DETAILED SOLUTIONS

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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 20

Full Syllabus Test 4 : Paper-II

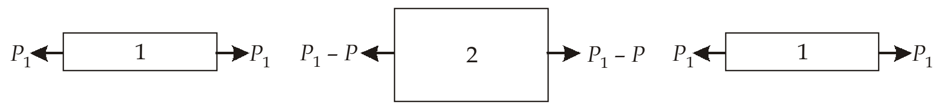
1.	(d)	23.	(a)	45.	(d)	67.	(b)	89.	(a)	111.	(c)	133.	(b)
2.	(a)	24.	(c)	46.	(c)*	68.	(b)	90.	(c)	112.	(b)	134.	(c)
3.	(b)	25.	(b)	47.	(d)	69.	(b)	91.	(a)	113.	(d)	135.	(c)
4.	(a)	26.	(d)	48.	(d)	70.	(b)	92.	(a)	114.	(b)	136.	(d)
5.	(a)	27.	(d)	49.	(a)	71.	(a)	93.	(a)	115.	(b)	137.	(a)
6.	(d)	28.	(a)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

** Answer key & explanation has been updated of question no. 46*

** Marks to all for question no. 42*

DETAILED EXPLANATIONS

1. (d)



$\because$ Total elongation of bar = 0

$$\Rightarrow \quad \frac{P_1 a}{A_1 E} + \frac{(P_1 - P)b}{A_2 E} + \frac{P_1 a}{A_1 E} = 0$$

$$\Rightarrow \quad \frac{P_1(2a)}{A_1} + \frac{P_1 b}{A_2} - \frac{Pb}{A_2} = 0$$

$$\Rightarrow \quad \frac{P_1}{400} + \frac{P_1}{600} - \frac{24}{600} = 0$$

$$\Rightarrow \quad P_1 = \frac{2}{5} \times 24 = \frac{48}{5}$$

$$\therefore \quad \sigma_2 = \frac{(P_1 - P)}{A_2}$$

$$= \frac{\left(\frac{48}{5} - 24\right)\text{kN}}{600\ \text{mm}^2} = -24\ \text{MPa}$$

2. (a)

$$\frac{\sigma_{core}}{\sigma_{metal}} = \frac{E_{core}}{E_{metal}} = \frac{9}{80} > \frac{\sigma_{perm,core}}{\sigma_{perm,metal}}\left(= \frac{5}{60}\right)$$

Hence concrete core is vulnerable.

$$\therefore \quad \frac{P_{core}}{P_{metal}} = \frac{A_{core}E_{core}}{A_{metal}E_{metal}} = \frac{(200 \times 200) \times 9}{\left(250^2 - 200^2\right) \times 80} = \frac{1}{5}$$

$$\therefore \quad P = P_{\text{core}} + P_{\text{metal}}$$

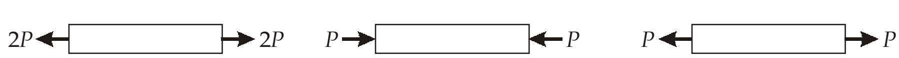
$$= \sigma_{\text{core}} \cdot A_{\text{core}} + \sigma_{\text{metal}} \cdot A_{\text{metal}}$$

$$= \sigma_{\text{core}}(200 \times 200) + \frac{80}{9}\sigma_{core}\left(250^2 - 200^2\right)$$

$$= 5(200 \times 200) + \frac{80}{9}(5)\left(250^2 - 200^2\right)$$

$$= 1200\ \text{kN}$$

3. (b)



$$U = \frac{(2P)^2\left(\frac{L}{3}\right)}{2AE} + \frac{P^2\left(\frac{L}{3}\right)}{2AE} + \frac{P^2\left(\frac{L}{3}\right)}{2AE}$$

$$= \frac{P^2L}{AE}$$

4. (a)

$$\sigma = \frac{P}{A} = \frac{85 \times 1000}{\frac{\pi}{4} \times 30^2} = 120.25 \text{ MPa}$$

$$\varepsilon = \frac{\sigma}{E} = \frac{120.25}{70 \times 10^3}$$

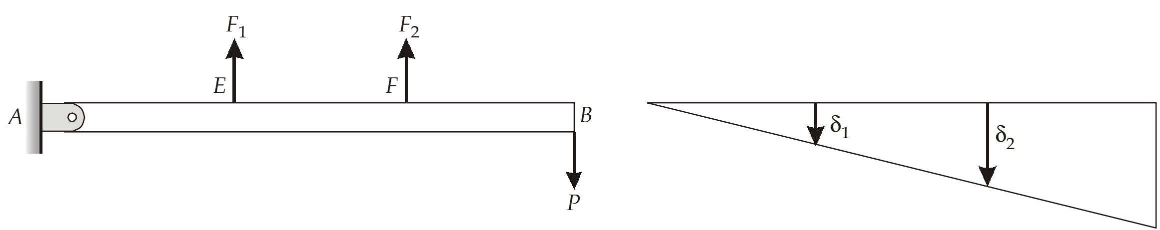
$$\Delta V = V_0 \varepsilon (1 - 2\mu)$$

$$= \frac{\pi}{4} \times 30^2 \times 3000 \times \frac{120.25}{70 \times 1000}\left(1 - 2 \times \frac{1}{3}\right)$$

$$= 1214.3 \text{ mm}^3$$

$$\simeq 1215 \text{ mm}^3$$

5. (a)



$$\Sigma M_A = 0$$

$\Rightarrow$ $$F_1 \times b + F_2 \times 2b = P \times 3b$$

$\Rightarrow$ $$F_1 + 2F_2 = 3P \quad \text{...(i)}$$

Also, $$\delta_2 = 2\delta_1$$

$\Rightarrow$ $$F_2 = 2F_1 \quad \text{...(ii)}$$

From (i) and (ii)

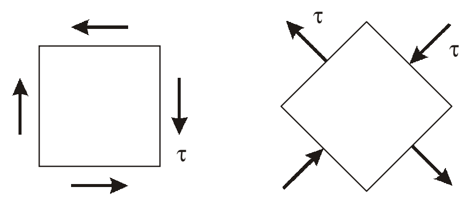
$$F_1 = \frac{3P}{5}, \quad F_2 = \frac{6P}{5}$$

$\therefore$ $$\sigma_2 = \frac{F_2}{A} = \frac{6 \times P}{5A} = \frac{6 \times 5 \times 1000}{5 \times 100} = 60 \text{ MPa}$$

6. (d)

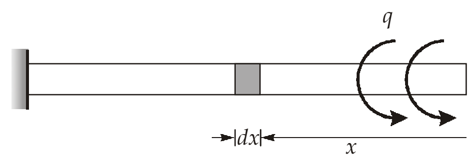
$$\tau_{max} = \frac{Tr}{J}$$

$$= \frac{12 \times 10^6 \times 50}{\frac{\pi}{32} \times \left[100^4 - 80^4\right]} = 103.5 \text{ MPa} \simeq 104 \text{ MPa (say)}$$



Max tensile stress = 104 MPa

7. (c)



$\because$ q = Torque of constant intensity per unit length

$$T_x = qx$$

$\therefore$

$$U = \int_0^L \frac{T_x^2 dx}{2GI_P} = \frac{1}{2GI_P}\int_0^L (qx)^2\, dx$$

$$= \frac{q^2L^3}{6GI_P}$$

8. (d)

For cantilever section BC,

$$\delta_{BC} = \frac{qb^4}{8EI}$$

Using superposition,

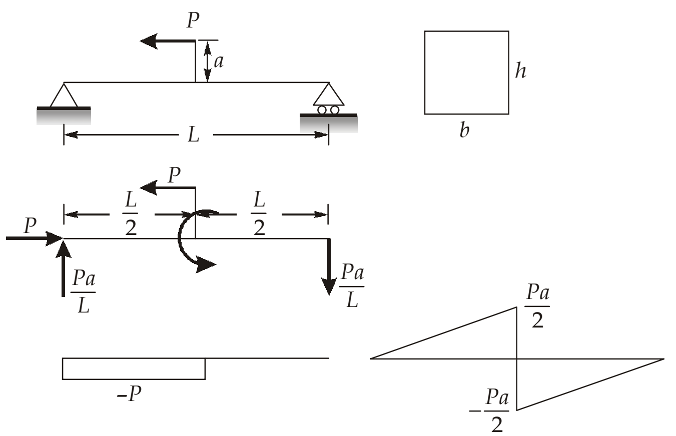
$$\delta = \frac{qb^4}{8EI} + \frac{2\left(\frac{P}{3}\right)b^3}{3EI}$$

$$= \frac{qb^4}{8EI} + \frac{2Pb^3}{9EI}$$

9. (c)

Elements below the neutral axis will experience flexural tension in case of sagging. Shear stresses are zero at extreme fibres with finite value in between.

10. (a)



Axial thrust diagram

Bending moment diagram

$$\sigma_{compressive} = \frac{P}{A} + \frac{M}{Z} = \frac{P}{bh} + \frac{\left(\frac{Pa}{2}\right)}{\left(\frac{bh^2}{6}\right)}$$

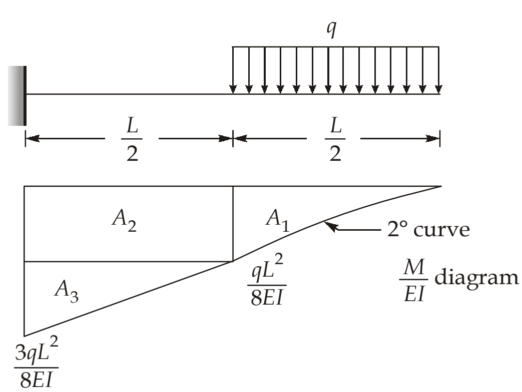
$$= \frac{P}{bh} + \frac{3Pa}{bh^2} \qquad (b = 250 \text{ mm}; h = 250 \text{ mm})$$

$$= \frac{100 \times 1000}{250 \times 250} + \frac{3 \times 100 \times 1000 \times 250}{250 \times 250 \times 250}$$

$$= 1.6 + 4.8$$

$$= 6.4 \text{ MPa}$$

11. (c)



$$\theta = \frac{qL^2}{8EI} \times \frac{1}{3} \times \frac{L}{2} + \frac{qL^2}{8EI} \times \frac{L}{2} + \frac{1}{2} \times \frac{L}{2} \times \frac{qL^2}{4EI}$$

$$= \frac{7qL^3}{48EI}$$

12. (b)

$$k = \frac{CD^4}{64R^3 n}$$

$$k_2 = \frac{CD^4}{64R^3 (n/2)}$$

$$= 2k$$

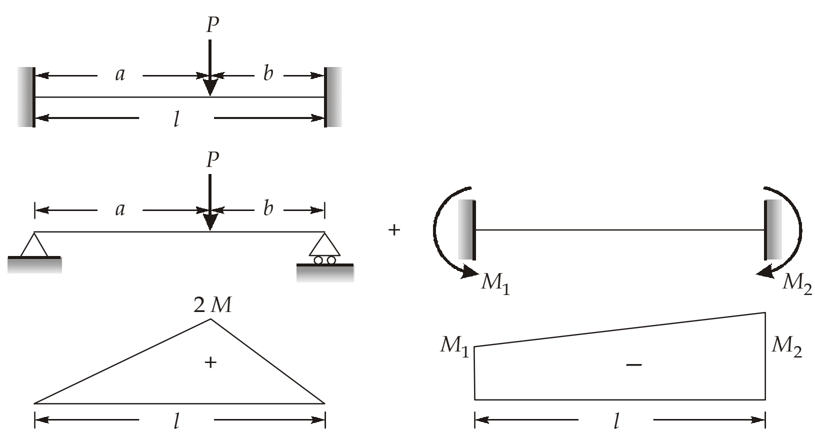
13. (d)

The bending stress is zero at neutral axis.

The bending stress in the rectangular beam section varies linearly.

When a cantilever is loaded vertically downwards at its free end, max compressive stress will develop at bottom fibre.

14. (c)



As the slope at the ends of fixed beam is zero. So, the area of total B.M.D. (fixed end moment + moment) will be zero.

$$\Rightarrow \quad \frac{M_1 + M_2}{2} \cdot l - \frac{1}{2} \cdot 2M \cdot l = 0$$

$$\Rightarrow \quad M_1 + M_2 = 2M$$

15. (c)

Displacement method of analysis is quite suitable for computer programming.

16. (b)

Using slope-deflection method,

$$M_{BC} = \frac{4EI}{L}(2\theta_B + \theta_C)$$

$$M_{BA} = \frac{2EI}{L}(2\theta_B + \theta_A)$$

$$M_{CB} = 0 = \frac{4EI}{L}(2\theta_C + \theta_B)$$

$$\Rightarrow \quad 2\theta_C + \theta_B = 0$$

$$\Rightarrow \quad \theta_C = -\frac{\theta_B}{2}$$

$$\Rightarrow \quad \theta_A = -\frac{\theta_B}{2}$$

$$M_{AB} = 0 = \frac{2EI}{L}(2\theta_A + \theta_B)$$

$$\Sigma M_B = M$$

At joint B, joint equillibrium condition,

$$\Rightarrow \quad M_{BC} + M_{BA} = M$$

$$\frac{2EI}{L}\left(6\theta_B + 2\theta_C + \theta_A\right) = M$$

$$\Rightarrow \quad 6\theta_B - \theta_B - \frac{\theta_B}{2} = \frac{ML}{2EI}$$

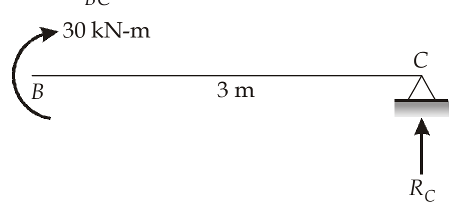
$$\Rightarrow \quad \theta_B = \frac{ML}{9EI}$$

So, $$\theta_C = \frac{-\theta_B}{2} = -\frac{ML}{18EI}$$

17. (b)

Joint	Member	k	D.F
B	BC	$\frac{3EI}{3} = EI$	0.5
	BA	$\frac{4EI}{4} = EI$	0.5

So, $$M_{BC} = 0.5 \times 60 = 30 \text{ kN-m}$$



$$\Sigma M_B = 0$$

$$\Rightarrow \quad R_C \times 3 = 30$$

$$\Rightarrow \quad R_C = 10 \text{ kN}$$

18. (b)

$$\text{KDI} = 3j - r_e - m + r_r$$

Number of joints = 11

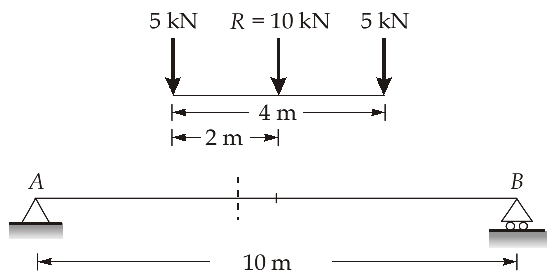
Number of external reactions (r_e) = 3 + 2 + 3 + 2 = 10

Number of members = 11

Number of redundant reactions = 2 + 2 = 4

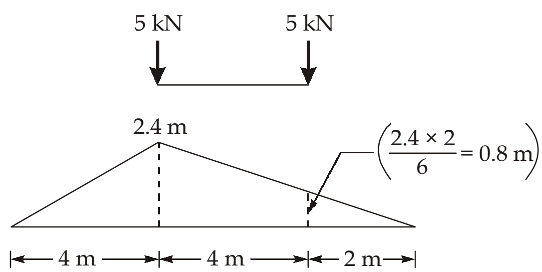
$$\text{KDI} = 3 \times 11 - 10 - 11 + 4$$
$$= 12 + 4$$
$$= 16$$

19. (b)



For maximum bending moment,

$$\text{Ordinate of ILD} = \frac{(5-1)\times(5+1)}{10} = 2.4 \text{ m}$$

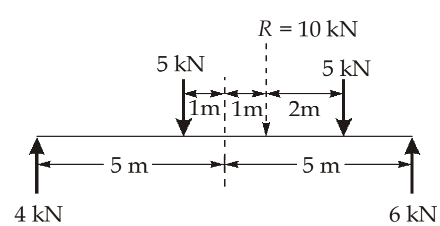


So, maximum bending moment $= 2.4 \times 5 + 0.8 \times 5$

$= 16$ kN-m

$$\therefore \quad \sigma_{max} = \frac{M}{Z} = \frac{16 \times 10^6}{16 \times 10^3} = 1000 \text{ MPa} = 1 \text{ GPa}$$

Alternatively,



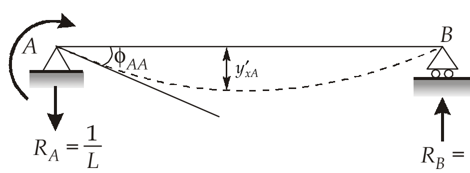
M_{max} = BM under left 5 kN load

$= 4(5 - 1)$

$= 16$ kNm

20. (d)

To draw ILD for moment at '*A*' replace the fixed joint by hinge joint



$$M_A = \frac{y'_{xA}}{\phi_{AA}}$$

y'_{xA} = Vertical deflection at x due to unit couple at A

ϕ_{AA} = Slope at A due to unit couple at A

$\because$ $$EI\frac{d^2y}{dx^2} = -M_x = -R_B x = -\frac{x}{L}$$

$$EI\cdot\frac{dy}{dx} = \frac{-x^2}{2L} + c_1$$

$$EI(y) = \frac{-x^3}{6L} + c_1 x + c_2$$

At $x = 0$, $y = 0$

$\Rightarrow$ $$c_2 = 0$$

At $x = L$, $y = 0$

$\Rightarrow$ $$0 = \frac{-L^2}{6} + c_1 L$$

$\Rightarrow$ $$c_1 = \frac{L}{6}$$

$\Rightarrow$ $$EI(y) = \frac{-x^3}{6L} + \frac{Lx}{6}$$

$\Rightarrow$ $$y'_{xA} = \frac{1}{EI}\left(-\frac{x^3}{6L} + \frac{Lx}{6}\right)$$

At $x = L$

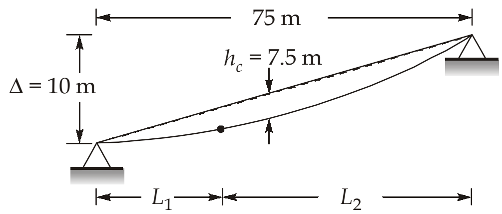
$$\phi_{AA} = \frac{1}{EI}\left(-\frac{L^2}{2L} + \frac{L}{6}\right) = -\frac{L}{3}\cdot\frac{1}{EI}$$

$$M_A = \frac{-\frac{x^3}{6L} + \frac{Lx}{6}}{-\frac{L}{3}} = \frac{x^3}{6L}\times\frac{3}{L} - \frac{Lx}{6}\times\frac{3}{L}$$

$$= \frac{1}{2}\left[\frac{x^3}{L^2} - x\right]$$

$$M_A = \frac{1}{2}\left[\frac{x^3}{L^2} - x\right]$$

21. (b)

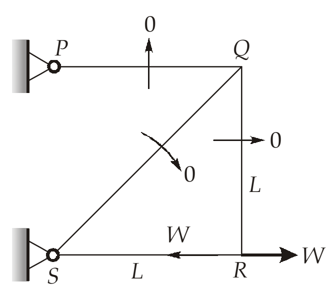


Let the lowest point is at L_1 distance from left end,

$$L_1 = L\left[\frac{1}{2} - \frac{\Delta}{8h_c}\right]$$

$$= 75\left[\frac{1}{2} - \frac{10}{8 \times 7.5}\right] = 25 \text{ m}$$

22. (d)



So, force in member PQ, QR, SQ is zero
Force in member SR is W (Tensile)

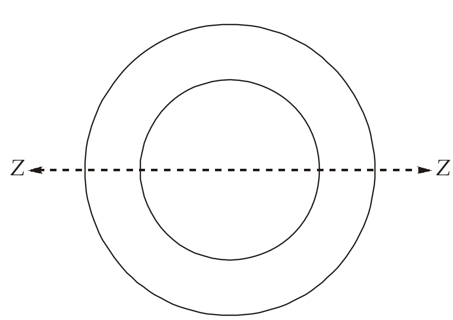
24. (c)

k_1 = Factor depends on probability factor or risk coefficient.
k_2 = Depends upon terrain, height and structure size.
k_3 = Topography factor.
k_4 = Importance factor in cyclonic region.

25. (b)

Compact section have capacity to develop plastic moment of resistance, but have inadequate plastic hinge rotation capacity for formation of plastic mechanism before buckling.

27. (d)



Moment of inertia about *zz*-axis

$$I_Z = \frac{\pi}{64}\left(D^4 - d^4\right)$$

Elastic section modulus

$$Ze_z = \frac{\pi}{64}\frac{\left(D^4 - d^4\right)}{D/2} = \frac{\pi}{32}\frac{D^4 - d^4}{D}$$

$$\text{Plastic section modulus } Zp_z = \frac{A}{2}(\bar{y}_1 + \bar{y}_2)$$

$$A = \frac{\pi}{4}\left(D^2 - d^2\right)$$

$$\bar{y}_1 = \bar{y}_2 = \frac{14}{9\pi}$$

$$Zp_z = \frac{\pi}{8}\left(D^2 - d^2\right)\times\frac{14}{9\pi}\times 2$$

So,

$$\text{Shape factor} = \frac{Z_{p_z}}{Ze_z} = \frac{\frac{\pi}{8}\left(D^2 - d^2\right)\times\frac{28}{9\pi}}{\frac{\pi}{32}\frac{D^4 - d^4}{D}}$$

$$= \frac{4\times 28D}{9\pi\left(D^2 + d^2\right)}$$

$$= \frac{4\times 28\times 2}{9\pi\times[4+1]} = 1.58$$

28. (a)

For same strength, lesser number of bolts are required as compared to ordinary bolts.

29. (a)

$$V_{dsb} = 2A_{nb}\times\frac{f_{ub}}{\sqrt{3}\times\gamma_{mb}}\times\beta_{pkg}$$

If thickness of packing plate is more than 6 mm, the shear strength of the joint will have to be reduced by the use of coefficient as

$$\beta_{pkg} = 1 - 0.0125\, t_{pkg} = 1 - 0.0125 \times 8 = 0.9$$

$$V_{dsb} = 2\times\frac{\pi}{4}(20)^2\times 0.78\times\frac{400}{\sqrt{3}\times 1.25}\times 0.9\times 10^{-3}\ \text{kN}$$

$$= 81.49 \text{ kN}$$

30. (b)

Rebound-Hammer method is used for calculating strength of concrete.

31. (a)

Block shear strength will be minimum of T_{db_1} and T_{db_2}

$$T_{db_1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m_0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m_1}}$$

$$= \left(\frac{1100\sqrt{3} \times 250}{\sqrt{3} \times 1.1} + \frac{0.9 \times 200 \times 410}{1.25} \right) \times 10^{-3}$$

$$= 309.04 \text{ kN}$$

$$T_{db_2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m_1}} + \frac{A_{tg} f_y}{\gamma_{m_0}}$$

$$= \left(\frac{0.9 \times 1000\sqrt{3} \times 410}{\sqrt{3} \times 1.25} + \frac{220 \times 250}{1.1} \right) \times 10^{-3}$$

$$= 345.2 \text{ kN}$$

So, block shear strength $= 309.04$ kN

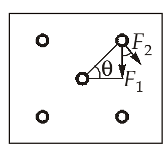
32. (c)

Web bearing strength $= \left[b + 2.5\left(t_f + R\right) \right] t_w \times \dfrac{f_y}{\gamma_{m_0}}$

$$= \left[75 + 2.5(20 + 10) \right] \times \frac{8.8 \times 250}{1.1} \text{N}$$

$$= 300 \text{ kN}$$

33. (c)



$$F_1 = \frac{P}{n} = \frac{10}{5} = 2 \text{ kN}$$

$$F_2 = \frac{P.e.r}{\Sigma r^2} = \frac{10 \times 0.5 \times \left(\sqrt{100^2 + 75^2}\right) \times 10^3}{4 \times \left(\sqrt{100^2 + 75^2}\right)^2} = 10 \text{ kN}$$

$$\cos\theta = \frac{100}{125} = \frac{4}{5}$$

So,

$$F_R = \sqrt{F_1^2 + F_2^2 + 2F_1 F_2 \cos\theta}$$

$$= \sqrt{2^2 + 10^2 + 2 \times 2 \times 10 \times \frac{4}{5}}$$

$$= 11.66 \text{ kN}$$

34. (c)

When no access is provided.

For $\theta \le 10°$ live load = 0.75 kN/m^2 of plan area

For $\theta > 10°$

Live load is reduced by 0.02 kN/m^2 for every degree increase in slope over 10°.

So,
$$\text{Live load} = 0.75 - 0.02[16 - 10] = 0.63 \text{ kN/m}^2$$

36. (d)

The zone between the end of the beams and the section where only longitudinal stresses exist is called anchorage zone. Stress direction due to P-force becomes parallel to each other in longitudinal direction.

37. (b)

For a normal density concrete the splitting strength is about two-third of the modulus of rupture.

38. (b)

For M30 concrete,

$$\text{Modulus of rupture, } f_{cr} = 0.7\sqrt{30} = 3.83 \text{ MPa}$$

$$\text{Section modulus, } z = \frac{bD^2}{6} = \frac{300 \times 600^2}{6} = 18 \times 10^6 \text{ mm}^3$$

$$\text{Cracking moment, } M_{cr} = f_{cr}Z = 3.83 \times 18 \times 10^6$$
$$= 68.94 \times 10^6$$
$$\simeq 69 \times 10^6 \text{ Nmm}$$
$$= 69 \text{ kNm}$$

39. (c)

Effective depth of a beam is defined as the distance between the centroid of the area of tension reinforcement and the maximum compression fibre.

$$k_b = \frac{280}{280 + 3\sigma_{st}}$$

40. (a)

Let the section is under-reinforced so that $f_{st} = 0.87\, f_y$

$\therefore$ $C = T$

$\Rightarrow$ $0.36 \times 25 \times 300 \times x_u = 0.87 \times 500 \times 4 \times \frac{\pi}{4} \times 20^2$

$\Rightarrow$ $x_u = 202.5$ mm

For Fe500, $x_{u,\lim} = 0.46d = 0.46 \times (600 - 50)$

$= 253$ mm $(> x_u)$ Thus section is under-reinforced

$\therefore$ Lever arm $= d - 0.42x_u$

$= 550 - 0.42 \times 202.5$

$$= 464.95 \text{ mm}$$
$$\simeq 465 \text{ mm}$$

41. (b)

As per **Clause 29.2** of **IS 456:2000**

For simply supported beam, $(LA) = 0.2(l + 2D) \quad \left(\text{For } 1.0 \le \frac{l}{D} < 2\right)$

$$= 0.2\,(7 + 2 \times 5)$$
$$= 3.4 \text{ m}$$

For cantilever beam, $(LA) = 0.2(l + 1.5D) \quad \left(\text{For } 1.0 \le \frac{l}{D} < 2.5\right)$

$$= 0.2\,(7 + 1.5 \times 5)$$
$$= 2.9 \text{ m}$$

42. (#)*

$$w = 300 \text{ mm}$$
$$\frac{l_0}{12} = \frac{2.8 \times 1000}{12} = 233.33 \text{ mm}$$

$\therefore$ For $W > \dfrac{l_0}{12}$

As per **Clause 22.2 b(3) of IS 456 : 2000,**

In the case of spans with roller or rocket bearings, the effective span shall always be the distance between the centres of bearings.

43. (c)

For one way shear stress, $\tau_v = \dfrac{V_u}{bd}$

Factored earth pressure acting on the footing $= \dfrac{400 \times 1000}{2500 \times 2500}$

$$= 0.064 \text{ N/mm}^2$$

Factored vertical shear force at critical section i.e. at 'd' distance away from face of column

$$= 0.064 \times 2500 \times \left[\left(\frac{2500 - 400}{2}\right) - 300\right]$$
$$= 120 \text{ kN}$$

$\therefore$ One-way shear stress, $\tau_v = \dfrac{120 \times 10^3}{2500 \times 300} = 0.16 \text{ N/mm}^2$

44. (c)

Ultimate load carrying capacity of helically reinforced column is given by,

$$P_u = 1.05(0.4 f_{ck} A_c + 0.67 f_y A_{sc})$$

$$= 1.05\left(0.4 \times 20 \times \left(\frac{\pi}{4} \times 300^2 - 1600\right) + 0.67 \times 415 \times 1600\right) \text{N}$$

$$= 1047.4 \text{ kN} \simeq 1047 \text{ kN (say)}$$

45. (d)

For post-tensioned beam,

$$\text{Shrinkage strain} = \frac{2 \times 10^{-4}}{\log(T+2)} = \frac{2 \times 10^{-4}}{\log_{10}(18+2)}$$

$$= \frac{2 \times 10^{-4}}{\log 20} = \frac{2 \times 10^{-4}}{\log 10 + \log 2}$$

$$= \frac{2 \times 10^{-4}}{1.3}$$

$\therefore$ Loss of stress in tendons $= E_s \times$ Shrinkage strain

$$= 2.1 \times 10^5 \times \frac{2 \times 10^{-4}}{1.3} = 32.30 \text{ N/mm}^2$$

46. (c)*

Equivalent lateral stiffness of columns,

$$k = \frac{12EI}{L^3} + \frac{12 \times EI}{L^3}$$

$$= \frac{24 \times 30 \times 10^{12}}{3000^3} = 26666.67 \text{ N/mm}$$

$$\text{Natural frequency, } w_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{26666.67}{\left(200 \times \frac{10^3}{9810}\right)}}$$

$$= 36.166 \text{ rad/sec}$$

$$\text{Natural time period, } T = \frac{2\pi}{w_n} = \frac{2\pi}{36.166}$$

$$= 0.173 \text{ sec}$$

49. (a)

Materials productivity is defined as the quantity of workdone per unit of materials.

i.e. $$\text{Material productivity} = \frac{\text{Work units achieved}}{\text{Materials quantity consumed}}$$

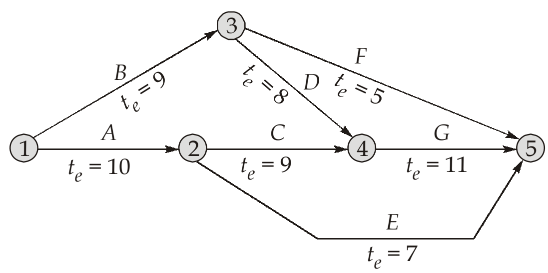
50. (b)

Backhoe can be used for excavation below the ground level (i.e. lower elevation).

52. (b)

$$\text{Project length} = 55 \text{ weeks}$$
$$\text{Variance} = 12 \text{ weeks}$$
$$\text{Standard deviation, } \sigma = \sqrt{12}$$
$$Z = \frac{T_s - T_e}{\sigma} = \frac{T_s - 55}{\sqrt{12}}$$
$$\Rightarrow \quad T_s = 55 + 1.35 \times \sqrt{12}$$
$$= 59.68 \text{ weeks}$$

53. (d)

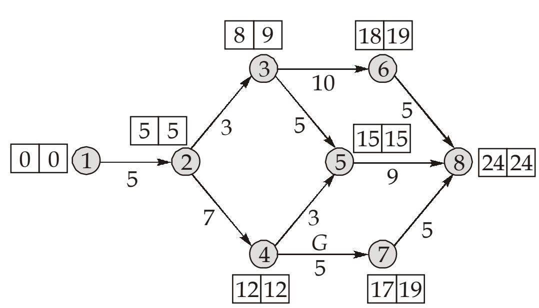


$$\text{Estimated time} = \frac{t_0 + 4t_m + t_p}{6}$$
$$\text{Standard deviation, } \sigma = \frac{t_p - t_0}{6}$$

The critical path is A – C – G or 1 – 2 – 4 – 5

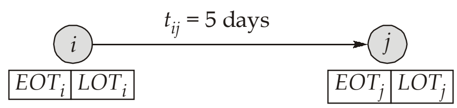
$$\text{Project duration} = 30 \text{ days}$$
$$\text{Standard deviation of project} = \sqrt{\sigma_A^2 + \sigma_C^2 + \sigma_G^2}$$
$$= \sqrt{\left(\frac{18-6}{6}\right)^2 + \left(\frac{22-4}{6}\right)^2 + \left(\frac{22-4}{6}\right)^2}$$
$$= \sqrt{2^2 + 3^2 + 3^2} = \sqrt{22} = 4.69$$

54. (a)



Total float of activity, E = 15 – 8 – 5 = 2 days

55. (d)



$$\text{Activity time } (t_{ij}) = 5 \text{ days}$$

$$\text{Free float} = 10 \text{ days} = \left[EOT_j - EOT_i\right] - t_{ij}$$

$$\Rightarrow \quad 10 = \left[EOT_j - EOT_i\right] - 5 \quad \text{...(i)}$$

$$\text{Total float} = 10 \text{ days}$$

$$\Rightarrow \quad = \left[LOT_j - EOT_i\right] - t_{ij}$$

$$\Rightarrow \quad 10 = \left[LOT_j - EOT_i\right] - 5 \quad \text{...(ii)}$$

From (i) and (ii),

$$EOT_j = LOT_j \quad \text{...(iii)}$$

Adding (i) and (ii) and putting $EOT_j = LOT_j$

$$LOT_j - EOT_i = 15 \quad \text{...(iv)}$$

By definition, $LOT_i = LOT_j - t_{ij}$ ...(v)

By (iv) and (v),

$$LOT_i - EOT_i = 10 \text{ days}$$

Maximum delay in the occurrence of the preceding event (i) = $LOT_i - EOT_i$

= 10 days

56. (a)

$$\text{Total working hours} = 48 \times 25 \times 100$$

$$= 120000 \text{ hours}$$

$$\text{Frequency of injury} = \frac{15}{120000} \times 100000 = 12.5$$

58. (a)

Sand does not increase the strength of mortar.

60. (a)

The advantage of slump test is that it grants the facility to easily detect the difference in water content of successive batches of concrete of the same identical mix.

61. (b)

The contraction and expansion of impreg timbers are about 25 to 40 percent less than ordinary timber.

63. (b)

In the event of breakage, glasses do not form the sharp edges which may cause cutting and piercing injuries to human.

64. (a)

Cold shortness occurs due to excessive phosphorus in steel.

66. (d)

When $CaCl_2$ added upto 2 percent by weight of cement acts as accelerator, but on increasing the proportion, it acts as retarder and leads to flash set. $CaCl_2$ and NaCl are very useful to permit concreting in very cold weather (–23°C).

$CaCl_2$ and NaCl reduce the setting time of concrete.

67. (b)

In plywood, the number of layers/veners are usually odd.

68. (b)

Dressing of stone in done immediately after quarrying and before seasoning.

69. (b)

$$\text{Force } (F) = L \times (\pi D) \times \frac{\mu v}{t}$$

L, D, μ and t are invariant

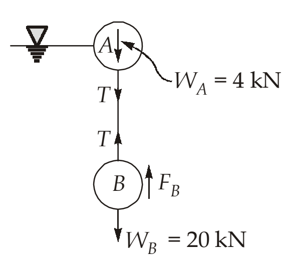
Hence,
$$\frac{F}{v} = \text{Constant}$$
$$\frac{F_1}{v_1} = \frac{F_2}{v_2}$$
$$\Rightarrow \quad F_2 = \frac{v_2}{v_1} \times F_1 = \frac{1.8}{1.5} \times 1250 = 1500 \text{ N}$$

70. (b)

Equating the pressure at both the limbs along horizontal plane x-x

$$P_M - \gamma_w(0.06 + 0.035) = P_N - \gamma_w(0.12 + 0.06) - \gamma_O(0.035)$$
$$\gamma_w = 9.81 \text{ kN/m}^3$$
$$\gamma_o = 0.83 \times 9.81 = 8.14 \text{ kN/m}^3$$
$$\therefore \quad P_M - P_N = 9.81 \times 0.095 - 9.81 \times 0.18 - 8.14 \times 0.035$$
$$= -1.12 \text{ kPa}$$

71. (a)



Volume of the sphere A and B,

$$V_A = V_B = V$$

$$= \frac{4}{3} \times \pi \times \left(\frac{1.5}{2}\right)^3$$

$$= 1.767 \text{ m}^3$$

or $$V = \frac{\pi}{6} d^3 = \frac{\pi}{6}(1.5)^3 = 1.767 \text{ m}^3$$

For lower sphere, buoyant force

$$F_b = 1.767 \times 9.81 = 17.33 \text{ kN}$$

$$\text{Tension, } T = W_B - F_b = 20 - 17.33 = 2.67 \text{ kN} \simeq 2.7 \text{ kN}$$

$$\text{Upper sphere, } F_b' = W_A + T = 4 + 2.7 = 6.7 \text{ kN}$$

If the sphere B is completely submerged then the buoyant force would have been $F_b = 1.767 \times 9.81 = 17.3$ kN

Since only 6.7 kN of buoyant force is being exerted

$$\% \text{ volume of sphere } B \text{ above water} = \frac{17.3 - 6.7}{17.3} \times 100 = 61.27\%$$

72. (c)

We know that critical time is given by

$$T_0 = \frac{2L}{C}$$

$$\Rightarrow \quad T_0 = \frac{2 \times 2000}{1000}$$

$$\Rightarrow \quad T_0 = 4 \text{ s.}$$

Actual time for valve closure, $T = 4$s.

We know that if $T \leq T_0$, then the closure is known as rapid closure or instantaneous closure. Therefore the peak water hammer pressure will be equal to the water hammer pressure head for instantaneous closure of the valve at the downstream end i.e. 60 m.

73. (b)

$$a_x = u \cdot \frac{\partial u}{\partial x} + v \cdot \frac{\partial u}{\partial y}$$

$$= (2x + 3y - 5)(2) + (5x - 2y - 9)(3)$$

$$= 4x + 6y - 10 + 15x - 6y - 27 = 19x - 37$$

$$a_y = u \cdot \frac{\partial v}{\partial x} + v \cdot \frac{\partial v}{\partial y}$$

$$= (2x + 3y - 5)(5) + (5x - 2y - 9)(-2)$$

$$= 10x + 15y - 25 - 10x + 4y + 18$$

$$= 19y - 7$$

$$\therefore \quad a = a_x\hat{i} + a_y\hat{j} = (19x - 37)\hat{i} + (19y - 7)\hat{j}$$

$$\therefore \quad a_{(1,1)} = (19 - 37)\hat{i} + (19 - 7)\hat{j}$$

$$= -18\hat{i} + 12\hat{j}$$

$$\therefore \quad |a| = \sqrt{18^2 + 12^2} = 21.63 \text{ m/s}^2$$

75. (d)

$$\because \quad \frac{V_m}{\sqrt{L_m}} = \frac{V_p}{\sqrt{L_p}}$$

$$\therefore \quad Q_r = A_r \cdot V_r$$

$$\Rightarrow \quad Q_r = (L_r)^{2.5}$$

$$\Rightarrow \quad \frac{8000}{0.2} = \left(\frac{4000}{L_m}\right)^{2.5}$$

$$\Rightarrow \quad L_m = 57.7 \text{ m}$$

76. (c)

The power curve shall not pass through the origin because certain amount of discharge is needed to produce power to overcome initial friction.

77. (d)

For prototype,

$$\text{Power, } P_p = \eta_0 \gamma_P Q_P H_P = 18500 \text{ kW}$$

$$\Rightarrow \quad Q_P = \frac{18500}{0.8 \times 9.81 \times 49} = 48.1 \text{ m}^3/\text{s}$$

$$\text{For a } \frac{1}{5} \text{ model, } \frac{D_m}{D_P} = \frac{1}{5}$$

$$\text{Head ratio, } \frac{H_m}{H_P} = \frac{25}{49}$$

$$\because \quad \frac{N_m D_m}{\sqrt{H_m}} = \frac{N_P D_P}{\sqrt{H_P}}$$

$$\Rightarrow \quad N_m = N_P\left(\frac{D_P}{D_m}\right)\sqrt{\frac{H_m}{H_P}}$$

$$= 250 \times \left(\frac{5}{1}\right)\sqrt{\frac{25}{49}}$$

$$= 892.9 \text{ rpm}$$

$$\text{Hence speed of model, } N_m = 892.9 \text{ rpm}$$

Discharge: $$\frac{Q_m}{N_m D_m^3} = \frac{Q_P}{N_P D_P^3}$$

$$\Rightarrow \quad Q_m = Q_P \left(\frac{D_m}{D_P}\right)^3 \left(\frac{N_m}{N_P}\right)$$

$$= 48.1 \times \left(\frac{1}{5}\right)^3 \left(\frac{892.9}{250}\right)$$

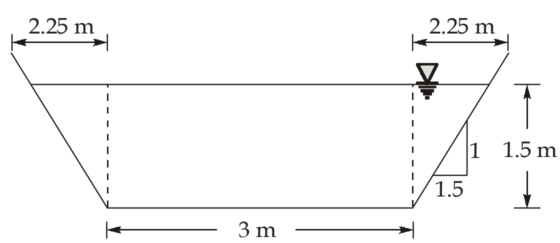
$$= 1.37 \text{ m}^3/\text{s}$$

78. (c)

Non-dimensional specific speed

$$N_S = \frac{N\sqrt{Q}}{(gH)^{3/4}} = \frac{100\sqrt{\frac{1.2}{60} \times 1000}}{(9.81 \times 25)^{3/4}} = 72.166$$

79. (b)



$$\because \quad F_r = \frac{V}{\sqrt{g\frac{A}{T}}}$$

$$\text{Top width, } T = 7.5 \text{ m}$$

$$\text{Flow area, } A = \frac{1}{2} \times (7.5 + 3) \times 1.5 = 7.875 \text{ m}^2$$

$$\therefore \quad V = \frac{Q}{A} = \frac{9}{7.875} = \frac{8}{7} \text{ m/s}$$

$$\therefore \quad F_r = \frac{8/7}{\sqrt{9.81 \times \left(\frac{7.875}{7.5}\right)}} = 0.36$$

80. (b)

Hydraulic jump occurs when super-critical flow ($y < y_c$) meets sub-critical flow ($y > y_c$).

82. (a)

We know that

$$\frac{C_u}{\sigma'_z} = 0.11 + 0.0037\, I_P\,\%$$

$$\sigma'_z = 4 \times 20 + 1(20 - 10)$$
$$= 90 \text{ kN/m}^2$$
$$I_P = 60 - 30 = 30\%$$
$$\therefore \quad \frac{C_u}{\sigma'_z} = 0.11 + 0.0037 \times 30$$
$$\Rightarrow \quad C_u = 0.221 \times 90 = 19.89 \text{ kN/m}^2 \simeq 19.9 \text{ kN/m}^2$$

84. (d)

$$C_u = \frac{D_{60}}{D_{10}} = \frac{0.22}{0.16} = 1.38$$
$$C_C = \frac{D_{30}^2}{D_{60}D_{10}} = \frac{0.19^2}{0.22 \times 0.16} = 1.03$$

85. (d)

Swellability of soils compacted on wet of optimum is low while it is high for soils compacted on dry of optimum.

86. (a)

$$I_D = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$
$$= \frac{0.91 - 0.5}{0.91 - 0.35} \times 100$$
$$= 73.21\% \simeq 73\%$$

87. (c)

Secondary consolidation continues much beyond primary consolidation and occurs at much slower rate.

88. (a)

$$Q = kH\frac{N_f}{N_D}$$
$$= 2 \times 10^{-3} \times 5 \times 100 \times \frac{3}{8} \times \frac{100}{1}$$
$$= 37.5 \text{ cm}^3/\text{s/m length of dam}$$

89. (a)

Mohr's envelope is unique for a given material and is independent of the stresses induced in the material while the Mohr's stress circle is directly related to the stresses imposed by the loading and is unrelated to the material strength.

90. (c)

The failure plane is always horizontal in the direct shear test.

91. (a)

The shear strength line is inclined at ϕ' to the σ axis.

92. (a)

- Zone I remains in a state of elastic equilibrium.
- Zone III is inclined at an angle $\left(45° - \frac{\phi}{2}\right)$ to the horizontal.

93. (a)

$$q_{nu} = CN_C \qquad (\because \text{ For } \phi = 0,\ N_\gamma = 0 \text{ and } N_q = 1)$$

$$\frac{D_f}{B} = \frac{1.5}{2} = 0.75 < 2.5$$

$$\therefore \quad N_C = 5\left(1 + \frac{0.2B}{L}\right)\left(1 + \frac{0.2D_f}{B}\right)$$

$$= 5 \times \left(1 + \frac{0.2 \times 2}{4}\right)(1 + 0.2 \times 0.75)$$

$$= 6.325$$

$$q_{nu} = 6.325 \times 15$$

$$= 94.875 \text{ kN/m}^2$$

$$\simeq 94 \text{ kN/m}^2$$

95. (b)

Declining balance method is used for calculating depreciation.

96. (c)

$$\text{Saturation population } P_s = \frac{2P_0P_1P_2 - P_1^2(P_0 + P_2)}{P_0P_2 - P_1^2}$$

In this question,

$$P_0 = 80000$$
$$P_1 = 160000$$
$$P_2 = 240000$$

$$P_s = \frac{2 \times 80000 \times 160000 \times 240000 - (160000)^2(80000 + 240000)}{80000 \times 240000 - (160000)^2}$$

$$= 320000$$

97. (c)

Aquifer : Porous as well as permeable. e.g. sand and gravel deposits.

Aquifuge : Geological formation, which is neither porous nor permeable. e.g. compact rock.

Aquiclude : Highly porous, containing large quantities of water, but essentially impervious. e.g. clay.

Aquitard : It is geological formation, which does not yield water freely to wells due to its lesser permeability, although seepage is possible through it. e.g. sandy clay deposit.

98. (c)

Enlarged end is called "Socket" or "Bell" and normal end is called "spigot".
This joint is somewhat flexible and allows pipes to be laid on flat curves without use of specials.

99. (b)

Total quantity of soft water required = 200000 litre
Total hardness to be removed = 400 – 50 = 350 ppm

Hence, $\frac{350}{400} \times 100 = 87.5\%$ of hardness has to be removed.

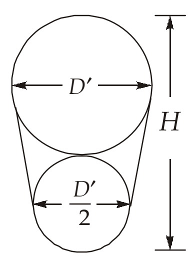
Now, assuming that part of total requirement will be softed to zero degree hardness and then raw water will be added to get the water of desired hardness (50 ppm), we can say that only 87.5% of the raw water needs to be softened to zero degree hardness and the balance 12.5% is added as raw water to obtain 50 ppm of hardness.

∴ Quantity of water to be treated = $2 \times 10^5 \times 0.875 = 1.75 \times 10^5$ litres

Amount of hardness removed = $1.75 \times 10^5 \times 400 = 70$ kg

Quantity of resin required = $\frac{70}{10} = 7$ cum

100. (a)



$$D = 1.54 \text{ meter}$$
$$D' = 0.84 \times D = 0.84 \times 1.54 = 1.2936 \text{ m}$$

So, height $= D' + \frac{D'}{2} = 1.5D'$

$= 1.5 \times 1.2936$

$= 1.94$ m

102. (c)

$$\text{BOD (mg}/l) = \frac{D_0 - D_S - (B_1 - B_2)(1-P)}{P}$$

[$B_1 - B_2 = 0.6$ mg/l, $P = \frac{20}{100} = 0.2$, $B_1 = D_0$ of seed water before incubation (mg/l), $B_2 = D_0$ of seed water after incubation]

$$= \frac{6.7 - 2 - (0.6)(1 - 0.2)}{0.2}$$

$$= 21.1 \text{ mg}/l$$

103. (c)

Suspended solids = 300 mg/l

Raw solids removed in sedimentation tank = 0.6 × 300 = 180 mg/l

Digested solids left after conversion part of raw sludge into liquid and gas in digestion tank = 0.6 × 180 = 108 mg/l.

Digested solids per million litre of water = 108 × 10^{-6} × 10^{6} = 108

Moisture content of digested sludge = 90%

∴ 10 kg of solids + 90 kg of water = 100 kg of sludge

∴ 108 kg of solids ≡ $\frac{90}{10} \times 108$ kg of water = 972 kg

So Volume of solids $= \frac{108}{G\rho} = \frac{108}{1.2 \times 10^3} = 0.09 \text{ m}^3$

Volume of water $= \frac{90}{10} \times \frac{108}{10^3} = 0.972 \text{ m}^3$

So, Volume of sludge = 0.09 + 0.972 = 1.062 m^3

104. (c)

BOD of sewage coming to aeration = 0.75 × 200

⇒ S_0 = 150 mg/l

Q = 180 × 35000 l/d = 6300 m^3/d

$$\frac{F}{M} = \frac{QS_0}{VX}$$

$$\Rightarrow \quad 0.35 = \frac{6300 \times 150}{V \times 2500}$$

$$\Rightarrow \quad V = 1080 \text{ m}^3$$

105. (a)

Electrical energy produced by 1200 MW power plant = 1200 MJ/s.

Since efficiency is 40%, so heat energy required to be produced to generate 1200 MJ/s of electric energy $= \frac{1200}{0.4} = 3000$ MJ/s.

Consumption of coal in producing 3000 MJ/s of heat energy $= \frac{3000}{30} = 100$ kg/s

$$\text{Sulphur content @ 3\%} = \frac{3}{100} \times 100 = 3 \text{ kg/s}$$

$$S + O_2 \rightarrow SO_2$$

$$32 \text{ gm of S} \equiv 64 \text{ gm of } SO_2$$

$$3 \text{ kg of S} \equiv 6 \text{ kg of } SO_2$$

$$\text{Hence, emission of } SO_2 = 6 \text{ kg/s}$$

106. (b)

Glaze is water drops which freeze to form ice when it comes in contact with cold ground and sleet is frozen raindrops which get frozen in their way through air at sub-freezing temperature.

107. (a)

Symon's raingauge is an example of non-recording raingauge.

109. (d)

$$\text{Total precipitation in given rainfall} = 0 + 0.2 + 0.45 + 0.75 + 1.15 + 0.9 + 0.15 = 3.6 \text{ cm}$$

$$W_{\text{index}} = \frac{P - R - I_a}{t} = \frac{3.6 - 2}{6} = 0.267 \text{ cm/hr}$$

Now for calculating ϕ-index, we will use rainfall data whose value is more than 0.267 cm/hr.

i.e. $P = 0.45 + 0.75 + 1.15 + 0.9 = 3.25$ cm

So, $\phi\text{-index} = \frac{3.25 - 2}{4} = 0.3125$ cm/hr

Check:

$$\text{Total runoff} = (0.45 - 0.3125) \times 1 + (0.75 - 0.3125) \times 1 + (1.15 - 0.3125) \times 1 + (0.9 - 0.3125) \times 1 = 2 \text{ cm}$$

110. (a)

$$q_p = 0.155 \text{ m}^3/\text{s/km}^2$$

$$W_{50} = \frac{5.87}{q_p^{1.08}} = \frac{5.87}{(0.155)^{1.08}} = 44 \text{ hr}$$

$$\therefore \quad W_{75} = \frac{W_{50}}{1.75} = \frac{44}{1.75} = 25 \text{ hr}$$

112. (b)

Flexibility is the ratio of change of discharge in the outlet to the rate of change of the discharge in the distributing channel.

$$\therefore \quad F = \frac{dq/q}{dQ/Q}$$

113. (d)

Breast wall is an RCC wall provided from the pond level upto river HFL (high flood level) to avoid spilling of the water over the canal regulator gates.

Biff wall is also called as deflector wall.

114. (b)

$$\text{Thickness of floor, } t = \frac{h}{G-1} = \frac{4.8}{3.4-1}$$

$$\Rightarrow \quad t = 2 \text{ m}$$

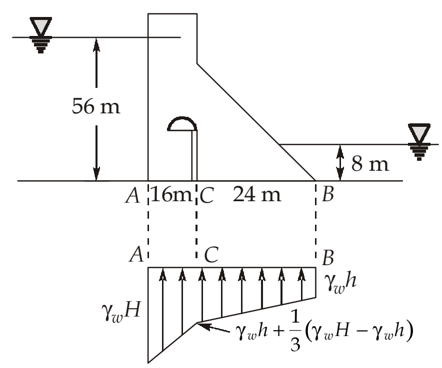
115. (b)

Let number of years are x, till the reservoir loses its 50% capacity

$$\therefore \quad 500 \times 0.15 \times 10^4 \times 0.90 \times x = 10 \times 10^6 \times 0.5$$

$$\Rightarrow \quad x = 7.407 \text{ years} \simeq 7.4 \text{ years}$$

117. (d)



$$\text{Uplift pressure at } C = \gamma_w h + \frac{1}{3}(\gamma_w H - \gamma_w h)$$

$$= 10 \times 8 + \frac{1}{3} \times (10 \times 56 - 10 \times 8)$$

$$= 240 \text{ kN/m}^2$$

120. (c)

$$\text{Curve resistance} = 0.0004 \text{ WD}°$$

$$= 0.0004 \times 60 \times 4$$

$$= 0.096 \text{ tonnes} = 96 \text{ kg}$$

121. (d)

Coning of wheel reduces the wear and tear of wheel flanges.

124. (a)

Circular shape is best suitable for non-cohesive soil and for tunnels to be driven by shield method.

126. (d)

$$N = +0.01 - (-0.008)$$
$$= 0.018$$

If $L > S$, then $L = \frac{Ns^2}{9.6} = \frac{0.018 \times 475^2}{9.6} = 423\,\text{m} < S\,(=475\text{ m})$

Since $L < S$ hence not OK

So assuming $L < S$

$\therefore$ $$L = 2S - \frac{9.6}{N} = 2 \times 475 - \frac{9.6}{0.018}$$
$$= 950 - 533.33$$
$$= 416.67 \text{ m}$$
$$\simeq 417 \text{ m} < S\,(= 475 \text{ m}) \quad \text{OK}$$

128. (a)

$$\frac{a}{h} = \frac{32}{18} = 1.778 > 1.724$$

$\because$ $\frac{a}{h} > 1.724, \quad \therefore \quad b = a$

$\Rightarrow$ $b = 32$ cm

129. (c)

$$A_{st} = \frac{f \times b \times h \times w}{\sigma_{st}}$$

$$A_{st} = \frac{1.5 \times \frac{7}{2} \times 0.24 \times 2400}{1400 \times 10^4}$$
$$= 2.16 \times 10^{-4} \text{ m}^2$$
$$= 2.16 \text{ cm}^2$$

130. (a)

Moving can method is used for counting traffic volume.

132. (c)

Error = Measured value – True value ...(i)

Error = –Correction

$\therefore$ –Correction = Measured value – True value

$\Rightarrow$ Measured value + Correction = True value ...(ii)

Hence both the equations are correct.

133. (b)

Tension correction is positive if the applied pull is more than the standard pull.

134. (c)

Mean of face left and face right reading eliminates collimation error.

Mean of right swing and left swing reading eliminate error due to friction and backlash.

135. (c)

$$\text{Height of rise} = 0.0673D^2 = 0.0673 \times 50^2 = 168.25 \text{ m}$$

137. (a)

Let O be the instrument station and A be the staff station

$$\therefore \quad V = 3000 \tan 2°30' = 132 \text{ m}$$

Since distance of 3000 m is quite large, the correction for curvature and refraction must be applied.

$$\therefore \quad C = 0.0673 \times D^2 = 0.0673 \times 3^2 = 0.6057 \text{ m}$$

$$\text{Hence RL of staff station} = RL \text{ of instrument axis} + V - 3 + C = 200 + 132 - 3 + 0.6057 = 329.6057 \text{ m}$$

138. (a)

$$D = \frac{ks}{m}\cos^2\theta + C\cos\theta$$

$$\Rightarrow \quad 100 = \frac{1000 \times 2}{m} \times 0.9945^2 + 0.5 \times 0.9945$$

$$\Rightarrow \quad m = 19.88$$

139. (d)

$$V = \frac{L}{3}\left[(A_1 + A_n) + 4(A_2 + A_4 + A_6) + 2(A_3 + A_5)\right]$$

$$= \frac{20}{3}\left[(42 + 11) + 4(64 + 16 + 26) + 2(72 + 18)\right]$$

$$= \frac{20}{3}[53 + 424 + 180]$$

$$= \frac{20}{3} \times 657 = 20 \times 219 = 4380 \text{ m}^3$$

140. (c)

$$\text{Difference in longitude} = 110°30' - 82°30' = 28°$$

Time corresponding to 28°

$$360° \equiv 24 \text{ hr}$$

$$\therefore \quad 28° \equiv \frac{24}{360} \times 28 \equiv 1.867 \text{ hours or } 1 \text{ hr } 52 \text{ min}$$

$\because$ The place is in east of standard meridian

$$\therefore \quad \text{LMT} = 18 \text{ hr } 39 \text{ min } 25 \text{ sec} + 1 \text{ hr } 52 \text{ min}$$

$= 20$ hr 31 min 25 sec

143. (c)

Biggest drawback of the concrete sewers is that they easily get corroded and pitted by the action of sulphuric acid produced from H_2S gas.

144. (a)

When the wall moves away from the backfill, a portion of the backfill located next to the retaining wall tends to break away from the rest of the soil mass and tends to move downwards and outwards relative to the wall. Since the shear resistance is mobilised in direction away from the wall, there is a resultant decrease in earth pressure.

147. (c)

The true stress is larger than the nominal stress because it is calculated with reduced area.

148. (c)

Strain hardening results in increased resistance to further deformation.