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2025

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GATE
Civil Engineering

Contents

Solved Papers (Topic-Wise)

Unit VI Geotechnical Engineering

Unit XIII Construction Materials and Management

Unit XIV General Aptitude

10 CHAPTER

Stability of Slopes

Stability of Infinite Slopes

1. With respect to a c-ϕ soil in an infinite slope, identify if the following two statements are True or False.

I. The stable slope angle can be greater than ϕ

II. The factor of safety of the slope does not depend on the height of soil in the slope.

(a) Both statements are False
(b) I is True but II is False
(c) I is False but II is True
(d) Both statements are True

[2001 : 1 Mark]

2. An infinite slope is to be constructed in a soil. The effective stress strength parameters of the soil are $c' = 0$ and $\phi' = 30°$. The saturated unit weight of the slope is 20 kN/m^3 and the unit weight of water is 10 kN/m^3. Assuming that seepage is occurring parallel to the slope, the maximum slope angle for a factor of safety of 1.5 would be

(a) 10.89° (b) 11.30°
(c) 12.48° (d) 14.73°

[2002 : 2 Marks]

3. A granular soil possesses saturated density of 20 kN/m^3. Its effective angle of internal friction is? 35 degrees. If the desired factor of safety is 1.5, the safe angle of slope for this soil, when seepage occurs at and parallel to the slope surface, will be

(a) 25° (b) 23°
(c) 20° (d) 13°

[2003 : 1 Mark]

4. An infinite soil slope with an inclination of 35° is subjected to seepage parallel to its surface. The soil has $c' = 100$ kN/m^2 and $\phi' = 30°$. Using the concept of mobilized cohesion and friction, at a factor of safety of 1.5 with respect to shear strength, the mobilized friction angle is

(a) 20.02° (b) 21.05°
(c) 23.33° (d) 30.00°

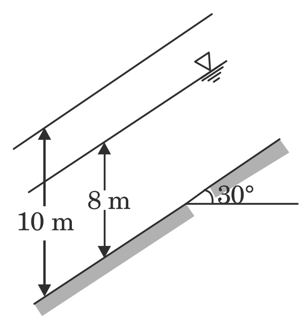
[2004 : 2 Marks]

5. For two infinite slopes (one in dry condition and other in submerged condition) in a sand deposit having the angle of shearing resistance 30°, factor of safety was determined as 1.5 (for both slopes). The slope angles would have been

(a) 21.05° for dry slope and 21.05° for submerged slope
(b) 19.47° for dry slope and 18.40° for submerged slope
(c) 18.4° for dry slope and 21.05° for submerged slope
(d) 22.6° for dry slope and 19.47° for submerged slope

[2005 : 2 Marks]

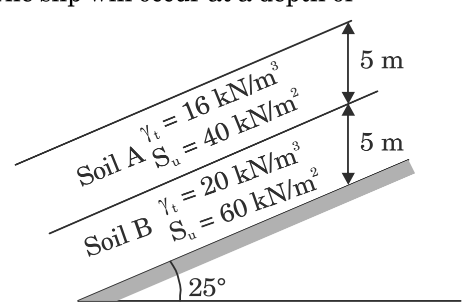
6. The factor of safety of an infinite soil slope shown in the figure having the properties c = 0, $\phi = 35°$, $\gamma_{dry} = 16$ kN/m^3 and $\gamma_{sat} = 20$ kN/m^3 is approximately equal to



(a) 0.70 (b) 0.80
(c) 1.00 (d) 1.20

[2007 : 2 Marks]

7. The soil profile above the rock surface at 25° infinite slope is shown in figure where S_u is undrain shear stress and γ_t is total unit weight. The slip will occur at a depth of



(a) 8.83 m (b) 9.79 m
(c) 7.83 m (d) 6.53 m

[2013 : 2 Marks]

8. A long slope is formed in a soil with shear strength parameters: $c' = 0$ and $\phi' = 34°$. A firm stratum lies below the slope and it is assumed that the water table may occasionally rise to the surface, with seepage taking place parallel to the slope. Use $\gamma_{sat} = 18$ kN/m^3 and $\gamma_w = 10$ kN/m^3. The maximum slope angle (in degrees) to ensure a factor of safety of 1.5, assuming a potential failure surface parallel to the slope, would be

(a) 45.3 (b) 44.7

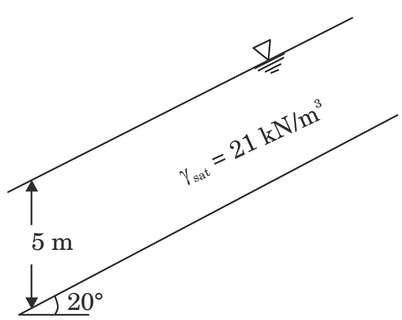
(c) 12.3 (d) 11.3

[2014 : 1 Mark, Set-I]

9. An infinitely long slope is made up of a c-ϕ soil having the properties: cohesion (c) = 20 kPa, and dry unit weight (γ_d) = 16 kN/m^3. The angle of inclination and critical height of the slope are 40° and 5 m, respectively. To maintain the limiting equilibrium, the angle of internal friction of the soil (in degrees) is____________.

[2014 : 2 Marks, Set-II]

10. The infinite sand slope shown in the figure is on the verge of sliding failure. The ground water table coincides with the ground surface. Unit weight of water $\gamma_w = 9.81$ kN/m^3.



The value of the effective angle of internal friction (in degrees, up to one decimal place) of the sand is ________________.

[2017 : 2 Marks, Set-I]

11. A granular soil has a saturated unit weight of 20 kN/m^3 and an effective angle of shearing resistance of 30°. The unit weight of water is 9.81 kN/m^3. A slope is to be made on this soil deposit in which the seepage occurs parallel to the slope up to the free surface. Under this seepage condition for a factor of safety of 1.5, the safe slope angle (in degree, round off to 1 decimal place) would be ______.

[2019 : 2 Marks, Set-I]

12. An earthen dam of height H is made of cohesive soil whose cohesion and unit weight are c and γ, respectively.

If the factor of safety against cohesion is F_c, the Taylor's stability number (Sn) is

(*a*) $\dfrac{\gamma H}{cF_c}$ (*b*) $\dfrac{c}{F_c \gamma H}$

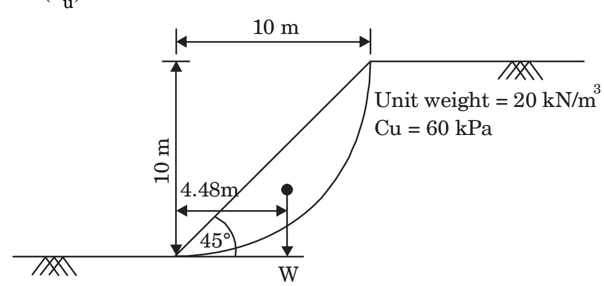
(*c*) $\dfrac{F_c \gamma H}{c}$ (*d*) $\dfrac{cF_c}{\gamma H}$

[2019 : 1 Mark, Set-II]

13. A fully submerged infinite sandy slope has an inclination of 30° with the horizontal. The saturated unit weight and effective angle of internal friction of sand are 18 kN/m^3 and 38° respectively. The unit weight of water is 10 kN/m^3. Assume that the seepage is parallel to the slope. Against shear failure of the slope, the factor of safety (round off to two decimal places) is ______.

[2020 : 1 Mark, Set-I]

14. A 10 m high slope of dry clay soil (unit weight = 20 kN/m^3), with a slope angle of 45° and the circular slip surface, is shown in the figure (not drawn to the scale). The weight of the slip wedge is denoted by W. The undrained unit cohesion (c_u) is 60 kPa.



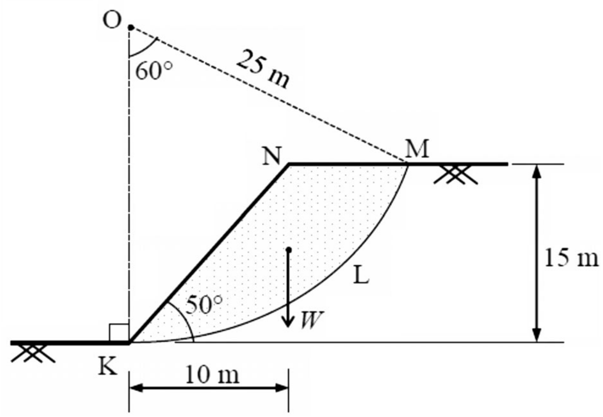
The factor of safety of the slope against slip failure, is

(a) 1.84 (b) 1.57

(c) 0.58 (d) 1.67

[2020 : 2 Marks, Set-II]

15. An unsupported slope of height 15 m is shown in the figure (not to scale), in which the slope face makes an angle 50° with the horizontal. The slope material comprises purely cohesive soil having undrained cohesion 75 kPa. A trial slip circle KLM, with a radius 25 m, passes through the crest and toe of the slope and it subtends an angle 60° at its center O. The weight of the active soil mass (W, bounded by KLMN) is 2500 kN/m, which is acting at a horizontal distance of 10 m from the toe of the slope. Consider the water table to be present at a very large depth from the ground surface.



Considering the trial slip circle KLM, the factor of safety against the failure of slope under undrained condition (*round off to two decimal places*) is ______________

[2021 : 2 Marks, Set-I]

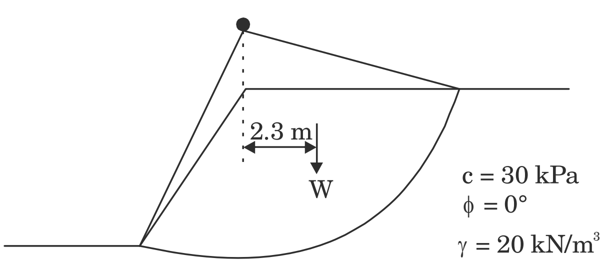
16. An infinite slope is made up of cohesionless soil with seepage parallel to and upto the sloping surface. The angle of slope is 30° with respect to horizontal ground surface. The unit weight of the saturated soil and water are 20 kN/m^3 and 10 kN/m^3 respectively.

The minimum angle of shearing resistance of soil (in degrees) for the critically stable condition of the slope is __ . (rounded off to the nearest integer).

[2024 : 2 Marks, Set-I]

Stability of Finite Slopes

17. The critical slip circle for a slope is shown below along with the soil properties



The length of the arc of the slip circle is 15.6 m and the area of soil within the slip circle is 82 m^2. The radius of the slip circles is 10.3 m. The factor of safety against the slip circle failure is nearly equal to

(a) 1.05 (b) 1.22
(c) 0.78 (d) 1.28

[2001 : 2 Marks]

18. **List-I** 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 comparatively weaker
3. Soil above the toe is comparatively stronger

Codes:

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

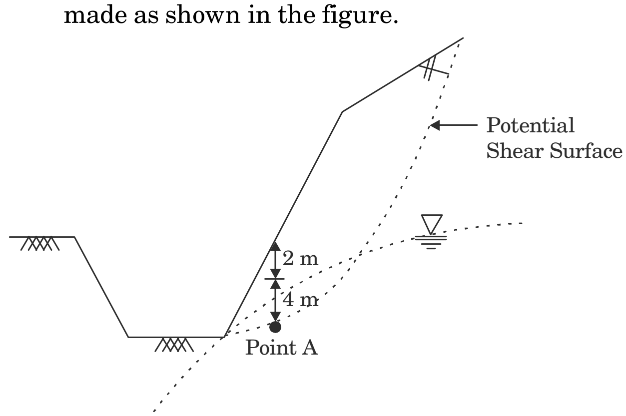
[2006 : 2 Marks]

19. In friction circle method of slope analysis, if r defines the radius of the slip circle, the radius of friction circle is

(a) r sin ϕ (b) r
(c) r cos ϕ (d) r tan ϕ

[2015 : 1 Mark, Set-II]

20. For the construction of a highway, a cut is to be made as shown in the figure.



The soil exhibits c´ = 20 kPA, ϕ´ = 18°, and the undrained shear strength = 80 kPa. The unit weight of water is 9.81 kN/m^3. The unit weights of the soil above and below the ground water table are 18 and 20 kN/m^3, respectively. If the shear stress at point A is 50 kPa, the factors of safety against the shear failure at this point, considering the undrained and drained conditions, respectively, would be

(a) 1.6 and 0.9 (b) 0.9 and 1.6
(c) 0.6 and 1.2 (d) 1.2 and 0.6

[2017 : 2 Marks, Set-II]

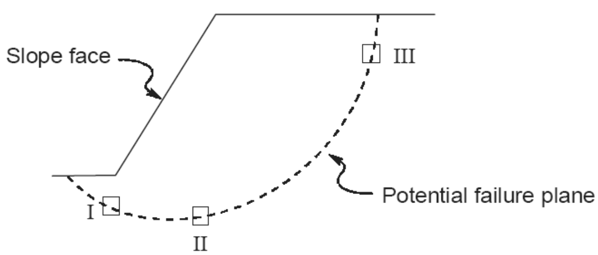
21. A possible slope failure is shown in the figure. Three soil samples are taken from different locations (I, II and III) of the potential failure plane. Which is the most appropriate shear strength test for each of the sample to identify the failure mechanism? Identify the correct combination from the following options:

P: Triaxial compression test

Q: Triaxial extension test

R: Direct shear or shear box test

S: Vane shear test



(a) I-Q, II-R, III-P (b) I-R, II-P, III-Q
(c) I-S, II-Q, III-R (d) I-P, II-R, III-Q

[2023 : 1 Mark, Set-I]

22. A soil having the average properties, bulk unit weight = 19 kN/m^3; angle of internal friction = 25° and cohesion = 15 kPa, is being formed on a rock slope existing at an inclination of 35° with the horizontal. The critical height (in m) of the soil formation up to which it would be stable without any failure is __________ (round off to one decimal place).

[Assume the soil is being formed parallel to the rock bedding plane and there is no ground water effect.]

[2023 : 2 Marks, Set-I]

Stability Number

23. A deep cut of 7 m has to be made in a clay with unit weight 16 kN/m^3 and a cohesion of 25 kN/m^2. What will be the factor of safety is one has to have a slope angle of 30°? Stability number is given to be 0.178 (from Taylor's chart) for a depth factor of 3.

(a) 0.80 (b) 1.1
(c) 1.25 (d) 1.0

[2000 : 1 Mark]

Common Data for Questions 24 and 25:

A canal having side slopes 1:1 is proposed to be constructed in a cohesive soil to a depth of 10 m below the ground surface. The soil properties are ϕ_u = 15°, c_u = 12 kPa, e= 1.0, G_s = 2.65.

24. If Taylor's Stability Number, Sn is 0.08 and if the canal flows full, the factor of safety with respect to cohesion against failure of the canal bank slopes will be

(a) 3.7 (b) 1.85
(c) 1.0 (d) None of these

[2003 : 2 Marks]

25. If there is a sudden drawdown of water in the canal and if Taylor's Stability Number for the reduced value of ϕ_w is 0.126, the factor of safety with respect to cohesion against the failure of bank slopes will be

(a) 1.85 (b) 1.18
(c) 0.84 (d) 0.53

[2003 : 2 Marks]

ANSWERS

1. (b)	**2.** (a)	**3.** (a)	**4.** (b)	**5.** (a)	**6.** (a)	**7.** (a)	**8.** (d)	**9.** (22.4°)	**10.** (34.33°)
11. (21.79°)		**12.** (b)	**13.** (0.6014 ≈ 0.60)		**14.** (a)	**15.** (1.94 to 1.98)		**16.** (49.10)	
17. (d)	**18.** (d)	**19.** (a)	**20.** (a)	**21.** (a)	**22.** (5.0)(5.0 – 5.2)		**23.** (c)	**24.** (b)	**25.** (d)

EXPLANATIONS

1. In c-ϕ soil in an infinite slope; for stability; FOS ≤ 1

where FOS = $\dfrac{\text{Shear strength}}{\text{Shear stress}}$

Stable slope angle (β) can be greater than ϕ.

$$\text{FOS} = \frac{c + \sigma \tan\phi}{\tau} \Rightarrow \frac{c + \gamma z \cos^2\beta \tan\phi}{\gamma z \cos\beta \sin\beta}$$

($\because$ $\sigma = \gamma z \cos^2 \beta$; and $\tau = \gamma z \cos \beta \sin \beta$)

Thus, FOS of slope depend on the height of soil in the slope.

Hence STATEMENT 2 is fals and 1 is TRUE.

2. Resisting Shear strength (τ_f) = c + σ tan ϕ

Driving strength (τ)

$$\text{FOS} = \frac{\tau_f}{\tau} = \frac{\text{Ressiting force}}{\text{Driving force}}$$

Resisting force (τ_f) = $c' + \bar{\sigma}_n \tan\phi$

= 0 + r'z cos²β tan φ

Driving force (τ) = $\gamma z \cos \beta \sin \beta$

$$\text{FOS} = \frac{r_{subz} \cos^2\beta \tan\phi}{\gamma\, z \cos\beta\, \sin\beta}$$

$$1.5 = \frac{(20-10)}{20}\frac{\tan 30^\circ}{\tan\beta}$$

Maximum slope angle (β) = 10.89°

3. Given, $\gamma_{sat} = 20\, kN/m^2$, $\phi = 35°$

F.O.S. = 1.5

But F.O.S. = $\dfrac{\tan\phi}{\tan i} = \dfrac{\tan 35°}{\tan i}$

$\therefore$ $\tan i$ = 0.4668

or i = 25°

4. $\tan \phi_m = \dfrac{\tan\phi}{\text{factor of safety}} = \dfrac{\tan 30}{1.5}$

$\therefore$ $\phi_m = 21.05.$

5. In infinite slope, for dry soil, F.S. = $\dfrac{\tan\phi}{\tan i}$

$$i = \tan^{-1}\left(\frac{\tan\phi}{F.S}\right)$$

$$= \tan^{-1}\left(\frac{\tan 30}{1.5}\right) = 21.05°$$

For submersed condition, F.S = $\dfrac{\tan\phi'}{\tan i}$

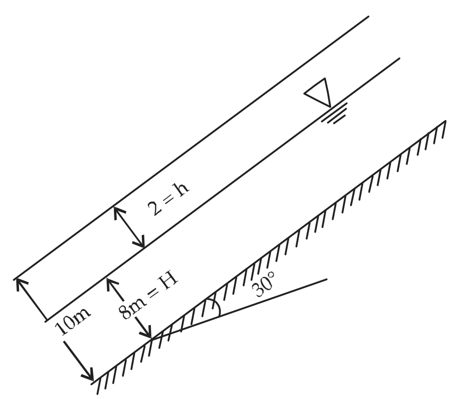
$\therefore$ i = 21.05°

6. Here, c = 0, $\phi = 35°$,

$g_{dry} = 10\, kN/m^3$, $g_{sat} = 29\, kN/m^3$

Factor of safety of infinite slope,

$$F_S = \frac{S}{T}$$



$$S = (g' H + h\, g_{dry}) \cos^2 i \tan\phi'$$
$$T = (g_{sat} \times H + g'_{dry} \times \lambda) \sin i \cos i$$

$$F_S = \frac{\left(g' H + h\, g_{dry}\right) \cos^2 i \tan\phi}{\left(g_{sat} \times H + g_{dry} \times h\right) \sin i \cos i}$$

$$= \frac{\left[(20-10) \times 8 + 2 \times 16\right] \cos^2 30 \times \tan 35°}{\left[20 \times 8 + 16 \times 2\right] \sin 30\ \cos 30°}$$

= 0.707

7. FOS = $\dfrac{\text{Resisting force}}{\text{Driving force}}$

FOS = $\dfrac{c+\bar{\sigma}_n \tan\phi}{\tau}$

effective normal stress $\sigma_z = \gamma_{sub} z \cos^2\beta$

$\tau = r_{sat}$ z cos β sin b

Case: I For first 5m layer;

$\therefore$ FOS = $\dfrac{40+16\times(x)\cos^2\beta\tan\phi}{16\times(x)\cos\beta\sin\beta}$

$\Rightarrow \dfrac{40}{16x\dfrac{\sin^2\theta}{2}}$ $(\because \phi = 0)$

FOS = $\dfrac{40}{8x\sin 50^\circ}$

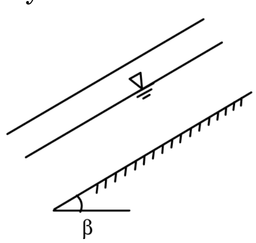
At x = 5m;

FOS = $\dfrac{40}{8\times5\times\sin 50^\circ} = \dfrac{1}{\sin 50^\circ}$

i.e. $\boxed{\text{FOS} > 1}$ $(\because$ sin 50° value is less than 1)

Since FOS > 1; hence no slip will occur in 1st layer.

8.



$c' = 0$, $\phi' = 34°$

γ_{sat} = 18 kN/m³

γ_w = 10 kN/m³

F.O.S. = 1.5

$\gamma_{sub} = \gamma_{sat} - \gamma_w$

When water table rises to surface

$= 18 - 10$

$= 8$ kN/m³

F.O.S. = $\dfrac{\gamma_{sub}}{\gamma_{sat}}\dfrac{\tan\phi}{\tan\beta}$

$\Rightarrow$ $1.5 = \dfrac{8}{18}\times\dfrac{\tan 30^\circ}{\tan\beta}$

$\Rightarrow$ $\tan\beta = 0.199$

$\Rightarrow$ $\beta = 11.30°$

9. For infinitly long slope applying the Equation

$\dfrac{c}{\gamma H_c} = (\tan i - \tan\phi)\times\cos^2 i$

c = 20 KN/m², $\gamma_d = \gamma$ = 16 KN/m², H_C = 5m

i = 40°, ϕ = ?

$\dfrac{20}{16\times5} = (\tan 40^\circ - \tan\phi)\times\cos^2 40$

$0.25 = (\tan 40^\circ - \tan\phi)\times 0.587$

$\tan\phi = \tan 40^\circ - 0.426 = 0.413$

$\phi = 22.4°$

10. FOS = $\dfrac{\text{Shear strength}}{\text{Shear stress}}$

FOS = $\dfrac{c+\sigma_n\tan\phi}{\tau}$

Vertical stress can be resolved in two components;

$\sigma = \sigma_z\cos\beta = \gamma_z\cos^2\beta$

$\tau = \sigma_z\sin\beta = \gamma_z\cos\beta\sin\beta$

In case of sand c = 0

FOS = $\dfrac{\gamma_z\cos^2\beta\tan\phi}{\gamma_z\cos\beta\sin\beta}$

FOS = $\dfrac{\gamma_{sub}(5)\tan\phi}{\gamma_{sat}(5)\tan\beta}$

FOS = $\dfrac{(21-9.81)\tan\phi}{21\tan 20^\circ}$

$\tan\phi = \dfrac{21\times\tan 20^\circ}{11.19}$ $(\because$ FOS = 1)

$\phi = 34.33°$

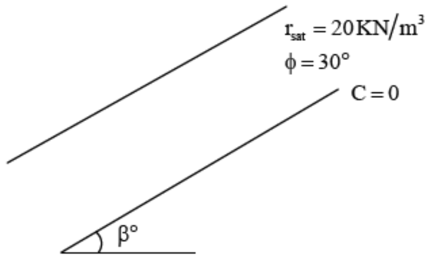
11. F.O.S = 1.5

If there is seepage parallel to the slope

F.O.S = $\dfrac{C^1+\gamma^1 z.\cos^2\beta.\tan\phi}{\gamma_{sat}.z.\cos\beta.\sin\beta}$

F.O.S = $\dfrac{\gamma^1 z.\cos^2\beta.\tan\phi}{\gamma_{sat}.z.\cos\beta.\sin\beta}$

F.O.S = $\dfrac{\gamma^1}{\gamma_{sat}}\dfrac{\tan\phi}{\tan\beta}$



$$1.5 = \frac{(20-9.81)}{9.81}\frac{\tan 30}{\tan\beta}$$

$$\frac{\tan 30}{\tan\beta} = 1.444$$

$\tan\beta = 0.399 \Rightarrow \beta = 21.79°$

12. Stability number, $S_n = \frac{C}{F_c\gamma H}$

13. For infinite slope:

Sand : C = 0

$\beta = 30°$

$\gamma_{sat} = 18$ kN/m^3

$\phi = 38°$

$\gamma_w = 10$ kN/m^3, $Y' = Y_{sat} - Y_w = 18 - 10 = 8$ kN/m^3

$$\text{FOS : } F = \frac{\gamma'}{\gamma_{sat}} \times \frac{\tan\phi}{\tan\beta}$$

$$= \frac{8}{18} \times \frac{\tan 38°}{\tan 30°}$$

$$= 0.6014 \approx 0.60$$

14. (a)

15. As we know that,

$$FOS(F) = \frac{\text{Resisting moment}}{\text{Actuating moment}}$$

$$FOS(F) = \frac{C_u\hat{L}R}{w\bar{x}}$$

$\hat{L}$ = length of ac KLM

$\bar{x}$ = Distance of 'w' from toe

$$\Rightarrow FOS(F) = \frac{75 \times 2\pi \times 25 \times \frac{60}{36} \times 25}{2500 \times 100}$$

$\Rightarrow$ FOS (F) = 1.96

16. As given that

The angle of slope

$(\beta) = 30°$

The unit weight of the saturated soil

$(\gamma_{sat}) = 20$ kN/m^3

The unit weight of the water

$(\gamma_w) = 10$ kN/m^3

The unit weight of the sub

$$\gamma'_{sub} = \gamma_{sat} - \gamma_w$$
$$= (20 - 10) = 10 \text{ kN/m}^3$$

As we know that

$$FOS = \frac{\gamma'_{sub}}{\gamma_{sat}} \times \frac{\tan\phi}{\tan\beta} \geq 1 \quad \text{...(i)}$$

$\therefore$ For critically stable condition (FOS) = 1

Now, by putting all values in eq. (i);

$$\because \quad 1 = \frac{(10)}{20} \times \frac{\tan\phi}{\tan 30°}$$

$$\tan\phi = 10 \times \tan 30°$$

$$= 10 * \left(1/\sqrt{3}\right)$$

So, $\phi = 49.10°$

17. $w \times d = \frac{Cu}{F} \times l_\alpha \times \gamma$

$$\therefore \quad F = \frac{C_u \times l_a \times \gamma}{w \times d} = \frac{30 \times 15.6 \times 10.3}{82 \times 1 \times 20 \times 2.3} = 1.28$$

18. In case of slopes of limited extent, there are 3 kind of failure may occr:

(i) Face failure $\rightarrow$ It occurs when soil above the toe is comparatively weaker

(ii) Base failure $\rightarrow$ It occurs when soil above the toe comparatively stronger.

(iii) Toe failure $\rightarrow$ When the soil above and below the toe have same strength.

Hence; A $\rightarrow$ 3

B $\rightarrow$ 2

C $\rightarrow$ 1

19. Friction Circle method assumes circular slip surface of radius (r). The resultant reaction between the two portions of the soil mass is tangential to a concentric smaller circle of radius of $r \sin\phi$ which is called friction circle.

20. Case-I : For Undrained condition

$$\text{F.O.S} = \frac{\text{Resisting shear strength}}{\text{Acting shear stress}}$$

$$= \frac{80}{50} = 1.6$$

Case-II : For Drained condition

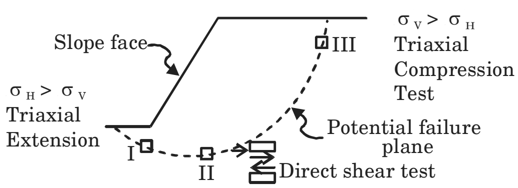
$$\text{F.O.S} = \frac{\bar{\sigma}\tan\phi' + c'}{\text{Acting shear stress}}$$

$$= \frac{[2\times 18 + 4(20-9.81)]\times\tan 18^\circ + 20}{50}$$

$$= \frac{[36 + 4\times 10.19]\times\tan 18^\circ + 20}{50}$$

$$= 0.9$$

21. According to the Question:



Hence, option (a) is the correct answer.

22. As Given that,

$\gamma_1 = 19\ \text{kN/m}^3$

$\phi = 25^\circ$

$C = 15\ \text{kPa}$

$\beta = 35^\circ$

For C-ϕ soil

$$\text{FOS} = \frac{C + \gamma_t z\cos^2\beta\tan\phi}{\gamma_t z\cos\beta\sin\beta}$$

For critical height (FOS) = 1

So, for critical height of slope

$C + \gamma H_C\cos^2\beta\tan\phi = \gamma H_C\sin\beta\cos\beta \qquad (\because z = H_c)$

$\Rightarrow 15 + 19\times H_C\times\cos^2 35^\circ\tan 25^\circ = 19\times H_C \times\sin 35^\circ\cos 35^\circ$

So, $\quad H_C = 5.03\ \text{m}$

23. $H = 7\text{m};\ r = 16\ \text{kN/m}^3;\ C = 25\ \text{kN/m}^2$

$s = 0.178$ for (D.F. = 3 and $i = 30^\circ$). $F_c = ?$

From $\quad s = \dfrac{C}{F_c rH}$

$$F_c = \frac{25}{0.178\quad 16\quad 7} = 1.25$$

24. Stability number is given by

$$S_n = \frac{C}{F\cdot\gamma_{sub}\cdot H}$$

$$\Rightarrow \quad F = \frac{C}{S_n\ \gamma_{sub}\ H}$$

where, $\quad C$ = undrained cohesion

$$\gamma_{sub} = \gamma_{sat} - \gamma_\omega$$

or

$$\gamma_{sub} = \gamma_{sat} - \gamma_\omega = \left(\frac{G+e}{1+e}\right)\gamma_\omega - \gamma_\omega = \left(\frac{G+e}{1+e} - 1\right)$$

$$\gamma_\omega = \left(\frac{2.65+1}{1+1} - 1\right)\times 10 = 8.25\ \text{kN/m}^2$$

H = depth of soil = 10 m

S_n = stability number = 0.08

$$\therefore \quad F = \frac{12}{0.08\times 8.25\times 10} = \mathbf{1.822}$$

25. Factory of safety, $F = \dfrac{C}{S_n\ \gamma_{sat}\times H}$

Here, γ_{sat} because it is a case of sudden draw down

$$\therefore \quad F = \frac{12}{0.126\times 18.25\times 10} = \mathbf{0.53}$$

11 CHAPTER

Shallow Foundation

Bearing Capacity based on Analytic Method

1. The ultimate bearing capacity of a soil is300 kN/m^2. The depth of foundation is 1 m and unit weight of soil is 20 kN/m^3. Choosing a factor of safety of 2.5, the net safe bearing capacity is

   (a) 100 kN/m^3 (b) 112 kN/m^3
   (c) 80 kN/m^3 (d) 100.5 kN/m^3

   [2000 : 1 Mark]

2. Two footings, one circular and the other square, are founded on the surface of a purely cohensionless soil. The diameter of the circular footing is same as that of the side of the square footing. The ratio of their ultimate bearing capacities is

   (a) 3/4 (b) 4/3
   (c) 1.0 (d) 1.3

   [2000 : 1 Mark]

3. The following two statements are made with reference to the calculation of net bearing capacity of a footing in pure clay soil ($\phi = 0$) using Terzaghi's bearing capacity theory. Identify if they are True or False.

   I. Increase in footing width will result in increase in bearing capacity.
   II. Increase in depth of foundation will result in higher bearing capacity

   (a) Both statements are True
   (b) Both statements are False
   (c) I is True but II is False
   (d) I is False but II is True

   [2001 : 1 Mark]

4. The width and depth of a footing are 2 and 1.5 m respectively. The water table at the site is at a depth of 3 m below the ground level. The water table correction factor for the calculation of the bearing capacity of soil is

   (a) 0.875 (b) 1.000
   (c) 0.925 (d) 0.500

   [2001 : 1 Mark]

5. Two circular footings of diameters D_1 and D_2 are resting on the surface of the same purely cohesive soil. The ratio of their gross ultimate bearing capacities is

   (a) $\frac{D_1}{D_2}$ (b) 1.0
   (c) $\left(\frac{D_1}{D_2}\right)^2$ (d) $\frac{D_2}{D_1}$

   [2004 : 1 Mark]

6. There are two footings resting on the ground surface. One footing is square of dimension The other is strip footing of width 'B'. Both of them are subjected to a loading intensity of q. The pressure intensity at any depth below the base of the footing along the centre line would be

   (a) equal in both footings
   (b) large for square footing and small for strip footing
   (c) large for strip footing and small for square footing
   (d) more for strip footing at shallow depth (< B) and more for square footing at large depth (>B)

   [2005 : 1 Mark]

7. A strip footing (8 m wide) is designed for a total settlement of 40 mm. The safe bearing capacity (shear) was 150 kN/m^2 and safe allowable soil pressure was 100 kN/m^2. Due to importance of the structure, now the footing is to be redesigned for total settlement of 25 mm. The new width of the footing will be

   (a) 5 m (b) 8 m
   (c) 12 m (d) 12.8m

   [2005 : 2 Marks]

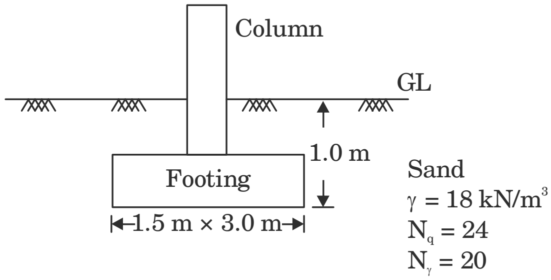
8. The bearing capacity of a rectangular footing of plan dimensions 1.5 m × 3 m resting on the surface of a sand deposit was estimated as 600 kN/m^2 when the water table is far below the base of the footing. The bearing capacities in kN/m^2 when the water level rises to depths of 3 m, 1.5 m and 0.5 m below the base of the footing are

   (a) 600,600,400 (b) 600,450,350
   (c) 600,500,250 (d) 600,400,250

   [2007 : 2 Marks]

Linked Answer Questions 9 and 10:

A column is supported on a footing as shown in the figure below. The water table is at a depth of 10 m below the base of the footing.



9. The net ultimate bearing capacity (kN/m2) of the footing based on Terzaghi's bearing capacity equation is

(a) 216 (b) 432
(c) 630 (d) 846

[2008 : 2 Marks]

10. The safe load (kN) that the footing can carry with a factor of safety 3 is

(a) 282 (b) 648
(c) 945 (d) 1269

[2008 : 2 Marks]

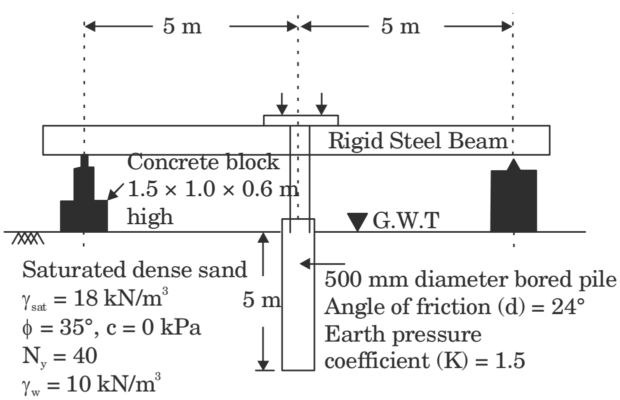
11. A footing 2 m × 1 m exerts a uniform pressure of 150 kN/m^2 on the soil. Assuming a load dispersion of 2 vertical to 1 horizontal, the average vertical stress (kN/m^2) at 1.0 m below the footing is

(a) 50 (b) 75
(c) 80 (d) 100

[2008 : 2 Marks]

Common Data for Questions 12 and 13:

Examine the test arrangement and the soil properties given below:



12. The maximum pressure that can be applied with a factor of safety of 3 through the concrete block, ensuring no bearing capacity failure in soil using Terzaghi's bearing capacity equation without considering the shape factor, depth factor and inclination factor is

(a) 26.67 kPa (b) 60kPa
(c) 90kPa (c) 120kPa

[2009 : 2 Marks]

13. The maximum resistance offered by the soil through skin friction while pulling out the pile from the ground is

(a) 104.9 kN (b) 209.8 kN
(c) 236 kN (d) 472 kN

[2009 : 2 Marks]

Linked Answer Questions 14 and 15:

The unconfined compressive strength of a saturated clay sample is 54 kPa.

14. The value of cohesion for the clay is

(a) zero (b) 13.5 kPa
(c) 27 kPa (d) 54kPa

[2010 : 2 Marks]

15. If a square footing of size 4 m × 4 m is resting on the surface of a deposit of the above clay, the ultimate bearing capacity of the footing (as per Terzaghi's equation) is

(a) 1600 kPa (b) 316 kPa
(c) 200 kPa (d) 100kPa

[2010 : 2 Marks]

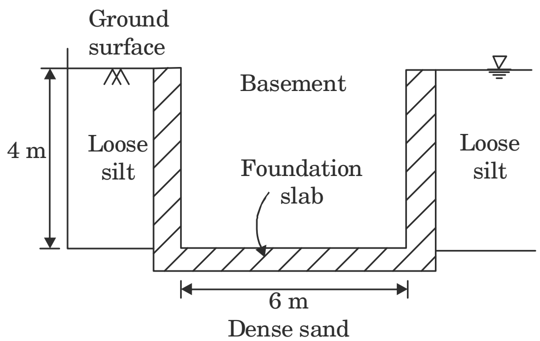
16. An embankment is to be constructed with a granular soil (bulk unit weight = 20 kN/m^3) on a saturated clayey silt deposit (undrained shear strength = 25 kPa). Assuming undrained general shear failure and bearing capacity factor of 5.7. The maximum height (in m) of the embankment at the point of failure is

(a) 7.1 (b) 5.0
(c) 4.5 (d) 2.5

[2012 : 1 Mark]

Linked Answer Question 17 :

A multistorey building with a basement is to be constructed, the top 4 m contains loose silt below which dense sand layer is present upto a great depth. Ground water table is at the ground surface. The foundation consists of the basement slab of 6 m width which will rest on the top of dense sand as shown in figure. For dense sand saturated unit weight is 20 kN/m^3 and bearing capacity factor N_q = 40, N_y = 45, for loose silt saturated unit weight = 18 kN/m^3, N_g = 15, N = 20. Effective cohesion C is zero for both soils. Neglect shape factor and depth factor. Average elastic modulus E, and Poisson ratio p of dense sand is 60 × 10^3 kN/m^2 and 0.3 respectively.



17. Using factor of safety = 3, the net safe bearing capacity (in kN/m^2) of the foundation is

(a) 610 (b) 320

(c) 983 (d) 693 **[2013 : 2 Marks]**

18. A square footing (2 m × 2 m) is subjected to an inclined point load, Pas shown in the figure below. The water table is located well below the base of the footing. Considering one-way eccentricity, the net safe load carrying capacity of the footing for a factor of safety of 3.0 is kN_________.

The following factors may be used:

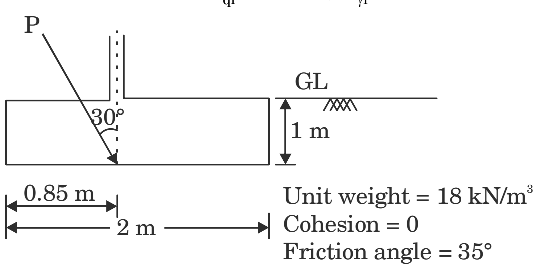
Bearing capacity factors:

$N_q = 33.3$, $N_\gamma = 37.16$;

Shape factors: $F_{qs} = F_{\gamma s} = 1.314$;

Depth factors: Fqd = Fyd = 1.113;

Inclination factors: $F_{qi} = 0.444$, $F_{\gamma i} = 0.02$.



[2015 : 2 Marks, Set-I]

19. Net ultimate bearing capacity of a footing embedded in a clay stratum

(a) increases with depth of footing only

(b) increases with size of footing only

(c) increases with depth and size of footing

(d) is independent of depth and size of footing

[2015 : 1 Mark, Set-II]

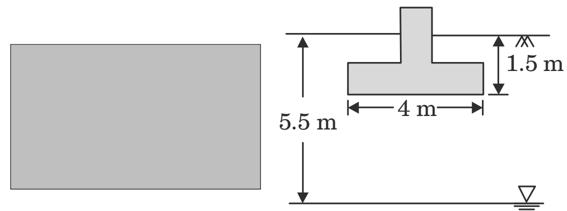
20. A strip footing is resting on the surface of a purely clayey soil deposit. If the width of the footing is doubled, the ultimate bearing capacity of the soil

(a) becomes double (b) becomes half

(c) becomes four-times (d) remains the same

[2016 : 1 Mark, Set-II]

21. A 4 m wide strip footing is founded at a depth of 1.5 m below the ground surface in a c-ϕ soil as shown in the figure. The water table is at a depth of 5.5 m below ground surface. The soil properties are : d = 35 kN/m^2, ϕ' = 28.63°, γ_{sat} = 19 kN/m^3, γ_{bulk} = 17 kN/m^3 and γ_w = 9.81 kN/m^3. The values of bearing capacity factors for different ϕ' are given below.



Using Terzaghi's bearing capacity equation and a factor of safety F_s = 2.5, the net safe bearing capacity (expressed in kN/m^2) for local shear failure of the soil is__________

[2016 : 2 Marks, Set-II]

22. A strip footing is resting on the ground surface of a pure clay bed having an undrained cohesion c_u. The ultimate bearing capacity of the footing is equal to

(a) $2\pi C_u$

(b) πC_u

(c) $(\pi + 1) C_u$

(d) $(\pi + 2) C_u$

[2017 : 1 Mark, Set-I]

23. The percent reduction in the bearing capacity of a strip footing resting on sand under flooding condition (water level at the base of the footing) when compared to the situation where the water level is at a depth much greater than the width of footing, is approximately

(a) 0

(b) 25

(c) 50

(d) 100

[2018 : 1 Mark, Set-I]

24. The width of a square footing and the diameter of a circular footing are equal. If both the footings are placed on the surface of sandy soil, the ratio of the ultimate bearing capacity of circular footing to that of square footing will be

(a) $\frac{4}{3}$ (b) 1

(c) $\frac{3}{4}$ (d) $\frac{2}{3}$

[2018 : 1 Mark, Set-I]

25. A square footing of 4m side is placed at 1 m depth in a sand deposit. The dry unit weight (γ) of sand is 15 kN/m^3. This footing has an ultimate bearing capacity of 600 kPa. Consider the depth factors; $d_q=d_\gamma=1.0$ and the bearing capacity factor: $N_\gamma=18.75$. This footing is placed at a depth of 2m in the same soil deposit. For a factor of safety of 3.0 per Terzaghi's theory, the safe bearing capacity (in kPa) of this footing would be ______.

[2019 : 2 Marks, Set-I]

26. A square footing of 2 m sides rests on the surface of a homogeneous soil bed having the properties cohesion c = 24 kPa, angle of internal friction $\phi = 25°$ and unit weight γ 18 kN/m^3. Terzaghi's bearing capacity factors for $\phi = 25°$ are $N_c = 25.1$. $N_q = 12.7$, $N_\gamma = 9.7$, $N'_c = 14.8$, $N'_q = 5.6$, and $N'_\gamma = 3.2$. THe ultimate bearing capacity of the foundation (in kPa, round off to 2 decimal places is ________.

[2019 : 2 Marks, Set-II]

27. Match the following in Column X with Column Y:

	Column X	Column Y
(P)	In a triaxial compression test, with increase of axial strain in loose sand under drained shear condition, the volumetric strain	(I) decreases.
(Q)	In a triaxial compression test, with increase of axial strain in loose sand under undrained shear condition, the excess pore water pressure	(II) increases.
(R)	In a triaxial compression test, the pore pressure parameter "B" for a	(III) remains same.
(S)	For shallow strip footing in pure saturated clay, Terzaghi's bearing capacity factor (Nq) due to surcharge	(IV) is always 0.0.
		(V) is always 1.0.
		(VI) is always 0.5.

Which one of the following combinations is correct?

(a) (P)-(I), (Q)-(II), (R)-(V), (S)-(V)

(b) (P)-(II), (Q)-(I), (R)-(IV), (S)-(V)

(c) (P)-(I), (Q)-(III), (R)-(VI), (S)-(IV)

(d) (P)-(I), (Q)-(II), (R)-(V), (S)-(VI)

[2022 : 2 Marks, Set-II]

28. A 2 m wide strip footing is founded at a depth of 1.5 m below the ground level in a homey, pure clay bed. The clay bed has unit cohesion 40 kPa. Due to seasonal fluctuations of water table from peak summer to peak monsoon period, the net ultimate bearing capacity of the footing as per Terzaghi's theory

(a) decrease (b) become zero

(c) remain the same (d) increase

[2024 : 1 Mark, Set-I]

Types of Foundation and Shear Failure

29. Likelihood of general shear failure for an isolated footing in sand decreases with

(a) decreasing footing depth

(b) decreasing inter-granular packing of the sand

(c) increasing footing width

(d) decreasing soil grain compressibility

[2011 : 1 Mark]

30. Four columns of building are to be located within a plot size of 10 m × 10 m. The expected load on each column is 4000 kN. Allowable bearing capacity of soil deposit is 100 kN/m^2. The type of foundation to be used is

(a) Isolated foundation

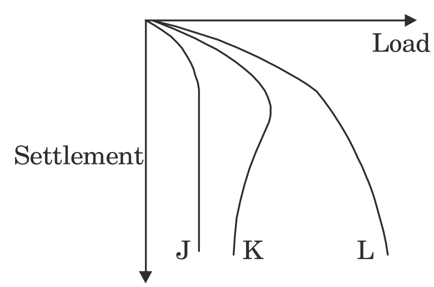
(b) Raft foundation

(c) Pile foundation

(d) Combined foundation

[2013 : 1 Mark]

31. **Group-I** contains representative load-settlement curves for different modes of bearing capacity failures of sandy soil. **Group-II** enlists the various failure characteristics. Match the load-settlement curves with the corresponding failure characteristics.



	Group-I		Group II
P.	Curve J	1.	No apparent heaving of soil around the footing
Q.	Curve K	2.	Rankine's passive zone develops imperfectly
R.	Curve L.	3.	Well defined slip surface extends to ground surface

	P	Q	R
(a)	1	3	2
(b)	3	2	1
(c)	3	1	2
(d)	1	2	3

[2014 : 2 Marks, Set-I]

32. For the following statements:

P – The lateral stress in the soil while being tested in an oedometer is always at-rest.

Q – For a perfectly rigid strip footing at deeper depths in a sand deposit, the vertical normal contact

R – The corrections for overburden pressure and dilatancy are not applied to measured SPT-N values in case of clay deposits.

The correct combination of the statements is

(*a*) P – TRUE; Q – TRUE; R– TRUE

(*b*) P – FALSE; Q – FALSE; R – TRUE

(*c*) P – TRUE; Q– TRUE; R– FALSE

(*d*) P – FALSE; Q– FALSE; R – FALSE

[2019 : 2 Marks, Set-I]

Bearing Capacity based on Field Test

33. A plate load test was conducted in sand on a 300 mm diameter plate. If the plate settlement was 5 mm at a pressure of 100 kPa, the settlement (in mm) of a 5 m × 8 m rectangular footing at the same pressure will be

(a) 9.4 (b) 18.6

(c) 12.7 (d) 17.8

[2001 : 2 Marks]

34. The observed value of the standard penetration number (N) at 10 m depth of silty sand deposit is 13. The unit weight of the soil is 16 kN/m^3. The N value after correcting for the presence of fines will be

(a) 12 (b) 13

(c) 14 (d) 15

[2002 : 1 Mark]

35. In a plate load test conducted on cohesionless soil, a 600 mm square test plate settles by 15 mm under a load intensity of 0.2 N/mm^2. All conditions remaining the same, settlement of a 1m square footing will be

(a) less than 15 mm (b) greater than 25 mm

(c) 15.60 mm (d) 20.50 mm

[2003 : 1 Mark]

36. During the subsurface investigations for design of foundations, a standard penetration test was conducted at 4.5 m below the ground surface. The record of number of blows is given below:

Penetration depth (cm)	**Number of blows**
0-7.5	3
7.5-15	3
15-22.5	6
22.5	- 30.6
30 - 37.5	8
37.5	- 45.7

Assuming the water table at ground level, soil as fine sand and correction factor for overburden as 1.0, the corrected 'N' value for the soil would be

(a) 18 (b) 19

(c) 21 (d) 33

[2005 : 2 Marks]

37. The number of blows observed in a Standard Penetration Test (SPT) for different penetration depths are given as follows:

Penetration of sampler	**Number of blows**
0-150 mm	6
150-300 mm	8
300 - 450 mm	10

The observed N value is

(a) 8 (b) 14

(c) 18 (d) 24

[2007 : 1 Mark]

38. Dilatancy correction is required when a strata is

(a) cohesive and saturated and also has N value of SPT > 15

(b) saturated silt/fine sand and N value of SPT < 10 after the overburden correction

(c) saturated silt/fine sand and N value of SPT > 15 after the overburden correction

(d) coarse sand under dry condition and N value of SPT < 10 after the overburden correction

[2009 : 1 Mark]

39. A plate load test is carried out on a 300 mm × 300 mm plate placed at 2 m below the ground level to determine the bearing capacity of a 2 m × 2 m footing placed at same depth of 2 m on a homogeneous sand deposit extending 10 m below ground. The ground water table is 3m below the ground level. Which of the following factors does not require a correction to the bearing capacity determined based on the load test?

(a) Absence of the overburden pressure during the test

(b) Size of the plate is much smaller than the footing size

(c) Influence of the ground water table

(d) Settlement is recorded only over a limited period of one or two days

[2009 : 2 Marks]

40. **Group-I** enlists in-situ field tests carried out for soil exploration, while **Group-II** provides a list of parameters for sub-soil strength characterization. Match the type of tests with the characterization parameters.

Group-I

P. Pressuremeter Test (PMT)

Q. Static Cone Penetration Test (SCPT)

R. Standard Penetration Test (SPT)

S. Vane Shear Test (VST)

Group-II

1. Menard's modulus (Em)
2. Number of blows (N)
3. Skin resistance (fc)
4. Undrained cohesion (cu)

	P	Q	R	S
(a)	1	3	2	4
(b)	1	2	3	4
(c)	2	3	4	1
(d)	4	1	2	3

[2014 : 2 Marks, Set-II]

41. The plate load test was conducted on a clayey strata by using a plate of 0.3 m × 0.3 m dimensions, and the ultimate load per unit area for the plate was found to be 180 kPa. The ultimate bearing capacity (in kPa) of a 2 m wide square footing would be

(a) 27 (b) 180

(c) 1200 (d) 2000

[2017 : 1 Mark, Set-II]

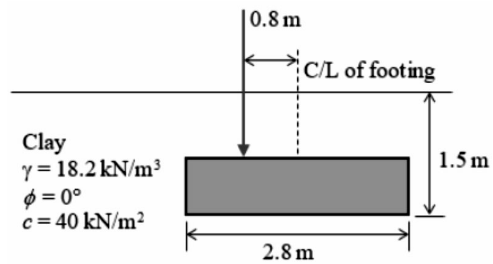
42. In a soil investigation work at a site, Standard Penetration Test (SPT) was conducted at every 1.5 m interval up to 30 m depth. At 3 m depth, the observed number of hammer blows for three successive 150 mm penetrations were 8, 6 and 9 respectively. The SPT N-value at 3 m depth, is

(a) 23 (b) 17

(c) 15 (d) 14

[2020 : 1 Mark, Set-I]

43. A rectangular footing of size 2.8 m × 3.5 m is embedded in a clay layer and a vertical load is placed with an eccentricity of 0.8 m as shown in the figure (not to scale). Take Bearing capacity factors: $N_c = 5.14$, $N_q = 1.0$, and $N\gamma = 0.0$; Shape factors: $s_c = 1.16$, $s_q = 1.0$ and $s_\gamma = 1.0$; Depth factors: $d_c = 1.1$, $d_q = 1.0$ and $d_\gamma = 1.0$; and Inclination factors: $i_c = 1.0$ and $i_q = 1.0$ and $i_\gamma = 1.0$.



Using Meyerhoff's method, the load (in kN, round off to two decimal places) that can be applied on the footing with a factor of safety of 2.5 is _______

[2021 : 1 Mark, Set-II]

44. At a site, Static Cone Penetration Test was carried out. The measured point (tip) resistance q_c was 1000 kPa at a certain depth. The friction ratio (f_r) was estimated as 1% at the same depth. The value of sleeve (side) friction (in kPa) at that depth was ________ . (in *integer*)

[2022 : 1 Mark, Set-I]

45. A square footing of size 2.5 m × 2.5 m is placed 1.0 m below the ground surface on a cohesionless homogeneous soil stratum. Considering that the groundwater table is located at the base of the footing, the unit weights of soil above and below the groundwater table are 18 kN/m^3 and 20 kN/m^3, respectively, and the bearing capacity factor N_q is 58, the net ultimate bearing capacity of the soil is estimated as 1706 kPa (unit weight of water = 10 kN/m^3).

Earlier, a plate load test was carried out with a circular plate of 30 cm diameter in the same foundation pit during a dry season, when the water table was located beyond the plate influence zone. Using Terzaghi's bearing capacity formulation, what is the ultimate bearing capacity (in kPa) of the plate?

(a) 110.16 (b) 61.20

(c) 204.00 (d) 163.20

[2023 : 2 Marks, Set-I]

46. A standard penetration test (SPT) was carried out at a location by using a manually operated hammer dropping system with 50% efficiency. The recorded SPT value at a particular depth is 28. If an automatic hammer dropping system with 70% efficiency is used at the same location, the recorded SPT value will be

(a) 28 (b) 20
(c) 40 (d) 25

[2023 : 1 Mark, Set-II]

47. Which of the following statement(s) is/are CORRECT?

(a) Swell potential of soil decreases with an increase in the shrinkage limit.
(b) In electrical resistivity tomography, the depth of current penetration is half of the spacing between the electrodes.
(c) Among the several corrections to be applied to the SPT-N value, the dilatancy correction is applied before all other corrections.
(d) Both loose and dense sands with different initial void ratios can attain similar void ratio at large strain during shearing.

[2024 : 2 Marks, Set-I]

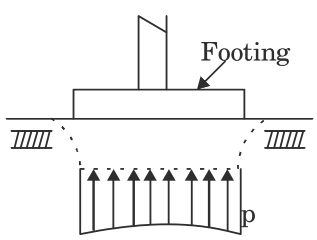
Settlement of Foundation

48. The two criteria for the determination of allowable bearing capacity of a foundation are

(a) tensile failure and compression failure
(b) tensile failure and settlement
(c) bond failure and shear failure
(d) shear failure and settlement

[2000 : 1 Mark]

49. The figure given below represents the contact pressure distribution underneath a



(a) rigid footing on saturated clay
(b) rigid footing on sand
(c) flexible footing on saturated clay
(d) flexible footing on sand

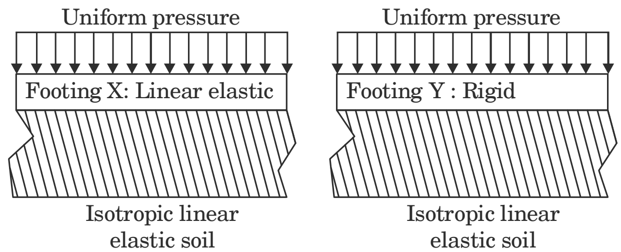
[2004 : 2 Marks]

50. A test plate 30 cm × 30 cm resting on a sand deposit settles by 10 mm under a certain loading intensity. A footing 150 cm × 200 cm resting on the same sand deposit and loaded to the same, load intensity settles by

(a) 2.0 mm (b) 27.8 mm
(c) 30.2 mm (d) 50.0 mm

[2008 : 2 Marks]

51. Two geometrically identical isolated footings, X (linear elastic) and /(rigid), are loaded identically (shown alongside). The soil reactions will



(a) be uniformly distributed for Y but not for X
(b) be uniformly distributed for X but not for Y
(c) be uniformly distributed for both X and Y
(d) not be uniformly distributed for both Xand Y

[2011 : 1 Mark

52. The foundation slab is subjected to vertical downward stresses equal to net safe bearing capacity derived in the above question. Using influence factor I_f = 2.0, and neglecting embedment depth and rigidity corrections, the immediate settlement of the dense sand layer will be

(a) 58 mm (b) 111 mm
(c) 157 mm (d) 126 mm

[2013 : 2 Marks]

53. The contact pressure for a rigid footing resting on clay at the centre and the edges are respectively

(a) maximum and zero
(b) maximum and minimum
(c) zero and maximum
(d) minimum and maximum

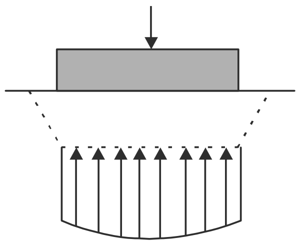
[2014 : 1 Mark, Set-II]

54. A circular raft foundation of 20 m diameter and 1.6 m thick is provided for a tank that applies a bearing pressure of 110 kPa on sandy soil with Young's modulus, E_s' = 30 MPa and Poisson's ratio, v_s = 0.3. The raft is made of concrete (E_c = 30 GPa and v_c = 0.15). Considering the raft as rigid, the elastic settlement (in mm) is

(a) 50.96 (b) 53.36
(c) 63.72 (d) 66.71

[2014 : 2 Marks, Set-II]

55. The contact pressure and settlement distribution for a footing are shown in the figure.



The figure corresponds to a

(a) rigid footing on granular soil

(b) flexible footing on granular soil

(c) flexible footing on saturated clay

(d) rigid footing on cohesive soil

[2018 : 1 Mark, Set-II]

56. The reason(s) of the nonuniform elastic settlement profile below a flexible footing, resting on a cohesionless soil while subjected to uniform loading, is/are :

(a) Variation of friction angle along the width of the footing

(b) Variation of soil stiffness along the width of the footing

(c) Variation of friction angle along the depth of the footing

(d) Variation of soil stiffness along the depth of the footing

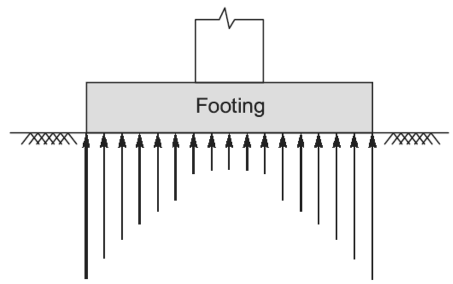
[2023 : 1 Mark, Set-II]

57. A square footing is to be designed to carry a column load of 500 kN which is resting on a soil stratum having the following average properties : bulk unit weight = 19 kN/m^3; angle of internal friction = 0° and cohesion = 25 kPa. Considering the depth of the footing as 1 m and adopting Meyerhoff's bearing capacity theory with a factor of safety of 3, the width of the footing (in m) is _________ (round off to one decimal place)

[Assume the applicable shape and depth factor values as unity; ground water level at greater depth.]

[2023 : 2 Marks, Set-II]

58. The contact pressure distribution shown in the figure belongs to a



(a) flexible footing resting on a cohesionless soil.

(b) rigid footing resting on a cohesive soil.

(c) flexible footing resting on a cohesive soil.

(d) rigid footing resting on a cohesionless soil.

[2024 : 1 Mark, Set-II]

ANSWERS

1. (b) **2**. (a) **3.** (b) **4.** (a) **5.** (b) **6.** (c) **7.** (d) **8.** (a) **9.** (c) **10.** (c)
11. (a) **12.** (b) **13.** (a) **14.** (c) **15.** (c) **16.** (a) **17.** (Marks to All) **18.** (440) **19.** (d)
20. (d) **21.** (298.48) **22.** (d) **23.** (c) **24.** (c) **25.** (270) **26.** (353.92) **27.** (a) **28.** (c)
29. (b) **30.** (c) **31.** (a) **32.** (c) **33.** (d) **34.** (b) **35.** (b) **36.** (c) **37.** (c) **38.** (c)
39. (d) **40.** (a) **41.** (b) **42.** (c) **43.** (439.00 to 442.00) **44.** (10 to 10) **45.** (a) **46.** (b)
47. (a, d) **48.** (d) **49.** (a) **50.** (b) **51.** (b) **52.** (c) **53.** (d) **54.** (b) **55.** (a)
56. (a, b, d) **57.** (3.5) (3.3 – 3.7) **58.** (b)

EXPLANATIONS

1. Here $q_f = 300\,kN/m^2$,

D = Im, $r = 20\,kN/m^3$, F = 2.5

$$q_{nf} = q_f - \gamma_D$$
$$= 300 - 20 \times 1 = 280\,kN/m^2$$

$$\therefore \quad NSBC = \frac{q_{nf}}{F} = \frac{280}{2.5} = 112\,kN/m^2.$$

2. Since C = 0; D = 0

$$\therefore \quad \frac{(q_f)cir}{(q_f)sq} = \frac{0.3 \quad N_q}{0.4 \quad N_q} \quad \frac{3}{4}$$

3. $q_u = cN_C + \gamma D_f N_q + 0.5\gamma BN_q$

For pure alongevil,

$$\phi = 0,$$
$$N_C = 5.7,$$
$$N_q = 1, N_\gamma = 0$$
$$\therefore \quad q_u = cN_C + \gamma D_f$$
$$q_{nu} = cN_C + \gamma D_f - \gamma D_f$$
$$= cN_C$$

4. $$W\gamma = 0.5 + 0.5\,\frac{b}{B}$$

$$= 0.5 + 0.5 \times \frac{1.5}{2}$$

$$= 0.875$$

5. $q_{ult} = 1.3\,CN_c + \gamma DN_q + 0.5\,\gamma BN_q$

For clay, $N_C = 5.7$; $N_q = 1$; $N_q = 0$

For D = 0, $q_{ult} = 1.3\,CN_C$

For square footing, $q_{ult} = 1.3\,CN_C$

∴ ratio = 1.0

6. Pressure intensity at any depth 'z' below the base of footing along the centre line is:

$\sigma_z = qI$

I = Influence value.

$$I = \frac{L}{b}$$

The value of I for strip footing is infinity and for square footing is 1/one

Henc; the pressure intensity at any depth is higher for strip footing than square footing.

7. Given: Safe Bearing capacity

(Shear) $(Q_S) = 150\,KN/m^2$

Safe allowable pressure $(Q_a) = 100\,KN/m^2$

Load permeter length of footing (P)

$= B \times [\text{min. of } (Q_s, Q_a)]$

$= 8 \times [\text{min. of } (150, 100)]$

$= 8 \times 100$

= 800 KN/m

All owable pressure for 25 mm settlement

$$= \left(\frac{100}{40}\right) \times 25$$

Load carrying capacity = Width × allowable pressure = 62.5 KN/m^2

800 = B × 62.5

$\boxed{B = 12.8\,m}$

8. Size of footing = 1.5m × 3m (B × L)

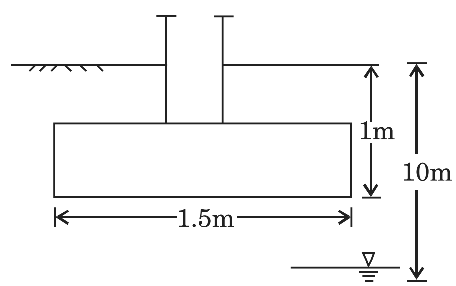
If the water table is at the depth (b) equal or more than B from the footing, it has no effect on bearing capacity of footing

So when water table is at 3m below > (B = 1.5m), bering capacity = 600 kN/m^2 (same)

When water table at 7.5 m below, = 600 kN/m^2

When water table rise upto B depth below base of footing, beaning capacity starts to decreasing

9. Since the water table is at 10m below ground surface that is greater than 1.5 m, so there is no effect of water table.



Ultimate Bearing capacity,

$$q_u = cN_c + qN_q + 0.5\,\gamma\,BN\gamma$$

Here, C = 0

$N_q = 24$, $N_\gamma = 20$

$B = 1.5m., \gamma = 18\,kN/m^3.$

$$\therefore \quad q_u = 0 + 18 \times 1 \times 24 + 0.5 \times 1.5 \times 18 \times 20$$
$$= 702\,kN/m^2$$
$$\text{Net ultimate} = 702 - \gamma . D_f$$
$$= 702 - 18 \times 1 = 684\,kN/m^2.$$

On safer side 630 (as per choices given)

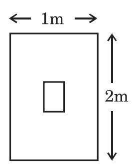
10. If factor of safety is 3, then

$$\text{Net safe bearing capacity} = \frac{630}{3} = 210\,\text{kN/m}^2$$

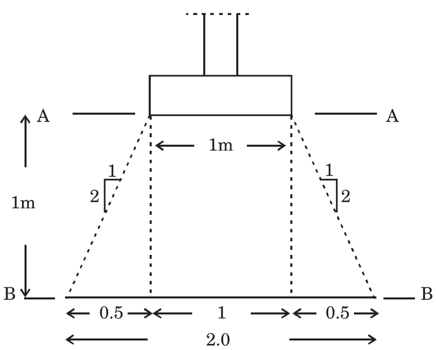
$$\text{Safe load} = 210 \times \text{Area}$$

$$= 210 \times 1.5 \times 3 = 945\,\text{kN}$$

11.



Plan



At level A – A, Plan area

$$= 2 \times 1 = 2\text{m}^2$$

At level B – B, Plan area

$$= \{(2 + 2 \times 0.5)(1 + 2 \times 0.5)\}$$

$$= 6\text{m}^2$$

So, pressure intensitiy at level B – B (1m. below the A – A)

$$= 150 \times \frac{2}{6}$$

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

12. As per Terzaghi's theory;

Ultimate load carrying capacity (q_u) is

$$q_u = CN_C + rD_fN_g + \frac{1}{2}rBN_r$$

For a saturated dense sand; C = 0 and

Bearing capacity is determined at surface so $D_f = 0$

$$q_u = \frac{1}{2}r_{sub}BN_r$$

$$= \frac{1}{2} \times (18 - 10) \times 1 \times 40$$

= 160 Kpa

Safe allowable Bearing capacity $Q_{safe} = \dfrac{q_u}{FOS}$

$$Q_{safe} = \frac{160}{3} = 53.33\text{ Kpa}$$

From given option; the closs one is 60 Kpa.

Hence option (b) is correct.

13. The maximum resistance offered by soil through skin friction (q_f)

q_f = Average frictional stress × Area

$$= \left(\frac{1}{2}\sigma_r \cdot k\right) \cdot A \cdot \tan\delta$$

Where; $\sigma_v = r_{sub} \cdot H$

$= (18 - 10) \times 5$

$$= 40\frac{\text{KN}}{\text{m}^2}$$

$$\therefore\ q_f = \frac{1}{2} \times 1.5 \times 40 \times (\pi DL)\tan\delta$$

$$= \frac{1}{2} \times 1.5 \times 40 \times \pi \times 0.5 \times 5\tan(24^\circ) = 104.9\text{ KN}$$

14. Unconfined strength of saturated clay,

$$q_u = 54\text{ kPa}$$

$$\therefore\ \text{Cohesion} = \frac{\text{Unconfined compressive strength}}{2}$$

$$= \frac{q_u}{2} = \frac{54}{2} = 27\text{ kPa}$$

15. Given : Footing is square ; $D_F = 0$

According to Terzaghi, bearing of square footing is given by

$$q_u = 1.3\,cN_C + \gamma D_f N_q + 0.4\gamma BN_\gamma$$

where, $\phi = 0$ (for clay)

$$N_C = 5.7,\ N_q = 1.0,\ N_\gamma = 0$$

$$\therefore\quad q_u = 1.3 \times 27 \times 5.7 + 0 + 0$$

$$= 200\text{ kPa.}$$

16. Given: Undrained shear strength 25 kPa

Bearing capacity factor (N_C) = 5.7

Now, at the point of failure;

Stress caused by emban Kuent = Bearing Capacity

$\sigma = q_u$

$\gamma \cdot H = CNC$

$20 \times H = 5.7 \times 25$

H = 7.1m

$\therefore$ The maximum height of the embankment is 7.1 m

17. Ultimate Bearing capacity for a strip footing is:

$$q_u = CN_C + rD_f Nq + \frac{1}{2} rBN_r$$

As given, effective cohesion (c) is zero.

$$q_u = r_2^1 D_f N_g + \frac{1}{2} r_1^2 BNr$$

$$q_u = (18-10) \times 4 \times 40 + \frac{1}{2} \times (20-10) \times 6 \times 45$$

$$\begin{bmatrix} \because N_q = 40 \\ N_v = 45 \end{bmatrix}$$

= 2630 Kn/m^2

Safe Bearing capacity = $\frac{q_{nu}}{F} \Rightarrow \frac{q_u - r_{sub} D_f}{F}$

$$q_{ns} = \frac{2630-(18-10)\times 4}{3}$$

qns = 866 KN/m^2

18. $q_{safe} = \frac{q_{nu}}{3}$

$$q_{nu} = cN_c + qN_q + 0.5\gamma BN_\gamma - 8\Delta$$

$$C = 0$$

$$q_{nu} = q(N_q - 1) + 0.5\gamma BN_\gamma$$

$$q_{ns} = \frac{1}{3}\left(_q((N_q - 1)F_{qs} \times F_{qd} + F_{qp} + 0.5\gamma BN_\gamma \times F_{\gamma s} \times G_{\gamma o} \times F_{\gamma p}\right)$$

$$q_{ns} = \frac{1}{3}(18 \times 1(33.3 - 1)\ 1.314 \times 1.113 \times 0.444 + \frac{1}{2} \times 2 \times 18 \times 37.16 \times 1.314 \times 1.113 \times 0.02)$$

$$= \frac{397.03}{3} = 132.264 \text{ kN/m}^2$$

For one way shear eccentricity area to be reduced.

Reduced area of footing = 2 × 1.7 = 3.4 m^2

Load carrying capacity = 1.32 × 3.4

= 440 kN Appro.

19. For clay,

$$q_{nu} = {}_C N_C$$

No depth or size factor is present.

20. Bearing capacity of clayey soild does not depend upon the size of footing.

Therefore, the bearing capacity remains same.

21. $q_u = cN_C + 8D_f N_q + 0.5\ B\ \gamma N_\gamma$

$$q_u = \frac{2}{3} \times 35 \times 17.7 + 17 + 1.5 \times 7.4 + 0.5 \times 4 \times 17 \times 5$$

q_u = 771.7 kN/m^2

$$q_{nu} = q_u - \gamma D_f$$
$$= 771.7 - 17 \times 1.5$$
$$q_{nu} = 746.2 \text{ kN/m}^2$$

$$q_{net} = \frac{q_{nu}}{F}$$

$$= \frac{746.2}{2.5}$$

$$= 298.48 \text{ kN/m}^2$$

22. Ultimate load carrying capacity as per prandtl is:

$$q_0 = CN_C + rD_f N_q + \frac{1}{2} r BN_r$$

for pure clay $\rightarrow \phi = 0 \rightarrow N_q = 1\ N_r = 0$

$q_u = CN_C + rD_f$

Now, since footing is resting at surface so $D_f = 0$

$q_u = CN_C$

$q_u = 5.14\ C_u$

$\because N_C = 5.14$ as per prandi where C_u = undrained cohesion

$q_u = (3.14 + 2)\ C_u$

$q_u = (p + 2)C_u$

23. For strip footing on sand (c = 0)

$$q_u = \gamma D_f N_q + 0.5B\gamma N_\gamma$$

In flooding condition water level rises to base of footing hence IIIrd term unit weight of soil will change and IInd term unit weight will be unaffected.

$\therefore$ $q_u = \gamma D_f N_q + 0.5B\gamma N_\gamma$

$\because$ $\gamma \simeq \frac{1}{2}\gamma_{sat}$

Hence third term reduced and second term will be same thereby percentage reduction will not be 50%.

According to option approach answer should be 25%.

Note : If water table rises to ground level then both γ will reduce to γ hence percentage reduction would be approximately 50%.

24. Footing placed on surface of sandy soil

$\therefore$ $D_f = 0$

For square footing, $q_u = CN_C + \gamma D_f N_q + 0.4B\gamma N_\gamma$

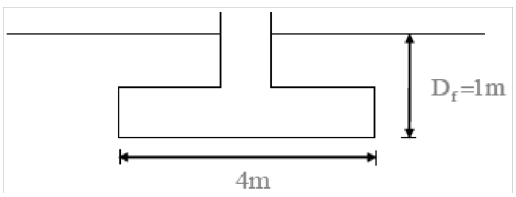
For circular footing, $q_u = CN_C + \gamma D_f N_q + 0.3B\gamma N_\gamma$

For sandy soil, $C = 0$

$$\therefore \quad \text{Ratio} \frac{(q_u)_{circular}}{(q_u)_{square}} = \frac{3}{4}$$

25. Given that soil is sand $\Rightarrow C = 0$

Also given ultimate bearing capacity (q_u) = 600 kPa



sand, $\gamma_d = 15$ kN/m^3

As per Terzaghi's theory, For square footing

Ultimate bearing capacity (q_u)

$$= 1.3CN_C + \gamma D.N_q + 0.4\gamma B.N_\gamma$$

$$600\text{kPa} = 0 + 15 \times 1 \times N_q + 0.4 \times 15 \times 4 \times 18.75$$

$$600 = 15N_q + 450$$

$$\Rightarrow N_q = \frac{600 - 450}{15} = \frac{150}{15} = 10$$

$$\therefore N_q = 10$$

Now, the depth of footing (D_f) = 2 m

Net ultimate bearing capacity (q_{nu})

$$= 1.3 \times CN_C + \gamma D(N_q - 1) + 0.4\gamma B \times N_\gamma$$

$$= 0 + 15 \times 2 \times (10 - 1) + 0.4 \times 15 \times 4 \times 18.75$$

= 270 + 450 = 720 kPa

Safe bearing capacity (q_{safe})

$$= \frac{q_{nu}}{\text{F.O.S.}} + \gamma D_f = \frac{720}{3} + 15 \times 2 = 240 + 30$$

$$\Rightarrow q_{safe} = 270\text{kPa}$$

26. For surface footing, $D_f = 0$

Sicne ϕ value given (25°) is less than 29°, the soil undergoes local shear failure.

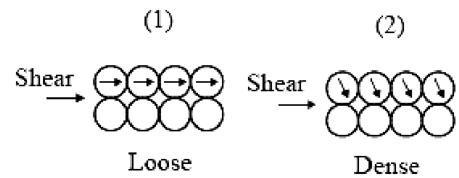
For LSF, $q_u = 1.3\, C_m\, N'_c + \gamma\, D_f\, N_q' + 0.4\, \gamma B\, N\gamma'$ [square footing]

$$= 1.3 \times \frac{2}{3} \times C\, N_c' + 0 + 0.4\, \gamma\, B\, N\gamma'$$

$$= 1.3 \times \frac{2}{3} \times 24 \times 14.8 + 0 + 0.4 \times 18 \times 2 \times 3.2$$

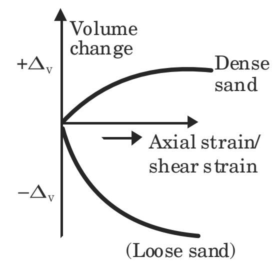
= 353.92 kPa

27. In triaxial compression test ;

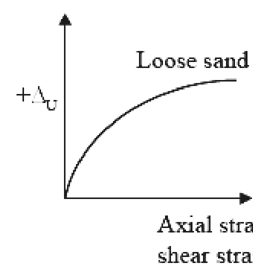


During shearing loose sand tends to decrease in volume & becomes dense, positive pore pressure develop due to compression of soil. Configuration of loose sand change from (1) and (2) ;

(P) When increase of axial strain in loose sand under drained shear condition, then the volumetric strain decreases.



(Q) When increase of axial strain in loose sand under undrained shear condition, the excess pore water pressure increase



(R) The pore pressure parameter 'B' for fully saturated soil is always 1

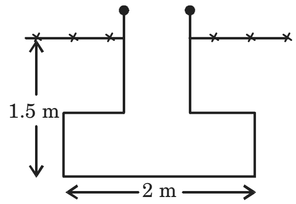
(S) Shallow strip footing in pure saturated clay.

Tezaghi's bearing capacity factor (Nq) due to surcharge is 1.

Hence, option (a) is correct answer.

28. According to the question :

Here, cohesion is given to be constant.



As we know that :

Ultimate bearing capacity,

$(q_u) = CN_C + \gamma Df\, N_q + 0.5\, B_\gamma N_\gamma$

We also know that,

For, pure clay, $\phi = 0$

So, $N_C = 5.7$, $N_q = 1$, $N_\gamma = 0$

$q_u = 5.7\, C + \gamma Df + 0$

Net ultimate bearing capacity $(q_{nu}) = 5.7\, C + q - q$

$q_{nu} = 5.7\, C$

So, q_{nu} does not depend on presence of water table and it will not change with water table fluctuations.

Hence, option (c) is the correct answer.

29. General shear failure occurs in soil possessing Brittle type shear stress curve. It is used for Dense sand. Now if intergranular packing of sand decrease, then sand will become loose.

Hence general shear failure will derease.

30. Expected load coming on each column = 4000 KN

No. of Column = 4

Total load coming from all column = 4 × 4000

= 16000 KN

In raft footing,

Pressure coming to soil = $\frac{P}{A} = \frac{16000}{10 \times 10}$

= 160 KM/m² > 100 KN/m²

Therefore, pressure acting downwards to soil is more than bearing capacity of soil, so the raft is not provided this condition.

So go for pile foundation.

31. K → General shear failure

L → Local shear failure

J → Punching shear failure

General shear failure (Q) : Well define failure pattern(3)

Local shear failure (L) : Rankine passive zone developes(2)

Punching shear failure : No heaving of soil around footing

32. (a)

33. For cohesionless soil,

$$S_f = S_p\left[\frac{B_f(B_p+.3)}{B_p(B_f+.3)}\right]^2 = 5\left[\frac{5(0.3+.3)}{.3(5+0.3)}\right]^2 = 17.8\text{ mm}$$

34. Standard penetration number (N) at 10 depth is 13. The corrected N-value for fines will be 13 only. Because the dilatency correction is required only if N-value is greater than 15. in saturated fine sand and silt. Hence the correction is not applicable for N-value of 13. So corrueted N-value is 13.

35. We know,

$$\rho_F = \rho_p\left[\frac{B_f(0.3+1.0)}{B_\rho(0.3+0.0.06)}\right]^2 > 25\, mm$$

where, B_f=100mm, B_P=600mm

36. For first 15 cm penetration is NOT consider and the next 30 cm penetration is taken. So no. of blows are:

N = 6 + 6 + 8 + 7 = 27

Now correction are applied:

(i) Overburden correction: $N' = C_N \cdot N$

$= 1 \times 27$ ($\because C_N = 1$)

N' = 27

(ii) Dilatancey correction: Since no. of blows are greater than 15 hence correction is applied.

Corrected $N'' = 15 + \frac{1}{2}(N' - 15)$

$= 15 + \frac{1}{2}(27 - 15)$

= 21

37. The first penetration of sampler is for seating of sampler. So it is not considered.

Hence, for SPT test Number of blows for total penetration $N = 8 + 10 = 18$

38. Dilatancy correction is applied to the corrected N-value obtained from over-burden correction and if over burden corrected N-value is more than 15 in saturated silt and fine sand.

39. Correction to the Bearing capacity is required if the size of plate is much smaller then the footing size.

If the depth of water table below the foundation level is less than or equal to width of footing then correction to Bearing capacity is requied.

If settlement is recorded only over a limited period of our or two days as in lase of sand in which immediate settlement occues than no correction is required.

40. Pressuremeter test – Menard's Modulus (E_m)
Static cone Penetration test – Skin Resistance (f_c)
Standard Penetration test – Number of blows (N)
Vane shear test – It is undrained cohesion (c_k)
the correct choice is (*a*)

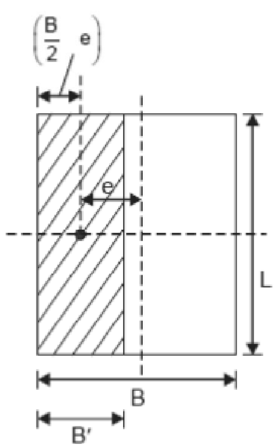
41. In plate load test bearing capacity of clay does not depend upon size of footing.

$$q_{up} = q_{uf} \text{(for clay)}$$

$\therefore$ Ultimate bearing capacity of a 2m wide square footing = 180 kPa

42. Given : At 3m depth
$N_1 = 8 \rightarrow$ 1st 15 cm
$N_2 = 6 \rightarrow$ 2nd 15 cm
$N_3 = 9 \rightarrow$ 3rd 15 cm
Standard penetration number is the total number of Blows required for last 30 cm by neglecting First 15 cm.
So, observed SPT number.
$N = N_2 + N_3$
$= 6 + 9 = 15$

43. According to the question.



So,

$$B' = 2\left(\frac{B}{2} - e\right)$$

$= (B - 2e) = 2.8 - 2 \times 0.8 = 1.2$ m
$L' = L = 3.5$ m
$q_u = CN_c \cdot s_c d_c i_c + qN_q s_q d_q i_q + (0.5)B'\gamma O_\gamma s_\gamma d_\gamma i_\gamma$
$q_u = CN_c \cdot s_c d_c i_c + {}_q N_q s_q d_q i_q$ $[q = \gamma D_f]$
Load that can be applied on the footing is the (gross safe bearing capacity) × L′B′

As we know that
Gross safe bearing capacity

$$= \frac{q_{nu}}{F.O.S} = \gamma D_f$$

$$= \frac{(q_u - \gamma D_f)}{F.O.S} + \gamma D_f$$

$q_u = (40 \times 5.14)(1.16 \times 1.1 \times 1) + (18.2 \times 1.5)(1) \times (1 \times 1 \times 1)$
$q_{nu} = q_u - \gamma D_f = (40 \times 5.14)(1.16 \times 1 \times 1)$
$\Rightarrow$ Load that can be applied on the footing

$$= \left[\frac{40 \times 5.14 \times 1.16 \times 1.1}{2.5} + 18.2 \times 1.5\right] \times (3.5 \times 1.2)$$

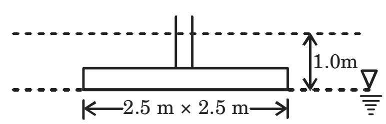
kN
= 555.4 kN
When net load is asked, load that can be applied
= 555.4 – (18.2 × 1.5) × 3.5 × 1.2
= 440.74 kN

44. As given that
Static cone penetration test
$q_t = 1000$ kPa
Friction ratio, $f_r = 1\%$
$q_s = ?$

$$f_r = \frac{\text{Sleeve friction, } (q_s)}{\text{Point resistance, } (q_t)}$$

$\therefore$ $q_s = f_r \cdot q_t$
$= 0.01 \times 1000 = 10\ \text{kN/m}^2 = 10$ kPa

45. As Given that :
$\gamma_t = 18\ \text{KN/m}^3$
$V_{sat} = 20\ \text{KN/m}^3$
$q_{nu} = 1706$ kPa
$\gamma_\omega = 10\ \text{kN/m}^3$
$D_f = 1.0$ m
B = 2.5 m



For footing : $q_{nu} = 1706$ kPa
As we know that

$$q_{nu} = 1706 = \{1.3\ CN_C + q(N_q - 1) + 0.4 B\gamma N_\gamma\}$$

$(\therefore q = \gamma_t D_f, \gamma = \gamma_{sat} - \gamma_w \ \&\ N_C = 0)$
$1706 = 1.3\ CN_C + \gamma_t D_f(N_q - 1) + 0.4\ B(\gamma_{sat} - \gamma_\omega) N_\gamma$
$1706 = 18 \times 1 \times (58–1) + 0.4 \times 2.5 \times (20 – 10) N_\gamma$

$$N_\gamma = \left[\frac{1706 - 18 \times 57}{0.4 \times 2.5 \times 10}\right]$$

$N_\gamma = 68$

For plate :

$$q_{uplate} = 1.3CN_C + \gamma D_f N_q + 0.3\, dy_t\, N_\gamma$$

$$\left\{\therefore N_C, N_q = 0 \;\&\; d = 30\,cm = 0.3\,m\right\}$$

[Surcharge at the plate level is zero]

$$q_{uplate} = 0 + 0 + 0.3 \times 0.3 \times 18 \times 68$$

$$q_{uplate} = 110.16 \text{ KPa}$$

46. As we know that,

$$\text{Efficiency of blow} \propto \frac{1}{\text{Number of blows}}$$

$$\propto \frac{1}{\text{SPT value}}$$

From this we have

$$\Rightarrow \quad \eta_1 N_1 = \eta_2 N_2$$

So, $$0.5 \times 28 = 0.7 \times N_2$$

$$\Rightarrow \quad N_2 = \frac{0.5 \times 28}{0.7} = 20$$

Hence, option (b) is correct answer.

47. Out of the given options, only statements (a) and (d) are correct. Here's why:

(a) **Swell potential of soil decreases with an increase in the shrinkage limit**

This statement is also **TRUE**. Shrinkage limit is the minimum water content at which soil will shrink further upon drying. Soils with higher shrinkage limits tend to have a greater potential for volume change. As the water content falls below the shrinkage limit, the soil particles become tightly packed, limiting further swelling when water is reintroduced. Therefore, a higher shrinkage limit indicates lower swell potential.

(b) In electrical resistivity tomography the depth of current penetration is half of the spacing between the electrodes

This statement is **FALSE**. The depth of current penetration in electrical resistivity tomography (ERT) depends on various factors like electrode configuration, soil properties, and applied voltage. It's generally much deeper than half the electrode spacing.

(c) Among the several corrections to be applied to the SPT-N value the dilatancy

This statement is **FALSE** & incomplete and requires more contexts to determine accuracy. Dilatancy can be a factor influencing the Standard Penetration Test (SPT) N-value, but it's not the only correction applied. SPT N-value can be affected by factors like overburden pressure, energy ratio (hammer efficiency), and groundwater level. So, dilatancy correction is applied to the already corrected N-values for overburden pressure. Corrections are applied to account for these factors and provide a more representative N-value.

(d) Both loose and dense sands with different initial void ratios can attain similar void ratio at large strain during shearing

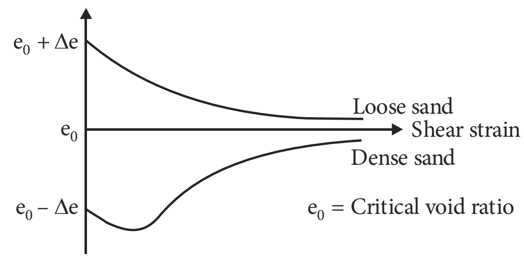


Fig. Shear strain vs Void ratio curve

This statement is **TRUE**. Void ratio refers to the ratio of voids (empty spaces) to the volume of solids in a soil sample. During a large value of shearing strain (applying stress and causing deformation), both the initially loose and initially dense sands experience changes in their internal structure. Loose sand will tend to densify (decrease void ratio) as it gets packed together under shear. Conversely, dense sand might initially dilate (increase void ratio) to accommodate deformation before potentially densifying at larger strains. With enough shearing, both loose and dense sands can reach a similar, more stable void ratio.

48. Allowable Bearing capacity can be defined as the maximum intensity of loading that can be imposed on soil without having shear failure and settlement.

49. External work done $= W_u \times \dfrac{L\theta}{2}$

Internal work done by positive moment

$$= M_p \times 3\theta$$

Equating external and internal work done, have

$$W_u \times \frac{L\theta}{2} = M_p \times 3\theta$$

$$\therefore \quad W_u = \frac{6M_p}{L}$$

50. Settlement of foundation in sand is given by (by plate load test)

$$S_f = S_p\left[\frac{B_f(B_p + 0.3)}{B_p(B_f + 0.3)}\right]^2$$

where, B_p = size of plate = 30 cm = 0.3m

B_f = width of footing = 150 cm = 1.5 m

S_p = selltement of plate =10 mm
= 1 cm. = 0.01m

$$\therefore \quad S_f = 0.01 \times \left[\frac{1.50(.30+0.3)}{0.3(1.5+0.3)}\right]^2$$
$$= 0.0278\text{ m} = 27.8\text{ mm}$$

51. For linear elastic (Flexible footing) soil pressure is uniform for Rigid footing, settlement of footing is uniform and soil. Pressure distribution at the base of footing is depend on tpe of soil hence not uniform for rigid type of footing.

52. Immediate settlement is calculated based on theory of clasticity

(Net elastic settlement on flexible surface)

$$(S_i) = \frac{q_{ns}B(1-\mu^2)I_f}{E_s}$$

where; I_f = influence factor = 2.0

q_{ns} = net foundation pressure

B = width of foundation

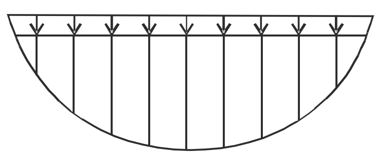
μ = Poisson's ratio

E_s = Modulus of elasticity

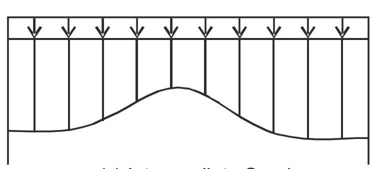
$$\therefore S_i = \frac{866 \times 6(1-(0.3)^2) \times 2}{60 \times 10^3}$$

S_i = 157.61 mm

53. Minimum at centre & maximum at Edge.



(b) Cohession less Sand



(c) Intermediate Sand

Fig. Contact pressure distribution under rigid footing.

54. Immediate settlement is calculated based on theory of elasticity.

(Net immediate settlement on flexible surface)

$$(Si) = \frac{qB(1-\mu^2)I_f}{E_s}$$

$$Si = \frac{[110 \times 20(1-(0.3)^2)]}{(30 \times 103)} \times I_f$$

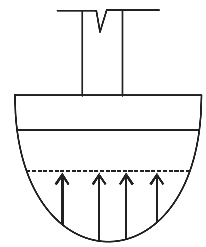
[$\because$ Influence factor for rigid footing is 0.8]

$\therefore$ Net immediate settlement on rigid footing

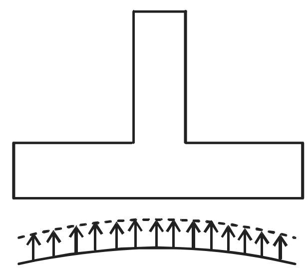
= 0.8 × 66.73

= 53.36mm

55. For rigid footing on granular soil; Pressure developed is more at centre.



56. According to the question,



The modulus of elasticity varies with width of footing, so there is a variation in the stiffness along the width of footing.

In the non-uniform elastic settlement profile below a flexible footing resting on cohesionless soil subjected to uniform loading is due to the non-linear behaviour of the soil. When a flexible footing is place on cohesionless soil, the soil deforms non-linearly due to the soil's low shear strength.

This leads to a differential settlement, where the soil settles more near the edges of the footing than in the centre. The non-uniform settlement profile is also influenced by the size and shape of the footing, as well as the intensity and distribution of the applied load.

Additionally, the soil's compressibility and deformation characteristics play a crucial role in determining the magnitude and distribution of the settlement. The soil's compressibility, characterized by its compressin index, affects the rate of settlement, while its hear strength, characterized by its compression index, affects the rate of settlement, while its shear strength, characterized by its friction angle, affects the distribution of the settlement.

Hence, option (a, b & d) are the correct answer.

57. As given in equation,

Shape factor Sc, Sq, Sr = 1

and depth factor d_c, d_v, d_r = 1

As we know that,

As per Meyerhoff's theory,

$q_u = CN_cS_cd_ci_c + qN_qS_qd_qi_q + 0.5_\gamma BN_\gamma S_\gamma d_\gamma i_\gamma$

For $\phi = 0$, $N_c = 5.14$, $N_q = 1$ and $N_\gamma = 0$

Assuming number inclination of loading.

Also, considering shape, depth and inclination factor as 1, we get

$$\Rightarrow q_u = 5.14 \times 25 + \gamma D_f$$

$$\Rightarrow q_{nu} = q_u - \gamma D_f = 5.14 \times 25$$

$$\Rightarrow q_{ns} = \frac{q_{nu}}{FOS} = \frac{5.14 \times 25}{3} = 42.83 \text{ kN/m}^2$$

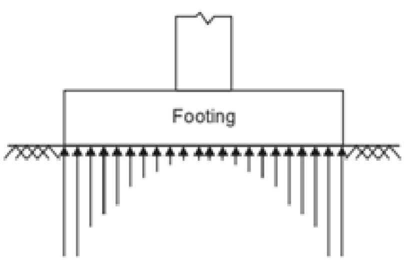
So, $\frac{500}{B^2} \le 42.83$

$B \ge 3.41$ cm

Hence, B = 3.4 m

So, i.e., i_q i_r = 1

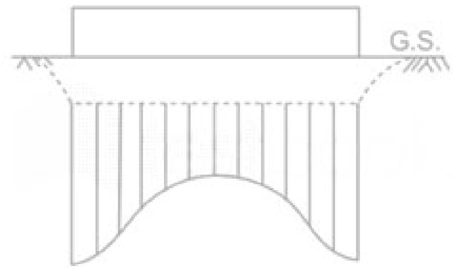
58. The contact pressure distribution shown in the figure belongs to a option (b) rigid footing resting on cohesive soil.



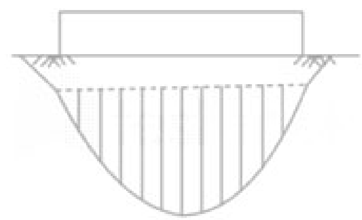
The above figure is a black and white sketch of a footing, with a text label "Footing" below it. There are no shading or other visual cues to indicate variations in pressure. However, based on what we know about contact pressure distribution for different footing and soil types, we can interpret the scenario:

Rigid footing : A rigid footing is less likely to deform under load compared to a flexible footing. In the absence of any visual bending or settling of the footing in the image, we can assume it's rigid.

Under Riqid footing : For riqid footings resting on cohesive soils, the settlement is uniform but contact pressure varies. At edqes contact pressure is maximum and at the center, it is minimum which forms an inverted bowl shape as shown in the below figure.



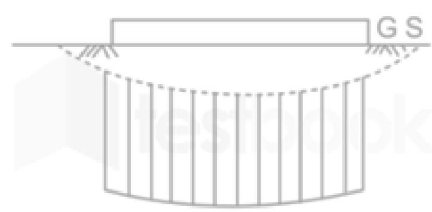
If the rigid footing is resting on Cohesionless soils, the contact pressure is maximum at the center and gradually reduces to zero towards edges. The settlement is uniform in this case also.



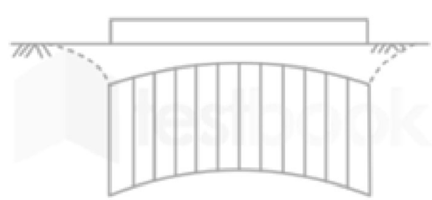
Cohesive soil : Cohesive soils have internal friction that allows them to stick together to some extent. This can influence the pressure distribution under the footing.

For a rigid footing on cohesive soil, the soil tends to offer more resistance near the edges, resulting in a **higher pressure near the edges and lower pressure near the center**, which aligns with the description of the pressure distribution in the image.

Under flexible footing : For flexible footing on cohesive soil, the settlement is maximum at the center of footing and minimum at the edges which form a bowl-like shape as shown in the below figure.



When a flexible footing is laid on the Cohesionless soil, the settlement at the center becomes minimum while at edges it is maximum which exact opposite case of the settlement of flexible footing over cohesive soil.



Hence, option (b) is the correct answer.