CLASS TEST

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SOIL MECHANICS

CIVIL ENGINEERING

Date of Test : 04/05/2023

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)

$$\because \quad I_D = \frac{\dfrac{1}{\gamma_{d\min}} - \dfrac{1}{\gamma_d}}{\dfrac{1}{\gamma_{d\min}} - \dfrac{1}{\gamma_{d\max}}}$$

$$\Rightarrow \quad 0.7 = \frac{\dfrac{1}{14} - \dfrac{1}{\gamma_d}}{\dfrac{1}{14} - \dfrac{1}{17}}$$

$$\Rightarrow \quad \gamma_d = 15.97 \text{ kN/m}^3$$

$$\because \quad \gamma = \gamma_d (1 + w)$$

$$\Rightarrow \quad \gamma = 15.97 (1 + 0.08)$$

$$\Rightarrow \quad \gamma = 17.25 \text{ kN/m}^3$$

2. (b)

$$n = 0.5$$

$$\therefore \quad e = \frac{n}{1-n} = \frac{0.5}{0.5} = 1$$

$$\therefore \quad \gamma = \frac{(G+Se)\gamma_w}{1+e} = \frac{(2.7+0.7\times1)\times10}{1+1} = 17 \text{ kN/m}^3$$

3. (a)

$$\because \quad q = KH\frac{N_f}{N_D}$$

$K = 6.67 \times 10^{-7}$ m/s, $H = 6$ m, $N_D = 18$,

$N_f = 8 - 1 = 7$ ($\because$ 8 flow lines will correspond to 7 flow channels)

$$q = 6.67\times10^{-7}\times6\times\frac{7}{18}$$

$$= 6.67\times10^{-7}\times6\times\frac{7}{18} \times 60 \times 60 \times 24$$

$$= 0.134 \text{ m/m/day}$$

4. (b)

$$\sigma_z = \frac{2q}{\pi z} = \frac{2\times150}{\pi\times5}$$

$$= 19.099 \text{ kN/m}^2$$

5. (c)

Initial pore water pressure = 110 kPa

Excess pore water pressure = 100 kPa

After 40% consolidation, remaining excess porewater pressure = 100 × (1 – 0.4) = 60 kPa

So total pore pressure = 110 + 60 = 170 kPa

6. (a)

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

$$S_i = \frac{500}{1.5\times 1.5}\times 1.5\left[\frac{1-0.5^2}{2\times 10^3}\right]\times 0.5$$

$$= 0.0625 \text{ m} = 62.5 \text{ mm}$$

8. (c)

$$A_r = \frac{160^2 - 145^2}{145^2}\times 100 = 21.78\%$$

Since area ratio is greater than 20% so the soil sample is disturbed.

10. (a)

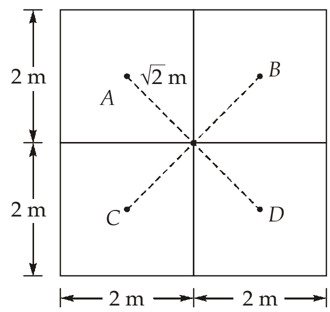
$$k_{eq} = \frac{z_1+z_2+z_3+z_4}{\frac{z_1}{k_1}+\frac{z_2}{k_2}+\frac{z_3}{k_3}+\frac{z_4}{k_4}}$$

$$= \frac{3+2+4+1}{\frac{3}{2}+\frac{2}{1}+\frac{4}{4}+\frac{1}{3}} = 2.07 \text{ mm/s}$$

11. (b)

Total load, $Q = 200 \times 4 \times 4 = 3200$ kN

Divide this load in four equal squares of 2 m × 2 m size, as shown in figure,



$\therefore$ Load in each part square $= \frac{3200}{4} = 800$ kN

The distance from A to O *i.e.* $AO = \sqrt{2}$ m

By symmetry, the stress σ_z at O at 4 m depth is four times of that caused by one load.

So,
$$\sigma_z = \frac{4\times 800}{4^2}\times\frac{3}{2\pi}\times\left[\frac{1}{1+\left(\frac{\sqrt{2}}{4}\right)^2}\right]^{5/2}$$

$$= 71.136 \text{ kN/m}^2$$

$$\simeq 71.14 \text{ kN/m}^2$$

12. (c)

$$\beta = 9°,\ \phi = 27°$$

$$K_a = \cos\beta\left(\frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}\right) \quad \text{...(i)}$$

Putting values in (i), we get, $K_a = 0.392$

$$K_p = \cos\beta\left(\frac{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}\right) \quad \text{...(ii)}$$

Putting values in (ii), we get, $K_p = 2.488$

$$\therefore \quad \frac{K_p}{K_a} = \frac{2.488}{0.392} = 6.35$$

13. (b)

Designing as a floating raft,

Applied load + over burden + self weight = weight of soil excavated

$$\Rightarrow \quad \frac{\left(1+0.3\frac{B}{L}\right)CN_C + \gamma D_f - \gamma D_f + \text{over burden}}{F} = \gamma D_f$$

$$\Rightarrow \quad \frac{\left(1+0.3\times\frac{8}{10}\right)\times 15\times 5.7 + 20}{1.5} = 15\times D_f$$

$$\Rightarrow \quad D_f = 5.6 \text{ m}$$

14. (b)

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

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

$$= 1189.88 \text{ kN}$$

15. (d)

Negative skin friction in individual action = $n\left[\alpha\,\bar{c}\,A\right]$

$= 9 \times 0.9 \times 20 \times 1.3 \times 3$

$= 631.8$ kN

Negative skin friction for pile group = $\alpha\bar{c}(4BL) + \text{weight of soil in negative zone}$

$= \alpha\bar{c}(4BL) + \gamma AL$

$= 1 \times 20(4 \times 2.5 \times 3) + 16 \times 2.5^2 \times 3$

$= 900$ kN

So, $Q = 900$ kN

16. (c)

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

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

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

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

$$= 0.188$$

i.e. $ws = 18.8\%$

17. (a)

As per Karman-Cozney relation

$$\because \quad k = CD^2\left(\frac{\gamma_w}{\mu}\right)\left(\frac{e^3}{1+e}\right)$$

$$\therefore \quad k \propto \frac{e^3}{1+e}$$

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

$$\Rightarrow \quad \frac{k_1}{k_2} = \frac{(0.27)^3}{1+0.27} \times \frac{1+0.15}{(0.15)^3}$$

$$k_1 = 5.28\,k_2$$

$$\therefore \quad \text{Percentage change in permeability} = \frac{k_2 - k_1}{k_1} \times 100$$

$$= \frac{k_2 - 5.28k_2}{5.28k_2} \times 100 = -81.06$$

$$\therefore \quad \text{Percentage change} = 81.06\%$$

18. (c)

$$C_{u\text{ (undisturbed)}} = \frac{T}{\pi d^2\left[\frac{h}{2}+\frac{d}{6}\right]} = \frac{35 \times 1000}{\pi \times 60^2 \times \left[\frac{100}{2}+\frac{60}{6}\right]}$$

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

$$C_{u\text{ (remoulded)}} = \frac{5 \times 1000 \times 10^3}{\pi \times 60^2\left[\frac{100}{2}+\frac{60}{6}\right]} \text{ kN/m}^2 = 7.368 \text{ kN/m}^2$$

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

19. (a)

$$S \times e = wG$$

$$\Rightarrow \quad e = \frac{2.7 \times 0.2222}{1} \simeq 0.6$$

$$\gamma_{sat} = \left(\frac{G+e}{1+e}\right)\gamma_w = \left(\frac{2.7+0.6}{1+0.6}\right) \times 10$$

$$= 20.625 \text{ kN/m}^3$$

Effective stress at centre of clay layer

$$\bar{\sigma}_0 = (18 - 10) \times 2 + (20.625 - 10) \times 0.5$$

$$\Rightarrow \quad \bar{\sigma}_0 = 21.31 \text{ kN/m}^2$$

Load distribution dimensions at the centre of clay layer = 2 + 0.75 + 0.75 = 3.5 m

Increase in stress due to load,

$$\Delta\sigma = \frac{200}{3.5 \times 3.5}$$

$$= 16.33 \text{ kN/m}^2$$

$$\Delta H = \frac{C_c H}{1+e}\log_{10}\left(\frac{\bar{\sigma}_0 + \Delta\sigma}{\bar{\sigma}_0}\right)$$

$$= \frac{0.4 \times 1}{1+0.6}\log_{10}\left(\frac{21.31 + 16.33}{21.31}\right)$$

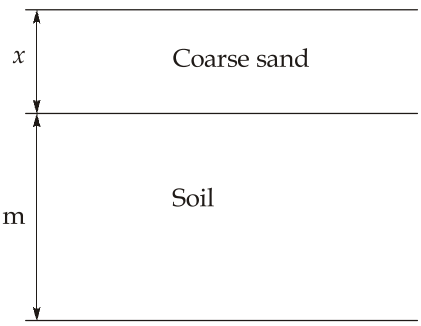
$$= 0.06176 \text{ m} = 61.67 \text{ mm}$$

20. **(c)**

Samples obtained from auger are disturbed samples

Degree of expansiveness	DFS percent
Low	< 20
Moderate	20 to 35
High	35 to 50
Very High	> 50

21. **(b)**



$$i_{cr} = \frac{G-1}{1+e} = (G-1)(1-n)$$

$$\Rightarrow \quad i_{cr} = (2.7 - 1)\ (1 - 0.3)$$

$$\Rightarrow \quad i_{cr} = 1.19$$

$$i_{\text{allowable}} = \frac{1.19}{\text{FOS}}$$

$$\Rightarrow \quad i_{\text{allowable}} = \frac{1.19}{1.5} = 0.7933$$

$$\therefore \quad (2 + x) \times 0.7934 = 1.90$$

$$\Rightarrow \quad 2 + x = 2.395$$

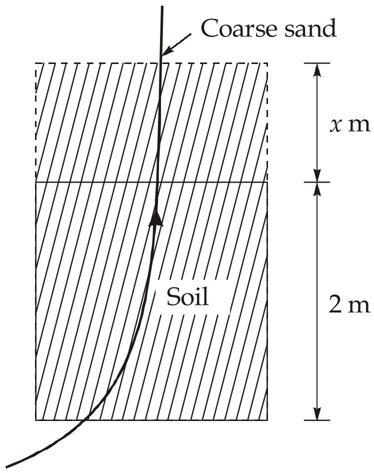
$$\Rightarrow \quad x = 0.395 \text{ m} \simeq 0.4 \text{ m}$$

Alternatively

Given, $n = 0.3,\ G_s = 2.7$

Seepage head, $H_L = 1.9$ m

FOS = 1.5



$$\text{FOS} = \frac{\text{Buoyand weight}}{\text{Seepage force}}$$

$$= \frac{\gamma_{\text{sub}}(2+x)A}{\gamma_w h_L A} = \frac{\left(\frac{G_s - 1}{1+e}\right)\gamma_w(2+x)}{\gamma_w \times h_L}$$

$$= (G_s - 1)\frac{(1-n)(2+x)}{h_L}$$

$$1.5 = (2.7-1)\frac{(1-0.3)(2+x)}{1.9}$$

$$(2+x) = \frac{1.5\times1.9}{1.7\times0.7}$$

$$x = \frac{1.5\times1.9}{1.7\times0.7}-2$$

$$= 0.395 \simeq 0.4 \text{ m}$$

22. (a)

Given, $w_p = 35\%$, $I_p = w_L - w_p = 10\%$, $w_L = (I_p + w_p = 10 + 35) = 45\%$

We know that, $$\frac{V_L - V_P}{w_L - w_P} = \frac{V_P - V_d}{w_P - w_s}$$

Given, $$V_d = (1 - 0.25)V_p = 0.75\ V_p$$
$$V_d = (1 - 0.32)V_L = 0.68\ V_L$$

$$\therefore \quad w_p - w_s = \frac{(w_L-w_p)(V_p-V_d)}{(V_L-V_p)} = \frac{10\left(\frac{1}{0.75}-1\right)V_d}{\left(\frac{1}{0.68}-\frac{1}{0.75}\right)V_d}$$

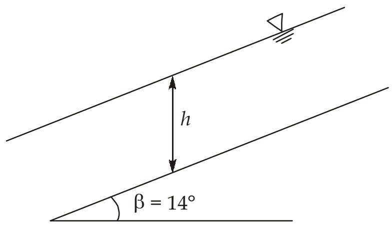
$$\Rightarrow \quad w_p - w_s = 24.28$$

$$\Rightarrow \quad w_s = 35 - 24.28 = 10.72\%$$

$$\text{Shrinkage ratio, } R = \frac{(V_1-V_2)/V_d}{w_1-w_2}\times100 = \frac{(V_L-V_d)/V_d}{w_L-w_s}\times100$$

$$= \frac{\left(\frac{1}{0.68}-1\right)}{45-10.72}\times100 = 1.372 \approx 1.37$$

23. (a)



$$\phi = 30°$$
$$\gamma_t = 20 \text{ kN/m}^3$$

FOS with seepage

$$\frac{\gamma_{sub}}{\gamma_{sat}}\times\frac{\tan\phi}{\tan\beta} = \frac{(20-10)}{20}\times\frac{\tan(30°)}{\tan(14°)} = 1.16$$

24. (b)

$$\gamma_{sat} = \frac{G+e}{1+e}\times\gamma_w = \frac{2.65+1}{1+1}\times 9.81 = 17.9 \text{ kN/m}^3$$

$$\gamma' = \gamma_{sat} - \gamma_w = 17.9 - 9.81 = 8.1 \text{ kN/m}^3$$

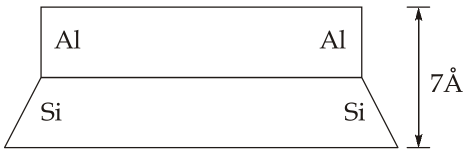
For sudden drawdown $\gamma = \gamma_{sat}$

$$\phi_w = \frac{\gamma'}{\gamma_{sat}}\times\phi_u = \frac{8.1}{17.9}\times 15 = 6.8°$$

$$F_C = \frac{C_u}{S_n\times\gamma H} = \frac{12}{0.126\times 17.9\times 5} = 1.06$$

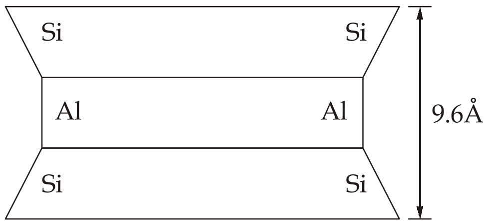
25. (c)

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.



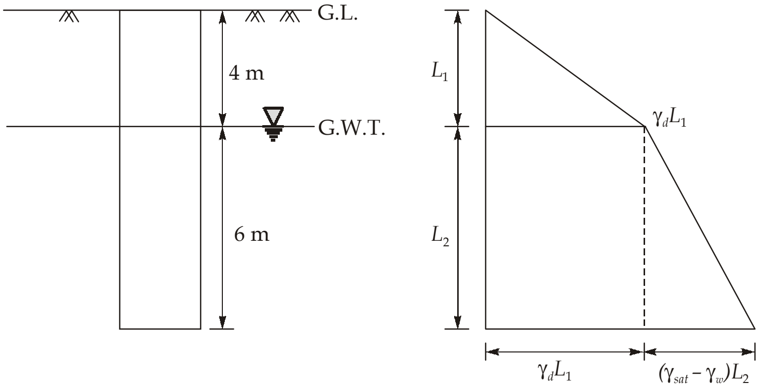
The interlayer bonding between the tops of silica sheets is mainly due to Vander walls' forces and is thus, very weak compared to hydrogen or other ion bonding.

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.

26. (c)

- Local shear failure, generally occurs in soil having somewhat plastic stress-strain curve e.g., loose sand and soft clays.
- Cyclic pile load test is carried out when it is required to required to determine, skin friction and end bearing capacity separately for a pile load on a single pile.

27. (c)



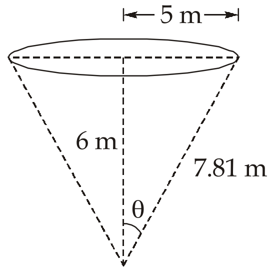
Total axial frictional resistance

$$= \frac{\gamma_d L_1 + 0}{2} \times k \times \tan\delta \times A_1 + \gamma_d L_1 \times k \times \tan\delta \times A_2 + \frac{[(\gamma_{sat} - \gamma_w) \times L_2]}{2} \times k \times \tan\delta \times A_2$$

$$\Rightarrow P_a = \frac{18 \times 4 + 0}{2} \times 0.9 \times \tan 28° \times 4 \times 2 + 72 \times 0.9 \times \tan 28° \times 6 \times 2 + \frac{[(20 - 9.81) \times 6]}{2} \times 0.9 \times \tan 28° \times 6 \times 2$$

= 726.82 kN

28. (b)



$$q_z = q\,(1 - \cos^3\theta)$$

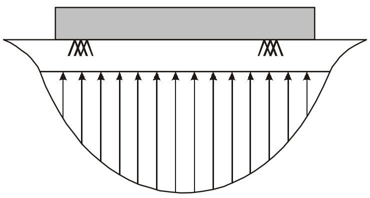
$$q = 6 \text{ kN/m}^2$$

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

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

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

29. (a)



Rigid footing on sand

30. (a)

As more than 50% is retained on 75 μ IS sieve, the soil is coarse-grained.

$$\text{Coarse fraction} = 100 - 45 = 55\%$$
$$\text{Gravel fraction} = 100 - 60 = 40\%$$
$$\text{Sand fraction} = 55 - 40 = 15\%$$

As more than half the coarse fraction is larger than 4.75 mm sieve, the soil is gravel.

Also, $I_P = w_L - w_P = 40 - 12 = 28\%$

A-line, $I_P = 0.73\,(w_L - 20)$

$= 0.73\,(40 - 20) = 14.6\%$

$\because$ I_P is above A-line, therefore the soil should be GC as per IS classification.

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