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Soil Mechanics

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CLASS TEST 2019-2020

CIVIL ENGINEERING

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ANSWER KEY ➤ Soil Mechanics

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

DETAILED EXPLANATIONS

1. (b)

Water table correction in SPT is given by

$$N = 15 + \frac{1}{2}(N' - 15) = 15 + \frac{1}{2}(32 - 15)$$
$$= 15 + 8.5 = 23.5$$

$\therefore$ Corrected SPT value = 23

2. (a)

$$k \propto D_{10}^2$$

$$\therefore \quad \frac{k_1}{k_2} = \frac{(D_{10})_1^2}{(D_{10})_2^2} = \frac{(0.6)^2}{(0.3)^2} = 4$$

3. (a)

$$C_C = \frac{D_{30}^2}{D_{60}D_{10}} \text{ and } C_u = \frac{D_{60}}{D_{10}}$$

$$\therefore \quad \frac{D_{30}}{D_{10}} = \sqrt{C_C C_u} = \sqrt{1.5 \times 6} = 3.00$$

4. (a)

$$h = \frac{4\sigma}{\gamma d} = \frac{4 \times 0.073}{9.81 \times 0.05} \quad (\because \text{ Surface tension for water, } \sigma = 0.073 \text{ N/m})$$

$$h = 0.62 \text{ m}$$

$\therefore$ Capillary tension $= h \cdot \gamma_w$

$$= 0.62 \times 9.81 = 6.1 \text{ kN/m}^2$$

5. (b)

Given $\frac{\mu_1}{\mu_2} = 1.5$ and $\frac{1-\mu_1}{1-\mu_2} = 0.9$

$$\therefore \quad \frac{K_1}{K_2} = \left(\frac{\mu_1}{1-\mu_1}\right) \times \left(\frac{1-\mu_2}{\mu_2}\right)$$

$$= \frac{1.5}{0.9} = 1.666$$

6. (b)

$$\text{Exit gradient} = \frac{\text{Potential drop in last field}}{\text{Length of flow line of last square}} = \frac{18/12}{2} = 0.75$$

7. (b)

It is a coarse-soil, as only 7% are finer than 75 micron sieve.

It is a sandy soil because more than 50% of the coarse fraction passes through 4.75 mm sieve.

Size of aggregates varies linearly

<u>To calculate</u> D_{60}

$$\frac{80-7}{4.75-0.075} = \frac{80-60}{4.75-D_{60}}$$

$$\Rightarrow \quad D_{60} = 3.47 \text{ mm}$$

<u>To calculate</u> D_{30}

$$\Rightarrow \quad \frac{80-7}{4.75-0.075} = \frac{80-30}{4.75-D_{30}}$$

$$\Rightarrow \quad D_{30} = 1.548 \text{ mm}$$

Similarly, $D_{10} = 0.267$ mm

$\Rightarrow$ Uniformity Coefficient $C_u = \dfrac{D_{60}}{D_{10}} = 12.99 > 6$

and Coefficient of curvature $C_c = \dfrac{D_{30}^2}{D_{60} \times D_{10}} = 2.59$

$\Rightarrow$ $1 < C_c < 3$

$\therefore$ The soil is well graded and finer particles are non-plastic, so it is silt.

$\therefore$ It is SW – SM

8. **(d)**

As we know the relation,

$$\frac{s_f}{s_p} = \left[\frac{B_f}{B_p}\left(\frac{B_p+30}{B_f+30}\right)\right]^2$$

$$\Rightarrow \quad s_f = 12\left[\frac{300}{30}\left(\frac{30+30}{300+30}\right)\right]^2$$

$$\therefore \quad s_f = 39.67 \text{ mm}$$

9. **(c)**

For 50% consolidation, the value of time factor (T_v) will be same for both soils.

$$T_v = \frac{C_{v_1}t_1}{(d_1)^2} = \frac{C_{v_2}t_2}{(d_2)^2}$$

where, $C_{v_2} = 2C_{v_1}$

$$d_1 = \frac{d}{2}$$

$$d_2 = d$$

$$t_1 = 6 \text{ months}$$

$$\Rightarrow \quad \frac{C_{v_1} \times 6}{(d/2)^2} = \frac{2C_{v_1} \times t_2}{(d)^2}$$

$$\therefore \quad t_2 = 12 \text{ months}$$

10. (a)

$\phi' = 28°$, $\gamma_{sat} = 19$ kN/m^3, $F = 3$, $\beta = ?$, $\gamma' = 19 - 10 = 9$ kN/m^3

As we know that,

$$\text{Factor of safety} = \frac{\gamma' \tan\phi'}{\gamma_{sat} \tan\beta}$$

$$\Rightarrow \quad 3 = \frac{9 \times \tan 28°}{19 \times \tan\beta}$$

$$\Rightarrow \quad \tan\beta = 0.08395$$

$$\therefore \quad \beta = 4.80°$$

11. (b)

$$\text{Shrinkage Ratio} = \frac{\left(\frac{V_L - V_d}{V_d}\right) \times 100}{(w_L - w_s)} = \frac{\left(\frac{10-6}{6}\right) \times 100}{(50-15)} = 1.905\%$$

12. (a)

$$K_x = \frac{Zk + Z\frac{k}{3} + Z\frac{k}{2} + Z2k}{4Z} = \frac{23}{24}k$$

$$K_Z = \frac{4Z}{\frac{Z}{k} + \frac{3Z}{k} + \frac{2Z}{k} + \frac{Z}{2k}} = \frac{8}{13}k$$

13. (b)

Soil A - 1 kg $\quad w_C = 100\%$

$\therefore \quad w_S = 500$ gm

$w_W = 500$ gm

Soil B - 1 kg $\quad w_C = 50\%$

$\therefore \quad w_S = 666$ gm

$w_W = 333$ gm

$$\text{Water content of mixed soil} = \frac{\text{Wt. of water}}{\text{Wt. of soil solid}} = \frac{500 + 333}{500 + 666} = 0.7144 \text{ or } 71.44\%$$

14. (d)

1. Zone 1 : Makes an angle of ϕ with horizontal
2. Zone 2 : It remains in plastic equilibrium
3. Zone 3 : Makes an angle of $\left(45° - \frac{\phi}{2}\right)$ with horizontal

15. (d)

Utimate bearing capacity is given by

Circular footing:

$$Q_{uc} = 1.3\, cN_c + \gamma D_f N_q + 0.3\, b\gamma N_\gamma$$

Square footing:

$$Q_{us} = 1.3\, cN_c + \gamma D_f N_q + 0.4\, b\gamma N_\gamma$$

For cohesionless soil : $c = 0$

For footing on surface of soil: $D_f = 0$

$$\therefore \quad \frac{Q_{uc}}{Q_{us}} = \frac{0.3}{0.4} = 0.75$$

16. (b)

17. (a)

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

Ultimate bearing capacity of single $= \alpha\, c_u\, (\pi D)L$ (Neglecting End Bearing)

$$= 0.8 \times 50 \times (\pi \times 0.5) \times 15$$

$$= 942.5 \text{ kN}$$

18. (a)

$$A_t = \frac{I_P}{C}$$

where, C = Fraction of clay particles $= \dfrac{0.34}{1.5}$

$$I_P = 0.6 - 0.26 = 0.34$$

$$\therefore \quad A_t = \frac{(0.6 - 0.26)}{(0.34/1.5)} = 1.5$$

19. (b)

$$T_V = \frac{C_V t}{d^2} = \frac{\pi}{4} U^2$$ (For $U < 60\%$ consolidation)

$$\because \quad t \propto U^2$$

$$\frac{t}{178} = \left(\frac{60}{40}\right)^2$$

$$\therefore \quad t = 400.5 \text{ days}$$

Extra time required $= 400.5 - 178 = 222.5$ days

20. (a)

$$w = \left[\frac{(M_2 - M_1)}{(M_3 - M_4)} \cdot \left(\frac{G-1}{G}\right) - 1\right] \times 100$$

Where, $M_2 - M_1 = 1000$ gm

$M_3 = 2000$ gm

$M_4 = 1480$ gm

$\therefore$
$$w = \left[\frac{1000}{2000-1480} \times \left(\frac{2.67-1}{2.67}\right) - 1\right] \times 100$$
$$= 20.3\ \%$$

21. (c)

$$\frac{D_f}{B} = \frac{1.2}{2.5} = 0.48 < 2.5$$

$\therefore$ It is a shallow foundation

$$N_c = 6\left[1 + 0.2\left(\frac{D_f}{B}\right)\right]$$
$$= 6\left[1 + 0.2 \times \frac{1.2}{2.5}\right] = 6.576$$

$\therefore$
$$q_{nu} = cN_c$$
$$= 2.75 \times 6.576 \qquad \left(\because\ c = \frac{q_u}{2} = \frac{5.5}{2} = 2.75\ \text{t/m}^2\right)$$
$$= 18.084\ \text{t/m}^2$$

$\therefore$
$$q_s = \left(\frac{q_{nu}}{\text{FOS}}\right) + \gamma D_f$$
$$= \frac{18.084}{3} + 1.8 \times 1.2 = 8.2\ \text{t/m}^2$$

22. (b)

Given: $e_0 = 0.85$, $e_f = 0.73$, $\Delta\sigma_0 = (2-1)\ \text{kg/cm}^2 = 1\ \text{kg/cm}^2$

$\Delta e = (0.85 - 0.73) = 0.12$, $k = 3.3 \times 10^{-4}$ cm/sec

$\therefore$ Coefficient of volume change,

$$m_v = \frac{\Delta e}{(1+e_0)} \times \frac{1}{(\Delta\sigma_0)} = \frac{0.12}{(1+0.85)} \times \frac{1}{1}$$
$$m_v = 0.065\ \text{cm}^2/\text{kg}$$

$\therefore$ Coefficient of consolidation,

$$C_v = \frac{k}{(m_v \gamma_w)} = \frac{3.3 \times 10^{-4}}{(0.065 \times 10^{-3} \times 1)} = 5.08\ \text{cm}^2/\text{sec}$$

23. (b)

As we know the relation,

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

$\therefore$
$$e_1 = \frac{G\gamma_w}{\gamma_d} - 1 = \frac{2.65 \times 9.81}{16.65} - 1 = 0.56$$

$$V_1 = 2070\ \text{m}^3$$

Now, $$e_2 = \frac{n}{1-n} = \frac{0.33}{0.67} = 0.493$$

and, $$\frac{V_1}{1+e_1} = \frac{V_2}{1+e_2}$$

∴ $$V_2 = \frac{2070\times(1.493)}{1.56} = 1981.1\ \text{m}^3$$

24. (c)

The horizontal distance between two points along the sand stratum = 21 m

Vertical distance between these two points = $\frac{21}{15} = 1.4$ m

∴ Actual length of sand sample between two points = $\sqrt{(21)^2+(1.4)^2} = 21.047$ m

Now, $$Q = kiA$$

where, $$i = \frac{H_L}{L} = \frac{3.5}{21.047}$$

$$Q = 5 \text{ litres per hour} = \frac{5000}{60\times60}\text{cm}^3/\text{sec}$$

(∵ 1 litre = 1000 ml = 1000 cc)

$$A = 4 \text{ m depth} \times 1 \text{ m width}$$

$$A = 40000\ \text{cm}^2$$

Substituting these values, we get

⇒ $$\frac{5000}{60\times60} = k\left(\frac{3.5}{21.047}\right)\times 40000$$

∴ $$k = 2.09\times10^{-4}\ \text{cm/sec}$$

25. (d)

Effective stress at 5 m depth, $\bar{\sigma}_1 = \gamma_d \times 2.4 + \gamma_{sub}\times 2.6$

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

⇒ $$16.68 = \frac{2.7\times9.81}{1+e}$$

⇒ $$e = 0.588$$

$$\gamma_{sub} = \left(\frac{G-1}{1+e}\right)\gamma_w = \frac{2.7-1}{1+0.588}\times9.81 = 10.5\ \text{kN/m}^3$$

∴ $$\bar{\sigma}_1 = (16.68\times2.4 + 10.5\times2.6) = 67.33\ \text{kN/m}^2$$

The shear strength of the soil,

$$\tau_{f_1} = \bar{\sigma}_1\tan\phi = 67.33\times\tan36° = 48.92\ \text{kN/m}^2$$

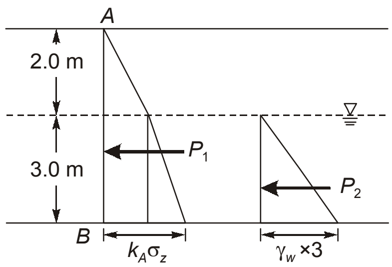
Now water table rises upto ground level,

$$\bar{\sigma}_2 = \gamma_{sub} \times 5 = 10.5 \times 5 = 52.5 \text{ kN/m}^2$$

and, $$\tau_{f_2} = \bar{\sigma}_2 \tan\phi = 52.5 \times \tan 36° = 38.14 \text{ kN/m}^2$$

∴ Decrease in shear strength = 48.92 – 38.14 = 10.78 kN/m^2

26. (c)



$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 28°}{1+\sin 28°} = 0.36$$

$$\rho_d = 1.61 \text{ gm/cc} \qquad \text{(given)}$$

$$\gamma_d = \rho_d \times g = 1.61 \times 9.81 = 15.79 \text{ kN/m}^3$$

$$\gamma_{sub} = \rho_{sub} \times g = 0.95 \times 9.81 = 9.32 \text{ kN/m}^3$$

The total active pressure at the base is given by

$$P_A = K_a \sigma_z + 3\gamma_w$$

Where, $$\sigma_z = \gamma_{dry} \times 2.0 + \gamma_{sub} \times 3$$

$$P_A = 0.36\,[15.79 \times 2.0 + 9.32 \times 3.0] + 3 \times 9.81$$

$$P_A = 50.86 \text{ kN/m}^2$$

27. (c)

Bulk density, $$\rho = \frac{1.855}{0.945 \times 10^{-3}} = 1962.96 \text{ kg/m}^3$$

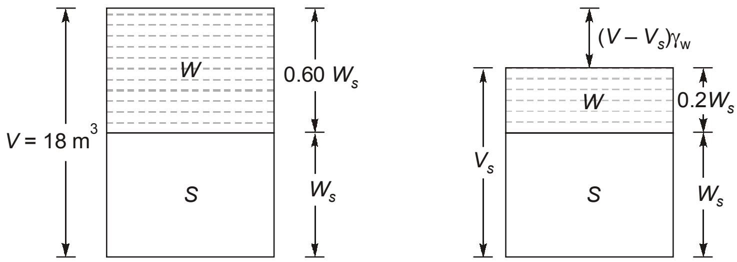
Dry density, $$\rho_d = \frac{\rho}{1+w} = \frac{1962.96}{1+0.16} = 1692.21 \text{ kg/m}^3$$

and $$\rho_d = \frac{(1-\eta_a)G\rho_w}{1+wG}$$

⇒ $$1-\eta_a = \frac{1692.21 \times (1+0.16 \times 2.68)}{2.68 \times 1000} = 0.9022$$

∴ $$\eta_a = 0.0978 \text{ or } 9.78\ \%$$

28. (c)



At liquid state	At shrinkage state
w = 60%	w = 20%
V = 18 m³	V = ?
S = 1	S = 1

$$\gamma_d = \frac{G_s\gamma_w}{1+\frac{wG_s}{S}}$$

At liquid limit,

$$\frac{W_s}{18} = \frac{G_s\gamma_w}{1+0.6\times 2.6} \quad \text{...(i)}$$

At shrinkage limit,

$$\frac{W_s}{V} = \frac{G_s\gamma_w}{1+0.20\times 2.6} \quad \text{....(ii)}$$

Dividing equation (i) by the equation (ii),

$$\Rightarrow \quad \frac{V}{18} = \frac{1+0.20\times 2.6}{1+0.60\times 2.6}$$

$$\therefore \quad V = 10.7 \text{ m}^3$$

29. (b)

Equivalent height of surcharge is, $z_e = \frac{q}{\gamma} = \frac{36}{18} = 2 \text{ m}$

Thus the problem reduces to the calculation of active earth pressure due to height

$$z = H + z_e = 4 + 2 = 6 \text{ m}$$

$$k_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 30°}{1+\sin 30°} = \frac{1}{3}$$

The pressure intensity at the base of the wall is given as

$$p_a = k_a\gamma z = \frac{1}{3}\times 18\times 6 = 36 \text{ kN/m}^2$$

The pressure intensity at the top of the wall is $= k_a \times q = \frac{1}{3}\times 36 = 12 \text{ kN/m}^2$

The pressure distribution is thus trapezoidal, therefore magnitude of active earth pressure,

$$P = \frac{1}{2}(12+36)\times 4 = 96 \text{ kN/m}$$

The distance of point of application from the base is

$$\bar{z} = \frac{H}{3}\left(\frac{2a+b}{a+b}\right) = \frac{4}{3}\times\left(\frac{2\times 12+36}{12+36}\right) = 1.67 \text{ m}$$

30. (a)

Original length of specimen, $L = 9$ cm

Initial cross-sectional area, $A_1 = \frac{\pi}{4}\times(4)^2 = 12.57 \text{ cm}^2$

Change in length at failure, $\Delta L = 1$ cm

$$\text{Area at failure, } A_2 = \frac{A_1}{1-\frac{\Delta L}{L}} = \frac{12.57}{1-\frac{1}{9}}$$

$$A_2 = 14.14 \text{ cm}^2$$

$$\therefore \quad \text{Unconfined compressive strength, } q_u = \frac{\text{Failure load}}{A_2} = \frac{465}{14.14} = 32.88 \text{ N/cm}^2$$

or $q_u = 328 \text{ kN/m}^2$ or 328 kPa

$$\therefore \quad \text{Shear strength, } c_u = \frac{q_u}{2} = \frac{328}{2} = 164 \text{ kPa}$$

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