CLASS TEST

S.No. : 01 JPCE_SOIL_141023

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CIVIL ENGINEERING

SOIL MECHANICS

Duration : 1:00 hr. **Maximum Marks : 50**

Read the following instructions carefully

1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q.No. 1 to Q.No. 10 carry 1 mark each

Q.1 Given that coefficient of curvature is 1.2, D_{30} = 3.2 mm and D_{10} = 0.6 mm. Based on this information, the soil can be classified as
(a) uniformly graded sand
(b) very fine sand
(c) well graded sand
(d) poorly graded sand

Q.2 A 2 m layer of soil with (n = 0.30 and G_s = 2.70) is subjected to an upward seepage head of 1.90 m. What depth of coarse sand will be required above this soil to provide a factor of safety of 1.5 against piping? (Assume the coarse sand has same porosity and specific gravity as that of soil.)
(a) 0.6 m (b) 0.4 m
(c) 0.7 m (d) 0.8 m

Q.3 What is the value of time factor for Taylor's square root of time fitting method?
(a) 0.898 (b) 0.848
(c) 0.636 (d) 0.748

Q.4 A fully saturated capillary zone of thickness 3 m exists above water table in a fine silty sand deposit. What is the pore water pressure at 1.0 m above the water table?
[γ_w = 10 kN/m^3]
(a) 20 kN/m^2 (b) 10 kN/m^2
(c) –10 kN/m^2 (d) –20 kN/m^2

Q.5 If U_r and U_v are the average degrees of consolidation due to radial and vertical drainage respectively, and U is the overall degree of consolidation, then what is the value of U_v if U_r and U are 30% and 70% respectively?
(a) 79.81% (b) 57.14%
(c) 63.46% (d) 42.85%

Q.6 The equation of the effective stress failure envelope for normally consolidated clay (C = 0) is $\tau_f = \bar{\sigma}\tan 30°$. A drained triaxial test was conducted with the same soil at a chamber confining pressure of 69 kN/m^2. What will be the deviator stress at failure?
(a) 207 kN/m^2 (b) 279 kN/m^2
(c) 138 kN/m^2 (d) 201 kN/m^2

Q.7 Consider the following statements:
1. Friction circle method is based on total stress analysis.
2. The friction circle method assumes a wedge failure surface.
3. Taylor's stability number is based on friction circle analysis.

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

Q.8 Consider the following statements:
1. The ratio of τ_{ff} to σ_{ff} is maximum on the plane of maximum shear stress.
2. Direct shear test is useful for free draining soils only.
3. In direct shear test, there is a rotation of the principal planes between the start of the test and the failure of the soil.

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

Q.9 Which of the given below filter specification is not correct for the prevention of erosion and piping?

(a) $\dfrac{D_{15}(\text{filter})}{D_{85}(\text{protected material})} < 5$

(b) $4 < \dfrac{D_{15}(\text{filter})}{D_{15}(\text{protected material})} < 20$

(c) $\dfrac{D_{50}(\text{filter})}{D_{50}(\text{protected material})} < 25$

(d) $\dfrac{D_{50}(\text{filter})}{D_{85}(\text{protected material})} < 25$

Q.10 The intensity of active earth pressure at a depth of 10 m in dry sand is 60 kN/m^2. The unit weight of the sand is 18 kN/m^3. The angle of shearing resistance will be:
(a) 15° (b) 30°
(c) 60° (d) 45°

Q. No. 11 to Q. No. 30 carry 2 marks each

Q.11 The Atterberg limits of a given soil are: LL = 60%, PL = 45% and SL = 28%. The specific gravity of the soil solids is 2.70. A sample of this soil at liquid limit has a volume of 20 cc. What will be the final volume if the sample is brought to its shrinkage limit?

(a) 19.30 cc (b) 13.40 cc
(c) 15.40 cc (d) 17.60 cc

Q.12 A confined aquifer 5 m thick gives a steady discharge of 40 l/sec through a well of diameter 0.6 m. The height of water in the well which was 16 m above the base before pumping dropped to 12 m. The radius of influence is 300 m. What is the coefficient of permeability?

(a) 2.2 mm/sec (b) 3.1 mm/sec
(c) 1.8 mm/sec (d) 2.6 mm/sec

Q.13 A sample of clay was coated with paraffin wax and its mass, including the mass of wax, was found to be 584.3 gm. The sample was then immersed in water and the volume of water displaced was found to be 342 ml. The mass of the sample without wax was 575.8 gm, and the water content of the representative specimen was 20%. What will be dry density of sample? [Sp. gravity of wax = 0.85]

(a) 1.445 g/cc (b) 1.734 g/cc
(c) 1.76 g/cc (d) 1.48 g/cc

Q.14 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. What will be the total passive thrust on the wall?

(a) 681.44 kN/m (b) 1091.44 kN/m
(c) 646 kN/m (d) 1291.44 kN/m

Q.15 A raft footing is to be constructed on a 8 m thick clay layer which lies between two sand layers. In order to predict the time rate of settlement of the building, 3 cm thick undisturbed sample of the soil was tested in a laboratory under double drainage condition. The sample was found to have undergone 50% settlement in 15 minutes. What will be the time required for 50% settlement of the building?

(a) 541 days (b) 603 days
(c) 689 days (d) 741 days

Q.16 In a Proctor compaction test, the soil specimen in one of the observation had a bulk density of 19 kN/m^3 and the moisture content was 17%. What is the additional moisture content required to saturate the soil specimen? [Use G = 2.7]

(a) 10% (b) 23.37%
(c) 6.37% (d) 15.47%

Q.17 The following data were recorded in a constant head permeability test.
Internal diameter of permeameter = 7.5 cm
Head lost over a sample length of 18 cm = 24.7 cm
Quantity of water collected in 60s = 626 ml
Porosity of soil sample = 44%
What is the seepage velocity during the test?

(a) 0.236 cm/s (b) 0.336 cm/s
(c) 0.436 cm/s (d) 0.536 cm/s

Q.18 In an in-situ vane shear test on a saturated clay, a torque of 35 Nm was required to shear the soil. The diameter of the vane was 60 mm and length 100 mm. The vane was then rotated rapidly to cause remoulding of the soil. The torque required to shear the soil in this case was 5 Nm. The sensitivity of the clay will be

(a) 5 (b) 9
(c) 7 (d) 11

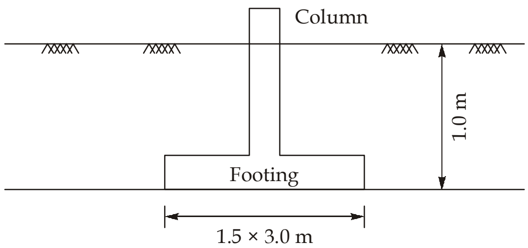
Q.19 An infinite slope, with a slope angle of 14° made up of a cohesionless soil having $\phi = 30°$ and $\gamma_{sat} = 20$ kN/m^3. It experiences seepage with the water table at the surface. Assuming unit weight of water as 10 kN/m^3, factor of safety against failure is _____

(a) 1.16 (b) 2.31
(c) 1.56 (d) 2.01

Q.20 Consider the following statements with respect to secondary consolidation:
1. Secondary consolidation occurs at a much slower rate than primary consolidation.
2. Secondary consolidation occurs at a constant effective stress.
3. Secondary consolidation is not associated with the dissipation of pore water.
4. Terzaghi theory of consolidation can be applied to find the rate of secondary consolidation.

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

Q.21 A column is supported on a footing on cohesionless soil as shown in figure below. The water table is at a large depth below base of footing.



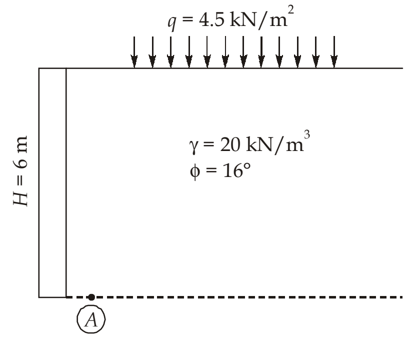
Use, γ = 18 kN/m^3, N_q = 24, N_γ = 20, FOS = 3
Based on Terzaghi's bearing capacity theory, the net safe bearing capacity (in kN/m^2) of soil is ____.
(a) 675 (b) 219
(c) 601 (d) 315

Q.22 A precast concrete pile is driven with 80 kN drop hammer falling through a height of 1.5 m. The set value observed is 4 mm per blow. The load carrying capacity of the pile using ENR formula with a factor of safety of 6 will be
(a) 537 kN (b) 689 kN
(c) 638 kN (d) 413 kN

Q.23 A rectangular footing 1 m × 3 m is placed at a depth of 3 m in a saturated clay having an UCS of 100 kN/m^2. According to Skempton, the net ultimate bearing capacity is
(a) 400 kN/m^2 (b) 426 kN/m^2
(c) 472 kN/m^2 (d) 495 kN/m^2

Q.24 A 5 m high retaining wall having a smooth vertical back face retain a layered horizontal backfill. Top 2 m thick layer of the backfill is sand having an angle of internal friction, ϕ = 30° while the bottom layer is 3 m thick clay with cohesion, c = 30 kPa. Assume unit weight of sand and clay as 20 and 18 kN/m^3, respectively. The total passive earth pressure per unit length of the wall is ____________ kN/m.
(a) 601 (b) 301
(c) 401 (d) 501

Q.25 A 6 m deep excavation of sand is supported by a smooth vertical wall. The backfill is horizontal and supports a surcharge of 4.5 kN/m^2 on its surface as shown below:



Active earth pressure at A is _____.
(a) 35.96 kN/m^2 (b) 85.96 kN/m^2
(c) 70.96 kN/m^2 (d) 219.12 kN/m^2

Q.26 A canal having side slope 1 to 1 is proposed to be constructed in a cohesive soil to a depth of 5 m below ground surface. The soil properties are given below:

ϕ_u = 15°, C_u = 12 kN/m^2, e = 1, G_s = 2.65

Also for ϕ_u = 15°, β = 45°, S_n = 0.08,

and for ϕ = 6.8°, β = 45°, S_n = 0.126

The factor of safety with respect to cohesion against failure of the bank slopes when there is a sudden drawdown of water in the canal will be
(a) 3.7 (b) 1.06
(c) 2.06 (d) 4.2

Q.27 Which of the following statement is correct?
(a) Stress isobar can be prepared using Boussinesq stress distribution theory.
(b) Equivalent point load method yields accurate results.
(c) Westergaard's method helps in determination of stress distribution for non layered soils.
(d) Boussinesq's theory of stress distribution in soils deals with layered soils only.

Q.28 The time for a clay layer to achieve 90% consolidation is 15 years. The time required to achieve 90% consolidation if the layer were half as thick, 3 times more permeable and 4 times more compressible would be
(a) 45 years (b) 25 years
(c) 5 years (d) 3 years

Q.29 The relationship between the specific gravity of sand (G) and the hydraulic gradient (i) to initiate quick condition in the sand layer having porosity of 30% is
(a) $G = 1.43i + 1$ (b) $G = 1.43i - 1$
(c) $G = 1.03i + 1$ (d) $G = 1.53i - 1$

Q.30 The initial cross-sectional area of a clay sample was 18 cm^2. The failure strain was 25% in an unconfined compression test. The corrected area of the sample at failure would be
(a) 18 cm^2 (b) 13.5 cm^2
(c) 24 cm^2 (d) 26 cm^2

■■■■

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SOIL MECHANICS

CIVIL ENGINEERING

Date of Test : 14/10/2023

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

Coefficient of curvature, $C_c = 1.2$

Now, $$C_c = \frac{D_{30}^{\,2}}{D_{60} \times D_{10}}$$

$$\Rightarrow \quad 1.2 = \frac{(3.2)^2}{D_{60} \times 0.6}$$

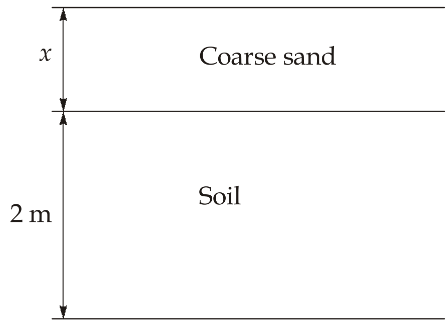
$$\Rightarrow \quad D_{60} = \frac{3.2^2}{1.2 \times 0.6} = 14.22 \text{ mm}$$

So, $$C_u = \frac{D_{60}}{D_{10}} = \frac{14.22}{0.6} = 23.70$$

$\therefore$ $C_u > 6$ and C_c lies between 1 and 3.

Hence, the soil is well graded sand.

2. (b)



Critical hydraulic gradient,

$$i_{cr} = \frac{G-1}{1+e} = (G-1)(1-n)$$

$$\Rightarrow \quad i_{cr} = (2.7 - 1)\,(1 - 0.3)$$

$$\Rightarrow \quad = 1.19$$

$$i_{\text{allowable}} = \frac{1.19}{\text{FOS}}$$

$$\Rightarrow \quad i_{\text{allowable}} = \frac{1.19}{1.5} = 0.7933$$

$$\therefore \quad (2 + x) \times 0.7933 = 1.90$$

$$\Rightarrow \quad 2 + x = 2.395$$

$$\Rightarrow \quad x = 0.395 \text{ m} \simeq 0.4 \text{ m}$$

3. (b)

For Taylor's square root of time fitting method,

Degree of consolidation, $U = 90\%$

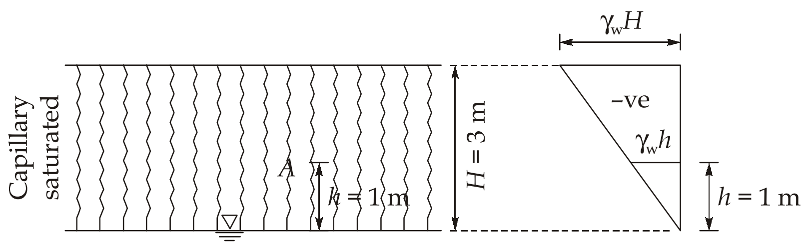
For $U = 90\% > 60\%$

$$T_v = 1.781 - 0.933 \times \log_{10}(100 - \%U)$$

$$= 1.781 - 0.933 \times \log_{10}(100 - 90)$$

$$= 0.848$$

4. (c)



Pore water pressure 1m above G.W.T. is

$$u = -\gamma_w h$$

For $h = 1$ m, $\quad u = -10 \times 1$

$\Rightarrow \quad u = -10 \text{ kN/m}^2$

5. (b)

Given, $\quad U_r = 30\%$

$$U = 70\%$$

We know, $\quad (1 - U) = (1 - U_r)(1 - U_v)$

$\Rightarrow \quad (1 - 0.7) = (1 - 0.3)(1 - U_v)$

$\Rightarrow \quad U_v = 1 - \dfrac{0.3}{0.7} = \dfrac{4}{7}$

$\Rightarrow \quad U_v = 57.14\%$

6. (c)

For normally consolidated clay,

Given, $\quad \tau_f = \bar{\sigma} \tan 30°$

$\Rightarrow \quad \phi = 30° \qquad [\because C' = 0]$

Now, $\quad \bar{\sigma}_1 = \bar{\sigma}_3 \tan^2\left(45° + \dfrac{\phi}{2}\right)$

$$\bar{\sigma}_1 = 69 \tan^2\left(45° + \dfrac{30°}{2}\right)$$

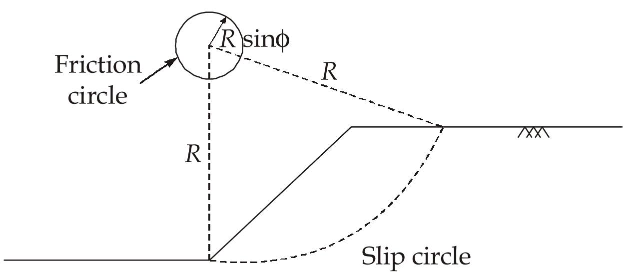
$\Rightarrow \quad \bar{\sigma}_1 = 207 \text{ kN/m}^2$

$\therefore \quad (\Delta\bar{\sigma}_d)_f = \bar{\sigma}_1 - \bar{\sigma}_3 = 207 - 69 = 138 \text{ kN/m}^2$

7. (c)

Friction circle method:

- Based on total stress analysis.
- In this method it is assumed that the resultant force R on the rupture surface is tangential to a circle of radius $R \sin\phi$, which is concentric with trial slip circle.



8. (b)

The ratio of τ_{ff} and σ_{ff} is maximum on the plane of maximum obliquity and not on the plane of maximum shear stress.

9. (d)

To prevent possibility of erosion and piping, filter must have grain sizes that satisfy following requirements:

(i) $$\frac{D_{15\,(\text{filter})}}{D_{85(\text{protected material})}} < 5$$

It ensures that no significant invasion of particles from the protected material to the filter.

(ii) $$4 < \frac{D_{15(\text{filter})}}{D_{15(\text{protected material})}} < 20$$

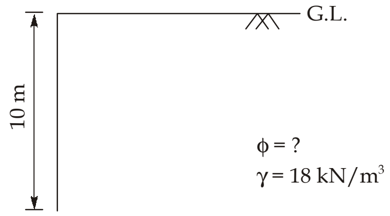
It ensures that sufficient head is lost in filter without build-up of seepage pressure (specifies the lower limit of material.

(iii) $$\frac{D_{50(\text{filter})}}{D_{50(\text{protected material})}} < 25$$

This is the additional guideline for the selection of material.

10. (b)

$$p_a = K_a(\gamma z)$$



where K_a is coefficient of active earth pressure

$\Rightarrow$ $$60 = K_a \times 18 \times 10$$

$\Rightarrow$ $$K_a = \frac{1}{3}$$

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

$\Rightarrow$ $$\phi = 30°$$

11. (b)

At liquid limit, $w_L = 60\%,\ V_L = 20$ cc, $S = 1$

At shrinkage limit, $w_s = 28\%,\ V_s = ?,\ S = 1$

We know that, $$\gamma_d = \frac{G\gamma_w}{1+e} = \frac{G\gamma_w}{1+\frac{wG}{S}}$$

and $$\gamma_d = \frac{W_s}{V}$$

So, at liquid limit, $$\frac{W_s}{20} = \frac{G\gamma_w}{1+0.6\times 2.7} \quad \text{...(i)}$$

At shrinkage limit, $$\frac{W_s}{V} = \frac{G\gamma_w}{1+0.28\times 2.7} \quad \text{...(ii)}$$

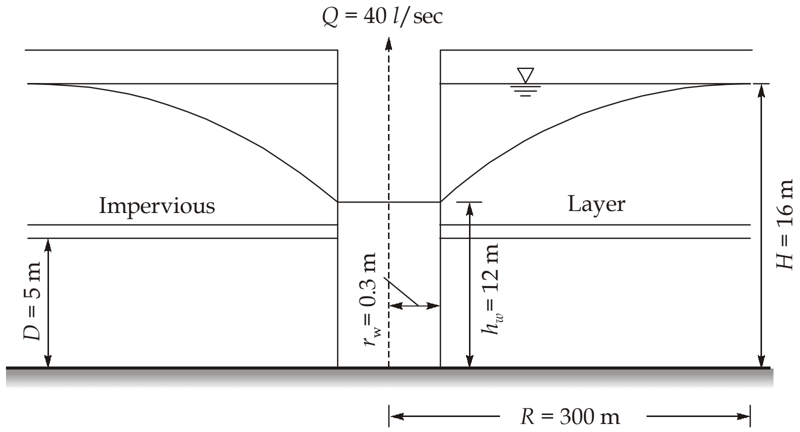
From eq. (i) and (ii)

$$\frac{1+0.28\times 2.7}{V} = \frac{1+0.6\times 2.7}{20}$$

$$\Rightarrow \quad \frac{V}{20} = \frac{1+0.28\times 2.7}{1+0.6\times 2.7} = \frac{1.756}{2.62}$$

$$\Rightarrow \quad V = 13.40 \text{ cc}$$

12. (a)



For confined aquifer,

By Dupit's equation, $$k = \frac{2.303 Q \log_{10}\left(\frac{R}{r_w}\right)}{2\pi D (H - h_w)}$$

Given, $Q = 40\ l/\text{sec} = 0.04\ \text{m}^3/\text{sec}$, $R = 300$ m, $r_w = 0.3$ m, $D = 5$ m, $H = 16$ m, $h_w = 12$ m

Hence, $$k = \frac{2.303\times 0.04\times \log\left(\frac{300}{0.3}\right)}{2\pi\times 5\times(16-12)}$$

$$= 2.199 \times 10^{-3} \text{ m/sec} \simeq 2.2 \text{ mm/sec}$$

13. (a)

Mass of paraffin wax, $M_p = 584.3 - 575.8 = 8.5$ gm

Weight of soil, $W = 575.8$ gm

Volume of paraffin wax, $V_p = \dfrac{M_p}{G_p \times \rho_w} = \dfrac{8.5}{0.85\times 1} = 10$ ml $\qquad (G_p = 0.85)$

Volume of soil, $V = 342 - 10 = 332$ ml

Bulk density, $\rho_b = \dfrac{W}{V} = 1.734$ g/cc $\qquad (\because 1 \text{ ml} = 1 \text{ cc})$

$\therefore$ Dry density, $\rho_d = \dfrac{\rho_b}{1+w} = \dfrac{1.734}{1+0.2} = 1.445$ g/cc

14. (d)

The passive earth pressure coefficient is

$$k_p = \frac{1+\sin\phi}{1-\sin\phi} = \frac{1+0.259}{1-0.259} = 1.699$$

The passive pressure at a depth z is given by,

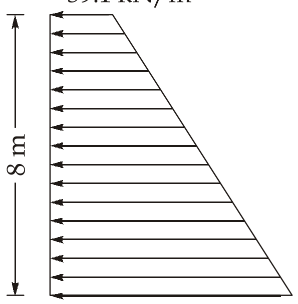
$$p_p = k_p \gamma z + 2C\sqrt{k_p}$$

At z = 0 m, $$p_p = 2\times 15\times\sqrt{1.699} = 39.1 \text{ kN/m}^2$$

At z = 8 m, $$p_p = 18\times 1.699\times 8 + 2\times 15\sqrt{1.699}$$

$$= 283.76 \text{ kN/m}^2$$

$\therefore$ Total passive thrust, $$p_p = \frac{1}{2}[39.1 + 283.76]\times 8 = 1291.44 \text{ kN/m}$$



15. (d)

For 50% consolidation,

$$T_V = \frac{C_V t}{h^2}$$

$\Rightarrow$ $$C_V = \left(\frac{T_V \times h^2}{t}\right)$$

In the laboratory test,

$$T_{V\,50} = \frac{\pi}{4}\times 0.5^2 = 0.196$$

$$t = 15 \text{ min}$$

$$h = \frac{H}{2} = \frac{3}{2} = 1.5 \text{ cm} \qquad [\because \text{Double drainage}]$$

So, $$C_V = \frac{T_V \times h^2}{t} = \frac{0.196\times 1.5^2}{15}$$

$\therefore$ $$= 0.0294 \text{ cm}^2/\text{min}$$

In the case of actual building,

$$h = \frac{8\times 100}{2} = 400 \text{ cm}$$

$\therefore$ $$t = \frac{T_V \times h^2}{C_V} = \frac{0.196\times 400^2}{0.0294\times 60\times 24}$$

$\Rightarrow$ $$t = 740.74 \text{ days} \simeq 741 \text{ days}$$

16. (c)

Given, γ_b = 19 kN/m^3, w_1 = 17%

So, dry density, $$\gamma_d = \frac{\gamma_b}{1+w} = \frac{19}{1+0.17} = 16.24 \text{ kN/m}^3$$

Also, $$\gamma_d = \frac{G\gamma_w}{1+e} = \frac{2.7\times 9.81}{1+e} = 16.24$$

$$\Rightarrow \qquad e = \frac{2.7 \times 9.81}{16.24} - 1 = 0.631$$

When the soil is fully saturated, $S = 1$,

$$\therefore \qquad S \cdot e = w \cdot G$$

So, new moisture content,

$$w_2 = \frac{S \cdot e}{G} = \frac{1 \times 0.631}{2.7} = 0.2337 \text{ or } 23.37\%$$

$\therefore$ Additional moisture content required

$$= 23.37 - 17 = 6.37\%$$

17. (d)

For constant head permeability test,

$$k = \frac{Q}{Ai} = \frac{626}{\frac{\pi}{4} \times 7.5^2 \times 60 \times \frac{24.7}{18}} = 1.72 \times 10^{-1} \text{ cm/s}$$

Now, Discharge velocity, $V = ki$

$$= 1.72 \times 10^{-1} \times \frac{24.7}{18} = 0.236 \text{ cm/s}$$

Seepage velocity, $\frac{V}{n} = \frac{0.236}{0.44}$

$$V_s = 0.536 \text{ cm/s}$$

18. (c)

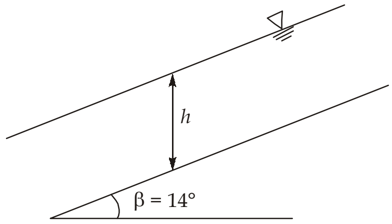
$$q_{u \text{ (undisturbed)}} = \frac{T}{\pi d^2 \left[\frac{h}{2} + \frac{d}{6}\right]} = \frac{35 \times 1000}{\pi \times 60^2 \times \left[\frac{100}{2} + \frac{60}{6}\right]}$$

$$= 0.05158 \text{ N/mm}^2 = 51.58 \text{ kN/m}^2$$

$$q_{u \text{ (remoulded)}} = \frac{5 \times 1000 \times 10^3}{\pi \times 60^2 \left[\frac{100}{2} + \frac{60}{6}\right]} \text{ kN/m}^2 = 7.368 \text{ kN/m}^2$$

$$\therefore \quad \text{Sensitivity of the clay} = \frac{q_{u\text{(undisturbed)}}}{q_{u\text{(remoulded)}}} = \frac{51.58}{7.368} = 7$$

19. (a)



$$\phi = 30°$$
$$\gamma_{sat} = 20 \text{ kN/m}^3$$

FOS against failure =

$$\frac{\gamma_{sub}}{\gamma_{sat}} \times \frac{\tan\phi}{\tan\beta} = \frac{(20-10)}{20} \times \frac{\tan(30°)}{\tan(14°)} = 1.16$$

20. (a)

- Experimentally it has been shown that the compression of soil layer does not stop when excess pore water pressure has dissipated to zero but continues at a gradually decreasing rate at constant effective stress. This phenomenon is known as secondary compression.
- Since, secondary consolidation is not governed by the dissipation of excess hydrostatic pressure, Terzaghi's theory of consolidation cannot be applied to find the rate of secondary consolidation.

21. (b)

As per Tergazhi, for rectangular footing

Ultimate bearing capacity,

$$q_u = \left(1+0.3\frac{B}{L}\right)cN_c + \gamma \cdot D_f N_q + \left(1-0.2\frac{B}{L}\right)\cdot\frac{1}{2}B\gamma N_\gamma$$

Now, $C = 0$,

So, $$q_u = 18\times1\times24+\left(1-0.2\times\frac{1.5}{3.0}\right)\times1.5\times\frac{1}{2}\times18\times20$$

$$= 432 + 243 = 675 \text{ kN/m}^2$$

Net ultimate bearing capacity,

$$q_{nu} = q_u - \gamma \cdot D_f = 675 - 18 \times 1 = 657 \text{ kN/m}^2$$

Net safe bearing capacity,

$$q_{ns} = \frac{q_{nu}}{\text{FOS}} = \frac{657}{3} = 219 \text{ kN/m}^2$$

22. (b)

Given, $W = 80$ kN, $H = 1.5$ m $= 150$ cm, $S = 4$ mm $= 0.4$ cm, $C = 2.5$ cm for drop hammer

Hence, $$Q_c = \frac{WH}{(S+C)\text{FOS}} = \frac{80\times150}{(0.4+2.5)6} = 689.66 \text{ kN} \simeq 689 \text{ kN (say)}$$

23. (a)

As per Skempton, $q_{nu} = CN_C$ (where C is the cohesion)

Given, UCS = 100 kN/m²

$$\Rightarrow \quad C = \frac{UCS}{2} = 50 \text{ kN/m}^2$$

For $\frac{D_f}{B} \geq 2.5, \left[\frac{D_f}{B} = \frac{3}{1} = 3\right]$

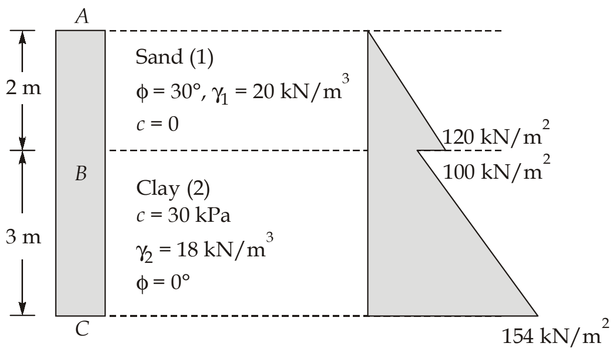
N_c for rectangular footing

$$= 7.5\left(1+\frac{0.2B}{L}\right) \leq 9$$

$$= 7.5\left(1+\frac{0.2\times 1}{3}\right) = 8 \leq 9$$

$$q_{nu} = 8 \times 50 = 400 \text{ kN/m}^2$$

24. (d)



$$K_{P_1} = \frac{1+\sin\phi}{1-\sin\phi} = 3$$

$$K_{P_2} = 1 \qquad (\because \phi_{clay} = 0°)$$

$$p_B = K_{P_1}\gamma_1 z_1 = 3\times 20\times 2 = 120 \text{ kN/m}^2$$

$$p'_B = K_{p_2}\gamma_1 z_1 + 2c\sqrt{K_{P_2}}$$

$$= 1\times 20\times 2 + 2\times 30\sqrt{1} = 100 \text{ kN/m}^2$$

$$p_c = K_{p2}\times\gamma_1 z_1 + K_{p_2}\gamma_2 z_2 + 2c\sqrt{K_{P_2}}$$

$$= 1\times 20\times 2 + 1\times 18\times 3 + 2\times 30\sqrt{1} = 154 \text{ kN/m}^2$$

Therefore total passive earth pressure per unit length of the wall is

$$p_a = \frac{1}{2}\times 120\times 2 + \frac{1}{2}(154+100)\times 3$$

$$= 120 + 381 = 501 \text{ kN/m}$$

25. (c)

$$\phi = 16°$$

$$k_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin(16°)}{1+\sin(16°)} = 0.57$$

At A:

$$p_a = k_a \cdot \bar{\sigma}_z - 2c\sqrt{k_a} \quad (\because c = 0)$$

$$p_a = k_a \cdot \bar{\sigma}_z = 0.57 \times (4.5 + 20 \times 6) = 70.965 \text{ kN/m}^2$$

26. (b)

$$\gamma_{sat} = \frac{G+e}{1+e} \times \gamma_w = \frac{2.65+1}{1+1} \times 9.81 = 17.9 \text{ kN/m}^3$$

$$\gamma' = \gamma_{sat} - \gamma_w = 17.9 - 9.81 = 8.1 \text{ kN/m}^3$$

For sudden drawdown $\gamma = \gamma_{sat}$

$$\phi_w = \frac{\gamma'}{\gamma_{sat}} \times \phi_u = \frac{8.1}{17.9} \times 15 = 6.8°$$

$$F_C = \frac{C_u}{S_n \times \gamma_{sat} \times H} = \frac{12}{0.126 \times 17.9 \times 5} = 1.06$$

27. (a)

- Equivalent point load method is an approximate method.
- Boussinesq's equation can't be applied to sedimentary deposits.
- West

28. (c)

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

$$T_v = \frac{k}{m_v \gamma_w} \times \frac{t}{d^2}$$

$\because$ Percentage consolidation required is same in both the cases.

$\therefore$ $T_v = T_v'$

$$\frac{k}{m_v \gamma_w} \times \frac{t}{d^2} = \frac{k'}{m_v' \gamma_w} \times \frac{t}{d^2}$$

$$\frac{k}{m_v} \times \frac{15}{d^2} = \frac{3k}{4m_v} \times \frac{t}{(d/2)^2} \qquad [\because k' = 3k \text{ \& } m_v' = 4\text{m}]$$

$$15 = 3t$$

$$t = 5 \text{ years}$$

29. (a)

$$i = \frac{G-1}{1+e}$$

$$n = 0.3$$

$$\therefore \quad e = \frac{n}{1-e} = \frac{0.3}{1-0.3} = \frac{0.3}{0.7} = 0.43$$

$$G = 1.43i + 1$$

30. (c)

Given, initial area, $A_0 = 18 \text{ cm}^2$

Failure strain = 25% = 0.25

$$\text{Corrected area} = \frac{A_0}{1-\varepsilon} = \frac{18}{1-0.25}$$

$$= \frac{18}{0.75} = 24 \text{ cm}^2$$

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