CLASS TEST

S.No. : 03 IGCE-EFGH-300623

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SOIL MECHANICS

CIVIL ENGINEERING

Date of Test : 30/06/2023

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (a)

Equivalent permeability,

$$k_e = \sqrt{k_x k_y}$$

$$13 \times 10^{-7} = \sqrt{3\times 10^{-7} \times k_y}$$

$$k_y = \frac{169\times 10^{-14}}{3\times 10^{-7}}$$

$$k_y = 5.63 \times 10^{-6} \text{ cm/s}$$

2. (d)

To prevent possibility of erosion and piping filter must have grain sizes that satisfy following requirements:

(i) $\dfrac{D_{15\,(\text{filter})}}{D_{85(\text{protected material})}} < 5$

It ensures that no significant invasion of particles from the protected material to the filter.

(ii) $4 < \dfrac{D_{15(\text{filter})}}{D_{15(\text{protected material})}} < 20$

It ensures that sufficient head is lost in filter without build-up of seepage pressure (specifies the lower limit of material.

(iii) $\dfrac{D_{50(\text{filter})}}{D_{50(\text{protected material})}} < 25$

This is the additional guideline for the selection of material.

3. (c)

$$S_n = \frac{C}{\gamma H} = \frac{60}{18\times 6} = 0.56$$

4. (d)

5. (b)

$\because$
$$q = k.H.\frac{N_f}{N_D}$$

$$= \frac{3\times 10^{-3}}{60}\times 4\times \frac{14}{10} \text{ m}^3\text{/s per m length of the dam}$$

$$= 2.8 \times 10^{-4} \text{ m}^3\text{/s per m length of the dam}$$

$$= 280 \text{ cm}^3\text{/s per m length of dam}$$

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6. (c)

$$i_c = \frac{G-1}{1+e} = \frac{2.65-1}{1+0.75} = 0.943$$

Permissible upward gradient = 30% of critical gradient

$$= 0.943 \times 0.30 = 0.2829 \simeq 0.28$$

7. (b)

Equivalent horizontal permeability

$$k_{eq} = \frac{k_1h_1 + k_2h_2}{h_1+h_2} = \frac{2kh+kh}{h+h}$$

$$\Rightarrow \quad k_{eq} = 1.5\text{ k}$$

9. (c)

Consistency of soil refers to the resistance offered by it against forces that tends to deform or rupture the soil aggregate. It is related to strength.

11. (a)

Given weight of water = 52 gm

Total weight water of soil sample = 320 gm

Calcium carbide method of determination of water content give water content in terms of total weight of soil,

i.e.,
$$w_t = \frac{w_w}{w} = \frac{52}{320} = 0.1625$$

Since, water content is defined w.r.t. soil solids.

Hence, w_t can be converted into w in terms of weight of soil solid as

$$w = \frac{w_w}{w_s} = \frac{w_t}{1-w_t} = \frac{0.1625}{1-0.1625}$$

$$= 0.1940 = 19.40\%$$

12. (c)

Given, $\gamma_b = 19\text{ kN/m}^3$, $w = 17\%$

So, dry density,
$$\gamma_d = \frac{\gamma_b}{1+w} = \frac{19}{1+0.17} = 16.24\text{ kN/m}^3$$

Also,
$$\gamma_d = \frac{G\gamma_w}{1+e} = \frac{2.7\times 9.81}{1+e} = 16.24$$

$$\Rightarrow \quad e = \frac{2.7\times 9.81}{16.24} - 1 = 0.631$$

When the soil is fully saturated, $S = 1$,

$$\therefore \quad S\cdot e = w\cdot G$$

So, new moisture content,

$$w = \frac{S\cdot e}{G} = \frac{1\times 0.631}{2.7} = 0.2337 \text{ or } 23.37\%$$

$\therefore$ Additional moisture content required

$$= 23.37 - 17 = 6.37\%$$

13. (b)

$$C_V = \frac{K}{m_V \gamma_w}$$

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

$$\Rightarrow \quad m_V = \frac{0.8-0.45}{(150-75)(1+0.8)}$$

$$\Rightarrow \quad m_V = 2.6 \times 10^{-3} \text{ m}^2/\text{kN}$$

$$\therefore \quad C_V = \frac{1.4\times10^{-9}}{2.6\times10^{-3}\times9.81}$$

$$\Rightarrow \quad C_V = 5.4889 \times 10^{-8} \text{ m}^2/\text{s}$$

$$\Rightarrow \quad C_V = 0.0549 \times 10^{-6} \text{ m}^2/\text{s} \simeq 0.055 \times 10^{-6} \text{ m}^2/\text{s}$$

14. (c)

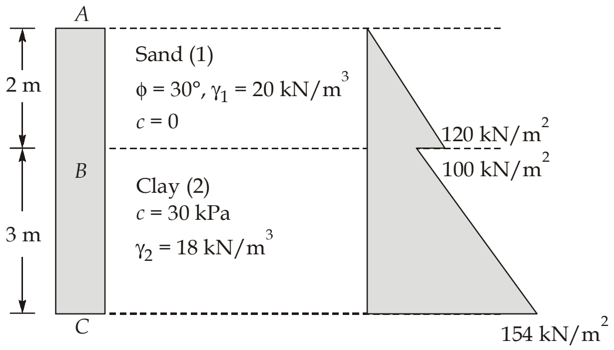
$$C_{u\text{ (undisturbed)}} = \frac{T}{\pi d^2\left[\frac{h}{2}+\frac{d}{6}\right]} = \frac{35\times1000}{\pi\times60^2\times\left[\frac{100}{2}+\frac{60}{6}\right]}$$

$$= 0.05158 \text{ N/mm}^2 = 51.58 \text{ kN/m}^2$$

$$C_{u\text{ (remoulded)}} = \frac{5\times1000\times10^3}{\pi\times60^2\left[\frac{100}{2}+\frac{60}{6}\right]} \text{ kN/m}^2 = 7.368 \text{ kN/m}^2$$

$$\therefore \quad \text{Sensitivity of the clay} = \frac{C_{u\text{(undisturbed)}}}{C_{u\text{(remoulded)}}} = \frac{51.58}{7.368} = 7$$

15. (b)



$$K_{P_1} = \frac{1+\sin\phi}{1-\sin\phi} = 3$$

$$K_{P_2} = 1 \qquad (\because \ \phi_{clay} = 0°)$$

$$p_b = K_{P_1}\gamma_1 z_1 = 3\times20\times2 = 120 \text{ kN/m}^2$$

$$p_B' = K_{p_2}\gamma_1 z_1 + 2c\sqrt{K_{P_2}}$$

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$$= 1 \times 20 \times 2 + 2 \times 30\sqrt{1} = 100\,\text{kN/m}^2$$

$$p_c = K_{p2} \times \gamma_1 z_1 + K_{p_2}\gamma_2 z_2 + 2c\sqrt{K_{P_2}}$$

$$= 1 \times 20 \times 2 + 1 \times 18 \times 3 + 2 \times 30\sqrt{1} = 154\text{ kN/m}^2$$

Therefore total passive earth pressure per unit length of the wall is

$$p_a = \frac{1}{2} \times 120 \times 2 + \frac{1}{2}(154 + 100) \times 3$$

$$= 120 + 381 = 501\text{ kN/m}$$

16. (b)

Given:

Weight of pile,	P_s	= 22 kN
Shaft diameter,	D_0	= 340 mm
Under-ream dia,	D_u	= 700 mm
Undrained shear strength,	C	= 60 kPa
	α	= 0.3, $N_C = 9$

Ultimate tensile capacity will be due to

1. Friction along the length of pile (P_1)
2. Bearing action caused by under-reamed portion (P_2)
3. Self weight of pile (P_3)

Tensile capacity due to friction

$$P_1 = f_s \times A_s$$

$$= \alpha \,.\, C\,(\pi D_0)\,(L - \text{Depth of under-ream})$$

$$= 0.3 \times 60 \times \pi \times 0.34 \times (10 - 0.42) = 184.19\text{ kN}$$

Tensile capacity due to bearing action

$$P_2 = C\,N_C \cdot A$$

$$= \frac{60 \times 9\pi(D_u^2 - D_o^2)}{4}$$

$$= \frac{60 \times 9 \times \pi(0.7^2 - 0.34^2)}{4} = 158.79\text{ kN}$$

$\therefore$ $P = P_1 + P_2 + P_3$

$$= 184.19 + 158.79 + 22$$

$$= 364.98 \simeq 365\text{ kN}$$

17. (b)

$$q_u = 1.3\,C\,N_C + \gamma D_f N_q + 0.4\,\gamma B N_\gamma \cdot R_\gamma$$

$\because$ $C = 0$

$\therefore$ $q_u = \gamma D_f N_q + 0.4\,\gamma B N_\gamma \cdot R_\gamma$

$$R_\gamma = 0.5\left(1 + \frac{D}{B}\right) = 0.5\left(1 + \frac{2.5}{3}\right) = 0.917$$

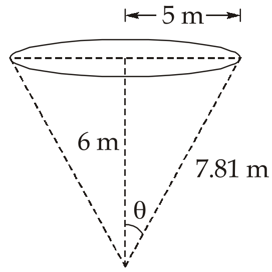
$\therefore$ $q_u = 18 \times 1 \times 21 + 0.4 \times 20 \times 3 \times 17 \times 0.917$

$$= 752.136\text{ kN/m}^2$$

$\therefore \quad q_{nu} = q_u - \gamma D_f = 752.136 - 18 \times 1$
$= 734.136 \text{ kN/m}^2$

$\therefore \quad q_{ns} = \dfrac{q_{nu}}{\text{FOS}} = \dfrac{734.136}{2.5} = 293.65 \text{ kN/m}^2$

18. (b)



$q_z = q\,(1 - \cos^3\theta)$
$q = 6 \text{ kN/m}^2$

$\cos\theta = \dfrac{6}{7.81}$

$q_z = 6 \times \left[1 - \left(\dfrac{6}{7.81}\right)^3\right]$

$= 3.28 \text{ kN/m}^2$

19. (b)

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

$$= \frac{0.198}{0.198 - (1.653 - 1.548)} = 2.129 \simeq 2.13$$

20. (d)

$\because \quad S_i = qB\left(\dfrac{1-\mu^2}{E_s}\right) \times I_f$

$$= \frac{600}{2 \times 3} \times 2 \times \left(\frac{1 - 0.25^2}{20000}\right) \times 1.06$$

$= 9.94 \times 10^{-3}$ m
$= 9.94$ mm

So final depth of footing $= D_f + S_i$
$= 1000 + 9.94 = 1009.94$ mm
$\simeq 1010$ mm

21. (c)

Shrinkage limit, $\quad ws = w_1 - \Delta w$

$$= w_1 - \frac{\Delta V \cdot \rho_w}{M_S}$$

$$= \frac{M_1 - M_d}{M_d} - \frac{(V_1 - V_d)\rho_w}{M_d}$$

$$= \frac{55.4 - 39.8}{39.8} - \frac{(29.2 - 21.1) \times 1}{39.8} = 0.188$$

i.e. $\quad ws = 18.8\%$

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22. (b)

Volume of soil

257.6 cc

230 cc

Water content

$w_s = 0.151$ | w_1 = unknown
$w_{soil} = 450$ gm | $w_{solid} = 391$ gm
$w_{solid} = 391$ gm
$w_w = 450 - 391 = 59$ gm
$w_s = 0.51$
$\gamma_d = \frac{391}{230} = 1.7$ g/cc

$$V_2 = 1.12 \times 230 = 257.6 \text{ cc}$$

{∵ 12% increment in original volume}

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

We, also know, $R = \dfrac{\dfrac{V_1 - V_s}{V_s}}{w_1 - w_s}$

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

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

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

$$\therefore \quad w_w = w_1 \times w_{solid} = 0.22 \times 391 = 86.64 \text{ gm}$$

$$\Delta w_w = 86.64 - 59 = 27.02 \text{ gm}$$

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

23. (d)

$$D = 30 \text{ cm} = 0.3 \text{ m}$$

$$L = 12 \text{ m}$$

$$C = \frac{\sigma_1}{2} = \frac{200}{2} = 100 \text{ kN/m}^2$$

$$\gamma = 20 \text{ kN/m}^3$$

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

$$Q_{up} = 9C \frac{\pi}{4} D^2 + \alpha \bar{c} \pi D_L$$

$$\Rightarrow \quad Q_{up} = 9(100)\left(\frac{\pi}{4} \times 0.3^2\right) + 0.6(100)(\pi \times 0.3 \times 12)$$

$\Rightarrow \quad Q_{up} = 742.20$ kN

For 16 piles, $\quad Q_{ug} = n\, Q_{up}$

$= 16 \times 742.20 = 11875.20$ kN

24. (a)

$$I_D = \frac{\dfrac{1}{(\gamma_d)_{min}} - \dfrac{1}{(\gamma_d)}}{\dfrac{1}{(\gamma_d)_{min}} - \dfrac{1}{(\gamma_d)_{max}}}$$

$$\Rightarrow \quad 0.75 = \frac{\dfrac{1}{1.7} - \dfrac{1}{\gamma_d}}{\dfrac{1}{1.7} - \dfrac{1}{2.1}}$$

$\Rightarrow \quad \gamma_d = 1.983$ g/cc

We know,

$$\gamma_d = \frac{G\gamma_w}{1+e}$$

$$\Rightarrow \quad 1.983 = \frac{2.7 \times 1}{1+e}$$

$\Rightarrow \quad e = 0.3616$

$$\therefore \quad n = \frac{e}{1+e} = 0.2656 \simeq 0.27$$

25. (b)

$$\text{Discharge} = \frac{200\text{ ml}}{20\text{ min}} = \frac{200 \times 10^3}{20 \times 60} = \frac{500}{3}\text{ mm}^3/\text{sec}$$

$$k_{eq} = \frac{\sum Z_i}{\sum \dfrac{Z_i}{k_i}}$$ [∵ Flow is normal to bedding plane]

$$k_{eq} = \frac{150 + 150}{\dfrac{150}{0.04} + \dfrac{150}{k}}$$

$$i = \frac{600 - 300}{300} = 1$$

$A = 80\text{ cm}^2 = 80 \times 10^2\text{ mm}^2$

$q = k_{eq}\, i A$

$$\Rightarrow \quad \frac{500}{3} = \frac{300}{\left(\dfrac{150}{0.04} + \dfrac{150}{k}\right)} \times 1 \times 80 \times 10^2$$

$\Rightarrow \quad k = 0.014$ mm/sec

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26. (c)

$$n = \frac{V_V}{V} = 0.7 = \frac{V_V}{200}$$

$\Rightarrow$ $$V_V = 140 \text{ m}^3$$

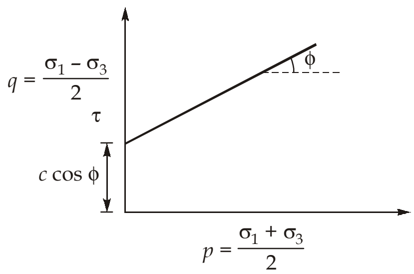
Now, $$S = \frac{V_W}{V_V} = \frac{V_V - V_a}{V_V} = \left(1 - \frac{V_a}{V_V}\right)$$

$\Rightarrow$ $$0.40 = 1 - \frac{V_a}{V_V}$$

$\Rightarrow$ $$\frac{V_a}{V_V} = 0.6$$

$\Rightarrow$ $$V_a = 0.6 \times 140 = 84 \text{ m}^3$$

27. (b)



$$\frac{\sigma_1 - \sigma_3}{2} = C\cos\phi + \frac{\sigma_1 + \sigma_3}{2}\sin\phi \quad \text{...(i)}$$

As, $$q = 8\sqrt{3} + 0.7p \quad \text{...(ii)}$$

$\therefore$ $$C\cos\phi = 8\sqrt{3}$$ (on comparing equations (i) and (ii)

and $$\sin\phi = 0.7$$

$\Rightarrow$ $$\phi = \sin^{-1}(0.7) = 44.43°$$

$\therefore$ $$C\cos 44.43° = 8\sqrt{3}$$

$\Rightarrow$ $$C = 19.40 \text{ kPa}$$

28. (a)

$$S_P = S_f\left[\frac{B_P(B_f + 0.3)}{B_f(B_P + 0.3)}\right]^2 \text{ for sandy soils}$$

$\Rightarrow$ $$15 = S_f\left[\frac{0.3(1.5+0.3)}{1.5(0.3+0.3)}\right]^2$$

$\Rightarrow$ $$S_f = \frac{15}{0.36} = 41.67 \text{ mm}$$

29. (b)

$$\sigma_z = \frac{2q'}{\pi z}\left[\frac{1}{1+\left(\frac{x}{z}\right)^2}\right]^2$$

$$= \frac{2\times 120}{\pi \times 3.5}\left[\frac{1}{1+\left(\frac{2}{3.5}\right)^2}\right]^2$$

$$= 12.40 \text{ kN/m}^2$$

30. (b)

As the flow is in upward direction.

∴ $P_H = H_1 + Z + iZ$

Where, H_1 = Height of water above soil surface = 2 m

Z = Vertical depth of section = 1 m

i = Hydraulic gradient = $\frac{\Delta h}{L} = \frac{2}{4} = 0.5$

∴ $P_H = 2 + 1 + 0.5\,(1)$

⇒ $P_H = 3.5$ m

Datum head = 3 m

∴ Total head = 3 + 3.5 = 6.5 m

Head loss = Total available head – Total head at P

= (4 + 2 + 2) – (7.5) = 1.5 m

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