DETAILED SOLUTIONS

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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 26

Full Syllabus Test 10 : Paper-II

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

** Answer Key has been changed for Q. No. 71*

DETAILED EXPLANATIONS

1. (a)

Compression of two springs, $\Delta_1 = 80 - 65 = 15$ mm

$\Delta_2 = 75 - 65 = 10$ mm

$$w_1 = \frac{\Delta_1 G_1 d_1^4}{8n_1 D_1^3} = \frac{15 \times 80 \times 10^3 \times 7^4}{8 \times 10 \times 100^3} = 36.015 \text{ N} \simeq 36 \text{ N}$$

$$w_2 = \frac{\Delta_2 G_2 d_2^4}{8n_2 D_2^3} = \frac{10 \times 80 \times 10^3 \times 8^4}{8 \times 8 \times 125^3} = 26.2 \text{ N}$$

Therefore, $w = w_1 + w_2$

$= 36 + 26.2$

$= 62.2$ N

2. (d)

$$\text{Direct normal stress} = \frac{P}{bh} = \frac{30 \times 10^3}{50 \times 150} = 4 \text{ N/m}^2 \text{ (T)}$$

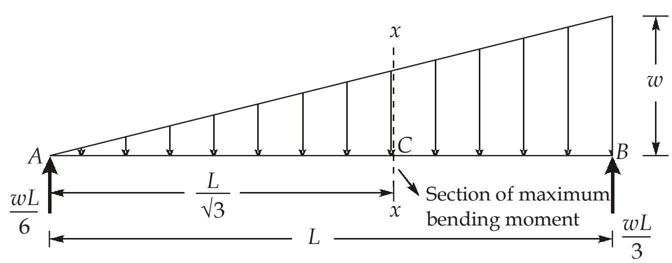
$$\text{Bending normal stress} = \frac{Pey}{I} = \frac{Pa \times 6}{bh^2} = \frac{30 \times 10^3 \times 150 \times 6}{50 \times 150^2} = 24 \text{ N/m}^2 \text{ (C)}$$

$\therefore$ Resultant normal stress at A = 4(T) + 24(C)

= 20 N/mm^2 (C)

3. (d)

4. (a)



Loading diagram

$$\text{Bending moment at section } x\text{-}x = \frac{wL}{6} \times \frac{L}{\sqrt{3}} - \frac{1}{2} \times \frac{L}{\sqrt{3}} \times \frac{w}{\sqrt{3}} \times \frac{L}{\sqrt{3} \times 3}$$

$$= \frac{wL^2}{6\sqrt{3}} - \frac{wL^2}{18\sqrt{3}}$$

$$= \frac{(3-1)wL^2}{18\sqrt{3}} = \frac{wL^2}{9\sqrt{3}}$$

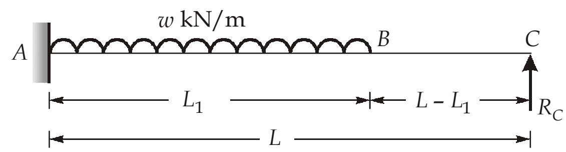
5. (a)

$$\theta_A = \frac{M_0 L}{3EI} + \frac{2M_0 L}{6EI} = \frac{2M_0 L}{3EI}$$

$$\theta_B = \frac{2M_0L}{3EI} + \frac{M_0L}{6EI} = \frac{5M_0L}{6EI}$$

6. (c)

7. (b)



$$\Delta_C = 0$$

$$\Rightarrow \quad \frac{wL_1^4}{8EI} + \frac{wL_1^3}{6EI}(L - L_1) = \frac{R_CL^3}{3EI}$$

$$\Rightarrow \quad \frac{1\times 4^4}{8} + \frac{1\times 4^3}{6}(6-4) = \frac{R_C \times 6^3}{3}$$

$$\Rightarrow \quad 32 + \frac{64}{3} = 72R_C$$

$$\Rightarrow \quad R_C = 0.74 \text{ kN}$$

8. (d)

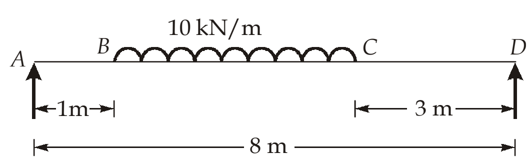
All the given statements are correct assumptions of simple bending.

9. (a)

10. (a)

Shape of kern for rectangular section is Rhombus.

11. (d)



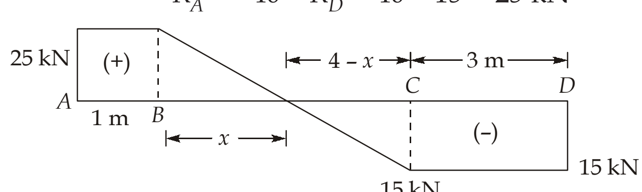
$$R_A + R_D = 10 \times 4 = 40 \text{ kN}$$

$$M_A = 0$$

$$\Rightarrow \quad R_D \times 8 = 10 \times 4 \times 3$$

$$\Rightarrow \quad R_D = 15 \text{ kN}$$

$$\therefore \quad R_A = 40 - R_D = 40 - 15 = 25 \text{ kN}$$



SFD

$$\frac{25}{x} = \frac{15}{4-x}$$

$$20 - 5x = 3x$$
$$x = 2.5 \text{ m}$$

So, maximum bending moment will occur at point of zero SF

∴ BM at 3.5 m from support A is maximum

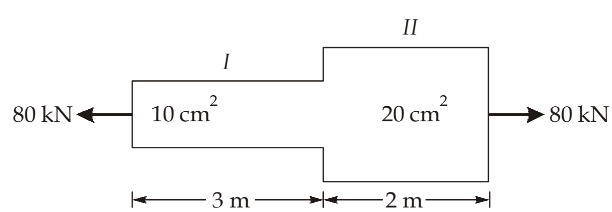
So, $$BM_{max} = 25 \times 3.5 - 10 \times \frac{2.5^2}{2}$$
$$= 56.25 \text{ kNm}$$

12. (a)

$$\tau_{max} = 1.5\,\tau_{avg} \text{ for rectangular section}$$
$$\tau_{max} = \frac{4}{3}\tau_{avg} \text{ for circular section}$$

Shear stress for triangular section is maximum at a height $\frac{h}{2}$ from base (or vertex).

13. (c)



$$U = U_I + U_{II}$$
$$= \left(\frac{P^2L}{2AE}\right)_I + \left(\frac{P^2L}{2AE}\right)_{II}$$
$$= \frac{(80 \times 10^3)^2 \times 3000}{2 \times 10 \times 100 \times 2 \times 10^5} + \frac{(80 \times 10^3)^2 \times 2000}{2 \times 20 \times 100 \times 2 \times 10^5}$$
$$= 64000 \text{ Nmm}$$
$$= 64 \text{ Nm}$$

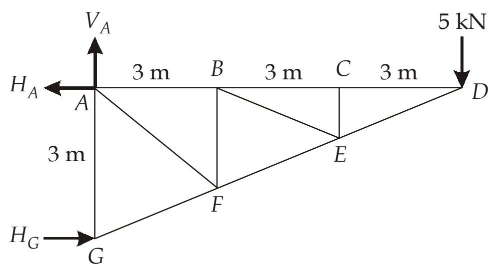
14. (a)

According to maximum principal strain theory,

$$\frac{f}{E} = \frac{(\sigma_1 - \mu\sigma_2)}{E}$$

∴ The equivalent tensile stress, $f = 120 - 0.25 \times 52$
$$= 120 - 13$$
$$= 107 \text{ N/mm}^2$$

15. **(c)**



$$\sum F_y = 0$$

$\Rightarrow$ $$V_A - 5 = 0$$

$\Rightarrow$ $$V_A = 5 \text{ kN}$$

$$\sum M_G = 0$$

$\Rightarrow$ $$H_A \times 3 - 5 \times 9 = 0$$

$\Rightarrow$ $$H_A = 15 \text{ kN}$$

$\therefore$ $$R_A = \sqrt{H_A^2 + V_A^2} = \sqrt{15^2 + 5^2} = 15.8 \text{ kN}$$

16. **(b)**

Before the temperature rise,

$$\text{Horizontal thrust, } H = \frac{wl^2}{8h} = \frac{25 \times 20^2}{8 \times 4} = 312.5 \text{ kN}$$

Increase in the rise of the arch due to rise in temperature,

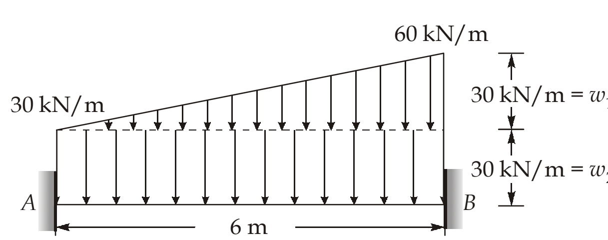
$$dh = \frac{l^2 + 4h^2}{4h} \cdot \alpha \Delta T$$

$$= \frac{20^2 + 4 \times 4^2}{4 \times 4} \times 12 \times 10^{-6} \times 40 = 0.01392 \text{ m}$$

$\because$ $$\frac{dH}{H} = -\frac{dh}{h}$$

$\Rightarrow$ $$dH = -\frac{0.01392}{4} \times 312.5 = 1.0875 \text{ kN (decrease)} \simeq 1.1 \text{ kN (say)}$$

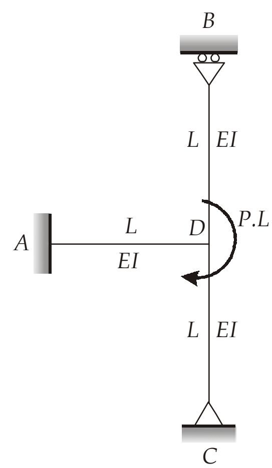
17. **(d)**



$$M_A = \frac{w_2 L^2}{12} + \frac{w_1 L^2}{30}$$

$$= \frac{30 \times 6^2}{12} + \frac{30 \times 6^2}{30} = 126 \text{ kN-m}$$

18. (b)



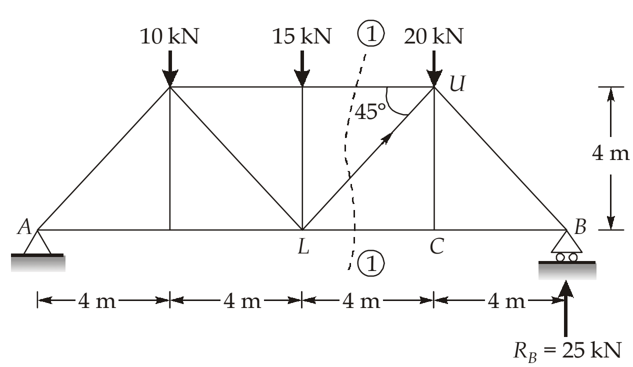
$$\text{D.F. for DA} = \frac{\frac{4EI}{L}}{\frac{4EI}{L} + \frac{3EI}{L}} = \frac{4}{7}$$

$$\therefore \quad M_{DA} = \frac{4}{7} PL$$

$$\therefore \quad M_A = \frac{M_{DA}}{2} = \frac{2}{7} PL$$

19. (c)

20. (a)



$$\Sigma M_A = 0$$

$$\Rightarrow 10 \times 4 + 15 \times 8 + 20 \times 12 - R_B \times 16 = 0$$

$$\Rightarrow \quad R_B = 25 \text{ kN}$$

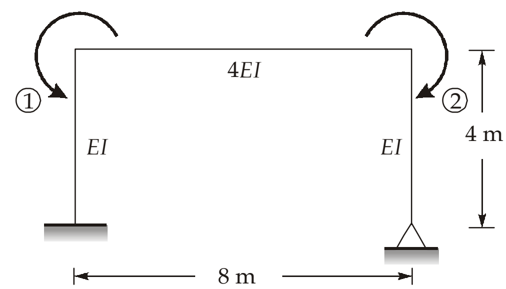
Cut the section (1)-(1) as shown in figure.

$$\Sigma F_y = 0$$

$$\Rightarrow \quad F_{UL} \times \sin 45° - 20 + 25 = 0$$

$$F_{UL} = -5\sqrt{2}\text{ kN} = 5\sqrt{2}\text{ kN (T)}$$

21. (a)



$$k_{11} = \frac{4EI}{4} + \frac{4(4EI)}{8} = 3EI$$

$$k_{21} = \frac{2(4EI)}{8} = EI$$

$$k_{12} = EI$$

$$k_{22} = \frac{4(4EI)}{8} + \frac{3(EI)}{4} = \frac{11EI}{4}$$

$$\therefore \quad [k] = \begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix} = \begin{bmatrix} 3EI & EI \\ EI & \frac{11EI}{4} \end{bmatrix} = EI\begin{bmatrix} 3 & 1 \\ 1 & \frac{11}{4} \end{bmatrix}$$

22. (b)

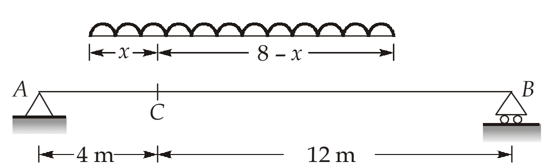
$$\Sigma M_A = 0$$

$$\Rightarrow \quad P \times \frac{L}{2} - R_C \times L + P \times \frac{3L}{2} = 0$$

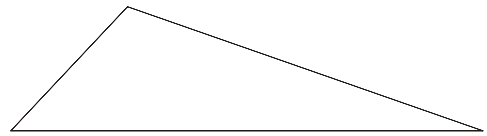
$$\Rightarrow \quad R_C \times L = 2PL$$

$$\Rightarrow \quad R_C = 2P$$

23. (b)



$$\frac{x(L-x)}{L} = \frac{4(16-4)}{16} = 3\text{ units}$$



ILD for BM at C

Load position,

$$\text{Average load on AC} = \text{Average load on CB}$$

$$\frac{wx}{4} = \frac{w(8-x)}{12}$$

$$\Rightarrow \quad 3x = 8 - x$$

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

$$\text{So, head of UDL from } A = 4 + (8 - x)$$

$$= 4 + (8 - 2)$$

$$= 10 \text{ m}$$

24. (d)

According to Cl 5.6 of **IS 800:2007** serviceability limit state is limit beyond which the service criteria specified below, are no longer met:

(a) Deflection limit

(b) Vibration limit

(c) Durability consideration

(d) Fire resistance

According to Table 5 of **IS 800:2007**

Partial safety factor for resistance of member governed by yielding and buckling is 1.1 and by ultimate stress is 1.25.

According to Cl 4.5.2

When a plastic method of analysis is used the following conditions must be satisfied.

(a) The yield stress of grade of steel used shall not exceed 450 MPa.

(b) The stress-strain diagram shall have a plateau at the yield stress, extending for at least six times the yield the yield strain.

(c) The ratio of the tensile strength to the yield stress specified for grade of steel shall not be less than 1.2.

(d) The cross-section of members not containing plastic hinges should be at least that of compact section.

25. (a)

Advantages of bolted connection:

1. The erection can be speeded up.
2. Less skilled persons are required.
3. The overall cost of bolted construction is cheaper than that of riveted connection because of reduced labour and equipment costs.

General objections to the use of bolts:

1. Cost of material is high, about double that of rivets.

2. When subjected to vibrations or shocks, bolts may get loose.
3. The tensile strength of the bolts is reduced because of area reduction at the root of the thread.

26. (a)

- Plastic moment capacity depends on area of cross-section and its distribution.
- Plastic moment capacity is independent of length of beam and this can be shown as.

$$M_p = f_y \frac{A}{2}(\bar{y}_1 + \bar{y}_2)$$

27. (c)

IS 800:2007 limits the maximum slenderness ratio to 400 for members always under tension except for pretensioned members. This limit is there to check the undesirable vibrations or deflections.

28. (a)

The number of battens shall be such that the member is divided into not less than 3 bays.

29. (b)

Equivalent stress on a fillet weld is given by,

$$f_e = \sqrt{f_a^2 + 3q^2}$$

$$= \sqrt{200^2 + 3 \times 40^2}$$

$$= 211.66 \text{ N/mm}^2 \simeq 212 \text{ N/mm}^2$$

30. (d)

Design strength of a tension member has three limit states:

1. Limit state of yielding
2. Limit state of fracture
3. Block shear failure

31. (a)

The attachment of the lug angle to the gusset should be capable of developing 20% in excess of the force in outstanding leg. The attachment of the lug angle to the angle member should be capable of developing 40% in excess of that force.

32. (a)

Intermediate vertical stiffener increases the buckling resistance of web caused by shear.

While horizontal stiffeners are used to increase the buckling resistance of web caused by bending.

33. (d)

- Purlins are designed as continuous beams.
- Sag rods are designed as tension members.
- A beam section is classed as low shear case when the factored shear force is less than $0.6V_d$.

34. (c)

Nominal diameter of bolt = 20 mm
Then diameter of hole = 20 + 2 = 22 mm
Minimum pitch = 2.5 × 20 = 50 mm
Minimum end/edge distance = 1.5 × 22 = 33 mm
Let n be the number of bolts, then
$2 \times 33 + (n - 1) \times 50 = 140$
$\Rightarrow \quad n = 2.48$
Therefore, maximum 2 number of bolts can be provided.

35. (d)

36. (a)

Penultimate support is the support next to the end support.
$\therefore$ Over penultimate support,

$$\text{BM due to dead load} = -\frac{w_d l^2}{10}$$

$$\text{BM due to live load} = -\frac{w_l l^2}{9} \qquad \text{[Refer Table 12 of \textbf{IS 456:2000}]}$$

Given $\quad w_d = 6 \text{ kN/m}$
$\quad w_l = 3 \text{ kN/m}$

$$\therefore \quad \text{BM} = \frac{-w_d l^2}{10} - \frac{w_l l^2}{9}$$

$$= \frac{-6 \times 25}{10} - \frac{3 \times 25}{9} = -23.33 \text{ kNm}$$

37. (a)

A circular beam supported on multiple columns is a situation where both primary torsion and secondary torsion coexist.

38. (b)

$$\tau_v = \frac{V_u}{b_w d} = \frac{53 \times 1000}{230 \times 460}$$

$$= 0.50 \text{ N/mm}^2 < \tau_c \; (= 0.608 \text{ N/mm}^2)$$

Also, $\quad \tau_{c,\max} = 0.625\sqrt{f_{ck}}$

$$= 0.625\sqrt{20} = 2.8 \text{ N/mm}^2$$

$$> \tau_v \qquad \text{(OK)}$$

$$\therefore \quad \tau_v < \tau_c < \tau_{c,\max}$$

Hence minimum shear reinforcement has to be provided,

$$\frac{A_{sv}}{b_w s_v} \geq \frac{0.4}{0.87 f_y}$$

$$\Rightarrow \qquad \frac{2\times\frac{\pi}{4}\times 6^2}{230\times s_v} \geq \frac{0.4}{0.87\times 415}$$

$$\Rightarrow \qquad s_v \leq 221.92 \text{ mm}$$

$$\Rightarrow \qquad s_v = 220 \text{ mm} \qquad \text{(say) OK}$$

39. (b)

$$\text{Minimum vertical spacing} = \text{Maximum of}\left[15\text{ mm}, \frac{2}{3}\times\text{Max. aggregate size, bar dia.}\right]$$

$$= \text{Maximum of}\left[15\text{ mm}, \frac{2}{3}\times 20, 12\right]$$

$$= \text{Maximum of}\left[15\text{ mm}, 13.33\text{ mm}, 12\text{ mm}\right]$$

$$= 15\text{ mm}$$

40. (c)

As per **IS 456:2000**

$$k = 1.6 - 0.002D$$

D is the overall depth,

$$D = \text{d + effective depth}$$
$$= 120 + 30 = 150 \text{ mm}$$
$$k = 1.6 - 0.002 \times 150$$
$$= 1.3$$

41. (d)

42. (c)

As the depth of the beam increases, the shear stress at failure decreases.

43. (c)

For seismic design, the stirrups and ties should have a 135° hook with a 6 d_b extension (but not less than 65 mm) at each end that is embedded in the concrete area.

44. (d)

45. (b)

$$\text{Initial prestressing force, } P = \frac{615}{0.82} = 750 \text{ kN}$$

$$e = 80 \text{ mm}$$

$$\text{Area of beam} = 250 \times 320 = 80000 \text{ mm}^2$$

$$\text{Top fibre stresses} = \frac{P}{A}\left(1 - \frac{6e}{d}\right)$$

$$= -4.6875 \text{ N/mm}^2 \simeq -4.7 \text{ N/mm}^2$$

$$\text{Bottom fibre stresses} = \frac{P}{A}\left(1+\frac{6e}{d}\right) = 23.44 \text{ N/mm}^2$$

46. (d)

Given, E_s = 210 kN/mm^2 and E_c = 35 kN/mm^2

So, $$\text{modular ratio, } m = \frac{E_s}{E_c} = \frac{210}{35} = 6$$

$$\text{Prestressing force} = \frac{320\times 1000}{1000}\text{kN} = 320 \text{ kN}$$

$$A = 200 \times 300 = 6 \times 10^4 \text{ mm}^2$$

$$I = \frac{200\times 300^3}{12} = 45\times 10^7 \text{ mm}^4$$

Stress in concrete at the level of steel

$$f_c = \left[\frac{320\times 10^3}{6\times 10^4} + \frac{320\times 10^3\times 50\times 50}{45\times 10^7}\right]$$

$$= \frac{16}{3}+\frac{16}{9} = 7.11 \text{ N/mm}^2$$

Loss due to elastic deformation of concrete = mf_c

$= 6 \times 7.11$

$= 42.66 \text{ N/mm}^2 \simeq 42 \text{ N/mm}^2$

47. (d)

48. (b)

Tilt : This movement is within the vertical plane of the blade. Tilting permits concentration of dozer driving power on a limited portion of the blade's length.

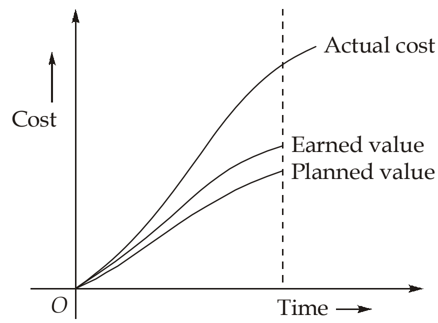
Pitch : This is a pivotal movement about the point of connection between the dozer and blade.

Angling : Turning the blade so that it is not perpendicular to the direction of the dozer's travel is known as angling.

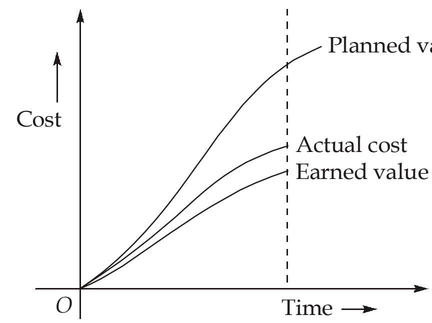
49. (b)

Used primarily in the construction industry, the term refers to the expediting technique in which design and planning phases of a project are not actually completed before the building phase is shorted.

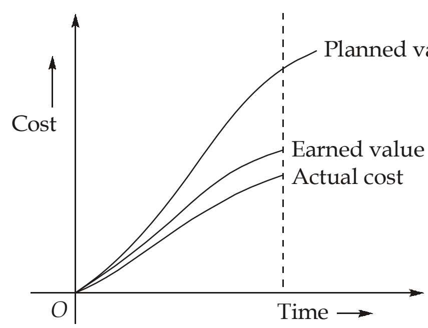
50. (c)



Positive schedule variance, negative spending variance

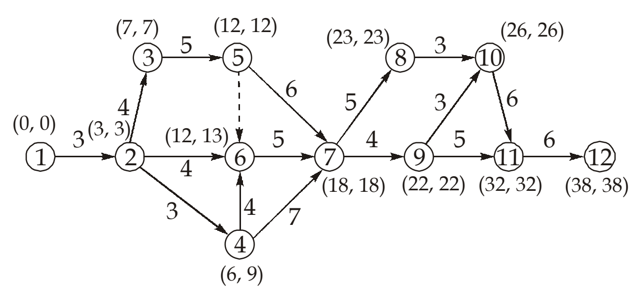


Negative schedule variance, negative spending variance



Negative schedule variance, positive spending variance

51. (c)



The project completion time is 38 days

Critical path is 1-2-3-5-7-8-10-11-12

52. (a)

The payback period for an investment may be taken as the number of years it takes to repay the original invested capital.

53. (c)

Normal time for both activities

For P, $T_{NP} = 6$ days

For Q, $T_{NQ} = 8$ days

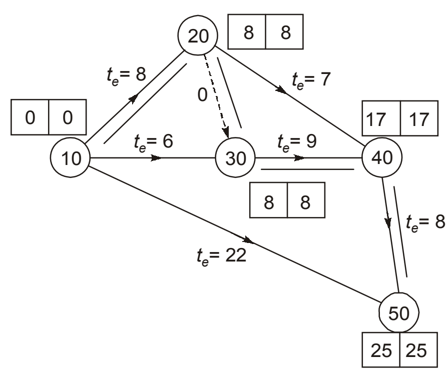
Either of the activities can be crashed and tabular representation of crashing is as follows:

Activity		Direct cost		Total time	Total cost
P	Q	P	Q		
6	8	12	15	14	27
5	8	14	15	13	29
5	7	14	17	12	31
5	6	14	19	11	33
5	5	14	21	10	35
4	5	17	21	9	38
3	5	21	21	8	42

Increase in direct cost between a combined duration of 13 days and 9 days = 38 – 29 = 9

54. **(d)**

55. **(d)**



Critical path is given by 10 - 20 - 30 - 40 - 50

∴ The earliest expected occurrence time (T_E) for the event 50 is 25 days.

56. **(d)**

57. **(c)**

58. **(c)**

59. **(c)**

Low heat cement sets slower than OPC. Setting time has no relation with strength of cement. Gypsum acts as retarder. So, option (c) is correct.

60. **(c)**

61. **(c)**

62. **(a)**

63. **(c)**

Magnesite bricks are basic refractory with more than 90% magnesium oxide (MgO).

64. (b)

1 m^3 of freshly mixed concrete corresponds to 1.54 m^3 of dry volume of concrete

$$\therefore \quad \text{Cement content} = \frac{1.54}{7} = 0.22 \text{ m}^3$$

$$\therefore \quad \text{Coarse aggregate} = 0.22 \times 4 = 0.88 \text{ m}^3$$

65. (a)

Druxiness is indicated by white decayed spots which are concealed by healthy wood, formed due to access of fungi.

66. (b)

$$\text{Mean dimension} = \frac{50+40}{2} = 45 \text{ mm}$$

$$\text{Slot for flakiness index} = \frac{3}{5} \times 45 = 27 \text{ mm}$$

67. (c)

68. (c)

The increase in strength of cement with time depends on the C_2S content of cement. C_2S is responsible for the ultimate strength of cement. Rapid hardening cement has the highest C_2S content.

69. (a)

$$\because \quad h_f = \frac{H}{3} = \frac{600}{3} = 200 \text{ m}$$

$$\therefore \quad H_{\text{exit}} = \frac{2H}{3} = \frac{2 \times 600}{3} = 400 \text{ m}$$

$$\because \quad h_f = \frac{8 fLQ^2}{\pi^2 g D^5}$$

$$\Rightarrow \quad 200 = \frac{8 \times 0.12 \times 4 \times 10^3 \times Q^2}{\pi^2 \times 10 \times 0.2^5}$$

$$\Rightarrow \quad Q = 0.0405 \text{ m}^3/\text{s}$$

$$\therefore \quad P_{\text{exit}} = \rho Q g H_{exit}$$

$$= 1000 \times 0.0405 \times 10 \times 400 \text{ W}$$

$$= 162 \text{ kW}$$

70. (b)

$$H = 10 \text{ cm}$$

$$\text{Horizontal distance, } x = 20 \text{ cm}$$

$$\text{Vertical distance, } y = 10.5 \text{ cm}$$

$$C_V = \frac{x}{2\sqrt{yH}} = \frac{20}{2\sqrt{10 \times 10.5}} = 0.9759 \simeq 0.976$$

$$\therefore \quad C_C = \frac{C_d}{C_V} = \frac{0.6}{0.976} = 0.61$$

71. (a)

72. (d)

$$\psi = 4(y^2 - x^2)$$

$$\text{At } (2, 4)\ \psi_1 = 4(4^2 - 2^2) = 48 \text{ units}$$

$$\therefore \quad \text{At } (4, 5)\ \psi_2 = 4(5^2 - 4^2) = 36 \text{ units}$$

$$Q_{\text{per unit width}} = |\psi_2 - \psi_1|$$

$$\Rightarrow \quad Q = 48 - 36 = 12 \text{ units}$$

73. (b)

$$\because \quad T = \frac{3A}{C_d \times L\sqrt{2g}}\left[\frac{1}{\sqrt{H_2}} - \frac{1}{\sqrt{H_1}}\right]$$

$$= \frac{3 \times 80 \times 80}{0.62 \times 1.5 \times 4.43}\left[\frac{1}{\sqrt{4}} - \frac{1}{\sqrt{9}}\right]$$

$$= 776.7 \text{ sec}$$

$$= 12.94 \text{ min}$$

74. (c)

75. (c)

76. (b)

$$\text{Flow rate, } Q_r = (L_r)_H \cdot (L_r)_v^{3/2}$$

$$\Rightarrow \quad \frac{Q_m}{Q_p} = \left(\frac{1}{100}\right)\left(\frac{1}{25}\right)^{3/2}$$

$$\Rightarrow \quad \frac{Q_m}{1800} = \frac{1}{100} \times \frac{1}{125}$$

$$\Rightarrow \quad Q_m = 0.144 \text{ m}^3/\text{s} \simeq 0.14 \text{ m}^3/\text{s}$$

77. (b)

$$T = \dot{m}V_{w_1}r_1 - \dot{m}V_{w_2}r_2$$

It is given that at exit, water does not have moment

i.e. $V_{W_2} = 0$

$$T = \dot{m}V_{w_1}r_1$$

$$\Rightarrow \quad 1800 \times 9.81 = (1000 \times 20) \times V_{w_1} \times 2$$

$$\Rightarrow \quad V_{w_1} = 0.44 \text{ m/s}$$

78. (c)

$$\because \quad \frac{N}{\sqrt{H}} = \text{Constant}$$

$$\therefore \quad \frac{400}{\sqrt{49}} = \frac{N_2}{\sqrt{64}}$$

$$\Rightarrow \quad N_2 = 457.14 \text{ rpm}$$

79. (b)

Pumps in series increase the head not discharge.

80. (d)

81. (a)

82. (a)

Peat is a highly organic soil, consisting almost entirely of vegetative matter.

83. (d)

As the equipotential lines come closer to each other in a flow net, the length of flow for the same drop in head becomes smaller and the gradient of flow will consequently be higher.

If two flow lines meet, it would imply that the water flowing in the flow path between them has disappeared.

Flow net is a function of the geometry of flow space only.

84. (b)

Soil structure becomes more dispersed as the compaction water content is increased, as the compactive energy is increased and as one uses a method of compaction that induces more shearing strains in the soil such as the kneading compaction.

85. (d)

86. (d)

$$\Delta u = B\left(\Delta\sigma_3 + A\left(\Delta\sigma_1 - \Delta\sigma_3\right)\right)$$

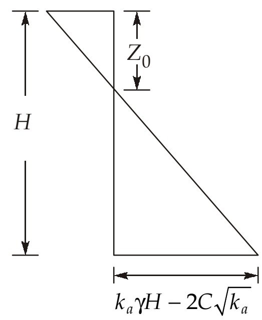
$$\Delta\sigma_1 = 3 \times 17 = 51 \text{ kN/m}^3$$

$$\Delta\sigma_3 = \frac{51}{2} = 25.5 \text{ kN/m}^2$$

$$\therefore \quad \Delta u = 0.8\left(25.5 + 0.6\left(51 - 25.5\right)\right)$$

$$= 32.64 \text{ kN/m}^2$$

87. (d)



$$p_A = \frac{1}{2}\left(k_a y H - 2C\sqrt{k_a}\right)\left(H - Z_0\right)$$

$$= \frac{1}{2}\left(k_a \gamma H - 2C\sqrt{k_a}\right)\left(H - \frac{2C}{\sqrt{k_a}\gamma}\right)$$

$$= \frac{k_a \gamma H^2}{2} - 2CH\sqrt{k_a} + \frac{2C^2}{\gamma}$$

88. (d)

- The forces between the slices are neglected and each slice is considered to be an independent column of soil of unit thickness.
- The shear strength at different points on the slip surface varies according to the value of the effective normal stress at these points.
- Swedish circle method is also known as method of slices.

89. (c)

The assumptions are:

1. Consolidation and flow are one dimensional.
2. Soil is completely saturated and homogeneous.
3. Darcy's law is valid.
4. Soil grains and water, both are incompressible.
5. Strains are small.
6. Unique relationship between void ratio and effective stress.

90. (c)

Equation of A-line $= 0.73\ (w_L - 20)$

$= 0.73\ (60 - 20) = 29.2$

$w_L = 60$

$\Rightarrow$ $I_P = w_L - w_P$

$= 60 - 50 = 10$

As $I_{P,\ soil} < I_P$ of A-line

$\therefore$ The point lies below the A-line and hence soil will be classified as MH.

91. (d)

$$S_i = \frac{qB(1-\mu^2)}{E} \times I_f$$

$$= \frac{150 \times 2 \times (1-0.5^2)}{6 \times 10^4} \times 1.5$$

$$= 5.625 \times 10^{-3} \text{ m}$$

$$= 5.625 \text{ mm} \simeq 5.63 \text{ mm}$$

92. (d)

93. (d)

The characteristics of general shear failure are :

1. A well defined failure pattern.
2. A sudden, catastrophic failure accompanied by tilting of foundation.
3. A bulging of ground surface adjacent to foundation.
4. The ultimate load can be easily located as the load-settlement curve indicates that failure is abrupt in general shear mode.

   General shear failure mode is typical of soils possessing brittle-type stress strain behaviour (eg. dense sand)

94. (a)

Maximum hourly draft of maximum day = $2.7q_{avg}$

$$q_{avg} = 350000 \times 280 \times 10^{-6} \text{ MLD}$$

$$= 98 \text{ MLD}$$

∴ Maximum hourly draft of maximum day = 2.7 × 98

$$= 264.6 \text{ MLD}$$

95. (c)

Certain springs, sometimes discharge hot water due to presence of sulphur in them.

96. (c)

Amoebic dysentery is the disease caused by protozoal infections.

97. (a)

Quantity of copperas required per 1 million litre of water

$$= 10 \times 1 \times 10^6 \times 10^{-6} = 10 \text{ kg}$$

The chemical reaction that takes place is:

$$FeSO_4 \cdot 7H_2O + CaO \rightarrow Fe(OH)_2 + CaSO_4 + 4H_2O$$

Molecular mass of copperas ($FeSO_4 \cdot 7H_2O$) = 56 + 32 + (4 × 16) + (7 × 18) = 278 g/mole

Since, one molecule of copperas requires one molecule of lime

So 278 gram of copperas ≡ 56 gm of quick lime

⇒ 10 kg of copperas = $\frac{56}{278} \times 10 = 2.0$ kg of quick lime

98. (c)

The normal dose of this disinfectant varies between 1 to 2 mg/l with a contact period of 4 to 6 hours.

99. (a)

Starch iodide test is laborious and costly and hence generally not used for testing public supplies. Orthotolidine test gives false results when there are impurities like iron, manganese, nitrate etc.

100. (b)

Let D is diameter of circular sewer and b be the side of equivalent square sewer.

The discharge capacity of circular sewer while running full is

$$Q = \frac{1}{N}\left(\frac{\pi}{4}D^2\right)\left(\frac{D}{4}\right)^{2/3}\sqrt{S} \quad \text{...(i)}$$

$$\because \quad R = \frac{A}{P}$$

Here, $A = b \times b = b^2$, $P = b + b + b = 3b$

$$\therefore \quad R = \frac{b^2}{3b} = \frac{b}{3}$$

$\therefore$ Discharge capacity of square section running nearly full,

$$Q = \frac{1}{N}\left(b^2\right)\left(\frac{b}{3}\right)^{2/3}\sqrt{S} \quad \text{...(ii)}$$

From equation (i) and (ii), we get

$$\frac{1}{N}\left(\frac{\pi}{4}D^2\right)\left(\frac{D}{4}\right)^{2/3}\sqrt{S} = \frac{1}{N}\left(b^2\right)\left(\frac{b}{3}\right)^{2/3}\sqrt{S}$$

$$\Rightarrow \quad \frac{D^{8/3}}{b^{8/3}} = \frac{4}{\pi} \times \frac{(4)^{2/3}}{(3)^{2/3}} = \left[\left(\frac{4}{3}\right)^{1/3}\right]^2 \times \frac{4}{\pi}$$

$$= 1.21 \times \frac{4}{\pi} = 1.54$$

$$\Rightarrow \quad \frac{D}{b} = (1.54)^{3/8}$$

101. (d)

Relative stability is the ratio of oxygen available in effluent to total oxygen required to satisfy its first stage BOD demand.

The decolourisation is caused by the enzymes produced by anaerobic bacteria.

The sooner (less than 4 days or so) decolourisation takes place, effluent sample may be taken relatively unstable.

102. (a)

$$\text{Organic loading, } u = 160 \text{ gm/m}^3\text{/day}$$

$$= \frac{160 \times 10^{-3}}{10^{-4}} \text{ kg/hact-m/day}$$

$$= 1600 \text{ kg/hact-m/day}$$

Efficiency of standard rate trickling filter $= \dfrac{100}{1 + 0.0044\sqrt{u}}$

$$= \frac{100}{1 + 0.0044\sqrt{1600}} \simeq 85\%$$

103. (a)

We know,
$$\frac{Q_R}{Q} = \frac{X_T\,(\text{MLSS})}{\dfrac{10^6}{\text{SVI}} - X_T\,(\text{MLSS})}$$

$$\Rightarrow \quad \frac{1}{3} = \frac{2000}{\dfrac{10^6}{\text{SVI}} - 2000}$$

$$\Rightarrow \quad \frac{10^6}{\text{SVI}} - 2000 = 6000$$

$$\Rightarrow \quad \frac{10^6}{\text{SVI}} = 8000$$

$$\Rightarrow \quad \text{SVI} = \frac{10^6}{8000}$$

$$= 125 \text{ ml/g}$$

104. (d)

105. (c)

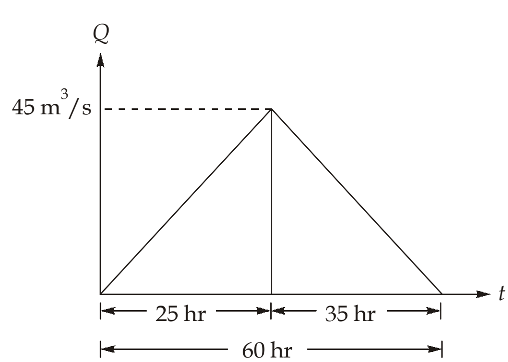
106. (b)

These are the regions of high pressure.

107. (c)

108. (a)

109. (a)



$$\text{Rainfall excess} = \frac{\frac{1}{2}\times(60\times3600)\times45}{250\times10^6}\text{ m} = 1.944\text{ cm}$$
$$= 19.44\text{ mm}$$

110. (d)

111. (d)

Flow-duration curve is also known as "discharge-frequency curve".

112. (a)

Duty achieved by inundation canal water is low. It is a disadvantage of inundation canal.

113. (d)

$$\text{Flexibility, } F = \frac{dq/q}{dQ/Q}$$
$$\Rightarrow \quad 0.5 = \frac{dq/q}{75\%}$$
$$\Rightarrow \quad \frac{dq}{q} = 0.5 \times 75\%$$
$$= 37.5\%$$

114. (b)

115. (b)

For particle on bed to be stationary

$$d \geq 11RS$$

Thus, $d_{\min} = 11RS$

where, $R = \frac{By}{B+2y} \simeq y \qquad [\therefore B >> y]$

$\therefore \quad d_{\min} = 11 \times y \times S$

$$\Rightarrow \quad \frac{36}{11\times2000} = S$$
$$S = 1.64 \times 10^{-3} = 0.00164$$

116. (a)

117. (d)

To prevent breaching of the canal bank, it should be strengthened properly so that valuable loss of irrigation and property is prevented due to breaching of canal section. There are four methods of strengthening a canal bank viz.:

1. External silting system
2. Internal silting system
3. Formation of berms by internal silting
4. Formation of back berm.

118. **(c)**

Lining being permanent, it is difficult to shift the outlets very often.

119. **(d)**

$$\text{CSA} = \frac{365\,NFD\left\{(1+r)^n - 1\right\}VDF \times (LDF)}{r}$$

$$= \frac{365 \times 2700 \times (1.791 - 1) \times 5.4 \times 0.75}{0.06 \times 10^6}\text{ msa}$$

$$= 52.62 \text{ msa}$$

120. **(c)**

121. **(a)**

122. **(c)**

Assuming $L > \text{SSD}$

$\therefore$ $$L = \frac{NS^2}{4.4} = \frac{\frac{8}{100} \times 130^2}{4.4}$$ [N = 2.75 – (–5.25) = 8%]

$$= 307.3 \text{ m} > \text{SSD } (=130 \text{ m})$$ OK

123. **(d)**

In addition to points given in question, transition curve should have the same radius as that of the circular curve at its junction with the circular curve.

124. **(d)**

Only for 29 hours in a year the traffic volume exceeds the design hourly volume.

$\therefore$ Percent time the designer willingly tolerate the unfavourable operating

$$= \frac{29 \times 100}{365 \times 24} = 0.33\%$$

125. **(c)**

126. **(a)**

Curve resistance for train on BG track $= 0.0004 \times W \times D$

$= 0.0004 \times 60 \times 5$

$= 0.12$ tonnes

127. **(d)**

128. **(c)**

129. **(d)**

130. **(c)**

131. (b)

Contour interval can not be variable.

132. (a)

$$\text{Scale} = \frac{6\text{ cm}}{1.8\text{ km}} = \frac{f}{H}$$

$$\Rightarrow \quad \frac{0.06}{1800} = \frac{0.15}{H}$$

$$\Rightarrow \quad H = 4500\text{ m} = 4.5\text{ km}$$

133. (c)

134. (a)

Volume of tape per metre run = 0.08 × 100 = 8 cm^3

Weight of the tape per metre run = 8 × 0.08 = 0.64 N

Total weight of the tape suspended between two supports = 0.64 × 10 = 6.4 N

$$\text{Sag correction} = \frac{nl_1(wl_1)^2}{24P^2}$$

$$= \frac{3\times 10(6.4)^2}{24\times 100^2} = 5.12\times 10^{-3}\text{ m}$$

$$= 5.12\text{ mm}$$

135. (c)

136. (d)

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

$$= 4380\text{ m}^3$$

137. (b)

Secular variation is the change in the declination at a place over the period of about 100-150 years.

138. (a)

Horizontal axis is the axis about which the telescope can be rotated in a vertical plane.

139. (c)

The latitude of a line is its projection onto the north-south meridian.

Since the man travels towards west, its projection on north-south meridian will be zero.

140. (c)

Idukki Dam is an arch dam.

Dykes introduce heterogeneity in the region.

141. (b)

142. (a)

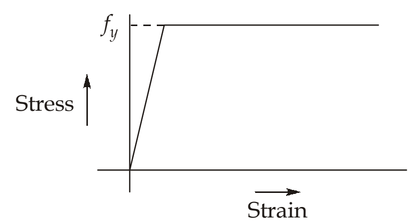
143. **(a)**
Both statement are correct and statement II is correct reason of statement I.

144. **(a)**
Post tensioning is generally uneconomical for vertical prestressing due to large number of anchorages required and the losses of prestress encountered.

145. **(b)**
Minimum pitch should be ensured for following reasons:
1. To prevent bearing failure of members between two bolts.
2. To permit efficient installations.

In long joints, the forces shared by the end bolts may be so high that it may lead to progressive joint failure. That's why the value of maximum pitch should be limited.

146. **(a)**
Plastic analysis and design is based on idealized stress-strain curve.



147. **(c)**

$\frac{COD}{BOD}$ ratio helps in monitoring wastewater treatments.

$\frac{COD}{TOC}$ ratio may vary from zero for an organic material resistant to dichromate oxidation, to 5.33 for methane.

148. **(d)**
For chunk sampling, it is necessary that the soil has a trace of cohesion.
Chunk samples are not suitable, if these are to be transported to long distances because they are likely to get disturbed during transit.

149. **(b)**

150. **(b)**