5 CHAPTER

Principle of Effective Stress, Capillarity and Permeability

Q.1 Consider the following soil strata given below.

H_1	k_1
H_2	k_2
H_3	k_3

Which of the following statements are correct?
1. Head loss is same in horizontal direction.
2. Head loss is same in vertical direction.
3. Discharge is same in horizontal direction.
4. Discharge is same in vertical direction.

(a) 2 and 4 (b) 1 and 3
(c) 2 and 3 (d) 1 and 4

Q.2 Permeability of soil depends on which of the following factors?
1. Adsorbed water 2. Head
3. Degree of saturation

(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

Q.3 Which of the following statement is correct?
(a) Capillary water and adsorbed water constitute pore water.
(b) Capillary water and gravity water constitute pore water.
(c) Adsorbed water and gravity constitute pore water.
(d) Adsorbed water, capillary water and gravity water constitute pore water.

Q.4 Assertion (A): When a dry sand is slightly moistened and loosely dumped, its volume increases.
Reason (R): Apparent cohesion holds the solids together to form cluster and enclose large volume of voids.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.5 Assertion (A): If a surcharge q is applied over infinitely large area, effective stress will remain unchanged immediately after application of surcharge.
Reason (R): Total pressure increases by same amount but pore pressure remains constant.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.6 Consider the following statements related to stress:
1. Total stress includes self-weight of soil mass and not the effect of surcharge.
2. Effective stress is transmitted by one layer to other through grain to grain contact.
3. Pore water pressure is transmitted equally in all the directions.
4. Contact stress and effective stress are different thing and effective stress is much higher than contact stress.

Which of the above statements are wrong?
(a) 1 and 2
(b) 1, 2 and 3
(c) 1 and 4
(d) 2 and 4

Q.7 Which of the following statement is correct?
(a) Permeability is directional.
(b) Discharge velocity is greater than seepage velocity.
(c) Clay is having highest porosity & permeability among gravels, silt, sand & clay.
(d) Permeability is inversely proportional to temperatures.

Q.8 Match the Column-I with the effective stress distribution diagram in Column-II.

Column-I

A. GL, GW_T, Z_1, γ, Z, γ_{sat}

B. GW_T, GL, Z_1, Z, γ_{sat}

C. q kN/m², Z, γ_{sat}, Short term analysis

D. q kN/m², Z, γ_{sat}, Long term analysis

Column-II

1. q, $q + \gamma Z$

2. γZ

3. $\gamma Z_1 + \gamma' Z$

Codes:

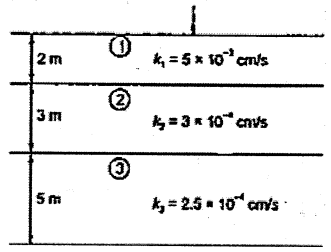
	A	B	C	D
(a)	3	2	2	1
(b)	3	2	1	2
(c)	1	1	3	3
(d)	2	2	1	3

Q.9 If head loss is doubled and length of soil sample is made 4 times in constant head permeability test, then, permeability of soil sample becomes
(a) remains unchanged
(b) becomes 2 times
(c) become 1/2 times
(d) becomes 8 times

Q.10 Which of the following is used to check the consistency of test in falling head permeability test if test is performed in two stages in which head difference falls from h_1 to h_2 and then h_2 to h_3 in same time?

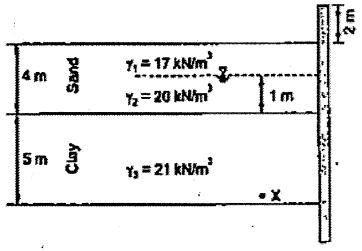
(a) $h_1 = \sqrt{h_2 h_3}$ (b) $h_2 = \sqrt{h_1 h_3}$
(c) $h_3 = \sqrt{h_1 h_2}$ (d) $h_2 = \sqrt{h_1 / h_3}$

Q.11 Consider a three layered soil strata the value of thickness and coefficient of permeability for different layer are given below. The value of head loss for layer 2 is 0.4 m. The value of total head loss through the soil strata and velocity through soil strata '3' are



(a) 1.216 m, 6.08 5 10^{-5} cm/s
(b) 1.216 m, 0.4 × 10^{-4} cm/s
(c) 1.329 m, 8 × 10^{-5} cm/s
(d) 1.329 m, 0.4 × 10^{-4} cm/s

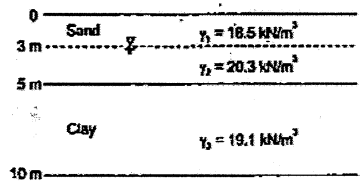
Q.12



From the above diagram, the value of effective stress at point X in kN/m^2 is

(a) 68.09 (b) 176
(c) 117.14 (d) 97.52

Q.13



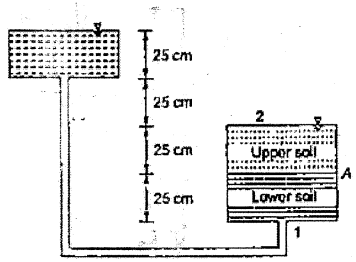
Consider the above soil strata. What will be the change in effective stress at 10 m, if water table rises 1 m above the ground surface?

(a) 122.93 (b) 98.9
(c) 24.03 (d) No change

Q.14 What will be the maximum permissible upward gradient, if a factor of safety of 3 is required against boiling in a sand? $n = 40\%$ and $G = 2.65$.

(a) 0.39 (b) 0.33
(c) 0.43 (d) 0.9

Q.15 Two different granular soils are placed in a permeameter tube and flow is allowed to take place under a constant total head. The total head and pressure head at point A in centimeters are respectively



(a) 75, 75 (b) 25, 50
(c) 25, 75 (d) 75, 25

Q.16 The coefficient of permeability of a soil is 5×10^{-5} cm/s for a certain pore fluid. If the viscosity of the pore fluid is reduced to half, the coefficient of permeability will be

(a) 5×10^{-5} cm/s (b) 10×10^{-5} cm/s
(c) 2.5×10^{-5} cm/s (d) 1.25×10^{-5} cm/s

Q.17 To draw flow net for anisotropic soils, keeping the vertical dimension unaltered, a transformed section has to be drawn by multiplying all horizontal dimensions by

(a) $\sqrt{\frac{k_y}{k_x}}$ (b) $\frac{\sqrt{k_x}}{k_y}$

(c) $\sqrt{\frac{k_x + k_y}{k_y - k_y}}$ (d) $\frac{k_x}{k_y}$

Q.18 Direct measurement of permeability of a soil specimen at any stage of loading in consolidation test can be made

(a) only in a fixed ring type of consolidometer
(b) only in a floating ring type of consolidometer
(c) both (a) and (b)
(d) None of the above

Q.19 The liquefaction of loose sand deposits may be caused by

(a) dilatancy (b) thixotropy
(c) sensitivity (d) None of the above

Q.20 The exit gradient for fine sand is taken as

(a) 1/6 to 1/7 (b) 1/4 to 1/5
(c) 1/4 to 1/3 (d) 1/2 to 1/3

Q.21 A flow line makes angles θ_1 and θ_2 with the normal to the interface of two soils having permeabilities k_1 and k_2 before and after deflection. According to the law of deflection of the flow lines at the interface of the dissimilar soils,

(a) $\frac{\sin\theta_1}{\sin\theta_2} = \frac{k_1}{k_2}$ (b) $\frac{\cos\theta_1}{\cos\theta_2} = \frac{k_1}{k_2}$

(c) $\frac{\tan\theta_1}{\tan\theta_2} = \frac{k_1}{k_2}$ (d) $\frac{\tan\theta_2}{\tan\theta_1} = \frac{k_1}{k_2}$

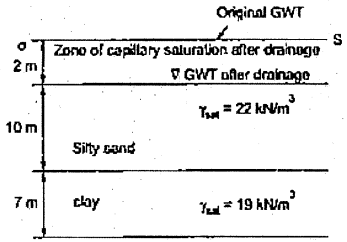
Q.22 A particular soil sample is subjected to test for the determination of permeability coefficient in two separate constant head permeameters, whose specification are as under:

	Permeameter A	Permeameter B
Diameter of sample	D	$2D$
Length of sample	$2L$	L

If the tests on both the permeameters are conducted with equal head of water applied on the samples, then the ratio of amount of water discharged through the permeameters A and B during a period of one hour will be:

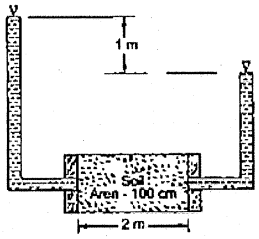
(a) 4.000 (b) 1.000
(c) 0.250 (d) 0.125

Q.23 For the soil strata as shown in figure, the water table is lowered by drainage by 2 m and if the top 2 m thick silty sand stratum remains saturated by capillary action even after lowering of water table, the increase in effective vertical pressure in kPa at mid-height of clay layer will be



(a) 0.2 (b) 2
(c) 20 (d) 200

Q.24 In the situation shown in the given figure, the coefficient of permeability of the soil is 10^{-3} cm/s. The discharge in one minute will be



(a) 2 ml (b) 3 ml
(c) 6 ml (d) 12 ml

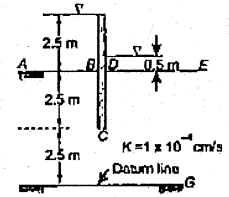
Q.25 Consider the following data obtained in falling head permeability tests regarding four soil-samples A, B, C and D.

Time (Minute)	Height of water column in cm A	B	C	D
0	40	40	40	40
10	32	30	20	36
20	25.6	22.5	12	32.4

Which one of the above soil-sample has internally inconsistent data?

(a) A (b) B
(c) C (d) D

Q.26 A sheet pipe is driven into a sandy bed as shown in the given figure. The head along the upstream bed AB and the head along the downstream bed DE, respectively, are



(a) 2.5m and 0.5m (b) 2m and 0.5m
(c) 7.5m and 5.5m (d) 5m and 5.5m

■■■■

Answers — Principle of Effective Stress, Capillarity and Permeability

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

Explanations — Principle of Effective Stress, Capillarity and Permeability

2. (c)
Permeability of soil depends on:
(i) Size of particles
(ii) Void ratio
(iii) Particle shape
(iv) Degree of saturation
(v) Structure of soil
(vi) Properties of water
(vii) Entrapped gases
(viii) Adsorbed water
(ix) Foreign impurities
(x) Presence of minerals in the water

5. (c)
Immediately after application of load, all the load is taken by pore water, hence total stress and pore pressure increases by same amount.

6. (c)
Total stress include self-weight and surcharge. Contact stress and effective stress are different and contact stress is much higher than effective stress.

7. (a)

$$V_s = \frac{V}{n} \qquad (n < 1)$$

$\therefore \quad V_s > V$

Clay is having highest porosity but permeability is less.

9. (b)

$$k = \frac{VL}{Ath_L}$$

$$k \propto \frac{L}{h_L}$$

$$k' \propto \frac{4L}{2h_L}$$

$$\frac{k'}{k} = 2$$

$$\Rightarrow \quad k' = 2k$$

10. (b)

$$k = \frac{2.303aL}{At}\log\frac{h_1}{h_2}$$

$$\frac{h_1}{h_2} = \frac{h_2}{h_3}$$

$$\Rightarrow \quad h_2^2 = h_1h_3$$

$$\Rightarrow \quad h_2 = \sqrt{h_1h_3}$$

11. (b)

$$k_z = \frac{10}{\frac{2}{5\times10^{-3}} + \frac{3}{3\times10^{-4}} + \frac{5}{2.5\times10^{-4}}}$$

$$= 3.29 \times 10^{-4} \text{ cm/s}$$

$$V = ki$$

$$= 3\times10^{-4} \times \frac{0.4}{3} = 0.4\times10^{-4} \text{ cm/s}$$

$$0.4 \times 10^{-4} = 3.29\times10^{-4} \times \frac{h}{10}$$

$$\Rightarrow \quad h = 1.216 \text{ m}$$

12. (c)

$$\sigma = 17\times3 + 20\times1 + 21\times5$$
$$= 176 \text{ kN/m}^2$$
$$u = 6\times9.81 = 58.86 \text{ kN/m}^2$$
$$\therefore \quad \bar{\sigma} = 176 - 58.86$$
$$= 117.14 \text{ kN/m}^2$$

13. (c)
Before rise of water table

$$\bar{\sigma}_1 = 18.5\times3 + 20.3\times2 + 19.1\times5 - 9.81\times7$$
$$= 122.93 \text{ kN/m}^2$$

After rise of water table

$$\bar{\sigma}_2 = 1\times9.81 + 20.3\times5 + 19.1\times5 - 11\times9.81$$
$$= 98.9 \text{ kN/m}^2$$
$$\Delta\bar{\sigma} = 122.93 - 98.9$$
$$= 24.03 \text{ kN/m}^2$$

14. (b)

$$i_C = (G-1)(1-n)$$
$$= (2.65-1)(1-0.4) = 0.99$$
$$\therefore \quad \text{FOS} = \frac{i_C}{i}$$
$$\Rightarrow \quad i = \frac{i_C}{\text{FOS}} = \frac{0.99}{3} = 0.33$$

15. (b)
Datum is at top of bottom soil.
Datum head at A = –25 cm
At 1 total head = 100 – 50 = 50 cm
Pressure = 100
Datum head = –50
Total head loss from 1 to 2 is 50 cm.

$\therefore$ Head loss between land $A = \frac{1}{2}\times50 = 25$ cm

Total head at A = Total head at 1 – head loss between 1 and A.
$= 50 - 25 = 25$
$DH + PH = TH$
$PH = TH - DH$
$= 25 - (-25) = 50$ cm

16. (b)

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

Thus, $k \propto \frac{1}{\mu}$

Hence, k will get doubled.
So, $k = 2\times(5\times10^{-5})$
$= 10\times10^{-5}$ cm/s

18. (a)
It can be made only in fixed ring type.

22. (d)

$$\frac{q_A}{q_B} = \frac{k\frac{h}{L_A}\times A_A}{k\frac{h}{L_B}\times A_B}$$

$$= \frac{1}{4\times2} = \frac{1}{8} = 0.12$$

23. (c)
Before lowering of water table, effective stress at mid height of clay layer

$$\bar{\sigma} = 12\times\gamma_{sat} + 3.5\gamma_{sat}(\text{clay}) - 15.5\,\gamma_w$$

After lowering

$$\bar{\sigma} = 12\gamma_{sat} + 3.5\gamma_{sat}(\text{clay}) - 13.5\,\gamma_w$$

Change in stress

$$\Delta\bar{\sigma} = 2\gamma_w = 2\times10 = 20 \text{ kN/m}^2 = 20 \text{ kPa}$$

24. (b)
Discharge per minute, $q = kiA$

$$= 10^{-3}\times\frac{1}{2}\times100\times60 = 3 \text{ m}^3$$

25. (c)
For the data to be internally consistent,

$$\frac{h_1}{h_2} = \frac{h_2}{h_3}$$

$$\Rightarrow \quad h_2 = \sqrt{h_1h_3}$$

For soil sample A

$$h_2 = 32 \text{ cm} = \sqrt{25.6\times40}$$

For soil sample B

$$h_2 = 30 \text{ cm} = \sqrt{22.5\times40}$$

For soil sample C

$$h_2 = 20 \text{ cm} \neq \sqrt{40\times12}$$

Hence inconsistent