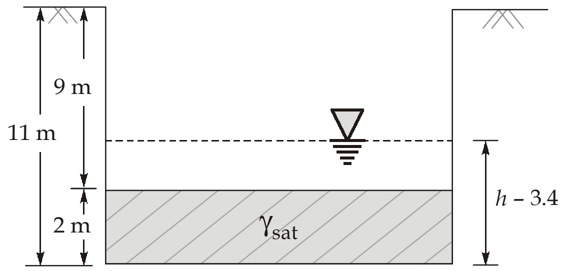
$$m_v = \frac{0.8 - 0.45}{(150-75)(1+0.8)}$$

$$m_v = 2.59 \times 10^{-3} \text{ m}^2/\text{kN}$$

$$\therefore \quad C_v = \frac{1.4 \times 10^{-9}}{2.59 \times 10^{-3} \times 9.81}$$
$$= 5.5 \times 10^{-8} \text{ m}^2/\text{s}$$

15. (a)





$$\gamma_{sat}(4) = \gamma_w(h) \qquad\qquad \gamma_{sat}(2) = \gamma_w(h - 3.4)$$

$$\Rightarrow \quad \gamma_{sat} = \frac{10h}{4} \quad ...(i) \qquad \Rightarrow \quad \gamma_{sat} = \frac{10(h-3.4)}{2} \quad ...(ii)$$

Equate both equation (i) and equation (ii)

$$\frac{10h}{4} = \frac{10(h-3.4)}{2}$$

$$\Rightarrow \quad 2h = 4h - 13.6$$

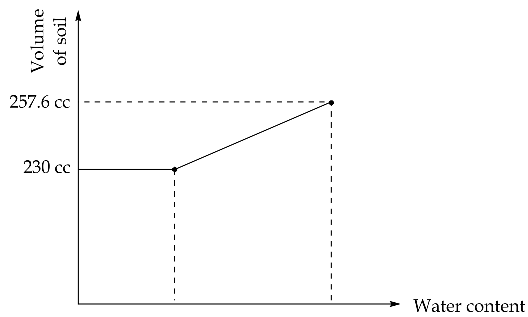
$$\Rightarrow \quad h = 6.8 \text{ m}$$

$$\therefore \quad \gamma_{sat} = \frac{10 \times 6.8}{4} = 17 \text{ kN/m}^3$$

$$\because \quad \gamma' = \gamma_{sat} - \gamma_w$$

$$= 17 - 10 = 7 \text{ kN/m}^3$$

16. (b)



$w_s = 0.151$ $\qquad$ w_1 = unknown
$w_{soil} = 450$ gm $\qquad$ $w_{solid} = 391$ gm
$w_{solid} = 391$ gm
$w_w = 450 - 391 = 59$ gm
$V_s = 230$ cc

$$\therefore \quad \gamma_d = \frac{391}{230} = 1.7 \text{ g/cc}$$

$$V_1 = 1.12 \times V_s \qquad \{\because \text{12\% increment in original volume}\}$$

$$= 1.12 \times 230 = 257.6 \text{ cc}$$

Now, shrinkage ratio, $R = \dfrac{\gamma_d}{\gamma_w} = 1.7$

Also we know, $R = \dfrac{\dfrac{V_1 - V_s}{V_s}}{w_1 - w_s}$

$\Rightarrow \quad 1.7 = \dfrac{\dfrac{(257.6 - 230)}{230}}{w_1 - 0.151}$

$\Rightarrow \quad w_1 = 0.22 \simeq 22\%$

Now, $w_w = w_1 \times w_{solid}$

$= 0.22 \times 391 = 86.64$ gm

$\Delta w_w = 86.64 - 59 = 27.64$ gm

$\Delta V_w = 27.64$ cc $\quad (\because \gamma_w = 1$ g/cc$)$

17. (d)

$\sigma_1 = 150$ kN/m^2; $\theta_c = 52°$

We know $\theta_c = 45° + \dfrac{\phi}{2} = 52°$

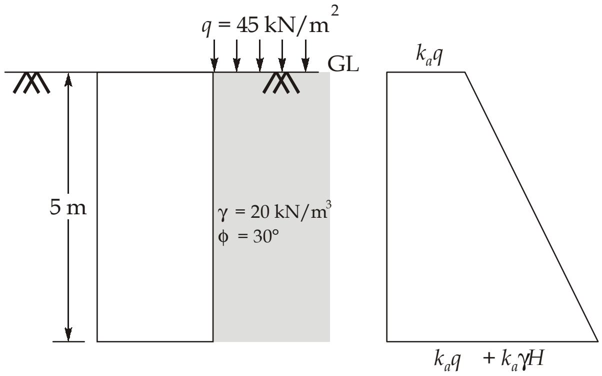
$\therefore \quad \phi = 14°$

$\therefore \quad \sigma_1 = \sigma_3 \tan^2\left(45° + \dfrac{\phi}{2}\right) + 2c\tan\left(45° + \dfrac{\phi}{2}\right)$

$\Rightarrow \quad 150 = 0 + 2c\tan\left(45° + \dfrac{14}{2}\right) \quad \{\sigma_3 = 0$, as tensile unconfined$\}$

$\therefore \quad c = 58.6$ kPa

18. (b)



Active earth pressure at base,

$= k_a q + k_a \gamma H \quad$ where $k_a = \dfrac{1 - \sin\phi}{1 + \sin\phi} = \dfrac{1 - \sin 30°}{1 + \sin 30°} = \dfrac{1}{3}$

$p_a = \dfrac{1}{3}(45) + \dfrac{1}{3}(20)(5) = 48.33$ kN/m^2

19. (a)

$r = 5$ m; $Q = 1800$ kN; $z = 2$ m

$\therefore \quad \dfrac{r}{Z} = \dfrac{5}{2} = 2.5$

$$\sigma_z = \frac{3Q}{2\pi z^2}\left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]^{5/2}$$

$$= \frac{3\times1800}{2\pi(2)^2}\left[\frac{1}{1+(2.5)^2}\right]^{5/2}$$

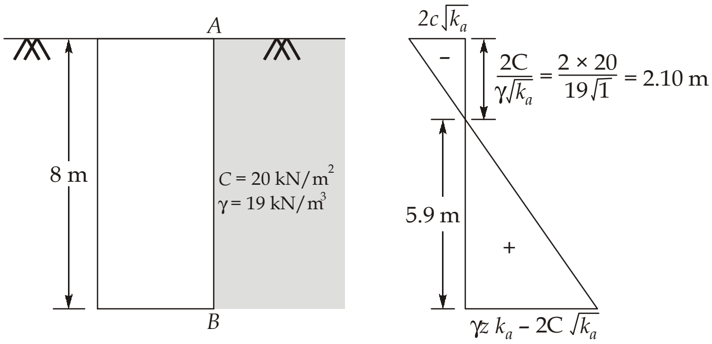
$$= 1.52 \text{ kN/m}^2$$

20. (b)

Black cotton soil contains montmorillonite.

21. (a)

Cohesion, $C = 40/2 = 20 \text{ kN/m}^2$



$\gamma = 19 \text{ kN/m}^3$; $k_a = 1$

$$(p_a)_B = k_a\gamma z - 2a\sqrt{k_a}$$

$$= 19(8)(1) - 2(20)\sqrt{1}$$

$$= 112 \text{ kN/m}^2$$

Active earth pressure on wall

$$= \frac{1}{2}\times112\times5.9 = 330.4 \text{ kN/m}$$

$$\text{Location of pressure} = \frac{5.9}{3} = 1.97 \text{ m from bottom}$$

$$\therefore \text{ Overturning moment} = 330.4 \times 1.97 = 650.89 \text{ kNm/m}$$

22. (d)

$$\text{FOS} = \frac{C'+\gamma' H\cos^2\beta\tan\phi}{\gamma_{sat}H\cos\beta\sin\beta}$$

For FOS = 1, at $H = H_C$

$$\therefore \quad H_C = \frac{C'}{\cos^2\beta[\gamma_{sat}\tan\beta - \gamma'\tan\phi']}$$

$$\Rightarrow \quad H_C = \frac{12}{\cos^2(18°)[19\tan18° - (19-9.81)\tan15°]}$$

$$\Rightarrow \quad H_C = 3.57 \text{ m}$$

23. (a)

$$Q_u = CN_cA_b + \alpha\bar{C}A_s$$

$$\Rightarrow \quad 900 = 40(9)[0.4^2] + \alpha\bar{c}(4 \times 0.4 \times 10)$$

$$\Rightarrow \quad \alpha\bar{C} = 52.65$$

So for pile of cross-section 250 mm × 250 mm, ultimate load carrying capacity is

$$Q_u = CN_cA_b + \alpha\bar{C}A_s$$

$$= 40(9)(0.25^2) + 52.65(4 \times 0.25 \times 18)$$

$$= 970.2 \text{ kN} \simeq 970 \text{ kN}$$

24. (c)

$$Q = Am + Pn$$

$$Q_1 = A_1m + P_1n \quad [Q_1 = 70 \text{ kN}; A_1 = 0.3^2 = 0.09 \text{ m}^2, P_1 = 4 \times 0.3 = 1.2 \text{ m}]$$

$$\Rightarrow \quad 70 = 0.09\,m + 1.2\,n \quad \text{... (i)}$$

$$Q_2 = A_2m + P_2n \quad [Q_2 = 240 \text{ kN}; A_2 = 1^2 = 1 \text{ m}^2, P_2 = 4 \times 1 = 4 \text{ m}]$$

$$\Rightarrow \quad 240 = m + 4\,n \quad \text{...(ii)}$$

Solving equations (i) and (ii),

$$m = 9.52$$

$$n = 57.62$$

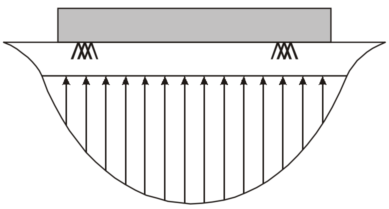
∴ For 2.5 m square footing

$$Q = 9.52(2.5^2) + 57.62(4 \times 2.5)$$

$$\Rightarrow \quad Q = 635.70 \text{ kN}$$

25. (a)

26. (a)



Rigid footing on sand

27. (c)

Dispersion of soil particles reduces the size of voids available for flow because of which permeability gets reduced.

28. (b)

$$\text{Ultimate pull} = \alpha\bar{C}A_s + W_P$$

$$= 0.5 \times 120 \times (\pi \times 0.5 \times 12) + \frac{\pi}{4} \times 0.5^2 \times 12 \times 25$$

$$= 1189.88 \text{ kN}$$

29. (b)

Given:

W = Weight of hammer = 3 tonne = 30 kN

Q_{ap} = 25 tonne = 250 kN

FOS = 6 (for engineering news record formula)

C = Combined temporary correction i.e., 0.25 cm for steam hammer

H = Height of fall = 100 cm

$$Q_{up} = \frac{WH}{S+C}$$

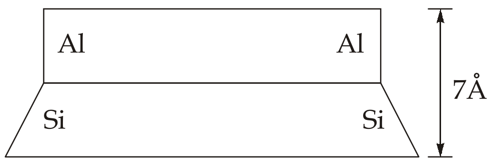
$$\Rightarrow \quad Q_{ap} = \frac{WH}{(S+C)FOS}$$

$$\therefore \quad 250 = \frac{30 \times 100}{(S+0.25)6}$$

$$\Rightarrow \quad S = 1.75 \text{ cm}$$

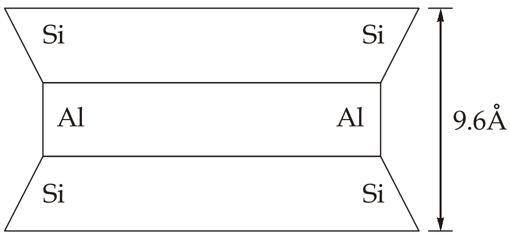
30. (c)

The Kaolinite structural unit consists a alternating layers of silica tetrahedral with the tips embedded in an alumina (gibbsite) octahedral unit as shown.



The combined silica-gibbsite sheet are held together by hydrogen bonding.

The structural unit montmorillonite mineral is composed of two silica sheets and one alumina (gibbsite) sheet as shown.



The interlayer bonding between the tops of silica sheets is mainly due to Vander walls' forces and is thus, very weak compared to hydrogen or other ion bonding.

Bentonite is a montmorillonite clay derived from volcanic ash. It is used in drilling oil wells and in soil exploration as a 'drilling mud' and as a clay grout.

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