DETAILED SOLUTIONS

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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 18

Full Syllabus Test 2 : Paper-II

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

** Answer key & explanation has been updated of question 123*

DETAILED EXPLANATIONS

2. (a)

For tapering bar of circular cross-section,

$$\Delta_0 = \frac{4PL}{\pi E D_1 D_2}$$

$$\text{Actual extension, } \Delta_0 = \frac{4PL}{\pi E(D)\times(3D)} = \frac{4PL}{3\pi E D^2}$$

$$\text{Average diameter of bar} = \frac{3D+D}{2} = 2D$$

$$\text{Approximate extension, } \Delta = \frac{4PL}{\pi\times(2D)^2\times E} = \frac{4PL}{4\pi D^2 E}$$

$$\therefore \text{ Error in computation of extension of bar} = \left(1-\frac{\Delta}{\Delta_0}\right)\times 100$$

$$= \left(1-\frac{3}{4}\right)\times 100 = 25\%$$

3. (a)

$$\frac{\tau}{R} = \frac{C\theta}{L} = \frac{T}{J}$$

$$\Rightarrow \quad \tau = \frac{TR}{J}$$

$$\therefore \quad \tau_{max} = \frac{T\times d_0}{2\times\frac{\pi}{32}\left(d_0^4-d_i^4\right)} = \frac{12\times10^6\times100\times16}{\pi(100^4-80^4)}$$

$$\tau_{max} = 103.5 \text{ MPa}$$

5. (a)

$$\in_{BC} = \frac{\sigma_y}{E} - \frac{\mu\sigma_x}{E}$$

$$\because \quad \in_{BC} = 0$$

$$\Rightarrow \quad 0 = \sigma_y - \mu\times\sigma_x$$

$$\Rightarrow \quad \sigma_y = \mu\sigma_x$$

$$= 0.25\times 75$$

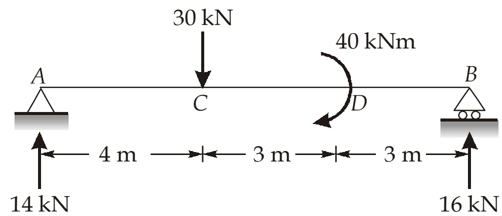
$$= 18.75 \text{ N/mm}^2$$

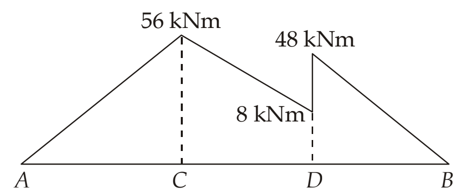
6. (c)

$$V_A + V_B = 30 \text{ kN}$$

$$\Sigma M_A = 0$$

$$\Rightarrow \quad V_B \times 10 = 30 \times 4 + 40$$
$$\Rightarrow \quad V_B = 16 \text{ kN}$$
$$\therefore \quad V_A = 30 - V_B = 14 \text{ kN}$$





BMD

$$\therefore \quad \text{Maximum BM} = 56 \text{ kNm}$$

7. (c)

$$\sigma_{p1/p2} = \frac{\sigma_x + \sigma_y}{2} \pm \frac{1}{2}\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$$
$$= \frac{40+80}{2} \pm \frac{1}{2}\sqrt{(80-40)^2 + 4 \times 30^2}$$
$$= 60 \pm \frac{1}{2}\sqrt{40^2 + 3600}$$
$$= 60 \pm \frac{1}{2} \times \sqrt{5200}$$
$$= 60 \pm 36.06$$
$$= 96.06 \text{ N/mm}^2 \simeq 96 \text{ N/mm}^2$$

8. (b)

Deflection of B due to self weight of portion AB of wire,

$$\delta l_1 = \frac{\left(\frac{W}{2}\right)\left(\frac{L}{2}\right)}{2AE}$$
$$= \frac{10 \times 8 \times 10^3}{2 \times 4 \times 200 \times 10^3} = 0.05 \text{ mm}$$

Deflection of wire at B due to weight of the wire BC

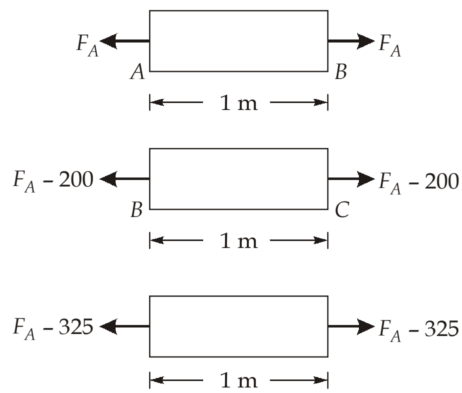
$$\delta l_2 = \frac{\left(\frac{W}{2}\right)\left(\frac{L}{2}\right)}{AE}$$
$$= \frac{10 \times 8 \times 10^3}{4 \times 200 \times 10^3} = 0.1 \text{ mm}$$

∴ Total deflection of point B of wire,

$$\delta l_B = \delta l_1 + \delta l_2$$
$$= 0.05 + 0.1 = 0.15 \text{ mm}$$

9. (a)

FBD of each section is shown below,



Since ends are fixed so total extension = 0

$$\Rightarrow \frac{F_A \times 1}{AE} + \frac{(F_A - 200) \times 1}{AE} + \frac{(F_A - 325) \times 1}{AE} = 0$$

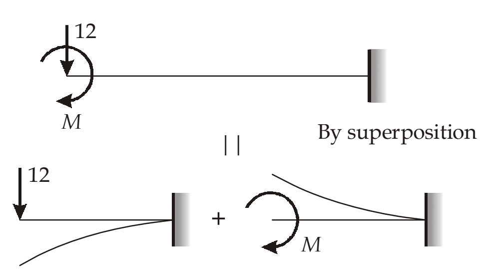
$$\Rightarrow 3F_A - 525 = 0$$

$$\Rightarrow F_A = 175 \text{ kN}$$

Force in section BC, $F_{BC} = 175 - 200$
$$= -25 \text{ kN}$$

So, stress in section BC, $\sigma_{BC} = \frac{F_{BC}}{A} = \frac{-25000}{2500} = -10 \text{ N/mm}^2$

11. (c)



Since deflection at free end is zero.

⇒ (↓) defl. due to load = (↑) defl. due to moment

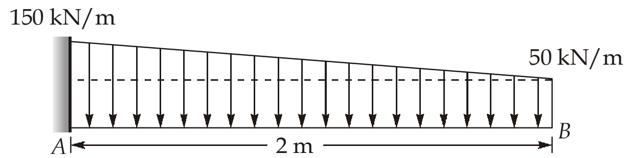
$$\frac{Pl^3}{3EI} = \frac{Ml^2}{2EI}$$

$$\frac{12 \times (2)^3}{3EI} = \frac{M \times (2)^2}{2EI}$$

$$M = \frac{12\times8}{3\times2}$$

$$\Rightarrow \quad M = 16 \text{ kNm (CW)}$$

12. (c)



$$y_B = \frac{w_1 l^4}{8EI} + \frac{w_2 l^4}{30EI}$$

$$\Rightarrow \quad y_B = \frac{50\times\left(2\times10^3\right)^4}{8\times10^{13}} + \frac{100\times\left(2\times10^3\right)^4}{30\times10^{13}}$$

[w_1 = 50 kN/m, w_2 = 100 kN/m]

$$\Rightarrow \quad y_B = \frac{5\times16}{8} + \frac{16}{3} = 10 + 5.33$$

$$= 15.33 \text{ mm}$$

13. (a)

As carbon content increases elongation before fracture decreases i.e. ductility of steel decreases but ultimate strength of steel increases.

14. (b)

$$E = 3K(1 - 2\mu)$$

$$\frac{E}{K} = 3 \times (1 - 2 \times 0.3)$$

$$\frac{E}{K} = 3 \times 0.4 = 1.2$$

15. (c)

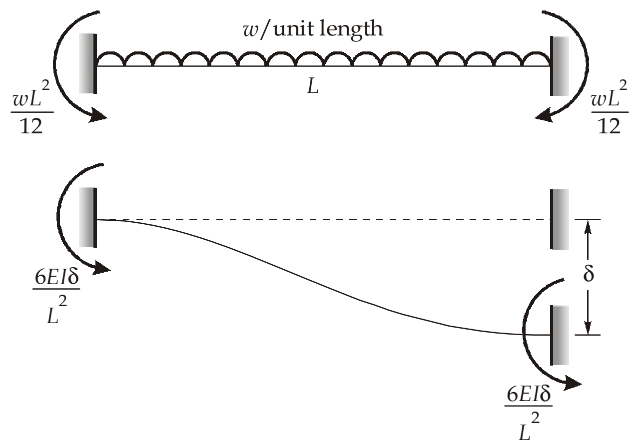
Distribution factor

Joint	Member	Distribution Factor
B	BC	0.5
	BA	0.5

Joint	A	B	B	C
DF	1	0.5	0.5	1
FEM	0	0	$-\frac{wl^2}{12}$	$\frac{wl^2}{12}$
Balance		$\frac{wl^2}{24}$	$\frac{wl^2}{24}$	
C.O.M	$\frac{wl^2}{48}$			$\frac{wl^2}{48}$
Final	$\frac{wl^2}{48}$	$\frac{wl^2}{24}$	$-\frac{wl^2}{24}$	$\frac{5wl^2}{48}$

$$\therefore \quad \frac{M_{Bc}}{M_{CB}} = \frac{\frac{wl^2}{24}}{\frac{5wl^2}{48}} = \frac{48}{5\times 24} = \frac{2}{5}$$

17. (a)



$$M_{fA} = \frac{wL^2}{12} + \frac{6EI\delta}{L^2}$$

$$= \frac{wL^2}{12} + \frac{6EI}{L^2}\times\frac{wL^4}{36EI}$$

$$= \frac{wL^2}{12} + \frac{wL^2}{6}$$

$$= \frac{(1+2)\,wL^2}{12} = \frac{wL^2}{4}$$

18. (c)

$$\because \quad H = \frac{wL^2}{8h} = \frac{2\times 120^2}{8\times 12} = 300 \text{ kN}$$

$$\because \quad \frac{\delta H}{H} = -\frac{3}{16}\left(\frac{L}{h}\right)^2 \alpha\Delta T$$

$$= -\frac{3}{16}\left(\frac{120}{12}\right)^2 \times 6\times 10^{-6}\times 20$$

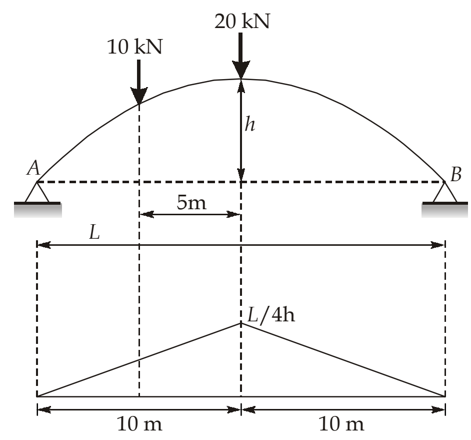
$$= -2.25 \times 10^{-3}$$

$$\therefore \quad \delta H = -2.25 \times 10^{-3} \times 300 = -0.675 \text{ kN}$$

$$= 0.675 \text{ kN (decrease)}$$

19. (c)

In case of a three hinged parabolic arch, the influence line diagram for horizontal thrust is linear. Maximum thrust will be induced at the supports when 20 kN load is at the crown.



ILD for horizontal thrust

Ordinate of the ILD at a distance of 5 m from A

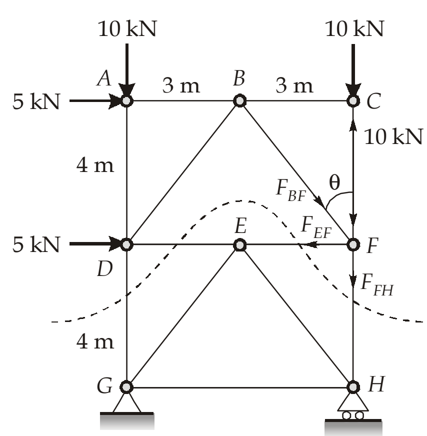
$$= \frac{5}{10} \times \frac{L}{4h} = \frac{1}{2} \times \left(\frac{20}{4 \times 4}\right) = 0.625 \text{ kN}$$

Also, $$\frac{L}{4h} = \frac{20}{4 \times 4} = 1.25 \text{ kN}$$

Thus, **horizontal thrust,**

$$H = 10 \times 0.625 + 20 \times 1.25 = 31.25 \text{ kN}$$

20. (c)



Cut the truss as shown in figure,

$$\Sigma M_D = 0$$

$$\Rightarrow \quad 5 \times 4 + 10 \times 6 + F_{FH} \times 6 = 0$$

$$\Rightarrow \quad F_{FH} = -\frac{40}{3} \text{ kN}$$

$$= \frac{40}{3} \text{kN (Compression)} = 13.33 \text{ kN (C)}$$

Equilibrium of joint F

$$\Sigma F_y = 0$$

$$\Rightarrow \quad -10 - F_{BF} \times \cos\theta - \left(-\frac{40}{3}\right) = 0$$

$$\Rightarrow \quad F_{BF} = \frac{3.33}{\cos\theta} = \frac{3.33 \times 5}{4} = 4.16 \text{ kN}$$

$$\Sigma F_x = 0$$

$$F_{EF} = F_{BF} \sin\theta$$

$$= 4.16 \times \frac{3}{5} \text{ kN} = 2.49 \text{ kN}$$

$$\therefore \quad F_{EF} = 2.5 \text{ kN (Tensile)}$$

21. (c)

$$M_{fAB} = -\frac{12 \times 5^2}{12} = -25 \text{ kNm}$$

$$M_{fBA} = 25 \text{ kNm}$$

$$M_{fBC} = -\frac{WL}{8} = -\frac{25 \times 8}{8} = -25 \text{ kNm}$$

$$M_{fCB} = 25 \text{ kNm}$$

Joint	Member	Distribution Factor	Distribution Factor
B	BA	$\frac{3EI}{5} = \frac{3EI}{5}$	0.44
	BC	$\frac{3E(2I)}{8} = \frac{6EI}{8}$	0.56

Joint	A	B	B	C
DF	1	0.44	0.56	1
FEM	–25	25	–25	25
Release	25			–25
C.O.M		12.5	–12.5	
Final moment	0	37.5	–37.5	0

So, $\quad M_B = 37.5 \text{ kNm}$

22. (d)

$$f_{21} = \text{Deflection at (2) due to unit rotation at (1)}$$

$$= -\frac{L^2}{2EI}$$

Alternatively,

$$f_{21} = f_{12}$$

$$= \text{Deflection}$$

$$\text{At (1) due to unit load at (2)} = \frac{-PL^2}{2EI}$$

$$= \frac{-L^2}{2EI} \qquad (\because P = 1)$$

23. (b)

The springs are in series.

$$\therefore \quad \frac{1}{k_{eq}} = \frac{1}{k_{spring}} + \frac{1}{k_{cantilever}}$$

$$\frac{1}{k_{eq}} = \frac{1}{20} + \frac{1}{7234}$$

$$\Rightarrow \quad k_{eq} = 19.94 \text{ N/cm}$$

$$w = \sqrt{\frac{k_{eq} \times g}{W}} = \sqrt{\frac{19.94 \times 981}{250}} \qquad \{\because \; g = 981 \text{ cm/s}^2\}$$

$$\Rightarrow \quad w = 8.85 \text{ rad/s}$$

$$\therefore \quad f = \frac{w}{2\pi} = \frac{8.85}{2\pi} = 1.4 \text{ cycle per second}$$

24. (c)

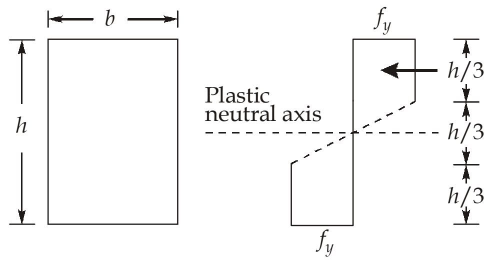
$$\text{Strength of weld per mm} = \frac{0.7 \times 5 \times 410}{\sqrt{3} \times 1.5} = 552 \text{ N/mm}$$

$$\therefore \quad \text{Required length of weld} = \frac{700 \times 10^3}{552} = 1268 \text{ mm}$$

$$\therefore \quad 1268 = 2 \times 300 + 250 + 4x$$

$$\Rightarrow \quad x = 104.5 \simeq 105 \text{ mm}$$

26. (c)



$$M = M_1 + M_2$$

$$= f_y \times \frac{b(h/3)^2}{6} + f_y \times \frac{bh}{3} \times \frac{2h}{3}$$

$$= f_y \times \frac{bh^2}{54} + \frac{2 f_y bh^2}{9}$$

$$= \frac{13}{54} f_y bh^2$$

27. (b)

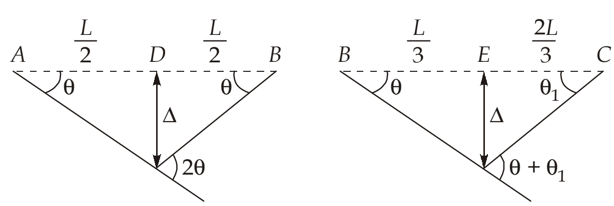
In the case of a continuous beam, the collapse load due to the beam mechanism forming in each span is calculated and the minimum collapse load is taken as the collapse load of the beam.

Span AB

The end A is a simple support and the end B is an intermediate support. Hence, the beam AB will act as a propped cantilever with B as the fixed end. Plastic hinges will be formed at B and D.

$$\text{External workdone} = \frac{2W_u L\theta}{2} = W_u L\theta$$

$$\text{Internal workdone} = M_P(\theta + \theta) + M_P\theta = 3M_P\theta$$



Case 1 **Case 2**

By principle of virtual work,

$$W_u L\theta = 3M_p\theta$$

Hence, $$W_u = \frac{3M_P}{L}$$

Span BC

Here, the end B is an intermediate support and the end C is a simple support. Hence the beam BC acts as a propped cantilever, with end B fixed. Plastic hinges will form at B and E.

$$\Delta = \frac{L}{3}\theta = \frac{2}{3}L\theta_1$$

Hence, $\theta_1 = \frac{\theta}{2}$

$$\text{External workdone} = \frac{3W_u L\theta}{3} = W_u L\theta$$

$$\text{Internal workdone} = M_P\theta + M_P(\theta + \theta_1)$$

$$= M_P\theta + M_P\left(\theta + \frac{\theta}{2}\right) = 2.5M_P\theta$$

By the principle of virtual work,

$$W_u L\theta = 2.5\, M_p\theta$$

Hence, $W_u = \frac{2.5M_P}{L}$

Collapse load is taken minimum of the above two cases.

Therefore, the collapse load of the continuous beam is $\frac{2.5M_P}{L}$.

28. (a)

For class '*b*' buckling imperfection factor (α) is 0.34

$$\phi = 0.5 \times \left[1 + \alpha(\lambda - 0.2) + \lambda^2\right]$$

[where λ is non-dimensional effective slenderness ratio]

$$= 0.5 \times [1 + 0.34\,(0.49 - 0.2) + 0.49^2]$$

$$= 0.669$$

$$\text{Stress reduction factor, } \chi = \frac{1}{\phi + \left[\phi^2 - \lambda^2\right]^{1/2}}$$

$$= \frac{1}{0.669 + \left[0.669^2 - 0.49^2\right]^{1/2}}$$

$$= 0.889 \simeq 0.89$$

29. (c)

The slenderness ratio of lacing bar shall not exceed 145. Refer Cl. 7.6 of **IS 800:2007**.

30. (c)

Refer **Clause 10.12.2** of **IS 800:2007**

32. (b)

The distance between the centres of two adjacent fastners (pitch) in a line lying in the direction of stress, shall not exceed 16t or 200 mm, whichever is less in tension members and 12t or 200 mm, whichever is less, in compression members.

The maximum edge distance to the nearest line of fasteners from an edge of an un-stiffened part should not exceed 12tε, where $\varepsilon = \left(\frac{250}{f_y}\right)^{1/2}$ and t is the thickness of thinner outer plate.

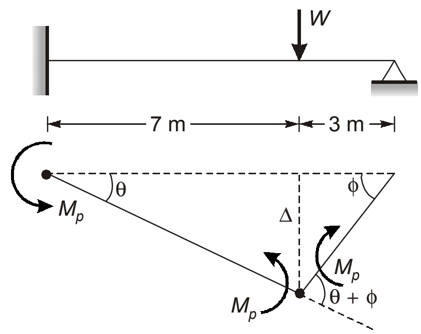
33. (d)

Method-I

Number of possible hinges, $n = 2$

Statical indeterminacy, $r = 1$

Number of independent mechanisms,



$$i = n - r = 2 - 1 = 1$$

$$\Delta = 7\theta = 3\phi$$

By principle of virtual work, we get,

$$W \times \Delta - M_p\theta - M_p(\theta + \phi) = 0$$

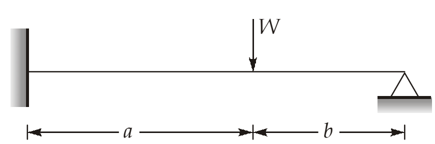
$$\Rightarrow \quad W \times 7\theta = 2M_p\theta + M_p\phi$$

$$\Rightarrow \quad W \times 7\theta = 2M_p\theta + M_p \times \frac{7\theta}{3}$$

$$\Rightarrow \quad 7W = \frac{6M_p + 7M_p}{3}$$

$$\Rightarrow \quad W = \frac{13M_p}{21}$$

Method-II



Where $(a + b) = L$

For standard cases

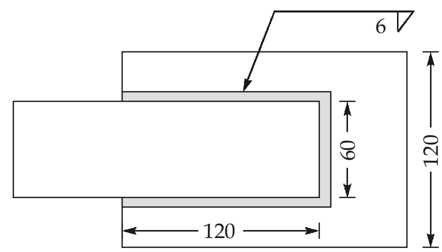
$$W_u = M_p \frac{(L+b)}{ab}$$

$$W_u = M_p \times \frac{(10+3)}{7 \times 3}$$

Here $a = 7$ m, $b = 3$ m

$$W_u = \frac{13}{21} M_p$$

34. (b)



$$P_w = f_b \times l_{eff} \times t_t$$
$$= 110\ (120 + 120 + 60) \times 0.7 \times 6 = 138.6 \text{ kN}$$
$$P_{plate} = \sigma_{at} \times A_{net} = 150 \times (60 \times 8) = 72 \text{ kN}$$

So permissible load = 72 kN

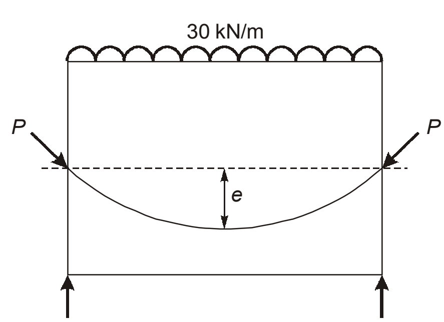
35. (c)

- Creep effects tend to reduce the stresses.
- In general, creep increases when
  - cement content is high,
  - water cement ratio is high,
  - aggregate content is low,
  - air entrainment is high,
  - relative humidity is low.

36. (d)

Refer **Cl.6.1** and Table 1 (Note 2) of **IS 1343:2012**

37. (b)



We know, $BM_{max} = \frac{wl^2}{8} = \frac{30 \times 8^2}{8} = 240 \text{ kNm}$

Note: Tendon profile shall follow the shape of bending moment diagram.

Also $BM_{max} = Pe$

$$\therefore \quad e = \left(\frac{BM}{P}\right) = \frac{240 \times 10^6 \text{ Nmm}}{1500 \times 10^3}$$

$$e = 160 \text{ mm}$$
$$e = 0.16 \text{ m}$$

38. (d)

$$l \leq 60 \times 400 \text{ mm}$$
$$l \leq 24 \text{ m}$$

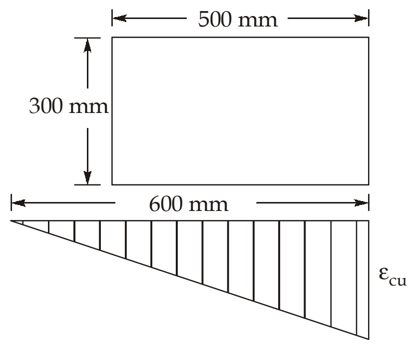
Also $$l \leq \frac{100(400)^2}{600} \leq 26.67 \text{ m}$$

Refer clause 25.3.2 and **IS 456:2000**.

39. (c)

Neutral axis depth: $x_u = 1.2 \times D = 1.2 \times 500 = 600$ mm

As the NA falls outside the section, the entire section is under compression, and the corresponding failure strain diagram is as shown below.



$$\varepsilon_{CU} = 0.002\left[1+\frac{\frac{3D}{7}}{x_u-\frac{3D}{7}}\right]$$

$$= 0.002\left[1+\frac{\frac{3\times500}{7}}{600-\frac{1500}{7}}\right] = 0.0031$$

40. (b)

$$x_{u,\text{ bal}} = \frac{700}{1100+0.87f_y} \times d$$

So it depends upon grade of steel only.

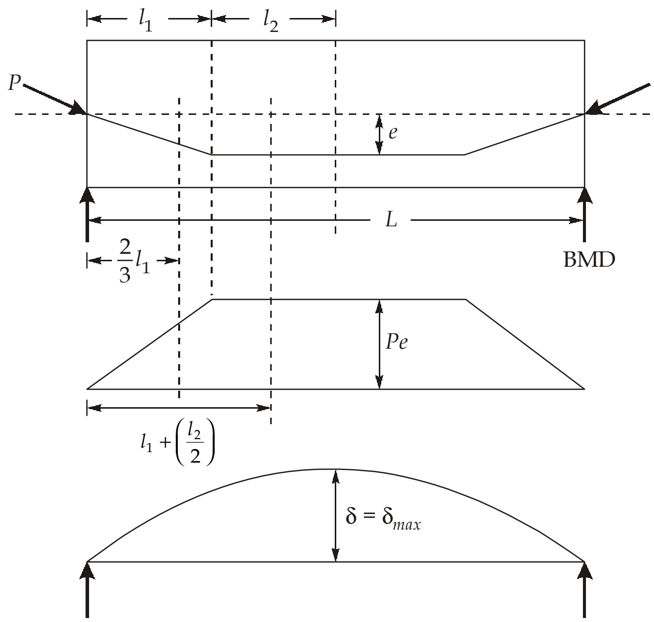
41. (b)

A tendon with a trapezoidal profile is shown in figure below. Considering the BMD, the deflection at the centre of the beam is obtained by taking the moment of area of the BMD over one half of the span.

Thus,

$$\delta = \frac{-Pe}{EI}\left[l_2\left(l_1+\frac{l_2}{2}\right)+\left(\frac{l_1}{2}\right)\left(\frac{2}{3}l_1\right)\right]$$

$$= \frac{-Pe}{6EI}\left[2l_1^2+6l_1l_2+3l_2^2\right]$$



In our case, we have

$$l_1 = \frac{10}{3} = 3.333 \text{ m}, l_2 = 1.667 \text{ m and } e = 100 \text{ mm}$$

$$P = 350 \times 1290 = 451500 \text{ N}$$

$$\therefore \quad \delta = \left(\frac{451500 \times 100}{6 \times 34 \times 10^3 \times 4.5 \times 10^8}\right)\left[2 \times 3333^2 + 6 \times (3333 \times 1667) + 3 \times 1667^2\right]$$

$$\Rightarrow \quad \delta = 31.42 \text{ mm}$$

$$\simeq 31 \text{ mm}$$

42. (c)

$$M_{u\text{lim}} = 0.138 f_{ck} bd^2$$

$$= 0.138 \times 20 \times 150 \times 300^2$$

$$= 37.26 \text{ kN-m}$$

43. (a)

Creep is inelastic deformation with time due to sustained loading.

44. (a)

As per **Cl.32.2.5** of **IS 456 : 2000**,

$$P = 0.3(t - 1.2e - 2e_a) f_{ck}$$

$$P = 0.3(h - 1.2e_x) f_{ck}$$

$$\Rightarrow \quad 1020 \text{ N/mm} = (400 - 1.2 \times 30) \text{ mm} \times 0.3 \times f_{ck}$$

$$\Rightarrow \quad f_{ck} = \frac{1020}{109.2} \text{N/mm}^2 = 9.34 \text{ MPa}$$

45. (d)

Given, $P_u = 500 \text{ kN}, P_{uz} = 1200 \text{ kN}$

$$\therefore \quad \frac{P_u}{P_{uz}} = \frac{500}{1200} = 0.417$$ which lies between 0.2 and 0.8

$$\alpha_\gamma = \frac{2}{3}\left(1 + \frac{5}{2}\frac{P}{P_z}\right)$$

(Refer **Cl.39.6** of **IS 456 : 2000**)

$$= \frac{2}{3}\left(1 + \frac{5}{2} \times \frac{500}{1200}\right) = 1.36$$

46. (b)

Minimum tension reinforcement is given by,

$$\frac{A_s}{bd} = \frac{0.85}{f_y}$$

$$A_s = \frac{0.85 \times 250 \times 400}{415} = 205 \text{ mm}^2$$

Maximum reinforcement $= 0.04\, bD$

$= 0.04 \times 250 \times (400 + 50)$ [$\because$ given effective cover = 50 mm]

$= 4500 \text{ mm}^2$

47. (d)

Burst event : When more than one activity leaves an event.

48. (c)

Nodes are usually represented by squares or rectangles in AON networks but any other geometrical shape can also be used.

49. (b)

As $\sigma^2 = 16$

$\therefore$ $\sigma = 4$

$$\therefore \quad Z = \frac{T_S - T_E}{\sigma} = \frac{18 - 20}{\sqrt{16}}$$

$$= \frac{-2}{4} = -0.5$$

For $Z = 0.5$,

Probability = 69.2%

For $Z = -0.5$,

Probability = 100 – 69.2 = 30.8%

50. (c)

$$\text{Variance, } \nu = \left(\frac{t_p - t_0}{6}\right)^2$$

Here t_p = 1 hour = 60 minutes, t_0 = 5 minutes

$$\therefore \quad \nu = \left(\frac{60-5}{6}\right)^2 = 84.03 \text{ minutes}$$

52. (b)

Free float is that duration by which an activity can be delayed without delaying any succeeding activity.

Interfering float is equal to head event slack.

55. (b)

$$\text{Tension in toe cable} = \text{Rolling resistance + Grade resistance}$$

$$\text{As grade resistance} = 10 \text{ kg/tonne/1\% slope}$$

$$\therefore \quad 1105 \text{ kg} = \frac{R \times 13000}{10^3} + \frac{10 \times 13000}{10^3} \times 4$$

$$\text{So rolling resistance} = 45 \text{ kg/tonne}$$

64. (d)

Good sand should be well-graded.

Type of sand	Fineness modulus
Fine sand	2.2 - 2.6
Medium sand	2.6 - 2.9
Coarse sand	2.9 - 3.2

68. (d)

Plastic generally have good resistance to biological hazards.

69. (b)

This is because viscous forces in a fluid are due to cohesive force and molecular momentum transfer. On liquids, the cohesive forces predominates the molecular momentum transfer, due to closely peaked molecules and with the increase in temperature, the cohesive force decreases with result of decreasing viscosity. But in cases of gases the cohesive forces are small and molecular momentum transfer predominates with the increase in temperature, molecular momentum transfer increases and hence viscosity increases.

70. (a)

In case of multi-stage pumps, since the same liquid flows through each impeller, the discharge of a multi-stage pump is same as the discharge passing through each impeller of the series.

These pumps require priming

$$\left(\frac{gH}{N^2D^2}\right)_m = \left(\frac{gH}{N^2D^2}\right)_p$$

71. (b)

$$\frac{f_e L_e}{D_e^5} = \frac{f_1 L_1}{D_1^5} + \frac{f_2 L_2}{D_2^5}$$

Friction factor is same for all pipes (as given material is same for all the pipes).

$$\therefore \quad \frac{L_e}{D_e^5} = \frac{L_1}{D_1^5} + \frac{L_2}{D_2^5}$$

$$\Rightarrow \quad \frac{5000}{D_e^5} = \frac{2000}{(0.4)^5} + \frac{500}{(0.2)^5}$$

$$\Rightarrow \quad \frac{5000}{D_e^5} = \frac{2000 \times 10^5}{1024} + \frac{500 \times 10^5}{32}$$

$$\Rightarrow \quad \frac{5000}{D_e^5} = \frac{10^8}{1024} \times (2 + 16)$$

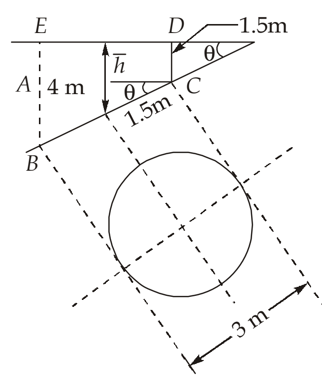
$$\Rightarrow \quad D_e^5 = \frac{1024 \times 5000}{10^8 \times 18}$$

$$\Rightarrow \quad D_e = \frac{4}{10}\left(\frac{5}{18}\right)^{1/5} = 0.4(0.278)^{1/5}$$

$$= 0.4 \times 0.774 = 0.31 \text{ m}$$

$$= 310 \text{ mm}$$

72. (c)



$$A = \frac{\pi}{4} d^2 = \frac{\pi}{4}(3)^2 = 7.0686 \text{ m}^2$$

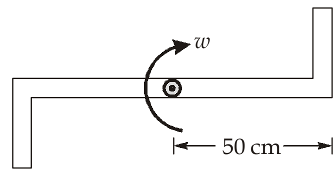
$$\therefore \quad \bar{h} = 1.5 + 1.5 \sin\theta$$

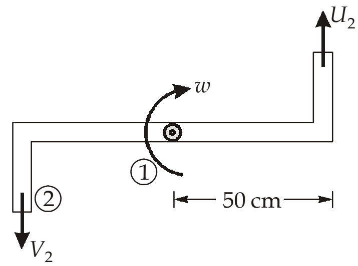
$$\therefore \quad \bar{h} = 1.5 + 1.5 \times \frac{5}{6} = 2.75 \text{ m}$$

$$\therefore \quad \text{Total pressure } (F) = \rho g A \bar{h}$$

$$= 1000 \times 9.81 \times 7.0685 \times 2.75 = 190.693 \text{ kN} \simeq 190.69 \text{ kN}$$

73. (c)





$$V_2 = wr$$

$$a = 1\text{ cm}^2,\ Q = 2500\text{ cm}^3/\text{s}$$

$$V_2 = \frac{(Q/2)}{a} = \frac{Q}{2\times a} = \frac{2500}{2\times 1} = 1250\text{ cm/s} = 12.5\text{ m/s}$$

$$\text{Torque, } T = -\rho Q r(U_2 - V_2) = 0$$

$$U_2 = V_2 = 12.5\text{ m/s}$$

$$U_2 = wr$$

$$w = \frac{V_2}{r} = \frac{12.5}{0.5} = 25\text{ rad/s}$$

So,

$$N = \frac{w}{2\pi}\times 60$$

$$= \frac{25\times 60}{2\pi} = \frac{750}{\pi}\text{ RPM}$$

74. (b)

$$L_r = \frac{1}{500},\ h_r = \frac{1}{100}$$

$$T_r = \frac{L_r}{V_r}$$

$$V_r \propto \sqrt{h_r} \qquad \text{(as by Froude's number)}$$

$$\therefore \quad T_r = \frac{L_r}{V_r} = \frac{\frac{1}{500}}{\frac{1}{\sqrt{100}}} = \frac{\frac{1}{500}}{\frac{1}{10}} = \frac{1}{50}$$

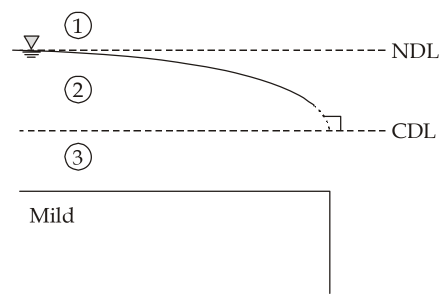
$$T_r = \frac{T_m}{T_p}$$

$$\Rightarrow \quad T_m = \frac{1}{50} \times 12 \text{ hours}$$

$$= \frac{12 \times 60 \times 60}{50} = 864 \text{ sec}$$

76. (b)

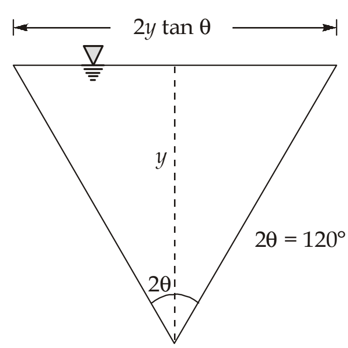
All free fall curves are zone II profiles. Since the critical depth (y_c) is less than the normal depth (y_n), therefore the slope is mild. Thus, the gradually varied profile is M_2.



As CDL is below NDL

$\Rightarrow$ Mild slope profile $\rightarrow M_2$

77. (b)



As we know,
$$\frac{Q^2 T_c}{g A_c^3} = 1$$

$$T_c = 2y_c \tan\theta$$

$$A_c = \frac{1}{2} \times 2y_c \tan\theta \cdot y_c = y_c^2 \tan\theta$$

So,
$$\frac{(Q)^2 \times 2y_c \tan\theta}{g \times \left(y_c^2 \tan\theta\right)^3} = 1$$

$$\Rightarrow \quad y_c = \left(\frac{2Q^2}{g} \cdot \frac{1}{\tan^2\theta}\right)^{1/5} = \left[\frac{2 \times (3)^2}{10} \times \frac{1}{\left(\sqrt{3}\right)^2}\right]^{1/5}$$

$$= \left(\frac{6}{10}\right)^{1/5} = \frac{1.43}{1.58} = 0.90$$

Alternatively,

$m = \tan\theta = \tan 60° = \sqrt{3}$

$$y_c = \left(\frac{2Q^2}{gm^2}\right)^{1/5}$$

$$= \left[\frac{2\times 3^2}{10\times(\sqrt{3})^2}\right]^{1/5} = \left(\frac{3}{5}\right)^{1/5}$$

$$= \left(\frac{6}{10}\right)^{1/5} = 0.9$$

78. (b)

$$\text{Pressure at } N = p_A + \rho g h$$
$$= p_A + \rho g \times 0.6$$
$$\text{Pressure at } M = p_A + \text{Pressure due to water} + \text{Pressure due to mercury}$$
$$= p_A + \rho g\,(0.5) + 13.6\,\rho g\,(0.1)$$
$$= p_A + 1.86\,\rho g$$

Given: $$p_N = \frac{P_M}{3}$$

$$\Rightarrow \quad (p_A + 0.6\rho g)\times 3 = p_A + 1.86\rho g$$

$$\Rightarrow \quad p_A = 0.03\,\rho g = 0.2943 \text{ kPa}$$

79. (d)

$$w = \frac{2\pi N}{60} = \frac{2\pi\times 60}{60} = 6.283 \text{ rad/s}$$

$$y = \frac{w^2 r^2}{2g}$$

$$\Rightarrow \quad y_1 - y_2 = \frac{w^2}{2g}\left(r_1^2 - r_2^2\right)$$

$$= \frac{(6.283)^2}{2g}\left(0.3^2 - 0.15^2\right)$$

$$= 0.136 \text{ m or } 13.6 \text{ cm}$$

80. (c)

u = constant for $0 \le y \le \frac{2B}{3}$

Consider unit width of conduit

$$V_{avg} = \frac{\int_0^{2B/3} u\,dy + 0}{(B \times 1)}$$

$$= \frac{u\left(\frac{2B}{3}\right)}{B} = \frac{2}{3}u$$

Now,

$$\alpha = \frac{1}{V_{avg}^3 B}\left[\int_0^{\frac{2}{3}B} u^3 dy + \int_{\frac{2}{3}B}^{B} u^3 dy\right]$$

$$= \frac{1}{\left(\frac{2}{3}u\right)^3 B} u^3 [y]_0^{\frac{2}{3}B}$$

$$= \frac{27}{8B} \times \frac{2B}{3} = \frac{9}{4} = 2.25$$

81. (d)

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

$$= (t^2 + 3y)(0) + (4t + 5x)(3) + 2t$$

$= 12t + 15x + 2t$

$= 14 \times 2 + 15 \times 5$

$= 103$ units

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

$= (t^2 + 3y)(5) + 0 + 4$

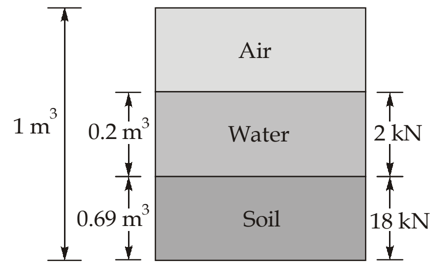
$= 5t^2 + 15y + 4 = 5(2)^2 + 15(3) + 4 = 69$ units

So,

$$a = \sqrt{a_x^2 + a_y^2}$$

$$= \sqrt{103^2 + 69^2} = 123.98 \text{ unit} \simeq 124 \text{ units}$$

82. (c)



$$V_S = \frac{18}{2.6 \times 10} = 0.69 \text{ m}^3$$

$$V_W = \frac{2}{10} = 0.2 \text{ m}^3$$

$$n_a = \frac{V_a}{V_{total}} = \frac{1-(0.69+0.2)}{1} \times 100$$

$$= 11\%$$

83. (a)

$$\frac{V_L - V_S}{V_L} = 0.4$$

$\Rightarrow$ $$V_L = \frac{1}{0.6} V_S$$

$$\frac{V_P - V_S}{V_P} = 0.2$$

$\Rightarrow$ $$V_P = \frac{1}{0.8} V_S$$

$\therefore$ $$SR = \frac{\frac{V_L - V_P}{V_S}}{w_L - w_P} = \frac{\frac{1}{0.6} - \frac{1}{0.8}}{0.5 - 0.25} = 1.67$$

84. (a)

Activity values of minerals	
Mineral	**Activity value**
Na - Montmorillonite	4 - 7
Ca - Montmorillonite	1.5
Illite	0.5 - 1.3
Kaolinite	0.3 - 0.5
Quartz	0

85. (d)

$$\text{Relative compaction} = \frac{\gamma_d(\text{insitu})}{\gamma_d(\text{max})} \times 100$$

$$= \frac{1+e_{\min}}{1+e_{insitu}} \times 100 \qquad \left(\because \gamma_d = \frac{G\gamma_w}{1+e}\right)$$

$$= \frac{1+0.35}{1+0.6} \times 100 = 84.38\%$$

86. (a)

$$\text{Critical hydraulic gradient, } i_c = \frac{(G-1)}{1+e}$$

$$= (G - 1)(1 - n)$$

$$= (2.65 - 1)(1 - 0.45)$$

$$= 0.9075$$

$$\therefore \quad \text{Permissible hydraulic gradient} = \frac{0.9075}{4} = 0.227$$

87. (c)

Punching shear failure occurs in soil possessing the stress-strain characteristics of a very plastic soil.

Typical features of this mode are:

(a) Poorly defined shear planes.

(b) Soil zones beyond the loaded are being litle affected.

(c) Significant penetration of a wedge shaped soil zone beneath the foundation.

(d) Ultimate load can't be clearly recorgnized.

88. (d)

Tension pile : Pile used to resist uplift load and are thus in tension.

Batter pile : In case of large lateral loads, piles are driven at an angle and hence termed as batter piles.

Compaction pile : Short pile used for compacting loose sand deposits.

Anchor pile : Pile used to provide anchorage against horizontal pull as in case of anchored buckheads.

89. (b)

$$K = \frac{a}{A} \times \frac{L}{t} \ln \frac{h_1}{h_2}$$

$$= \frac{0.31}{44.41} \times \frac{12.2}{15 \times 60} \ln \frac{75}{25}$$

$$= 1.03 \times 10^{-4} \text{ cm/s}$$

90. (d)

$$\tau_f = C' + \bar{\sigma}_n \tan\phi$$

$$= 16 + (200 - 80) \tan 30°$$

$$= 85.28 \text{ kN/m}^2$$

$$\simeq 85 \text{ kN/m}^2$$

91. (b)

Assumptions of Rankine's earth pressure theory:

1. The backfill soil is isotropic, homogeneous, and cohesionless.
2. The soil is in a state of plastic equilibrium during active and passive earth pressure conditions.
3. The rupture surface is a planar surface which is obtained by considering the plastic equilibrium of the soil.
4. The backfill surface is horizontal.
5. The back of the wall is vertical and smooth.

92. (a)

$$\text{Stability number} = \frac{C}{\gamma H} = \frac{1}{2 \times 5} = 0.1$$

93. (d)

After over-burden correction,

$$N = N'\left(\frac{350}{\bar{\sigma}+70}\right) \qquad \left(\bar{\sigma} \ngtr 280 \text{ kN/m}^2\right)$$

$$= 32 \times \left(\frac{350}{130+70}\right) = 56$$

After dilatancy correction,

$$N_C = 15 + \frac{1}{2}(N-15) \qquad (\text{for } N > 15)$$

$$= 15 + \frac{1}{2}(56-15) = 35.5 \simeq 35\,(\text{say})$$

94. (b)

Present population = 27500

Population after 20 years , P_n = 45500

∴ Increase in population per year, $\bar{x}$ is given by

$$P_n = P_0 + n\bar{x}$$

$$\Rightarrow \qquad \bar{x} = \frac{P_n - P_0}{n} \qquad (n = 20)$$

$$= \frac{45500 - 27500}{20} = 900$$

Now for population of 27500, water consumption = 4000 m^3/day

Hence, population for water consumption of 6000 m^3/d

$$= \frac{27500}{4000} \times 6000 = 41250 \text{ persons}$$

∴ Population at design capacity = 41250 persons

∴ Number of years from now when plant will reach at design capacity is given by,

$$P_n = P_0 + n\bar{x}$$

$$\Rightarrow \quad n = \frac{41250 - 27500}{900}$$

$$= 15.28 \text{ years}$$

95. (c)

pOH of sample A = 9.6

∴ pH of sample A = 14 – 9.6 = 4.4

pOH of sample B = 12.6

∴ pOH of sample B = 14 – 12.6 = 1.4

Also, $$\text{pH} = -\log_{10}\left[\text{H}^+\right]$$

$$\therefore \quad -\log_{10}\left[\text{H}^+\right]_A = pH_A$$

$$\Rightarrow \quad [\text{H}^+]_A = 10^{-4.4}$$

Similarly, $$[\text{H}^+]_B = 10^{-1.4}$$

$$\therefore \quad \frac{\left[\text{H}^+\right]_A}{\left[\text{H}^+\right]_B} = \frac{10^{-4.4}}{10^{-1.4}} = \frac{1}{1000}$$

$$\Rightarrow \quad \left[\text{H}^+\right]_B = 1000 \times \left[\text{H}^+\right]_A$$

Sample B is 1000 times more acidic than sample A.

96. (a)

$$\eta = \frac{V_s}{V_0} \times 100$$

$$\Rightarrow \quad 84 = \frac{0.12}{V_0} \times 100$$

$$\Rightarrow \quad V_0 = \frac{1}{7} \text{ cm/sec}$$

Now, $$Q = 396 \text{ m}^3\text{/hr}$$

$$= 0.11 \text{ m}^3\text{/sec}$$

Also, $$V_0 = \frac{Q}{BL}, \text{ where BL = Plan area}$$

$$\therefore \quad BL = \frac{Q}{V_0} = \frac{0.11}{\left(\frac{1}{7}\right) \times 10^{-2}}$$

$$= 77 \text{ m}^2$$

97. (d)

Sludge Volume Index (SVI) is defined as the volume occupied (in ml) by 1 g of solids in the mixed liquid after settling for 30 min.

Now, MLSS = 2200 mg/l

∴ In 1l sample,

Solids = 2200 mg

⇒ W = 2.2 g

and settled volume = 180 ml

Hence, $$\text{SVI} = \frac{V}{W} = \frac{180}{2.2} = 81.82 \text{ ml/g}$$

98. (b)

$$\text{Ambient lapse rate} = \frac{23.75 - 16.25}{642 - 22} \times 1000$$

$$= 12.097°\text{C/km} > 9.8\ °\text{C/km}$$

When the ambient lapse rate exceeds the adiabatic lapse rate, the ambient lapse rate is said to be super adiabatic.

99. (b)

$$V_1(100 - P_1) = V(100 - P)$$

$$\Rightarrow \frac{V_1}{V} = \frac{100-98}{100-96} = \frac{2}{4} = \frac{1}{2} = 0.5$$

$$\therefore \text{Volume reduction} = \frac{V - V_1}{V} \times 100 = (1 - 0.5) \times 100$$

$$= 50\%$$

100. (b)

Specific capacity of a well is not constant but decreases as the discharge increases.
It can shown by the equation,

$$\text{Specific capacity} = \left[\frac{1}{C_1 + C_2 Q}\right]$$

The coefficient C_1 and C_2 are determined by pumping test data of drawdown at various discharges.

102. (a)

Iron salts impart more corrosiveness to water than that which is imparted by alum.

103. (d)

Methods of protecting concrete sewers from hydrogen sulphide corrosion are:

1. Proventing the entry of wastes containing sulphides.
2. Reducing the sulphate contents by pre-treating the sewage.
3. Aerating and chlorinating the sewage.
4. By adequately ventilating the sewers.

5. By making the sewers to run full.
6. By adding such chemicals to sewage that may neutralize the already present sulphur compounds.

104. (d)

In effluent irrigation, the chief consideration is the successful disposal of sewage.
In sewage farming, the chief consideration is the successful growing of the crops.

105. (b)

Moisture content of sludge, obtained from trickling filters, is as high as 99% or so. It is an advantage of trickling filter.

106. (a)

$$W = \frac{P - R - I_a}{t_e}$$

$$= \frac{90\text{ cm} - 20\text{ cm} - 10\text{ cm}}{2\text{ hours}} = 30\text{ cm/hour}$$

107. (c)

$$W_{75} = \frac{W_{50}}{1.75} = \frac{35}{1.75} = 20\text{ hours}$$

108. (d)

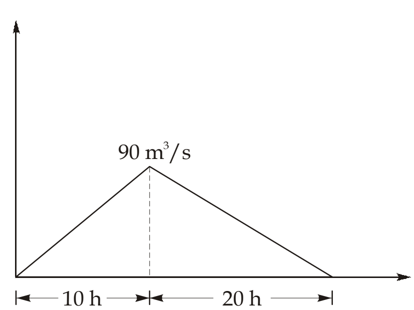
$$\bar{R} = 1 - (1 - P)^n$$

$$= 1 - \left(1 - \frac{1}{50}\right)^{10} = 1 - \left(\frac{49}{50}\right)^{10}$$

$$= 1 - 0.817 = 0.183$$

$$\therefore \quad \bar{R} = 18.3\%$$

109. (c)



$$\text{Depth} = 1\text{ cm}$$

$$\text{Volume of runoff} = A \times 1 \times 10^{-2}\text{ m}^2$$

But, $$\text{Volume of runoff} = \text{Area of the unit hydrograph}$$

$$= \frac{1}{2} \times 30 \times 90 \times 3600$$

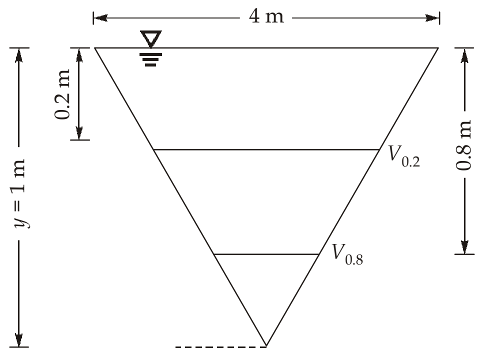
$$= 486 \times 10^4 \text{ m}^3$$

$$\therefore \quad A \times 10^{-2} = 486 \times 10^4$$

$$\Rightarrow \quad A = 486 \times 10^6 \text{ m}^2$$

$$\Rightarrow \quad A = 486 \text{ km}^2$$

110. (c)



$$V_{0.2} = 0.5 \text{ m/s}$$

$$V_{0.8} = 0.3 \text{ m/s}$$

$$V = \frac{V_{0.2} + V_{0.8}}{2} = \frac{0.5 + 0.3}{2} = 0.4 \text{ m/s}$$

$$Q = AV = \frac{1}{2} \times 1 \times 4 \times 0.4 = 0.8 \text{ m}^3\text{/s.}$$

111. (d)

$$Q_2 = C_0 I_2 + C_1 I_1 + C_2 Q_1$$

$$= 0.048 \times 20.0 + 0.429 \times 10.0 + 0.523 \times 10.0 \text{ m}^3\text{/s}$$

$$= 10.48 \text{ m}^3\text{/s}$$

112. (d)

Based on SAR value, irrigation water is classified into four types:

(i) Low sodium water, SAR 0 - 10

(ii) Medium sodium water, SAR 10 - 18

(iii) High sodium water, SAR 18 - 26

(iv) Very high sodium water, SAR - above 26

113. (b)

The consumptive use is computed from the Blaney-Criddle equation as,

$$C_u = k \sum f$$

where,

$$f = \frac{P}{40}[1.8t + 32]$$

Computations are done in the tabular form as shown below.

Month	t (°C)	P (%)	f
Nov	19.0	7.19	11.9
Dec	16.0	7.15	10.9
Jan	15.0	7.30	10.8
			$\Sigma f = 33.6$

$$C_u = k\sum f = 0.75 \times 33.6 = 25.2 \text{ cm}$$

$$Re = 1.2 + 0.8 = 2 \text{ cm}$$

$$\therefore \quad \text{CIR} = C_u - Re = 25.2 - 2.0 \text{ cm}$$

$$= 23.2 \text{ cm}$$

114. (b)

The volume of water stored between the normal pool level and the minimum pool level is known as the useful storage.

116. (b)

$$\text{Total volume of water required} = 2500 \times 10^4 \text{m}^2 \times \frac{18}{100}$$

$$= 25 \times 10^4 \times 18 \text{ m}^3$$

$$\therefore \quad \text{Discharge required} = \frac{25 \times 10^4 \times 18}{25 \times 24 \times 3600} = 2.08 \text{ m}^3/\text{sec}$$

118. (a)

$$\text{Sensitivity, } S = \frac{dq/q}{dG/D}$$

q = Discharge through the outlet

dq = Change in discharge through the outlet

G = Gauge reading

D = Depth of water in the distributing channel

$$\therefore \quad S = 0.65$$

$$\Rightarrow \quad \frac{da}{D} = 50\% = 0.5$$

$$\therefore \quad \frac{dG}{q} = S \times \frac{dG}{D} = 0.65 \times 0.5$$

$$= 0.325$$

$$= 32.5\%$$

119. (d)

$$\text{For free mean speed } K = 0$$

$$\Rightarrow \quad u_{sf} = 60 \text{ km/hr}$$

For K_{jam} $\quad u = 0$

$$\therefore \qquad K_j = \frac{60}{0.6} = 100 \text{ vpkm}$$

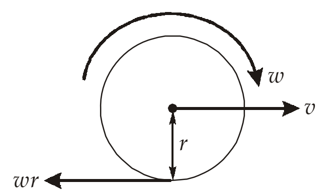
Now,
$$q_{max} = \frac{u_{sf} \times K_j}{4} = \frac{60 \times 100}{4}$$
$$= 1500 \text{ vph}$$

121. (a)

$l = 6.5$ m, $R = 40$ m

$$\text{Off tracking} = \frac{l^2}{2R}$$
$$= \frac{6.5^2}{2 \times 40} = 0.528 \text{ m} \simeq 0.53 \text{ m}$$

122. (c)



$v > wr \Rightarrow$ Skidding

$v < wr \Rightarrow$ Slipping

$v = wr \Rightarrow$ Pure rotation

123. (b)

The effective green time denotes that in the given total time (green time and amber time) saturation flow occurs only for small length of time. The initial delay for start of first vehicle and clearance of vehicles in the amber time causes flow to be reduced. Thus

Effective green time, $(G_e) = G + A - L$

Actual green time, $(G) = 26$ sec

Amber time $(A) = 2.5$ sec

Total lost time, L = Initial lost time (L_i) + Final lost time (L_f)

$L_i = 2.5$ sec

$L_f \leq A$

In the absence of any data on the final lost time, it can be taken to be equal to amber time

$$\therefore \qquad G_e = 26 + 2.5 - (2.5 + 2.5)$$
$$= 23.5 \text{ sec}$$

127. (c)

Length of BG rail = 13 m

$$\text{Number of BG rails in 850 m length} = \frac{850}{13} = 65.4$$

$$\text{Sleeper density} = 13 + 5 = 18 \text{ per rail}$$

$$\therefore \quad \text{Number of sleepers} = 18 \times 65.4 = 1177.2 \simeq 1178$$

128. (b)

Airport reference temperature,

$$T = \frac{2}{3} \times T_{av} + \frac{1}{3} T_{\max}$$

$$= \frac{2}{3} \times 39 + \frac{1}{3} \times 51 = \frac{78 + 51}{3}$$

$$= \frac{129}{3} = 43°\text{C}$$

129. (a)

Mooring is provided for anchoring a boat or ship.

130. (a)

Horonjeff's equation, $R = \dfrac{0.388W^2}{\dfrac{T}{2} - S}$

$W = 18$ m, $T = 22.5$ m, $S = 6 + \dfrac{6.6}{2} = 9.3$ m

$$\therefore \quad R = \frac{0.388 \times 18^2}{\dfrac{22.5}{2} - 9.3} = 64.5 \text{ m}$$

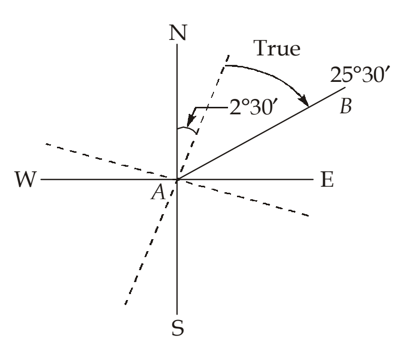
131. (c)

Meaning of accretion is siltation.

132. (b)

Ephemeris error describes the difference between expected and actual position of a satellite. Multipath error is generated when a signal arrives, by different ways, at the antenna.

133. (b)



$$\text{True bearing} = 25°30' + \delta_E$$

$$= 25°30' + 2°30'$$

$= 28°$

Magnetic bearing when declination is 5°30′ W

$= \text{True bearing} + \delta_W$

$= 28° + 5°30'$

$= 33°30'$

134. (a)

Error due to curvature and refraction $= 0.0673d^2$ (where d is in km)

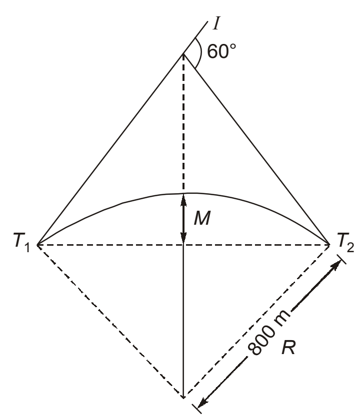
$= 0.0673 \times 1 = 0.0673$ m

Error due to collimation = Total error – Error due to curvature and refraction

$= 0.04 - 0.0673$

$= -0.0273$ m

135. (b)



Length of long chord,

$T_1T_2 = 2R\sin(\Delta/2)$

$= 2 \times 800 \times \sin(60°/2)$

$= 800$ m $(\because \Delta = 60°)$

Length of mid-ordinate,

$M = R[1 - \cos(\Delta/2)]$

$= 800[1 - \cos(60/2)]$

$= 800 \times 0.134 = 107.2$ m

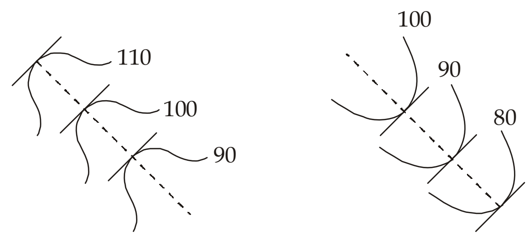
136. (a)

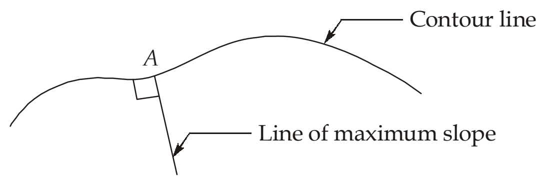
Raster data is a series of cell to which values are assigned. Quality of raster data depends upon the cell size.

Vector data consists of points, lines, polylines and arc.

Raster data has a simple data structure but it requires large memory.

137. (d)





138. (d)

$$\text{Number of photographs per strip} = 1 + \frac{20 \times 1000}{150 \times 25 \times (1-0.6)} \simeq 15$$

$$\text{Number of strips} = 1 + \frac{16000}{150 \times 25 \times (1-0.3)} \simeq 8$$

$\therefore$ Number of photographs = 15 × 8 = 120

139. (a)

Ceylon ghat tracer is a form of clinometer.
Pantograph is used to enlarge or reduce plans.

140. (b)

- A tubular compass is an improved version of a trough compass. A trough compass does not lend itself to very precise setting owing to parallax arising from the difficulty of ensuring that the eye is in the vertical plane of the needle. This difficulty is overcome by using a tubular compass.
- When trough compass is used in conjugation with a plane table, the sides of the box are used as a ruler to plot the north direction. When fitted on a theodolite, it is used to align the telescope in the meridian.

141. (d)

The traffic rotary is an effective traffic management system if the traffic volume is upto 3000 veh/hr.

142. (c)

The beam bends about its strong axis upto the critical load at which it buckles laterally.

145. (c)

HGL grade line slope may go up and down due to disturbances, no need of extra source of supply.

147. (c)

Invar is an alloy containing 36% nickel and 64% iron.

148. (c)

IS 1892 : 1979 recommends that the inside clearance should be from 1 - 3%. The outside clearance should not be much greater than the inside clearance. Its value usually lies between 0 and 2 percent.

Inside clearance is meant to reduce friction between the soil sample and the sampler when the soil enters the tube, by allowing for elastic expansion. If the inside clearance is too large, there will be too much of lateral expansion. Outside clearance will help reduce friction while the sampler is being driven and when it is being withdrawn after the soil sample has been collected.

149. (c)

The total torque transmitted depends on diameter and also on elastic properties.