GEOTECHNICAL ENGINEERING TEST 3

Number of Questions: 30 **Time: 75 min.**

Directions for questions 1 to 30: Select the correct alternative from the given choices.

1. If w represents natural water content & w_L, w_p, w_s represents Liquid limit, Plastic limit, Shrinkage limit respectively; choose the incorrect pair from the following.

(A) Plasticity Index $(I_p) = w_L - w_P$

(B) Shrinkage Index $(I_s) = w_p - w_s$

(C) Liquidity Index $(I_L) = \dfrac{w - w_p}{w_L - w_p}$

(D) Consistency Index $(I_C) = \dfrac{w - w_L}{w_L - w_P}$

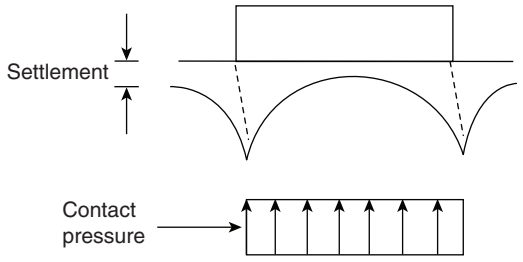
2. The symbol 'SM' indicates

(A) Sandy silt
(B) Medium silt
(C) Silty sand
(D) Medium sand

3. For a given flow net, if number of flow channels and number of potential drops are found as 12 and 8; then what would be the shape factor of the flow net?

(A) 4
(B) 1.67
(C) 1.5
(D) 1.71

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

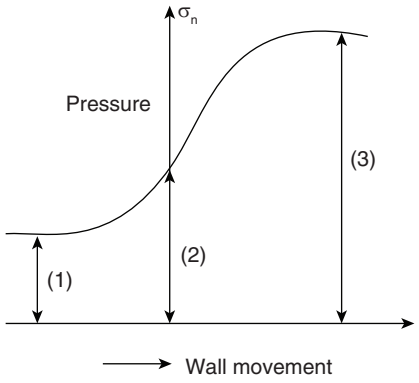


(A) Rigid footing on Sand
(B) Flexible footing on Clay
(C) Flexible footing on Sand
(D) Rigid footing on Clay

5. If uniform surcharge of 120 kN/m^2 is placed on the backfill with $\Phi = 30°$, the increase in pressure is (in kN /m^2)

6. The cohesion and density of a soil are 1.8 t/m^2 and 2 t/m^2. If Stability number is taken as maximum, for a factor of safety against 2.5 what will be the safe height of the slope in meters? _____

7.



Identify the correct one from the following. (p_o, p_a, p_p indicates at rest, active and passive earth pressures respectively)

(A) (1) – p_o, (2) – p_a, (3) – p_p
(B) (1) – p_a, (2) – p_o, (3) – p_p
(C) (1) – p_p, (2) – p_o, (3) – p_a
(D) (1) – p_o, (2) – p_p, (3) – p_a

8. In a falling head permeability test the initial head of 1.2 m dropped to 0.4 m in 4 hours, the diameter of the stand pipe being 5 mm. The soil specimen was 300 mm long and of 150 mm diameter. The coefficient of permeability of the soil is _____

(A) 2.54×10^{-5} cm/sec
(B) 2.54×10^{-6} cm/sec
(C) 2.54×10^{-4} cm/sec
(D) 2.54×10^{-7} cm/sec

9. Sand Bath method is used to determine ___

(A) Specific gravity
(B) Unit weight
(C) Moisture content
(D) Particle Size distribution

10. The number of blows observed in a Standard Penetration test for different penetration depths are given as follows.

Penetration of Sampler	Number of blows
0 – 100 mm	2
100 – 200 mm	4
200 – 350 mm	7
350 – 400 mm	10

The observed 'N' value is _____

11. For a Sand deposit having Specific gravity 2.65 and moisture content 25%; what will be the relative density in saturated condition if loose and Compacted void ratios are given as 0.92 and 0.41 respectively

(A) 49% (B) 51%
(C) 39% (D) 31%

12. For a particular soil sample, if D_{10}, D_{30} and D_{60} is given as 425 μ, 2.36 mm and 4.75 mm respectively. Then match the following

	Group – I		Group – II
1.	Coefficient of Curvature	a.	1.81
2.	Coefficient of Uniformity	b.	2.76
3.	Permeability	c.	11.2

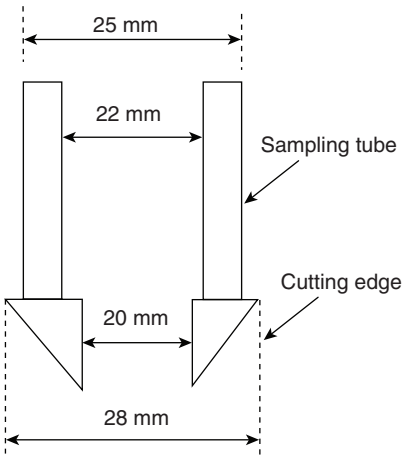
(A) 1 – a, 2 – b, 3 – c
(B) 1 – c, 2 – b, 3 – a
(C) 1 – a, 2 – c, 3 – b
(D) 1 – b, 2 – c, 3 – a

13. In a 8m thick stratum of fine sand having submerged density of 11 kN/m^3, quick sand condition occurred at a depth of 5.2 m of excavation. What is the depth of lowering of ground water table required for making an excavation 6 m deep?
(Take γ_w as 10 kN/m^3)
(A) 1.76 m (B) 1.68 m
(C) 0.88 m (D) 0.74 m

14. The vertical stress at some depth below the centre of 3 m × 4 m rectangular footing due to certain load intensity is 100 kN/m^2. What will be the vertical stress in kN /m^2 below the corner of 1.5 m × 2 m rectangular footing at the same depth and same load intensity?

15. An unsupported excavation is made to the maximum depth in a clay soil having $\gamma = 21$ kN/m^3, $C = 80$ kN/m^2 and $\Phi = 30°$. What will be the active earth at pressure the base level of excavation, according to Rankine's theory?
(A) 184.8 kN/m^2 (B) 92.4 kN/m^2
(C) 1462.4 kN/m^2 (D) 277.18 kN/m^2

16. For the sampler shown in the figure Area ratio, Inside clearance and outside clearance are respectively



(A) 96%, 12%, 10%
(B) 49%, 11%, 9%
(C) 49%, 9%, 11%
(D) 96%, 10%, 12%

17. Match List – I (Roller type) with List – II (Soil type)

	List – I		List – II
1.	Sheep foot roller	a.	Gravel in WBM Road
2.	Pneumatic roller	b.	Dry sand
3.	Smooth heavy roller	c.	Hearting of earthen dam
4.	Vibratory roller	d.	Casing of earthen dam

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

18. The water content of saturated soil and the specific gravity were found to be 30% and 2.65 respectively. Assuming the unit weight of water to be 10 kN/m^3, submerged unit weight (in kN/m^2) and porosity of the soil are _____
(A) 19,0.6 (B) 9,0.45
(C) 9,0.6 (D) 19,0.78

19. When an unconfined compression test is conducted on a cylinder of soil, it fails under axial stress of 1.5 kg/cm^2. If an angle of internal friction of the soil is 30°, what will be the cohesion of the soil? _____
(A) 0.43 kg/cm^2 (B) 0.67 kg/cm^2
(C) 0.75 kg/cm^2 (D) 0.35 kg/cm^2

20. A square footing of size 5 m × 5 m is resting on the surface of a deposit of saturated clay having an unconfined compressive strength of 54 kPa, What will be the net safe bearing capacity of the footing (in kPa) if factor of safety is given as 2.5? _____

21. A square group of 16 piles was driven into soft clay extending to a large depth. The diameter and length of the piles were 30 cm and 12 m respectively. If the cohesion of clay is given as 5 t/m^2, for the pile spacing 100 cm c/c what is the capacity of the pile group? (Take adhesion factor as 0.75 and FOS = 1.75)
(A) 733 *t* (B) 417 *t*
(C) 550 *t* (D) 623 *t*

22. In a constant head permeameter with cross section area of 10 cm^2, when the flow was taking place under a hydraulic gradient of 0.6 the amount of water collected in 60 seconds is 720 CC. The permeability of the soil is ____.
(A) 0.2 cm/sec (B) 0.02 cm/sec
(C) 0.002 cm/sec (D) 2 cm/ sec

23. What is the shear strength in terms of effective stress on a plane with in the saturated soil mass at a point where total normal stress is 245 kPa and pore water pressure is 80 kPa. The effective shear stress parameters are c^1 = 12 kPa, and $\phi' = 30°$.
(A) 105.3 kPa (B) 106.3 kPa
(C) 107.3 kPa (D) 108.3 kPa

24. Sieve analysis on a dry soil sample of mass 1000 g showed that 980 g and 270 g of soil pass through

4.75mm and 75 μ sieve, respectively. The liquid limit and plastic limits of the soil fraction passing through 425 μ sieves are 55% and 25% respectively. The soil may be classified as _____

(A) *GC* (B) *SM*
(C) *GM* (D) *SC*

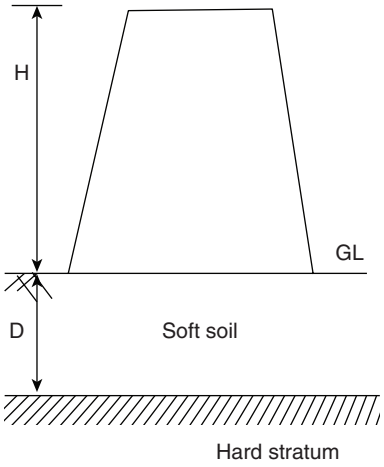
25. Identify the incorrect pair from the following
(A) Alluvial soils - Transported by running water
(B) Lacustrine soils - Deposited at the bottom of lakes
(C) Talus - soil transported by gravitational force
(D) Loess - soil transported by glaciers

26. In a plate load test with size of plate 30 × 30 cm; bearing capacity and settlement were noted as 15 kPa & 6 mm respectively in a sandy soil. Then find the bearing capacity and settlement under a footing of size 2.1 m × 2.1 m under the same pressure intensity?
(A) 15 kPa and 42 mm
(B) 15 kPa and 18.4 mm
(C) 105 kPa and 18.4 mm
(D) 105 kPa and 42 mm

27. A footing carries a load of 1200 tons and is of 3.2 m square. It rests in dense sand of 8 m thickness overlaying a clay layer of 2.8 m. The clay layer overlies hard rock. The depth of foundation is 1.5 m Liquid limit of clay is 48% and void is 0.95. The saturated unit weight of sand and clay are given as 1.86 t/m^3 and 1.76 t/m^3 respectively Take the load distribution as 2V to 1H. Assume that the site is flooded and determine the ultimate settlement due to consolidation of clay layer?
(A) 150 mm (B) 170 mm
(C) 190 mm (D) 210 mm

28. If a clay test specimen of 25 mm thick, under double drainage condition attained 50% of primary consolidation in 50 minutes. How long will it take for the same clay layer of 10 m thick to reach the same degree of consolidation under the condition that 'clay is drained on the top surface only'.
(A) 15.4 years (B) 61.7 years
(C) 85.6 years (D) None

29.



For the given slope, the failure expected to be ___
(A) Toe failure
(B) Base failure
(C) Face failure
(D) Can't say/ Data inadequate

30. Identify the false statements from the list given.
(i) Skempton's theory is suitable for clays only.
(ii) The discharge between any two adjacent flow lines is constant
(iii) If water table rises σ^1 and u increases but σ decreases.
(iv) The westergaard analysis is suitable for stratified soils
(A) (iii) and (iv) (B) (i) and (iii)
(C) (iii) only (D) (iv) only

Answer Keys

1. D	**2.** C	**3.** C	**4.** C	**5.** 40 kN/m^2		**6.** 1.37 to 1.40	**7.** B	**8.** B	
9. C	**10.** 21	**11.** B	**12.** D	**13.** B	**14.** 25	**15.** B	**16.** D	**17.** B	**18.** B
19. A	**20.** 80	**21.** B	**22.** D	**23.** C	**24.** D	**25.** D	**26.** C	**27.** B	**28.** B
29. B	**30.** C								

Hints and Explanations

1. consistency Index, $Ic = \dfrac{w_L - w}{w_L - w_p}$ Choice (D)

3. Shape factor $= \dfrac{N_f}{N_d}$

$= \dfrac{12}{8} = 1.5$ Choice (C)

5. Increase in pressure $= Ka.\ q$

$Ka = \dfrac{1-\sin\phi}{1+\sin\phi} = \dfrac{1-\frac{1}{2}}{1+\frac{1}{2}} = \dfrac{1}{3} = \dfrac{1}{3}$

$Ka.\ q = \dfrac{1}{3} \times 120 = 40$ kN/m^2 Ans: 40 kN/m^2

6. $S_n = \dfrac{C}{Fc.\gamma H}$

$0.261 = \dfrac{1.8}{2.5 \times 2 \times H}$

$H = 1.38\text{m}$

Ans: 1.37 to 1.40

7. $p_a < p_o < pp$ Choice (B)

8. $K = 2.303\ \dfrac{aL}{At} \log_{10}\left(\dfrac{h_1}{h_2}\right)$

Given; $h_1 = 1.2\text{m}$ and $h_2 = 0.4\text{m}$

Area of stand pipe $(a) = \dfrac{\pi}{4} \times 5^2 = 19.635\text{mm}^2$

Area of soil specimen $(A) = \dfrac{\pi}{4} \times 150^2 = 17671.46\text{mm}^2$

$\therefore \quad k = 2.303 \times \dfrac{19.635 \times 300}{17671.46 \times 4 \times 60 \times 60} \log_{10}$

$K = 2.54 \times 10^{-5}$ mm/sec

$= 2.54 \times 10^{-6}$ cm/sec Choice (B)

9. Oven drying method, pycnometer method, calcium carbide method, Sand Bath method, are used to determine water content of the soil. Choice (C)

10. $N = 4 + 7 + 10 = 21$

N value is taken as the sum of blows for the last 300 mm penetration. Ans : 21

11. Given that soil is in Saturated condition, then void ratio, $e = wG$

$e = 0.25 \times 2.65 = 0.66$

$$\text{Relative Density} = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

$$= \frac{0.92 - 0.66}{0.92 - 0.41} \times 100$$

$$= 50.98 \approx 51\%$$

Choice (B)

12. Given,

$D_{10} = 425\ \mu = 425 \times 10^{-3}\text{mm} = 0.425$ mm

$D_{30} = 2.36$ mm

$D_{60} = 4.75$ mm

(i) $C_c = \dfrac{D_{30}^2}{D_{60} \times D_{10}} = \dfrac{2.36^2}{4.75 \times 0.425} = 2.76$

(ii) $C_u = \dfrac{D_{60}}{D_{10}} = \dfrac{4.75}{0.425}$

(iii) Permeability; $k = 100\ D_{10}^2$

It should be noted that 'D' is in cm's here

$\Rightarrow \quad K = 100\ (0.425 \times 10^{-1})^2 = 0.181$ cm/sec

$K = 1.81$ mm/sec Choice (D)

13. Quick sand conditions

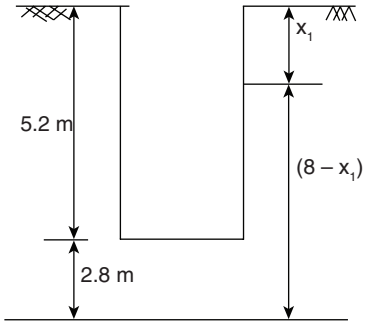
$\gamma_{sat}\, z - \gamma_w h = 0$

Let WT is at x_1, initially

$\sigma^1 = \gamma_{sat}\, Z - \gamma_w h = 0$

$21\ (2.8) - 10\ (8 - x_1) = 0$

$x_1 = 2.12$ m



To make an excavation of 6 m deep,

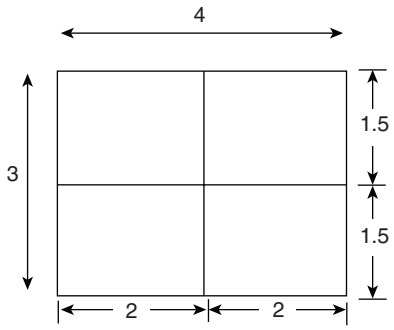
$21\ (2) - 10\ (8 - x_2) = 0$

$x_2 = 3.8$ m

$\therefore$ Lowering of $WT = 3.8 - 2.12 = 1.68$ m.

Choice (B)

14.



Since 3 m × 4 m rectangle consists of 4 no. of 1.5 m × 2 m;

Vertical stress at the corner of 1.5 m × 2 m rectangle = $\dfrac{1}{4}$ × (vertical stress at centre of 3 m× 4 m rectangle)

$= \dfrac{1}{4} \times 100 = 25\ \text{kN/m}^2$ Ans: 25

15. Maximum depth of Unsupported excavation $= H_c$

$= \dfrac{4c}{\gamma\sqrt{K_a}}$

$K_a = \dfrac{1 - \sin\phi}{1 + \sin\phi} = \dfrac{1 - \frac{1}{2}}{1 + \frac{1}{2}}$

$\therefore \quad K_a = \dfrac{1}{3}$

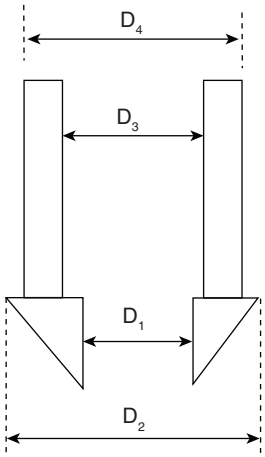
$\Rightarrow \quad H_c = \dfrac{4 \times 80}{21\sqrt{\frac{1}{3}}} = 26.40\text{m}$

$P_a = K_a.\ \gamma H - 2c\ \sqrt{K_a}$

$= \dfrac{1}{3} \times 21 \times 26.40 - 2 \times 80 \times \sqrt{\dfrac{1}{3}} = 92.42\ \text{kN/m}^2$

Choice (B)

16.



$$\text{Area ratio} = \frac{D_2^2 - D_1^2}{D_1^2} \times 100 = \frac{28^2 - 20^2}{20^2} \times 100 = 96\%$$

$$\text{Inside clearance} = \frac{D_3 - D_1}{D_1} \times 100$$

$$= \frac{22 - 20}{20} \times 100 = 10\%$$

$$\text{Outside clearance} = \frac{D_2 - D_4}{D_4} \times 100 = \frac{28 - 25}{25} \times 100$$

$$= 12\%$$ Choice (D)

17. Sheep foot roller – Hearing of earthen down
Pneumatic roller – Casing of earthen down
Smooth heavy roller – Gravel in WBM road
Vibratory roller – Dry Sand Choice (B)

18. $G = 2.65$
$w = 0.30$
$\gamma_w = 10$ kN/m^3

$$e = \frac{wG}{s\gamma}$$

$$e = \frac{0.3 \times 2.65}{1} = 0.80$$

$$\gamma_{sat} = \frac{\gamma_w (G + e)}{1 + e} = \frac{10(2.65 + 0.80)}{1.8}$$

$$= 19.14 \text{ kN/m}^3 = 19 \text{ kN/m}^3$$

$$\gamma^1 = \gamma_{sat} - \gamma_w = 19 - 10 = 9 \text{ kN/m}^3$$

$$\text{Porosity, } n = \frac{e}{1 + e}$$

$$n = \frac{0.8}{1.8} = 0.45$$ Choice (B)

19. $\Phi = 30°$
Unconfined compression test, so

$$\sigma_1 = 2C \tan \alpha$$

$$\alpha = 45 + \Phi/2 = 60°$$

$$\Rightarrow \quad 1.5 = 2C \tan 60°$$

$$\therefore \quad C = 0.43 \text{ kg/cm}^2$$ Choice (A)

20. Given is a square footing.
So,

$$q_{ult} = 1.3\, CN_C + \gamma D N_q + 0.4\, \gamma\, BN\gamma$$

Unconfined compressive strength,

$$q_u = 2c$$

$$\Rightarrow \quad C = \frac{54}{2} = 27 \text{ kPa}$$

For clay; $(\Phi = o)$

$$N_c = 5.7,\ N_q = 1 \text{ and } N\gamma = 0$$

$$q_{netult} = (1.3CNc + \gamma\, DN_q) - \gamma D$$

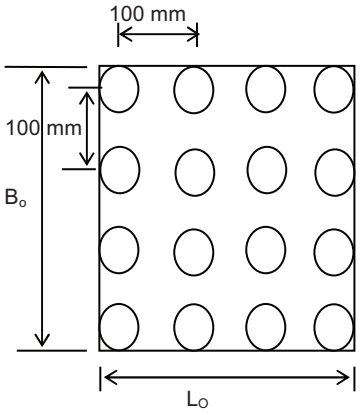
$$q_{netult} = 1.3\, CNc + \gamma D\, N_q - \gamma D$$

$$\therefore \quad q_{netult} = 1.3\, CN_c$$

$$q_{netsafe} = \frac{1.3CN_c}{F.S} = \frac{1.3 \times 27 \times 5.7}{2.5} = 80 \text{ kPa}$$

Ans: 80 kPa

21.



(i) Based on individual pile failure mode

$$Q_{gi} = n\,[A_b CN_c + A_s\, \alpha C]$$

$$= 16\left[\frac{\pi}{4} \times 0.3^2 \times 5 \times 9 + \pi \times 0.3 \times 12 \times 0.75 \times 5\right]$$

$$= 729.46 \text{ t}$$

(ii) Based on Block failure mode

$$Q_{gb} = A_B.\, CN_c + A_{s.} C$$

A_B = Area of block = $B_o.\, L_o$
A_s = Surface area of block = $2\,(B_o .+ L_o)\,.\,L$
$B_o = 3s + d = L_o = 330$cm

$$\therefore \quad A_B = 3.3 \times 3.3 = 10.90 \text{ m}^2$$

Similarly, $A_s = 2\,(3.3 + 3.3)\,12 = 158.4\text{m}^2$

$$Q_{gb} = 10.90(5)\,(9) + (158.4)\,(5) = 1282\ .5\text{t}$$

$$\therefore \quad Q_g = \text{smaller of } Q_{gi} \text{ and } Q_{gb} = 729.46\text{t}$$

$$Q_s = \frac{729.46}{1.75} = 416.8t = 417\text{t}$$ Choice (B)

22. $Q = \text{KiA}$

$$Q = \frac{720\text{cm}^3}{60\,\text{sec}} = 12 \text{ cm}^3/\text{sec}$$

$$\Rightarrow \quad 12 = K \times 0.6 \times 10$$

$$K = 2 \text{ cm/sec}$$ Choice (D)

23. $S = c^1 + \sigma^1 \tan \Phi^1$

$\sigma^1 = 245 - 80 = 165$

$\therefore \quad S = 12 + (165 \times \tan 30°) = 107.26$ kPa Choice (C)

24. As more than 50% of soil passes through 4.75mm sieve and retains on 75 μ sieve, it is Sand.

$I_p = w_L - w_p = 30$

Equation of A line $I_p = 0.73\ (w_L - 20)$

$= 0.73\ (35) = 25.55$

Falls above the A line so it clayey soil

$\therefore$ Given Soil is Clayey Sand. Choice (D)

25. Loess is the soil transported by wind. Choice (D)

26. Given is a Sandy soil,

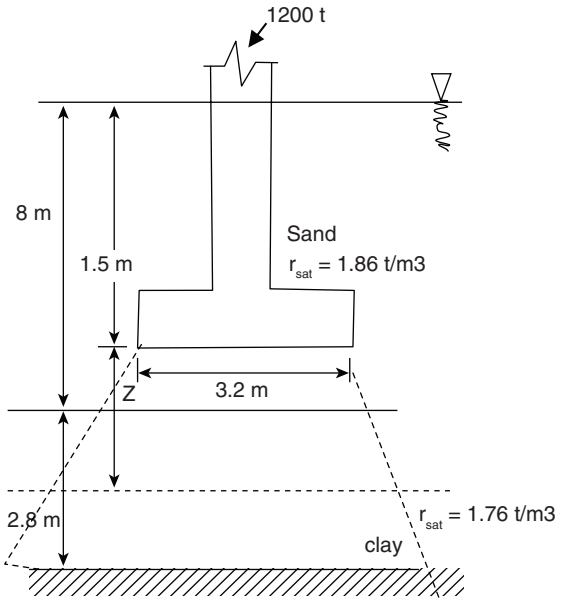
$$\frac{S_F}{S_P} = \left[\frac{B_F\left(B_P + 0.3\right)}{B_P\left(B_F + 0.3\right)}\right]^3$$

$S_P = 6$mm, $B_F = 2.1$m and $B_p = 0.3$ m

$$S_F = \left[\frac{2.1(0.6)}{0.3(2.4)}\right]^2 \times 6 \text{ mm} = 18.375 = 18.4 \text{ mm}$$

$$\frac{q_F}{q_p} = \frac{B_F}{B_p} q_F = \frac{2.1}{0.3} \times 15 = 105 \text{ kPa}$$ Choice (C)

27.



$$\frac{\Delta H}{H} = \frac{c_c}{1+e_0} \log_{10}\left(\frac{\sigma_f^1}{\sigma_0^1}\right)$$

$C_c = 0.009\ (w_L - 10) = 0.009\ (48 - 10) = 0.342$

$\sigma_0^1 = \gamma^1\ (8) + \gamma^1\ (2.8/2)$

$\therefore \quad \sigma_0^1 = 0.86\ (8) + 0.76\ (1.4) = 7.944$ t/m^3

$$\Delta\ \sigma^1 = \frac{1200}{(3.2+z)^2}$$

$Z = 8 - 1.5 + 1.4 = 7.9$m

$$\Delta\ \sigma^1 = \frac{1200}{(3.2+7.9)^2} = 9.74 \text{ t/m}^3$$

$\sigma_f^1 = \sigma_0^1 + \Delta\sigma^1$

$= 7.944 + 9.74 = 17.684$ t/m^3

$$\therefore \quad \Delta H = H\ \frac{C_c}{1+e_0} \log_{10}\left(\frac{\sigma_f^1}{\sigma_0^1}\right)$$

$$= 2.8 \times \frac{0.342}{1+0.95} \log_{10}\left(\frac{17.684}{7.944}\right) = 0.17\text{m}$$

$\therefore \quad \Delta H = 170$ mm Choice (B)

28. $T_v = \dfrac{C_v t}{d^2}$

T_v and C_v are same for the given soil as % degree consolidation is same

$t \propto d^2$

$$\frac{t_1}{t_2} \propto \left(\frac{d_1}{d_2}\right)^2$$

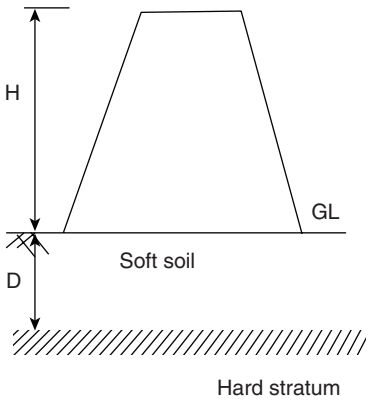
$$d_1 = \frac{25}{2} = 0.0125\text{m}, \ d_2 = 10\text{m}$$

$t_1 = 50 \times 60$ sec $= 3000$ sec

$$\Rightarrow \quad \frac{3000}{t_2} = \left(\frac{0.0125}{10}\right)^2$$

$\therefore \quad t_2 = 61.728$ years Choice (B)

29.



Depth factor, $D_F = \dfrac{H+D}{H}$

For any value of D

$D_F > 1$

From the given figure; $D > O$ and $H > D$

$\Rightarrow$ So; irrespect of H and D values, $D_F > 1$

So; Base failure

$D_F = 1 \rightarrow$ Toe failure

$D_F < 1 \rightarrow$ Face failure

$D_F > 1 \rightarrow$ Base failure Choice (B)

30. If water table rises, σ and u increases but σ^1 decreases. Choice (C)