DETAILED SOLUTIONS

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ESE 2025 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

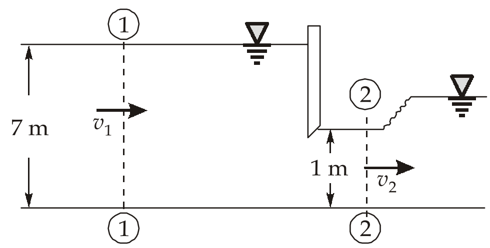
Test 18

Full Syllabus Test 2 : Paper-II

1.	(c)	26.	(c)	51.	(c)	76.	(c)	101.	(c)	126.	(c)
2.	(a)	27.	(b)	52.	(c)	77.	(d)	102.	(b)	127.	(b)
3.	(b)	28.	(b)	53.	(c)	78.	(a)	103.	(a)	128.	(c)
4.	(d)	29.	(b)	54.	(b)	79.	(b)	104.	(d)	129.	(a)
5.	(b)	30.	(a)	55.	(b)	80.	(a)	105.	(a)	130.	(c)
6.	(c)	31.	(b)	56.	(b)	81.	(d)	106.	(b)	131.	(b)
7.	(a)	32.	(c)	57.	(a)	82.	(d)	107.	(a)	132.	(d)
8.	(c)	33.	(c)	58.	(c)	83.	(c)	108.	(d)	133.	(b)
9.	(b)	34.	(c)	59.	(b)	84.	(a)	109.	(d)	134.	(b)
10.	(c)	35.	(c)	60.	(d)	85.	(d)	110.	(c)	135.	(c)
11.	(d)	36.	(c)	61.	(a)	86.	(d)	111.	(d)	136.	(b)
12.	(a)	37.	(a)	62.	(b)	87.	(c)	112.	(c)	137.	(c)
13.	(b)	38.	(b)	63.	(d)	88.	(b)	113.	(b)	138.	(c)
14.	(c)	39.	(d)	64.	(c)	89.	(d)	114.	(a)	139.	(b)
15.	(b)	40.	(b)	65.	(c)	90.	(b)	115.	(b)	140.	(b)
16.	(b)	41.	(b)	66.	(a)	91.	(a)	116.	(d)	141.	(b)
17.	(c)	42.	(c)	67.	(d)	92.	(a)	117.	(d)	142.	(c)
18.	(d)	43.	(b)	68.	(c)	93.	(b)	118.	(b)	143.	(b)
19.	(c)	44.	(b)	69.	(b)	94.	(c)	119.	(d)	144.	(a)
20.	(a)	45.	(a)	70.	(b)	95.	(d)	120.	(d)	145.	(d)
21.	(b)	46.	(c)	71.	(a)	96.	(a)	121.	(a)	146.	(a)
22.	(d)	47.	(c)	72.	(c)	97.	(b)	122.	(b)	147.	(d)
23.	(c)	48.	(c)	73.	(b)	98.	(c)	123.	(c)	148.	(c)
24.	(d)	49.	(d)	74.	(a)	99.	(b)	124.	(c)	149.	(d)
25.	(a)	50.	(a)	75.	(b)	100.	(d)	125.	(c)	150.	(c)

DETAILED EXPLANATIONS

1. (c)



From continuity equation,

$$Q = 7 \times 6 \times v_1 = 1 \times 6 \times v_2$$

$$\Rightarrow \quad v_2 = 7v_1$$

Neglecting frictional losses between (1) and (2), Bernoulli's equation between these two sections is,

$$7 + \frac{v_1^2}{2g} = 1 + \frac{v_2^2}{2g}$$

$$\Rightarrow \quad 7 + \frac{v_1^2}{2g} = 1 + 49\frac{v_1^2}{2g}$$

$$\Rightarrow \quad v_1 = 1.566 \text{ m/s}$$

$$Q = 6 \times 7 \times 1.566 = 65.72 \text{ m}^3/\text{s} \simeq 65.8 \text{ m}^3/\text{s}$$

2. (a)

$$Q = 16 \text{ m}^3/\text{s}, b = 4 \text{ m}$$

$$q = \frac{Q}{b} = \frac{16}{4} = 4 \text{ m}^3/\text{s/m}$$

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{4^2}{9.81}\right)^{1/3} = 1.17 \text{ m}$$

Sluice gate opening for $v = 3$ m/s

$$y = \frac{q}{v} = \frac{4}{3} = 1.33 \text{ m/s}$$

Since $y > y_c$

$\therefore$ Hydraulic jump is not expected.

3. (b)

4. (d)

$$H = 20 \text{ m}, \quad \eta_0 = 86\%$$

$$P = 36750 \text{ kW}, \psi = 0.60$$

$$\eta = 0.35$$

$$d = 0.35D$$

$$Q = \frac{\pi D^2}{4}(1 - n^2) v_f$$

where, $v_f = \psi\sqrt{2gH}$

$$\eta_0 = \frac{P}{\gamma Q H}$$

$$\Rightarrow \quad Q = \frac{36750 \times 10^3}{9810 \times 20 \times 0.86} = 217.8 \text{ m}^3/\text{s}$$

$$\therefore \quad D^2 = \frac{4Q}{\pi(1-n^2)\psi\sqrt{2gH}} = \frac{4 \times 217.8}{\pi(1-0.35^2) \times 0.6 \times 19.8}$$

$$\Rightarrow \quad D^2 = 26.60$$

$$\therefore \quad D = 5.16 \text{ m}$$

5. (b)

In a reaction turbine, the point of minimum pressure is usually at the outlet end of a blade on its convex side.

6. (c)

The possible causes for insufficient pressure of supply could be:

- Presence of air through leaks in suction pipe.
- Impeller diameter is too small.
- Speed is too low.
- Valve setting is improper.
- Impeller is damaged.
- Packing in casing is defective.

7. (a)

Volume of water applied = 650 m^3

Water wasted = 10% of 650 m^3 = 65 m^3

Water used in raising moisture capacity up to field capacity = 650 – 65 = 585 m^3

Depth of water used in raising moisture content upto field capacity from

$$\text{Existing moisture content} = \frac{585 \text{ m}^3}{1000 \text{ m}^2} = 0.585 \text{ m}$$

Water depth required in root zone of depth of '*d*'

$$= \frac{\gamma_d}{\gamma_w} \times d \times (\text{Upper limit of M.C.} - \text{Lower limit of M.C.})$$

$$\therefore \quad 0.585 = \frac{1450}{1000} \times 1.8 \text{ m } (F.C. - 0.08)$$

$$\Rightarrow \quad (F.C. - 0.08) = 0.224$$

$$\Rightarrow \quad \text{F.C.} = 0.304 = 30.4\%$$

8. (c)

Deformations are dependent upon the swelling pressure developed by the given expansive soil, when it imbibes water in its intralayers.

9. **(b)**

The crest of the under-sluice portion of the weir is kept at a lower level than the crest of the normal portion of the weir.

10. **(c)**

$$\text{SAR} = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} = \frac{28}{\sqrt{\frac{2.5+2}{2}}} = \frac{28}{\sqrt{2.25}}$$

$$= \frac{28}{1.5} = 18.67$$

For $18 \le \text{SAR} < 26$; water is high sodium water.

11. **(d)**

12. **(a)**

$$\text{Fetch length, } F < 32 \text{ km}$$

$$\text{Wave height, } h_w = 0.032\sqrt{V \times F} + 0.763 - 0.271\,(F)^{1/4}$$

$$\Rightarrow \quad h_w = 0.032\sqrt{20.25 \times 16} + 0.763 - 0.271\,(16)^{1/4}$$

$$\Rightarrow \quad h_w = 0.032 \times 18 + 0.763 - 0.271 \times 2$$

$$\Rightarrow \quad h_w = 0.797 \text{ m} \simeq 0.8 \text{ m}$$

13. **(b)**

A larger spacing is preferred for wider rivers than for narrower rivers.

14. **(c)**

$$\eta_d = \left(1 - \frac{y}{d_w}\right) \times 100$$

where d_w = Average depth of water stored

$$= \frac{1.2 + 1.5 + 1.8}{3} = 1.5 \text{ m}$$

and y = Average of absolute values of deviation from average depth

$$\Rightarrow \quad y = \frac{|1.5 - 1.2| + |1.5 - 1.5| + |1.8 - 1.5|}{3} = 0.2 \text{ m}$$

$$\therefore \quad \eta_d = \left(1 - \frac{0.2}{1.5}\right) \times 100$$

$$\Rightarrow \quad \eta_d = 86.67\%$$

15. (b)

The consumptive use may be defined as the amount of water used in the evapotranspiration from an area under vegetation plus the water used by the plants in their metabolic process for building of plant tissues.

16. (b)

$$\text{Total rainfall over area} = 600 \times 10^4 \text{ m}^2 \times 2.0 \text{ cm/h} \times 10^{-2} \text{ m} \times 8 \text{ h} \times 10^{-6} \text{ Mm}^3$$

$$= 0.96 \text{ Mm}^3$$

$$\text{Total runoff} = 0.6 \text{ Mm}^3$$

$$\therefore \quad \text{Total infiltration} = 0.96 - 0.6 = 0.36 \text{ Mm}^3$$

$$\text{Infiltration depth} = \frac{0.36 \times 10^6 \text{ m}^3}{600 \times 10^4 \text{ m}^3} \; 0.06 \text{ m} = 6 \text{ cm}$$

$$\therefore \quad \text{Infiltration rate} = \frac{6 \text{ cm}}{8 \text{ h}} \; 0.75 \text{ cm/h}$$

17. (c)

The shape of stream hydrograph and hence the peak flow is essentially controlled by the storm and the physical characteristics of the basin. Evapotranspiration plays minor role in this.

18. (d)

19. (c)

Dilution method is particularly attractive method for small turbulent streams, such as those in mountainous areas.

20. (a)

$$\text{Number of rain gauges, } m = 5$$

$$\text{Mean annual rainfall, } \overline{P} = \frac{82.6 + 104.7 + 120.8 + 109.2 + 70.4}{5} = 97.54 \text{ cm}$$

$$\text{Standard deviation, } \sigma_{m-1} = 20.54 \text{ cm}$$

$$\text{Coefficient of variation, } C_v = 100 \times \frac{\sigma_{m-1}}{\overline{P}} = 100 \times \frac{20.54}{97.54} = 21.06$$

$$\therefore \quad \text{Standard error, } e = \frac{C_v}{\sqrt{m}} = \frac{21.06}{\sqrt{5}} = 9.42\%$$

21. (b)

$$\text{Peak of flood hydrograph} = 100 \text{ m}^3/\text{s}$$

$$\text{Peak of DRH} = 100 - \text{Base flow} = 100 - 20 = 80 \text{ m}^3/\text{s}$$

$$\text{Depth of effective rainfall, } R = P - \text{Losses}$$

$$\Rightarrow \quad R = 7.0 \text{ cm} - 0.25 \text{ cm/h} \times 8 \text{ h}$$

$$\Rightarrow \quad R = 5.0 \text{ cm}$$

$$\text{Peak of 8 hr unit hydrograph} = \frac{\text{Peak of DRH}}{R} = \frac{80}{5} = 16 \text{ m}^3/\text{s}$$

If rainfall had been 9.50 cm in 8 hours then

effective rainfall i_{eff} = 9.5 cm – 0.25 cm/h × 8 hours = 7.5 cm

∴ New peak of flood hydrograph = 7.5 cm × 16 m^3/s + 20 m^3/s = 140 m^3/s

$$\text{Percent change in peak flood discharge} = \frac{140-100}{100}\times 100 = 40\%$$

22. (d)

Stress distribution at the ends of the bar depends on how the axial load is applied. If the load is distributed uniformly over the ends, the stress pattern will be uniform. However if the load is concentrated over a small area, there will be high localised stresses and non-uniform stress distribution near the load.

23. (c)

Axial strain from Hooke's law,

$$\in = \frac{\sigma}{E} = \frac{P}{AE} = \frac{25\pi}{\frac{\pi\times 20^2}{4}\times 70}$$

$$= 3.57 \times 10^{-3}$$

Now, lateral strain, $\in_{lateral} = -\mu\in$

$$= -3.57\times 10^{-3}\times\frac{1}{3} = -1.19\times 10^{-3}$$

∴ Decrease in diameter,

$$\Delta d = \in_{lateral}\cdot d = 1.19\times 10^{-3}\times 20$$

$$= 0.0238 \text{ mm}$$

24. (d)

The shear strain varies linearly with the dista nce from the centre of the circular cross-section.

25. (a)

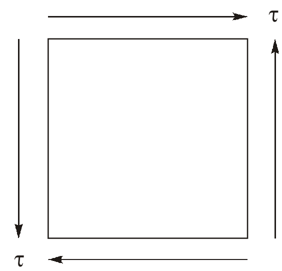
Maximum value of shear stress,

$$\tau_{max} = \frac{Tr}{I_p} = \frac{12\times 10^3\times 0.05}{\frac{\pi}{32}\left[0.1^4 - 0.08^4\right]}$$

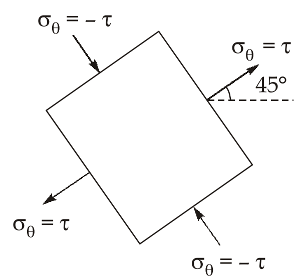
$$= \frac{12\times 10^3\times 0.05\times 32}{\pi\times 0.1^4\times\left[1-(0.8)^4\right]} = \frac{12\times 10^3\times 0.05\times 32}{\pi\times 0.1^4\times 0.6}\text{N/m}^2$$

$$= 101.589\times 10^6 \text{ N/m}^2 \simeq 101.86 \text{ MPa}$$

Now stress element for pure shear is as shown below.



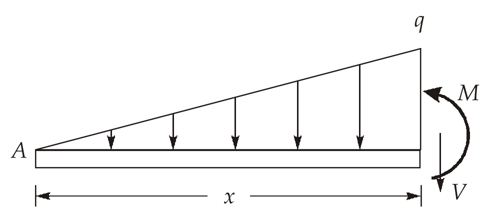
If the element is rotated by 45° then,



∴ Maximum tensile stress will be 101.86 MPa.

26. (c)

Cut the beam at 'x' distance from left hand end and treating this part of the beam as free body.



The intensity of the distributed load is

$$q = \frac{q_0 x}{L}$$

$$\therefore \quad \text{Total downward load} = \frac{q_0 x^2}{2L}$$

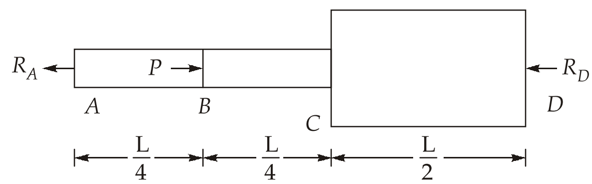
Considering moment equilibrium about an axis through the cut section,

$$\Rightarrow \quad \frac{-q_0 x^2}{2L} \times \frac{x}{3} - M = 0$$

$$\Rightarrow \quad M = \frac{-q_0 x^3}{6L}$$

27. (b)

Let the reactions be R_A and R_D at ends A and D respectively,



For equilibrium, $$\Sigma F_x = 0$$

$$\Rightarrow \quad R_A + R_D = P \quad \text{...(i)}$$

Applying compatibility equation,

$$\Delta L_{AB} + \Delta L_{BC} + \Delta L_{CD} = 0$$

$$\Rightarrow \quad \frac{R_A\left(\frac{L}{4}\right)}{AE} + \frac{(R_A - P)\frac{1}{4}}{AE} + \frac{-R_D\left(\frac{L}{2}\right)}{2AE} = 0$$

$$\Rightarrow \quad 2R_A - R_D = \text{P} \quad \text{...(ii)}$$

From (i) and (ii),

$$R_A = \frac{2P}{3}$$

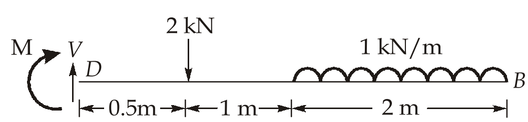
∴ Displacement of joint B,

$$\delta_B = \frac{\frac{2P}{3} \times \frac{L}{4}}{AE} = \frac{PL}{6AE}$$

28. (b)

Consider free-body diagram of beam as shown below.

At consider point-D 0.5 m from fixed support,



Applying equilibrium equations,

$$\Sigma M_D = 0$$

$$\Rightarrow \quad M = -2 \times 0.5 - 1 \times 2 \times \left(1.5 + \frac{2}{2}\right)$$

$$= -1 - 5$$

$$= -6 \text{ kN-m}$$

29. (b)

In Euler's theory of long column, self-weight of the column is ignored.

30. (a)

Maximum flexural stress,

$$\sigma_{max} = \frac{M}{Z}$$

where $Z = \frac{BD^2}{6} = \frac{200 \times 280^2}{6} = 2.613 \times 10^6 \text{ mm}^3$

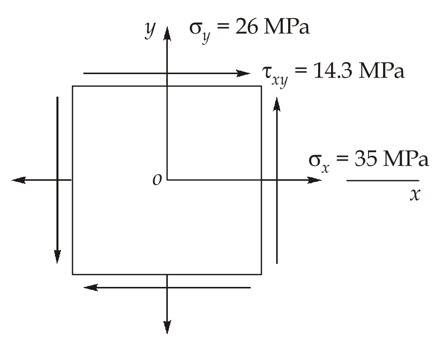
Maximum bending moment, $M = \frac{wL^2}{8} = \frac{6.5 \times 5^2}{8} = 20.31 \text{ kN-m}$

$\therefore$ $\sigma_{max} = \frac{20.31 \times 10^6}{2.613 \times 10^6} \simeq 7.8 \text{ MPa}$

31. (b)

32. (c)

Given,



We know that,

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$\Rightarrow$ $$\sigma_{1,2} = \frac{35+26}{2} \pm \sqrt{\left(\frac{35-26}{2}\right)^2 + 14.3^2}$$

$$\sigma_{1,2} = 30.5 \pm \sqrt{4.5^2 + 14.3^2} \simeq 30.5 \pm 15$$

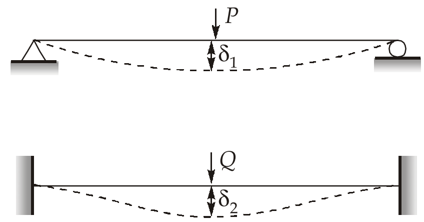
$\therefore$ $\sigma_1 = 45.5$ MPa and $\sigma_2 = 15.5$ MPa

$\therefore$ $\frac{\sigma_1}{\sigma_2} = \frac{45.5}{15.5} \simeq 2.94$

33. (c)

The maximum shear stresses acting on a cross-section of a wide flange beam always occur at the neutral axis. However, the maximum shear stresses acting on inclined planes usually occur either at the top and bottom of the beam or in the web where it meets the flange because of the presence of normal stresses.

34. (c)



$\because$ $\delta_1 = \dfrac{Pl^3}{48EI}$; $\delta_2 = \dfrac{Ql^3}{192EI}$

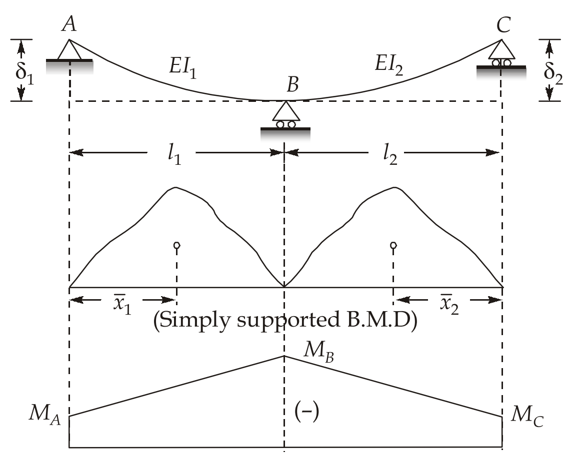
For $\delta_1 = \delta_2$

$\Rightarrow$ $\dfrac{Pl^3}{48EI} = \dfrac{Ql^3}{192EI}$

$\Rightarrow$ $Q = 4P$

35. (c)

Three moment theorem

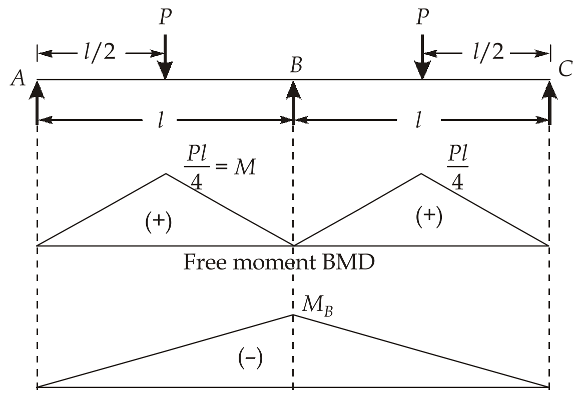


$$M_A\left(\frac{l_1}{I_1}\right) + 2M_B\left(\frac{l_1}{I_1} + \frac{l_2}{I_2}\right) + M_C\left(\frac{l_2}{I_2}\right) = -6\left(\frac{A_1\bar{x}_1}{I_1 l_1} + \frac{A_2\bar{x}_2}{I_2 l_2}\right) + 6E\left(\frac{\delta_1}{l_1} + \frac{\delta_2}{l_2}\right)$$

AB and *BC* should be prismatic beam individually.

36. (c)

37. (a)



By three-moment theorem,

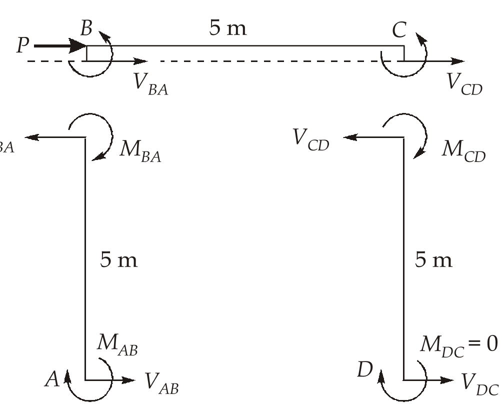
$$M_A\left(\frac{l_1}{I_1}\right) + 2M_B\left(\frac{l_1}{I_1}+\frac{l_2}{I_2}\right) + M_C\left(\frac{l_2}{I_2}\right) = -6\left(\frac{A_1\bar{x}_1}{I_1 l_1}+\frac{A_2\bar{x}_2}{I_2 l_2}\right)$$

$$\Rightarrow \quad 2M_B(2l) = -6\left[\frac{\left(\frac{1}{2}\times l\times M\right)\times\frac{l}{2}}{l}\times 2\right]$$

$$\Rightarrow \quad M_B = \frac{-3}{4}(M) = -0.75\text{ M}$$

38. (b)

39. (d)



$$\Sigma F_x = 0 \Rightarrow V_{BA} + V_{CD} + P = 0 \quad \text{...(i)}$$

$$\Sigma M_A = 0 \Rightarrow M_{AB} + M_{BA} - V_{BA}\times 5 = 0$$

$$\Rightarrow \quad V_{BA} = \frac{M_{AB}+M_{BA}}{5}$$

$$\Sigma M_D = 0 \Rightarrow M_{DC} + M_{CD} - V_{CD}\times 5 = 0$$

$$\Rightarrow \quad V_{CD} = \frac{M_{CD}}{5} \quad (\because M_{DC} = 0)$$

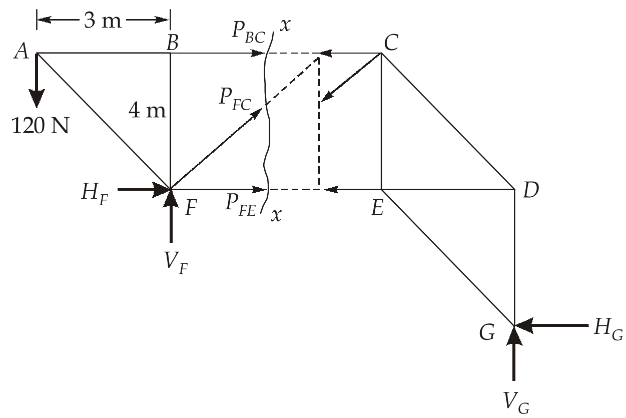
On putting the values of V_{BA}, V_{CD} in equation (i) we get

$$\left(\frac{M_{AB}+M_{BA}}{5}\right)+\left(\frac{M_{CD}}{5}\right)+P = 0$$

$$\Rightarrow \quad M_{AB}+M_{BA}+M_{CD}+5P = 0$$

40. **(b)**

Pass a section *x-x* through *BC*, *FC* and *FE*.



Taking moments about *F*,

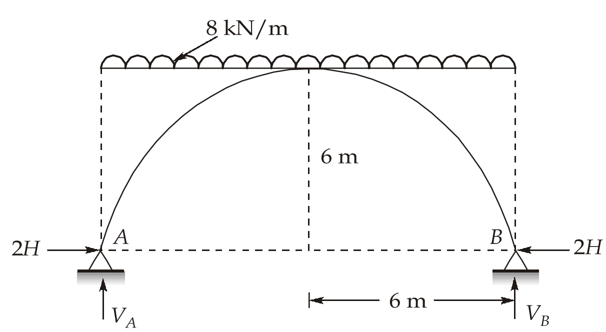
$$\Sigma M_F = 0 \quad \Rightarrow \quad P_{BC}\times 4 - 120\times 3 = 0$$

$$\Rightarrow \quad P_{BC} = \frac{120\times 3}{4}$$

$$\Rightarrow \quad P_{BC} = 90 \text{ N (Tensile)}$$

41. **(b)**

For two hinged semicircular arch subjected to uniformly distributed load, the horizontal thrust is given by $\left(\frac{4}{3}\left(\frac{wR}{\pi}\right)\right)$.



Here, $$2H = \frac{4}{3}\left(\frac{wR}{\pi}\right) \quad (\because \text{ Loading at left half of span})$$

$$\Rightarrow \quad H = \frac{2}{3}\times\frac{8\times 6}{\pi}$$

$$\Rightarrow \quad H = \frac{32}{\pi}$$

42. (c)

Number of independent mechanisms is,

$$n = N - r$$

where, N = Number of possible plastic hinges

r = Number of redundancies.

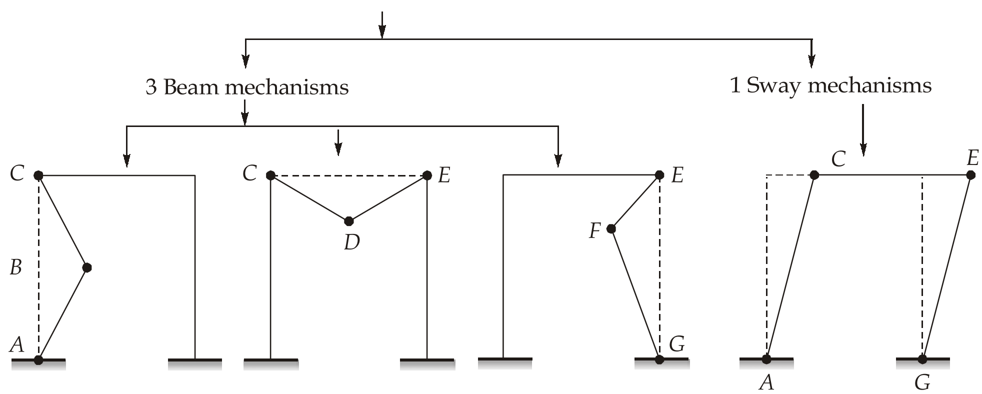
For the given frame.

$$N = 7(\text{A, B, C, D, E, F, G})$$

$$r = 3$$

$\therefore$ $n = 7 - 3$

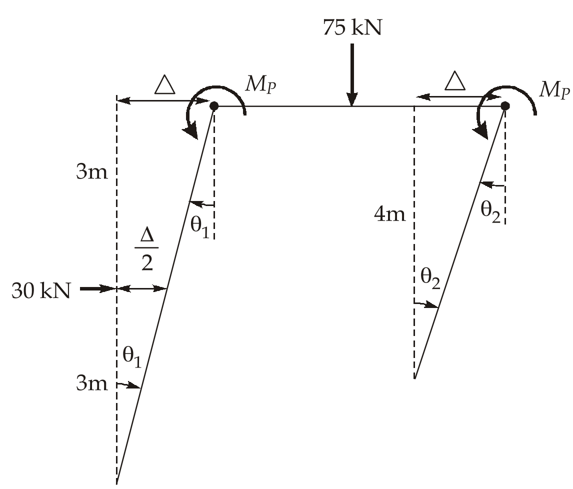
$\Rightarrow$ $n = 4$



NOTE: Combined mechanism is a dependent mechanism, which depends upon beam and sway mechanisms.

43. (b)

Sway mechanism:



Let: M_p is the plastic moment capacity for the given frame.

$$\Delta = 6\theta_1 = 4\theta_2$$

$\Rightarrow$ $\theta_2 = 1.5\theta_1$

By principle of virtual work.

$$M_p\,\theta_1 + M_p\theta_2 = 30 \times \frac{\Delta}{2}$$

$$\Rightarrow \quad M_p\theta_1 + M_p \times 1.5\theta_1 = 15 \times 6\theta_1$$

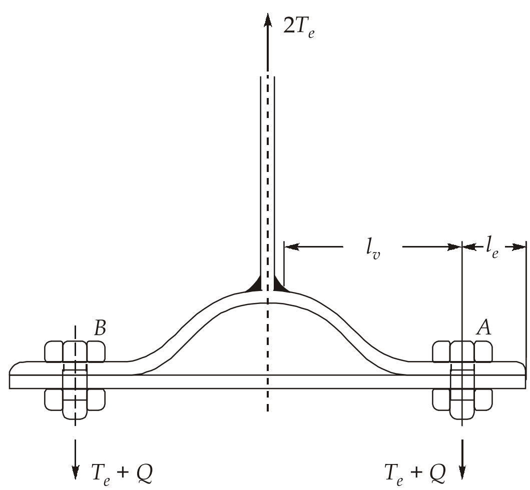
$$\Rightarrow \quad 2.5\,M_p = 15 \times 6$$

$$\Rightarrow \quad M_p = 36 \text{ kN-m}$$

44. (b)

- Fatigue is not just about the maximum stress but about how stress varies over time. Structures can endure high stress if its static.
- Residual stresses can influence fatigue life but they are not a primary cause of fatigue.
- Fatigue is defined by repeated loading unloading cycles.
- Stress fluctuations are fundamental to fatigue.

45. (a)



As per IS 800:2007 (Cl. 10.4.7)
The prying force Q is given by

$$Q = \frac{l_v}{2l_e}\left[T_e - \frac{\beta\eta f_o b_e t^4}{27 l_e l_v^2}\right] \simeq \frac{T_e l_v}{2l_e}$$

where;

l_v = distance from bolt centre line to the toe of the fillet weld.
l_e = distance between prying force and bolt centre line and in minimm of either the end distance or the value given by

$$1.1t\sqrt{\beta\frac{f_o}{f_y}}$$

β = 1 for pretensioned bolt and 2 for non-pretensioned bolt
η = 1.5 (for LSM)
b_e = effective width of flange per pair of bolts
f_o = proof stress
t = thickness of end plate

46. (c)

Refer IS 800 : 2007 (Cl. 10.5.5)

47. (c)

$$A_{eff} = \min \begin{cases} (B - nd_o)t \\ \left(B - nd_0 + \dfrac{np^2}{4g}\right)t \end{cases}$$

$$\Rightarrow \quad A_{eff} = \min \begin{cases} (300 - 3 \times 25) \times 10 = 2250\,\text{mm}^2 \\ \left(300 - 3 \times 25 + \dfrac{2 \times (50)^2}{4 \times 100}\right) \times 10 = 2375\,\text{mm}^2 \end{cases}$$

$$\Rightarrow \quad A_{eff} = 2250\ \text{mm}^2$$

48. (c)

As per IS 800:2007 (Cl. 6.3.3)

$$T_{dn} = \alpha\left(\frac{A_n f_u}{\gamma_{m1}}\right)$$

where

$$\alpha = \begin{cases} 0.6\,(\text{for one or two bolt}) \\ 0.7\,(\text{for three bolt}) \\ 0.8\,(\text{for four or more bolt}) \end{cases}$$

49. (d)

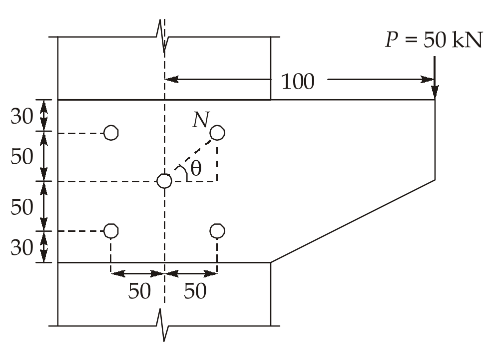
Given: diameter of bolt, $d = 18$ mm

As per IS 800:2007 (Cl. 7.6.2)

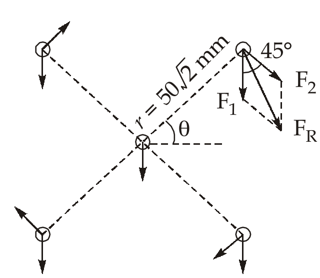
In bolted/riveted construction, the minimum width of lacing bars shall be three times the nominal diameter of the end bolt/rivet.

$$b_{min} = 3d = 3 \times 18 = 54\ \text{mm}$$

50. (a)



(All in mm)



Here, $\theta = 45°,\ r = 50\sqrt{2}$ mm

Direct shear force, $F_1 = \dfrac{50}{5} = 10$ kN

Force in extreme bolt (1) due to moment (P.e)

$$F_2 = \frac{(Pe)r}{\Sigma r_i^2} = \frac{(Pe)r}{4r^2} = \frac{Pe}{4r}$$

$$\Rightarrow \quad F_2 = \frac{50 \times 100}{4 \times 50\sqrt{2}} = \frac{25}{\sqrt{2}} \text{ kN}$$

Maximum resultant force,

$$(F_R)_{max} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$= \sqrt{10^2 + \left(\frac{25}{\sqrt{2}}\right)^2 + 2 \times 10 \times \frac{25}{\sqrt{2}} \times \frac{1}{\sqrt{2}}} = 25.74 \text{ kN}$$

51. **(c)**

Refer IS 800: 2007 (Cl. 8.7.2.6)

52. **(c)**

As per IS 800 : 2007 (Cl. 10.3.6)

A bolt that is required to resist both design shear force (V_b) and design tensile force (T_b) at the same time shall satisfy.

$$\left(\frac{V_b}{V_{db}}\right)^2 + \left(\frac{T_b}{T_{db}}\right)^2 \leq 1.0$$

where, V_{db} = Design shear capacity of bolt

T_{db} = Design tension capacity of bolt

53. **(c)**

- Surface tension minimizes the surface area of a liquid due to cohesive forces, thus minimizing suface energy.
- As temperature increases, surface tension decreases and at the critical temperature, it becomes zero. So, statement 2 is incorrect.

54. **(b)**

Floating body	Submerged body	Result
G below B	G below M	Stable
G above B	G above M	Unstable
G coincides B	G coincide M	Neutral

where, G = Centre of gravity

B = Centre of buoyancy

M = Metacentre

55. (b)

Given: $u = ax$ and $v = -ay$

Equation of streamline is given by

$$\frac{dx}{u} = \frac{dy}{v}$$

$$\Rightarrow \quad \frac{dx}{ax} = \frac{dy}{-ay}$$

Integrating both sides

$$\int \frac{dx}{x} = -\int \frac{dy}{y}$$

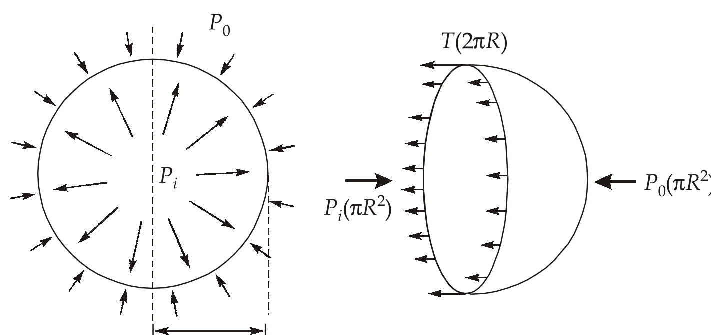
$$\Rightarrow \quad \log_e x = -\log_e y + \log_e C$$

$$\Rightarrow \quad \log_e x = \log_e \left(\frac{C}{y}\right)$$

$$\Rightarrow \quad xy = C$$

This represents a rectangular hyperbola.

56. (b)



Liquid droplet

For equilibrium,

$$P_i(\pi R^2) = P_0(\pi R^2) + T(2\pi R)$$

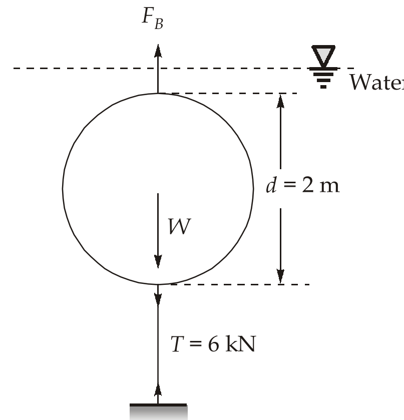
$$\Rightarrow \quad P_i - P_0 = \frac{T(2\pi R)}{\pi R^2} = \frac{2T}{R}$$

$$\Rightarrow \quad \Delta P = \frac{2T}{R}$$

57. (a)

- Kinematic similarity implies that the streamline patterns in the model and prototype are similar.
- Discharge is a measure of flow rate, not specifically a crtierion for kinematic similarity.
- Shape is related to geometric similarity.
- Force is related to dynamic similarity.

58. **(c)**



Given: $d = 2\text{ m}, T = 6\text{ kN}$

Now, for equilibrium

$$F_B = W + T$$

$$\Rightarrow \quad W = F_B - T$$

$$\Rightarrow \quad W = \frac{4}{3}\pi\left(\frac{2}{2}\right)^3 \times 10 - 6$$

$$\Rightarrow \quad W = 35.88\text{ kN}$$

59. **(b)**

- **Horizontal Component:** The horizontal component of hydrostatic force in any chosen direction on any area (plane or curved) is equal to the projection of the area on a vertical plane normal to the chosen direction. The horizontal force acts through the centre of pressure of the vertical projection.
- **Vertical Component**: The vertical component of the hydrostatic force on any surface (plane or curved) is equal to the weight of volume of liquid extending above the surface of the object to the level of the free surface. This vertical component passes through the centre of gravity of the volume considered. The volume and the free surface can be real or imaginary.

60. **(d)**

61. **(a)**

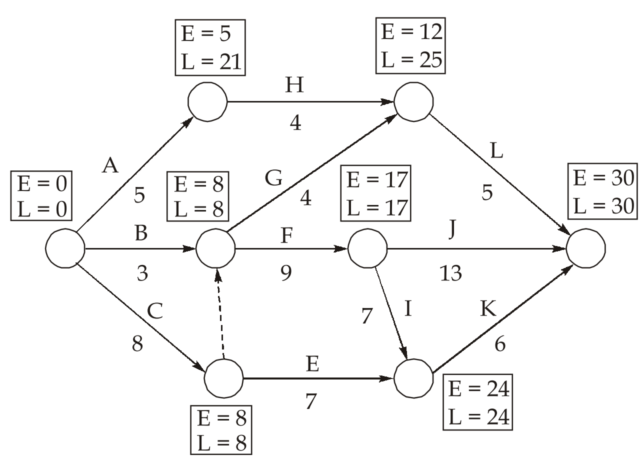
m_T (Expected mean time of the project) = $m_1 + m_2 + m_3 \ldots + m_n$

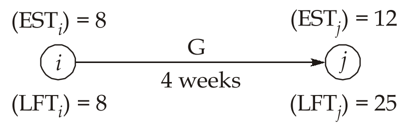
v_T (Variance of the project) = $v_1 + v_2 + v_3 + \ldots\ldots v_n$

σ_T (Standard deviation of the project) = $\sqrt{v_T}$

$$\Rightarrow \quad \sigma_T = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \ldots\ldots + \sigma_n^2}$$

62. **(b)**





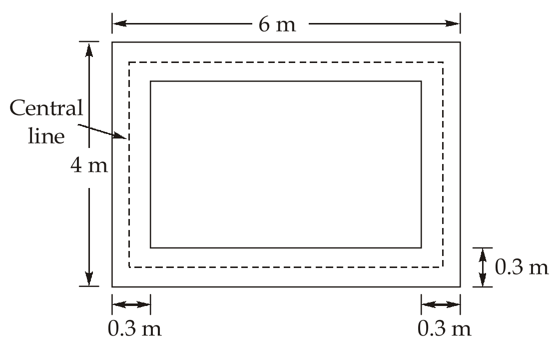
$$(LST)_G = LFT_j - t_{ij} = 25 - 4 = 21 \text{ weeks}$$
$$= 21 \times 7 = 147 \text{ days}$$

63. (d)

- It does not facilitate the work of controlling, monitoring and updating the project.
- As the floats of non-critical activities cannot be obtained from a bar chart, no resource levelling is possible.
- It does not reflect the uncertainty in activity duration.

64. (c)

65. (c)



$$\text{Central line length for long wall} = 6 - \frac{0.3}{2} - \frac{0.3}{2} = 5.7 \text{ m}$$

$$\text{Central line length for short wall} = 4 - \frac{0.3}{2} - \frac{0.3}{2} = 3.7 \text{ m}$$

$$\text{Total central line length} = 2(5.7 + 3.7) = 18.8 \text{ m}$$

66. (a)

Tilting mixers are easy to clean.

67. (d)

In PERT, the standard deviation (σ) is used to measure the uncertainty of the estimate.

$$\text{Uncertainty} \propto \text{S.D}$$

$$\text{Standard deviation, } \sigma = \left(\frac{t_p - t_o}{6}\right)$$

For P: $\sigma_P = \frac{9-4}{6} = \frac{5}{6} = 0.833$

For Q: $\sigma_Q = \frac{10-3}{6} = \frac{7}{6} = 1.167$

For R: $\sigma_R = \frac{8-4}{6} = \frac{4}{6} = 0.667$

For S: $\sigma_S = \frac{8-5}{6} = \frac{3}{6} = 0.50$

The engineer with the least uncertainty is the once with the smallest standard deviation. Hence, engineer S is least uncertain or most certain.

68. **(c)**

The distribution curve for the time taken to complete each activity of a project resembles a β-distribtuion curve and the distribution curve for the time taken to complete entire project in general resembles a normal distribution curve.

69. **(b)**

70. **(b)**

Torsion balance method is a laboratory method.

71. **(a)**

$$N = 25 \text{ (for closing 2 mm groove)}$$

$$\therefore \quad w = 18 - \log_{10} 25$$

$$\Rightarrow \quad w = 18 - \log_{10} (5)^2$$

$$\Rightarrow \quad w = 18 - 2\log_{10} 5 = 18 - 2 \times 0.7$$

$$\Rightarrow \quad w = 16.6\%$$

72. **(c)**

73. **(b)**

$$I_D = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

$$\Rightarrow \quad I_D = \frac{0.8 - 0.65}{0.8 - 0.35} \times 100 = 33.33\%$$

$$\gamma_{d,\,max} = \frac{G\gamma_w}{1 + e_{min}} = \frac{2.67 \times 9.81}{1 + 0.35} = 19.40 \text{ kN/m}^3$$

$$\gamma_{d\,(\text{in situ})} = \frac{G\gamma_w}{1 + e} = \frac{2.67 \times 9.81}{1 + 0.65} = 15.87 \text{ kN/m}^3$$

$$\text{Relative compaction} = \frac{15.87}{19.40} \times 100 = 81.8\% \simeq 82\%$$

74. **(a)**

$$K = \frac{2.303\, aL}{At} \log_{10}\left(\frac{h_1}{h_2}\right)$$

All being constant except h_1 and h_2

$$\therefore \quad \frac{h_1}{h_2} = \frac{h_2}{h_3}$$

$$\Rightarrow \quad h_2^2 = h_1 h_3$$

$$\Rightarrow \quad h_2 = \sqrt{h_1 h_3}$$

75. **(b)**

Permeability cannot be measured from flownet and infact flownet is used to obtain rate of flow, pure water pressure, exit gradient and seepage pressure.

76. **(c)**

As per Boussinesq's theory

$$\sigma_r = \frac{3Q}{2\pi z^2}\left(\frac{1}{1+\left(\frac{r}{z}\right)^2}\right)^{5/2}$$

$$\Rightarrow \quad \sigma_r = \frac{3\times15\times10^3}{2\pi\times3^2}\left(\frac{1}{1+\left(\frac{3}{3}\right)^2}\right)^{5/2} = \frac{3\times15\times10^3\times1}{2\pi\times3^2\times2^{2.5}}$$

$$\Rightarrow \quad \sigma_r = 140.6\,\text{N/m}^2$$

77. **(d)**

The behaviour of highly over consolidated clay is similar to that of dense sand which is more stable and less compressible.

78. **(a)**

Given: $\phi = 30°,\ \sigma_1 = 200\ \text{kN/m}^2,\ C = 40\ \text{kN/m}^2$

$$\sigma_1 = \sigma_3\tan^2\left(45° + \frac{\phi}{2}\right) + 2C\tan\left(45° + \frac{\phi}{2}\right)$$

$$\Rightarrow \quad 200 = \sigma_3\tan^2\left(45° + \frac{30°}{2}\right) + 2\times40\tan\left(45° + \frac{30°}{2}\right)$$

$$\Rightarrow \quad 200 = \sigma_3\tan^2(60°) + 2\times40\tan(60°)$$

$$\Rightarrow \quad 200 = 3\sigma_3 + 80\sqrt{3}$$

$$\sigma_3 = 20.48\ \text{kN/m}^2$$

79. **(b)**

Width of sliding wedge at top of wall is $H\cot\left(45° - \frac{\phi}{2}\right)$.

80. **(a)**

Inside clearance should be between 1-3%.

81. **(d)**

$$q_u = 1.3C_m N_C' + \gamma D_f N_q' + 0.4\,\gamma B N_\gamma'$$

$$\text{Cohesion, } C = \frac{UCS}{2} = \frac{90}{2} = 45\ \text{kN/m}^2$$

For local shear failure $\quad C_m = \frac{2}{3}C = \frac{2}{3}\times45 = 30\ \text{kN/m}^2$

Also for pure clay

$$N_q = 1 \text{ and } N_\gamma = 0$$

$$\therefore \quad q_u = 1.3 \times 30 \times 5.7 + 17.6 \times 1.5 + 0$$

$$\Rightarrow \quad q_u = 248.7 \text{ kN/m}^2$$

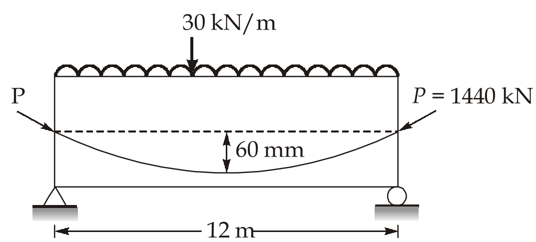
82. (d)

83. (c)

For bored cast in-situ pile, point resistance is taken as 50% of point resistance of driven pile.

84. (a)

85. (d)



Intensity of equivalent load due to parabolic cable.

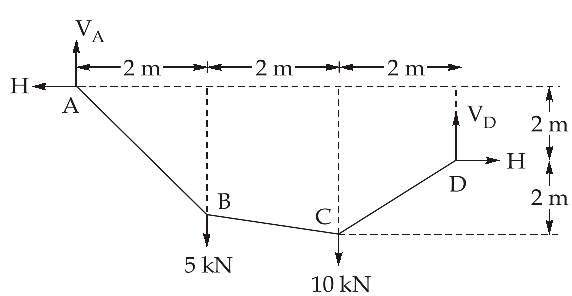
$$w_P = \frac{8Ph}{l^2}$$

$$w_P = \frac{8 \times 1440 \times 0.06}{12^2} = 4.8 \text{ kN/m}$$

So, net downward UDL $w_{net} = 30 - 4.8 = 25.2$ kN/m

$$\text{Maximum shear force at support} = \frac{25.2 \times 12}{2} = 151.2 \text{ kN}$$

86. (d)



$\Sigma F_y = 0 \quad \Rightarrow \quad V_A + V_D = 15$ kN ...(1)

Taking moments about point C (from right side)

$$V_D \times 2 - H \times 2 = 0$$

$\Rightarrow \quad V_D = H$ ...(2)

Taking moment about point C (left side)

$$V_A \times 4 - H \times 4 - 5 \times 2 = 0$$

$$\Rightarrow \quad V_A = H + \frac{5}{2} \quad \text{...(3)}$$

From eqs. (1), (2) and (3)

$$\left(H + \frac{5}{2}\right) + H = 15$$

$$\Rightarrow \quad H = \frac{25}{4} = 6.25\,\text{kN}$$

$$\therefore \quad V_A = H + \frac{5}{2} = 8.75 \text{ kN}, \; V_D = H = 6.25 \text{ kN}$$

87. (c)

- $\tau_{c\,max}$ is based on diagonal compression failure.
- It depends only on the grade of concrete only (not on the grade of steel).

88. (b)

Refer IS 456 : 2000 (Cl 8.2.2.3)

89. (d)

Given: span = 12 m > 10 m

As per IS 456 : 2000 [Cl 23.2.1 (a) and (b)]

$$\frac{\text{Span}}{\text{Effective depth}} \le 20 \times \left(\frac{10}{\text{Span}}\right)$$

$$\le 20 \times \frac{10}{12} = 16.67$$

90. (b)

$$C = T$$

$$\Rightarrow \quad 0.36 f_{ck}\, b\, x_u = 0.87 f_y\, A_{st}$$

$$\Rightarrow \quad x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b}$$

As, A_{st} increases then depth of neutral axis also increases. So neutral axis shift towards tension steel.

As per IS 456 : 200 (Cl 26.5.1.1)

The minimum area of tension reinforcement shall be not less than that given by

$$\frac{A_{st}}{bd} = \frac{0.85}{f_y}$$

So, statement 3 is incorrect.

91. (a)

Refer IS 456 : 2000 (Cl 26.5.1.3)

- Side face reinforcement is distributed equally on faces at a spacing not exceeding 300 mm or web thickness whichever is less.

  So, statement 3 is incorrect.

92. (a)

$$\text{Aspect ratio } (r) = \frac{8}{3} = 2.67 > 2 \text{ (One way slab)}$$

$$\text{Dead load} = 0.150 \times 25 \times 1 = 3.75 \text{ kN/m}$$

$$\text{Dead load due to finish} = 1 \text{ kN/m}$$

$$\text{Live load} = 3 \text{ kN/m}$$

$$\text{Total working load} = 7.75 \text{ kN/m}$$

$$\text{Ultimate load } w_u = 1.5 \times 7.75 = 11.625 \text{ kN/m}$$

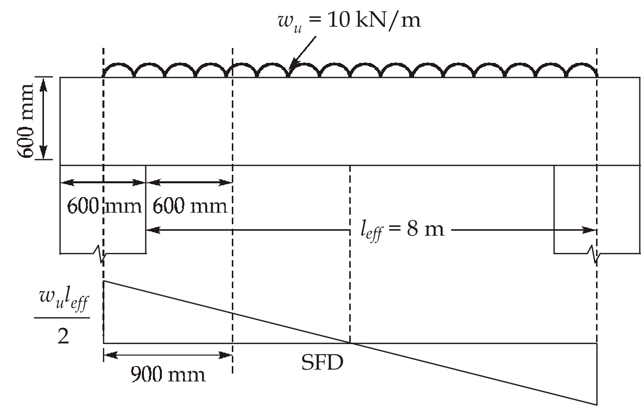
$$d = 150 - 20 - \frac{12}{2} = 124 \text{ mm}$$

$$l_{\text{eff}} = \min.\begin{cases} 3 + 0.124 = 3.124 \text{ m} \\ 3 + 0.230 = 3.230 \text{ m} \end{cases} = 3.124 \text{ m}$$

$$\therefore \quad M_u = \frac{w_u l_{eff}^2}{8} = \frac{11.625 \times (3.124)^2}{8} = 14.18 \text{ kNm}$$

93. (b)

Critical section for shear is located at a distance d (effective depth) from the face of column.



$$\text{Distance from center of support } (d') = 600 + \frac{600}{2} = 900 \text{ mm}$$

Design shear force

$$V_d = \frac{w_u l_{eff}}{2} - w_u \times d' = \frac{10 \times 8}{2} - 10 \times 0.9$$

$$= 40 - 9 = 31 \text{ kN}$$

94. (c)

In the Lee-McCall system, the tendons are comprised of high-tensile bars of diameter varying from 12 to 40 mm which are threaded at the ends. After tensioning, each bar is anchored by screwing a nut and washer tightly against the end plates.

95. (d)

- In prestressed concrete, a parabolic cable produces an upward thrust that creates an upward moment which counteracts the downward moment due to uniformly distributed load.
- If the cable is concentric, (that is cable lies on centroidal axis) then it only produces axial compression without causing bending in the member.

96. (a)

97. (b)

In industrial towns, stones are preserved by application of solution of baryta, $Ba(OH)_2$ i.e. Barium hydroxide.

98. (c)

99. (b)

HAC has high heat of hydration. So it is suitable for use in cold regions.

100. (d)

101. (c)

102. (b)

Although all are important but the amount of mixing water added most significantly affects total shrinkage.

103. (a)

Grading minimizes cement content.

104. (d)

$$\text{Volume of wet concrete} = 2\text{m}^3$$

$$\text{Volume of dry concrete} = (52 \text{ to } 54)\% \text{ more than wet concrete.}$$

$\therefore$ Taking it to be 54%

$$\text{Volume of dry concrete} = 2 \times 1.54 = 3.08 \text{ m}^3$$

$$\text{Volume of coarse aggregate} = \frac{4}{7} \times 3.08 = 1.76 \text{ m}^3$$

105. (a)

106. (b)

107. (a)

Trigonometric levelling by reciprocal observation eliminates errors due to curvature and refraction.

108. (d)

109. (d)

Let x = Length of rectangle

y = Width of rectangle

$\therefore$ $A = xy$

$$\therefore \quad e_A = \sqrt{\left[\frac{\partial(xy)}{\partial x}(e_x)\right]^2 + \left[\frac{\partial(xy)}{\partial y}(e_y)\right]^2}$$

$$\Rightarrow \quad e_A = \sqrt{(60\times 0.02)^2 + (50\times 0.01)^2}$$

$$\Rightarrow \quad e_A = \sqrt{1.44+0.25} = 1.3 \text{ m}^2$$

110. (c)

$$l = 20 \text{ cm} = 200 \text{ mm}$$
$$w = 20 \text{ cm} = 200 \text{ mm}$$
$$P_l = 60\%$$
$$P_s = 20\%$$
$$\text{Scale} = 1 \text{ cm} : 200 \text{ m} \quad \Rightarrow \quad S = 1 : 20000$$

Net ground length covered by one photograph is,

$$L = (1-P_l)\times\frac{l}{S} = (1-0.6)\times\frac{200}{1/20000}\text{mm} = 1.6 \text{ km}$$

$$W = (1-P_s)\times\frac{w}{S} = (1-0.2)\times\frac{200}{1/20000}\text{mm}$$

$$\Rightarrow \quad W = 3.2 \text{ km}$$

$$\therefore \quad \text{Ground area} = 1.6 \times 3.2 \text{ km}^2$$
$$= 5.12 \text{ km}^2$$

111. (d)

112. (c)

$$\frac{l\sin\alpha}{S} = 0.025$$

$$\Rightarrow \quad l = \frac{0.025\times S}{\sin\alpha} = \frac{0.025\times 10}{0.052}$$

$$\Rightarrow \quad l = 4.81 \simeq 4.8 \text{ m}$$

113. (b)

114. (a)

- Theodolites are equipped with an internal focussing telescope to facilitate transiting.
- The telescope normal position means that the vertical circle of the theodolite is to the left of observer.

115. (b)

$$A = d\left[\left(\frac{O_o+O_n}{2}\right)+O_1+O_2+O_3+\ldots O_{n-1}\right]$$

d is not constant

$$A_1 = 5\left[\left(\frac{3+6}{2}\right)+4+5.5+5\right] = 95 \text{ m}^2$$

$$A_2 = 10\left[\left(\frac{6+4.5}{2}\right)+4\right] = 92.5 \text{ m}^2$$

$$\therefore \quad \text{Total area} = A_1 + A_2 = 92.5 + 75 = 187.5 \text{ m}^2$$

116. (d)

Local mean time difference = $\frac{45°30'}{15}$ = 3h 2m 0s. Since the place is east of Greenwich LMT is more than GMT

$$\therefore \quad \text{LMT} = \text{GMT} + 3\text{h } 2\text{m } 0\text{s}$$

$$\Rightarrow \quad \text{GMT} = 8\text{h } 43\text{m } 14\text{s} - 3\text{h } 2\text{m}$$

$$\Rightarrow \quad \text{GMT} = 5\text{h } 41\text{m } 14\text{s AM}$$

117. (d)

$$D = KS + C$$

Anallactic lens makes $C = 0$

$$\therefore \quad D \propto S$$

118. (b)

$$\frac{C'}{A} = \frac{2.303}{T}\log_{10}\frac{S_1}{S_2}$$

S_1 = Initial drawdown = 2.5 m

S_2 = Final drawdown = 2.5 – 2.25 = 0.25 m

$$T = 60 \text{ min} = \frac{60}{60}\text{ hr} = 1 \text{ hr}$$

$$\frac{C'}{A} = \frac{2.303}{1}\log_{10}\frac{2.5}{0.25}$$

$$\Rightarrow \quad \frac{C'}{A} = 2.303$$

Yield from the well of 3m dia., $Q = \left(\frac{C'}{A}\right)\times A \times S$

$$= 2.303 \times \frac{\pi}{4}\times 3^2 \times 3.5 = 56.9 \text{ m}^3/\text{hr}$$

119. (d)

Lead pipe may cause lead poisoning hence are avoided for domestic water supply. Asbestos pipes have low coefficient of expansion and also joints are flexible, so no expansion joints are required.

120. (d)

Anaerobic digestion releases CO_2, H_2S, CH_4 gases but oxidation pond involves aerobic process.

121. **(a)**

Physical scrubbing: The gasesous contaminant diffuses into the liquid phase and dissolves in scrubbing liquor.

Chemical scrubbing: Gaseous contaminant chemically react with a solvent in the scrubbing liquor.

122. **(b)**

$$\text{Weight of carbonates} = 120 \text{ mg}$$

$$\text{Number of milli equivalents of carbonates} = \frac{\text{Weight (in mg)}}{\text{Equivalent weight (in g)}} = \frac{120}{30} = 4$$

$$\text{Weight of bi-carbonates} = 61 \text{ mg}$$

$$\text{Number of milli equivalents of bi-carbonates} = \frac{\text{Weight (in mg)}}{\text{Equivalent weight (in g)}} = \frac{61}{61} = 1$$

$$\text{Weight of hydroxide} = 34 \text{ mg}$$

$$\text{Number of milli equivalents of hydroxide} = \frac{\text{Weight (in mg)}}{\text{Equivalent weight (in g)}} = \frac{34}{17} = 2$$

$$\text{Total number of milli equivalents (in 500 ml)} = 4 + 1 + 2 = 7$$

$$\text{Total number of milli equivalents in 1 litre solution} = \frac{7}{500} \times 1000 = 14 \text{ milli equivalents}$$

$$= 14 \times 50 = 700 \text{ mg}/l \text{ as } CaCO_3$$

123. **(c)**

$$\text{Sound pressure level (dB)} = 20\log_{10}\left(\frac{P}{P_0}\right)$$

$$P_0 \text{ (Reference pressure)} = 2 \times 10^{-5} \text{ N/m}^2$$

$$P \text{ (Sound pressure)} = 4000 \text{ } \mu \text{ bar}$$

$$= 4000 \times 10^{-6} \times 10^5 \text{ N/m}^2 = 400 \text{ N/m}^2$$

$$\text{SPL} = 20\log_{10}\left(\frac{400}{2 \times 10^{-5}}\right)$$

$$= 20 \log_{10} (2 \times 10^7)$$

$$= 20 [(\log_{10} 2) + 7] = 20 \times 7.3 = 146 \text{ dB}$$

124. (c)

125. **(c)**

It can be uniformly applied to entire body of water.

126. **(c)**

127. **(b)**

Fly nuisance, odour nuisance and ponding problem are the main operational troubles of trickling filters.

128. **(c)**

129. (a)

Various mechanical devices used for removal of particulate matters:

Name of device	Minimum particle size (μm)	Efficiency of removal
1. Gravitational settling chamber	> 50	< 50%
2. Centrifugal collectors including cyclone collectors and dynamic precipitator	5 – 25	30 – 90%
3. Wet scrubbers of collectors including spray towers	> 10	< 80%
4. Cyclonic scrubbers	> 2.5	< 80%
5. Venturi scrubbers (Also used for gaseous pollutants)	> 0.5	< 99%
6. Electrostatic precipitator	> 1	95 – 99%
7. Fabric filters	< 1	> 99%

130. (c)

The engineering surveys for finalizing a highway alignment are conducted in four main stages, in the following order:

1. Map study : This is the first step where existing maps are analyzed for shortest feasible corridors.
2. Reconnaissance survey : Field visits are made to observe and record physical conditions of the shortlisted routes.
3. Preliminary survey : More detailed data is collected to evaluate and compare the various route options.
4. Final location and detailed surveys: The best route is selected and surveyed thoroughly for design and construction.

131. (b)

Radius of curve beyond which no super elevation is required is given by

$$R = \frac{v^2}{225 \text{ camber}} = \frac{90^2}{225 \times 0.03}$$

$$\Rightarrow \quad R = 1200 \text{ m}$$

132. (d)

Given:

$$\text{Ruling gradient} = 6\%$$

$$\text{Radius of curve } R = 60 \text{ m}$$

$$\text{Grade compensation} = \min\begin{cases}\left(\dfrac{30+R}{R}\right)\% \\ \dfrac{75}{R}\%\end{cases} = \min\begin{cases}\left(\dfrac{30+60}{60}\right) = 1.5\% \\ \dfrac{75}{60} = 1.25\%\end{cases}$$

$$\therefore \quad \text{Grade compensation} = 1.25\%$$

133. (b)

Given:

$$\text{Length of wheel base } l = 6 \text{ m}$$

$$\text{Radius of curve } R = 36 \text{ m}$$

$$\text{Off-tracking} = \frac{l^2}{2R} = \frac{6^2}{2 \times 36} = 0.5 \text{ m}$$

134. (b)

135. (c)

136. (b)

$$\text{C.S.I.} = \frac{S + 10H}{20}$$

Where;

S = strength index, both for green and dry timber at 12% moisture content.

H = Hardness index, both for green end dry timber at 12% moisture content.

NOTE:

Types of sleeper	Minimum C.S.I
Track sleeper	783
Crussing sleeper	1352
Bridge sleeper	1455

137. (c)

Length of each rail on a B.G. track = 12.8 m

$$\text{Total number of rails required} = \frac{640}{12.8} = 50 \text{ rails}$$

Number of sleepers per rail = 12.8 + 5 = 17.8 = 18 sleepers/rail

Therefore, total number of sleepers required

= 50 × 18 = 90 sleepers.

138. (c)

- Runway gradient: Slope affects acceleration/deacceleration performance.
- Runway width and side clearance: Ensures safe maneuvering space.
- Cross-wind: Critical for maintaining control during take-off or landing.
- Obstructions: Avoid physical hazards and turbulence.

139. (b)

- IRC has recommended minimum radius of central island to be 1.33 times the radius of entry curve.
- For smooth flow of traffic, the weaving should be small but not less than 15°

140. (b)

- Angularity number for aggregates used in highway construction is 7 to 10.
- Angularity number = $\left(67 - \dfrac{wG}{S}\right)$

  w = weight of water filled in cylinder
  For $S = 1$ $\quad e = GW$
- In angularity number, the value 67 represents the volume of solids (in%) of most rounded gravel in well compacted state which would then have 33% voids.

141. (b)

The lower end of the suction pipe is provided with a foot value which is immersed in liquid and serves to prevent the liquid from flowing back into the sump when the pump is not working.

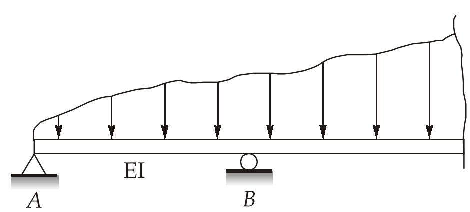
142. (c)

Maximum principal strain theory over estimates the elastic strength of ductile materials.

143. (b)

This principle is applicable to both statically determinate and indeterminate structures.
It is Mathematically derived from Betti's theorem by applying a virtual unit force (or moment) and using the reciprocal nature of the displacements and reactions.

144. (a)



From slope deflection equation

$$M_{AB} = \bar{M}_{AB} + \frac{2EI}{L}\left(2\theta_A + \theta_B - \frac{3\Delta}{L}\right)$$

$$\Rightarrow \quad 0 = \bar{M}_{AB} + \frac{2EI}{L}\left(2\theta_A + \theta_B - \frac{3\Delta}{L}\right) \quad ...(i)$$

$$M_{BA} = \bar{M}_{BA} + \frac{2EI}{L}\left(2\theta_B + \theta_A - \frac{3\Delta}{L}\right) \quad ...(ii)$$

Equation (ii) – Equation (i) ÷ ii

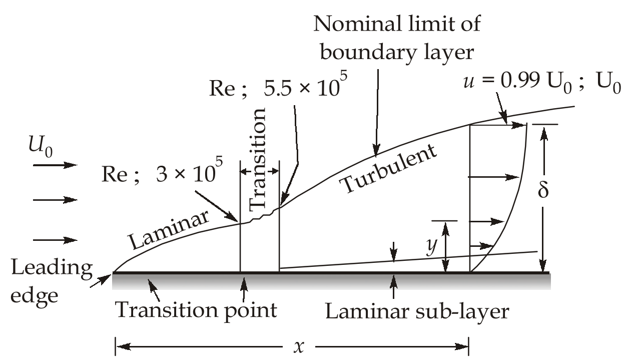
$$M_{BA} = \bar{M}_{BA} - \frac{\bar{M}_{AB}}{2} + \frac{2EI}{L}\left[\frac{3\theta_B}{2} - \frac{3}{2}\left(\frac{\Delta}{L}\right)\right]$$

$$\Rightarrow \quad M_{BA} = \bar{M}_{BA} - \frac{\bar{M}_{AB}}{2} + \frac{3EI}{L}\left(\theta_B - \frac{\Delta}{L}\right)$$

This is called modified slope deflection equation. If far end of member has zero final end moment then modified slope deflection equation can be used to reduce the number of unknowns in the simultaneous equations.

145. (d)

Flow in the boundary layer is not always laminar. It starts as laminar near the leading edge of a surface but can transition to turbulent flow further downstream depending on Reynolds number and surface roughness.



In turbulent boundary layers, especially near walls (like pipe walls or flat plates), there exists a thin laminar sublayer.

146. (a)

The portal bracing is provided in a through bridge in the plane of the end posts. It is more flexible form of bracing compared to a cross frame as it causes bending moment in the end posts. Such bracings should be used only in through bridges where cross-frame cannot be used.

147. (d)

If liquid limit of oven dried sample is less than the three fourth of in-situ soil sample then soil is organic otherwise inorganic.

148. (c)

Low heat cement preserves the form of brick at high temperature and prevents shrinkage by reducing the amount of heat generated during the hydration of cement.

149. (d)

London smog was primarily caused by a combination of industrial emissions, SO_2, PM and weather conditions.

150. (c)

- PCU is a factor used in traffic engineering to convert different types of vehicles (like trucks, buses, bicycles etc) into a common unit.
- It is based on how a vehicle effects traffic flow, not how much damage it causes to the road.
- PCU is a measure of relative space requirement of different class of vehicles as compared to a passenger car.

■■■■