S.No. : 08 KS_CE_S_161019

Soil Mechanics

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# CLASS TEST 2019-2020

## CIVIL ENGINEERING

**Date of Test : 16/10/2019**

## ANSWER KEY ➤ Soil Mechanics

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

## Detailed Explanations

2. (a)

$$C_C = \frac{\Delta e}{\log_{10}\frac{p}{p_0}} = \frac{0.3}{\log_{10}\frac{100}{10}} = \frac{0.3}{\log_{10}10} = 0.3$$

3. (d)

Corrected SPT value,

$$N = 15+\frac{1}{2}(N'-15) = 15+\frac{1}{2}(34-15) = 15 + 9.5 = 24.5$$

4. (b)

$$\text{Plasticity index, } I_P = w_L - w_P = 38 - 26 = 12\%$$

$$\text{Activity, } A = \frac{I_P}{\%\text{ clay finer than }2\,\mu} = \frac{12}{48} = 0.25$$

5. (c)

$$\frac{\text{Energy transferred in modified Proctor test}}{\text{Energy transferred in standard Proctor test}} = \frac{5\text{ layers}}{3\text{ layers}}\times\frac{4.9\text{kg}}{2.6\text{kg}}\times\frac{450\text{ mm}}{310\text{ mm}}\times\frac{25\text{ blows}}{25\text{ blows}} = 4.56$$

6. (a)

Ultimate 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, $D_f = 0$

$$\therefore \quad \frac{Q_{uc}}{Q_{us}} = \frac{0.3\times 2B\gamma N_\gamma}{0.4B\gamma N_\gamma} = \frac{0.3\times 2}{0.4} = 1.5$$

($\because$ $B' = 2B$)

7. (c)

Given, $D_{60} = 0.35$ mm; $D_{30} = 0.18$ mm

$D_{10} = 0.05$ mm

$$\therefore \quad C_c = \frac{D_{30}^2}{D_{60}\times D_{10}} = \frac{(0.18)^2}{0.35\times 0.05} = 1.85$$

$\because$ $1 < C_c < 3$

Hence, the soil is well graded.

8. (a)

$$\text{Normal stress at failure, } \sigma = \frac{0.36}{36\times 10^{-4}} = 100\text{ kN/m}^2$$

$$\text{Shear stress resisted, } \tau = \frac{0.18}{36\times 10^{-4}} = 50\text{ kN/m}^2$$

Using Coulomb's equation, $\tau = \sigma\tan\phi$

$$\Rightarrow \quad \tan\phi = \frac{\tau}{\sigma} = 0.5$$

$$\Rightarrow \quad \phi = \tan^{-1}(0.5) \simeq 26.6^\circ$$

9. (d)

$$U = \frac{2}{\sqrt{\pi}} \cdot \sqrt{T_v} \qquad \text{For} \le 60\%$$

Where, $$T_v = \frac{C_v}{d^2} \cdot t$$

∴ $$U = \frac{2}{\sqrt{\pi}} \cdot \sqrt{\frac{C_v \cdot t}{d^2}} = \frac{2}{\sqrt{\pi} \cdot d}\sqrt{C_v \cdot t}$$

⇒ $$U = \frac{2}{d} \cdot \sqrt{\frac{C_v \cdot t}{\pi}}$$

10. (b)

$$k = \frac{\gamma_w}{\eta} k' = 3 \times 10^{-7} \text{ cm/sec}$$

$$3 \times 10^{-7} \text{ cm/s} = \left[\frac{1 \text{ g/cm}^3}{0.0911 \times 10^{-4} \text{ g-sec/cm}^2}\right] k'$$

$$k' = 0.2733 \times 10^{-11} \text{ cm}^2$$

11. (b)

$$e = \frac{n}{1-n} = \frac{0.3}{1-0.3} = 0.43$$

$$i_e = \frac{G-1}{1+e} = \frac{2.67-1}{1+0.43}$$

$$= 1.1678$$

Now, $$\text{FOS} = 1.5$$

∴ $$i = \frac{i_c}{\text{FOS}} = \frac{1.1678}{1.5} = 0.7785$$

$$i = \frac{h}{L}, \text{ h} = 1.95 \text{ m}$$

$$L = \frac{h}{i} = 2.5 \text{ m}$$

∴ depth of coarse sand needed

$$= 2.5 - 1.5 = 1 \text{ m}$$

12. (b)

$$I_L = \frac{w - w_P}{I_P}$$

$$I_P = w_L - w_P$$

$$I_s = w_P - w_S$$

Put, values to get answer as,

$$I_L = \frac{25-20}{15} = 0.33$$

$$I_P = 35 - 20 = 15$$

$$I_S = 20 - 10 = 10$$

13. (c)

$$K = 100D_{10}^2 = 100 \times (0.01)^2 \text{ cm/s} = \frac{0.01}{100} \text{ m/s}$$

$$q = kHz\frac{N_f}{N_d} = \frac{0.01}{100} \times 3 \times \frac{1}{2} = 1.5 \times 10^{-4} \text{ m}^3\text{/s/m}$$

14. (b)

For fully saturated soil $S = 1$

We know that, $e = wG = 0.35\,G$

Also, $$\frac{\gamma}{\gamma_w} = \left(\frac{G+eS}{1+e}\right)$$

$$\Rightarrow \quad 1.9 = \frac{G+e}{1+e}$$

Since, $e = 0.35\,G$

$$\Rightarrow \quad 1.9 = \frac{G+0.35G}{1+0.35G}$$

$$\Rightarrow \quad G = 2.77$$

On oven drying, the mass specific gravity = 1.75

So, $$\frac{\gamma_d}{\gamma_w} = 1.75$$

Shrinkage limit, $$w_s = \left(\frac{\gamma_w}{\gamma_d} - \frac{1}{G}\right)$$

$$\Rightarrow \quad w_s = \left(\frac{1}{1.75} - \frac{1}{2.77}\right)$$

$$\Rightarrow \quad w_s = 0.2104 = 21.04\%$$

15. (c)

Given, $C_c = 0.4$, $e_1 = 0.6$, $\sigma_1 = 1.5 \text{ kg/cm}^2$ and $\sigma_2 = 3 \text{ kg/cm}^2$

Now, $$C_c = \frac{e_1 - e_2}{\log\frac{\sigma_2}{\sigma_1}}$$

$$\Rightarrow \quad 0.4 = \frac{0.6 - e_2}{\log\left(\frac{3}{1.5}\right)}$$

$$\Rightarrow \quad e_2 = 0.48$$

$\therefore$ Settlement, $$\Delta H = \frac{C_c H_c}{1+e_1}\log\frac{\sigma_2}{\sigma_1}$$

$$\Delta H = \frac{0.4 \times 5}{1+0.6}\log\frac{3}{1.5} = 0.376 \text{ m} \simeq 0.38 \text{ m}$$

16. (b)

Active earth pressure, $p_a = \sigma_z k_a - 2c\sqrt{k_a}$

where, $\sigma_z = (q + \gamma z)$

and
$$k_a = \tan^2\left(45 - \frac{\phi}{2}\right) = \frac{1}{\tan^2\left(45 + \frac{\phi}{2}\right)} = \frac{1}{\tan^2\alpha}$$

The depth with zero pressure,
$$z = \frac{1}{\gamma}\left[\frac{2c}{\sqrt{k_a}} - q\right] = \frac{2c}{\gamma}\tan\alpha - \frac{q}{\gamma}$$

17. (d)

$$\phi = 0,\ c_u = 17 \text{ kN/m}^2$$
$$\gamma = 16 \text{ kN/m}^3$$
$$k_a = \frac{1-\sin 0°}{1+\sin 0°} = 1$$
$$\text{Depth of tension crack} = \frac{2c_u}{\gamma\sqrt{k_a}} = \frac{2\times 17}{16\sqrt{1}} = 2.125 \text{ m}$$

18. (c)

The ultimate load capacity of piles
$$= 3 \times 7500 = 22500 \text{ kN}$$
The load capacity of single pile
$$= c_u N_c A_b + \alpha \bar{c}_u A_s = 200 \times 9 \times \frac{\pi}{4} \times (0.4)^2 + 0.62 \times 150 \times 15 \times 0.4\pi$$
$$= 1979.20 \text{ kN}$$
$$\therefore \quad \text{Number of piles} = \frac{22500}{1979.20} = 11.37 \text{ piles} \simeq 12 \text{ piles}$$
Hence use 12 number of piles.

19. (d)

$$e_0 = 0.70,\ \bar{\sigma}_0 = 50 \text{ kN/m}^2$$
$$e_1 = 0.65,\ \bar{\sigma}_1 = 100 \text{ kN/m}^2$$
Coefficient of compressibility,
$$a_v = -\frac{\Delta e}{\Delta\bar{\sigma}} = -\frac{(0.65-0.70)}{(100-50)} \text{m}^2/\text{kN}$$
$$= \frac{0.05}{50} \text{m}^2/\text{kN} = 0.001 \text{ m}^2/\text{kN}$$
Modulus of volume change or coefficient of volume decrease,
$$m_v = \frac{a_v}{(1+e_0)} = \frac{0.001}{(1+0.70)} = \frac{0.001}{1.7} \text{ m}^2/\text{kN}$$
$$= 5.88 \times 10^{-4} \text{ m}^2/\text{kN}$$
$$\text{Compression index, } C_C = -\frac{\Delta e}{\Delta(\log\bar{\sigma})} = -\frac{(0.65-0.70)}{(\log_{10}100 - \log_{10}50)}$$
$$= \frac{0.05}{\log_{10}\frac{100}{50}} = \frac{0.05}{\log_{10}2} = \frac{0.050}{0.301} = 0.166$$

20. (c)

$$k_0 = 0.5$$
$$\Rightarrow \quad k_0 = 1 - \sin\phi = 0.5$$

$\therefore$ $\sin\phi = 0.5$

Also, $k_a = \dfrac{1-\sin\phi}{1+\sin\phi} = \dfrac{1-0.5}{1+0.5} = \dfrac{1}{3}$

$$k_p = \frac{1-0.5}{1+0.5} = 3$$

$$k_a \times k_p = 1$$

$$k_0 = \frac{\mu}{1-\mu}$$

$\Rightarrow$ $0.5 = \dfrac{\mu}{1-\mu}$

$\Rightarrow$ $\mu = \dfrac{1}{3}$

21. (b)

$$\sigma_3 = 1 \text{ kg/cm}^2$$

$$\alpha = 45° + \frac{\phi}{2} = 45° + \frac{20}{2} = 55°$$

$$\sigma_1 = \sigma_3 \tan^2\alpha + 2c\tan\alpha = 1\cdot\tan^2 55° + 2\times 0.8 + \tan 55°$$

$$= 4.32 \text{ kg/cm}^2$$

Deviator stress $= \sigma_1 - \sigma_3 = (4.32 - 1) \text{ kg/cm}^2 = 3.32 \text{ kg/cm}^2$

22. (b)

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

here, $\alpha = 45°$

$\therefore$ $\sigma_1 = \sigma_3 + 2c$

$\Rightarrow$ $c = \dfrac{\sigma_1 - \sigma_3}{2}$

23. (c)

The time periods 0 to 10 and 10 to 20 minutes are equally spaced. So let the initial height of water column be $h_0$ at $t = 0$

Let at $t = 10$ min, height of water column = $h_1$

and at $t = 20$ min, height of water column = $h_2$

$$k = \frac{2.3\,aL}{A\Delta t}\log\left(\frac{h_0}{h_1}\right) = \frac{2.3\,aL}{A\Delta t}\log\left(\frac{h_1}{h_2}\right)$$

$$h_0 h_2 = h_1^2 \Rightarrow h_1 = \sqrt{h_0 h_2}$$

| Samples | $h_1$ | $\sqrt{h_0 h_2}$ |
|---|---|---|
| A | 32 | 32 |
| B | 30 | 30 |
| C | 20 | $\sqrt{480} > 20$ (inconsistent) |
| D | 36 | 36 |

24. (b)

$$G = \frac{W_s}{W_s - (W_3 - W_4)}$$

Initially, $W_s = 1.04$ N ; $W_3 = 5.38$ N ; $W_4 = 4.756$ N

$$\therefore \quad G = \frac{1.04}{1.04-(5.38-4.756)} = 2.50$$

If some air is entrapped while the weight $W_3$ is taken, the observed value of $W_3$ will be lower than if water occupied this air space.

Since the air entrapped is given as 3 m$l$, this space, if occupied by water, would have enhanced the weight $W_3$ by 0.03 N.

$$\therefore \quad W_3' = 5.38 + 0.03 = 5.41 \text{ N}$$

$$\therefore \quad \text{Correct value of } G = \frac{1.04}{1.04-(5.41-4.756)} = \frac{1.040}{0.386} = 2.694$$

$$\text{Percentage error} = \frac{(2.694-2.500)}{2.694} \times 100 = 7.2\%$$

25. (d)

$$\text{Shrinkage limit} = \frac{(M_1 - M_3) - (V_1 - V_2)\rho_w}{M_s}$$

$$= \frac{(16.5-10.9)-(9.75-5.4)\times 1}{10.9} = 0.1147 = 11.47\%$$

$$\text{Shrinkage limit} = \frac{1}{SR} - \frac{1}{2.63}$$

$$\Rightarrow \quad SR = 2.02$$

26. (a)

Cohesion of clay,

$$C_u = \frac{T}{\pi D^2\left(\frac{H}{2}+\frac{D}{6}\right)} = \frac{1000}{\pi 10^2 \times \left(\frac{20}{2}+\frac{10}{6}\right)}$$

$$= \frac{1}{\pi\left(1+\frac{1}{6}\right)} = \frac{1}{\pi}\times\frac{6}{7} \text{ kg/cm}^2$$

27. (a)

We know that; $Q_{sf} = \bar{\sigma}_n \tan\delta$

i.e $Q_{sf} = \left(k\bar{\sigma}_0 \times \tan\delta\right) \times A_p \times l$

i.e

$$Q_{sf} = \frac{k \times \left(\frac{\gamma \times l}{2}\right) \times \tan\delta \times A_p \times l}{\text{FOS}}$$

$$\Rightarrow \quad 277 \times 2.5 = 1 \times \tan(0.75 \times 30) \times \pi \times 0.3 \times \frac{21}{2} \times l^2$$

$$\Rightarrow \quad l = 13 \text{ m}$$

So, depth of liquefication is 18 – 13 = 5 m.

28. (c)

$$\text{Final settlement, } \rho_f = \frac{C_S \cdot H}{1+e_0}\log_{10}\frac{\sigma'_p}{\sigma'_0} + \frac{C_S \cdot H}{1+e_0}\log_{10}\frac{\sigma'}{\sigma'_p}$$

Here, $\sigma'_0 = 40 \text{ kN/m}^2,\ \sigma'_p = 60 \text{ kN/m}^2,\ \sigma' = 40 + 50 = 90 \text{ kN/m}^2$

$\therefore$ $$\rho_f = \frac{0.05}{1+1.3}\times 3\log_{10}\frac{60}{40} + \frac{0.28}{1+1.3}\times 3\log_{10}\frac{90}{60}$$

or $\rho_f = 0.01148 + 0.06431$

$= 0.07579 \text{ m} = 75.8 \text{ mm}$

29. (c)

$$\text{Depth of tension crack} = \frac{2C_u}{\gamma} = \frac{q_u}{\gamma}$$

$$= \frac{2\times 1000}{2} = 1000 \text{ cm} = 10 \text{ m}$$

30. (a)

$$S_i = qB\left(\frac{1-\mu^2}{E_s}\right)\times I$$

$q$ = load per unit area = 100 kN/m$^2$

$B$ = 2 m (characteristic length of loaded area)

$\mu$ = 0.5

$E_s = 5 \times 10^4$ kN/m$^2$

$I$ = Influence factor = 1.36

$$S_i = 100\times 2\left(\frac{1-(0.5)^2}{5\times 10^4}\right)\times 1.36 = 0.00408 \text{ m}$$

$\Rightarrow$ $S_i = 4.08$ mm

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