Stability of Earth Slopes

Q.1 Taylor's stability number curves are used for the analysis of stability of slopes. The angle of shearing resistance used in the chart is the
(a) effective angle (b) apparent angle
(c) mobilized angle (d) weighted angle

Q.2 For an infinite slope in cohesionless soil mass, factor of safety
(a) increases with depth
(b) decreases with depth
(c) remains same
(d) None of these

Q.3 Consider the following forces:
1. Weight of the sliding wedge of slope.
2. Resultant reaction 'R' of the slip.
3. Total cohesive resistance developed along the slip circle.
4. Critical height of slope.

Which of these are taken into consideration in the friction circle method for the equilibrium of sliding sector in the stability analysis of slope?
(a) 1, 2 and 4 (b) 1, 3 and 4
(c) 1, 2 and 3 (d) 2, 3 and 4

Q.4 For base failure of a slope, the depth factor D is
(a) zero (b) 1
(c) $0 < D < 1$ (d) $D > 1$

Q.5 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 upstream 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.6 Which of the following statements are CORRECT?
I. In case of finite slope, the sliding is rotational whereas in infinite slope, the sliding is translational.
II. Variation in c value is generally more as compared to ϕ, hence larger factor of safety can be used for angle of internal friction.
III. With respect to a c-ϕ soil in an infinite slope, the factor of safety of the slope does not depend on the height of soil on the slope.
(a) I and II (b) II and III
(c) I and III (d) All of these

Q.7 In the slope stability analysis by friction circle method, the radius of friction circle is
(a) $R\cos\phi$ (b) $R\sin\phi$
(c) $R\tan\phi$ (d) $R\sec\phi$

Q.8 An excavation was made in saturated soft clay ($\phi_u = 0$) with its sides vertical. When the depth of excavation reached 6 m, the sides caved in. The value of cohesion of the clay, if unit weight of clay is 20 kN/m³ will be
(a) 15 kN/m² (b) 20 kN/m²
(c) 30 kN/m² (d) 40 kN/m²

Q.9 For a clay slope of height 10 m, the stability number is 0.05, bulk density is 20 kN/m³ and cohesion is 25 kN/m². The critical height of the slope in this soil is
(a) 4.0 m (b) 12.5 m
(c) 25 m (d) 15 m

Q.10 List-I given below gives the possible types of failure for a finite soil slope and List-II gives the reasons for these different types of failure. Match the items in List-I with the items in List-II and select the correct answer from the codes given below the lists:

List-I
A. Base failure
B. Face failure
C. Toe failure

List-II
1. Soils above and below the toe have same strength
2. Soil above the toe is relatively weaker
3. Soil above the toe is relatively stronger

Codes:

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

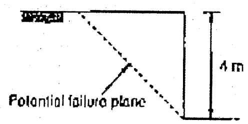
Q.11 Assertion (A): The factor of safety obtained in the Fellenius method of slices is conservative.
Reason (R): In the Fellenius method, the effect of horizontal forces acting on the sides of slices are neglected, but the effect of shearing forces acting on the sides of slices are included.
(a) both 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.12 For a soil, cohesion is 15 kN/m³ unit weight is 20 kN/m³ and the factor of safety is 1.5 along with stability number of 0.05. The safe maximum height of slope is
(a) 5.0 m (b) 8.0 m
(c) 10.0 m (d) 12.0 m

Q.13 Factor of safety against sliding of a slope, is the ratio of
(a) actual cohesion to that required to maintain stability of slope
(b) shear strength to shear stress along the surface
(c) neither (a) nor (b)
(d) both (a) and (b)

Q.14 The factor of safety of an infinite slope in a sand deposit is found to be 1.732. The angle of shearing resistance of the sand is 30°. The average slope of the sand deposit is
(a) $\sin^{-1}(0.333)$ (b) $\cos^{-1}(0.252)$
(c) $\tan^{-1}(0.333)$ (d) $\cot^{-1}(0.621)$

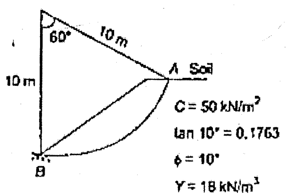
Q.15 Using $\phi_u = 0$ analysis and assuming palnner failure as shown in the figure below, the minimum factor of safety against shear failure of a vertical cut of height 4 m in a pure clay having c_u = 120 kN/m² and γ_{sat} = kN/m³ is



(a) 1 (b) 6
(c) 10 (d) 20

Q.16 A canal 6 m deep runs through a soil having C_u = 18 kN/m², ϕ_u = 10°, e = 0.80 and G_s = 2.72. The angle of slope of bank is 45°. If sudden drawdown takes place upto the bed level of the canal, the factor of safety is
(For β = angle of slope of bank = 45°, ϕ_u = 10°, S_n = 0.108, ϕ_u = 4.88°, stability number = 0.137)
(a) 2.96 (b) 2.14
(c) 1.41 (d) 1.14

Common data question:
Consider a sliding surface *AB* in the figure below:



Normal effective pressure on sliding surface *AB* is 255 kN/m² downward tangential disturbing force along *AB* is 840 kN.

Q.17 The factor of safety with respect to shear strength criteria is
(a) 1.468 (b) 0.68
(c) 0.86 (d) 0.98

Q.18 The factor of safety with respect to height is
(a) 1.846 (b) 1.264
(c) 1.341 (d) 1.628

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Answers **Stability of Earth Slopes**

1. (d)	2. (c)	3. (c)	4. (d)	5. (d)	6. (a)	7. (b)	8. (c)	9. (c)	10. (d)
11. (c)	12. (c)	13. (d)	14. (c)	15. (b)	16. (d)	17. (b)	18. (a)		

Explanations **Stability of Earth Slopes**

2. (c)

$$\text{FOS} = \frac{\tan\phi}{\tan i}$$

It does not depend on depth.

8. (c)
Critical height of an unsupported cut in a c-ϕ soil is $2z_0$ = 6 m

$$\Rightarrow \quad z_0 = 3\text{ m}$$

$$\text{where} \quad z_0 = \frac{2c}{\gamma\cdot\sqrt{K_A}}$$

$$\Rightarrow \quad 3 = \frac{2\times c}{20\times\sqrt{\frac{1-\sin 0°}{1+\sin 0°}}}$$

$$\Rightarrow \quad c = 30\text{ kN/m}^2$$

9. (c)
Stability number,

$$S_n = \frac{c}{\gamma\cdot H_c}$$

$$\therefore \quad H_c = \frac{c}{\gamma S_n} = \frac{25}{0.05\times 20} = 25\text{m}$$

10. (d)
Face failure or slope failure can occur when the slope angle β is very high and the soil close to the toe is quite strong or the soil in the upper part of slope is relatively weak.
Base failure can occur when the soil below the toe is relatively weak and soft and the slope is flat.
Toe failure occurs in steep slopes when the soil mass above the base and below the base is homogeneous.

12. (c)

$$S_n = \frac{C}{\gamma H_C}$$

$$\Rightarrow \quad S_n = \frac{C}{\gamma \text{FOS}\times H}$$

$$\Rightarrow \quad H = \frac{15}{0.05\times 1.5\times 20} = 10\text{ m}$$

14. (c)

$$\text{FOS} = \frac{\sigma\tan\phi}{\sigma\tan\beta}$$

$$\Rightarrow \quad 1.732 = \frac{\tan\phi}{\tan\beta} = \frac{\tan 30°}{\tan\beta}$$

$$\Rightarrow \quad \beta = \tan^{-1}(0.333)$$

16. (d)

$$\gamma_{sat} = \left(\frac{G_s + e}{1+e}\right)\gamma_w$$

$$= \left(\frac{2.72+0.80}{1+0.80}\right)\times 9.81 = 19.18 \text{ kN/m}^3$$

Submerged weight,

$$\gamma' = \gamma_{sat} - \gamma_w$$
$$= 19.18 - 9.81 = 9.37 \text{ kN/m}^3$$

For sudden drawdown, reduced ϕ is used.

$$\phi_u = \left(\frac{\gamma'}{\gamma_{sat}}\right)\times \phi_u$$

$$= \frac{9.37}{19.18}\times 10 = 4.88^\circ$$

$$\gamma = \gamma_{sat}$$

$$\Rightarrow \quad F_c = \frac{C_u}{S_n \gamma H} = \frac{18}{0.137\times 19.18\times 6} = 1.14$$

17. (b)

We know,

$$\text{FOS} = \frac{C_m r\theta + \Sigma N \tan\phi}{\Sigma T}$$

$$= \frac{\left(50\times 10\times \frac{\pi}{3}\right) + (255\times \tan 10^\circ)}{840}$$

$$= 0.680$$

18. (a)

$$i = 30^\circ$$

$$H_c = \frac{C}{\gamma \cos^2 i(\tan i - \tan\phi)} \text{ww}$$

$$= \frac{50}{18\cos^2 30^\circ(\tan 30^\circ - \tan 10^\circ)}$$

$$= 9.23\text{m}$$

$$H = 10 \sin i = 10 \sin 30^\circ = 5 \text{ m}$$

$$\text{FOS} = \frac{H_c}{H} = \frac{9.23}{5} = 1.846$$

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