11 CHAPTER

Lateral Earth Pressures and Retaining Walls

Q.1 The coefficient of earth pressure at rest in terms of Poisson's ratio (μ) is

(a) $\frac{\mu}{1+\mu}$ (b) $-\frac{\mu}{1-\mu}$

(c) $-\frac{\mu}{1+\mu}$ (d) $\frac{\mu}{1-\mu}$

Q.2 Match Column-I with Column-II and select the correct answer using the codes given below:

Column-I

A. Active pressure
B. Passive pressure
C. Earth pressure at rest

Column-II

1. Wall moves towards backfill
2. No movement of wall
3. Wall moves away from backfill

Codes:

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

Q.3 Consider the following assumptions:

1. The backfill is dry and homogeneous.
2. The sliding wedge acts as a rigid body.
3. The back face of the wall is plane.
4. The position and direction of the earth thrust are known.

Which of these assumptions are common to Rankine's and Coulomb's earth pressure theories?

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

Q.4 Consider the following statements:

1. Culmann's graphical method of determining the earth pressure is based on Coulomb's wedge theory.
2. Rankine's theory of lateral earth pressure is more versatile than Coulomb's theory.
3. A gravity retaining wall together with the retained backfill and supporting wall is an indeterminate system.

Which of these statements are correct?

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

Q.5 Consider the following statements:

Active earth pressure will be developed in the backfill when the

1. horizontal strain is 0.5%
2. horizontal strain is 1%
3. mobilized shearing resistance along the failure plane is the minimum.
4. mobilized shearing resistance along the failure plane is a maximum.

Which of these statements are correct?

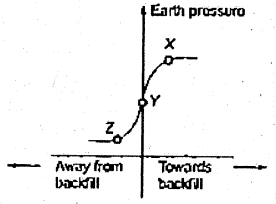
(a) 1 and 3 (b) 1 and 4
(c) 2 and 3 (d) 2 and 4

Q.6 The effect of cohesion of a soil is to

(a) decrease both the active as well as passive earth pressure intensities
(b) decrease the active earth pressure intensity but increase the passive earth pressure intensity
(c) increase the active earth pressure intensity but decrease the passive earth pressure intensity
(d) increase both the active as well as passive earth pressure intensities

Q.7 The lateral pressure distribution behind a flexible bulk head differs from the active earth pressure distribution given by Rankine, due to
(a) arching effect of soil
(b) over consolidation of soil
(c) plastic failure of soil
(d) none of these

Q.8 Earth pressure and resultant possibility of wall movement are shown in the diagram below.



Lateral movement of retaining wall

The earth pressure points marked as X, Y and Z in the diagram denotes respectively
(a) Active, Rest and Passive
(b) Rest, Active and Passive
(c) Passive, Active and Rest
(d) Passive, Rest and Active

Q.9 For a perfectly cohesionless soil, active and passive earth pressure coefficients are 1/3 and 3 respectively. What is the value of coefficient of earth pressure at rest for above said soil?
(a) 1.00 (b) 0.66
(c) 0.50 (d) 0.33

Q.10 Why are weep holes provided at the back of retaining walls?
(a) To reduce the active earth pressure on the walls.
(b) To reduce the build-up of hydrostatic pressure.
(c) To provide better compaction.
(d) To increase the passive earth pressure.

Q.11 Passive pressure in soil is associated with
(a) lateral expansion of the soil
(b) lateral compression of the soil
(c) zero lateral strain
(d) None of these

Q.12 To stabilize a concrete cantilever retaining wall against sliding, the ratio of sliding force to resisting force should be
(a) ≥ 1.55 (b) ≤ 1.55
(c) ≥ 1.0 (d) ≤ 0.645

Q.13 The following refer to the stability analysis of an earth dam under different conditions:
1. Stability of downstream slope during steady seepage.
2. Stability of downstream slope during sudden drawdown.
3. Stability of upstream and downstream slopes during construction.

Which of these statements are correct?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

Q.14 The critical height of an unsupported vertical cut in a cohesive soil is given by

(a) $\frac{4c}{\gamma}\tan\left(45°+\frac{\phi}{2}\right)$

(b) $\frac{2c}{\gamma}\tan\left(45°+\frac{\phi}{2}\right)$

(c) $\frac{4c}{\gamma}\cot\left(45°+\frac{\phi}{2}\right)$

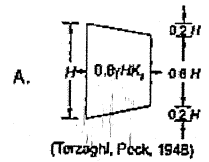
(d) $\frac{2c}{\gamma}\cot\left(45°+\frac{\phi}{2}\right)$

where, c = unit cohesion
ϕ = angle of internal friction
γ = unit weight of soil

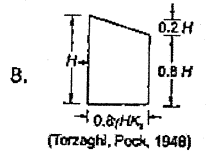
Q.15 Effect of cohesion (c) in soil is to reduce the earth pressure by
(a) $2c\tan\alpha$ (b) $c\cot\alpha$
(c) $2c\cot\alpha$ (d) $\frac{2c}{\cot\alpha}$

Q.16 Match List-I (Pressure distribution for strutted excavation of foundation trench) with List-II (Soil type) and select the correct answer using the codes given below the lists:

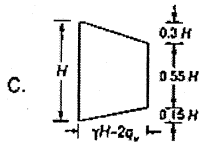
List-I

A.


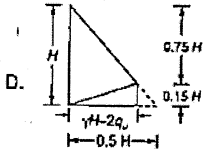
(Terzaghi, Peck, 1948)

B.


(Terzaghi, Peck, 1948)

C.


(Terzaghi, Peck, 1948)

D.


(Tschebotarff, 1973)

List-II
1. Dense sand
2. Moderately stiff clay
3. Loose sand
4. Plastic clay

Codes:

	A	B	C	D
(a)	1	3	4	2
(b)	4	2	1	3
(c)	2	4	3	1
(d)	1	2	3	4

Q.17 Match List-I (structure) with List-II (Deformation) and select the correct answer using the codes given below the lists:

List-I
A. Retaining wall
B. Bridge abutment
C. Cantilever sheet pile
D. Anchored bulkhead

List-II
1. The wall moves about the dredge line as a rigid structure
2. The wall moves in the form of elastic line, with a point of contraflexure
3. The bottom moves away from soil
4. The top of the wall moves away from the soil

Codes:

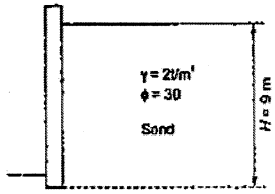
	A	B	C	D
(a)	3	4	1	2
(b)	3	4	2	1
(c)	4	3	1	2
(d)	4	3	2	1

Q.18 A rigid retaining wall, 6 m high is restrained from yielding. The backfill consists of cohesionless soil having $\phi = 26°$ and $\gamma = 19\ kN/m^3$. The total earth pressure per metre length of the wall is
(a) 134 kN/m
(b) 873 kN/m
(c) 900 kN/m
(d) 192 kN/m

Q.19 A retaining wall with soft saturated clay backfill is 7 m high. If backfill is in undrained condition then the active force after the occurrence of the tensile crack is ($\gamma = 16\ kN/m^3$, $c_u = 17\ kN/m^2$)
(a) 154 kN/m (b) 190 kN/m
(c) 210 kN/m (d) 120 kN/m

Q.20 A retaining wall 8 m high with a smooth vertical back retains a clay backfill with $c' = 15\ kN/m^2$, $\phi = 15$ and $\gamma = 18\ kN/m^3$. (Given $\sin 15° = 0.25$). The pressure at top will nearly will be equal to in kN/m^2
(a) 35.2 (b) 23.0
(c) 27.6 (d) 11.5

Q.21 Active earth pressure per meter length on the retaining wall with a smooth vertical back as shown in figure will be



(a) 81 t (b) 27 t
(c) 2 t (d) 1 t

Q.22 During a site reconnaissance survey, it was observed that 10 m height of soil is standing without any lateral support. What is the cohesive strength of soil with $\phi = 0$ and $\gamma = 20$ kN/m³?
(a) 100 kPa (b) 50 kPa
(c) 25 kPa (d) 200 kPa

Q.23 Given:
μ_1 = Poisson's ratio of soil sample 1
μ_2 = Poisson's ratio of soil sample 2
k_1 = Coefficient of earth pressure at rest for soil sample 1
If $\mu_1/\mu_2 = 1.5$ and $(1-\mu_1)/(1-\mu_2) = 0.875$, then the value of k_1/k_2 will be
(a) 1.3125 (b) 1.7143
(c) 1.9687 (d) 1.8213

Q.24 A retaining wall of height 8 m retains dry sand. In the initial state, the soil is loose and has a void ratio of 0.5, $\gamma_d = 17.8$ kN/m³ and $\phi = 30°$. Subsequently, the backfill is compacted to a state where void ratio is 0.4, $\gamma_d = 18.8$ kN/m³ and $\phi = 35°$. The ratio of initial passive thrust to the final passive thrust, according to Rankine's earth pressure theory, is
(a) 0.38 (b) 0.64
(c) 0.77 (d) 1.55

Q.25 Assertion (A): Rankine's earth pressure theory is a simplified form of Coulomb's earth pressure theory.
Reason (R): Coulomb's theory considers effect of pore pressure.
(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

■■■■

Answers Lateral Earth Pressures and Retaining Walls

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

Explanations Lateral Earth Pressures and Retaining Walls

1. (d)
For rest condition

$$\epsilon_h = 0$$

$$\frac{\sigma_h}{E} - \mu\frac{\sigma_h}{E} - \frac{\mu\sigma_v}{E} = 0$$

$$\sigma_h(1-\mu) = \mu\sigma_v$$

$$\frac{\sigma_h}{\sigma_v} = \frac{\mu}{1-\mu}$$

9. (c)

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

and $$k_p = 3 = \frac{1+\sin\phi}{1-\sin\phi}$$

$$\Rightarrow \quad \sin\phi = \frac{1}{2}$$

$$\phi = 30°$$

Now, for a perfect cohesionless soil, the earth pressure coefficient at rest,

$$k_0 = 1-\sin\phi$$

$$= 1-\frac{1}{2} = \frac{1}{2}$$

11. (b)
Passive pressure compresses soil horizontally. It occurs when the retaining wall moves towards the backfill. Active pressure stretches soil horizontally and exerts tensile force in soil layer. It occurs when the retaining wall moves away from the backfill.

12. (d)
Factor of safety against sliding

$$F_s = \frac{\Sigma F_R}{\Sigma F_d}$$

ΣF_R = sum of the horizontal resisting forces
ΣF_d = sum of horizontal driving forces.
Usually $F_s \geq 1.55$
∴ Ratio of sliding force to resisting force

$$\leq \frac{1}{1.55} \leq 0.645$$

13. (b)
For earth dam during steady seepage, the critical condition occurs for *D/S* slope. For rapid drawdown case *U/S* slope represents critical condition. In both cases the pore water pressure is determined from flow net.
During construction, the excess pore pressure is likely to develop and stability of *U/S* and *D/S* slopes during or immediately after construction should be considered.

14. (a)

$$p_a = K_a\gamma z - 2c\sqrt{K_a}$$

At $z = z_c$, $p_a = 0$

$$\Rightarrow \quad 0 = K_a\gamma z_c - 2c\sqrt{K_a}$$

$$\Rightarrow \quad z_c = \frac{2c}{\gamma\sqrt{K_a}}$$

$$\Rightarrow \quad z_c = \frac{2c}{\gamma}\tan\left(45°+\frac{\phi}{2}\right)$$

Critical height of an unsupported vertical cut,

$$H_c = 2z_c$$

$$= \frac{4c}{\gamma}\tan\left(45°+\frac{\phi}{2}\right)$$

15. (c)

$$p_a = k_a\gamma z - 2c\sqrt{k_a}$$

$$\Rightarrow \quad p_a = \frac{\gamma z}{N_\phi} - \frac{2c}{\sqrt{N_\phi}}$$

where,

$$N_\phi = \tan^2\left(45+\frac{\phi}{2}\right) = \text{influence value} = k_p$$

$$\therefore \quad p_a = \frac{\gamma z}{\tan^2\left(45+\frac{\phi}{2}\right)} - \frac{2c}{\tan\left(45+\frac{\phi}{2}\right)}$$

$$= \gamma z\cot^2\left(45+\frac{\phi}{2}\right) - 2c\cot\left(45+\frac{\phi}{2}\right)$$

Hence earth pressure reduces by 2c cot.

16. (d)
Since the wall is restrained from yielding, the wall will be subjected to earth pressure at rest.

$$P_0 = \frac{1}{2}\times k_0\times\gamma H^2$$

$$k_0 = 1-\sin 26° = 0.5616$$

$$\therefore \quad P_0 = \frac{1}{2}\times 0.5616\times 19\times 6^2$$

$$= 192.1 \text{ kN/m length of wall}$$

19. (b)

$$K_a = \frac{1-\sin 0°}{1+\sin 0°} = 1$$

$$Z_0 = \frac{2c}{\gamma\sqrt{K_a}} = \frac{2\times 17}{16\times\sqrt{1}} = 2.125 \text{ m}$$

When the crack develops, the soil in the depth Z_0 becomes inactive

$$\therefore \quad P_a = \frac{1}{2}\times K_a\times\gamma\times(H-Z_0)^2$$

$$= \frac{1}{2}\times 1\times 16\times(7-2.125)^2$$

$$= 190.125 \text{ kN/m}$$

20. (b)

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = 0.589$$

$$\therefore \quad \sigma_1 = k_a\gamma h - 2c\sqrt{k_a}$$

At top $h = 0$

$$\sigma = -2c\sqrt{k_a}$$

$$= -2\times 15\times\sqrt{0.589}$$

$$= 23\,\text{kN/m}^2$$

21. (b)

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

$$P = \frac{1}{2}\times k_a\gamma\times H^2$$

$$= \frac{1}{2}\times\frac{1}{3}\times 2\times 9^2 = 27t$$

22. (b)

$$H = \frac{4C}{\gamma\sqrt{k_a}}$$

$$k_a = 1$$

$$10 = \frac{4\times c}{20}$$

$$\Rightarrow \quad c = 50\,\text{kPa}$$

23. (b)

$$k_1 = \frac{\mu_1}{1-\mu_1}$$

$$k_2 = \frac{\mu_2}{1-\mu_2}$$

$$\therefore \quad \frac{k_1}{k_2} = \left(\frac{\mu_1}{1-\mu_1}\right)\Big/\left(\frac{\mu_2}{1-\mu_2}\right)$$

$$= \left(\frac{\mu_1}{\mu_2}\right)\left(\frac{1-\mu_2}{1-\mu_1}\right)$$

$$= \frac{1.5}{0.875} = 1.7143$$

24. (c)

$$\gamma_d = 17.8\,\text{kN/m}^3$$

$$\phi = 30°$$

$$e = 0.5$$

$$k_{p_1} = \frac{1+\sin 30°}{1-\sin 30°} = 3$$

$$\therefore \quad p_{p_1} = \frac{1}{2}k_{p_1}\gamma H^2$$

$$= \frac{1}{2}\times 3\times 17.8\times 8^2$$

$$= 1708.8\,\text{kN/m}$$

$$k_{p_2} = \frac{1+\sin 35°}{1-\sin 35°} = 3.69$$

$$\therefore \quad p_{p_2} = \frac{1}{2}\times 3.69\times 18.8\times 8^2$$

$$= 2220\,\text{kN/m}$$

$$\therefore \text{Ratio } \frac{p_{p_1}}{p_{p_2}} = \frac{1708.8}{2220} = 0.77$$