DETAILED SOLUTIONS

MADE EASY

India's Best Institute for IES, GATE & PSUs

Test Centres: Delhi, Hyderabad, Bhopal, Jaipur, Bhubaneswar, Pune, Kolkata

ESE 2024 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 4

Section A : Solid Mechanics [All Topics]
Section B : Environmental Engineering-I [Part Syllabus]
Section C : Geo-technical & Foundation Engineering-I [Part Syllabus]

1.	(b)	16.	(b)	31.	(d)	46.	(c)	61.	(d)
2.	(a)	17.	(a)	32.	(b)	47.	(a)	62.	(a)
3.	(b)	18.	(b)	33.	(a)	48.	(d)	63.	(c)
4.	(a)	19.	(c)	34.	(a)	49.	(c)	64.	(c)
5.	(b)	20.	(b)	35.	(b)	50.	(b)	65.	(b)
6.	(c)	21.	(a)	36.	(b)	51.	(c)	66.	(a)
7.	(c)	22.	(c)	37.	(c)	52.	(a)	67.	(b)
8.	(d)	23.	(a)	38.	(b)	53.	(d)	68.	(a)
9.	(b)	24.	(d)	39.	(b)	54.	(b)	69.	(d)
10.	(c)	25.	(b)	40.	(a)	55.	(b)	70.	(c)
11.	(b)	26.	(c)	41.	(d)	56.	(d)	71.	(b)
12.	(a)	27.	(d)	42.	(d)	57.	(b)	72.	(a)
13.	(a)	28.	(d)	43.	(c)	58.	(c)	73.	(c)
14.	(a)	29.	(b)	44.	(c)	59.	(b)	74.	(d)
15.	(c)	30.	(b)	45.	(b)	60.	(c)	75.	(c)

DETAILED EXPLANATIONS

2. (a)

$$\text{Percentage decrease in area} = \frac{\text{Original area} - \text{Area at the failure}}{\text{Original area}} \times 100$$

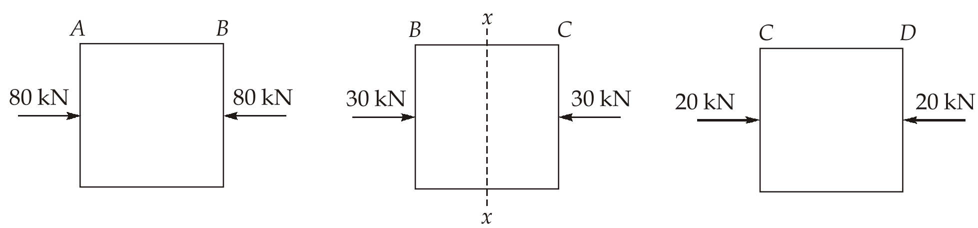
$$= \frac{\frac{\pi}{4}\times 3^2 - \frac{\pi}{4}\times 2.8^2}{\frac{\pi}{4}\times 3^2} \times 100$$

$$= \frac{3^2 - 2.8^2}{3^2} \times 100$$

$$= \frac{1.16}{9} \times 100 = 12.9\%$$

3. (b)

The *FBDs* of the members *AB, BC* and *CD* having axial forces are shown below.



∴ At section *x-x*,

$$\text{Normal stress, } \sigma = \frac{P}{A} = \frac{30\times 10^3}{900}$$

$$= 33.33 \text{ N/mm}^2 \text{ (Compressive)}$$

4. (a)

Material	Poisson's ratio
Aluminium	0.33
Brass	0.34
Bronze	0.34
Cast iron	0.2 - 0.3
Concrete	0.1 - 0.2
Copper	0.33 - 0.36
Glass	0.05 - 0.1
Pure rubber and perfectly plastic material	0.5

5. (b)

Stress of same magnitude and of different nature are obtained on principal planes.

6. (c)

For a cylindrical rod,

$$\text{Volumetric strain, } \varepsilon_v = \frac{\delta l}{l} + \frac{2\delta d}{d}$$

where δd is change in diameter

Now,
$$\text{Poisson's ratio, } \mu = \frac{-\dfrac{\delta d}{d}}{\dfrac{\delta l}{l}}$$

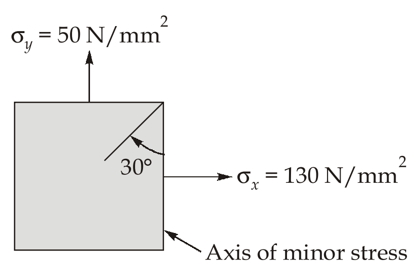
$$\Rightarrow \quad 0.3 = \frac{-\dfrac{\delta d}{d}}{\dfrac{\delta l}{l}}$$

$$\Rightarrow \quad \frac{\delta d}{d} = -\frac{0.3\delta l}{l}$$

So,
$$\varepsilon_v = \frac{\delta l}{l} + 2 \times \left(-0.3\frac{\delta l}{l}\right)$$
$$= \frac{0.4\delta l}{l}$$

7. (c)

Given:



Tangential (or shear stress) τ is given by,

$$\tau = \frac{\sigma_y - \sigma_x}{2} \cdot \sin 2\theta$$
$$= \frac{50 - 130}{2} \times \sin(-2 \times 30°)$$
$$= -40 \times -0.866$$
$$= 34.64 \text{ N/mm}^2$$

9. (b)

$$\text{Strain energy per unit volume} = \frac{\tau^2}{2G} = \frac{50^2}{2 \times 8 \times 10^4} = 0.0156 \text{ N/mm}^2$$

11. (b)

Due to temperature rise, there will be stress in y-direction only as the plate is allowed to expand in x-direction.

$\therefore$ Expansion in y-direction $= 0$

$$\Rightarrow \quad L\alpha\Delta T - \frac{\sigma_c L}{E} = 0$$

$$\Rightarrow \quad \sigma_c = E\alpha\Delta T$$

Now, expansion in x-direction, $\Delta_x = L\alpha\Delta T - \mu\left(\frac{-\sigma_c \times L}{E}\right)$

$$= L\alpha\Delta T + \frac{\mu\sigma_c L}{E}$$

$$= L\alpha\Delta T + \mu L\alpha\Delta T$$

$$= L\alpha\Delta T(1 + \mu)$$

$$= 1.5 \times 10^{-6} \times 20 \times (1 + 0.25)$$

$$= 3.75 \times 10^{-5} \text{ m}$$

$$= 0.0375 \text{ mm}$$

12. (a)

We know that,

Rate of change of shear force, $\frac{dV}{dx}$ = Load intensity

$\therefore$ In portion AE, $w_1 = \frac{25-(-5)}{3} = 10$ kN/m

and in portion DB, $w_2 = \frac{15-(5)}{2} = 5$ kN/m

13. (a)

- SFD is one degree higher than loading intensity diagram.
- BM is either maximum or minimum at a section where shear force changes sign.

14. (a)

The bending stress will be maximum where BM is maximum,

$\therefore$ Maximum BM $= \frac{WL}{4} = \frac{75 \times 4000}{4} = 7.5 \times 10^4$ N-mm

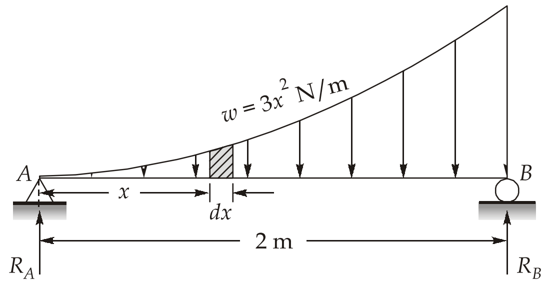
Also, $\frac{M}{I} = \frac{\sigma_{max}}{y_{max}}$

$$\Rightarrow \quad \sigma_{max} = \frac{M}{I} \times \frac{D}{2}$$

$$= \frac{7.5 \times 10^4}{1.06 \times 10^5} \times \frac{40}{2} = 7.075 \times 2 \text{ N/mm}^2$$

$$= 14.15 \text{ N/mm}^2$$

15. (c)



Let us consider an element of length dx at distance x from A.

Now, $\Sigma M_B = 0$,

$$\Rightarrow \quad R_A \times 2 - \int_0^2 3x^2\, dx(2-x) = 0$$

$$\Rightarrow \quad R_A \times 2 = \int_0^2 (6x^2 - 3x^3)\,dx = 2\left[x^3\right]_0^2 - \frac{3}{4}\left[x^4\right]_0^2 = 16 - \frac{3}{4} \times 16 = 4 \text{ N}$$

$$\Rightarrow \quad R_A = 2 \text{ N}$$

16. (b)

Twisting moment M at D, will act as BM in member BC.

$$\therefore \quad \text{Deflection at } C = \frac{M\left(\frac{L}{2}\right)^2}{2EI} = \frac{ML^2}{8EI}$$

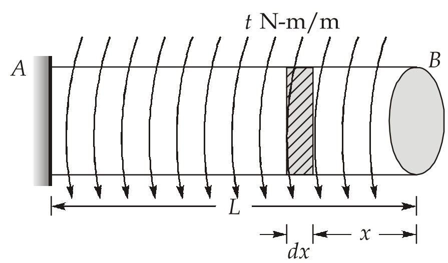
17. (a)

Neutral axis will pass through the centre of beam's cross-section.

$$\text{Allowable stress in wood, } \sigma_{wood} = 10 \text{ MPa}$$

$$\text{Allowable stress in steel, } \sigma_{steel} = 10 \times m \times \left(\frac{20}{25}\right) = 10 \times 20 \times \left(\frac{4}{5}\right) = 160 \text{ MPa}$$

18. (b)



Let us consider an element of length dx at x from B.

Internal torque acting at distance x from free end,

$$T_x = tx$$

$$\therefore \quad \text{Strain energy, } U = \int_0^L \frac{T_x^2 dx}{2GJ} = \int_0^L \frac{t^2x^2 dx}{2GJ} = \frac{t^2}{2GJ}\left[\frac{x^3}{3}\right]_0^L = \frac{t^2L^3}{6GJ}$$

19. (c)

For a semicircular section,

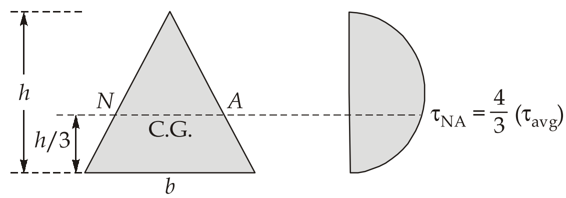
$$e = \frac{4R}{\pi}$$

where 'e' is distance of shear centre from centre of semi-circle.

So, $$e = \frac{4 \times 2\pi}{\pi} = 8 \text{ cm}$$

20. (b)

For a triangular section,



$\therefore$ $$\tau_{N.A.} = \frac{4}{3}\left[\frac{F}{\frac{1}{2}bh}\right] = \frac{8F}{3bh} = \frac{8 \times 40 \times 10^3}{3 \times 250 \times 200} = 2.13 \text{ N/mm}^2$$

21. (a)

For simply supported beam,

$$\text{Slope at ends, } \theta = \frac{WL^2}{16EI} = 0.01845 \text{ rad}$$

$$\text{Deflection at mid-span, } \delta = \frac{WL^3}{48EI} = \frac{\theta \cdot L}{3} = \frac{0.01845 \times 5000}{3} = 30.75 \text{ mm}$$

22. (c)

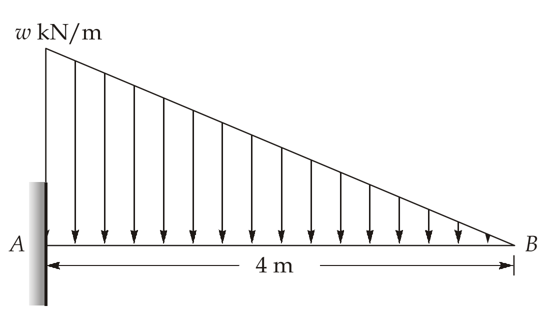
Given : d = 18 mm; n = 30; $G = 8 \times 10^4$ N/mm^2; D = 180 mm

$$\text{Stiffness of spring, } k = \frac{Gd^4}{8D^3 n} = \frac{8 \times 10^4 \times 18^4}{8 \times (180)^3 \times 30} = \frac{180}{30} = 6 \text{ N/mm}$$

24. (d)

Young's modulus of steel decreases with increase in temperature.

25. (b)

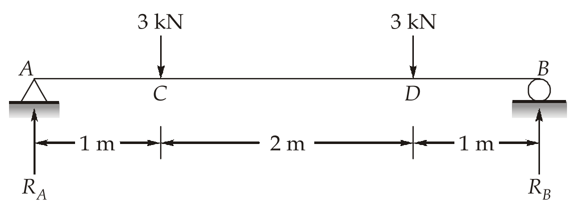


For the given loading on cantilever beam,

At free end B, $\theta_B = \dfrac{wL^3}{24EI}$ and $\delta_B = \dfrac{wL^4}{30EI}$

$$\therefore \quad \frac{\delta_B}{\theta_B} = \frac{\dfrac{wL^4}{30EI}}{\dfrac{wL^3}{24EI}} = \frac{24L}{30} = \frac{4}{5}\times 4 = \frac{16}{5} = 3.2$$

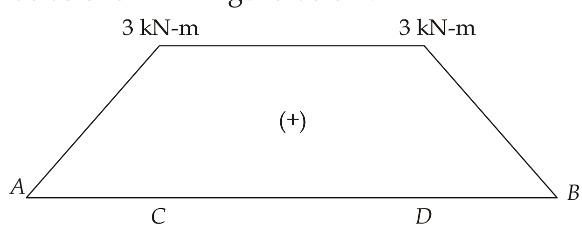
26. (c)



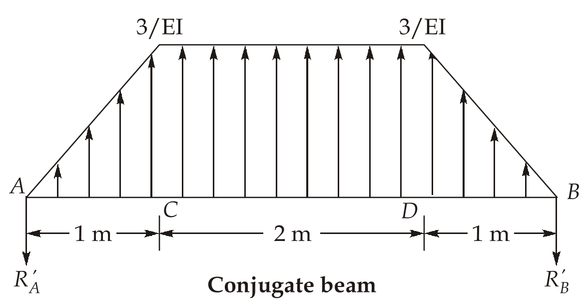
As the load on the beam is symmetrical, reactions R_A and R_B are equal

$$\therefore \quad R_A = R_B = 3 \text{ kN}$$

Its BMD will be as shown in figure below:



BMD



M/EI-diagram

Conjugate beam

As the loading is symmetrical

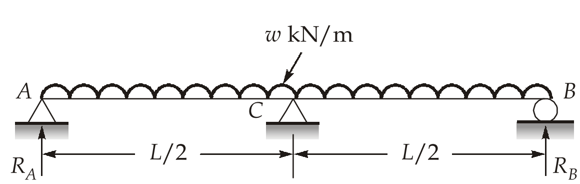
$$\therefore \quad R'_A = R'_B = \frac{1}{2}\left[\left(\frac{1}{2}\times 1\times\frac{3}{EI}\right)\times 2 + \frac{2\times 3}{EI}\right] = \frac{4.5}{EI}$$

According to conjugate beam method,

$$\text{Slope at ends} = \text{Shear force at ends} = R'_A = R'_B$$

$$= \frac{4.5}{EI}$$

27. (d)



Let us assume prop reaction R at C.
Using compatibility condition at C,

$$\delta_C = 0$$

$$\frac{5wL^4}{384EI} - \frac{RL^3}{48EI} = 0$$

$$\Rightarrow \quad R = \frac{5wL}{8}$$

Since the loading is symmetric, reactions R_A and R_B will be equal and can be computed as,

$$R_A = R_B = \frac{wL - \frac{5wL}{8}}{2} = \frac{3wL}{16}$$

29. (b)

$$\text{Power} = T\omega$$

$$\Rightarrow \quad 20\,\pi^2 \times 10^3 = T \times (2\pi \times 2) \qquad [\because \quad \omega = 2\pi f]$$

$$\Rightarrow \quad T = 5000\,\pi \text{ N-m}$$

$$\text{Allowable shear stress, } \tau_{max} = \frac{16T}{\pi D^3} \qquad \text{where '}D\text{' is diameter in 'm'.}$$

$$\Rightarrow \quad 50 \times 10^6 = \frac{16 \times 5000\pi}{\pi \times D^3}$$

$$\Rightarrow \quad D^3 = \frac{1}{625}$$

$$\Rightarrow \quad D = \frac{1}{8.55} = 0.117 \text{ m} = 117 \text{ mm}$$

30. (b)

For hollow circular section

$$e \le \frac{D_0^2 + D_i^2}{8D}$$

$$\Rightarrow \quad e \le \frac{D^2 + \left(\frac{D}{2}\right)^2}{8D}$$

$$\Rightarrow \quad e \le \frac{5D}{32}$$

31. (d)

$$\text{Circumferential stress, } \sigma_c = \frac{pd}{2t} = \frac{pr}{t} = \frac{0.75 \times 720}{7.5} = 72 \text{ MPa}$$

$$\text{Longitudinal stress, } \sigma_L = \frac{\sigma_c}{2} = \frac{72}{2} = 36 \text{ MPa}$$

$$\text{Circumferential strain, } \varepsilon_C = \frac{1}{E}[\sigma_C - \mu\sigma_L] = \frac{1}{2 \times 10^5} \times [72 - 0.3(36)]$$

$$= \frac{61.2}{2 \times 10^5} = 3.06 \times 10^{-4}$$

32. (b)

Since, there is no shear stress acting on given planes, therefore given stresses are principal stresses.

$\therefore \quad \sigma_1 = 50$ MPa, $\sigma_2 = 10$ MPa and $\sigma_3 = 0$ MPa

Absolute maximum shear stress,

$$\tau_{abs} = \text{maximum of } \left[\left(\frac{\sigma_1 - \sigma_3}{2}\right), \left(\frac{\sigma_1 - \sigma_2}{2}\right), \left(\frac{\sigma_2 - \sigma_3}{2}\right)\right]$$

$$= \frac{\sigma_1 - \sigma_3}{2} = \frac{50 - 0}{2} = 25 \text{ MPa}$$

33. (a)

$$\text{Major principal stress, } \sigma_1 = \frac{16}{\pi D^3} \times \left[M + \sqrt{M^2 + T^2}\right]$$

$$\therefore \quad \sigma_1 = \frac{16}{\pi \times 90^3} \times \left[20 + \sqrt{20^2 + \left(10\sqrt{5}\right)^2}\right] \times 10^6 \text{ N/mm}^2$$

$$= \frac{16 \times 50 \times 10^6}{\pi \times 729 \times 10^3} \text{MPa} = \frac{1097.4}{\pi} \text{ MPa}$$

34. (a)

Principal strains are given as,

$$\varepsilon_{P1/P2} = \frac{\varepsilon_x + \varepsilon_y}{2} \pm \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\phi_{xy}}{2}\right)^2}$$

$$= \frac{900 \times 10^{-6} + 100 \times 10^{-6}}{2} \pm \sqrt{\left(\frac{900 - 100}{2}\right)^2 + \left(\frac{200}{2}\right)^2} \times 10^{-6}$$

$$= \left(500 \pm \sqrt{400^2 + 100^2}\right) \times 10^{-6} = (500 \pm 412.3) \times 10^{-6}$$

$$= 912.3 \times 10^{-6}, 87.7 \times 10^{-6}$$

35. (b)

In maximum shear stress theory, yield locus is hexagon.

38. (b)

Height of chimney on the basis of SO_2 is

$$h = 14(Q_s)^{1/3} \quad \text{where } Q_s \text{ is } SO_2 \text{ emission in kg/hr}$$

Now, $\quad SO_2$ emission $= 25 \times 1.536 \times 12$

$= 460.8$ t/year

$$\therefore \quad Q_s = \frac{460.8}{300 \times 24} = 0.064 \text{ t/hour} = 64 \text{ kg/hour}$$

$$\therefore \quad h = 14 \times (64)^{1/3}$$

$= 56$ m

39. (b)

- If C/N ratio is more, nitrogen will be used up and carbon will be left over thereby leaving the digestion of organic matter incomplete.
- If C/N ratio is less, carbon will soon get exhausted and fermentation ceases, leaving nitrogen which will combine with the hydrogen to form NH_3. This can kill or inhibit the growth of bacteria.

40. (a)

As per geometric increase method

$$P_n = P_o(1+r)^n = 70000(1+0.2)^2 = 100800$$

41. (d)

$$\text{Discharge, } Q = 0.005 \text{ cumec} = 0.005 \times 60 \times 60 = 18 \text{ m}^3/\text{hr}$$

We know that, $$Q = \left(\frac{C'}{A}\right) \times A \times S$$

where, $$\frac{C'}{A} = 1 \text{ m}^3/\text{hr/m}^2/\text{m of depression head for coarse sand}$$

$\therefore$ $$18 = 1 \times A \times 3$$

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

$\Rightarrow$ $$\frac{\pi}{4} d_w^{\,2} = 6 \Rightarrow d_w = \sqrt{\frac{6 \times 4}{\pi}} = 2.8 \text{ m}$$

42. (d)

$$\text{Total alkalinity} = \frac{90}{600} \times 1000 = 150 \text{ mg}/l \text{ as } CaCO_3$$

$$OH^- \text{ alkalinity} = 5 \text{ mg}/l \text{ as } CaCO_3$$

$\Rightarrow$ $$[OH^-] + \frac{1}{2}[CO_3^{2-}] = \frac{33}{600} \times 1000 = 55 \text{ mg}/l \text{ as } CaCO_3$$

$\Rightarrow$ $$5 + \frac{1}{2}[CO_3^{2-}] = 55 \text{ mg}/l \text{ as } CaCO_3$$

Total alkalinity caused by CO_3^{2-} ions = $2 \times 50 = 100$ mg/l as $CaCO_3$

44. (c)

Poliomyelitis is caused by polio virus.

45. (b)

Head loss of expanded bed = Head loss of unexpanded bed

$\Rightarrow$ $$H_L = D'(1-n')(G-1) = D(1-n)(G-1)$$

where D and n are the depth of bed and porosity respectively

$\Rightarrow$ $$1.21(1-n') = 0.8(1-0.4)$$

$\Rightarrow$ $$n' = 0.6033 \simeq 0.6$$

46. (c)

As per Stoke's law,

$$\text{Settling velocity, } V_s = \frac{g}{18}(G-1)\frac{d^2}{\nu}$$

Particle of size greater than d will be removed to the extent of 100%.

$$\text{Now, } \quad \frac{L}{V_f} = \frac{H}{V_s}$$

$$\Rightarrow \quad V_s = \frac{H}{L} \times V_f = \frac{3.5}{65} \times 1.22 = 0.066 \text{ cm/sec}$$

$$\text{Now, } \quad 0.066 \times 10^{-2} = \frac{(2.65-1) \times 9.81 \times d^2}{18 \times 0.01 \times 10^{-4}}$$

$$\Rightarrow \quad d = 2.709 \times 10^{-5} \text{ m} = 0.027 \text{ mm} \simeq 27 \text{ µm}$$

47. (a)

$$\text{Ferrous sulphate consumption} = 60 \times 10^{-6} \times 36000 \times 10^3 = 2160 \text{ kg/day}$$

Equivalents of $FeSO_4 \cdot 7H_2O$ (Eq. wt = 139 g/eq.) that would react with an equivalent of 90% CaO is,

$$= \frac{28}{0.90} = 31.11$$

$$\therefore \quad \text{Lime dose} = \frac{2160}{139} \times 31.11 = 483.44 \text{ kg/day}$$

48. (d)

Total hardness left after treatment = 85 mg/l

Carbonate hardness left after treatment = 37 mg/l

$\therefore$ Non-carbonate hardness left = 85 – 37 = 48 mg/l

Non-carbonate hardness of raw water = 99 mg/l

$\therefore$ Non-carbonate hardness to be removed from raw water

= 99 – 48 = 51 mg/l

Soda (Na_2CO_3) is required for removal of non-carbonate hardness.

$\because$ 100 mg/l of $CaCO_3$ requires = 106 mg/l of Na_2CO_3

$$\therefore \quad 51 \text{ mg}/l \text{ of } CaCO_3 \text{ will require} = \frac{106}{100} \times 51 = 54.06 \simeq 54.1 \text{ mg}/l \text{ of } Na_2CO_3$$

$\therefore$ Soda required for 1 ML of water = 54.1 kg

50. (b)

Fabric filter does not remove particles in wet state.

52. (a)

Surface over flow rate, (V_o) = 51.84 m^3/m^2-d

$$= \frac{51.84 \times 10^3}{24 \times 60 \times 60} = 0.6 \text{ mm/sec}$$

Particles which have settling velocity more than surface overflow rate will be 100% removed. Other particles are removed in the ratio of $\left(\frac{V_s}{V_o}\right)$.

$\therefore$Total percentage of particles removed = $23 + 65 \times \frac{0.3}{0.6} + 12 \times \frac{0.1}{0.6} = 57.5\%$

53. (d)

$$V = 250 \times 10^4 \times 3.5 = 875 \times 10^4 \text{ m}^3$$

$$S_r = 0.17,\ n = 0.41$$

Specific yield, $S_y = n - S_r = 0.41 - 0.17 = 0.24$

From, $$S_y = \frac{\Delta V}{V}$$

$\Rightarrow$ $$\Delta V = 0.24 \times 875 \times 10^4 = 2.1 \times 10^6 \text{ m}^3$$

54. (b)

Refer Table 2 of IS 10500 : 2012

56. (d)

Flocculating particles have type-2 settling. The Stoke's law cannot be used because flocculating particles continuously change their shapes and size.

57. (b)

- Volume of air, $V_a = \frac{V}{6}$ where V is total volume of soil mass

$\therefore$ Volume of water, $V_w = \frac{V}{3}$

$\therefore$ Volume of voids, $V_v = V_a + V_w = \frac{V}{6} + \frac{V}{3} = \frac{V}{2}$

$\therefore$ Volume of solids, $V_s = V - V_v = V - \frac{V}{2} = \frac{V}{2}$

$\therefore$ Void ratio, $e = \frac{V_v}{V_s} = \frac{V/2}{V/2} = 1$

Now, dry density, $\gamma_d = \frac{G\gamma_w}{1+e} = \frac{2.7 \times 10}{1+1} = 13.5 \text{ kN/m}^3$

58. (c)

In hydrometer, the reading on stem is marked from top to bottom.

59. (b)

Given: $w_L = 45\%$, $w_P = 2.5\%$, $w_n = 20\%$

- Consistency index of soil mass is given as

$$I_c = \frac{w_L - w_n}{w_L - w_P} = \frac{45-20}{45-25} = 1.25$$

• Liquidity index of soil mass is given as

$$I_L = 1 - I_c = 1 - 1.25 = -0.25$$

Now, $$\frac{I_c}{I_L} = \frac{1.25}{-0.25} = -5$$

60. **(c)**

Plasticity index of soil mass given by U-line is

$$I_P = 0.9\,[w_L - 8] = 0.9\,[40 - 8] = 28.8\%$$

61. **(d)**

To avoid segregation, filter should not contain the particles of size larger than 75 mm.

62. **(a)**

Critical hydraulic gradient, i_c is given as

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

$\Rightarrow$ $$i_c = (G - 1)\,(1 - n) = (2.6 - 1)\,(1 - 0.4) = 0.96$$

63. **(c)**

According to Boussinesq's equation, vertical stress below a point load (Q) is given as:

$$\sigma_v = \frac{3Q}{2\pi Z^2} = \frac{3\times 2000}{2\pi\times(5)^2} = 38.197\text{ kN/m}^2 \simeq 38.2\text{ kN/m}^2$$

66. **(a)**

Given: $C_r = 0.05$, $C_c = 0.25$, $H_o = 2$ m, $e_o = 1$

Now, final settlement is given as

$$\Delta H = \frac{C_r H_o}{1+e_o}\log\left[\frac{80}{50}\right] + \frac{C_c H_o}{1+e_o}\log\left[\frac{50+50}{80}\right]$$

$$= \frac{0.05\times 2\times 10^3}{1+1}\log[1.6] + \frac{0.25\times 2\times 10^3}{1+1}\log[1.25]$$

$$= [50\log(1.6) + 250\log(1.25)]\text{ mm}$$

67. **(b)**

As we know,

$$B = \frac{\Delta u_1}{\Delta\sigma_3}$$

$\Rightarrow$ $$\Delta u_1 = B.\Delta\sigma_3 \quad \text{...(i)}$$

and, $$\bar{A} = \frac{\Delta u_2}{\Delta\sigma_d}$$

$\Rightarrow$ $$\Delta u_2 = \bar{A}\cdot\Delta\sigma_d$$

But, $$\bar{A} = AB$$

$\therefore$ $$\Delta u_2 = AB\cdot\Delta\sigma_d = AB[\Delta\sigma_1 - \Delta\sigma_3]$$

Now, $\Delta u_{total} = \Delta u_1 + \Delta u_2$

$\Rightarrow$ $\Delta u_{total} = B\Delta\sigma_3 + AB(\Delta\sigma_1 - \Delta\sigma_3)$

$\therefore$ $\Delta u_{total} = B[\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3)$

68. (a)

The all round pressure (confining pressure) is zero in an unconfined compression test and the Mohr's circle passes through the origin.

69. (d)

The active earth pressure p_a at a depth H is given as

$$p_a = k_a\,\gamma.H \quad \text{where } k_a \text{ is active earth pressure coefficient}$$

where,
$$k_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 30°}{1+\sin 30°} = \frac{1}{3}$$

$\therefore$
$$p_a = \frac{1}{3}\times 15.5\times 6 = 31\text{ kN/m}^2$$

70. (c)

Coefficient of active earth pressure is given by,

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

For clay, $\phi = 0$

$\therefore$ $k_a = 1$

Now, active earth pressure at a depth z is given as

$$p_a = k_a(\gamma z) - 2C\sqrt{k_a}$$

$\therefore$
$$0 = k_a(\gamma z + q) - 2C\sqrt{k_a}$$

$\Rightarrow$
$$k_a(\gamma z + q) = 2C\sqrt{k_a}$$

$\Rightarrow$
$$1\times(18z + 20) = 2\times 20\sqrt{1}$$

$\Rightarrow$
$$z = 1.11\text{ m}$$

71. (b)

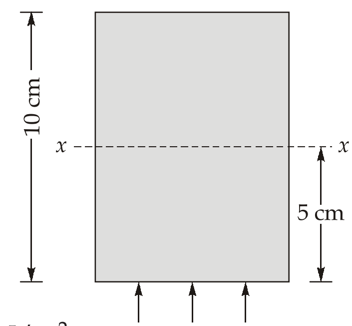
The average permeability of the deposit in vertical direction is given as:

$$k_v = \frac{H_1+H_2+H_3}{\frac{H_1}{k_1}+\frac{H_2}{k_2}+\frac{H_3}{k_3}} = \frac{6+22.5+12}{\frac{6}{8\times10^{-4}}+\frac{22.5}{50\times10^{-4}}+\frac{12}{15\times10^{-4}}}$$

$$= 20.25\times10^{-4}\text{ cm/s}$$

72. (a)

Discharge, Q is given as



$$Q = k\,i\,A$$

$$\Rightarrow \quad 0.08 = 0.002 \times i \times 50$$

$$\Rightarrow \quad i = 0.8$$

For section x-x

$$\text{Seepage pressure } p_s = iz\gamma_w$$

$$= 0.8 \times 0.05 \times 10 = 0.4 \text{ kN/m}^2$$

Now effective pressure at section x-x is given as

$$\bar{\sigma}_{xx} = (20 - 10) \times 0.05 - 0.4 = 0.10 \text{ kN/m}^2$$

73. (c)

$$T_V = \frac{C_V \cdot t}{d^2}$$

For a given degree of consolidation of a soil, T_V, and d are constant.

$$\therefore \quad t \propto \frac{1}{C_V} \propto \frac{m_V \gamma_w}{k} \qquad \left[\because\ C_V = \frac{k}{m_v \gamma_w}\right]$$

Hence, with decrease in permeability, consolidation time of a soil sample increases.

74. (d)

Phenomenon of quick sand can occur in the sands or silts and can not occur in gravel.

75. (c)

The phreatic line at the entrance goes downward.

❍❍❍❍