DETAILED SOLUTIONS

MADE EASY

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ESE 2022 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 20

Full Syllabus Test 4 : Paper-II

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

DETAILED EXPLANATIONS

1. (c)

$$\gamma_d = \frac{W_{solid}}{V_{soil}}$$

$$\Rightarrow \quad 1.6 = \frac{w_{solid}}{50}$$

$$\Rightarrow \quad W_{solid} = 80 \text{ gm}$$

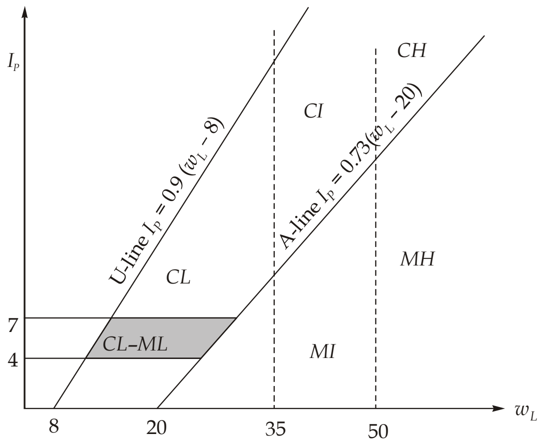
$$\therefore \quad w_w = 100 - 80 = 20 \text{ gm}$$

Now if 20 m*l* i.e., 20 cc water i.e., 20 gm of water is added then

$$W_w = 20 + 20 = 40 \text{ gm}$$

$$\therefore \quad W = \frac{W_w}{W_{solid}} = \frac{40}{80} = 0.5 \text{ i.e., } 50\%$$

2. (d)



3. (c)

$$u_{C\text{-}C} = 0$$

$$u_{B\text{-}B} = -\gamma_w h_c = -10 \times 2 = -20 \text{ kN/m}^2$$

$$u_{C\text{-}C} = +\gamma_w z = 10 \times 5 = 50 \text{ kN/m}^2$$

4. (c)

$$Q = Aki$$

$$Q = AK\left(\frac{\Delta h}{L}\right)$$

$$\Rightarrow \quad Q = (40 \times 40) \times (5 \times 10^{-5}) \times \left(\frac{100 - 80}{100}\right)$$

$$\Rightarrow \quad Q = 0.016 \text{ cm}^3/\text{sec}$$

5. (a)

Given: ΔH = 50 cm, H_0 = 5 cm, e_f = 0.3

$$\frac{\Delta H_0}{H_0} = \frac{e_0 - e_f}{1+e_0}$$

$$\Rightarrow \quad \frac{0.50}{5} = \frac{e_0 - 0.3}{1+e_0}$$

$$\Rightarrow \quad 0.5 + 0.5e_0 = 5e_0 - 1.5$$

$$\Rightarrow \quad 2 = 4.5e_0$$

$$\Rightarrow \quad e_0 = \frac{2}{4.5} = 0.44$$

6. (b)

we know that,
$$\gamma_d = \frac{G\gamma_w}{1+e}; \quad i_c = \frac{G-1}{1+e}; \quad \text{FOS} = \frac{i_c}{i}$$

$$\Rightarrow \quad 18 = \frac{2.7 \times 10}{1+e}$$

$$\Rightarrow \quad e = 0.5$$

$$\therefore \quad i_c = \frac{2.7-1}{1+0.5} = 1.133$$

$$i = \frac{1.133}{2} = 0.566$$

7. (b)

$$Q_{\text{safe}} = \left[\frac{CN_C}{FOS} + \gamma D_f\right] \times A_f$$

$$\because \quad \frac{D_F}{B} = 0, \; N_C = 6 \text{ (for square footing)}$$

$$\Rightarrow \quad 1500 = \left[\frac{C \times 6}{2}\right] \times (3 \times 3)$$

$$C = \frac{1500 \times 2}{6 \times 9} = 55.55 \text{ kPa}$$

8. (b)

$$\Delta H = \frac{C_s H_{100}}{1+e_{100}} \log\left(\frac{t}{t_{100}}\right) = \frac{0.02 \times 4}{1+0.4} \log\left(\frac{12}{3}\right)$$

$$= 0.0344 \text{ m}$$

$\therefore$ Thickness of soil after 12 years of primary settlement = 4 – 0.0344 = 3.9656 m

9. (b)

$$\mu = \frac{\sigma_3}{\sigma_1 + \sigma_3}$$

$$\Rightarrow \quad \mu = \frac{\sigma_3}{(\sigma_3 + \sigma_d) + \sigma_3}$$

$$\Rightarrow \quad \mu = \frac{130}{(130 + 180) + 130}$$

$$\Rightarrow \quad \mu = 0.295$$

10. (d)

- As fine grained soil has very high volume of voids, so 100% saturation can not be achieved because as we lift the hammer, air enters into the soil.
- Flow field is square only in case of isotropic medium of soil.
- A-factor is a function of over consolidation ratio.

12. (a)

Bearing capacity of cohesionless soil becomes 50% of its original value if water table during monsoon reaches to ground level.

13. (d)

- Compacting of backfill against a rigid wall results in increase K_o value.
- Rankine's assumption of smooth wall surface results in under-estimation of passive earth pressure and over-estimation of active earth pressure.
- Coefficient of earth pressure at rest, $K_o = \dfrac{\mu}{1-\mu}$

14. (a)

Bishop's circle method is based on effective stress approach and friction circle method is based on total stress analysis.

15. (c)

Daily BOD produced by 246 m^3 of waste water

$$= 246\ m^3/day \times 1400\ mg/l \times 10^{-6} \times 10^3$$

$$= 344\ kg/day$$

$$\text{Population equivalent} = \frac{344.4}{0.08} = 4305 \text{ persons}$$

16. (b)

$$BOD_5 \text{ of the mixture} = \frac{400 \times 300 + 2100 \times 0}{400 + 2100} = 48\ mg/l$$

$$\text{Ultimate BOD of mix} = 1.25 \times 48 = 60\ mg/l$$

$\therefore \quad BOD_t = L_0\left[1-10^{-k_D t}\right]$

$\Rightarrow \quad 48 = 60\left[1-10^{-k_D t}\right]$

$\Rightarrow \quad 0.8 = 1-10^{-5k_D}$

$\Rightarrow \quad 10^{-5k_D} = 0.20$

$\Rightarrow \quad -5k_D \log_{(10)} = \log 0.20$

$\Rightarrow \quad -5k_D \times 1 = \log\left(\frac{2}{10}\right) = \log 2 - \log_{10}$

$= 0.301 - 1$

$\therefore \quad k_D = \frac{-0.699}{-5} \simeq 0.14 \text{ day}^{-1}$

17. (a)

Mass of solids in fresh sludge = 3675 kg/day

Moisture content = 95%

Solid content = 5%

i.e. Mass of net sludge = $\frac{100}{5} \times 3675 = 73500$ kg/day

Volume of net sludge, $V_1 = \frac{73500}{1050} = 70 \text{ m}^3/\text{day}$

Digested sludge volume, $V_2 = V_1\left(\frac{100-P_1}{100-P_2}\right) = 70\left(\frac{100-95}{100-85}\right)$

$= 70 \times \frac{5}{15} = 23.33 \text{ m}^3/\text{ day}$

Digester capacity $= \left[V_1 - \frac{2}{3}(V_1 - V_2)\right] \cdot t$

$= \left[70 - \frac{2}{3}(70 - 23.33)\right] \times 30$

$= 1166.67 \text{ m}^3 \simeq 1167 \text{ m}^3$

18. (a)

The efficiency of upstream ESP is 70%.

So, 30% of particulate matter is not removed.

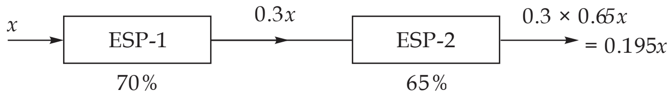
∴ Particulate matter removed by downstream ESP

$= 30 \times \frac{65}{100} = 19.5\%$

As these two ESPs are connected in series, the overall efficiency is,

$$\eta_o = (100 - 19.5) = 80.5\%$$

Alternatively,



$$\therefore \qquad \eta_0 = \frac{(1-0.195)x}{x} \times 100 = 80.5\%$$

20. (a)

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

where P is sound pressure in μ-Pa
and P_0 is reference pressure (20 μPa)

$$\therefore \qquad 40\text{dB} = 20\log_{10}\left(\frac{P}{20}\right)$$

$$\Rightarrow \qquad 2 = \log_{10}\left(\frac{P}{20}\right)$$

$$\Rightarrow \qquad \frac{P}{20} = 10^2$$

$$\Rightarrow \qquad P = 2000\ \mu\text{Pa} = 0.02\ \mu\text{bar} \qquad (\because 1\text{ bar} = 10^5\text{ Pa})$$

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

22. (a)
The inner annual rings surrounding the pith constitute the heartwood.

23. (d)

24. (a)
IS 5779 refers to burnt clay soling bricks.
IS 3583 refers to burnt clay paving bricks.

25. (a)
Crushing strength test, water absorption test and attrition test all are laboratory test.

26. (a)
Bakelite is thermosetting plastic.

29. (c)
Blaney-Criddle formula $\qquad E_T = k\Sigma f$

$$f = \frac{p}{40}(1.8t + 32)$$

30. (b)

$$\therefore \quad F_p = 3\sqrt{t}$$

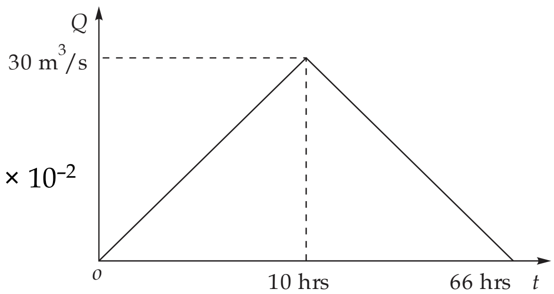
$$\therefore \quad f_p = \frac{dF_p}{dt} = \frac{3}{2}t^{\frac{1}{2}-1} = \frac{3}{2\sqrt{t}}$$

At $t = 4\text{h}$

$$f_p = \frac{3}{2\sqrt{4}} = \frac{3}{4} = 0.75 \text{ cm/hr}$$

31. (d)

$$Q_p = 30 \text{ m}^3/\text{s}$$
$$D = 66 \text{ hours}$$
$$CA = 400 \text{ km}^2$$



$$\frac{1}{2}Q_p \times D \times 3600 = CA \times R$$

$$\Rightarrow \quad \frac{1}{2} \times 66 \times 3600 \times 30 = 400 \times 10^6 \times R \times 10^{-2}$$

$$\Rightarrow \quad R = 0.891 \text{ cm}$$

$$\Rightarrow \quad R \simeq 0.9 \text{ cm}$$

$$\therefore \quad \frac{(UH)_p}{(DRH)_p} = \frac{1}{0.9}$$

$$\Rightarrow \quad \text{Peak discharge of 6 h } UH = \frac{30}{0.9} = 33.33 \text{ m}^3/\text{s}$$

32. (c)

The coefficient k is known as storage time constant and has the dimensions of time. It is approximately equal to the time of travel of a flood wave through the channel reach.

33. (c)

p = Probability of a rainfall of 20 cm in 24 hours occurring in any one year at station x is $\frac{1}{T}$.

$$p = \frac{1}{T} = \frac{1}{100} = 0.01$$

34. (b)

Dry volume of concrete = 1.5 × wet volume of concrete

$= 1.5 \times 10 = 15 \text{ m}^3$

$$\therefore \quad \text{Quantity of cement} = \frac{1}{1+3+6} \times 15 = 1.5 \text{m}^3$$

$$\text{Number of cement bag required} = \frac{1.5}{35 \times 10^{-3}} = 42.85 \simeq 43 \text{ bags}$$

35. (b)

$$d_{avg} = \frac{\sum_{i=1}^{n}\left(\frac{P_i + P_{i+1}}{2}\right)A_i}{\sum_{i=1}^{n} A_i}$$

$$\Rightarrow \quad d_{avg} = \frac{\frac{(15+12)}{2}92 + \frac{(12+9)}{2}128 + \frac{(9+6)}{2}120 + \frac{(6+3)}{2}175 + \frac{(3+1)}{2}85}{600}$$

$$= \frac{1242 + 1344 + 900 + 787.5 + 170}{600} = 7.4 \text{ cm}$$

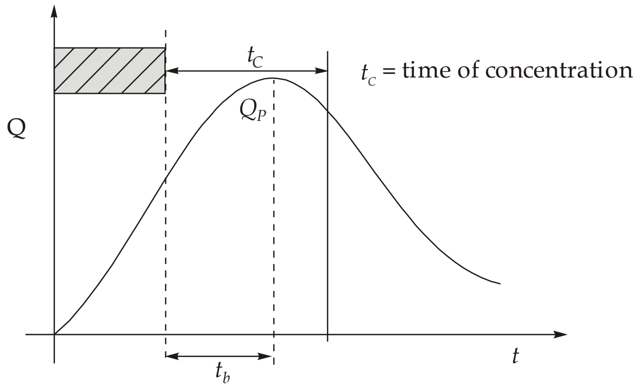
36. (a)

Time of concentration = Time of interval between the end of the rainfall excess and the point of inflection of the resulting surface runoff.

$$\text{Basin lag} = 8 - \frac{4}{2} = 6 \text{ hr}$$

$$\text{Time of concentration} = 10 - 4 = 6 \text{ hr}$$

$$\text{Ratio} = \frac{6}{6} = 1$$



t_b = basin lag or lag time

Basin lag (practical purposes) or lag time is the time difference between the centroid of effective rainfall hyetograph (rainfall excess) and peak of DRH.

37. (c)

- Applied load divided by the actual cross-sectional area is called as true stress whereas the applied load divided by the original cross-sectional area is called as nominal stress or conventional stress or engineering stress.
- Hooke's law of proportionality in a material is valid till its limit of proportionality.
- An isotropic material have same properties in all the directions.

38. (a)

$$\frac{\delta_{inst.}}{l} = \frac{1}{2000} = \text{Instantaneous strain}$$

$$\text{Instantaneous stress, } f_{inst.} = \frac{1}{2000} \times 2 \times 10^5 = 100 \text{ N/mm}^2$$

$$\therefore \quad \delta_{inst.} = \frac{1}{2000} \times 2 \times 10^3 = 1 \text{ mm}$$

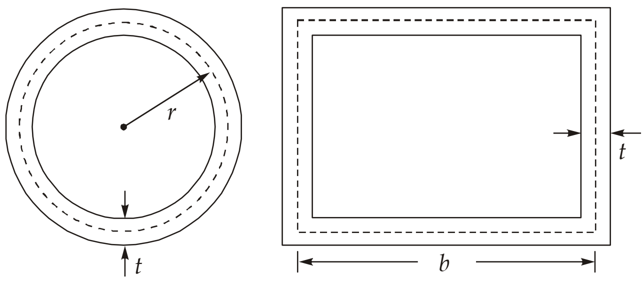
Now, $$\frac{f_{inst}^2}{2E} \times A \times L = W(h + \delta_{inst.})$$

$$\Rightarrow \quad \frac{100^2}{2 \times 2 \times 10^5} \times A \times 2 \times 10^3 = 100 \times (10 + 1) \times 9.81$$

$$\Rightarrow \quad 50 \times A = 981 \times 11$$

$$\Rightarrow \quad A = 215.82 \text{ mm}^2$$

39. (c)



For any thin-walled tube, shear flow,

$$f = \tau.t = \frac{T}{2A_m}$$

Mean areas, $$A_{m1} = \pi r^2 \text{ and } A_{m2} = b^2$$

Also, cross-sectional area of circular tube is,

$$A_1 = 2\pi rt$$

Cross-sectional area of square tube,

$$A_2 = 4bt$$

As, cross-sectional area of both the tubes are same.

$$\therefore \quad A_1 = A_2$$

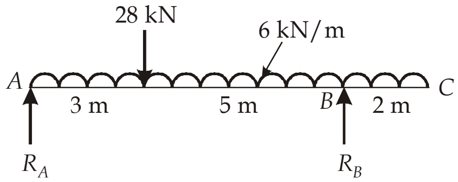
$$\Rightarrow \quad 2\pi rt = 4bt$$

$$b = \frac{\pi r}{2} \quad \text{...(i)}$$

$$\therefore \quad \frac{\tau_1}{\tau_2} = \frac{A_{m2}}{A_{m1}} = \frac{b^2}{\pi r^2}$$

$$\Rightarrow \quad \frac{\tau_1}{\tau_2} = \frac{(\pi r)^2}{4\pi r^2} = \frac{\pi}{4}$$

40. (b)



$$R_A + R_B = 60 + 28 = 88 \text{ kN}$$

$$\circlearrowleft \Sigma M_A = 0$$

$$R_B \times 8 - (28 \times 3) - (6 \times 10 \times 5) = 0$$

$$\Rightarrow \quad R_B = \frac{300 + 84}{8} = 48 \text{ kN}$$

$$\therefore \quad R_A = 88 - R_B = 88 - 48 = 40 \text{ kN}$$

Shear force at D,

$$V_D = 40 - 6 \times 5 - 28$$

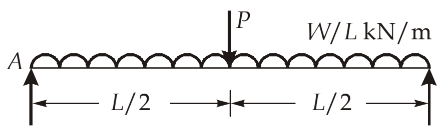
$$\Rightarrow \quad V_D = -18 \text{ kN}$$

$$\text{Bending moment at } D,\ M_D = 40 \times 5 - 6 \times 5 \times \frac{5}{2} - 28 \times 2$$

$$\Rightarrow \quad M_D = 200 - 75 - 56$$

$$M_D = 69 \text{ kNm}$$

41. (d)



Neglecting the self weight W, $M_{max} = \dfrac{PL}{4}$

$$(\sigma_{max})_1 = \frac{M_{max}}{I} \times y_{max} = \frac{PL}{4} \cdot \frac{y_{max}}{I} = kP$$

where $k = \dfrac{y_{max} L}{4I}$

If, however self weight of beam is considered, then

$$M_{max} = \frac{PL}{4} + \frac{WL}{8}$$

$$(\sigma_{max})_2 = \left(\frac{PL}{4} + \frac{WL}{8}\right)\frac{y_{max}}{I} = \left(P + \frac{W}{2}\right)\frac{L \cdot y_{max}}{4I}$$

$$= k\left(P + \frac{W}{2}\right)$$

Given, Percentage error = 4%

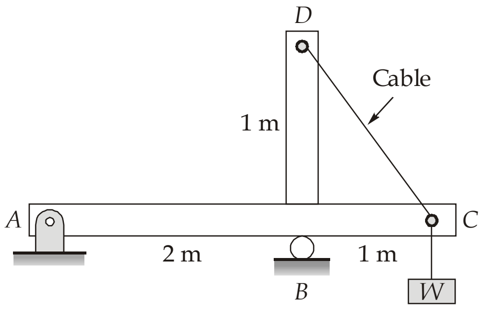
$$\therefore \quad 4 = \frac{k\left(P + \frac{W}{2}\right) - kP}{k\left(P + \frac{W}{2}\right)} \times 100$$

$$\Rightarrow \quad 4\left(P + \frac{W}{2}\right) = \frac{W}{2} \times 100$$

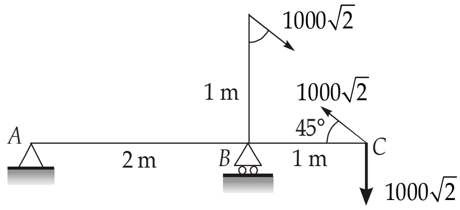
$$\Rightarrow \qquad 4P = 50\ W - 2W = 48\ W$$

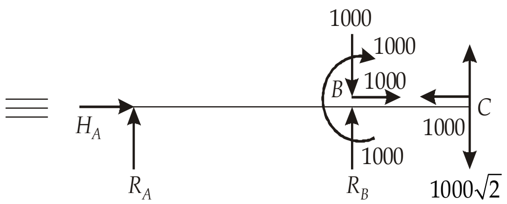
$$\therefore \qquad \frac{P}{W} = \frac{48}{4} = 12$$

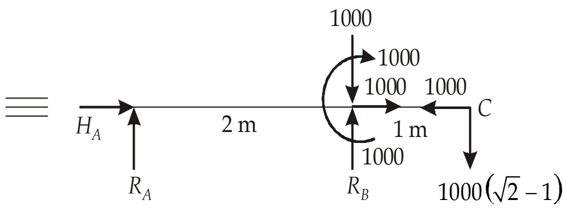
42. **(b)**



$$T = W = 1000\sqrt{2}\ \text{kN}$$







$$\Sigma F_x = 0$$

$$\Rightarrow \qquad H_A + 1000 - 1000 = 0$$

$$\Rightarrow \qquad H_A = 0$$

$$\Sigma F_y = 0 \quad \Rightarrow \quad R_A + R_B = 1000 + 1000\left(\sqrt{2} - 1\right)$$

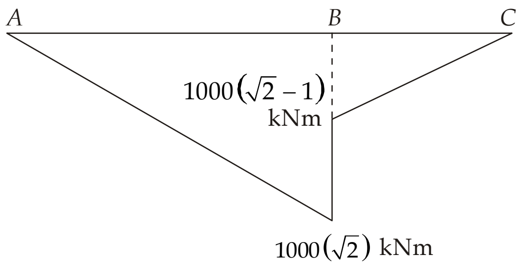
$$\Rightarrow \qquad R_A + R_B = 1000\sqrt{2} \qquad \text{...(i)}$$

$$\circlearrowleft \Sigma M_B = 0$$

$$\Rightarrow \quad R_A \times 2 + 1000 + 1000(\sqrt{2} - 1) = 0$$

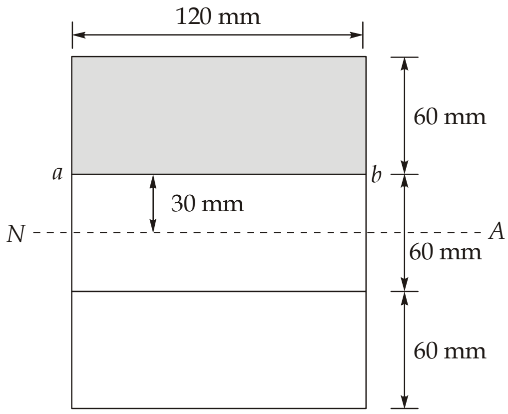
$$R_A = \frac{-1000\sqrt{2}}{2} = -500\sqrt{2}\ \text{kN}$$

BMD



$$\therefore \quad BM_{max} = 1000\sqrt{2}\ \text{kNm}$$

43. (c)



$$I_{NA} = \frac{bh^3}{12} = \frac{120 \times (180)^3}{12} = 5832 \times 10^4\ \text{mm}^4$$

$$\text{Maximum shear force, } V = \frac{wL}{2} = 1.25w\ \text{kN}$$

$$\text{At the glued joint ab, } \tau = \frac{VQ}{Ib} \quad \text{where } Q = A\bar{y}$$

$$\Rightarrow \quad \tau = \frac{(1.25w)(60 \times 120 \times 60)}{(5832 \times 10^4) \times (120)} = 7.716 \times 10^{-5}$$

But permissible value of shear stress $= 0.5\ \text{N/mm}^2$

$$\therefore \quad 0.5 = (0.7716 \times 10^{-4})\ w$$

$$\Rightarrow \quad w = 6480\ \text{N/m}$$

$$= 6.48\ \text{kN/m} \simeq 6.5\ \text{kN/m}$$

44. (c)

Let EI is in Nm^2

Due to uniformly varying load, $\delta_{c1} = \frac{wl^4}{30EI} = \frac{120 \times 10^4}{30 \times EI} = \frac{4 \times 10^4}{EI}$ m

$$\theta_{c1} = \frac{wl^3}{24EI} = \frac{120 \times 10^3}{24EI} = \frac{5 \times 10^3}{EI} \text{ rad}$$

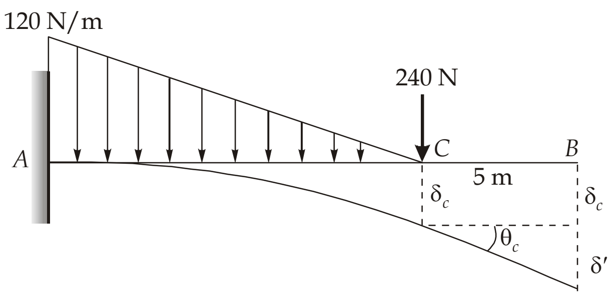
Due to concentrated load,

$$\delta_{c2} = \frac{Pl^3}{3EI} = \frac{240 \times 10^3}{3EI} = \frac{8 \times 10^4}{EI} \text{ m}$$

$$\theta_{c2} = \frac{Pl^2}{2EI} = \frac{240 \times 10^2}{2EI} = \frac{12 \times 10^3}{EI} \text{ rad}$$

$$\delta_c = \delta_{c1} + \delta_{c2} = \frac{4 \times 10^4}{EI} + \frac{8 \times 10^4}{EI} = \frac{12 \times 10^4}{EI}$$

$$\theta_c = \theta_{c1} + \theta_{c2} = \frac{5 \times 10^3}{EI} + \frac{12 \times 10^3}{EI} = \frac{17 \times 10^3}{EI}$$



$$\delta' = \theta_c \times 5 \text{ m}$$

$$\delta' = \frac{17 \times 10^3}{EI} \times 5 = \frac{85 \times 10^3}{EI} = \frac{8.5 \times 10^4}{EI}$$

$$\delta_B = \delta_C + \delta'$$

$$\Rightarrow \quad \delta_B = \frac{12 \times 10^4}{EI} + \frac{8.5 \times 10^4}{EI}$$

$$\Rightarrow \quad EI\delta_B = 20.5 \times 10^4 \text{ N-m}^3$$

$$= 205 \text{ kN-m}^3$$

45. (d)

Given: $I = 300 \times 10^4 \text{ mm}^4$

$A = 3000 \text{ mm}^2$

$$P = \frac{f_c A}{1+\alpha\left(\frac{l_{eff}}{r}\right)^2}$$

$$l_{eff} = \frac{2.4}{2} = 1.2\,\text{m} = 1200\,\text{mm}$$

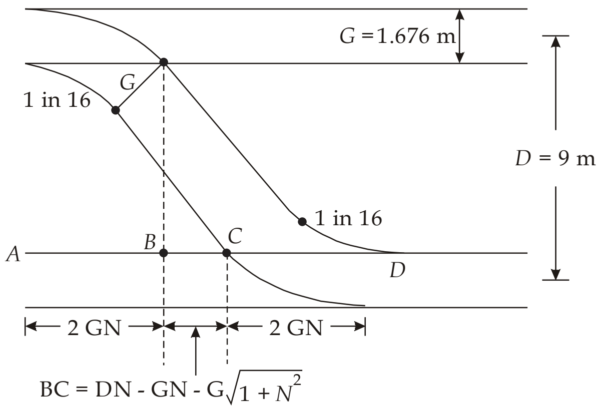
$$r^2_{min} = \frac{I}{A} = \frac{300\times10^4\,\text{mm}^4}{3000\,\text{mm}^2} = 1000\ \text{mm}^2$$

$$P = \frac{600\times3000}{1+\frac{1}{1600}\times\frac{1200^2}{1000}}$$

$$\Rightarrow \quad P = \frac{600\times3000}{1.9}$$

$$\Rightarrow \quad P = 947368.42\ \text{N} = 947.36\ \text{kN} \simeq 947\ \text{kN}$$

46. (d)



$$\text{Total crossing length} = 4GN + DN - GN - G\sqrt{1+N^2}$$

$$\simeq 2GN + DN \qquad \because G\sqrt{1+N^2} \simeq GN$$

$$= (2 \times 1.676 \times 16) + (9 \times 16)$$

$$= 197.632\ \text{m}$$

47. (d)

Bending stress due to bending moment M,

$$f_y = \frac{32M}{\pi d^3}$$

Similarly, shear stress produced by torque T acting alone is,

$$\tau = \frac{16T}{\pi d^3}$$

For the given state of stress,
Principal stresses acting on the shaft are

$$\sigma_{p1} = \frac{16T}{\pi d^3}$$

$$\sigma_{p2} = 0$$

$$\sigma_{p3} = \frac{-16T}{\pi d^3}$$

According to maximum principal strain theory,

$$\sigma_{p1} - \mu\sigma_{p2} - \mu\sigma_{p3} = f_y$$

$$\Rightarrow \quad \frac{16T}{\pi d^3} - 0 + \frac{0.3 \times 16T}{\pi d^3} = \frac{32M}{\pi d^3}$$

$$\Rightarrow \quad \frac{(16 + 4.8)T}{\pi d^3} = \frac{32M}{\pi d^3}$$

$$\Rightarrow \quad \frac{M}{T} = \frac{20.8}{32} = 0.65$$

48. (a)

On plane having maximum shear stress, normal stress equal to half of the sum of principal stresses exists.

49. (b)

$$\text{Poisson's ratio, } \mu = \frac{\text{lateral strain}}{\text{longitudinal strain}}$$

$$\Rightarrow \quad \mu = \frac{1}{4} = 0.25$$

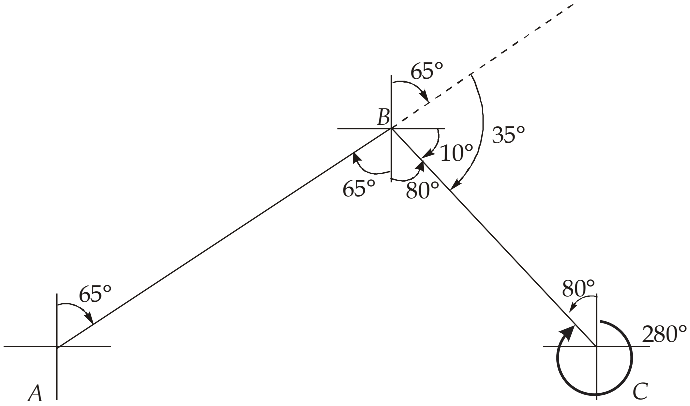
$$\therefore \quad E = 2G(1 + \mu)$$

$$\Rightarrow \quad G = \frac{1.2 \times 10^5}{2 \times 1.25} = 0.48 \times 10^5 \text{ N/mm}^2$$

50. (b)

- If a load is applied on shear centre, it will produce only bending and not twisting.
- If a section is made of two narrow rectangles, then shear centre lies on the junction of both the rectangles.

51. **(c)**



$\therefore$ Fore bearing of BC = $65° + (90° - 65°) + 10° = 100°$

$\therefore$ Back bearing of BC = $280°$ i.e. N80° W

52. **(a)**

- Wrong alignment of tape leads to –ve correction i.e. error is positive.
- If $P_0 > P_m$, then correction due to pull is negative i.e. error is positive.

53. **(c)**

54. **(b)**

- Use of sand in mortar does not provide strength, it only imparts readjustment of strength.
- For pointing work only cement mortar of 1 : 2 or 1 : 1 is suggestable to use.

55. **(a)**

$$M = t \times 24 \times [T°C - (-11)]$$

$$\Rightarrow \quad M = (10 \times 24) \times (15 + 11) = 6240 \text{ °C hour}$$

$$\therefore \quad \text{Percentage strength attained} = A + B\log\left(\frac{M}{1000}\right)$$

$$= 32 + 54\log\left(\frac{6240}{1000}\right)$$

$$= 32 + (54 \times 0.8) = 75.2\%$$

56. **(d)**

- Well graded aggregate results in more workable concrete mix because it has less volume of void and thus results in more free cement paste to flow, which increases workability.
- Air entraining admixture provides resistance against segregation of concrete because they makes the mix more homogeneous.
- A 100 mm cube gives less realistic (far from actual) result as compressive strength of concrete because it is subjected to high restraining effect of steel plates.
- Results of rebound hammer test, depend on shape of concrete structure.

57. (c)

Plasticizer increases the workability of concrete at a particular water cement ratio and also retards setting process as it makes layer over the cement particles which reduce rate of hydration.

58. (d)

- Balancing the sight length for backsight and foresight is done to eliminate the error due to small inclination of line of sight.
- Barometric method of levelling is based on principle that atmospheric pressure decreases with height.
- Dip of horizon is angle between line of sight and tangent to level surface.
- Correction due to refraction is done because line of sight is horizontal and deviates from level surface.

59. (b)

$$\text{Deflection angle, } \Delta = 180° - 120° = 60°$$

$$\text{Radius of curve, } R = \frac{1146}{D} = \frac{1146}{2}\,\text{m}$$

$$\text{Tangent length} = R\tan\frac{\Delta}{2}$$

$$= \frac{1146}{2}\times\tan\frac{60°}{2} = 330.8\text{ m} \simeq 331\text{ m}$$

60. (c)

$$\angle C = 180° - [\angle A + \angle B]$$
$$= 180° - [45°45'20'' + 52°30'40'']$$
$$= 81°44'0''$$

$$\text{Weight of } (A + B) = \frac{1}{\frac{1}{2}+\frac{1}{4}} = \frac{4}{3}$$

$\therefore$ $$\text{Weight of } C = \text{Weight of } [180° - (A + B)]$$
$$= \frac{4}{3}$$

61. (d)

$$\text{Difference in longitude} = 82°30' - 73°$$
$$= 9°30' \quad \{\because 1\text{ hr} = 15°\}$$
$$= 38\text{ min.}$$

$\therefore$ $$\text{LMT} = 9\text{ h } 20\text{ m} - 38\text{ m}$$
$$= 8\text{h } 42\text{ m}$$

$\therefore$ $$\text{GMT} = 9\text{ h } 20\text{ m} - 5\text{ h } 30\text{ m}$$
$$= 3\text{h } 50\text{ m}$$

$$\text{Difference between GMT and LMT} = 8\text{h } 42\text{ m} - 3\text{h } 50\text{ m} = 4\text{ h } 52\text{ min} = 292\text{ min.}$$

62. (c)

Inclination of camera axis about a line perpendicular to line of flight is known as tip whereas tilt is inclination of optical axis of camera about the line of flight.

63. (b)

$$\text{Latitude} = l\cos\theta \Rightarrow 100 = l\cos\theta \quad ...(1)$$

$$\text{Departure} = l\sin\theta \Rightarrow 300 = l\sin\theta \quad ...(2)$$

$$\therefore \quad \cos^2\theta + \sin^2\theta = 1$$

$$\frac{100^2}{l^2} + \frac{300^2}{l^2} = 1$$

$$\Rightarrow \quad \sqrt{100^2 + 300^2} = l$$

$$l = 316.23 \text{ m}$$

65. (d)

$$\text{Ruling gradient} = 2 \times \text{Camber}$$

$$\Rightarrow \quad \text{R.G} = 2 \times \frac{1}{64}$$

$$\Rightarrow \quad \text{R.G} = \frac{1}{32}$$

As per IRC 52 : 1981, minimum R.G. = $\frac{1}{30}$ (For plain and rolling terrain)

66. (b)

Methods of O and D study:

1. Interview method.
2. License plate method.
3. Return post card method.
4. Tag on car method.

Methods of speed and delay study:

1. Floating car method.
2. Interview method.
3. License plate method.
4. Photographic technique.
5. Elevated observation.

68. (b)

Runway length is increased by 7% per 300 m above MSL.

$$\text{So, correction for elevation} = \frac{7}{100} \times \frac{600}{300} \times L = 0.14L$$

$$\text{Length after elevation correction} = L + 0.14L = 1.14L$$

Total length after both temperature and elevation correction = 1.3 L

$$\therefore \quad \text{Correction due to temperature} = 1.14L \times x = 1.3L$$

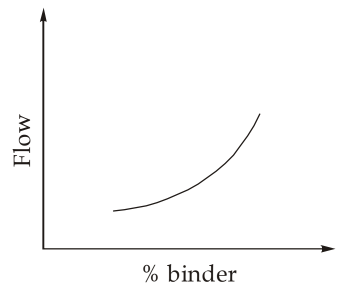
$$x = 1.1403$$

i.e. 14.03%

69. (d)

$$\sigma_{st} = 230 \text{ MPa}$$
$$\tau_{bd} = 2 \text{ MPa}$$
$$\phi = 16 \text{ mm}$$
$$\tau_{bd} \cdot \pi\phi \times L_d = \sigma_{st}\frac{\pi\phi^2}{4}$$
$$\Rightarrow \quad L_d = \frac{\sigma_{st}\phi}{4\tau_{bd}}$$
$$\Rightarrow \quad L_d = \frac{230 \times 16}{4 \times 2} = 460 \text{ mm}$$
$$\therefore \quad \text{Length of tie bar} = 2L_d + \text{gap}$$
$$= 2 \times (460) + 12 = 920 + 12 = 932 \text{ mm}$$

70. (b)



71. (b)

Grade resistance + curve resistance = Gradient resistance

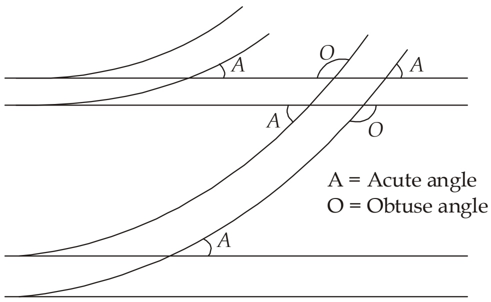
$$\Rightarrow \quad W\tan\theta + 0.0004 \times 3° \times W = \frac{W}{250}$$
$$\Rightarrow \quad \tan\theta = \frac{1}{250} - \frac{3}{2500} = \frac{7}{2500}$$

i.e. $\frac{1}{357.14}$

72. (c)

Flangeway clearance is distance between gauge and running face of stock and tounge rail at heel of switch, whereas heel divergence is distance between gauge or running face of tounge rail and stock rail at heel of switch.

Double turnout:



73. (c)

$$\text{Number of gate position} = \frac{\text{Runway capacity}(\text{air craft / hr})}{60 \times 2} \times \text{Gate occupancy time (min)}$$

$$= \frac{12}{60 \times 2} \times 60 = 6 \text{ gate}$$

74. (b)

$$\text{CCA} = 1200 \text{ ha}$$

$$\text{IOI}_{\text{sugarcane}} = \frac{20}{100} \times 1200 = 240 \text{ ha}$$

$$\text{IOI}_{\text{wheat}} = \frac{40}{100} \times 1200 = 480 \text{ ha}$$

$$\text{Discharge required for sugarcane} = \frac{240}{730} = 0.329 \text{ cumec}$$

$$\text{Discharge required for wheat} = \frac{480}{1800} = 0.267 \text{ cumec}$$

Since, sugarcane is a perennial crop and wheat is a rabi crop.

Discharge at the head of watercourse

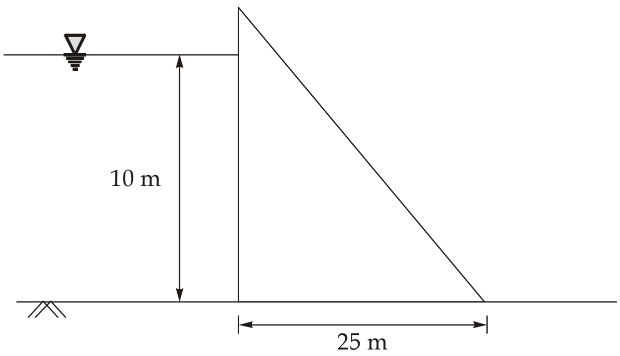
$$= 0.329 + 0.267 = 0.6 \text{ cumec}$$

$$\text{Design discharge} = \frac{0.6}{0.8} = 0.75 \text{ cumec}$$

75. (c)

Virgin rivers are the rivers in which water may completely dry before it joins another river or ocean.

77. (a)



$$\text{Max. shear stress, } \tau_0 = \gamma_w H \sqrt{G_c - C}$$

$$= 1000 \times 9.81 \times 10 \times \sqrt{2.5 - 0}$$

$$= 98100 \times \sqrt{2.5}$$

$$= 155109.71 \text{ N/m}^2$$

$$= 155.1 \text{ kN/m}^2 \simeq 155 \text{ kN/m}^2$$

78. (b)

$$V_o = 0.55\ my^{0.64}$$

$$\Rightarrow \quad V_o = 0.55 \times 1.1 \times 2^{0.64}$$

$$\Rightarrow \quad V_o = 0.943\ \text{m/s} \simeq 0.94\ \text{m/s}$$

79. (a)

$$\Delta P = \frac{8\sigma}{d}$$

$$\therefore \quad \frac{\Delta P_1}{\Delta P_2} = \frac{d_2}{d_1} = \frac{r_2}{r_1} = \frac{2r}{r} = 2$$

$$\Rightarrow \quad \Delta P_2 = \frac{\Delta P_1}{2}$$

80. (a)

Let V = Volume of metallic body

$$V_{oil} = 0.45\ V$$

$$V_{water} = 0.55V$$

In eq. $F_B = W$

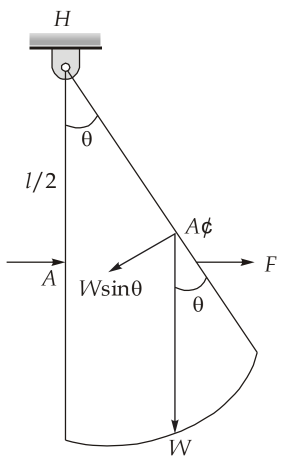
$$\Rightarrow \quad \rho_w \cdot V_w \cdot g + \rho_0 V_0 \cdot g = m_b g$$

$$\Rightarrow \quad 1000 \times 0.55\ V + 700 \times 0.45V = \rho_b \times V$$

$$\Rightarrow \quad \rho_b = 865\ \text{kg/m}^3$$

81. (c)

$$HA = HA' = \frac{l}{2}$$



$$\Sigma M_{hinge} = 0$$

$$\Rightarrow \quad F \times \frac{l}{2} = W \times \frac{l}{2} \times \sin\theta$$

$$\Rightarrow \quad \sin\theta = \frac{F}{W} = \frac{\rho A V^2}{W}$$

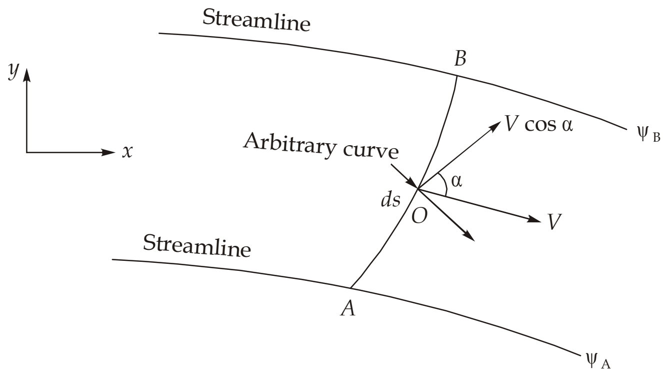
$$\Rightarrow \quad \sin\theta = \frac{\rho Q V}{W} = \frac{1000 \times 0.02 \times 20}{800}$$

$$\Rightarrow \quad \sin\theta = \frac{1}{2}$$

$$\therefore \quad \theta = 30°$$

82. (a)

The velocity potential function can also be defined as the integral of the tangential velocity component along a curve joining any two points.



The velocity potential of point B relative to point A is

$$\phi_B = \int_{AOB} V \cos\alpha \, ds$$

84. (a)

$$\frac{V_m}{\sqrt{gL_m}} = \frac{V_P}{\sqrt{gL_P}}$$

$$V_p = \frac{V_m\sqrt{L_P}}{\sqrt{L_m}}$$

$$\therefore \quad V_p = \frac{2 \times \sqrt{150}}{\sqrt{5}} = 10.95 \text{ m/s}$$

85. (a)

Pipes are in parallel

$$\therefore \quad (h_f)_A = (h_f)_B$$

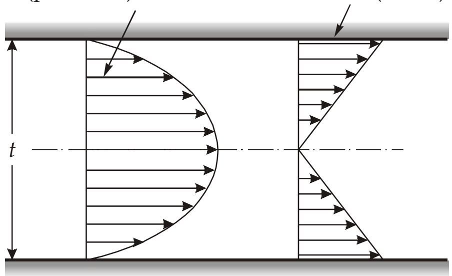
$$\Rightarrow \quad \frac{f_A l_A Q_A^2}{12 d_A^5} = \frac{f_B l_B Q_B^2}{12 d_B^5}$$

$$\Rightarrow \quad \frac{f_A}{f_B} = \left(\frac{Q_B}{Q_A}\right)^2$$

$$\Rightarrow \quad \frac{f_A}{f_B} = \frac{4f_A'}{4f_B'} = \left(\frac{8Q}{4Q}\right)^2$$

$$\Rightarrow \quad \frac{f_B'}{f_A'} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

86. (c)



$$\frac{U_{\max}}{U_{avg}} = \frac{3}{2}$$

87. (d)

For, $\quad Re < 5 \times 10^5$

laminar flow condition will prevail

$$\therefore \quad \frac{\delta_1}{\delta_2} = \sqrt{\frac{Re_2}{Re_1}}$$

$$\Rightarrow \quad \frac{\delta_1}{\delta_2} = \sqrt{\frac{62500}{40000}} = \frac{250}{200} = 1.25$$

$$\therefore \quad \frac{\delta_2}{\delta_1} = 0.8$$

88. (a)

Projected area of parachute $= \frac{\pi}{4} \times (2)^2 = \pi \text{ m}^2$

$\rho_{air} = 0.00125 \times 10^{-3} \times 100^3 = 1.25 \text{ kg/m}^3$

Drag force = Weight of man and parachute

$$\Rightarrow \quad \frac{1}{2}\rho V^2 C_D \times A = 1 \times 10^3$$

$$\Rightarrow \quad \frac{1}{2}\times 1.25\times V^2\times 0.5\times \pi = 10^3$$

$$\Rightarrow \quad V = 31.9 \text{ m/s} \simeq 32 \text{ m/s}$$

89. **(c)**

Radius of taxiway should not be less than 180 m if a supersonic aircraft supposed to land at airport.

92. **(c)**

Slip is negative when delivery pipe is short and suction pipe is long and pump is running at very high speed.

93. **(b)**

Subcritical flow $F_r < 1$

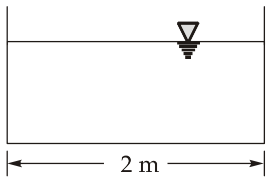
Adverse slope $\frac{dy}{dx} < 0$

We know that $\frac{dE}{dx} = \left(1-F_r^2\right)\frac{dy}{dx}$

$\Rightarrow \quad \frac{dE}{dx} < 0$

94. **(b)**

$B = 2$ m



For maximum discharge $\frac{Q^2T}{gA^3} = 1$

Maximum discharge corresponding to

$E = 1.5$ m will occur when

$E = E_c = 1.5$ m

But $E_c = \frac{3}{2}\times y_c = 1.5$

$\Rightarrow \quad y_c = 1$ m

$$\therefore \quad E = y + \frac{Q^2}{2g\left(B^2y^2\right)}$$

$$\Rightarrow \quad 1.5 = 1 + \frac{Q^2}{2\times 10\times 2^2\times 1^2}$$

$$\Rightarrow \quad 0.5 = \frac{Q^2}{20\times 4}$$

$$\Rightarrow \quad Q = \sqrt{40}\text{ m}^3/\text{s} = 6.3 \text{ m}^3/\text{s}$$

Alternatively, $y_c = \left(\frac{q^2}{g}\right)^{1/3}$

$\Rightarrow$ $1^3 \times 10 = q^2$

$\Rightarrow$ $q = \sqrt{10}\ \text{m}^3/\text{s}$

$\therefore$ $Q = qB = 2\sqrt{10}\ \text{m}^3/\text{s} = 6.3\ \text{m}^3/\text{s}$

96. (a)

For most efficient trapezoidal channel:

$$\text{Wetted perimeter} = 2\sqrt{3}y$$

$$\text{flow area} = \sqrt{3}y^2$$

$$\text{Hydraulic radius} = \frac{y}{2}$$

98. (a)

For 100% removal

$$V_s = V_o \text{ (overflow rate)}$$

We know that $V_h = \frac{L}{h}V_0$

$$V_h = \frac{L}{h}V_s$$

$\Rightarrow$ $V_s = \frac{V_h \times h}{L}$

Given $V_s = \frac{0.5 \times 4}{50} = \frac{0.04 \times 1000}{60} = 0.67\ \text{mm/s}$

99. (b)

From IS 10500 : 2012

Acceptable limit is 4 mg/lit (maximum)

Permissible limit in absence of alternate source

= no relaxation = 4 mg/lit (maximum)

100. (c)

We know $\frac{Z_e}{Z} = \frac{1-n}{1-n_e}$

$$z = 0.75\ \text{m}$$

$$z_e = 1.5 \times 0.75$$

$$n = 0.5$$

$$\frac{1.5 \times 0.75}{0.75} = \frac{1-0.5}{1-n_e}$$

$$\Rightarrow \quad 1.5 = \frac{0.5}{1-n_e}$$

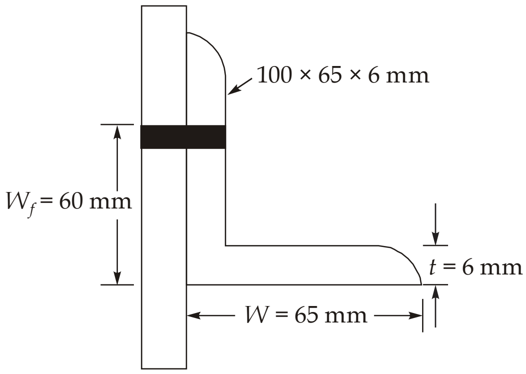
$$\Rightarrow \quad 1 - n_e = \frac{1}{3}$$

$$\Rightarrow \quad n_e = \frac{2}{3}$$

102. (d)

Water sample is initially mixed with $MnSO_4$ and (NaOH + KI). If white precipitate is obtained, then no dissolved oxygen is present in water sample. If reddish brown precipitate is obtained then DO is present in water sample.

103. (d)



$$\beta = 1.4 - 0.076\left(\frac{w}{t}\right)\left(\frac{f_y}{f_u}\right)\left(\frac{b_s}{L_c}\right)$$

$$w = 65 \text{ mm}, t = 6 \text{ mm}$$

$$\text{Shear leg width, } b_s = w + w_f - t = 65 + 60 - 6 = 119 \text{ mm}$$

$$\text{Length of end connection, } L_c = 4 \times 55 = 220 \text{ mm}$$

$$\beta = 1.4 - 0.076 \times \left(\frac{65}{6}\right) \times \left(\frac{250}{410}\right) \times \left(\frac{119}{220}\right) = 1.13$$

$$\geq 0.7$$

$$\leq \frac{0.9 \times \frac{410}{1.25}}{(250/1.1)} = 1.30$$

104. (a)

Given: d = 20 mm, d_0 = 22 mm

Net area:

Along ABC

$$A_{n1} = (180 - 22) \times 20 = 3160 \text{ mm}^2$$

Along *DEBC*

$$A_{n2} = \left[180 - 2 \times 22 + \frac{50^2}{4 \times 100}\right] \times 20$$

$$= 2845 \text{ mm}^2$$

Design tensile strength governed by yielding of plates:

$$T_{dg} = \frac{f_y}{\gamma_{mo}} A_g$$

$$= \frac{250}{1.1} \times (180 \times 20) \times 10^{-3}\,\text{kN} = 818.2\ \text{kN}$$

Design tensile strength governed by rupture of the net section:

$$T_{dn} = 0.9 \frac{f_u}{\gamma_{m1}} A_n$$

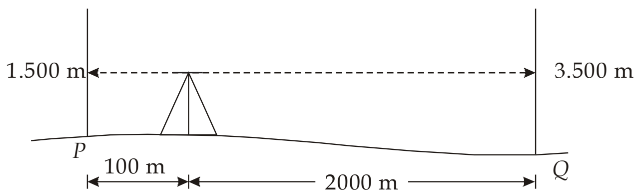
$$= 0.9 \times \frac{410}{1.25} \times \min.\left\{3160\,\text{mm}^2, 2845\,\text{mm}^2\right\}$$

$$= 0.9 \times \frac{410}{1.25} \times 2845 \times 10^{-3}\,\text{kN}$$

$$= 839.84 \simeq 840\ \text{kN}$$

Design tensile strength of the plate = 818.2 kN

105. **(c)**



Combined correction due to curvature and refraction = $0.0673(2)^2$ m

Correct reading on staff Q = $3.500 - 0.0673\ (2)^2$

= 3.2308 m

True difference = 3.2308 – 1.500

= 1.7308 m (fall from P to Q) or rise from Q to P.

106. **(d)**

Given: Fe 410 (E250) grade steel

$$f_y = 250\ \text{N/mm}^2, f_u = 410\ \text{N/mm}^2$$

Stress reduction factor

$$\chi = 0.852$$

Design compressive stress, $$f_{cd} = \chi \frac{f_y}{\gamma_{mo}} = 0.852 \times \frac{250}{1.1} = 193.64\ \text{N/mm}^2$$

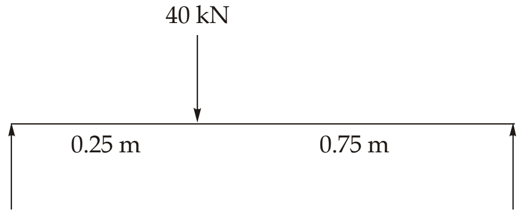
Design compressive strength:

$$P_d = f_{cd} \cdot A_e$$

$$= (193.64 \times 10466) \times 10^{-3}\ \text{kN}$$

$$= 2026.6\ \text{kN}$$

108. (b)



Collapse bending moment:

$$= \frac{P \cdot a \cdot b}{L}$$

$$= \frac{40 \times 0.25 \times 0.75}{1} = 7.5 \text{ kNm}$$

Equating plastic moment of resistance to collapse moment

$$M_p = f_y \cdot Z_p$$

$$\Rightarrow \quad 7.5 \times 10^6 = f_y \times \frac{50 \times (50)^2}{4}$$

$$\Rightarrow \quad f_y = \frac{7.5 \times 10^6 \times 4}{50 \times (50)^2} = 240 \text{ N/mm}^2$$

109. (c)

Design speed at the site, $V_z = k_1 \cdot k_2 \cdot k_3 \cdot V_b$

$= 1.0 \times 0.9 \times 1.0 \times 47 = 42.3$ m/s

Design wind pressure, $P_z = 0.6\, V_z^2$

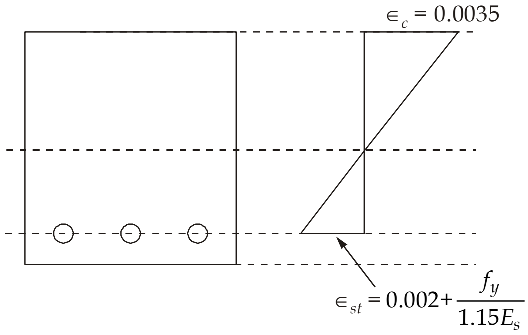
$= 0.6 \times (42.3)^2$

$= 1073.574$ N/m²

$\simeq 1074$ N/m²

110. (d)

Strain diagram as per IS 456 : 2000 is shown below.



111. (c)

$$BM_u = 185 \text{ kNm}$$

For Fe415, $BM_{u,\,\text{lim}} = 0.138 f_{ck} bd^2$

$$= 0.138 \times 20 \times 300 \times (675)^2 \text{ N.mm}$$
$$= 377 \text{ kNm}$$

$\therefore \quad BM_u < BM_{u,\,lim} \quad (\because$ Section is under-reinforced)

$\therefore \quad BM_u = 0.87 f_y A_{st} \times$ lever arm

$$\Rightarrow \quad A_{st} = \frac{185 \times 10^6}{0.87 \times 415 \times 540} = 948.87 \text{ mm}^2 \simeq 950 \text{ mm}^2$$

112. (a)

Spacing of main steel $\not>$ 3d or 300 mm.

Spacing of secondary steel $\not>$ 5d or 450 mm

113. (c)

$$f_s = 0.58 f_y \frac{(A_{st})_{req.}}{(A_{st})_{provided}} = 0.58 \times 500 \times \frac{1.25}{1.6}$$
$$= 226.56 \text{ N/mm}^2 \simeq 227 \text{ N/mm}^2$$

114. (a)

Refer IS 456 : 2000, Clause B- 5.2.2.

115. (a)

Since, column is axially loaded,

$$P_u = 1.5 \times 1200 = 1800 \text{ kN}$$
$$P_u = 0.4 f_{ck} \cdot A_c + 0.67 f_y A_{sc}$$
$$\Rightarrow \quad 1800 \times 10^3 = (0.4 \times 20 \times 0.99 A_g) + (0.67 \times 415 \times 0.01 Ag)$$

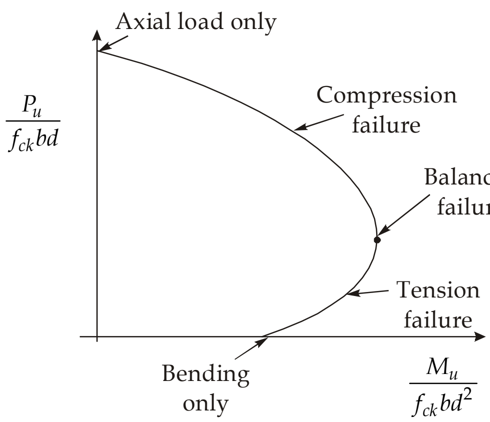
$[A_c = A_g - A_{sc}]$

After solving we get

$$A_g = 168216.44 \text{ mm}^2 = B^2$$
$$\therefore \quad B = 410.14 \text{ mm}$$

$\therefore$ Provide square column of size 420 mm × 420 mm.

116. (d)



117. (b)

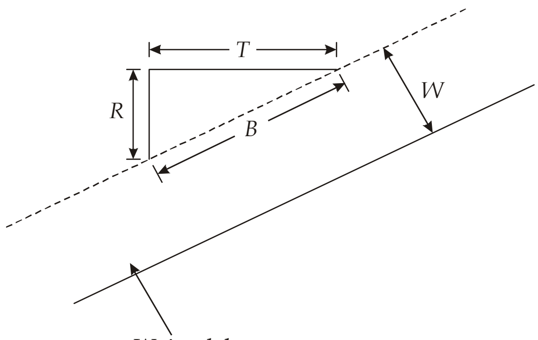
The base isolation of structure will introduce the flexibility (reduction in the stiffness) to the structure thereby increasing the natural period of the structure.

118. (a)

As per Cl. 10.2 (c)(2) of IS 3370 : 2009

It should not slump unduly in hot weather, or become brittle in cold weather.

119. (a)



Given:

$$G = T = 250 \text{ mm}$$
$$R = 150 \text{ mm}$$
$$\gamma_c = 25 \text{ kN/m}^3$$

Weight of each step (without waist) per m,

$$= \frac{\left(\frac{RT}{2}\right)\gamma_c}{G}$$

$$= \frac{\frac{1}{2} \times 0.15 \times 0.25 \times 25}{0.25}$$

$= 1.875$ kN/m per m width of staircase.

120. (b)

As per Clause 40.5.1 of IS 456 : 2000.

Shear failure at sections of beams and cantilevers without shear reinforcement will normally occur on plane inclined at 30°, to the horizontal.

121. (a)

$$\text{Development length, } L_d = \frac{\phi \sigma_{st}}{4\tau_{bd}}$$

$$= \frac{(0.87 f_y)\phi}{4 \times (1.2 \times 1.6)} = 47\,\phi$$

122. (d)

Refer IS 456 : 2000, Clause 26.2.3.

123. (c)

Upward uniformly distributed pressure provided by the cable,

$$w_p = \frac{8Ph}{l^2} = \frac{8 \times 1000 \times 0.1}{6^2} = 22.22 \text{ kN/m}$$

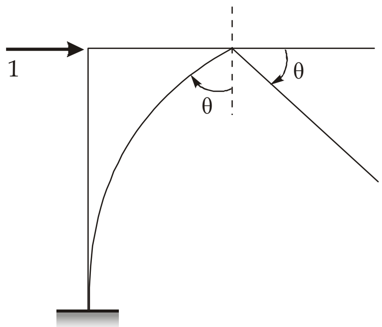
∴ Net downward load on the beam

$$= 35 - 22.22 = 12.78 \text{ kN/m}$$

124. (a)

- If the profile of the cable is properly selected which is called concordant cable profile, the profile does not produce reactions at the supports or secondary moments in the spans.
- Concordant cable profile is not unique for all types of loading and support conditions but depends upon the degree of indeterminacy of the structure, thus profile satisfies a set of geometrical conditions and located in a narrow zone.
- A concordant profile can be developed from the moment diagram due to external loads.
- A tendon profile in which the eccentricity is proportional at all cross-sections to the bending moment caused by any loading on a rigidly supported statically indeterminate structure.

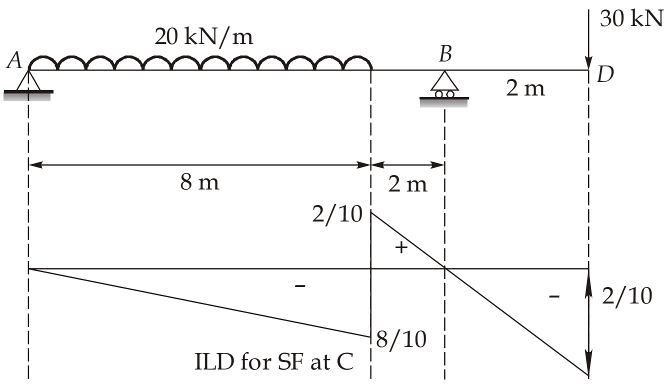
125. (c)



Deflection in co-ordinate direction '2' when unit force is given in co-ordinate direction '1'.

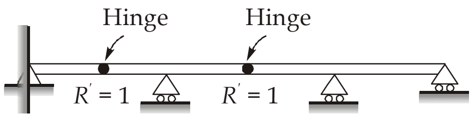
$$\therefore \quad f_{21} = \frac{L^2}{2EI} = \frac{(12)^2}{2(4EI)} = \frac{18}{EI}$$

126. (b)



Now, $$SF_{at\ c} = 20\left(\frac{1}{2}\times 8\times\left(\frac{-8}{10}\right)+30\left(\frac{-2}{10}\right)\right)$$
$$= -64 - 6 = -70 \text{ kN}$$

127. (a)



D_s = Number of support reactions removed to make it cantilever R'
$= 3 - (1 + 1 + 1) = 0$

128. (b)

Applying equilibrium equation at joint C,

$$\Sigma F_x = 0$$

$\Rightarrow$ $$F_{CD} = 25 \text{ kN (C)},$$

Remaining FC, DG and GH are zero force member.

129. (b)

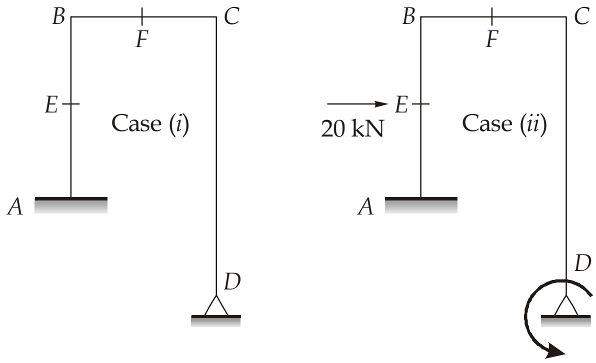
$$M_{BC} = M_{FBC} + \frac{2EI}{L}\left(2\theta_B + \theta_C - \frac{3\Delta}{L}\right)$$
$$= \frac{-4\times 6^2}{12} + \frac{2\times 4EI}{6}(2\theta_B + \theta_C)$$
$$= -12 + \frac{8}{3}EI\theta_B + \frac{4}{3}EI\theta_C$$

130. (a)

A	B	B	C
	4/7	3/7	
–75	+75	–45	+15
+75 →	+37.5	–7.5	← –15
0	112.5	–52.5	0
	–34.29	–25.71	0
0	78.21	–78.21	0

From above, moment at B is, 78.21 kNm.

131. (a)



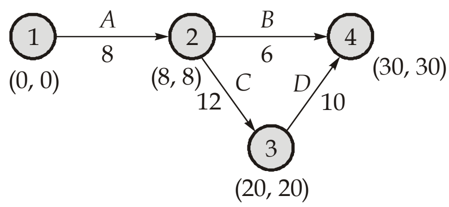
Using Betti's law

$$40 \times \Delta_F = 20 \times 2 \times 10^{-3} - 1.6 \times 0.1$$

$\Rightarrow$ $\Delta_F = -3$ mm i.e. 3 mm upwards.

132. (a)

Activity	Expected time (days)	Std. deviation (σ) (days)
A	8	2
B	6	1
C	12	2
D	10	1



Critical path : 1 – 2 – 3 – 4

$$(t_E)_{\text{Project}} = 8 + 12 + 10 = 30 \text{ days}$$

$$(\sigma)_{\text{Project}} = \sqrt{\sigma_A^2 + \sigma_C^2 + \sigma_D^2} = \sqrt{2^2 + 2^2 + 1^2}$$

$$\sigma_{\text{Project}} = \sqrt{9} = 3$$

$$\text{Proportional variation} = \frac{\sigma_{\text{Project}}}{(t_E)_{\text{Project}}} = \frac{3}{30} = 0.1$$

134. (c)

$$C_i = \text{Rs. } 16000$$

$$C_s = \text{Rs. } 1000$$

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

$$C_i - C_s = 15000$$

$$D_m = (C_i - C_s) \times D_f$$

Year	Order number	DF (depreciation factor)	Depreciation	Book value
1	5	5/15	5000	16000 – 5000 = 11000
2	4	4/15	4000	11000 – 4000 = 7000
3	3	3/15	3000	7000 – 3000 = 4000
4	2	2/15	2000	4000 – 2000 = 2000
5	1	1/15	1000	2000 – 1000 = 1000

Book value after 2 years = 7000

135. (d)

Maximum possible rimpull = $0.6 \times 15t$

$= 9t = 9000$ kg

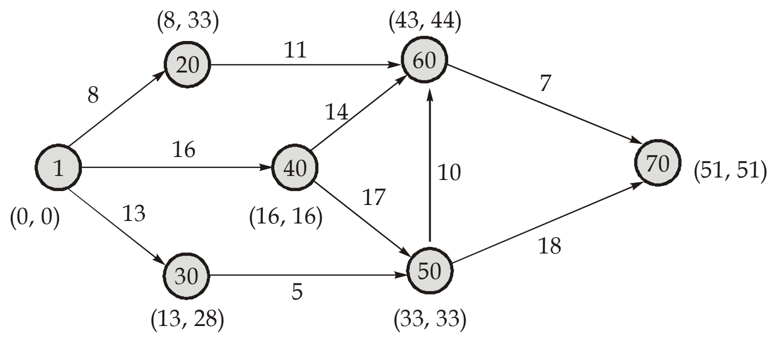
Rolling resistance = $50 \times 30 = 1500$ kg

Pull required for 1% slope for 30t = 10 kg/t × 30t = 300 kg

Rimpull available to negotiate the slope = 9000 – 1500 = 7500 kg

$$\text{Maximum slope} = \frac{7500}{300} = 25\%$$

136. (b)



∴ LFT of activity 40 – 60 = 44 days

LST of activity 40 – 60 = 44 – 14 = 30 days

137. (d)

Type of Cement	Specific Surface Not Less than cm^2/g
Ordinary Portland Cement (OPC)	2250
Rapid Hardening Cement (RHC)	3250
Low Heat Cement (LHC)	3200
Portland Puzzolana Cement (PPC)	3000
High Alumina Cement (HAC)	2250
Super Sulphate Cement (SSC)	4000

138. **(d)**

$$C_p \times i \times 1 = \text{Net income} \qquad \text{where, } c = \text{capitalised value}$$

$$\Rightarrow \quad C \times \frac{5}{100} \times 1 = 1 \text{ lakh}$$

$$\Rightarrow \quad C = \frac{100}{5} \times 1 = 20 \text{ lakhs} = \text{Rs. } 20{,}00{,} 000$$

139. **(c)**

Line of balance (LOB) diagram is used for repetitive mass projects in construction and manufacture industries such as mass-housing, high rise buildings, tunnels, pipelines etc. It demonstrates, the inter-relationships and caters for buffers between the activities. There is no buffering in network techniques like PERT, CPM, GERT etc.

140. **(b)**

At temperature more than 27°C, density of suspension comes out to be little lesser than actual.

142 **(a)**

A septic tank may be defined as a PST with a longer detention period (12 to 36 hours) along with digestion of the settled sludge carried out by anaerobic decomposition process.

145. **(d)**

A hinge support in a real beam remains as a hinged support in a conjugate beam.

146. **(c)**

Decrement in proportion of C_3A and C_3S will reduce amount of heat to be released during hydration. Increment in C_2S is to compensate lost strength on account of reducing C_3S.

147. **(d)**

During summer at mid-day, critical stress combination at the edge of the slab is wheel load stress + temperature warping stress – subgrade resistant stress.

148. **(c)**

Mixed cropping means sowing together of two and more crops in the same field and hence, decreasing the overall crop yield.

149. **(d)**

In practice the actual length of the weld is made of the effective length plus two times the weld size, but not less than four times the size of the weld.

150. **(d)**

In the case of stiffened suspension bridges, the stiffening girders may also be subjected to internal forces on account of the thermal changes.

■■■■